STAFF CEQA SCOPING

INFORMATIONAL DOCUMENT

PHASE II SEDIMENT QUALITY OBJECTIVES FOR ENCLOSED BAYS AND ESTUARIES OF CALIFORNIA

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State Water Resources Control Board

Division of Water Quality

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TABLES

FIGURES

List of Acronyms

BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
BPJ	Best Professional Judgment
BPTCP	Bay Protection and Toxic Cleanup Program
BSAF	Biota-sediment bioaccumulation factor
Cal/EPA	California Environmental Protection Agency
CECs	Contaminants of Emerging Concern
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQA	California Environmental Quality Act
COCs	Chemicals of Concern
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CTR	California Toxics Rule
CWA	Federal Clean Water Act
CWC	California Water Code
DPR	Department of Pesticide Regulation (Cal/EPA)
DOC	Department of Conservation
DTSC	Department of Toxic Substances Control (Cal/EPA)
EqP	Equilibrium Partitioning
ESA	Endangered Species Act
HERD	Human and Ecological Risk Division\
IRIS	Integrated Risk Information System (U.S. EPA)
MLOE	Multiple Lines of Evidence
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NTR	National Toxics Rule
OAL	Office of Administrative Law
OEHHA	Office of Environmental Health Hazard Assessment
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
POTW	Publicly Owned Treatment Works

RCRA	Resource Conservation and Recovery Act
RfD	Reference dose for non-carcinogens
RWQCBs	Regional Water Quality Control Boards (CalEPA)
RMP	Regional Monitoring Program
SARA	Superfund Amendments and Reauthorization Act
SCCWRP	Southern California Coastal Water Research Project
SIP	Policy for the Implementation of Toxic Standards for Inland Surface Waters
SQO	Sediment Quality Objective
SWRCB	State Water Resources Control Board
U.S.C.	United States Code (U.S.C.)
U.S. EPA	United States Environmental Protection Agency

1.0 Introduction

This staff informational document describes the State Water Resources Control Board's (State Water Board) ongoing program to develop and refine sediment quality objectives (SQOs), interpretive tools, and associated implementation policy; and summarizes factors that could be considered in the analysis of potential significant environmental effects under the California Environmental Quality Act (CEQA).

The State Water Board is developing SQOs for enclosed bays and estuaries in phases. In Phase I, staff developed the Water Quality Control Plan for Enclosed Bays and Estuaries Part 1 Sediment Quality adopted by the State Water Board in September 2008 and approved by United States Environmental Protection Agency (U.S. EPA) on August 25, 2009. This staff informational document addresses only Phase II of the SQO development effort. A detailed description of Phase 1 and Phase II are presented in Section 3.

This document is provided to the public for the purposes of receiving input on the scope of the State Water Board's CEQA analysis. The State Water Board will hold scoping workshops to assist staff in identifying the relevant issues during the environmental review process (See Cal. Code Regs., tit. 14, § 15083.). This document is not intended to fulfill the State Water Board's formal planning requirements under the Porter-Cologne Water Quality Control Act, the Federal Clean Water Act, or the California Environmental Quality Act. A draft staff report, substitute environmental document, and draft water quality control plan will be prepared and circulated to fulfill the State Water Board's formal water quality planning obligations at a later date.

Every effort has been made to present an accurate and up-to-date description of the anticipated technical framework and the means of implementing the SQOs. However, at this early point in the process, many issues remain unresolved. As a result, the technical framework and means to implement the SQOs that are eventually proposed for the State Water Board's consideration may differ significantly from those discussed in this document.

This document frequently refers to sediment quality-related reports and plans formally adopted by the State Water Board, and reports under development by staff. To avoid confusion, formal titles and short titles are described below.

The Water Quality Control Plan for Enclosed Bays and Estuaries Part 1 Sediment Quality adopted by the State Water Board that went into effect on August 25, 2009 is identified either by the full title or by short title "**Part 1***". The document supporting Part 1 entitled Staff Report for the Water Quality Control Plan for Enclosed Bays and Estuaries Part 1 Sediment Quality is referred to either by full title or by short title, "Part 1 Staff Report". Future project documents discussed in later sections include:

- Proposed amendments to the Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality referred to in this informational document as "Proposed Amendments to Part 1"; and

- Draft Staff Report supporting proposed Amendments to the Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality referred to in this informational document as “Phase II Staff Report”. (See Section 3 that describes Phase I and Phase II efforts and products.)

These future project documents will be circulated as draft and final draft documents until the State Water Board approves the documents as part of the State Water Board’s formal planning process.

2.0 Project Description

2.1 Proposed Project

The State Water Board is proposing the following project:

Amend portions of the Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality (Part 1) to incorporate amendments under development in this Phase II effort. Under Phase II, staff anticipates amending the following section of Part 1:

- Those parts of Sections V and VII that address the methodology to interpret and implement the SQO intended to protect **benthic*** communities from direct exposure to toxic pollutants in sediments within some estuarine habitats.

- Those parts of Sections VI and VII that address the methodology to interpret and implement the SQO intended to protect people exposed to contaminants in fish and shellfish (**seafood***) tissue derived from bay or estuarine sediments.

The proposed project will only apply to **surficial sediments*** within **enclosed bays*** and **estuaries***

2.2 Objectives of Proposed Project

The objectives of the proposed project are:

- Protect and restore those **beneficial uses*** at risk from pollutants in sediments within California’s enclosed bays and estuaries through the development of SQOs, interpretive tools, and an implementation policy.

- Comply with California Water Code section 13393 that requires the State Water Board to adopt SQOs for toxic pollutants that have been identified in toxic hot spots as part of the Bay Protection and Toxic Cleanup Program (BPTCP) and for other toxic pollutants of concern, including contaminants that may pose risk to human consumers of fish and shellfish.

- Provide regulators, stakeholders, and interested parties with a transparent, scientifically sound, and effective process to better assess direct and **indirect effects*** caused by pollutants in sediments within California’s enclosed bays and estuaries.

- Provide regulators, stakeholders, and interested parties with a transparent and effective process that will promote the protection of sediment quality-related beneficial uses and more effective management of polluted sediments.

- Avoid imposing monitoring and regulatory requirements that are more stringent than necessary to demonstrate that sediment-associated beneficial uses are protected.

