Scientific Planning and Review Committee:

# Recommendations on The Bay Protection and Toxic Cleanup Program Monitoring Activities

January 1997

State Of California
State Water Resources Control Board
Regional Water Quality Control Boards
Department of Fish and Game

**STATE WATER RESOURCES CONTROL BOARD**
**CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY**

STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS
DEPARTMENT OF FISH AND GAME

# SCIENTIFIC PLANNING AND REVIEW COMMITTEE:

## RECOMMENDATIONS ON THE BAY PROTECTION AND TOXIC CLEANUP PROGRAM MONITORING ACTIVITIES

JANUARY 1997

# PREFACE

The Scientific Planning and Review Committee (SPARC) was convened by the State Water Resources Control Board's Bay Protection and Toxic Cleanup Program (BPTCP) to review the scientific aspects of the Program's monitoring activities. SPARC has held two meetings. This report summarizes the SPARC recommendations.

The SPARC recommendations have been used by the BPTCP staff to (1) improve the Statewide monitoring approach and the Program's Quality Assurance Project Plan, (2) develop better ways to effectively identify polluted sites, and (3) train the scientists employed by the Department of Fish and Game, the Regional Water Quality Control Boards and the State Water Resources Control Board to provide more informed assessments of polluted sites.

SCIENTIFIC PLANNING AND REVIEW COMMITTEE

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# EXECUTIVE SUMMARY

The Scientific Planning and Review Committee (SPARC) was established by the State Water Resources Control Board in 1994 to review the scientific aspects of the Bay Protection and Toxic Cleanup Program (BPTCP) monitoring activities. The SPARC members are independent experts representing the fields of toxicology, benthic ecology, organic and inorganic chemistry, program implementation and direction, experimental design, and statistics. This report contains the recommendations of the SPARC that were solicited at technical workshops held April 12-13, 1995 and May 15-17, 1996. This report also contains the briefing documents provided to the SPARC prior to the two workshops.

During the two meetings the SPARC made over 100 recommendations on all aspects of BPTCP monitoring. The SPARC discussed approaches for interpreting the toxicity, chemistry, and benthic data collected during the BPTCP monitoring efforts. SPARC also addressed bioaccumulation of contaminants and several Region-specific issues. While differences of opinion are shared among the members, the SPARC reached a strong consensus on the BPTCP monitoring and data interpretation approaches.

There was a strong vote of confidence by SPARC for using a triad of measures (i.e., toxicity testing, sediment chemical measures, and assessments of benthic organisms) to identify the worst toxic hot spots. There was also agreement on the criteria for identifying toxic hot spots using the triad of measures.

Overall, it was clear that the SPARC endorsed the BPTCP's approaches for monitoring and data interpretation. SPARC also encouraged the BPTCP to publish the results of the monitoring efforts in peer-reviewed scientific literature.

BAY PROTECTION AND TOXIC CLEANUP PROGRAM
SCIENTIFIC PLANNING AND REVIEW COMMITTEE

## INTRODUCTION

The California Water Code established the Bay Protection and Toxic Cleanup Program (BPTCP) to protect the existing and future beneficial uses of California's bays and estuaries. The BPTCP has provided a new focus on identifying polluted and contaminated locations in California's bays and estuaries. The BPTCP has four major goals: (1) protect beneficial uses of bay and estuarine waters; (2) identify and characterize toxic hot spots; (3) plan for the prevention and control of further pollution at toxic hot spots; and (4) develop plans for remedial action at existing toxic hot spots and prevent the creation of new hot spots. The primary focus of the BPTCP has been on the identification of toxic hot spots.

The SWRCB established the SPARC in 1994. The SPARC brings together independent experts in the fields of toxicology, benthic ecology, organic and inorganic chemistry, program implementation and direction, experimental design, and statistics to review the monitoring approaches taken by the BPTCP. The committee has provided comments on the Program's monitoring approach(es), given input on the scientific merit of the approach(es) taken, and provided suggestions for monitoring improvement.

In 1995 and 1996 the Bay Protection and Toxic Cleanup Program (BPTCP) sponsored two meetings of the Scientific Planning and Review Committee (SPARC). The purpose of this report is to present the recommendations provided by the SPARC.

SCIENTIFIC PLANNING AND REVIEW COMMITTEE

APRIL 1995 RECOMMENDATIONS

**Focus of the April 1995 Workshop**

The workshop centered around the following key questions:

1. What is toxic?

2. How should we show association between toxicity, benthic community, etc. and chemical concentrations?

3. What is a benthic impact?

4. Should we use a probability-based sampling design (random sampling) or directed point sampling approach (i.e. based on best professional judgment)?

5. Should we use a screening and confirmation approach?

6. What biological methods should we use?

7. What chemical methods should we use?

Please refer to Appendix A for the issue papers that describe each of these issues.

**Recommendations**

The SPARC recommendations from the April 1995 meeting were:

**Issue 1. Toxicity**

1. The selection of toxic and reference sites will ultimately be a policy decision based on best available scientific approaches for determining biological response.

2. The reference envelope approach is preferred over simple comparison to laboratory controls, and there is agreement that this is the statistical approach to pursue for determining the level of toxicity suitable for meeting toxic hot spot toxicity criterion.

3. All toxicity data should be normalized to laboratory controls to account for any variation in laboratory factors or test organism condition.

4. Compare test site response to large reference envelope population from a comprehensive data base of reference site results for the protocol used.

5. Compare test site response to reference envelope population from samples collected concurrently with test samples.

6. A site is toxic if it falls below the reference envelope lower bounds for both the reference site data base and concurrent samples.

7. If a site is toxic relative to the large reference envelope population from the comprehensive database, but concurrent reference site results are low, the site should be revisited.

Selection of Reference Sites Within Each Region

Some level of pollution will always be unavoidable. However, reference sites should be selected through the following process:

1. Reference sites should not include those sites where toxicity is observed in association with pollution. Common sense and knowledge of local conditions should be used in order to avoid areas known to be disturbed or polluted.

2. Randomly sample the rest of the water body, conducting analyses of chemistry, benthic community structure, and toxicity.

3. Allow trained benthic ecologists to select the sites that have moderate to high species richness, abundant presence of amphipods or other indicator species, absence of indicators known to be characteristic of polluted sediments, and any other indicator of ecological health that can be argued convincingly.

4. Evaluate the chemistry data and narrow the sites to those that do not exceed more than one upper value of a PEL or ERM for existing chemistry guidelines.

5. Evaluate the toxicity data and eliminate only those sites that have extremely high toxicity, as determined by a qualified toxicologist, not by a priori criteria.

6. Once reference sites are chosen they are sampled along with test sites. Include the new reference site toxicity results in the reference envelope regardless of the magnitude of the toxicity response. The reference envelope toxicity result will fall where it may.

7. Compile a data base of toxicity responses from appropriately selected reference sites, and include past and current reference site data in the reference envelope. Allow the number of data points in the reference envelope to grow as more studies are completed in the area.

**<u>Issue 2. Association of Chemistry and Biological Effects</u>**

1. Causal relationships between chemistry and biological effects are desirable to provide evidence of links between pollutant concentrations and biological effects. However, correlation does not necessarily establish causality.

2. Development of spiked bioassay data could be used to unequivocally identify chemicals responsible for observed effects.

3. Simultaneous Extracted Metals and Acid Volatile Sulfides (SEM/AVS) data is essential for understanding metal effects.

4. Measurement of Total and Dissolved Organic Carbon (TOC and DOC) in the pore water is recommended to help understand organic and metal bioavailability.

5. The effect of oxidation state of the environment and of the chemical compounds should be investigated.

6. Pore water toxicity and chemistry are valuable in determining causal relationships.

7. It is recognized that sorbed pollutants may become bioavailable after ingestion and metabolism.

8. Professional judgement and knowledge of local conditions should be used to decide how best to allocate resources to determine causal relationships.

9. The Program should use all available criteria and biological measurements in assessing the relationships between chemistry and biological effects (i.e., use weight of evidence approach).

**<u>Issue 3. Benthic Impacts</u>**

No single index is defensible in a regulatory setting. A site should be characterized as "healthy", "intermediate", or "degraded" based on the best professional judgement of a qualified ecologist, using whatever methods are most appropriate to the site.

<u>Replication of Benthic Ecological Analysis</u>

An analysis of existing data should be conducted to determine benthic replication, keeping in mind the types of analyses that can be done with benthic data, the cost of the analysis and benefits derived. Do not replicate unless there is a clear reason to do so. Broad spatial/temporal coverage of sampling is usually preferable to replication at fewer stations/times.

**Issue 4. What is the most appropriate sampling design**

1. During the screening phase, sampling should incorporate a stratified random design in order to provide an opportunity to find unknown toxic hot spots.

2. Confirmation phase sampling should be based on grids covering the site of concern, with random placements of stations within grid blocks.

3. Grids should be configured to match site characteristics.

4. Temporal variations should be accounted for with repeated sampling at locations at least one meter apart.

5. Spatial and temporal scales should be based on knowledge of the site.

Field Replication

6. Random sampling over suitably sized grids may be preferable to replication. There is no need to replicate unless there is a clear and defensible reason why.

7. It would be best to conduct statistical analysis of past data to determine replication needs for future work.

**Issue 5. Toxic Hot spot designation (Screening and Confirmation approach)**

1. A three tiered data analysis approach should be used. This would include chemical, toxicity, and benthic community analyses. Having hits in all three components of a triad analysis, would classify a site as a worst case toxic hot spot. Hits on fewer than all three would result in classification as a site of concern. All sites could be ranked in this way.

2. Under the BPTCP, the screening phase would consist of using either toxicity or benthic community analysis or chemistry or bioaccumulation data or some combination of all of these. Screening should be flexible, designed to fit the Regional Board's needs. Analysis in this phase should be done only when needed to provide sufficient information to convince the Regional Boards to list or consider the site as a priority site of concern for further action. A hit in any of these analyses would elicit concern, trigger confirmation phase monitoring under the BPTCP and/or perhaps prompt a specific Regional Board to pursue some other type of regulatory review action. It would be very important to involve potential responsible parties as early in the process as possible and coordinate studies and funding.

3. The confirmation phase should consist of toxicity and chemistry and benthic community analyses on a previously visited site of concern or wherever previous evidence indicates a site may be impacted. A confirmatory hit in all three analyses performed during this phase would classify a site as a worst case toxic hot spot. This phase could also include intensive investigations to identify causal relationships, and intensive grid sampling necessary to show gradients and spatial extent.

4. Allow for a mechanism for de-listing sites if intensive studies prove preliminary designation was in error.

5. It is important to focus on the most impacted sites for successful toxic hot spot designation and application of regulatory actions.

**Issue 6. Appropriate Biological Methods**

1. Use the amphipod 10 day solid phase test and the sea urchin 96 hour larval development test in pore water for screening sites.

2. Use the amphipod solid phase test, the sea urchin larval development test in pore water, and the sea urchin larval development test at the sediment water interface (SWI) for confirmation. (A sensitive chronic test, such as the 28 day protocol for *Leptocheirus*, or tests using resident species may also be useful for confirmation).

3. Centrifuge pore water for bioassay test. Use non-sorbing centrifuge tubes such as stainless steel, glass and/or Teflon. Frozen storage is not acceptable for biological testing.

4. Pore water dilutions are not necessary for screening, but do provide additional information for confirmation.

5. Pore water toxicity coupled with chemical analyses may be useful for establishing correlations between chemistry and biological effects.

6. Use of the *Neanthes* test should be discontinued because it provides no additional information beyond that provided by the amphipod and sea urchin protocol.

7. Studies should be conducted to investigate whether inhibition of embryo/larval development in pore water and solid phase (SWI) exposures can be correlated, or is associated with ecological perturbation, such as impacts on benthic community structure.

Biomarkers

1. Biomarker analyses are currently difficult to interpret in terms of ecological effects. These types of analyses should not be used for toxic hot spot designation at present.

2. Biomarker analyses may be useful in monitoring cleanup activities to determine if there is continued exposure to pollutants.

Bioaccumulation

Recruit the services of a bioaccumulation expert into SPARC and examine how bioaccumulation can be used in the BPTCP.

**Issue 7. Appropriate Chemical Methods**

Metals

1. Perform SEM/AVS with caution in evaluating potential for metal toxicity. This value may change over time at individual sites due to fluctuations in the concentration of AVS.

2. Use performance-based approach rather than rigid protocols.

3. Do bulk-phase metals in screening.

4. Do pore water metals when deemed necessary. It may help determine causality for confirmation and cleanup planning.

5. Preserve original samples for pore water chemistry.

6. Sediment extracts can be frozen for a year for chemical analysis. The time listed in standard methods for water and waste water should be the maximum holding time (Mel Suffet, personal communication, December 1996).

Organics

The April 1995 meeting ended before the organic chemical methods could be fully discussed. Nevertheless, similar recommendations to metal chemical methods were made. Further examination of this topic is scheduled for the next SPARC meeting.

1. The analyte list should be expanded to include Diazinon and other organophosphate pesticides

2. Use performance-based approach rather than rigid protocols.

3. Do bulk-phase organics and TOC in screening.

4. Do pore water organics to help determine causality for confirmation and cleanup planning.

5. Preserve original samples for pore water chemistry.

6. Sediment extracts can be frozen for a year for chemical analysis.

**Region-specific Recommendations**

Region 1

If local problems can be identified without toxicity screening then proceed to use the available resources as effectively as possible.

Bioaccumulation data may be appropriate to identify problem chemicals, biological exposure and potential sources of pollution in Region 1.

Biological effects measurements (toxicity screening or benthic community analysis) should be considered in cases where unknown toxic hot spots are present.

Region 2

Sampling should be done at a predetermined standard depth in a way to avoid mixing oxic and anoxic sediments. It would be desirable to show the effects of changes in oxidation state on toxicity and toxicity/chemistry relationships.

Use appropriate amphipod species based on knowledge of species tolerance limits to ammonia, salinity, and grain size.

Determine how to include bioaccumulation data into toxic hot spot screening.

Region 5

Pursue monitoring of pesticide degradation products.

Request that the SWRCB, Regional Boards, and Federal agency executive management agree to coordinate monitoring programs and share information from studies in the Bay-Delta. Also that the two Regional Boards pursuing BPTCP work in the Bay-Delta coordinate the planning and monitoring work.

SCIENTIFIC PLANNING AND REVIEW COMMITTEE

MAY 1996 RECOMMENDATIONS

**Focus of the May Workshop**

The topics discussed in the May meeting addressed the following topics:

1. Review and incorporation of the SPARC recommendations into the Statewide monitoring approach.
2. Interpretation of toxicity data collected.
3. Interpretation of the benthic community data collected.
4. Setting priorities using a weight-of-evidence approach.
5. Review of the studies of water column toxicity and chemistry in the Central Valley Region.
6. Completion of the discussion on organic chemistry methods.
7. The use of bioaccumulation monitoring techniques.

The briefing document that describes each of these issues is presented in Appendix B.

**Recommendations**

The workshop centered around the following key issues:

**Issue 1: Determination of Significant Toxicity Relative to the Surrounding Water Body**

1. There is consensus support for the reference envelope concept because it includes all sources of laboratory and field variation affecting toxicity test results.
2. Unexplained toxicity in samples from reference sites should be considered a problem if it occurred in more than 25% of reference samples, and should not be considered a problem if it occurred in less than 10%. There was no SPARC resolution on how to use the reference envelope approach if unexplained toxicity occurred in 10%-25% of reference site samples.
3. Investigation of unexplained toxicity should be focussed on identifying either: (a) pollutants that have not been considered previously, or (b) natural toxicity. Identification of either would be a significant finding consistent with program goals.

4. The synergistic effect of mixtures of chemicals found at low concentrations should be considered in any investigation of unexplained bioeffects.

5. The reference envelope should include toxicity data from many different sampling times. Temporal variability should be investigated. If temporal variance exists (i.e., if multiple sites vary concurrently), then the reference envelope equations must be revised to take this factor into account.

6. The reference envelope for toxicity could include reference sites from a broad geographical area (as big as the entire West Coast) or be limited to the local study area, depending on study objectives.

7. Statistical power should be analyzed to determine the minimum number of reference site samples necessary for appropriate use of the reference envelope method. Effects of sample size on data distribution (e.g., normality) should also be examined.

8. To determine statistical significance, study site results should be compared to both:

   a. the tolerance limit derived from a reference envelope that includes previous data, and

   b. results from concurrently collected local reference site sample(s).

9. Regional Boards should set reference envelope "p" values appropriate for their Regions and study objectives. The "p" is the percentile of the reference distribution used to set tolerance limits. There was SPARC consensus that this value is critical in establishing toxicity thresholds, provides an explicit means of selecting the statistical parameters relevant to study objectives, and should be established through policy decisions.

10. Guidelines for selection of "p" values include:

    a. the degree of confidence that reference site samples are indicative of desired ambient water body conditions,

    b. the level of degradation exhibited by reference site samples, and

    c. the political or economic goals associated with designating study sites as toxic.

    Low "p" values would be appropriate for situations where there is high confidence that reference sites are indicative of desired environmental conditions, and the economic or political costs related to a finding of toxicity are high. Higher "p" values are more appropriate when reference sites are assumed to represent less than optimal conditions, or when policy impacts are less severe.

11. Economic analyses could be used in conjunction with information on reference site quality and regulatory goals to help establish suitable "p" values for reference envelope calculations.

12. There may be greater uncertainty associated with the use of low "p" values. The lower the "p" value, the farther it extends into the tail of the reference population distribution, where deviations from normality are most extreme. This should be investigated as part of an examination of sample size and data distribution.

13. The reference envelope approach is strongly tied to an assumption of normality of the underlying data distribution, and that distribution should be checked as a matter of routine. Any suggestion of strong departure from a bell-shaped or triangular distribution (e.g., skewness, multiple modes, or a flat distribution) should be cause to use the reference envelope approach results with caution. If the reference envelope approach produces tolerance limits that are counter to best professional judgment, the following steps should be taken:

    a. Check the data distribution, transform data if necessary.

    b. Consider switching test protocols (Criteria for protocol rejection should be established).

    c. Check that reference sites were selected appropriately.

    d. Check if the "p" value is appropriate. This may involve re-evaluation of reference sites, program goals, and/or policy considerations.

    e. If unexplained reference site toxicity exists, investigate it. Do not use a statistical test based on reference site data that are poorly understood.

**Issue 2: Selection of Reference Sites**

1. Do not consider nickel in evaluating reference site chemical pollution. However, use common sense in cases with highly elevated nickel concentrations.

2. While evaluation of SEM - AVS (simultaneously extracted metals minus acid volatile sulfide) is useful in evaluating potential for metal toxicity in reference samples, this

value may change over time at individual sites due to fluctuations in the concentration of AVS. In addition, generalizations regarding AVS effects on bioavailability may not apply to all toxic metals. The issue of whether or not AVS - SEM should be used in reference site selection was not resolved by SPARC at this meeting.

3. Effects Range-Median (ERM) and Probable Effects Level (PEL) values are very similar. The lower of the two should be used in screening concentrations of individual chemicals in reference site selection.

4. For reference site selection, a Total DDT concentration of 100 $\mu g/g$ TOC was suggested as a cutoff value, based on toxicity studies.

5. For reference site selection, use the sum of ERM quotients that totals less than 5. This value was supported by data from numerous studies described at the meeting by Ed Long. However, all available data and criteria (including EPA EqP and lowest AET) should be evaluated, especially in cases of unexplained toxicity.