2.3 Proposed Project Purpose

The purpose of the proposed project is to provide the State Water Resources Control Board and the Regional Water Quality Control Boards (Water Boards) with sound and reliable tools, and a consistent and transparent process for applying those tools to assess sediment quality in relation to the risk posed to benthic communities and human health by the **pollutants*** in sediments within enclosed bays and estuaries.

If adopted by the State Water Board, Phase II amendments described above in Section 2.1 would be incorporated into Part 1 and enforced by the State Water Board and those Regional Water Boards that encompass enclosed bays and estuaries. The affected regions consist of the North Coast, San Francisco Bay, Central Coast, Los Angeles, Central Valley, Santa Ana and San Diego Regional Water Boards. Staff anticipates that all discharges of toxic pollutants into enclosed bays and estuaries would be regulated under the proposed amendments to Part 1.

2.4 Process and Participants

A CEQA scoping meeting initiates the State Water Board's public planning process. Upon completion of the scoping meeting, staff and its technical team will review all comments received during the public comment period and begin collecting data and information for the CEQA analysis.

Currently, the technical team and State Water Board staff has many issues to address in order to prepare an indirect effects assessment and implementation framework. Upon completion of Phase II development phase, staff will prepare and circulate a draft Phase II staff report and proposed amendments to Part 1. The Phase II staff report will include a description of alternatives, a CEQA analysis and evaluation of factors required by the California Water Code (as described in Section 7.0) and proposed amendments. All technical developments will be submitted for independent peer review as required by Section 57004 of the California Health and Safety Code.

During Phase II, the State Water Board and technical team will receive input from three committees: Scientific Steering Committee (SSC), SQO Advisory Committee, and Agency Coordination Committee. The purpose of the SSC is to assess the scientific soundness and adequacy of the technical approach and ensure that the findings and conclusions are well supported. The SSC includes scientists from around the nation that have a high level of expertise and experience in analytical chemistry, biological assessment, **bioavailability***, and risk assessment. Staff from the State Water Board, Office of Environmental Health Hazard Assessment (OEHHA), members of the technical team and the SSC participating in Phase II is identified in Appendix A.

The SQO Advisory Committee is composed of members of the regulated community, environmental advocacy organizations, and regulators. This committee meets quarterly and advises State Water Board staff on issues relating to implementation of the SQOs. Members of the Agency Coordination Committee include U.S. EPA Region 9 staff, State and Regional Water Board staff, as well as staff from other agencies.

3.0 Background

A 2001 Superior Court decision (*San Francisco BayKeeper, Inc. v. State Water Resources Control Board*, October 2001) ordered the State Water Board to adopt SQOs pursuant to California Water Code section 13393. Section 13393 requires the State Water Board to adopt SQOs for toxic pollutants that have been identified in toxic hot spots as part of the Bay Protection and Toxic Cleanup Program (BPTCP) and for other toxic pollutants of concern. SQOs were never developed, as efforts were focused on the identification of hotspots until the program expired. In response to the court's decision, the State Water Board immediately initiated a phased process to develop SQOs, supporting tools, and an implementation policy.

3.1 Phase I Development Effort

Under Phase I of the SQO Program, the State Water Board made significant progress to protect sediment dwelling organisms from direct effects caused by exposure to pollutants in sediment within the major enclosed bays and harbors. A detailed description of Phase I can be found in the Part 1 Staff Report.

During this first phase of SQO development, the State Water Board and technical team developed a framework that relies on multiple lines of evidence (MLOE). The MLOE consist of sediment bioassays, benthic community health, and sediment chemistry that are applied to interpret [SNO1]the narrative SQO in Part 1 Section IV A. that states:

> *Pollutants in sediments shall not be present in quantities that, alone or in combination, are toxic to benthic communities in bays and estuaries of California. This narrative objective shall be implemented using the integration of multiple lines of evidence (MLOE) as described in Section V of Part 1.*

Implementation of this narrative objective includes requirements for monitoring and an iterative process to determine the cause of the biological effects and the responsible sources so that management actions are effective. However, for some habitats, there was too little data available for developing and/or refining existing indicators for all three lines of evidence. As a result, the indicators adopted for interpreting this narrative within estuarine water bodies are less robust and rely upon best professional judgment (BPJ) to a greater extent then those applicable to enclosed bays.

During Phase I, a narrative SQO was also proposed to protect humans from exposure to contaminants in fish tissue derived from bay or estuarine sediments. This narrative, subsequently adopted into Part 1 Section IV.B states

> *Pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health. This narrative objective shall be implemented as described in Section VI of Part 1.*

As with the interpretation of the narrative objective protecting benthic communities in estuarine waters, limited data hindered the development of a prescriptive methodology for interpreting the narrative objective protecting human health. As a result, Part 1 Section VI relies upon existing guidance and practices from U.S. EPA and Cal/EPA and best professional judgment to assess sediment quality relative to this narrative SQO. Phase I was completed when the State Water Board approved Resolution 2008-0070 adopting Part 1. Part 1 became effective upon approval by U.S. EPA on August 25, 2009.

3.2 Phase II Development Effort

Under Phase II, staff and the technical team are developing indicators to assess the risk to sediment dwelling organisms from direct effects within estuarine habitats and a framework and appropriate tools to assess the risk to humans exposed through the consumption of fish and shellfish containing contaminants that originated in bay and estuarine sediments. Pursuant to a Superior Court order dated March 19, 2007, the State Water Board must adopt and submit to the Office of Administrative Law all Phase II SQOs and related implementation policies by December 30, 2010. Staff anticipates that the Phase II SQOs will include a proposed final objective for direct effects for all estuaries in the State, and a proposed final objective for indirect effects for all bays and estuaries.

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4.0 Conceptual Model

4.1 Fate and Transport Processes

Contaminants in sediments are influenced by many physical chemical and biological processes that ultimately determine the distribution and bioavailability of these contaminants within enclosed bays and estuaries. There are many possible sources of contaminants that can contribute to **sediment contamination**” in embayments (Figure 4.1). Runoff and discharge from rivers, creeks, and drainage channels that carry storm water and dry weather runoff from the upland watershed are major **nonpoint sources***. Other nonpoint contaminant sources include atmospheric deposition and transport from groundwater into surface water bodies. Contaminants may also be discharged in effluents from point sources, such as municipal wastewater and industrial discharges located within embayments as well as spills leaks or accidental releases. A large portion of the contaminants from most of these sources may be associated with particles, either as suspended particles in the discharge or receiving water body. However, each of these discharges influences water and sediment quality on different spatial and temporal scales. This diversity of sources, combined with various physical mixing processes such as currents, tidal exchange, and ship traffic, can produce complex and widespread patterns of sediment contamination.