6. Benthic community data should not be the sole basis for reference site selection because:

    a. benthic community impacts can be hard to measure and/or interpret,

    b. the community may have adapted to pollutants, and

    c. relatively healthy benthic communities can exist in surface layers above polluted strata.

7. There was no resolution on the use of toxicity data in reference site selection. Contrasting issues of unexplained toxicity and potential for subjective data screening could not be resolved by the entire committee.

8. $H_2S$ and $NH_3$ at reference sites:

    a. Use toxicity test species that can tolerate reference site concentrations.

    b. Use exposure systems that can minimize reference site concentrations (e.g., Sediment Water Interface tests).

    c. $H_2S$ and $NH_3$ are less of an issue with amphipods than with embryos or larvae exposed in pore water tests.

    d. The program should use written guidelines for rejecting reference sample toxicity data when $H_2S$ or $NH_3$ are above threshold values for test species.

**Issue 3: Proposed Tiered Comparison to Determine Significant Toxicity**

Significant toxicity relative to the surrounding water body should be determined by comparing the test sample result to:

1. a tolerance limit calculated from a "universal" reference distribution, <u>and/or</u> a tolerance limit calculated from a "local" reference distribution,

2. results from one or more concurrently collected local reference site sample(s), and

3. 80% of the laboratory control survival.

Significant toxicity would be indicated if the sample result was below the tolerance limit selected for the study (either "universal" or "local" or both, above), <u>and</u> significantly lower than the result from a concurrently collected reference site sample (using a one-tailed t-test), <u>and</u> the sample mean survival was less than 80% of the laboratory control mean. (A "universal" reference distribution refers to one derived from sites from a broad geographical area, such as the entire West Coast of the United States.)

The first comparison [to the reference envelope tolerance limit(s)] accounts for all sources of laboratory and field variation affecting toxicity test results. The second comparison addresses the possibility of a unique toxicity event occurring in the water body at the time of sampling. The third comparison precludes a determination of toxicity when a statistically significant difference is smaller than generally believed to be biologically relevant.

The following should be considered in selecting local versus universal reference populations:

a. The "universal" envelope should be used if local reference site sample results fall within the "universal" reference envelope.

b. In "cleaner" areas or Regions, the local reference envelope should take precedence over the "universal".

c. In areas where local reference samples are more toxic than "universal" reference samples, Regional Board staff should select the reference distribution appropriate to meet study objectives.

**Issue 4: Central Valley Monitoring**

1. Consider measuring selenium.

2. Mercury is likely to become bioavailable in areas where high residence time allows methylation.

3. Mercury source tracking, *Ceriodaphnia* toxicity studies, and TIEs were well done. Suggestions for obtaining additional evidence for pesticide effects:

   a. Benthic communities should be evaluated and linked to toxicity.

   b. Water column community effects should be linked to toxicity.

   c. Investigate effects on Salmonid prey species and larval fish.

   d. Investigate sediment toxicity tests with flow-through site water.

   e. Model hydraulic system inputs and flow to further demonstrate fate.

4. EPA staff working with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) should be made aware of pesticide data to allow better coordination of management programs.

5. Coordinate Delta toxicity studies with California Endangered Species Act studies.

**Issue 5: Organic Chemistry Issues**

1. The SPARC supports the modification of current BPTCP organic analytical procedures to allow additional analytes to be measured from a single extraction, thereby expanding the analyte list in a cost effective way.

2. Additional analytes of concern that the program should consider measuring include:

   a. Cholinesterase inhibitors, such as the organo-phosphates diazinon and chlorpyrifos, and the carbamate carbofuran. BPTCP currently looks for chlorpyrifos but not the others (e.g., carbamates (methomyl) are used heavily in Elkhorn Slough). Organo-phosphates are important in Regions 5 and 2, and probably elsewhere.

c. Triazines (Atrazine in particular). Both Atrazine and Simazine are used in California. These are highly phytotoxic compounds.

d. Higher molecular weight polynuclear aromatic hydrocarbons (HMW PAHs) may be appropriate to add, though consideration should be given to determining the best HMW PAHs to add.

e. Nonylphenolic surfactants are estrogenic compounds which appear to have synergistic effects at low concentrations, and bioaccumulate. Analytical methods are poorly defined but these compounds may come through our current methods.

f. Alachlor and pthalates.

3. Sample matrix is important. As a guideline, for compounds with a low to moderate Log Octanol/Water Partition Coefficient (Log $K_{ow}$), it would be more useful to analyze for diazinon in water, pore water, and tissue rather than in sediment. Whereas for moderate to high Log $K_{ow}$, it would be best to measure the sediment and tissue rather than the aqueous phase.

4. PAH fingerprinting can be added to BPTCP analyses for minimal cost. All PAH signatures are not created equal. Rather than comparing the sum of 26 compounds in samples with different PAH profiles, the BPTCP should develop an index to describe a sample's PAH signature so that samples can be "typed" prior to statistical comparison.

5. Samples exhibiting bioeffects without concomitant elevated concentrations of measured chemicals (that may be related to unexplained toxicity) should be investigated to identify the source and nature of the toxicological agent in these cases.

6. For analysis of water samples, samples must be filtered using glass fiber filters. Plastic in filters actively binds organics. Total Organic Carbon (TOC), Dissolved Organic Carbon (DOC), and Total Suspended Solids (TSS) measurements should be taken on these samples in order to provide a normalizing index for analytical results. There remains an unresolved argument in the literature about filters vs centrifugation for sample analysis, but Dr. Suffet has found filtration to work well.

7. All chemistry data should continue to be reported in units of dry weight, along with normalizing factors like TOC and AVS, if possible.

**Issue 6: Bioaccumulation**

1. Bioaccumulation data and related health advisories should be used to identify chemicals of concern in a study area. The concentrations of those chemicals in test sediments should be given added consideration in the designation or ranking of sites.

2. A large area (e.g., an entire bay) can be considered an area of concern based on tissue contamination. In such cases, source control would be the preferred cleanup option, as activities such as sediment removal may be impractical.

3. Salmon should be considered for use in bioaccumulation studies.

4. Using models to back-calculate tissue concentrations affecting human and ecosystem health from sediment concentrations can lead to estimates of very low chemical concentrations of concern in sediments. However, the effects of bio-accumulating chemicals, and hot spot designation based on those chemicals, should not be totally dismissed because of low concentrations in sediments.

5. Persistence is not the only issue to consider when evaluating bioaccumulation information. Events of limited duration may still affect ecosystem and human health.

6. Fish (and other organism) tissue burdens in the Sacramento/San Joaquin River Delta should be investigated. The contamination observed in previous studies warrants an evaluation of potential risks to human and ecosystem health.

**Issue 7: Benthic Community Analyses**

1. Choice of indicator species used in BPTCP/EMAP Southern California Coastal Lagoons and San Diego Bay studies was appropriate. There was very little overlap in the presence of positive and negative indicator species.

2. Indicator species selection should be specific to study area. Indicator species should be selected prior to sample analysis, and should include species whose distributions are not limited by natural sediment characteristics likely to be found at study sites (such as grain size, TOC, etc.).

3. The following parameters should be measured (or sampled and preserved) *in situ* to assist with interpretation of benthic community analyses: grain size, salinity and concentrations of dissolved oxygen, ammonia, hydrogen sulfide, and TOC.

4. Numerical scaling of the benthic index should be re-evaluated and discussed with interested SPARC members and program staff.

5. The cutoff point indicating community degradation should not be chosen arbitrarily. Samples ranked between 1 and 2 on the present index should be individually re-evaluated to determine "degraded" status.

**Issue 8: Weight of Evidence Approach**

1. BPTCP should evaluate all three legs of the triad (chemistry, toxicity and benthic community analysis) to most effectively use the Weight of Evidence Approach. In the San Diego study, samples missing one leg of the triad should not be ranked as if there were no effect for that analysis. Missing data should be obtained before ranking all sites together, especially in cases where available data suggests possible degradation.

2. Weight of Evidence could be quantified using an approach similar to Chapman/Long's Ratio to Reference. However, it is informative to present each site with numerical values for each leg of the triad. These values could be either the data values from each analysis (such as percent survival for the toxicity tests), or the rank or percentage relative to other sites studied. These values should not be summed, but each leg should be presented individually. This was suggested in addition to color coding on maps, so that color would indicate hot spot status and numerical values would give a sense of the degree of impact.

3. The legs of triad should be applied independently and should not be expected to agree. Information from one type of analysis should not be disregarded because of different information from another type of analysis. Such cases should be evaluated individually to tease out useful information and supporting evidence.

4. It is not necessary to have two toxicity hits; toxicity, chemistry and benthic ecology should be treated equally.

5. Consider a sampling design that allows samples for all triad analyses to be taken from a single sediment grab. This allows synoptic sampling for all analyses, even if benthic or chemistry samples are archived, and could make sampling more economical.

6. High priority stations are sufficiently confirmed by the BPTCP weight of evidence approach to be considered for the next level of Regional Board or responsible party investigations. Moderate priority stations, and stations for which not all triad data are available, still need additional evidence from BPTCP triad approach prior to

follow-up by Regional Board or responsible party investigations.

7. Adjacent stations should be evaluated together to look for similar chemistry and bioeffects. A number of closely spaced sites exhibiting impacts and pollution from similar chemicals may qualify as an area of concern.

8. Confirmation should include consideration of spatial extent. Sites should be characterized by at least three stations.

9. The following points should be considered in using chemistry data in ranking sites:

    a. Do not use nickel at all (unless concentrations are extremely high) because there is little confidence in the available sediment guidelines.

    b. Use MacDonald's Palos Verdes data for DDT.

    c. Use both single chemical ERM quotients and quotient averages.

    d. Use the average of ERM or PEL quotients in applying the weight of evidence approach, as opposed to the sum of the quotient. This provides a natural cutoff point where averages exceeding 1 indicate elevated chemistry. This number should be used as a guide along with best professional judgment.

    e. Subdivide chemicals into groups likely to have additive effects to better estimate combined effects. For example, low molecular weight PAHs are likely to be additive in their biological effects.

    f. Even though the effects of many different chemicals are not always additive, combinations of chemicals are still likely to produce increased effects. ERMs and PELs do work empirically and should be used.

10. It was suggested that the BPTCP examine Washington State's algorithms for combining data to establish weight of evidence.

11. Weight of evidence assessments should always include graphical evaluation of the data.

12. The reference envelope approach has been applied to benthic community data and chemistry data (by Bob Smith). There was no consensus on whether this approach should be used by the BPTCP.

**Issue 9: Toxicity Identification Evaluations (TIEs)**

1. TIE of sediment pore water should be conducted if it furthers study objectives. TIE is especially important in establishing causal relationships.

2. The TIE approach may provide additional information to guide chemical analysis. There was general agreement that Region 5's investigation of pesticide toxicity supported the power of this approach.

3. For sediments, focus on pore water for TIEs, but realize that removing interstitial water from the sediment matrix may alter the physical availability of analytes. Sorption onto system components may effectively alter the characteristics of the sample and the outcome of the TIE. Removal of pore water from the sediment could be considered one step in the TIE process.

4. A non-filtered pore water treatment should be included in the TIE process. Total suspended solids and dissolved organic carbon are important in determining bioavailablity. These should be measured, although measuring TSS in pore water may be difficult.

5. Chemical analysis should be used as part of the TIE process to verify the compounds identified. Chemicals should be measured at the beginning and end of the TIE toxicity exposures to verify stability.

6. Be aware that there are multiple contaminants everywhere, which may confound the ability to remove toxicity in a TIE. Cumulative effects make it difficult to establish cause/effect relationships.

7. Be aware that TIE procedures may not always provide clear answers, and do not eliminate consideration of a site of concern solely on the basis of the inability of a TIE to identify responsible compounds.

MAJOR SUMMARY RECOMMENDATIONS OF THE
SCIENTIFIC PLANNING AND REVIEW COMMITTEE

**Major SPARC Recommendations (from the 1995 meeting)**

1. Base program decisions on defensible science to provide common ground for all participants and interested parties.

2. Prepare workplans in advance to allow adequate scientific review, efficient allocation of funds, and timely reporting.

3. Use a carefully considered weight-of-evidence approach to accomplish program goals.

4. Include a bioaccumulation expert on the SPARC and examine how bioaccumulation can be used in the BPTCP. Thought should be given to reconciling the two different aspects of toxic hot spot designation: human health risk vs. observed ecological effects.

5. Food web models are not sophisticated enough to allow development of sediment quality criteria based on fish tissue concentrations. The mobility of most fish species limits utility for designation of toxic hot spots on a reasonable scale.

6. Site specific investigations are necessary for toxic hot spot designations. Focus immediately on sites most likely to be successfully designated as a toxic hot spot.

7. Regional Boards must have authority and take responsibility for the planning of work in their respective regions. Local knowledge should be used to focus on the most relevant sites and analyses.

8. In designating toxic hot spots, follow a three-tiered approach: (1) carry out a flexible screening phase using any analysis of the triad or bioaccumulation technique; (2) a confirmation phase using all triad analyses (and); (3)intensive site specific studies demonstrating spatial extent, and causal relationships between pollutants and observed biological effects. It is very important to bring the potential responsible parties into the process as early as possible. Potential responsible parties, and other appropriate entities, should be brought into the process to cooperate in the funding and execution of post-confirmation studies.

9. Confirmation and intensive cleanup studies should use a stratified random sampling design, with grids of suitable size to cover the area of concern. Field replication of all measures (toxicity, chemistry, benthic community structure,

and bioaccumulation) should only be used when there is a clear and valid reason. Bioaccumulation studies should be focussed on contaminants in tissues of fish or other organisms.

10. Statistical significance of toxicity should be determined based on a comparison to a reference envelope.

11. Benthic community degradation should not be based on a single index. A single community index is too easily discredited. Benthic community degradation should be based on convincing evidence determined on a site specific basis by a qualified ecologist.

12. Performance-based chemistry should be used.

13. Pore water toxicity, concurrent chemistry and spiked assays may be useful to determine associations between pollutants and biological effects. Correlations are not nearly as convincing in demonstrating associations. The presence of multiple pollutants may complicate interpretation of toxicity test results. A TIE approach would also provide evidence of cause-effects relationships but should be used judiciously because of cost.

14. SEM/AVS are recommended for all samples.

15. Statewide and site-specific chemical objectives should be pursued.

16. Bioavailability concerns complicate interpretation of solid-phase sediment toxicity testing in evaluating the relationships between pollutant and biological effects.

17. Solid-phase sediment toxicity testing is useful for sediment quality assessment and toxic hot spot designation.

**Major SPARC Recommendations (from the 1996 meeting)**

1. The triad approach now used by the BPTCP is appropriate for identifying the most and least impacted sites, allowing the program to achieve its major goals.

2. BPTCP data collected to date allows for a scientifically defensible ranking of high priority sites. If further study, as part of confirmation or remediation, shows a site to be less of a problem than originally indicated, the site's status can be changed as part of the process. The data is currently sufficient to justify regulatory actions.

3. The State and Regional Boards should be actively cooperating with potential responsible parties to develop funding and study designs for the next level of investigation at sites identified by the BPTCP as sites of concern.

4. Moderately impacted sites should not be disregarded, especially if there are a number of moderately impacted sites in close proximity. Some action, such as source control, may be necessary even if there is not a single high priority station.

5. Sites that have significant toxicity, high chemistry, or a degraded benthic community, but are missing a leg of the triad, should be resampled to complete all three analyses. Information from sites of concern with only two legs of the triad measured should not be compared to sites with all triad components measured until the missing data are collected. Priority should not be downgraded (for sites with two legs of the triad measured) because of missing data.

6. "Other deleterious substances" (ODS), such as hydrogen sulfide, low dissolved oxygen, etc. that are likely to have resulted from human inputs should be considered as chemicals of concern.

7. The BPTCP provides a model for identifying problem sites that other states may wish to follow. SPARC encouraged the program to support publication of objectives, criteria, methods and results in the peer-reviewed literature to make them more widely accepted and available.

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| | |
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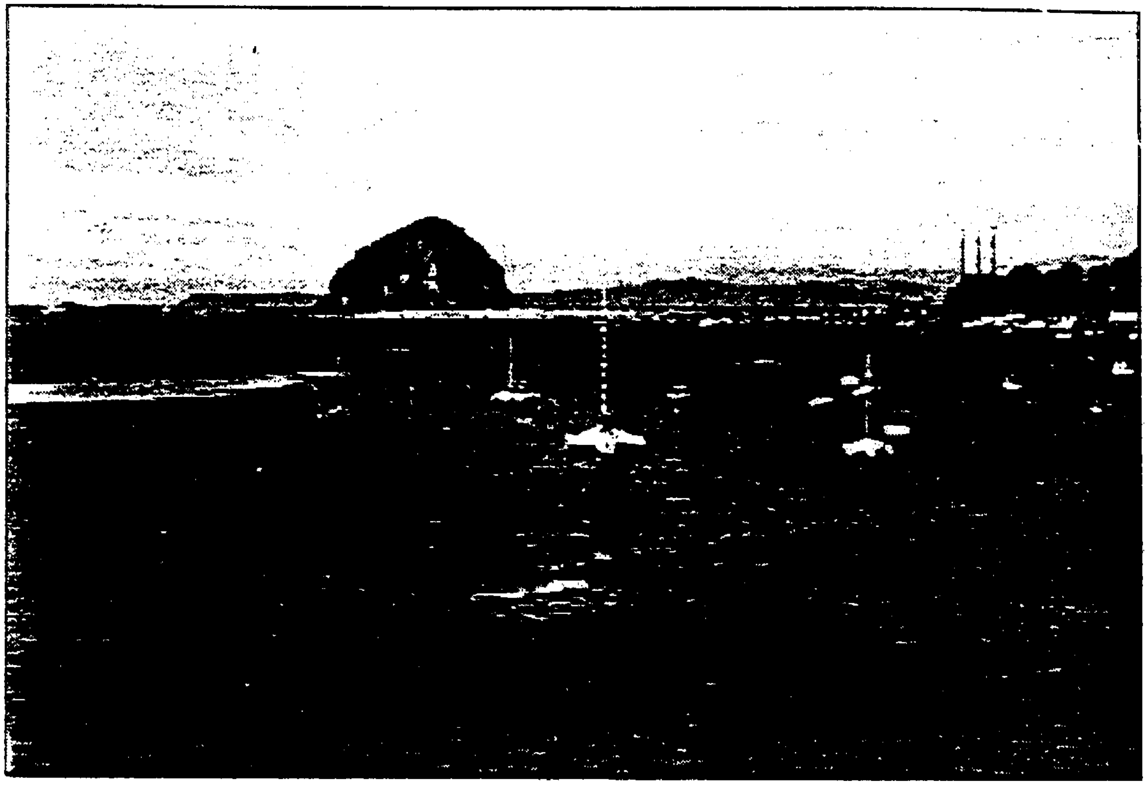
# A P P E N D I X   A

Scientific Planning and Review Committee
Briefing Document for the
Bay Protection and Toxic Cleanup Program

March 1995



# Scientific Planning and Review Committee Briefing Document for the Bay Protection and Toxic Cleanup Program

Department of Fish and Game
Regional Water Quality Control Boards
State Water Resources Control Board

STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS
DEPARTMENT OF FISH AND GAME

# SCIENTIFIC PLANNING AND REVIEW COMMITTEE:

# BRIEFING DOCUMENT FOR THE THE BAY PROTECTION AND TOXIC CLEANUP PROGRAM

MARCH 1995

# PREFACE

This briefing document was developed to assist the Scientific Planning and Review Committee (SPARC) in preparing for a technical workshop to review the monitoring programs of the State of California's Bay Protection and Toxic Cleanup Program (BPTCP). The purpose of the workshop is to solicit comments from the SPARC on the BPTCP monitoring approach(es), to give input on the scientific merit of the approach(es) taken, and to provide suggestions for monitoring improvement in the future.