Many factors affect the fate and distribution of sediment contaminants within enclosed bays and estuaries (Figure 4.1). Upon introduction into the water body, dissolved contaminants may bind to suspended particles in the water column or particle associated contaminants may desorb back into the water column. In brackish embayments in particular, flocculation and aggregation of small suspended particles into large agglomerates that then settle out of the water column is a primary mechanism for introduction of contaminants to surface sediments. Where river or tidal currents are present, some contaminants will be transported (advected) out of the system. The fraction that remains and eventually settles forms the sediment’s surface, a layer (5-20 cm) where a variety of physical, chemical, and biological processes occur. Most of the benthic **infauna*** resides in this surface layer. The layer of sediment below is less dynamic and contaminants that are contained in this layer generally exert little influence on organisms. However, contaminants in the deep sediment layer can affect habitat quality if they are transported to the surface by deep burrowing organisms, transformed into different chemical species under anaerobic conditions, or resuspended by physical processes such as sediment erosion or dredging.

Physical, chemical, and biological processes occurring in the surface layer can significantly affect the concentration, distribution, and chemical form of contaminants in both the sediment and water column (Figure 4.2). Particle bound contaminants can move into the water column by diffusion (desorption from particles), resuspension, or from the burrowing and feeding activities of many benthic organisms (bioturbation) (Figure 4.2). Sediment particle size and composition can affect the distribution and biological availability by binding to contaminants. Sediment particles vary from coarse sand with a diameter of about 1 mm to fine silts and clays with diameters less than 0.01 mm. These finer particles generally contain higher contaminant concentrations due to a much greater surface area and greater number of chemical sorption sites. Sediments contain variable amounts and types of organic carbon, including natural plant or animal detritus, microbial films, and anthropogenic materials such as ash, soot, wood chips, oils, and tars. The partitioning of many contaminants between sediment particles, water, and biota is strongly influenced by the nature of sediment organic carbon (Figure 4.2). The predominant forms for metals (or speciation) are largely governed by the reduction-oxidation (redox) potential (or Eh) and the co-occurrence of binding constituents such as sulfides, organic material, metal oxides, and clay minerals. Microbial activities also influence the characteristics of sediment contaminants. The microbial degradation of sediment organic matter can alter the pH and oxygen content of sediments, which may in turn affect the rates of metal desorption/precipitation. Bacterial metabolism or chemical processes can also transform or degrade some contaminants to other forms. In some cases, the transformation product may have greater biological availability or toxicity, such as methyl mercury. In other cases, such as for some pesticides, degradation may alter the contaminant so that it is no longer toxic.

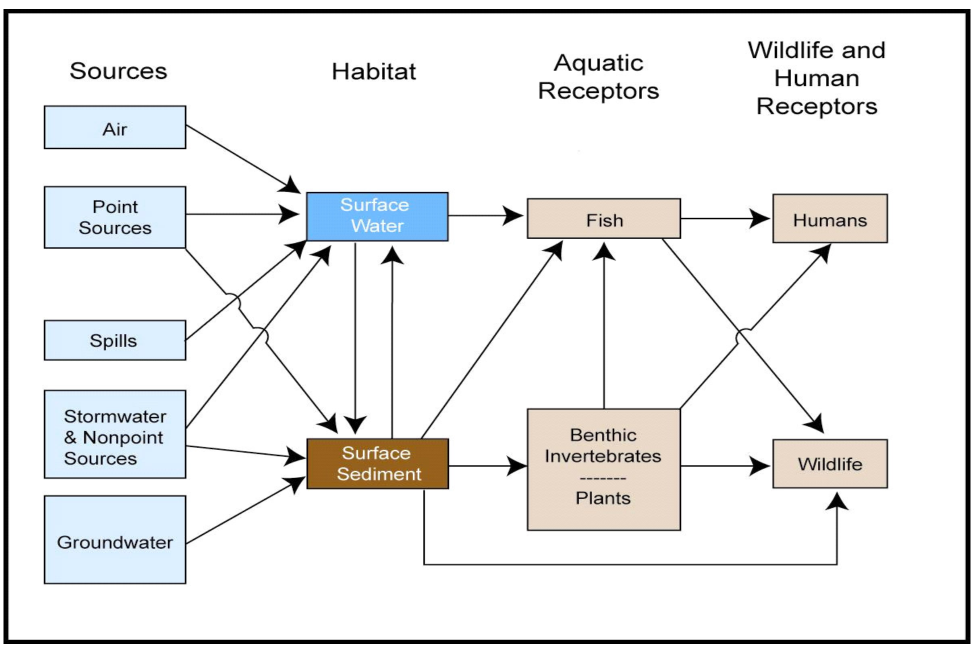

Figure 4.1. Principal Sources, Fates, and Effects of Sediment Contaminants in Enclosed Bays and Estuaries (Adapted from Bridges et al. 2005)

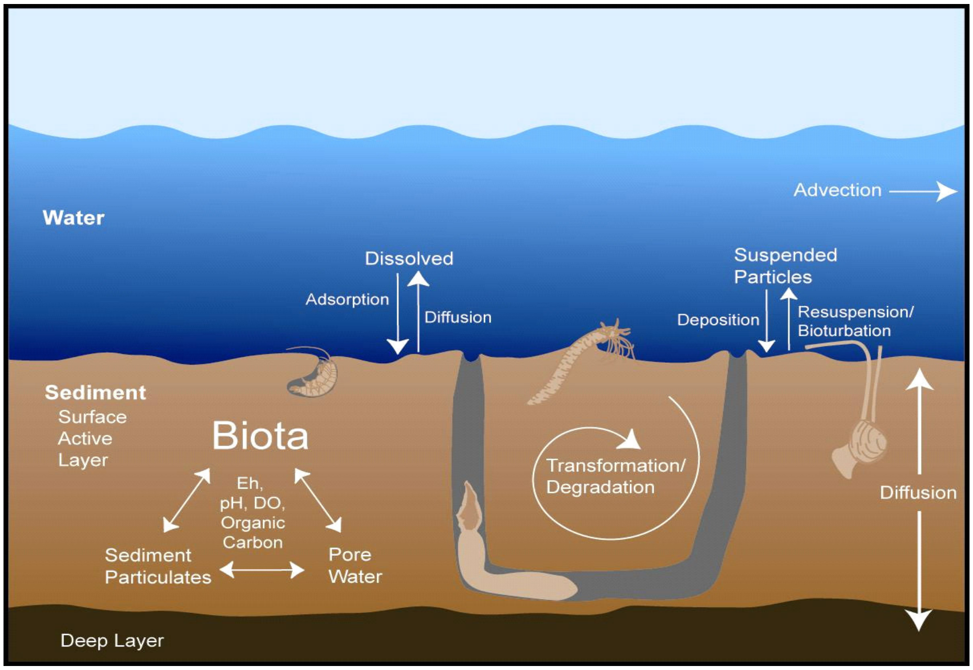

Figure 4.2. Sediment Processes Affecting the Distribution and Form of Contaminants

4.2 Receptors and Exposure Routes

California's bays and estuaries are home to a tremendous diversity of life. As such, there are multiple routes by which these organisms can be exposed to and affected by sediment contaminants. There are two general types of contaminant exposure: direct and indirect. Most of the direct exposure results from the contact of organisms with the sediment and sediment ingestion. Organisms living in the sediment are exposed through the uptake of contaminants from the pore water, which is the water associated with the sediment particles. This process is analogous to the exposure of water column organisms from dissolved contaminants. Organisms that ingest sediments may accumulate contaminants that are desorbed by digestive processes in the gut. Indirect contaminant exposure results from the consumption of contaminated prey. Examples include fish feeding on benthic invertebrates, birds feeding on benthic invertebrates or fish, and humans consuming fish (Figure 4.1).

4.2.1 Direct Effects to Benthic Invertebrates

Benthic invertebrates are generally at greatest risk for adverse effects from direct sediment contaminant exposure, because these organisms often live in continual direct contact with sediment/pore water and exhibit limited range or mobility. These invertebrates are also critical to the health of the aquatic ecosystem. Benthic invertebrates:

- Digest a significant portion of the organic detritus that settles out in bays and estuaries.
- Significantly enhance sediment mixing and oxygenate deeper sediments that stimulate bacteria-driven biogeochemical processes.
- Create habitat that enhances recruitment for other organisms.

- Provide food for most fish species that utilize bays and estuaries. Waterfowl and wetlands birds also rely on benthic invertebrates as a primary food source.

Within many habitats, a variety of taxa are present that exhibit different life histories. Species-specific differences in feeding strategies, metabolism, and contaminant uptake rates affect the amount of contaminant (or dose) accumulated by benthic organisms. Many species ingest significant quantities of sediment as a source of nutrition (Figure 4.2). The relative importance of sediment ingestion vs. sediment contact for contaminant exposure varies depending upon the life history of the species. As a result, benthic species vary in their sensitivity to sediment contamination. This in turn produces a gradation of benthic community composition change that corresponds to the magnitude of contaminant exposure. Changes in the benthic community, such as abundance and species composition, are a sensitive measure of the direct effects of sediment contamination, because these organisms live in the surface sediment layer. However, variations in sediment composition complicate this assessment because benthic organisms often have specific preferences or tolerances for variations in sediment grain size and organic content, in addition to other environmental factors such as water depth, salinity, and temperature. Consequently, the benthic community present at a **site*** may be altered by a variety of environmental factors in addition to adverse effects from contaminants. It is necessary to understand how these environmental factors affect benthic communities before the effects of contaminants can be discerned. The tools used to determine benthic community condition (benthic indices) often must be calibrated to specific habitat types (e.g., marine bays or low salinity estuaries) in order to provide an accurate assessment of biological condition.

4.2.2 Indirect Effects to Humans and Trophic Transfer

The relationships between contaminated sediments and the accumulation of pollutants in fish and shellfish tissue is influenced by many species-specific and site-specific factors, such as sediment organic content, complexity of the food web, species-specific feeding habits, home range and lipid content; factors that vary with both age and season (Figure 4.3). Certain types of trace metals and organic chemicals can accumulate in tissue from exposure to these pollutants in the water column, sediment, and prey tissue. **Bioaccumulation*** is the result of the uptake and retention of a chemical by an aquatic organism from the surrounding water, food, and sediment (Mackay and Fraser 2000). Contaminants such as PCBs, organochlorine pesticides, and methyl mercury have an affinity for tissue lipids and tend to be biomagnified in organisms. **Biomagnification*** is the process where chemicals accumulate at higher concentrations as they are transferred up a food web. Some of the biological factors affecting this process are lipid content, food web structure, diet, consumption rate and age. As a result of bioaccumulation and biomagnification, contaminants may accumulate at higher trophic levels at levels capable of causing unacceptable risks to human consumers and biota. Figure 4.3 illustrates the trophic transfer and contaminant flux from water and sediment into biota in a hypothetical food web for organochlorine pesticides and PCBs.

Primary productivity occurs in both the water column by phytoplankton and at the sediment water interface by algae and vascular plants attached to the sediment. Primary consumers such as zooplankton feed on primary producers. Benthic invertebrates, including crustaceans, mollusks, and polychaetes, have highly varied diets and may feed on detritus, sediment, algae, or other benthic fauna. Benthic invertebrates are consumed by resident and transient fish species (Figure 4.3). In this example, striped mullet and topsmelt predominantly consume sediment and attached algae, and shiner perch feed on both water column and benthic organisms. Many fish species consume mostly invertebrates, with some piscivory on smaller fish, including topsmelt and arrow goby. Human sport fishers catch and consume a variety of fish species within enclosed bays and estuaries. In this example of a southern California embayment or coastal lagoon, shiner perch, striped mullet, California corbina, spotted sand bass, and yellowfin croaker represent a major portion of the catch.

Contaminant transfer between sediment and biota can occur through a variety of routes; however, food-web trophic transfer (as represented by dietary uptake of invertebrates) is the most significant route of exposure for fish (Figure 4.3). The food web presented in Figure 4.3 encompasses the major transport pathways. Although the exact food web structure will vary among water bodies, the general food web components will be present in all circumstances. That is, all embayments will contain primary producers, primary consumers, and resident and transient fish and wildlife that consume some combination of these organisms. Higher trophic level predators (e.g., large sport fish, humans) will also consume resident fish from these water bodies. The spatial scale of the exposure generally increases with trophic level. Sedentary receptors such as benthic invertebrates and gobies exhibit high site fidelity ranging from less then one square meter (m^2) to 100 m^2 respectively. For receptors that exhibit high site fidelity and low trophic position, the relationship between organism exposure and contaminants in sediment can be evaluated directly with relatively simple tools and measures. Most resident fish are not sedentary and may forage over 0.5 square kilometers (km^2) to 50 km^2 or more within enclosed bays and estuaries. Over this larger area, quantifying exposure and contribution of contaminants from a specific portion of the forage area becomes difficult due to variations in contaminant distribution and bioavailability, preferential feeding in select habitats within foraging area, and **variability*** in diet, age, and lipid content.