The document is organized to focus SPARC on the most fundamental questions and concerns about the BPTCP monitoring approaches. The document presents the workshop agenda, a brief summary of the BPTCP, the overall monitoring approach to identify toxic hot spots, and issue papers describing the fundamental questions posed for SPARC including the approach used by the BPTCP. The issue papers are followed by regional summaries that generally contain specific monitoring objectives, overview of water bodies in the Region, studies completed to date or in progress, and regional questions for SPARC. The last chapter of the briefing document contains a complete list of the questions for SPARC developed by the Department of Fish and Game.

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SCIENTIFIC PLANNING AND REVIEW COMMITTEE (SPARC)
TECHNICAL WORKSHOP

April 12 and 13, 1995
Monterey, California

The Bay Protection and Toxic Cleanup Program (BPTCP) is sponsoring this technical workshop for the Program to bring together experts in the fields of toxicology, benthic ecology, organic and inorganic chemistry, program implementation and direction, experimental design, and statistics. The purpose of the workshop is to solicit comments from the Scientific Planning and Review Committee on the Program's monitoring approach(es), to give input on the scientific merit of the approach(es) taken, and to provide suggestions for monitoring improvement in the future.

The BPTCP is a Statewide Program legislatively mandated to identify toxic hot spots, to develop Toxic Hot Spot Cleanup Plans for each of the seven coastal Regional Water Quality Control Boards, and to prepare a consolidated Statewide Toxic Hot Spot Cleanup Plan.

**Focus of the Workshop**

The workshop will center around a discussion of the following key questions that have been identified by the State and Regional Boards and the Department of Fish and Game:

1. What is toxic?

2. How should we show association between toxicity, benthic community, etc. and chemical concentrations?

3. What is a benthic impact?

4. Should we use a probability-based sampling design (random sampling) or directed point sampling approach (i.e. based on best professional judgment)?

5. Should we use a screening and confirmation approach?

6. What biological methods should we use?

7. What chemical methods should we use?

For each of these questions, a brief issue paper outlining the options that have been evaluated is presented.

Each of the fundamental questions posed to the SPARC could take several days of discussion to fully evaluate and assess each facet of the question. It is the intent for this first workshop that SPARC hear the approaches being pursued by the program and comment on their appropriateness and usefulness. The SPARC is charged with determining if the approaches the Program is taking are scientifically credible and, if not, what approaches the Program should evaluate for use.

The BPTCP has two critical short-term needs: (1) to report monitoring data collected is San Diego Bay and (2) to plan for new monitoring scheduled for FY 1995-1996 (which begins July 1, 1995). To complete these tasks, the BPTCP needs to develop interim solutions on how to (1) evaluate the toxicity information collected and (2) associate biological effects with observed chemistry measurements.

It is anticipated that the Workshop discussion will lead to further questions for SPARC. The Program plans to convene another meeting of the group by the end of June, 1995 to continue the discussion on the BPTCP.

BAY PROTECTION AND TOXIC CLEANUP PROGRAM
SCIENTIFIC PLANNING AND REVIEW COMMITTEE (SPARC)
TECHNICAL WORKSHOP

April 12 and 13, 1995
Doubletree Hotel, Monterey CA

# A G E N D A

**Day 1: April 12, 1995**

| | |
|---|---|
| 8:00 to 8:30 | Welcome |
| 8:30 to 8:45 | Introductions<br>Max Puckett |
| 8:45 to 9:00 | Committee Goals and Anticipated Products<br>Max Puckett |
| 9:00 to 9:45 | Program Overview<br>Craig J. Wilson |
| 9:45 to 10:00 | Coffee Break |
| 10:00 to 11:00 | Regional Board Presentations |
| 11:00 to 11:30 | The Fundamental Questions<br>Max Puckett<br><br>What is toxic?<br>What measure of association between chemistry and biological effects?<br>What is a benthic impact?<br>Deterministic or probability-based sample collection?<br>Screening and confirmation approach?<br>What biological methods should be used?<br>What chemical methods should be used? |

| | |
|---|---|
| 11:30 to 1:00 | Lunch |
| 1:00 to 3:00 | Toxicity Endpoint<br>John Hunt and Brian Anderson |
| 3:00 to 3:15 | Coffee Break |
| 3:15 to 5:00 | Association with Toxic Pollutants<br>Craig Wilson and Max Puckett |

**Day 2: April 13, 1995**

| | |
|---|---|
| 8:00 to 8:30 | Coffee |
| 8:30 to 10:00 | Benthic Impacts<br>Carrie Bretz |
| 10:00 to 10:15 | Coffee |
| 10:15 to 11:30 | Random sampling vs. directed point sampling<br>Craig Wilson and Rusty Fairey |
| 11:30 to 12:30 | Lunch |
| 12:30 to 1:45 | Screening and confirmation approach<br>Craig Wilson and Rusty Fairey |
| 1:45 to 2:00 | Coffee Break |
| 2:00 to 4:00 | Biological and Chemical Methods<br>John Hunt, Brian Anderson and Mark Stephenson |
| 4:00 to 5:00 | Wrap-Up |

BAY PROTECTION AND TOXIC CLEANUP PROGRAM

PROGRAM SUMMARY

California Water Code, Division 7, Chapter 5.6 established a comprehensive program within the State Water Resources Control Board (State Water Board) to protect the existing and future beneficial uses of California's bays and estuaries. The Bay Protection and Toxic Cleanup Program (BPTCP) provides new focus on the State Water Board and the California Regional Water Quality Control Boards' (Regional Water Boards) efforts to control pollution of the State's bays and estuaries and to establish a program to identify toxic hot spots and plan for their cleanup. SB 475 (1989), SB 1845 (1990), and AB 41 (1989) added Chapter 5.6 Bay Protection and Toxic Cleanup (Water Code Sections 13390-13396.5) to Division 7 of the Water Code. Recent legislation (SB 1084 (1993)) extended program funding through 1998, the deadline for the regional toxic hot spot cleanup plans to 1998, and the Statewide cleanup plan until 1999.

**Program Activities**

The BPTCP has four major goals: (1) protect existing and future beneficial uses of bay and estuarine waters; (2) identify and characterize toxic hot spots; (3) plan for the prevention of further pollution and the remediation of existing hot spots; and (4) develop prevention and control strategies for toxic pollutants that will prevent creation of new hot spots or perpetuation of existing hot spots.

The BPTCP is a comprehensive effort by the State and Regional Water Boards to programmatically link standards development, environmental monitoring, water quality control planning, and site cleanup planning. The primary program activities are:

1. Development and amendment of the California Enclosed Bays and Estuaries Plan. This plan will contain the State's water quality objectives for enclosed bays and estuaries and contain the implementation measures for the objectives.

2. Development and implementation of regional monitoring programs designed to identify toxic hot spots. These monitoring programs includes analysis for a variety of chemicals, the completion of a variety of toxicity tests, measurements of biological communities, and various special studies to support the program.

3. Development of a consolidated database that contains information pertinent to describing and managing toxic hot spots.

4. Development of narrative and numeric sediment quality objectives for the protection of California enclosed bays and estuaries.

5. Preparation of criteria to rank toxic hot spots that are based on the severity of water and sediment quality impacts.

6. Development of regional and statewide toxic hot spot cleanup plans that include identification and priority ranking of toxic hot spots, strategies for preventing formation of new toxic hot spots, and cost estimates for remedial action recommendations.

7. Implementation of a fee system to support all BPTCP activities.

**Toxic Hot Spot Identification**

The Water Code defines toxic hot spots as locations in enclosed bays, estuaries, or the ocean where pollutants have accumulated in the water or sediment to levels which (1) may pose a hazard to aquatic life, wildlife, fisheries, or human health, or (2) may impact beneficial uses or (3) exceed State Water Board or Regional Water Board adopted water quality or sediment quality objectives.

To identify toxic hot spots, water bodies of interest have been assessed both on a regional and site-specific basis. Regional assessments require evaluating whether water quality objectives are attained and beneficial uses are supported throughout the waterbody. Existing data on enclosed bays and estuaries are relatively limited for the purposes of determining impacts on beneficial uses.

Where sites are not well characterized, regional monitoring programs have been implemented. This monitoring activity has been performed by the California Department of Fish and Game under contract with the State Water Board.

The consolidated statewide database required by legislation will eventually include all data generated by the regional monitoring programs. The statewide database will be updated regularly to serve as the information source for making toxic hot spot determinations. It will contain information on pollutant concentrations in water, sediment, and tissue and the impacts on water bodies. The database will also include geographic information system (GIS) capabilities to allow mapping and accurate site identification.

**Ranking Criteria**

The Water Code (Section 13393.5) requires the State Water Board to develop criteria for ranking toxic hot spots. The ranking criteria must consider the pertinent factors relating to public health and environmental quality. These factors include: (1) potential hazards to public health, (2) toxic hazards to fish, shellfish, and wildlife, and (3) the extent to which the deferral of a remedial action will result or is likely to result in a significant increase in environmental damage, health risks, or cleanup costs.

**Sediment Quality Objectives**

State law defines sediment quality objectives as "that level of a constituent in sediment which is established with an adequate margin of safety, for the reasonable protection of beneficial uses of water or prevention of nuisances" (Water Code Section 13391.5). Water Code Section 13393 further defines sediment quality objectives as: "...objectives...based on scientific information, including but not limited to chemical monitoring, bioassays or established modeling procedures." The Water Code requires adequate protection for the most sensitive aquatic organisms." Sediment quality objectives can be either numerical values based on scientifically defensible methods or narrative descriptions implemented through toxicity testing or other methods.

**Toxic Hot Spot Cleanup Plans**

The Water Code requires that each Regional Water Board must complete a toxic hot spot cleanup plan and the State Water Board must prepare a consolidated toxic hot spot cleanup plan. The State Water Board will develop a water quality control policy with guidance to the Regional Water Boards for consistent implementation of the BPTCP.

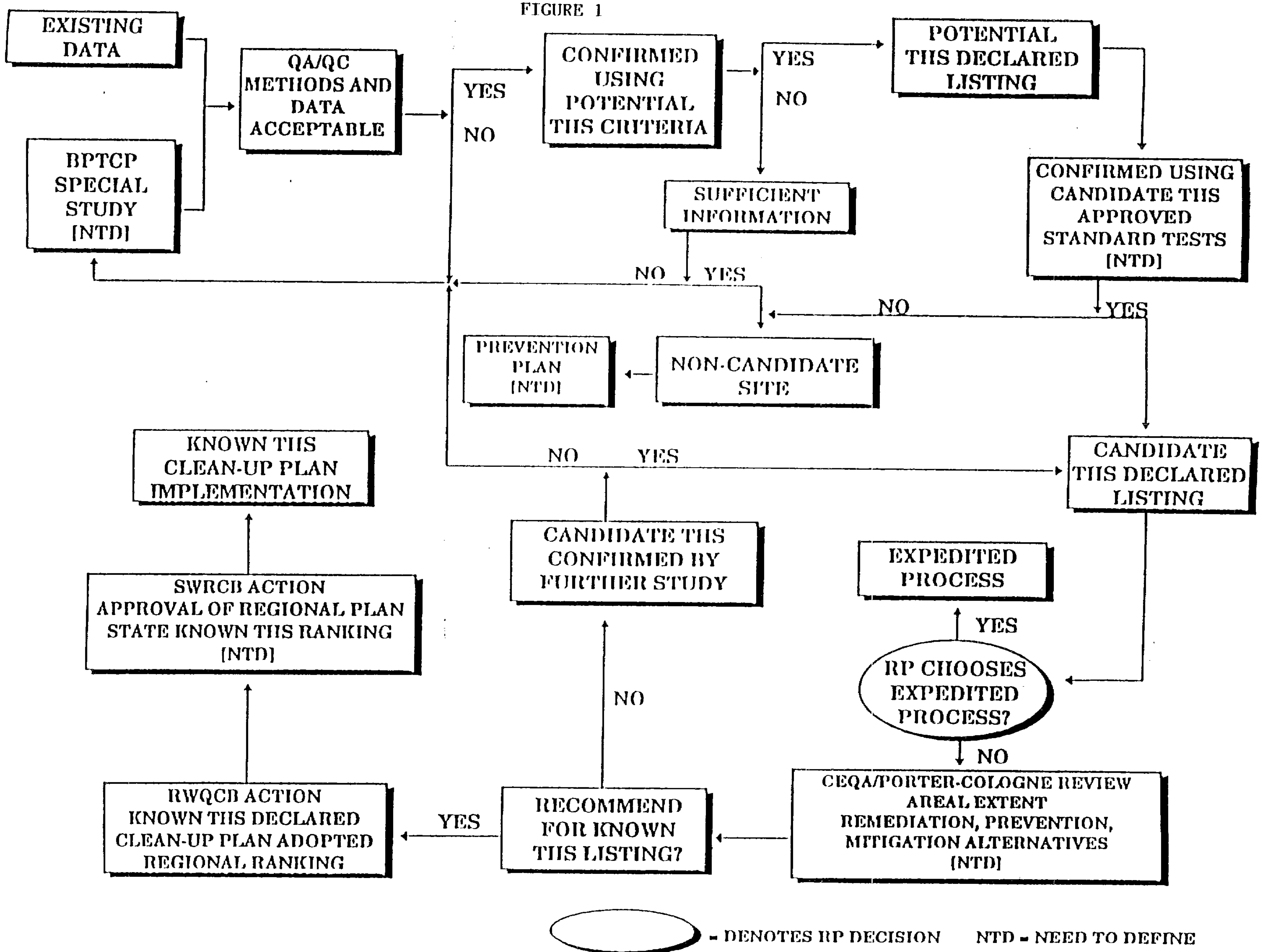
Each cleanup plan must include: (1) a priority listing of all known toxic hot spots covered by the plan; (2) a description of each toxic hot spot including a characterization of the pollutants present at the site; (3) an assessment of the most likely source or sources of pollutants; (4) an estimate of the total costs to implement the cleanup plan; (5) an estimate of the costs that can be recovered from parties responsible for the discharge of pollutants that have accumulated in sediments; (6) a preliminary assessment of the actions required to remedy or restore a toxic hot spot; and (7) a two-year expenditure schedule identifying State funds needed to implement the plan.

Within 120 days from the ranking of a toxic hot spot in a Regional cleanup plan, each Regional Water Board is required to begin reevaluating waste discharge requirements for dischargers who have contributed any or all or part of the pollutants which have caused the toxic hot spot. These reevaluations shall be used to revise water quality control plans and water quality control plan amendments wherever necessary; reevaluations shall be initiated according to the priority ranking established in cleanup plans.

Figure 1 is a flow chart that presents the relationships between the various program activities.

PROPOSED PROCESS TO DEVELOP REGIONAL TOXIC HOT SPOTS CLEAN-UP AND PREVENTION PLAN-FINAL* : 1/26/95

FIGURE 1




* DEFINED AT ADVISORY COMMITTEE MEETING OF 1/10/05

# THE DESIGN OF THE BAY PROTECTION AND TOXIC CLEANUP PROGRAM MONITORING PROGRAM

The Bay Protection and Toxic Cleanup Program (BPTCP) was initiated by the State Water Resources Control Board (SWRCB) in April 1990. As part of the legislated requirements of the program, the BPTCP has begun implementation of regional monitoring programs, development of a consolidated database, identification of toxic hot spots, and begun planning for the cleanup and prevention of toxic hot spots.

Section 13392.5 requires, in part, that the State develop monitoring programs that are composed of at least the following components:

1. Guidelines to promote standardized analytical methodologies and consistency in data reporting; and

2. Additional monitoring and analyses that are needed to develop a complete toxic hot spot assessment for each enclosed bay and estuary.

This briefing document is to present the approach used to identify toxic hot spots in California enclosed bays and estuaries. The Scientific Review Committee is requested to review the approach, to give input on the scientific merit of the approaches taken, and to provide suggestions for monitoring improvement in the future.

## Legislative Mandate

Section 13391.5 of the Water Code defines toxic hot spots as "...locations in enclosed bays, estuaries, or adjacent waters in the 'contiguous zone' or the 'ocean' as defined in Section 502 of the Clean Water Act (33. U.S.C. Section 1362), the pollution or contamination of which affects the interests of the State, and where hazardous substances have accumulated in the water or sediment to levels which (1) may pose a substantial present or potential hazard to aquatic life, wildlife, fisheries, or human health, or (2) may adversely affect the beneficial uses of the bay, estuary, or ocean waters as defined in the water quality control plans, or (3) exceeds adopted water quality or sediment quality objectives."

## Specific Definition of a Toxic Hot Spot

One of the most critical steps in the development of toxic hot spot cleanup plans is the identification of hot spots. Once they are identified the parties responsible for the sites could be liable for the cleanup of the site or further prevention of the discharges or activities that caused the hot spot. Because the cost of cleanup or added prevention could be very high, the SWRCB is considering categorizing toxic hot spots to distinguish between sites with little information (potential toxic hot spots) and areas with significantly more information (candidate toxic hot spots).

**Proposed Specific Definition**

Although the Water Code provides some direction in defining a toxic hot spot, the definition presented in Section 13391.5 is broad and somewhat ambiguous regarding the specific attributes of a toxic hot spot. The following specific definition provides the RWQCBs with a specific working definition and a mechanism for identifying and distinguishing between "potential," "candidate" and "known" toxic hot spots. A Candidate Toxic Hot Spot is considered to have enough information to designate a site as a Known Toxic Hot Spot except that the candidate hot spot has not been approved by the appropriate Regional Water Quality Control Board. Once a candidate toxic hot spot has been adopted into a toxic hot spot cleanup plan then the site shall be considered a known toxic hot spot and all the requirements of the Water Code shall apply to that site.

a. Potential Toxic Hot Spot

The Water Code requires the identification of suspected or "potential" toxic hot spots (Water Code Section 13392.5). Sites with existing information indicating possible impairment, but without sufficient information to be classified further as a "candidate" or "known" toxic hot spot are classified as "potential" toxic hot spots. Four conditions sufficient to identify a "potential" toxic hot spot are defined below. If any one of the following conditions is satisfied, a site can be designated a "potential" toxic hot spot:

1. Concentrations of toxic pollutants are elevated above background levels, but insufficient data are available on the impacts associated with such pollutant levels to determine the existence of a known toxic hot spot;

2. Water or sediments which exhibit toxicity in screening tests or test other than those specified by the State or Regional Boards;

3. Toxic pollutant levels in the tissue of resident or test species are elevated, but do not meet criteria for determination of the site as a known toxic hot spot, tissue toxic pollutant levels exceed maximum tissue residue levels (MTRLs) derived from water quality objectives contained in appropriate water quality

control plans, or a health advisory for migratory fish that applies to the whole water body has been issued for the site by OEHHA, DHS, or a local public health agency, the waterbody will be considered a potential toxic hot spot. Further monitoring is warranted to determine if health warnings are necessary at specific locations in the waterbody.

4. The level of pollutant at a site exceeds Clean Water Act Section 304(a) criterion, or sediment quality guidelines or EPA sediment toxicity criteria for toxic pollutants.

b. <u>Candidate Toxic Hot Spot</u>:

A site meeting any one or more of the following conditions is considered to be a "candidate" toxic hot spot.