The contaminant concentrations in fish tissue represent the net uptake from the entire foraging area. For upper trophic level fish with large forage range, contaminants in fish tissue collected in close proximity to a site may not represent the contaminant contribution from the site sediments. A substantial portion of the tissue contamination may come from sediments outside of the area of interest. The situation is even more complex with anadromous fish, migratory birds and marine mammals that spend a substantial portion of their lives away from the site or water body. For these types of animals, it is often difficult to determine the amount of contaminant exposure in these organisms that is due to feeding within the water body. Variations in movement and feeding behavior lead to wide variations in the strength of linkage between sediment contamination at a specific site and seafood contamination. As a result, the presence of fish at a specific site with tissue contamination that represents a human health concern is not conclusive evidence that the sediment at that site is the source of the contamination. The source of exposure may be sediments local to the site at or remote from that area, depending on the life history traits of the species.

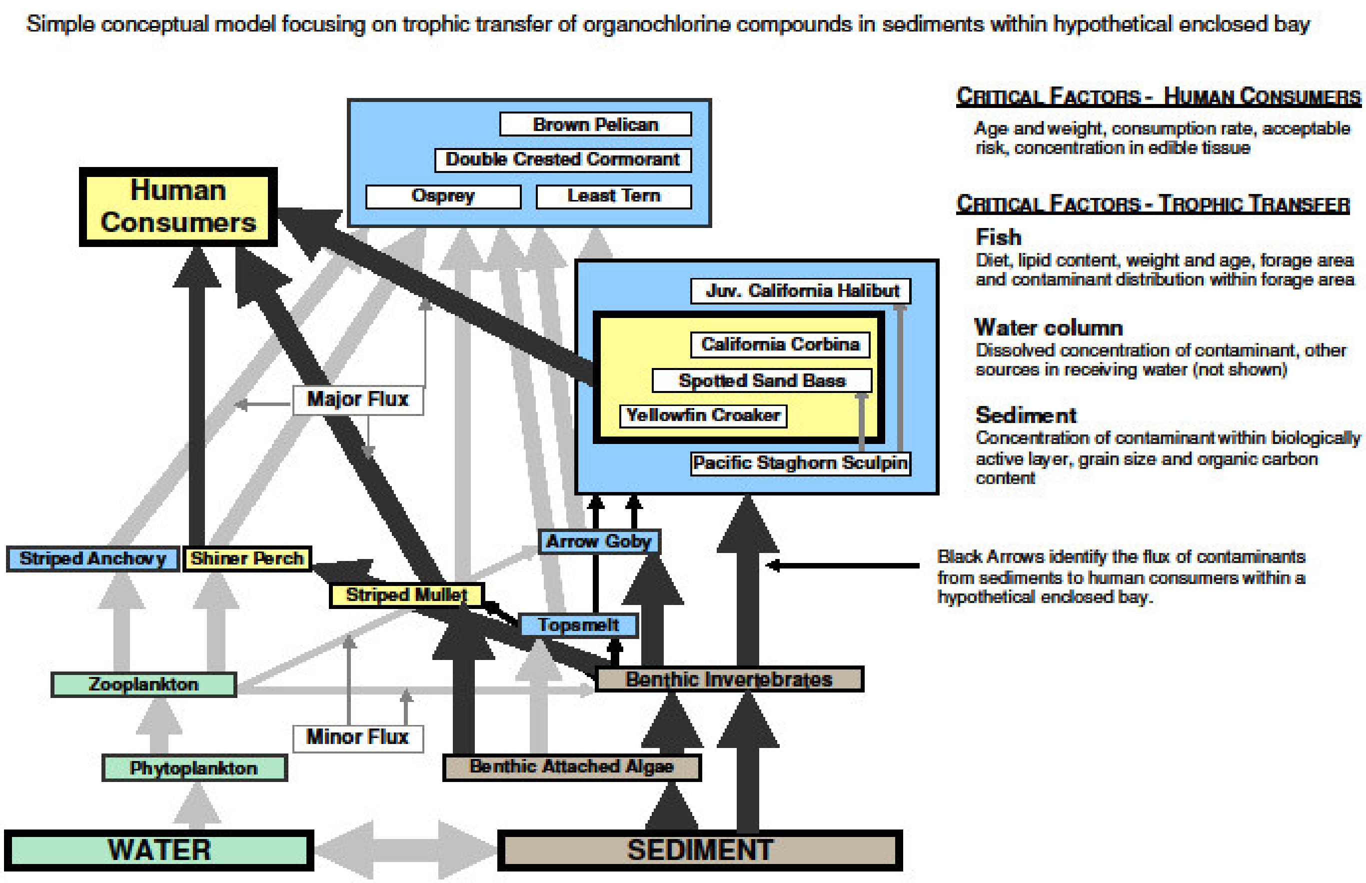

Figure 4.3 Hypothetical Conceptual Model and Food Web (modified from Cross and Allen, 1993, and Allen et al 2006).

5.0 Direct Effects Issues

This section describes the tools under development and implementation issues associated with direct effects that staff will evaluate during the development of the proposed amendments to Part 1.

5.1 Direct Effect Focus Areas

In Phase I of the SQO program, the State Water Board and technical team developed direct effects indicators for enclosed bays where large high quality data sets were available to support both development and the validation of the lines of evidence (LOE) adopted into Part 1 (State Water Board, 2008). In Phase II, technical resources associated with direct effects are focused on data collection and analysis in support of indicator development within select habitats. These habitats were selected because limited data hampered previous efforts in Phase I and the State Water Board and technical team identified partners willing to support field and laboratory efforts within these habitats. The two habitats are:

- Mesohaline portions of San Francisco Bay.
- Tidal freshwater (limnetic) portions of the Sacramento-San Joaquin Delta.

5.2 Development of Direct Effects Indicators

The mesohaline portions of San Francisco Bay include San Pablo Bay and the southern region of San Francisco Bay. Benthic index development for this habitat was incomplete in Phase I due to data limitations and **uncertainty*** regarding the composition of the benthic community assemblage characteristic of this habitat. Benthic index development activities will be continued in Phase II, with the objectives of clarifying the number and types of benthic community assemblages in San Francisco Bay and developing improved benthic indices. Recent sediment quality monitoring data for all regions of San Francisco Bay will be compiled, standardized, and interpreted in order to define the habitat-related assemblages in the **polyhaline*** and **mesohaline*** portions of the bay, which include north, central, and south San Francisco Bay. Benthic index development activities for the mesohaline assemblage will include calibration and validation of benthic index methods developed in Phase I as well as possible development of alternate methods. If analyses suggest that the benthic indices can be improved, staff may propose changes to the tools adopted within Part 1.

A lack of matched sediment chemistry, toxicity, and benthic community data limited development of direct effects assessment indicators for the lower portion of the Sacramento-San Joaquin Delta (lower Delta) in Phase I. Two surveys of delta sediment quality were conducted in 2007 and 2008 in order to provide data for indicator development. These data will be compiled and analyzed in order to determine the magnitude and extent of sediment contamination and toxicity and also the characteristics of benthic assemblages within the lower Delta. Additional analyses will be conducted to determine whether improved indicators of sediment toxicity, contamination, and benthic community disturbance can be developed for the region. If analyses suggest that current assessment tools can be improved, staff may propose changes to the tools adopted within Part 1.

5.3 Development of Amendments related to Direct Effects

The contents of Part 1 associated with direct effects are summarized below. In Phase II, staff anticipates that the direct effects indicators under development (described in Section 5.2) will require preparation of draft amendments to Section V of Part 1. However, staff does not anticipate that these proposed amendments to Part 1 incorporating new indicators and tools would necessitate significant amendments to Part 1, Section VII, Program of Implementation. With this constraint, staff realizes that Part 1 is unique. As Part 1 is applied to various sites and waterbodies, there may be some issues that arise that could be addressed by minor amendments to Section VII of Part 1. However staff resources are not available to re-evaluate significant portions of Sections V and VII. Future triennial reviews will be the appropriate mechanism for evaluating the need for additional amendments.

Contents of Part 1 associated with direct effects:

I. INTENT AND SUMMARY
- A. Intent of Part 1
- B. Summary of Part 1

II. USE AND APPLICABILITY OF SQOS
- A. Ambient Sediment Quality
- B. Relationship to other narrative objectives
- C. Applicable Waters
- D. Applicable Sediments
- E. Applicable Discharges

III. BENEFICIAL USES

IV. SEDIMENT QUALITY OBJECTIVES
- A. Aquatic Life – Benthic Community Protection

V. BENTHIC COMMUNITY PROTECTION
- A. MLOE Approach for Direct Effects SQO
- B. Limitations
- C. Water Bodies
- D. Field Procedures
- E. Laboratory Testing
- F. Sediment Toxicity
- G. Benthic Community Condition
- H. Sediment Chemistry
- I. Interpretation and Integration of MLOE
- J. MLOE Approach in other habitats

VII. PROGRAM OF IMPLEMENTATION
- A. Dredge Materials
- B. NPDES Receiving Water and Effluent Limits
- C. Exceedance of Receiving Water Limit
- D Receiving Water Limits Monitoring Frequency
- E. Regional Sediment Monitoring Considerations
- F. Stressor Identification
- G. Cleanup and Abatement
- H. Site-Specific Management Guidelines

VIII. GLOSSARY

6.0 Indirect Effects Issues

6.1 Indirect Effects Focus Areas

6.1.1 Contaminants

Many chemicals have the potential to bioaccumulate in tissue. Examples include cadmium, chlordane, DDT, dieldrin, dioxins and furans, lead, mercury, polybrominated diphenyl ethers (PBDEs), PCBs, pyrene, selenium, and tributyltin. Existing monitoring data for many of these compounds indicate mercury, chlorinated pesticides (chlordane, DDT, dieldrin), and PCBs are the most prevalent in bay and estuarine seafood (i.e. fish and shellfish) tissue and present the greatest risk to beneficial uses (State Water Board, 2006). Some chemicals such as PBDEs and other contaminants of emerging concern (CECs) may pose a significant risk to beneficial uses, however only a few targeted studies have been conducted to date (California Ocean Science Trust et al, 2009). As a result, very little is known about the fate, transport, and distribution of these CECs in the coastal waters, as well as sediments, tissue, and potential biological effects associated with long-term exposures. (A survey of CECs in coastal waters is under development by State Water Board and partners National Oceanic and Atmospheric Administration - Status and Trends and Southern California Coastal Water Research Project).

The contaminant of greatest concern in the Sacramento-San Joaquin Delta, San Francisco Bay, and other northern and central California coastal water bodies is mercury. Mercury has been a major priority for the State and Regional Water Boards for many years as evidenced by the number of total maximum daily loads (TMDLs) either adopted or under development (for San Francisco Bay, Walker Creek, Guadalupe River, and bay/delta tributaries such as Cache Creek), and the development of a statewide policy applicable to **inland*** waters, enclosed bays, and estuaries by the State Water Board (See http://www.waterboards.ca.gov/water_issues/programs/ocean/docs/mercury/mehg_scoping.pdf)

In this phase State Water Board staff is focusing on chlorinated pesticides and PCBs for the following reasons:

- Chlorinated pesticides and PCBs are widely distributed and pose risks to a variety of receptors including human consumers of seafood caught within bays and estuaries of California.
- The bioaccumulation of chlorinated pesticides and PCBs is more predictable than other compounds such as mercury and selenium, which increases the probability of developing a successful assessment framework.
- The general mechanisms of bioavailability and bioaccumulation of these compounds are likely to be similar to other compounds, including PBDEs and dioxins.

Once the framework is developed and functioning for chlorinated pesticides and PCBs, staff and technical team will adapt the framework to other contaminant groups and/or receptors in future efforts.