1. The site exceeds water or sediment quality objectives for toxic pollutants that are contained in appropriate water quality control plans or exceeds water quality criteria promulgated by the U.S. Environmental Protection Agency.

   This finding requires chemical measurement of water or sediment, or measurement of toxicity using tests and objectives stipulated in water quality control plans. Determination of a toxic hot spot using this finding should rely on recurrent measures over time (at least two separate sampling dates). Suitable time intervals between measurements must be determined.

2. The water or sediment exhibits toxicity associated with toxic pollutants, based on toxicity tests acceptable to the State Water Resource Control Board or the Regional Water Quality Control Boards.

   To determine whether toxicity exists, recurrent measurements (at least two separate sampling dates) should demonstrate an effect. Appropriate reference and control measures must be included in the toxicity testing. The methods acceptable to and used by the BPTCP may include some toxicity test protocols not referenced in water quality control plans (e.g., the Bay Protection and Toxic Cleanup Program Quality Assurance Project Plan). Toxic pollutants should be present in the media at concentrations sufficient to cause or contribute to toxic responses in order to satisfy this condition.

3. The tissue toxic pollutant levels of organisms collected from the site exceed levels established by

the United States Food and Drug Administration (FDA) for the protection of human health, or the National Academy of Sciences (NAS) for the protection of human health or wildlife. When a health advisory against the consumption of edible resident non-migratory organisms has been issued by OEHHA or DHS, on a site or waterbody, the site or waterbody is automatically classified a "candidate" toxic hot spot if the chemical contaminant is associated with sediment or water at the site or water body.

Acceptable tissue concentrations are measured either as muscle tissue (preferred) or whole body residues. Residues in liver tissue alone are not considered a suitable measure for known toxic hot spot designation. Animals can either be deployed (if a resident species) or collected from resident populations. Recurrent measurements in tissue are required. Residue levels established for one species for the protection of human health can be applied to any other consumable species.

<u>Shellfish:</u> Except for existing information, each sampling episode should include a minimum of three replicates. The value of interest is the average value of the three replicates. Each replicate should be comprised of at least 15 individuals. For existing State Mussel Watch information related to organic pollutants, a single composite sample (20-100 individuals), may be used instead of the replicate measures. When recurrent measurements exceed one of the levels referred to above, the site is considered a known toxic hot spot.

<u>Fin-fish:</u> A minimum of three replicates is necessary. The number of individuals needed will depend on the size and availability of the animals collected; although a minimum of five animals per replicate is recommended. The value of interest is the average of the three replicates. Animals of similar age and reproductive stage should be used.

4. Impairment measured in the environment is associated with toxic pollutants found in resident individuals.

Impairment means reduction in growth, reduction in reproductive capacity, abnormal development, histopathological abnormalities, or identification of adverse effects using biomarkers. Each of these measures must be made in comparison to a reference condition where the endpoint is measured in the same species and tissue is collected from an unpolluted reference site. Each of the test shall be acceptable to the SWRCB or the RWQCBs.

Growth Measures: Reductions in growth can be addressed using suitable bioassays acceptable to the State or Regional Boards or through measurements of field populations.

Reproductive Measures: Reproductive measures must clearly indicate reductions in viability of eggs or offspring, or reductions in fecundity. Suitable measures include: pollutant concentrations in tissue, sediment, or water which have been demonstrated in laboratory tests to cause reproductive impairment, or significant differences in viability or development of eggs between reference and test sites.

Abnormal Development: Abnormal development can be determined using measures of physical or behavioral disorders or aberrations. Evidence that the disorder can be caused by toxic pollutants, in whole or in part, must be available.

Histopathology: Abnormalities representing distinct adverse effects, such as carcinomas or tissue necrosis, must be evident. Evidence that toxic pollutants are capable of causing or contributing to the disease condition must also be available.

Biomarkers: Direct measures of physiological disruption or biochemical measures representing adverse effects, such as significant DNA strand breakage or perturbation of hormonal balance, must be evident. Biochemical measures of exposure to pollutants, such as induction of stress enzymes, are not by themselves suitable for determination of "candidate" toxic hot spots. Evidence that a toxic pollutant causes or contributes to the adverse effect are needed.

5. Significant degradation in biological populations and/or communities associated with the presence of elevated levels of toxic pollutants.

   This condition requires that the diminished numbers of species of individuals of a single species (when compared to a reference site) are associated with concentrations of toxic pollutants. The analysis should rely on measurements from multiple stations. Care should be taken to ensure that at least one site is not degraded so that a suitable comparison can be made.

In summary, sites are designated as "candidate" hot spots after generating information which satisfies any one of the five conditions constituting the definition.

c. Known Toxic Hot Spot:

A site meeting any one or more of the conditions necessary for the designation of a "candidate" toxic hot spot and has gone through a full State or Regional board hearing process, is considered to be a "known" toxic hot spot. A site will be considered a "candidate" toxic hot spot until approved as a known toxic hot spot in a Regional Toxic Hot Spot Cleanup Plan by the Regional Water Quality Control Board and approved by the State Water Resources Control Board.

## Monitoring Program Objectives

The four objectives of BPTCP regional monitoring are:

1. Identify locations in enclosed bays, estuaries, or the ocean that are toxic hot spots;

2. Determine the extent of biological impacts in portions of enclosed bays and estuaries not previously sampled (areas of unknown condition);

3. Confirm the extent of biological impacts in enclosed bays and estuaries that have been previously sampled; and

4. Assess the relationship between toxic pollutants and biological effects.

## Review of Preliminary Studies and Research

Each of the seven RWCQBs participating in the program has assembled information that was used to develop a preliminary list of potential and candidate toxic hot spots (SWRCB, 1993).

## Biological Monitoring Methods

The tests listed in Table 1 are acceptable to measure water and sediment toxicity. Other tests may be added to the list as deemed appropriate by the State or Regional Water Boards provided the tests have a detailed written description of the test method; Interlaboratory comparisons of the method; Adequate testing with water, wastewater, or sediments; and measurement of an effect that is clearly adverse and interpretable in terms of beneficial use impact.

## Chemical Methods

The BPTCP measures a variety of organic and inorganic pollutants in estuarine sediments (Stephenson et al. 1994). The BPTCP requires its laboratories to demonstrate comparability continuously through strict adherence to common Quality Assurance/Quality Control (QAQC) procedures, routine analysis of certified reference materials, and regular participation in an on-going series of interlaboratory comparison exercises (round-robins). This is a "performance-based" approach of quality assurance.

The method used by the BPTCP are those used in the NOAA National Status and Trends Program (Lauenstein et al. 1993) and the methods documented in the DFG QAQC Manual (DFG, 1992). Under the BPTCP performance-based chemistry QA program, laboratories are not required to use a single, standard analytical method for each type of analysis, but rather are free to choose the best or most feasible method within the constraints of cost and equipment.

## Sampling Strategy

### Screening Sites and Confirming Toxic Hot Spots

In order to identify known toxic hot spots a two-tier process was used. The first tier was a screening step where at least two toxicity tests were used at a site (Tables 2 and 3). Sediment grain size, total organic carbon (TOC) and $H_2S$ concentration were measured to differentiate pollutant effects found in screening tests from natural factors. Chemical analyses (metals and organics) were performed on a subset of the screening samples.

If effects were found at sites by these screening steps, some sites were retested (depending on available funding) to confirm the effects. In the confirmation step measurements were replicated and compared to reference sites or conditions. Chemical measurements (metals, organics, TOC, $H_2S$) and other factors (e.g., sediment grain size) were measured. Measurements of benthic community structure and, if needed, bioaccumulation were also made.

Table 1
Water and Sediment Toxicity Tests That Meet the Criteria For Acceptability

| Type of Toxicity Test | Organism Used: Common Name | Organism Used: Scientific Name | Reference |
|---|---|---|---|
| Solid Phase Sediment | Amphipod | Rhepoxinius | ASTM, 1993 |
| | Amphipod | Eohaustorius | ASTM, 1993 |
| | Amphipod | Ampelisca | ASTM, 1993 |
| | Amphipod | Hyalella | ASTM, 1993 |
| | Polychaete | Neanthes | Johns et. al., 1990 |
| Sediment Pore Water* | Bivalve larvae | Crassostrea | ASTM, 1993 |
| | | Mytilus | ASTM, 1993 |
| | Abalone larvae | Haliotis | Anderson et al., 1990 |
| | Echinoderm fertilization | Strongy-locentrotus | Dinnel et al., 1987; with modification by EPA, 1992 |
| | Giant kelp | Macrocystis | Anderson et al., 1990 |
| | Red alga | Champia | Weber et al., 1988 |
| | Fish embryos | Atherinops | Anderson et al., 1990 |
| | | Menidia | Middaugh et al., 1988 |
| | | Pimephales | Spehar et al., 1982 |
| | Cladoceran | Daphnia | Nebecker et al., 1984 |
| | | Cereodaphnia | Horning and Weber, 1985 |
| Ambient Water | Bivalve larvae | Crassostrea | ASTM, 1993 |
| | | Mytilus | ASTM, 1993 |
| | Abalone larvae | Haliotis | Anderson et al., 1990 |
| | Echinoderm fertilization | Strongylocen-trotus | Dinnel et al., 1987; with modifications by EPA, 1992 |
| | Giant kelp | Macrocystis | Anderson et al., 1991 |
| | Red alga | Champia | Weber et al., 1988 |
| | Mysid | Holmesimysis | Hunt et al., 1992 |
| | Fish embryos | Atherinops | Anderson et al., 1990 |
| | | Menidia | Middaugh et al., 1988 |
| | | Pimephales | Spehar et al., 1982 |
| | Fish larvae | Atherinops | Anderson et al., 1990 |
| | | Menidia | Peltier and Weber, 1985<br>Weber et al., 1988 |
| | | Pimephales | Peltier and Weber, 1985<br>Weber et al., 1988 |
| | Cladocerans | Daphnia | Nebecker et al., 1984 |
| | | Cereodaphnia | Horning and Weber, 1985 |

*Pore water tests (other than amphipods) alone can not be used to designate a candidate toxic hot spot.

Table 2

Screening Tests for
Toxic Hot Spot Identification

| Test Organism | Type | End Point |
|---|---|---|
| Rhepoxynius, Eohaustorius (Amphipod) | Bedded sediment | Survival |
| Haliotus, Mytilus, Crassostrea | Overlying water | Shell development |
| Strongylocentrotus (Sea urchin) | Sediment pore water | Fertilization, development, and/or anaphase aberration |
| Neanthes (Polychaete worm) | Bedded sediment | Survival and growth |

**A Battery of Screening Tests**

Selecting a battery of toxicity screening tests (Table 2) can improve cost-effectiveness by expanding the range of potential impacts to be evaluated. Although recurrent toxicity must be demonstrated to qualify a site as a "candidate" toxic hot spot, the degree of certainty for each of the measurements does not necessarily have to be equivalent. The cost of confirming toxicity at a site can be prohibitively high, especially if it includes a large number of field replicates and extensive reference site testing. The screening tests should allow for a relatively rapid lower cost assessment of the site.

Even though the list of acceptable tests is long (see Table 1), the State and Regional Water Boards have used between two and four tests to screen sites (Table 2). For all screening, at least one amphipod test was performed. Other tests were performed as needed depending on funding availability, the needs of collaborators (such as the National Oceanic and Atmospheric Administration or the EPA Environmental Monitoring and Assessment Program), test organisms sensitivity to the

Table 3

Types of Data Collected in Regional Monitoring Programs for the Identification of Toxic Hot Spots

| Type of Data | Screening | Confirmation |
|---|---|---|
| Toxicity testing | Suite of 4 tests (see Table 5) | Repeat of positive results |
| Field replicates | None | Three (if needed) |
| Lab replicates | Five | Five |
| Reference sites | None | Several |
| Physical analysis | Grain size | Grain size |
| Chemical analyses | Ammonia, hydrogen sulfide, TOC, pesticides, PCB, PAH, TBT, metals | Ammonia, hydrogen sulfide, TOC, pesticides, PCB, PAH, TBT, metals |
| Benthic community analysis | None | Five replicates |
| Bioaccumulation | None | Occasionally (sites with no pre-existing bioaccumulation data) |

Table 4

Sequence of Tasks for Designating Toxic Hot Spots

1. Select toxicity screening sites.
2. Sample screening sites.
3. Conduct battery of four toxicity screening tests; analyze for hydrogen sulfide, ammonia, TOC, and grain size.
4. Determine whether quality assurance requirements have been met.
5. Report on Items 3 and 4.
6. Select and match hits and potential reference sites for ammonia, hydrogen sulfide, and grain size.
7. Conduct metals and organic chemical analysis on subset of screening sites from Item 6.
8. Determine whether quality assurance requirements have been met.
9. Report on Items 7 and 8.
10. Select sites and toxicity tests for confirmation and reference sites.
11. Sample confirmation and reference sites.
12. Conduct subset of the battery of toxicity tests which were screening hits; analyze for hydrogen sulfide, TOC, and conduct benthic community analysis.
13. Conduct metals and organic chemical analyses.
14. Determine whether quality assurance requirements have been met.
15. Report on Items 12 through 15.
16. Conduct statistical and other analyses to determine whether sites qualify as toxic hot spots.

pollutants expected to be present, and the media (bedded sediment or pore water) thought to be contaminated.

## Site Selection

Two somewhat different approaches were used in BPTCP monitoring. Six of the coastal RWQCBs have used a design that combines toxicity testing, chemical analysis, and benthic community analysis in a two-phased screening-confirmation framework (Tables 3 and 4).

The Central Valley RWQCB, with jurisdiction over the Sacramento-San Joaquin Delta, has designed its program to respond to Delta conditions and to the water quality problems characteristic of that area. Fresh water toxicity testing combined with water chemistry (metals and pesticides) constitutes the main program components. Sediment toxicity testing could be added to the monitoring design at a later stage.

Four different categories of sites have been identified for sampling in the BPTCP monitoring program: (1) potential toxic hot spots base on existing information, (2) high risk sites based on existing information, (3) stratified random sites, and (4) reference sites. Potential toxic hot spots are the highest priority sites because some indication already exists that these sites have a pollution-related problem. These data are typically sites with information available on chemical contamination of mussel tissue, data documenting water and sediment toxicity, measurements of metals or organic chemicals in sediments, and, occasionally, biological impairment. These sampling efforts are typically point estimates.

There are many other sites that are considered "high risk" even though we have no monitoring information to support this contention. High risk sites are locations where a nearby activity (such as marinas, storm drains, and industrial facilities) are thought to be associated with a certain risk of toxicity. The measurements at high risk sites are either point estimates or selected probabilistically.

When little is known about the quality of a waterbody segment, the monitoring efforts should use a stratified, random sampling approach. These random sites are useful in determining the quality of larger areas in the State's enclosed bays and estuaries. This probabilistic approach will allow for the State and Regional Water Boards to make better estimates of area (percentage) of water bodies that is impacted. The State and Regional Water Boards have used the techniques used by the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (SWRCB et al. 1994).

Locating reference sites requires identification and testing of a variety of potential reference sites encompassing the expected range of grain size, TOC, and other characteristics. Existing data sets that describe chemical contamination, grain size, and TOC at marine and estuarine sites are reviewed. Since these sources yield an insufficient number of sites, fine-grained areas presumed to be relatively free of contamination are also examined. These sites may likewise prove to be rare, so sites with chemicals present, but experiencing low energy tidal flushing, will also be sampled. Sites with previous indication of no pollution, and those lacking sediment toxicity measurements will also be sampled. Finally, random selection of sites (as described above) may prove useful in locating reference sites.

**Toxicity Screening**

All tests included controls which were conducted in media known to exert minimal stress on test organisms. Both positive (toxicant present) and/or negative (toxicant absent) controls were used to ensure that test organisms are responding within expected limits (Table 3).

The screening step began with the collection of a single field sample from each site (Table 4, Steps 1 and 2). Five laboratory replicates were required to accommodate statistical comparison with the control. Although the lack of field replicates restricts statistical comparisons with other sites, this approach allowed the BPTCP to test more locations for toxicity within the allocated funding. Ammonia and hydrogen sulfide analyses are then performed on the media of all tests (Table 4, Step 3) to determine their relative contribution to any observed toxic affects. Grain size and TOC values were determined on all sediment samples to evaluate the presence of naturally occurring toxicity.

All these data, along with an assessment of quality assurance performance, were then reviewed. Toxicity hits and potential reference sites were selected and matched for ammonia, hydrogen sulfide, grain size, and TOC. A subset of the sites is selected for analysis of metals and organics after conducting confirmation testing (Table 4, Steps 4-9). Some of these sites were revisited for confirmation.

**Confirmation (i.e., Qualification as Candidate Toxic Hot Spots)**

Some of the screening sites (Table 4, Steps 10 and 11) with at least one positive test result were revisited to evaluate both the recurrent nature of the toxicity and impacts on the benthic community. This required repeat testing of potential toxic hot spots to ensure that toxicity was present or absent. Confirmation testing was more intensive because of (1) addition of field replicates (three to a site); (2) comparison to reference sites (unless water toxicity is the focus); and (3) benthic community analysis (Table 3).

For each positive toxicity test at a screening site, confirmation was performed for the same test. Generally, benthic analysis was also performed and added to an ever-enlarging nearshore benthic community database which will be periodically evaluated to determine whether impacted and non-impacted sites can be distinguished (Table 4, Step 12). When either recurrent toxicity was demonstrated with a positive confirmation test or benthic impacts were suspected, chemical analysis were also performed (Table 4, Step 13). Careful review of all quality assurance procedures was conducted and, upon approval, will be followed by statistical analysis of the data. Compared to screening, this analysis will be more comprehensive and will include measures of field variability in toxicity, benthic data, and reference site conditions.

Once both toxicity and benthic impacts have been confirmed through comparison with an appropriate reference site and appear to be due to human-causes the site will be declared a candidate toxic hot spot. When toxicity is present but benthic impacts are lacking, careful analysis will be performed to determine whether the two results are in conflict. Similarly, when toxicity is not demonstrated but benthic impacts are observed, careful review will be conducted to determine whether the same explanation prevails or whether some factor other than toxicants may be responsible. Further characterization of the site (such as areal extent, range of effects, and source determination) will be described in the cleanup plan and is not intended (unless samples are collected using a random or stratified random design) under this phase of the program.

## Quality Assurance

The BPTCP Quality Assurance Project Plan (Stephenson et al. 1994) presents a systematic approach that has been implemented within each major data acquisition and data management component of the program. Basic requirements specified in the QAPP are designed to: (1) ensure that collection and measurement procedures are standardized among all participants; (2) monitor the performance of the various measurement systems being used in the program to maintain statistical control and to provide rapid feedback so that corrective measures can be taken before data quality is compromised; (3) assess the performance of these measurement systems and their components periodically; and, (4) verify that reported data are sufficiently complete, comparable, representative, unbiased, and precise.

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## ISSUE PAPERS

1. What is toxic?

2. What measure of association between chemistry and biological effects?

3. What is a benthic impact?

4. Deterministic or probability-based sample collection?

5. Screening and confirmation approach?

6. What biological methods should be used?

7. What chemical methods should be used?

## ISSUE 1

**What is Toxic?**

or, more specifically:

What level of response in a sediment toxicity test demonstrates that the sample is toxic, and what statistical tests should be used to make that determination?

While very low survival of test organisms is clearly indicative of toxicity, many test results are in the intermediate range (50% to 80% survival or normal development). For hot spot identification, the program must state exactly where to draw the line between responses that do or do not indicate significant toxicity. A number of statistical methods have been suggested and employed, but we need to reach agreement on which method is the most appropriate and defensible for splitting the hair in a regulatory setting.

We have considered two main approaches. The first is to simply compare each sample against the negative control (such as home sediment or dilution water). If a statistical comparison shows a significant difference, then it can be assumed that the observed effect was caused by something inherent in the sample, and not by laboratory conditions or organism handling. However, no assumption can be made about the specific sample characteristic responsible for the observed effect (i.e. we have no experimental basis to assume the effect was caused by anthropogenic contaminants as opposed to grain size or other factors). In order to use this approach for hot spot identification, a fairly strong association would have to be established between toxicity and chemistry to independently determine that contamination was the probable cause of the observed biological effect.

In the second approach, each sample could be compared against one or more reference sites. If multiple reference sites are sampled, covering a range of sediment grain size and other characteristics, it is possible to account for a large portion of the natural variation between sites (i.e. the variation occurring in the absence of contaminant effects). Any test sample that had significantly lower survival or normal development relative to the population of reference sites could be considered significantly toxic, and it would be reasonable to assume that the toxicity was due to anthropogenic contamination. This approach attempts to consider the cause and effect in a single analysis. While this second approach is more directly defensible for hot spot designation, it has the disadvantage that reference site characteristics are hard to define, and reference sediments are difficult to locate in the field. It is not uncommon to observe low rates of survival or normal development in samples with low concentrations of measured contaminants. In these cases, the observed effect could be due to natural toxins, in which case the site might still be considered as a reference site. If, however, unmeasured anthropogenic contaminants are the cause of toxicity, and the site is used for reference, then the results of statistical analyses may be misinterpreted.

A variety of statistical methods could be used for either of the two main approaches. Statistical methods employed or considered for the first approach include the following:

1. t-tests have been used to compare each test sediment to the laboratory negative control. This method assumes that each comparison is a complete experiment and is not affected by other comparisons with other sites. Separate-variance t-tests have been used to adjust the degrees of freedom for unequal variances, which are commonly observed.

2. Analysis of Variance and Dunnett's tests have been used to compare all test sediments to the laboratory negative control, as above. Sample variances would have to be homogeneous.

3. We have also used a detectable difference approach (as suggested by Glen Thursby), where the Minimum Significant Difference (MSD) is calculated for a large number of individual comparisons, and the difference detectable in 90% of the cases is then used to determine significant difference from the control for all samples. For example, our data with the <u>Rhepoxynius</u> test indicate that the test can detect an 18% difference from the control 90% of the time. Therefore, if <u>Rhepoxynius</u> survival was 95% in the control, a sample with mean <u>Rhepoxynius</u> survival of $\leq$ 77% would be considered significantly less than the control. This approach is similar to t-tests and ANOVA, but depends on general trends in between-replicate variability, rather than on the variability found in a single comparison. The method tends to eliminate "skinny hits", small differences detected because of low between-replicate variability.

4. Equivalency tests could be used to compare the mean response from a test sediment to some standard toxic level. If, for example, we could state with confidence that 60% survival indicated toxicity, an equivalency test could use the between-replicate variability from the sediment toxicity test to determine whether that sediment was toxic (i.e. the mean result from that sample was significantly equal to or lower than the level considered toxic).

5. A standard cutoff line could be established based on previous data. For example, 80% of the control could be given as the cutoff, and anything less would be considered toxic. Schimmel et al. (1991) (EMAP), use this level to indicate toxicity, if the sample was also significantly different from the control in a t-test. Their objective,

however, was to discern general trends rather than identify hot spots for cleanup.

Statistical methods employed or considered for the second approach, in which test sites are compared to reference sites, include the following:

1. Any of the above methods could be used by substituting a reference site for the control.

2. A "reference envelope" analysis could be employed if results were available from multiple reference sites. This approach has been investigated by Bob Smith of EcoAnalysis, both in studies using benthic community data and in analyses of BPTCP data sets. In its simplest form, the method defines the mean and lower confidence limit of the reference site population, and any test site with a mean that is below the lower confidence limit is considered significantly toxic.

3. Outlier identifier methods, such as a Hampel Outlier Identifier, could be used to determine which sites were not part of the population of reference sites. This approach requires data from a relatively large number of reference sites.

   Any method dependent on comparisons with reference sites must be preceded by adoption of reference site criteria and location of sites that consistently meet those criteria. A number of questions have arisen regarding reference sites: Must samples from reference sites be uncontaminated (using what analyte list and concentration limits)? Must they be non-toxic? Must they be both uncontaminated and non-toxic? What range of grain size, TOC, salinity, etc. must be included in the reference site population? What are the geographical constraints (i.e. same water body, same state)? Can one fine-grained reference site suffice for all tests?

If toxicity tests are not evaluated in the context of reference site or background conditions, will the results have sufficient credibility for hot spot designations?

A final issue for consideration: What level of field replication is necessary for hot spot designation? A single replicate allows us to say that the sample (not the site) is toxic. Disregarding concerns about the spatial extent of toxicity, how many field replicates are sufficient to indicate that a site is toxic? How should field replication be considered in the statistical approach to determining sediment toxicity?

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## ISSUE 2

**How do we show association between toxicity, benthic community measurements, etc. and chemical concentration?**

The definition of a toxic hot spot requires that a determination of association of biological effect be associated with the response. There are several approaches available that allow a determination of chemical concentration in sediments can potentially contribute to the observed benthic or toxic effect.

Options Evaluated

1. Environmental Protection Agency (EPA) Sediment Quality Criteria (SQC)--Equilibrium Partitioning

   The EqP approach assumes that pollutants are generally in a state of thermodynamic equilibrium and that the relative concentration of a pollutant in any particular environmental compartment (sediment, pore water, ambient water, etc.) can be predicated using measured partitioning coefficients for specific substances in equilibrium equations. The EqP approach is currently limited to nonpolar, nonionic compounds although methods for metals are under development. The protection of sediment ingesting organisms is not addressed in this approach. Also the assumptions stated above have not been adequately tested. EPA has recently published (EPA, 1993a; 1993b; 1993c; and 1993d) draft SQC that could be used for this purpose.

2. Effects Range Low (ERL), Effects Range Median (ERM), Probable Effects Level (PEL), Threshold Effects Level (TEL)

   Two related efforts have been completed that provide an alternative approach for evaluating the quality of marine and estuarine sediments. These are the National Oceanic Atmospheric Administration (NOAA) (Long et al. 1995) and the sediment weight-of-evidence guidelines developed for the Florida Coastal Management Program (1993) and MacDonald, in press).

   Long et al. (1995) assembled data from throughout the country for which chemical concentrations had been correlated with effects. These data included spiked bioassay results and field data of matched biological effects and chemistry. The product of the analysis is the identification of two concentrations for each substance evaluated. One level, the Effects Range-Low (ER-L) was set at the 10th percentile of the ranked data and was taken to represent the point below which adverse effects are not expected to occur. The second level, the Effects Range-Median (ER-M), was set at the 50th percentile and interpreted as the point above which adverse effects are expected. A direct cause and effect linkage in the field data was not a requirement for inclusion in the analysis. Therefore, adverse biological effects recorded from a site could be attributed to both a high concentration of one substance and a low concentration of another substance if both substances were measured at the site. The adverse effect in field data could be caused by either one, or both, or neither of the two substances of concern.

The State of Florida efforts (1993, in press) revised and expanded the Long and Morgan (1990) data set and then identified two levels of concern for each substance: the "TEL" or threshold effects level, and the "PEL" or probable effect level. Some aspects of this work represent improvements in the original Long and Morgan analysis. First, the data was restricted to marine and estuarine sites, thereby removing the ambiguities associated with the inclusion of freshwater sites. Second, a small portion of the original Long and Morgan (1990) database was excluded, while a considerable increase in the total data was realized due to inclusion of new information. The basic criteria for data acceptance and for classifying the information within the database were essentially the same as used by Long and Morgan (1990).

The development of the TEL and PEL differ from Long and Morgan's development of ER-L and ER-M in that data showing no effects were incorporated into the analysis. In the weight-of-evidence approach recommended for the State of Florida, two databases were assembled; a "no-effects" database and an "effects" database. The PEL was generated by taking the geometric mean of the 50th percentile value in the effects database and the 85th percentile value of the no-effects database. The TEL was generated by taking the geometric mean of the 15th percentile value in the effects database and the 50th percentile value of the no-effects database. By including the no effect data in the analysis, a clearer picture of the chemical concentrations associated with the three ranges of concern; no-effects, possible effects, and probable effects, can be established.

3. Apparent Effects Thresholds (AET) and scatterplots

The AET approach is an empirical method applying the triad of chemical, toxicological, and benthic community field survey measures to determine a concentration in sediments above which adverse effects are always expected (statistically significant different of adverse effects are predicted at $p<0.05$) (EPA 1989). Each suite of measures consists of chemical and toxicological measures taken from subsamples of a single sample and benthic analysis conducted on separate samples collected at the same time and place. A large suite of chemical measures and a large number of sites are required before an AET value can be estimated. The method assumes a single toxicant is responsible for effects measured at a given site. In addition, the value generated is by design, an effect level rather than a protective level. While above the AET one can expect adverse effects, the method does not recognize that below the AET adverse effects may be attributed to the substance of concern. A major limitation of the method is that the observed relationships between effects and chemical concentrations are based on correlations only (the relationship does not demonstrate cause and effect).

4. Correlations

Correlations between toxicity or benthic community effects and chemical concentration can be used to show the relationship between these factors. Correlation analysis is most useful in assessing which chemicals study-wide (or throughout a specific dataset) may contribute to toxicity or benthic effects.

5. Multivariate Analysis

Patterns of occurrence of pollutants can be identified using multivariate techniques (cf. Anderson et al. 1988). Procedures such as Principal Components Analysis can be used to reduce a dataset from a large number of individual measurements which are often correlated with each other to a small number of uncorrelated factors, each group representing a group of pollutants that have a similar pattern distribution. These groups can be used in scatterplots, correlation calculations or subsequent multivariate analysis.

6. Sediment Toxicity Identification Evaluation

Sediment toxicity identification evaluation (TIE) methods can be used to make a better estimate of the cause-and-effect relationship between chemicals and toxicity. TIEs provides strong scientific evidence that a chemical or chemical is causing toxicity. When a specific discharger is identified and the chemical of concern is known, a study can be performed to link the observed effects with the chemical on a site-by-site basis. Standard procedures for TIEs are unavailable.

7. Weight of Evidence

Use any available sediment guidelines outline in Alternatives 1 through 4. This approach relies on a preponderance of evidence with all available chemical screening levels to indicate when effects produced by specific pollutants are likely to occur.

The program has used individual measures such as the PEL or ERM as the values to make determinations of association between chemicals and toxicity.

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ISSUE 3

**What is a benthic impact?**

Analytical Procedures For Assessing Benthic Community Degradation

The following issue paper summarizes the multistep procedures used previously for the analyses of benthic community data for the Bay Protection and Toxic Cleanup Program.

Sampling Design and Collection

Samples for benthic community analyses were collected from the same sediment grab as samples for grain size, total organic carbons, biotoxicity and chemical tests. However, unlike for the other analyses, samples for benthic communities are collected at only one time period per site. Therefore, spatial distribution, including replication, is the major concern in a sampling design for benthic data collection. To date, the design for the collection of benthic community samples has been evolving with each successive project. We used previous data to determine the appropriate number of replicates -- a standardized method is needed.

Sorting and Identifying

Individual benthic samples were processed and preserved immediately following collection. Laboratory processing of the benthic cores consisted of both rough and then fine sorting. Initial sorting separated animals into large taxonomic groups such as polychaetes, crustaceans, mollusks, and others (e.g. phoronids). These grouped animals were placed in separate vials. The vials contained pre-printed duplicate labels identifying the project, IDORG number, date collected, site/station and sample replicate number. Vials were bundled together according to station and placed in a specific area designated for the project. Sample residues were placed back into the original, internally-labeled jars for later re-examination by the QA Officer. Species identification and enumeration was conducted by highly experienced taxonomists. On occasion, specimens were sent to specialized expert taxonomists for species verification.

Data Analyses and Interpretation

The identification of degraded and undegraded habitat (as determined by benthic community structure) was conducted using several common and well-documented methods. The following tests have been used to assess benthic community data only- no formal integration with results of laboratory exposures or chemical analyses were made. Results from benthic analyses alone often warranted further examination of certain sites.

Post species identification analyses included initial statistical tests that defined individual stations by mean species abundance (using replicates), standard deviation, standard error, confidence limits, etc. Following these statistical summaries, several analyses were performed to identify relationships between community structure at each site including, diversity/evenness indices, habitat -- species composition analyses, dissimilarity matrices, assessment of indicator species and development of a benthic index, classification (cluster) and ordination (multidimensional scaling) analyses. Initially, a correlation matrix was produced from species density data from each site. From this matrix we ran several tests for association of variables.

Cluster analysis is a multivariate procedure for detecting natural groupings in data, and, for our purposes, data were grouped by average similarities in total composition and species abundance. We have used the average-linkage method which uses the average similarity of all species at each site. From this information we looked at site-related patterns such as which species dominated the community. Grouped stations were typically clustered at a conservative distance limit of 50-60% similarity-however, this level is purely arbitrary. At this juncture, physical parameters, typically grain size, were evaluated to determine if station clusters were influenced solely by habitat type. Since classification analyses have the tendency to force data into artificially distinct groups, another method, involving statistical rigor, was required to confirm the validity of group clusters. We chose multidimensional scaling.

Multidimensional scaling (MDS) has been used extensively in the analyses of benthic communities, particularly in estuarine and marine pollution studies. MDS is a procedure for fitting a set of points in space such that the distance between points correspond as closely as possible to a given set of dissimilarities. We chose multidimensional scaling over principal co-ordinate analyses because MDS is more flexible in terms of handling the large number of zero counts generally characteristic of species-samples matrices. It is important to note that, as with cluster analyses, MDS results are not definitive and must be used in conjunction with addition ecological information.

After classification and ordination patterns were determined, the raw data was reevaluated for species differences to determine which one(s) may have been responsible for influencing the observed patterns. Often, the presence of specific species indicated non-contaminated areas or sometimes sites of environmental recovery. Indicator species were selected on the basis of literature review (to determine distribution, life history strategies and habitat preference), and discussions with experienced benthic taxonomists (to address the benefits and limitations of using certain species as environmental stress indicators). Objective techniques from published literature have also been used.

Although there are problems with trying to simplify complex biological communities, we needed to develop a quantitative method that created a partition between degraded and undegraded areas. We previously realized that we could not conclusively identify "hot spots" using only results from benthic community analyses- but that benthic analyses could justly describe "environmentally stressed" areas. The benthic index was based on species (indicators) and group (general taxa) information-mainly community parameters such as species richness, abundance and presence of pollution indicators- that identify the "extremes" of the community characteristics. Sites were ranked according to these extremes and were represented by a single value. In general, decreasing numbers of species, increasing numbers of individuals, and decreasing diversity values are common responses observed near polluted areas. These trends were incorporated into the index. One of the important restrictions with the existing method is that it evaluates only a very limited data set in dividing groups and subsequent ranking. Sites identified as degraded (or undegraded) are derived from a combination of test documentation- indicator species, benthic index, diversity analyses. Data has been presented mainly as figures and summary tables.

Data Integration

Analyses of patterns associated with biological, chemical and biotoxic variables were conducted separately so as to not confound results by creating circular arguments from data interpretation. The final strategy of analyses would be to relate biological patterns with environmental data, both chemical and toxicological, to see if assumptions of site degradation are valid.

## ISSUE 4

**Should we use a probability-based sampling design (random sampling) or directed point estimates (based on best professional judgement)?**

The major objective of the BPTCP is to find toxic hot spots. Once these hot spots are identified the program needs to determine the areal extent of the toxic hot spots identified. The BPTCP has used both non-random and random sampling designs. The approaches used by the Environmental Protection Agency's Environmental Monitoring and Assessment Program has been used during the screening steps of BPTCP monitoring.

Options Evaluated

1. Use a worst-case sampling design for site selection (i.e. point estimates of pollution).

   This approach is based on previous knowledge about the presence and distribution of potential sources of sediment pollution in the water body or previously known pollutants or biological effects in the water body. This sample design is useful as an initial survey to determine the potential for pollution-related problems, followed by a more complete sampling later (if needed). This approach is most useful when there is adequate information available from previous studies on biological effects present, measurements of chemicals present, sources and other information.

   A limitation of this approach is that the data collected from this type of survey can only be evaluated in terms of the sampling stations that are sampled. The areal extent of the pollution or biological effects can not be determined.

2. Use a random or stratified random sampling design for site selection.

   This design is most useful when little is known about the likely distribution of pollutants or biological effects in a water body. To use this design a grid is established and stations are randomly selected with each location having an equal probability of being sampled. The number of samples can be selected statistically based on the requirements of the survey (i.e., the objectives of the study) and acceptability of error rates. A stratified random design is distinguished from a purely random design by the selection of zones (based on available information) that exhibit similar levels of pollution, similar source type, or other characteristics. Samples are randomly collected in the various zones that are selected.

Using these approaches provides a statistical basis for determining the areal extent of the identified pollution or biological effects.

3. Use a combination of Options 1 and 2.

The BPTCP has used Alternative 3. Most of the screening and confirmation sampling stations have been selected using available information or the likelihood of effects being present at a site (some human activity that raised concern). Random or stratified random sampling designs have been used to support screening of water bodies (e.g., San Diego Bay, Newport Bay and several coastal lagoons in Southern California).

**ISSUE 5**

**Should we use a screening and confirmation approach?**

Options Evaluated

1. Sample sites a single time.

   Under this option sites would be sampled one time and repeated sampling would not be required. This approach would only work with the definition of a toxic hot spot if information were available form other studies conducted prior to any new sampling because of the need for repeated measurements of effect.

   With this approach the samples collected may be collected with different equipment and tests may be performed with different test species.

2. Sample sites at least two times before toxic hot spots can be designated.

   In order to identify known toxic hot spots a two-tier process was used. The first tier was a screening step where a suite of toxicity tests is used at a site (one amphipod test and at least one other toxicity test (pore water, bedded sediment or overlying water test)). Sediment grain size, total organic carbon (TOC) and $H_2S$ concentration are measured to differentiate pollutant effects found in screening tests from natural factors. Chemical analyses (metals and organics) were performed on a subset of the screening samples.

   If effects were found at sites by these screening steps, the highest priority sites were retested to confirm the effects. In the confirmation step measurements were replicated. Chemical measurements (metals, organics, TOC, $H_2S$) and other factors (e.g., sediment grain size) were also measured. Measurements of benthic community structure were also be made.

   With this approach, the program measurements will be affected by temporal variability of the sites (between year variation if sampled in same season in following year or seasonal variation if sampled in different season).

3. Continue to sample at worst sites until well characterized (more than two samples).

   This option would repeat the monitoring identified in Option 2 until a few sites are very well characterized. Under this option uncertainty about a few sites would be decreased. New toxic hot spots would not be identified because effort would be focussed on characterizing sites already identified.

The program has implemented Option 2. While at least one amphipod test is performed at each site, the additional test(s) have not been consistently performed.

## ISSUE 6

**Are the toxicity testing methods the most appropriate for meeting program objectives?**

Toxicity tests, using a suite of organisms and protocols, have been the primary tool used to screen potential hot spots and reference sites, and have also been part of the "confirmation" phase of the program. If significant toxicity ("associated with toxic pollutants") is observed at least twice in samples from a given site, then that site can be considered a hot spot under the BPTCP hot spot criteria. Toxicity testing methods are described in the BPTCP QAPP.