6.1.2 Receptors and Route of Exposure

Part 1 includes a narrative SQO that states the following:

> *Pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health.*

Part 1 currently states that this narrative SQO shall be interpreted on a case-by-case basis, using Cal/EPA policies for fish consumption and risk assessment and U.S. EPA Human Health Risk Assessment policies. These approaches have been applied successfully to site assessment/site cleanups and in the development of TMDLs in California. However, a variety of factors have limited the use of these studies and the data collected in broad scale evaluations, across water bodies and regions. As a result, a key component of the Phase II effort is to develop a framework and tools that provide consistency in the type and quality of data collected and applied to interpret the data within a site segment or water body. The narrative SQO focuses on a specific exposure-receptor relationship within specific water bodies. Specifically this narrative SQO addresses the following:

- Humans as the target receptor.

- Exposure through consumption of seafood (fish and shellfish).

- Contaminants in bay and estuarine sediment that are transferred to seafood tissue.

The technical team is focusing primarily on organochlorine compounds such as DDTs and PCBs because the fate and transport of the contaminants within the aquatic environment is better understood then other commonly encountered bioaccumulative compounds. The focus for this effort is fish and shellfish (referred to as "seafood" in this document) regularly consumed by the public. The assessment framework and tools under development will answer two questions:

1. Do pollutant concentrations in seafood pose unacceptable health risks to human consumers?

2. Is sediment contamination at a site (area of interest within a water body) a significant contributor to chemical concentrations of concern in prey tissue?

These questions provide the basis for issues discussed below and in the following sections.

6.2 Estimating Risk to Seafood Consumers

In order to address the first question above, a relationship must be established between the parameter measured and the biological effects that could harm the receptor of interest. In this case, tissue concentrations can be related to the potential risk to humans using the methods applied to develop fish tissue advisories, fish tissue-related water quality criteria, and fish consumption-related TMDL targets. Two types of human health effects are evaluated in these programs: (1) the risk of developing cancer for carcinogenic chemicals; and (2) the risk of significant adverse health effects from non-carcinogens. The Office of Environmental Health Hazard Assessment (OEHHA) uses the following equations to establish tissue advisories and goals in California waters (Klasing, 2008):

Carcinogens

Tissue Concentration Threshold = ARL x BW / CR x CSF x (ED/AT) x CRF

Non-carcinogens

Tissue Concentration Threshold = RfD x BW / CR x CRF

Where

AT	= Averaging Time
ARL	= Acceptable Risk Level
BW	= Body Weight
CR	= Consumption Rate
CRF	= Cooking Reduction Factor
CSF	= Cancer Slope Factor
ED	= Exposure Duration
RfD	= Reference Dose

These equations are similar to those used by U.S EPA and other states. However, some values used may differ significantly from agency to agency. When the State Water Board is addressing tissue-related water quality, values used in the equations above are typically obtained from OEHHA or U.S. EPA, with two exceptions, consumption rate and acceptable risk level.

6.2.1 Consumption Rate

The selection of an appropriate consumption rate can have a significant impact on the tissue concentration threshold. In the past OEHHA has based tissue advisories on consumption survey data. Recently, however, OEHHA has altered its approach. Rather than rely upon consumption survey data, OEHHA now provides guidance in terms of meals per week. This approach is based upon a generally accepted standard unit of a single eight ounce serving consumed 1, 2 or 3 times per week, which corresponds to 32, 64 and 96 grams per day (Klasing, 2008). These values were selected for the following reasons:

- Using multiples of the 8-ounce meal enables the public to better understand the advisories relative to the size and number of meals they may be consuming.
- The Food and Drug Administration recommends that adults eat two 3-ounce meals (measured after cooking) of fish per week to receive the full health benefits associated with fish. This is equivalent to a single 8-ounce meal measured prior to cooking.

The Water Boards have typically relied upon consumption survey data when developing human health/tissue consumption-based water quality objectives or TMDL targets. The Water Boards have typically relied upon values reflecting the central tendency of the population of interest. Most frequently this represents the general population or sport fishers when addressing regional or statewide water quality issues.

Though fish tissue consumption surveys are not performed regularly in California, several important studies have been conducted over the past twenty years. Table 6.1 provides central tendency data from these studies. Because the consumption rates vary between streams, rivers, estuaries and ocean waters, studies conducted within enclosed bays and estuaries provide the most representative data for use in this program. Studies focused only upon enclosed bays and estuaries include the San Francisco Bay Survey (SFEI, 2000) and a survey of 500 low-income women in the Delta (Silver et al. 2007). Surveys in California and elsewhere have identified differences in consumption rates among subgroups within the study population. For example, a survey of low-income women found significantly higher sport fish consumption rates for sport fish consumers of Asian ethnicity (geometric mean = 12.4 grams per day) than for those of white ethnicity (geometric mean = 4.8 grams per day; Silver et al. 2007).

Results from consumption surveys have been used to support the development of human health-related water quality objectives for the California Ocean Plan and the derivation of consumption-related TMDL targets (Table 6.2). The California Ocean Plan Table B Human health based objectives were calculated using an average consumption rate for sport fishers in ocean water of 23 grams per day (SWRCB, 1990 and 2000). The California Regional Water Quality Control Board – San Francisco Bay Region applied a consumption rate of 32 grams per day based on a bay wide consumption survey to develop TMDL targets (CRWQCB-SFB, 2008). This value represents the avidity adjusted 95th percentile for all consumers based on four-week recall of 1,080 individuals. Other consumption rate dependent TMDL targets adopted by Regional Water Boards have used 6.5 grams, a national average used by U.S. EPA in the development of the California Toxic Rule (Fed. Reg. V65 No 97, 2000), or 21 grams per day, a median value for sport fishers from the Santa Monica Bay Study (Table 5.1). U.S. EPA has suggested that when regional data is insufficient, a value of 17.5 grams per days be applied to water quality criteria development. This value represents a 90th percentile consumption rate of the adult population during the years 1994 –1996 (USEPA, 2000) (Table 6.3). Staff will evaluate these values for consideration in Phase II and also develop alternatives that address more sensitive populations.

6.2.2 Acceptable Risk Level

In the past, OEHHA applied an acceptable cancer risk level of 1 x 10^{-5} (one cancer in 10,000 individuals) to legacy carcinogens. The latest methodology finalized in 2008 applies an acceptable risk level of 1 x 10^{-6} (one in one million) to calculate Fish Contaminant Goals (Klansing, et al, 2008). OEHHA used a 1 x 10^{-4} (one in ten thousand) cancer risk level to develop fish Advisory Tissue Levels to account for the health benefits of eating fish that are typically not factored into tissue contamination guidelines.