Toxicity tests used by the BPTCP to date include:

Solid-phase tests:

Amphipod 10-d survival test (Rhepoxynius, Eohaustorius, and Ampelisca)
Polychaete 20-d growth and survival (Neanthes)
Sea urchin 96-h embryo/larval development test at the sediment/water interface

Pore water tests:

Sea urchin 1-h fertilization test
Sea urchin 96-h embryo/larval development test
Abalone 48-h embryo/larval development
Bivalve 48-h embryo/larval development
Amphipod (Eohaustorius) 96-h survival test
(Pore water was extracted initially by piston squeezing and currently by centrifugation.)

Specific methods for each test are included in laboratory SOPs based on ASTM protocols (amphipods, bivalves), draft ASTM protocols (Neanthes, sea urchin larval development), or draft EPA protocols (abalone, sea urchin fertilization). The methods for the sea urchin larval development test at the sediment water interface are currently in peer-review, and are similar to methods described for bivalves in the Puget Sound Protocols, except that a screen is used to allow for more complete recovery of test larvae. To date, these methods have met test acceptability criteria a high percentage of the time, and have shown a broad range of sensitivity to test sediments, from highly sensitive (pore water tests) to highly tolerant (Neanthes test).

**Biomarkers**

Bioaccumulation data seems to be useful to the BPTCP because it can indicate a direct association between contaminants and organisms. Mussel watch has pinpointed many hot spots throughout the state, and the recent effort on bioaccumulation in fish from San Francisco Bay has indicated that most of the fish collected exceeded the EPA screening levels for PCBs and other contaminants. This has promulgated health risk warnings from the State and would appear to be a fairly useful method worthy of further consideration for classifying areas as hot spots. The major drawback to this approach is that fish are extremely mobile, and to use them to pinpoint a specific hot spot site is difficult, unless perhaps one can also show a link between sediment contaminants at the site with tissue contaminants in fish caught at the same site. One solution that has been suggested is that mussels and fish be used in concert. The mussels could be used to pinpoint hot spots, and the fish could be used to trigger health warnings. Is this mussel and fish approach worthwhile? Is bioaccumulation data of cost-effective and interpretable value to the program?

## ISSUE 7

**Are BPTCP Analytical Chemistry Methods Scientifically Sound and Appropriate?**

Analytical Methods, Analyte Lists, Detection Limits Currently Used in the BPTCP:

- o Please see list of BPTCP organic and metal analytes and detection limits in QAPP
- o Please see methods employed for organic and metal analyses in QAPP

What chemical methods should we be using?

Should we use EPA standard methods or use performance-based techniques? Many of the BPTCP fee-payers use EPA standard methods, due to permit requirements of the EPA, SWRCB, and US Army Corps of Engineers. Most of the national monitoring programs such as the NOAA Status and Trends program and EPA's EMAP program use a performance-based system, in which the participating laboratories must qualify to do the analysis by participating in the NOAA Status and Trends Program's Intercalibration Exercise.

The benefits of using EPA's methodology are:

1. They are well defined
2. There are many data sets that are available for comparison that are EPA methodology-based.

The disadvantages of using the EPA techniques are:

1. They can give inaccurate numbers.
2. The detection limits are almost invariably much higher than other techniques.
3. The techniques were developed 10 or 20 years ago for different equipment that was not as sophisticated as today's equipment (i.e. bench top GC/MS).
4. Two different laboratories can obtain very different sets of numbers using the same EPA technique, thus not insuring data comparability.
5. The laboratories using EPA techniques invariably state that the techniques have been modified, which further adds to doubts of comparability.

The pros of using a performance-based technique are:

1. They give accurate numbers and the detection limits are usually very low.
2. They are customized to take into consideration the latest in development of equipment or extraction techniques, thus leading to constant improvements.

3. The data is compatible and comparable with other programs participating in the NOAA program.
4. All our data to date has been collected by this technique, and if we changed there would be an unknown amount of incompatibility and incomparability.

The cons of the performance-based technique are:

1. The data may differ somewhat from that produced by the EPA technique.
2. The fee-payers, most of whom are required to utilize EPA standard techniques do not seem to understand the benefits/strengths of using performance-based techniques.

<u>Other issues/questions regarding chemical methods</u>

Should chemical analyses be performed upon pore water?

Trace organic and trace element compounds have been measured in bulk sediment exclusively, with the exception of 21 pore water samples which we performed a limited trace element analysis upon. If toxicity evaluations of pore water are to be incorporated into the final assessment of sediment quality, then it would seem that trace organics and elements should be measured in pore water.

It should be realized that the levels of organic compounds in pore water will be a function of the bulk concentration in the sediments, the water solubility of the compounds, and the organic content of the water (should we be measuring DOC in porewater, and not just TOC in sediments?). Preliminary toxicity tests could be performed to indicate the necessary detection limits to assess significant correlations with the chemistries.

Should the number/type of organic compounds currently analyzed for be increased/changed?

Please see the current analyte list in the BPTCP QAPP. Our thoughts on this question are that we should re-examine the list of compounds and make some changes/additions. Due to the nature of the toxicity tests being performed, there may be a higher tendency to indicate toxicity resulting from more water soluble compounds than those presently being determined by the BPTCP program.

Therefore, since correlations between chemistries and toxicity have been weak, it would seem desirable to expand the analyses into new classes of chemicals, such as aliphatics, pthalates, additional PCB's, etc. In order to expand this analysis in a coherent and cost-effective fashion, these expanded analyses might only be performed once a site has had fairly clear weight of evidence of being a hot spot, and a TIE approach would then seem to be very useful.

Should effort be directed toward identification of unknown peaks?

Almost invariably, numerous well-defined peaks appear on the chromatographs for compounds/classes of organic chemicals that we are not authorized to analyze. Perhaps by allocating as little as 5% of the resources dedicated toward organic analyses to attempting to at least index and quantitate these unknown peaks, we may find extremely useful information. The TIE approach may be a better approach, as analyte intensity does not necessarily correlate with toxicological impact.

Should chemistry be performed on screening samples, or just on confirmation samples?

To date, we have performed limited chemistry on screening samples, and on all confirmation samples taken. The hot spot criteria require an association with some level of anthropogenic chemical contaminants, necessitating chemistry to be performed on confirmation samples. It does not appear that there is any overwhelming need to perform chemistry on screening samples, unless perhaps we are trying to determine that a particular site is CLEAN and free of particular contaminants, for possible use as a field reference site (if indeed lack of contaminants is a prerequisite for field reference sites). A discussion of the rationale and timing for authorizing chemistry to be performed would be useful and helpful.

# REGIONAL SUMMARIES

REGIONAL WATER QUALITY CONTROL BOARD
NORTH COAST REGION
(REGION 1)

REGIONAL SUMMARY

**Monitoring Goals and Objectives**

The overall goal is to collect data on sediment, water column and soil pore water quality in order to:

1. Identify types and distribution of toxic pollutants in North Coastal bays and estuaries, including spatial and temporal variations, for the purpose of identifying the location, extent and degree of toxicity of toxic hot spots.

2. Identify the condition of the resource/ecosystem and the effects of toxic hot spots on various species of the aquatic community. This will include characterization of background (reference) conditions of the resource/ecosystem.

3. Establish a database to measure future trends in the condition of toxic hot spots and their effects on the aquatic community.

Sampling and analysis techniques will be standardized techniques used statewide as recommended by the SWRCB study group [BPTCP Monitoring and Surveillance Task Force]. Specific water bodies and monitoring goals and objectives are as follows:

**Arcata Bay and Humboldt Bay Segments**

1. Determine if dioxins or furans from airborne fallout, rainfall runoff or other form of discharge from two pulp mills have accumulated in sediments of Arcata Bay and all Humboldt Bay segments.

2. Determine if pentachlorophenol, tetrachlorophenol or dioxins/furans discharged near Mad River Slough, McDaniel Slough or south of Eureka as a result of discharges from wood treatment activities at lumber and plywood mills have accumulated in sediments of Arcata Bay and all Humboldt Bay segments.

3. Determine if polynuclear aromatic hydrocarbons or chlorinated solvents from various industrial complexes have accumulated in sediments along the Arcata or Eureka waterfronts.

4. Determine if pesticides in rainfall runoff from lily bulb growing activities in Arcata bottoms have accumulated in sediments of Arcata Bay and North Humboldt Bay.

5. Determine if polynuclear aromatic hydrocarbons from past activities of coal and oil gasification by historic gas utility companies have accumulated in sediments of Arcata Bay or North Humboldt Bay.

6. Determine if petroleum hydrocarbons or heavy metals from petroleum fuel storage/usage along the bay shoreline have accumulated in sediments.

7. Determine if bacteria contained in rainfall runoff from dairies and urban storm drains are adversely affecting commercial or sport shellfish harvesting. Identify climatic effects on bacterial concentrations.

8. Determine if constituents in toxic leachate from extensive redwood bark fill are accumulating in sediments of Humboldt Bay.

9. Determine if solvents, petroleum hydrocarbons, tributyltin or other metals from boats and boat servicing activities have accumulated in sediments around boat basins (Fields Landing, Woodley Island, Eureka small boat basin).

10. Determine if petroleum hydrocarbons or metals contained in urban runoff have accumulated in sediments in the vicinity of storm drain outlets or other portions of the bay where sediments are deposited.

11. Sample animal-sediment pairs at several locations to determine if toxic constituents accumulate to a higher degree in the tissue of the test animal or in the sediment. Identify natural (background) sediment conditions (sulfide and/or physical factors) which favor/disfavor animal recruitment.

12. Compare quality of Arcata and Humboldt Bay sediments with that of other, similar bays in California (Tomales, San Pablo ?). This would necessitate analyzing sediments from other, similar bays for the same constituents such as dioxins, furans, tetrachlorophenol, pentachlorophenol and polynuclear aromatic hydrocarbons.

13. Identify and diagnose stressed biological communities. Distinguish between sulfide and nonsulfide causes, favorable and nonfavorable factors.

14. Characterize sediment types and locations in all bay segments for physical factors related to sediment deposition (grain size, stratigraphy) and pollutant affinity.

<u>Bodega Harbor</u>

1. Determine if solvents, petroleum hydrocarbons, tributyltin or other metals from boats and boat servicing activities

have accumulated in sediments around boat basins (Tides wharf area, Mason's Marina, Spud point Marina).

2. Determine if bacteria contained in rainfall runoff from dairies are adversely affecting sport shellfish harvesting. Identify climatic effects on bacterial concentrations.

**Eel River Estuary**

1. Determine if petroleum hydrocarbons or metals contained in urban runoff have accumulated in sediments.

**Klamath River Estuary**

None at this time.

**Mad River Estuary**

None at this time.

**Noyo River Estuary**

1. Determine if solvents, petroleum hydrocarbons, tributyltin or other metals from boats or boat servicing activities have accumulated in sediments.

**Russian River Estuary**

1. Determine if petroleum hydrocarbons or metals contained in urban runoff have accumulated in sediments.

2. Determine if pesticides in rainfall runoff from extensive wine grape vineyards throughout the watershed have accumulated in the sediments.

**Smith River Estuary**

1. Determine if pesticides from lily bulb growing activities have accumulated in sediments.

2. Determine if pentachlorophenol, tetrachlorophenol or other toxic compounds from wood treating activities at a lumber mill have accumulated in sediments.

REGIONAL WATER QUALITY CONTROL BOARD
SAN FRANCISCO BAY REGION
(REGION 2)

REGIONAL SUMMARY

## Physical Description of the Region

The San Francisco Bay/ Delta Estuary, the largest estuary on the west coast of North and South America, is the main waterbody in this Region included in the Bay Protection and Toxic Cleanup Program. The San Francisco Estuary receives runoff from 14 watersheds having a total area of over 5 million acres. The San Francisco Bay Regional Water Quality Control Board has jurisdiction over the area from the vicinity of Antioch at the confluence of the Sacramento and San Joaquin Rivers west to include Suisun Bay, San Pablo Bay, Central San Francisco Bay and South San Francisco Bay. The Central Valley Regional Water Quality Control Board, Region 5, has jurisdiction over the area east of Antioch that makes up the Sacramento-San Joaquin Delta. Like all estuaries, the San Francisco Estuary is a trap for suspended particulate matter. It is estimated that the total annual amount of sediment deposited throughout the Bay is 4.38 metric tonnes. Because the Bay is so shallow, 40% is less than 2 m deep and 70% less than 5 m deep, sediment resuspension and redistribution is very high compared to other estuarine systems (i.e, Chesapeake Bay, Hudson River and Puget Sound). Tidal action, currents and wind play a large role in the resuspension and transport of sediments especially in the large, shallow embayments of Suisun, San Pablo and the South Bay.

Suisun Bay is a shallow embayment surrounded by Suisun Marsh, the largest brackish water marsh in the United States. The narrow Carquinez Strait joins Suisun Bay with San Pablo Bay. San Pablo Bay is a large, shallow, open bay that is largely influenced by outflow from the Delta. It is the deposition site for many of the fine-grained sediments carried out of the Delta by high winter flows. The Central Bay is the deepest part of San Francisco Bay and has the most oceanic influence. South San Francisco Bay receives much smaller amounts of freshwater inflow from the surrounding watershed and, as a result, is more like a shallow tidal lagoon. Tributaries to the San Francisco Estuary, as well as, several coastal embayments and lagoons, which have a relatively low level of anthropogenic impact, are also included in this program.

Sources of contaminants to San Francisco Bay include over 200 permitted discharges, including 50 POTWs with a combined design flow of 829 MGD, urban runoff, many boatyards and marinas, dredging activities and historical dumping. In addition, historical mining activities and agricultural runoff are sources of metals and pesticides from higher up in the watershed. All of these sources of contaminants plus the fill of wetlands and water diversions have been the major impacts to the health of the Estuary.

## Philosophy of Monitoring in the Region

The main philosophy in the Region towards monitoring is the measurement of ambient trends in the watershed through the Regional Monitoring Program and comparison of those trends and measurements to monitoring programs being conducted near points of discharge. In this Region many dischargers have conducted their own monitoring programs (Local Effects Monitoring Programs) or special studies, many of which have included sediment studies. In 1993, we instituted a Regional Monitoring Program, managed by the San Francisco Estuary Institute, in which water column chemistry and toxicity, sediment chemistry and toxicity, bioaccumulation and benthic community analysis are analyzed several times a year throughout the Estuary (from the South Bay to the Sacramento-San Joaquin Rivers). Since one of the major long term goals of this strategy is to gain a clear understanding of ambient conditions and spatial and temporal trends in the watershed, and compare them to areas where there are current or historical discharges, the identification and characterization of reference sites has been very important, especially for sediment toxicity tests.

## Bay Protection and Toxic Cleanup Studies

These studies are described according to discipline and emphasis in the program (sediment studies, bioaccumulation studies and transport studies) and not necessarily in chronological order.

1. San Francisco Estuary Pilot Regional Monitoring Program: Sediment Studies

   The main objectives of this study were to: 1) screen critical habitats (marshes and mudflats) near potential sources of contamination to identify potential toxic hot spots, 2) develop a baywide sediment monitoring program that would act as a pilot program to define ambient conditions and 3) evaluate the use of various sampling and testing methods to use in monitoring programs. To achieve the first objective, sediment chemistry and toxicity were measured at 32 stations in critical habitats throughout the estuary. To achieve the second objective, sediment was collected at 15 stations that were thought to reflect ambient conditions. These samples were collected during wet and dry seasons and were geographically distributed throughout the Estuary. Sediment chemistry and toxicity were measured. In both the critical habitat study and the baywide study three toxicity tests were used: the solid phase 10 day amphipod test using

Eohaustorius, the bivalve larvae development test using an elutriate and the Menidia growth and survival test using an elutriate. In the second baywide run the Menidia test was eliminated due to lack of sensitivity. For all of these samples the depositional layer was sampled which was characterized by brown, loose sediment lacking the smell of hydrogen sulfide. This layer varied between 2 to over 20 cm. A reference site in Tomales Bay was used to compare sediment chemistry and toxicity with test sites.

To evaluate various sampling and testing methods a study was conducted on a sediment gradient that had been contaminated by a oil refinery. The main purposes of the gradient study were to: 1) determine which toxicity tests or phases (solid phase, elutriate, or pore water) could best distinguish between highly contaminated, moderately contaminated and relatively uncontaminated sites, 2) evaluate the degree to which field replication increases the ability to distinguish between sites, 3) determine the effects of sample depth, 4) determine the relationship between toxicity and factors that may effect toxicity including the levels of chemical contaminants, total organic carbon, grain size, ammonia and sulfides and 5) determine the relationship between toxicity test results and benthic community analysis. Five field replicates were collected at each of four stations on the gradient. Samples of the depositional layer were collected, as well as, samples one foot deep for each of the field replicates. Tests included solid phase and pore water chemistry, the 10 day solid phase amphipod test using Eohaustorius, the bivalve development test using an elutriate and pore water and benthic community analysis. On a subset of samples biomarker measurements (exposing speckled sandabs to sediment in a lab and analyzing for P450, EROD activity, stress proteins and histopathology), as well as, pore water tests that included sea urchin fertilization, development, cytologic and cytogenic effects, nematode broodsize and mutagenic effect, amphipod tests using intact cores and bacterial mutagenicity were conducted.

Using data from the baywide and critical habitat studies, areas were identified that had high levels of contaminants and/or toxicity. These areas are included in the potential toxic hot spot list. The results of the baywide and critical habitat studies showed that nickel exceeded the ERM in all samples and seemed to be the result of geologic deposits. The Tomales Bay reference site, although removed from sources of contamination, was toxic approximately half of the time when compared to controls. Other stations along the coast that were evaluated to be used for reference sites because of the lack of contaminant sources also proved to be toxic in toxicity tests. The Menidia growth and survival test seemed to be the least sensitive of the three tests conducted in these studies. The baywide studies have formed the basis of the sediment portion of the Regional Monitoring Program.

In the gradient study, contaminants measured in the solid phase significantly correlated with each other and with related variables such as organic carbon and nitrogen. Concentrations of metals, extracted with aqua regia, were poor predictors of pore water metal concentrations. The amphipod test was significantly correlated with all of the contaminant and related variables and had low field variability. Toxicity was higher in the deeper cores where chemical concentrations were higher. For the bivalve larvae tests, pore water tests were more toxic than elutriate tests, field variability was greater than laboratory variability, and toxicity was also greater in the deeper cores. Benthic community analysis could not detect differences between stations along the gradient. Sea urchin development had a strong relation to bivalve larvae development but a poor relation to sea urchin fertilization. In the pore water tests neither ammonia or sulfides seemed high enough to cause toxicity. The PAH content of the sediment was significantly correlated with P-4501A content of the gills, hepatic EROD activity and gill histopathology. Although these were the major findings of the gradient study, analysis of this data is continuing through another Regional Board contract.

In addition to these results, this study provided the groundwork for a data management system currently being used by the Bay Protection and Toxic Cleanup Program and the San Francisco Estuary Regional Monitoring Program.

2. Reference Site Study

The main purposes of this study are to: 1) identify sediment reference sites in San Francisco Bay to use in toxicity tests, 2) recommend sediment toxicity test protocols to use in monitoring sediment toxicity in San Francisco Bay, 3) develop sediment Toxicity Identification Evaluation (TIE) protocols that can be used in San Francisco Bay and 4) identify the cause of toxicity at contaminated and previously identified reference sites. This study is currently in progress but nearing completion. For this study five potential sediment reference sites were chosen. Two sites were in San Pablo Bay, one site was in the Central Bay and two sites were in the South Bay. Chemical analysis has been or will be conducted at all sites that do not show toxicity. Sediment samples from Tomales Bay and several contaminated sites were also collected for comparison. All potential reference sites had three field replicates. In addition, all potential reference sites, except those in the South Bay, were sampled three times during the year during different hydrologic conditions. Since the most likely locations to find reference sites were in San Pablo and the Central Bay, those sites were chosen first. Since these sites seemed to be good reference sites based on results from the first two sampling events, additional sites were chosen in the South Bay. Between seven to nine toxicity tests were performed on each sample. These tests were: 1) the 10 day solid phase amphipod test using Eohaustorius, 2) the 10 day solid phase amphipod test using Ampelisca, 3) the 10 day amphipod test using Eohaustorius in undisturbed cores, 4) the 10 day amphipod test using Eohaustorius in pore water, 5) the bivalve larvae development test in pore water, 6) the urchin larvae development test in pore water, 7) the urchin larvae development test using a sediment/water interface exposure, 8) the Neanthes growth and survival test and 9) a 10 day solid phase test using Nubelia. Toxicity tests were dropped out of the study based on their level of control survival, performance at reference sites and sensitivity to contaminated sites.

The first step in this project was to develop Sediment TIE protocols for the 10 day amphipod test, the bivalve larvae development test and the urchin larvae development test using pore water. When all laboratory tests were completed including pore water extraction experiments, testing the sensitivity of the various organisms to TIE manipulations and spiking experiments, the field portion of the study began. Samples were collected at the reference sites with enough field replication to try to determine field variability and during different hydrologic cycles to try to determine seasonal variability. By collecting the samples in this way, we hope to identify reference sites, determine the variability at those sites for statistical purposes, and identify sediment toxicity tests that perform well at reference sites but are sensitive to contaminated sites. Once this study is completed and reference sites are identified, testing of these sites will continue and data will be added to develop a "reference envelop" for these sites. In addition, we performed the amphipod test with undisturbed cores and the urchin test using a sediment/water interface to evaluate the environmental relevance of the standard amphipod and urchin tests. These tests could possibly be used in confirming toxic hot spots.

When samples were found to be toxic, a TIE was performed using the pore water test that exhibited toxicity. The first two field TIEs were performed on sediment from Islais Creek, where the City of San Francisco has had their main outfall for decades, and on the Tomales Bay sediment. After removing ammonia and hydrogen sulfide from the Islais Creek sample, toxicity remained. After running TIEs on both samples results seemed to indicate that in both samples toxicity was being caused by a polar organic degradation product. Additional work has been performed to try to extract and identify the cause of this toxicity. Draft reports for this study are due July 1995.

3. Screening for Sediment Toxicity in San Francisco Bay

In this study, 49 sites will be screened for toxicity using the 10 day solid phase amphipod test using Eohaustorius and the urchin development test using pore water. Preliminary results from the reference site study seem to indicate that these are the two most reliable standard tests. Sediments from reference sites identified in the reference site study will be sampled concurrently. Test results from reference sites will be compared to test site results. This study has just begun.

4. Contaminant Levels in Fish Tissue in San Francisco Bay

Since one of the working definitions of a toxic hot spot involves the suitability of fish for human consumption, we conducted this study to measure contaminant levels in fish caught and consumed by anglers in San Francisco Bay. The main objectives of the study were to identify, to the maximum extent possible, the chemicals, species and geographical areas of concern in San Francisco Bay. This study was designed in a coordinated effort between state agencies, environmental groups and anglers. Thirteen fishing piers were sampled for fish with a small habitat range. Other regions of the Bay were sampled for fish that had a larger habitat range. The species of fish that were collected were white croaker (which was the highest priority fish based on its feeding behavior and lipid content), shiner surfperch, walleye surfperch, leopard sharks, brown smoothhound sharks, striped bass, sturgeon and halibut. EPA Screening Values based on the consumption rate of 30 grams per day were used to screen the data for potential chemicals of concern.

Results showed that: 1) The EPA guidance document, Guidance For Assessing Chemical Contaminant Data For Use In Fish Advisories- Volume 1- Fish Sampling And Analysis (EPA 823-R-93-002, 1993), was an effective tool for designing the pilot study and analyzing data collected from the San Francisco Bay study. 2) Based on EPA screening values six chemicals or chemical groups were identified as potential chemicals of concern in San Francisco Bay. They were PCBs, mercury, dieldrin, total DDT, total chlordane and the dioxin/furans. 3) High levels of the pesticides dieldrin, total DDT and total chlordane were most often found in fish from the North Bay. 4) Levels of PCBs, mercury and the dioxin/furans were found at concentrations exceeding EPA screening values throughout the Bay. 5) Fish with high lipid content (croaker and shiner surfperch) in their muscle tissue generally exhibited higher organic contaminant levels. Fish with low lipid levels (halibut and shark) generally exhibited lower organic contaminant levels. 6) Of the Bay fish collected, white croaker consistently exhibited the highest tissue lipid concentrations. Lipophilic PCBs and pesticides concentrated to the highest levels in the muscle tissue of these fish. 7) Mercury levels were found to be the highest in the two shark species collected; the leopard shark and the brown smoothhound shark. Both the sharks and white croaker exhibit increasing mercury concentration with increasing fish size indicating bioaccumulation of this metal in Bay area fish. 8) Vallejo-Mare Island was the sampling location from which fish most often exhibited high levels of chemical contaminants. Oakland Inner Harbor also exhibited a high incidence of tissue contamination. As a result of this study, the Office of Environmental Health Hazard Assessment (OEHHA) has issued an interim health advisory for consuming fish caught in San Francisco Bay. OEHHA is currently in the process of using this data to conduct a thorough health risk assessment of consuming fish in San Francisco Bay. This study was designed partially due to the great interest on the part of the public in this issue. The results of this study have produced more public interest than any other of our Bay Protection studies.

5. Bioaccumulation of Trace Metals and Organics in Bivalves in San Francisco Bay

The California Mussel Watch Program, which has been measuring contaminant levels in bivalves throughout the state for the past 16 years, has proven to be a valuable tool for identifying areas with high levels of contaminants and for tracking trends in contaminants. This study was designed to test some of the assumptions inherent in the program and to determine if the program could be better designed for monitoring contaminants that bioaccumulate in San Francisco Bay. The main objectives of the study were to: 1) describe the distribution of trace metals and organics in organisms in San Francisco Bay; 2) determine the difference in contaminants collected during wet and dry seasons; 3) determine the differences between mussels transplanted high in the water column and down by the sediment at the same station; 4) determine the effect of depurating sediment from the guts of organisms on the contaminant levels in the whole body; 5) determine the optimum length of exposure for transplant organisms and

6) determine the differences in species uptake at selected stations. Eight bivalve transplant stations were chosen that were geographically spread from the South Bay to the Sacramento and San Joaquin Rivers. Three species of bivalves were transplanted depending on their salinity tolerances. These were the mussel Mytilus californianus, the fresh water clam Corbicula and the oyster Crassostrea gigas. Multiple species were transplanted at several stations. Bivalves were transplanted for 30, 60, 90 and 120 days. Bivalves were deployed during wet and dry seasons. At selected stations mussels were transplanted high in the water column and down by the sediment. Some mussels were depurated while some were not.

Results showed that most of the stations within San Francisco Bay accumulated contaminant levels that were significantly higher than controls collected at sites in more pristine locations. Stations in the South Bay, especially Coyote Creek, were significantly higher than the Central or North Bay stations for DDT, PCBs, chlordane, and PAHs. This was the first indication that organic contaminants may be a problem in the South Bay. Previously, Regional Board efforts were focusing on metals concentrations. Silver was significantly higher in the South and Central Bay than in the North Bay. There were no significant differences in contaminant levels between wet and dry seasons (this was a dry year) or between surface or bottom deployed mussels. A small number of metals was significantly different between depurated and undepurated mussels. An equilibrium appeared to be attained during the 90 to 120 day transplants for copper, mercury, lead, selenium and chlordane. No equilibrium was obtained in mussels for silver, PCBs and possibly DDT after 120 days. Oysters and mussels exhibited similar concentrations of chlordane, DDT and PCBs. However, PAHs and all metals were different between the two species. Recommendations are made in the report for deploying bivalves in San Francisco Bay based on these results.

## Projects to Collect Information for the Cleanup of the South Bay

The purpose of the following projects is to develop the information necessary to use a watershed management and wasteload allocation approach to attain water quality objectives in the South Bay. This information will be used to develop cleanup plans for the South Bay based on wasteload allocations, sediment dynamics and hydrodynamic modeling. The South Bay was identified as an impaired water body through the Clean Water Act 304(l) listing process and was designated a candidate toxic hot spot under the Bay Protection Program because of repeated exceedences of water quality objectives. The pollutants of concern identified at that time were heavy metals, and the sources were three POTWs and storm water. Advanced treatment is already in place at the treatment plants, and the effluent quality is quite high, so that additional treatment was expected to be very costly. In addition, it was unclear to what extent remobilization of sediment-bound pollutants (as opposed to ongoing discharges) was responsible for receiving water conditions. In order to determine what level of pollutant reduction was necessary to clean up the hot spot, additional information was needed to determine what level of discharge would result in the attainment of water quality standards. In addition to conducting these studies, stormwater is being monitored through another Regional Board program.

1. Wasteload Allocation Modeling

The purpose of this project was to use existing EPA models and available data to determine the allowable level of loading of copper, nickel and lead to the South Bay. CEAM used the WASP4 model for this purpose. The model incorporated hydrodynamics, sediment transport and sediment-water partitioning of metals. They concluded that significant reductions in loading were needed to attain water quality standards. However, based on comparisons of model results with current ambient water quality, Regional Board staff concluded that the model was not accurate enough to form the basis of regulatory decisions.

2. 2-D Hydrodynamic Modeling and Sediment Dynamics

This is the largest project in this category, and it has two components. After the experience with the CEAM model, we decided that existing models and data did not allow accurate modeling of pollutant fate and transport, but that modeling the physical processes could provide valuable information for estimating pollutant residence time. The goals of hydrodynamic modeling were to calculate the dry weather hydrodynamic residence time of the extreme south Bay, and estimate the dry weather sediment residence time of the South Bay, and use these two values as a range for pollutant (metals) residence time. The estimate of sediment residence time will be based on a the idealized approach of tracking a particle (in the model) that deposits and goes into suspension at the appropriate water velocities (determined from the suspended sediment monitoring). Modeling was (and is being) performed using TRIM2D (depth averaged), developed by Cheng and Casulli. Because of the lack of data describing sediment movement in the estuary, the sediment dynamics aspect of the project focuses on data collection rather than modeling. Time series of suspended sediment concentrations are being collected at 15 minute intervals at three locations in the South Bay (2 depths each) using optical backscatter (OBS) sensors. The data are analyzed to determine the influence of tides, wind, and freshwater inflows on suspended sediment concentrations. In addition to the South Bay stations, there are similar stations in Central Bay funded by the US Army Corps of Engineers and the Regional Monitoring program, and in Suisun Bay, funded by the USGS. Therefore, forcing factors for sediment resuspension can be compared for different parts of the Estuary. In addition to the long term stations, there have been several 30 day deployments of OBS sensors in shallow water, both in North and South Bay. This component of the project has produced three to four (depending on the station) years of suspended sediment data. Data analysis to date has determined that in the South Bay, the spring-neap tidal cycle is the most important factor in determining suspended sediment concentrations. Both data collection and data analysis continue.

3. South Bay Bathymetry

Hydrodynamic modelers have concluded that models (and TRIM2D in particular) are very sensitive to bathymetry. Much of the extreme South Bay is mudflats, for which depths are not included in NOAA maps. Therefore, the purpose of this project was to produce accurate bathymetry of the South Bay, south of Dumbarton Bridge, for use in hydrodynamic models. Aerial photos were taken over the course of a tidal cycle, so that the water level could be used as isobaths. Water levels were adjusted to 1929 NGVD elevations after surveying the benchmark using global positioning system. In addition, it was determined that MLLW is 1.25 below the NGVD datum, so that depths in the channel were corrected as well as in the flats. Products were a bathymetric map and a computerized bathymetric grid with resolution of 0.1 m. Volumes of the South Bay at different tidal elevations were calculated as well. Modelers at USGS district office and at Stanford are now using the new grid.

4. 3-D Hydrodynamic Modeling

The 2-D model described above is depth averaged, and it is unclear whether it can adequately characterize depth dependent phenomena such as stratification in wet weather and sediment transport. That's why the project described above will only estimate residence times for dry weather. The purpose of this project is to apply TRIM3D to the South Bay to estimate residence times. In addition to providing very high quality characterization of the hydrodynamics of the region, the project is a test case to determine whether (or under what conditions) the additional effort involved in 3D modeling is merited. This contract was executed last month, and has not yet produced results.

## Questions and Issues Particular to this Region

1. Reference Sites - This Region has placed a great deal of emphasis on identifying and characterizing sediment reference sites. We believe that this type of characterization is necessary in order to identify toxic hot spots.

2. Sediment Sample Depth - This Region has been sampling sediment for chemistry and toxicity first at the depositional layer and then for consistency at 5 cm. Other Regions have sampled at a depth of 2 cm. We believe that the dynamic nature of this Estuary requires deeper sampling. Results from the Pilot Regional Monitoring Program and USGS indicate that the top 2 centimeters is very mobile due to resuspension and transport. Sediments could be eroded away at a particular site or buried very quickly. Monitoring the top 2 cm in an ongoing monitoring program would make some sense, but sampling the top 2 cm to determine if there is a toxic hot spot, we believe, is not a sufficient characterization. Determining whether an area is depositional or erosional would come in to play when evaluating, during the cleanup plan process, whether an area is being capped or eroded.

3. Benthic Community Analysis - In the San Francisco Bay Estuary fluctuating salinity, water movement and grain size play a major role in determining benthic communities. In addition, exotic species are introduced frequently that play a major role in the makeup of the benthos. Although there has been a considerable amount of work to date on the benthos of the San Francisco Estuary, the effect of contaminants on the benthic community is still too unclear to take a sample and determine the cause of different species assemblages or biomass. In addition, it is very difficult to find appropriate reference sites. Even when sampling a contaminated gradient, the impact was unclear. Should we sample for benthic community analysis? It seems that it is a waste of funds until we know how to interpret the data. On the other hand, it is the most realistic evidence of impact. Any suggestions?

4. Designation of Hot Spots Based on Exceedences of Water Quality Objectives or Elevated Contaminant Levels in Tissues - In this Region we have data on the levels of metals and organics in the water column. We also have health advisories that have been issued for fish that have a fairly wide habitat range. Since a hot spot designation can be triggered by water quality objective exceedences that are contained in our Basin Plan or by Health Advisories, we would like some guidance on how to delineate this type of hot spot. Our main thought, at this time, is to address

both of these types of hot spots by developing watershed management plans and conducting ongoing monitoring programs.

5. Bioaccumulation in Screening - In the Bay Protection Program we are screening sites by measuring toxicity at a station. However, in this Region we believe that bioaccumulation from the sediments into higher trophic levels has led to Public Health Advisories for the consumption of fish and may be contributing to the decline of different populations. Currently, if there is no toxicity at a station that station is not revisited. Are we "missing the boat" by not screening for bioaccumulation?

6. The Use of Sediment Toxicity Identification Evaluations (TIEs) - For the Reference Site Study conducted in this Region we have developed methods for conducting TIEs in pore water with estuarine species. We believe that this is a very useful tool in determining if ammonia, hydrogen sulfide, anthropogenic contaminants or other natural factors are causing the toxicity seen in toxicity tests. Currently, if a station has ammonia or hydrogen sulfide levels that could impact a particular test that station is eliminated as a potential toxic hot spot. Yet, something else could be causing the toxicity. We believe that abbreviated TIEs could be used to determine if toxicity is actually being caused by ammonia or hydrogen sulfide and full TIEs could be used to identify the cause of toxicity either to designate a candidate toxic hot spot or to determine cleanup options for known toxic hot spots.

**<u>Additional Data</u>**

The San Francisco Estuary Regional Monitoring Program continually collects data on water column chemistry and toxicity, sediment chemistry and toxicity, and bioaccumulation. Dischargers conduct their own Local Effects Monitoring Programs. In addition, the Department of Defense and dredgers have conducted many investigations for base closures and dredging operations. In our preliminary toxic hot spot list 110 of these studies are listed. This list has been expanded to include 122 studies and is continuously being updated.

REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION
(REGION 4)

REGIONAL SUMMARY

**Physical Description**: The region contains two large deepwater harbors and one smaller harbor. There are small craft marinas within the harbors as well as tank farms, naval facilities, fish processing plants, boatyards, and container terminals. A number of separate small craft marinas occur along the coast; these contain boatyards, other small businesses, and dense residential development.

Several large concrete-lined rivers lead to unlined tidal prisms which are for the most part marine-influenced. Salinity may be greatly reduced following rains since these rivers drain large urban areas composed of mostly impermeable surfaces. Some of these tidal prisms receive a considerable amount of freshwater throughout the year from POTWs discharging tertiary-treated effluent. Lagoons are located at the mouths of other rivers draining relatively undeveloped areas with some degree of agricultural activity (Mugu Lagoon, and lagoons at the mouths of the Ventura and Santa Clara Rivers). There are also a few isolated coastal brackish water bodies receiving runoff from agricultural or residential areas.

**Results of Previous Studies (State Mussel Watch/Toxic Substance Monitoring/Regional Board Sediment Sampling)**: Previous work in deepwater harbors has revealed decreasing, but in some cases, still relatively high levels of DDT and its isomers in tissue and sediment. More recent SMW data for LA Harbor indicates that considerable water transport of DDT may be occurring in some areas since tissue samples rather than sediment are exhibiting high DDT concentrations. PCBs are also on the decrease but still show up in high concentrations in sediment and tissue near "problem sites." Other pesticides, except for TBT, are usually not a problem. Copper, zinc, and sometimes chromium tend to be elevated in sediment and tissue. PAHs are also a problem in inner harbor areas where liver lesions associated with the chemicals have been found in fish. The innermost part of LA Harbor (mouth of Dominguez Channel/Consolidated Slip) continues to show a degraded benthic community. Port Hueneme, the smaller deepwater harbor in Ventura County, is also contaminated with PCBs, DDT, and metals (sediment and tissue). Tissue and sediment samples from small craft marinas are generally moderately high to very high in copper, chromium, and zinc. Some small areas within the marinas are also high in PCBs, DDT, and chlordane.

Most of the tidal prisms of concrete-lined rivers have not been as thoroughly investigated; limited sampling of fish tissue and sediment indicate some metals and pesticides contamination. Some of the lagoons had not been investigated prior to the BPTCP. Of those previously sampled, some are virtually uncontaminated while others are very contaminated. Malibu Lagoon is located at the mouth of Malibu Creek which drains a large part of the Santa Monica Mountains. Development is mostly residential with some commercial. However, sediment turnover in the lagoon is frequent and contaminants do not reside long enough to bioaccumulate or be found in the sediment. On the other hand, Mugu Lagoon has been occupied by the Navy for many years and its presence appears to have contributed to high sediment metals concentrations in some areas; however, pesticides found in the lagoon seem to be originating from the extensive agricultural land in the area. Very high concentrations of banned chemicals such as DDT and toxaphene still persist in the drains leading to the lagoon. The effects from these persistent chemicals include reduced reproduction of the endangered light-footed clapper rail. The miscellaneous isolated brackish water bodies have been largely uninvestigated but merit attention due to their support of large numbers of migrating and overwintering birds.

**Sampling Goals**: The goal has always been to identify "hot spots", pursue identification of the problem's source, eliminate the source (permits, enforcement orders, etc.), and then go back and monitor for recovery of the hot spot. This is consistent with the goals of the BPTCP but on a much smaller scale.

**BPTCP-related Goals and Objectives:** Because of the results of previous monitoring, certain water bodies were designated candidate toxic hot spots right from the beginning (parts of LA/LB Harbors and Mugu Lagoon). The program goal for these sites was confirmation of candidate toxic hot spot status. The rest of the water bodies were to be screened for sediment toxicity with higher priority given to those water bodies designated as potential toxic hot spots from previous studies. My objectives for LA/LB Harbors were to target the candidate and potential hot spots preferentially in order to resolve whether sediment contamination resulted in an effect other than bioaccumulation (toxicity or benthic impacts). Unfortunately, my goals and those of NOAA, which supplied a large amount of additional money for more generic monitoring, were not compatible and many suspected hot spots (plus one candidate site) were not sampled. It's been suggested that these data (which includes some confirmation work) may be used for screening purposes instead. I would like to be able to do that and see no reason why it can't be done. There was also some concern about the timing of the sampling phases and the possibility that a lot of changes due to storm events had occurred. I don't think that's a problem, at least in the deepwater harbors. Previous sampling seems to indicate that sediment changes occur slowly over the years in these water bodies. At this point I would like to do confirmation work at the suspected hot spots and move on.

As for the rest of the region's water bodies, some time ago we were all requested to formulate monitoring plans for our water bodies. I planned on targeting sites with known and highly suspected problems (near storm drains, confluence of problem areas, etc.). Unfortunately, those plans were tossed when money ran out and instead screening of potential hot spots was accomplished with one sample per water body for the most part. I would prefer to concentrate more sites in higher priority water bodies and completely leave out water bodies I feel previous data tell me are of only moderate concern and extremely unlikely to gain attention to the point where a "cleanup" is conducted. These water bodies will still need remediation plans, but I think source control and prevention programs will be the answer.

**Issues/Questions Generated by This Work**: 1) Do we always need field replicates (for screening or confirmation) considering the extra costs involved and in what situations can we get away with not collecting them? 2) Is collecting AVS and SEM data worth the extra cost? If so, is it recommended this be done on a regular basis or only under certain circumstances? 3) Does porewater toxicity by itself tell us anything or is chemistry always needed? Is porewater toxicity and chemistry giving useful information or just more information? 4) Which would be better: utilizing several acute toxicity tests or having a mix of acute and chronic tests? 5) Should we be gathering chemistry data on nontoxic sites also? We aren't right now.

**General Issues/Questions**: With regards to the toxic hot spot definition, when "the water or sediment exhibits toxicity associated with toxic pollutants" the site is considered to be a toxic hot spot. While "what is toxic?" is certainly one question that immediately arises, that is already being dealt with in a number of ways, especially at DOD sites. The other question that arises is, "how strong an association do we need to have?" There has been a tendency thus far in the program to consider the "conventional (co-occurrence) approach" to be completely unacceptable.

The conventional approach appears to be comparison of test sites with a biased group (nontoxic, low pollutant-level) of reference sites. The argument against doing this is that there are probably sites out there that are nontoxic and relatively high in pollutants that are just not bioavailable. A RP might just argue about cleaning up a site exhibiting toxicity with high contaminants when high contaminants elsewhere don't cause a problem. This argument makes a lot of sense but I think the approach can be changed somewhat and still be useful. Why not compare the test sites to a nonbiased group of reference sites (not pollutant-level dependent).

The recommended approach thus far has been what's called the "internal AET approach." This is very conservative and requires a very rigid sampling scheme. It seems to be showing more a cause and effect of specific chemicals (probably just one step short of a TIE) rather than just an association. One of my suggestions has been to develop an approach midway between the two. Instead of clearly demonstrating an association between toxicity and manmade pollutants, why not demonstrate lack of association with natural pollutants?

REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION
(REGION 5)

REGIONAL SUMMARY

## Physical Features

The Sacramento-San Joaquin Delta estuary is of ecological, aesthetic, and economic significance to California. Total area of the delta encompasses 4,950 square miles, including 90 square miles of water area. The delta provides drainage for one forth of the total area of the State. Major estuarine and tidally-influenced rivers of the delta include the Sacramento River, Mokelumne River, Consumnes River, Old River, Middle River and the San Joaquin River. The delta has major State and federal water project facilities including the Clifton Court Forebay, and the Delta-Mendota and California Aqueducts. Delta facilities provide approximately 40 percent of California's drinking water. Two thirds of the water consumed in California comes from the delta. One half of California's anadromous fishery passes through or lives on the estuary. The Port of Sacramento and the Port of Stockton are on the north and south ends of the delta. Within the delta lies 70 leveed islands, and 550,000 acres of agriculture.

## Goals and Objectives

Regional goals include: implementation of regional surveillance monitoring program to identify hot spots and focus monitoring to define extent of hot spots; use monitoring results to assess and rank hot spots for cleanup; formulate cleanup plans; and adopt or revise waste discharge requirements to bring about cleanup. Additional needs include development of freshwater sediment and water column aquatic life criteria that can be used to further define hot spots in the freshwater and saline portions of the delta.

## Summary of Studies

Originally, the Central Valley Region monitoring plan included 7 fixed station water column sites for metals and 24 for EPA three species water column toxicity located throughout the delta. This was done to define the extent of metal objective exceedences and toxicity throughout the delta. This work would also be used to determine metal loading patterns to the delta during normal and high flow (storm) events. During the same period additional monitoring was performed to assess water column toxicity from urban and agricultural discharges in main channels and back sloughs. In addition to the above monitoring efforts, three special studies were designed to assess the impact of metals and related toxicity from the Northern Sacramento Valley and Sacramento Urban Storm Run-off. During toxicity tests a study of dissolved metals bioavailability was made.

Results of these projects have shown: significant toxicity from pesticide applications and discharges during peak runoff seasons (late winter, spring) in the form of short to mid-term pulse like movements into the delta from agricultural applications outside the delta; potentially significant mercury loads to the delta from coastal range streams during high flow events; significant toxicity in delta back sloughs due to pesticides in urban runoff from the Stockton area; and pesticides toxicity in urban stormwater sumps in Sacramento.

Current Monitoring program(s) - Because monitoring funds have been cut and problem areas have been identified, the regional fixed station monitoring approach was modified. A scaled back regional program is in place which is weighted to areas of the delta which have shown toxicity or potential problems in the past. Toxicity identification evaluations (TIEs) are being run on water indicating toxicity to determine responsible chemicals. Special projects are being used to determine the temporal and spatial extent and sources of toxicity from metals and pesticides.

- The 94/95 winter storms have provided extreme flow events which have indicated potentially significant and previously unknown sources of mercury to the delta and San Francisco Bay.

- Past bioassays have not indicated the presence of metal toxicity in Delta waters. These results were confirmed this winter.

- During the 94/95 winter the Board implemented a volunteer urban monitoring network to determine pesticide impacts on local creeks in the delta area. The purpose of the network is to sample Sacramento and Stockton area creeks, rainfall and atmospheric deposition and assist the Board in detecting pesticides. Diazinon and Chlorpyrifos have been found in California streams at levels that cause toxicity to bioassay organisms. Comparisons with literature values suggest that sensitive local organisms should also be affected. This study is designed to help determine how pesticides are moving into the urban creeks. The primarily results indicate that both pesticides are coming from orchard spraying and urban uses via runoff and atmospheric scavenging due to rainfall. The urban creeks and orchard drainage basins in the project area discharge to the delta.

**Additional Data Available**

1. Sacramento County and Sacramento City have implemented a semi-regional monitoring program to assessment ambient water quality conditions in the lower Sacramento River watershed primarily just upstream and downstream of the county urban area and including urban and industrial discharges. This program has been operating over the past 3 years with sampling events occurring every two weeks.

2. Deepwater ship channel maintenance projects have been performing sediment sampling and assessment prior to dredging activities during the past few years. This information is being gathered now by the Department of Water Resources and the Army Corp of Engineering for submittal to the Board for review and consideration of revised sediment assessment activities. This information may be limited in nature due to high detection limits and undocumented QA/QC.

3. USGS has been assisting the Board in identifying pesticide pulse movements and their fate in the Delta. They have also conducted a semi daily pesticide monitoring program at Tower Bridge in the City of Sacramento and at Vernalis on the San Joaquin River. These two sites are the legal upstream boundaries of the delta. The USGS has identified several new pesticides that may be of concern.

4. The Department of Pesticide Regulation has a pesticide monitoring program in the Sacramento River and San Joaquin River Watersheds. By in large their monitoring has confirmed Regional Board conclusions about pesticide concentrations in the two rivers.

5. The Department of Fish and Game has developed and continue to work on draft hazard assessment documents for agricultural pesticide commonly observed in the Sacramento and San Joaquin Rivers and delta at concentrations known to be toxic to sensitive aquatic life. Draft reports are out on Molinate, Thiobencarb, Methyl Parathion, Carbofuran, Diazion and Chlorpyrifos. No water quality objectives are available for these compounds. The hazard assessment reports may be helpful in prioritizing hot spot cleanups.

**General Issues and/or Questions**

1. Should we pursue freshwater sediment criteria given the budget constraints of the program when we are finding significant water column toxicity in the delta due to pesticides from surface water discharges (urban, agriculture) from within and outside the delta?

2. Should the program pay or support monitoring and assessment up the watershed (outside of the delta boundary) to provide information needed to write cleanup plans for sources (abandoned mercury mines, orchard runoff) of toxic hot spots?

3. Should the Board consider the entire Delta a Hot Spot for mercury based on the fish advisory or should the Board attempt to define specific areas or reaches of the Delta as a hot spot based on fish tissue exceeding human health protection values?

REGIONAL WATER QUALITY CONTROL BOARD
SANTA ANA REGION
(REGION 8)

REGIONAL SUMMARY

## Overview

### Anaheim Bay/Huntington Harbor Complex

Complex is approximately 5 miles long and one-half mile wide with one ocean inlet and three main freshwater sources (stormwater channels). Watershed is approximately 75 sq. miles, highly urbanized with heavy industrial and commercial activity.

1. Anaheim Marsh, Seal Beach National Wildlife Refuge, Seal Beach Navel Weapons Station, and Bolsa Chica Ecological Reserve - Remnants of larger coastal marshlands complex. Shallow, good tidal mixing in most of marsh, poor tidal mixing in Bolsa Chica.

   Problems: Copper, lead, chromium, zinc, DDT, DDE

2. Huntington Harbor - Heavily developed marina/urban setting. Moderate depth, periodically dredged.

   Problems: Copper, aldrin, chlordane, lead, zinc, DDT, DDE

### Newport Bay

Bay is approximately 4 miles long by three to one-half mile wide with one ocean inlet and two main freshwater sources (stormwater channels). Watershed is approximately 150 sq. miles, mostly urbanized/commercial with some agriculture and industry.

1. Lower Newport Bay - Urbanized setting, over 10,000 recreational boat slips, 9 boatyards. Dredged to moderate depth, main channel deeper. Good to moderate tidal mixing.

   Problems: cadmium, copper, lead, zinc, chlordane, PCB, tributyltin, endosulfan

2. Upper Newport Bay - State Ecological Reserve, estuarine wetlands. Main channel of moderate depth with mud flats in end of bay, moderate tidal mixing. Periodically dredged to remove trapped sediment.

   Problems: cadmium, lead, endosulfan, DDT

**Regional Monitoring Goals and Objectives**

1. Identify toxic hot spots

2. Determine if level of toxicity impairs beneficial uses of water bodies

3. Identify probable sources of toxic pollutants

**Regional Questions**

1. Which data analysis method should be used for the existing data and sites in our region?

2. Would a general weight of evidence approach work better than a strict set of criteria for designating toxic hot spots?

3. How does seasonal sediment deposition and removal affect toxicity results?

4. How should toxicity and chemical data collected over several years be interpreted in conjunction with seasonal sediment depositions?

5. If reference sites are used, should they be located within the general area or from a "clean" site outside the area if the area exhibits elevated levels for many constituents?

6. Are the porewater toxicity tests that have been preformed acceptable if the test organism does not naturally live in sediments?

7. What are ways to differentiate between natural variations in benthic community populations and anthropogenic induced impacts?

8. What conclusions can be made from a site with slightly elevated levels for a few constituents and high mortality on porewater toxicity test results?

**Data Available**

**Anaheim Bay/Huntington Harbor Complex**

| Source | Media/Tests | Results |
|---|---|---|
| Orange County EMA, 1979-95 | Water column, limited sediments | Background info |
| State Mussel Watch, 1983-94 | Bioaccumulation | Potential THS identified |

| | | |
|---|---|---|
| Toxic Substances Monitoring Program, 1983-94 | Bioaccumulation | Characterization |
| USFWS & USN, 1989 | Bioaccumulation | Unknown |
| Consultants Reports, 1992-93 | Sediments,Chem bioaccumulation | Potential THS identified |
| BPTCP/NOAA, 1992 | Sediments/Toxicity Chem | Screening/Potential THS identified |
| BPTCP Benthic Community Analysis, 1992 | Benthic Community | Characterization |
| BPTCP Screening, 1992 | Sediments/Toxicity Chem | Screening/Potential THS identified |
| BPTCP Screening, 1993 | Sediments/Toxicity Chem | Screening/Potential THS identified |
| BPTCP Confirmation, 1994 | Sediments/Toxicity? Chem | Confirmation of THS? |

## Newport Bay

| | | |
|---|---|---|
| Orange County EMA, 1979-95 | Water column, limited sediments | Background info |
| Seapy, 1981 | Benthic Community | Characterization |
| State Mussel Watch, 1983-94 | Bioaccumulation | Potential THS identified |
| Toxic Substances Monitoring Program, 1983-94 | Bioaccumulation | Characterization |
| Butler, 1988 | Benthic Community | Characterization |
| Rhine Channel Fish Tissue, 1992 | Bioaccumulation | Potential THS identified |
| BPTCP Screening, 1994 | Sediments/Toxicity? Chem | Screening/Potential THS identified |

REGIONAL WATER QUALITY CONTROL BOARD
SAN DIEGO REGION
(REGION 9)

REGIONAL SUMMARY

## San Diego Region Bays and Estuaries

### San Diego Bay

- Approximately 12 nautical miles in length and one-half to two miles wide
- Rainfall along coast about 10 inches per year, November to April
- Ship channel extends well into the southern area
- Population tributary to Bay maybe three-quarters of a million people
- Industrial activity goes back 100 years, with heavy military, aircraft, and shipbuilding activities since about 1940, and 50 million gallons per day of sewage discharges until 1963
- Each of the areas listed below represent approximately one-third of the Bay surface area

North Bay: Good tidal mixing, deeper, sandy bottoms, heavily developed shoreline, and heavy commercial and industrial activity

- Depths 8-41 ft with some deep scour areas, area mostly dredged
- Water temperatures about 16C in winter to 19C in summer
- Shoreline: Maybe 5,000 recreational and smaller commercial vessel slips, Naval Air Station and Submarine Base, and residential and commercial areas
- Runoff: 47 storm drains at least 30 inches in diameter
- Problems: Copper in marinas, PCB spills

Central Bay: Moderate tidal mixing, warmer water, area dredged to moderate depths, with heavy industrial activity

- Depths 5-38 ft with a narrow channel at northern end, mostly dredged
- Water temperatures intermediate between north and south Bay
- Shoreline: Maybe 2,000 recreational vessel slips and about 100 commercial and U.S. Navy ships, Naval Amphibious Base

and Naval Station, with four shipyards and heavy industrial and urban uses

- o Runoff: Three creeks, 16 storm drains at least 30 inches in diameter

- o Problems: Sediment oil deposits from spills along eastern shore near shipyards, copper from ship antifouling paints, PCB spills

South Bay: Poor tidal mixing, water warmed by power plant, mostly shallow

- o Depths 1-18 ft with area mostly undredged

- o Water temperatures up to about 21C in summer

- o Shoreline: Maybe 1,000 recreational vessel slips, some industrial uses, two rivers tributary, remnant salt marshes, salt ponds

- o Runoff: Two controlled rivers with relatively little flow, one creek, and only 3 storm drains at least 30 inches in diameter

- o Problems: Copper concentrate, now cleaned up, deposited at marine terminal in National City

**Mission Bay**

- o Approximately two nautical miles square

- o Bay dredged to 8-12 feet over entire area

- o Good tidal mixing in west Bay, poor in east

- o Two creeks tributary to east Bay

- o Shoreline: Maybe 2,000 recreational and party boat slips, residential and commercial uses, small remnant salt marsh in northeastern portion

- o Problems: Copper from antifouling paints

**Dana Point Harbor, Oceanside Harbor, and Del Mar Boat Basin at Camp Pendleton**

- o Small harbors dredged to accommodate small vessels

- o Shoreline: Marinas and boat repair facilities

- o Problems: Copper from antifouling paints and oil

**Coastal Lagoons (17)**

- Mouths intermittently closed with fluctuating salinities in lagoons, except Agua Hedionda (always open) and Buena Vista (converted to freshwater lake)

- Shoreline: Usually undeveloped with agricultural and light residential uses

- Problems: Tijuana receives Mexican sewage; Buena Vista, Batiquitos, San Elijo, San Dieguito, and Los Penasquitos have sewage sludge deposits.

**San Diego Region Monitoring Goals and Objectives**

- Identify known and potential toxic hot spots (but not at certain locations under previous San Diego Regional Board cleanup orders)

    - Identify chemicals causing toxicity and geographic extents and depths of chemicals

    - Identify probable sources of toxic pollutants and estimate probable contributions toward creation of toxic hot spots by each source

    - Estimate effects of causative agents on beneficial uses

- (If feasible:)
  Confirm at certain locations whether toxic hot spots exist after cleanups of toxic wastes (at certain boat yards, off storm drains, and at a copper concentrate transfer area)

- Review data to determine priority rankings of toxic hot spots

**San Diego Region Results**

**Known toxic hot spots:** None

**Potential toxic hot spots:**

24 in San Diego Bay (15 from R. Swartz' amphipod toxicity, 7 from Fish and Game sediment chemistry sampling, 4 from storm drain sediment chemistry sampling)
2 in Dana Point Harbor
2 in Oceanside Harbor

**San Diego Bay Questions**

1. Should the graphical method be used for data analysis to designate toxic hot spots?

2. Are the northern, central, and southern parts of San Diego Bay so different that reference sites need to be located within these areas?

3. Are pollutants in urban runoff dispersed so well that the effects cannot be measured at the points of entry?

4. Can recent discharges of PCBs and PAHs in sediments be differentiated from historic discharges?

5. Are PAH deposits under the site of the 10th Avenue Marine Terminal from a turn-of-the-century coal degasification plant entering San Diego Bay at levels which could cause toxicity?

6. Do sediments near boat yards and shipyards exhibit greater toxicity or show other detrimental effects than sediments at marinas and moorings where underwater hull cleaning takes place?

7. Can known toxic hot spots still be designated in areas where high percentages of sediment fines are found and where Rhepoxynius data are therefore excluded?

8. Does San Diego Bay have a characteristic toxicity pattern which sets it off from other bays due to its history of sewage discharges, industrial discharges, oil spills, and urban runoff?

9. Does waste heat from the South Bay Power Plant influence toxicity in the southern part of San Diego Bay?