U.S. EPA's Office of Water has defined a range of acceptable increases in risk of cancer from 1 x 10^{-4} to 1 x 10^{-6} (U.S. EPA 2000). EPA believes that states can apply either 1 x 10^{-5} or 1 x 10^{-6} for the general population as long highly exposed populations do not exceed 1 x 10^{-4}. This same range of acceptable risks (1 x 10^{-4} to 1 x 10^{-6}) is applied within U.S. EPA's Human Health Risk Assessment Guidance for Superfund (U.S. EPA 1991). Except for unusual circumstances, individuals should not be subject to environmental risks of greater then 1 x 10^{-4}.

In California, water quality objectives for carcinogens have been based upon an acceptable risk level of 1 x 10^{-6} (SWRCB, 2000, Fed. Reg. V65 No 97, 2000). For the development of TMDL targets, the Regional Water Boards have established acceptable risk levels in sediments and fish tissue at 1 x 10^{-5} to 1 x 10^{-6} (Table 6.2). Some states have adopted higher cancer risk factors to address naturally occurring contaminants. An example is Montana, where an acceptable risk factor of 1 x 10^{-3} was applied (Table 6.3). Staff will consider all these values in development of the proposed amendments to Part 1.

6.2.3 Hazard Quotient

The chronic non-cancer health effects of a contaminant are expressed as the hazard quotient. The hazard quotient is calculated from the amount of contaminant ingested divided by a reference dose. OEHHA and U.S. EPA develop reference dose values from literature. Typically U.S. EPA and OEHHA use a hazard quotient of 1 as the maximum acceptable value within all programs, though flexibility exists for site specific-conditions.

6.2.4 Other Human Health Risk Factors

This document only describes principle factors that affect the assessment and outcome of human health risk assessment. Additional factors will be evaluated within the Phase II Staff report. Such factors could include the means by which certain contaminants are analyzed such as PCBs congeners or the value of assessing risk of dioxin like PCBs using toxic equivalence (TEQ). Additional factors that will be addressed include the relationship to OEHHA fish tissue advisories, the assumptions used in the derivation of the advisories and the protection of seafood related beneficial uses.

Table 6.1 Relevant Consumption Survey Summaries

Study	Habitat	Population	Mean (g/d)	Median (g/d)	90th Percentile (g/d).	95th Percentile (g/d)
Santa Monica Bay Seafood Consumption 1991-1992[1]	Marine (Ocean)	Anglers in Santa Monica Bay	49.6	21.4	107.1	
San Francisco Bay Seafood Consumption Study[2]	Estuarine and Marine San Francisco Bay	4-week recall of consumers[6]	6.3		16.0	32
		12-month recall of consumers[6]	11	2.5	22.1	44.2
		4-week recall of recent consumers[6]	23	16	48	80
Estimated Per Capita Fish Consumption in the United States[3]	Estuarine and Marine	U.S. Population Finfish uncooked	11.4		43	75.6
		U.S. Population Shellfish uncooked	4.3		23.2	
		U.S. Population Fin and Shellfish uncooked	15.7		57.4	95.8
Extent of Fishing and Fish Consumption in Ventura and Los Angeles County[4] in 2005	River mouths and Estuaries	Anglers fishing in Ventura and Los Angeles Counties	34.9	16.2	70.6	
Fish consumption and advisory awareness among low-income women in the Delta[5]	Sacramento-San Joaquin Delta)	Low-income women who consumed sport fish, based on 30 day recall		10.5[7]		

1. Allen et al 1994
2. SFEI 2000
3. U.S. EPA 2002
4. SCCWRP 2008
5. Silver et al. 2007
6. Values adjusted for avidity bias
7. Geometric mean

Table 6.2 Summary of human health factors applied within California for water quality protection

Purpose and Source	Source of CSF	CR(g/d)	Basis for CR	ARL	Basis for ARL
California Toxics Rule* (CTR)	EPA IRIS	6.5	Average per capita rate for freshwater and estuarine fish and shellfish for U.S. population (Fed Reg Vol 65 No. 97 pages 31682 31719)	10^{-6}	Consistent w/ NTR and State derived Criteria. Protective at consumption rates 10 and 100 times higher. (Fed Reg Vol 65 No. 97 pages 31682 31719)
California Ocean Plan (SWRCB)	OEHHA/EPA IRIS (SWRCB, 2000)	23	DHS Recommendation (DHS 1989) and comparison to Santa Monica Bay Seafood Consumption Survey (Allen et al. 1996) (SWRCB, 1990)	10^{-6}	Selected based upon the need to be protective and the ability to meet the criteria (SWRCB, 1990)
TMDL for PCBs in San Francisco Bay	OEHHA	32	CR is the 95th percentile upper bound estimate of fish intake reported by fish-consuming anglers. (SFEI 2000) (CRWQCB – SFBR, 2008)	10^{-5}	More protective than 10-5risk level for general population mean as upper bound consumption rate is used for subpopulation. Target is protective of those consuming ten times more fish, 320 g/day, at a 10-4 risk. (CRWQCB - SFBR, 2008)
TMDL for OCL Compounds San Diego Creek and Newport Bay	OEHHA	21	From OEHHA (Brodberg et al 1999)	10^{-5}	Based upon OEHHA tissue screening values (Brodberg et al 1999)
TMDL for Toxic Pollutants in Marina Del Ray Harbor	EPA IRIS	6.5	CTR	10^{-6}	Final targets based upon CTR
Contaminant Tissue Goals for Common Sport fish	OEHHA	32	Based upon one 8 oz servings per week (8 oz equates to 32g/d)	10^{-6}	Intended to represent the standard goal for all fish tissue
Contaminant Advisories for Common Sport Fish	OEHHA	32/64/96	Based upon 1, 2, 3 x 8 oz servings per week (8 oz equates to 32g/d)	10^{-4}	Used to calculate Advisory Thresholds and attempts to balance the health benefits of omega 3 with risk associated with contaminant residues.
Tissue Screening Values OEHHA (Brodberg et al, 1999) (superceded, see above)	OEHHA	21	Consumption Survey (Allen et al. 1996)	10^{-5}	10^{-5} was selected for legacy pollutants to balance protection with other information including product bans, existing distribution and other factors.

ARL = Acceptable Risk Level
CSF = Cancer Slope Factor
CTR = California Toxics Rule
CR = Consumption Rate
g/d = Grams per day
IRIS = Integrated Risk Information System
ST =Sediment Target
TMDL =Total Maximum Daily Load

Table 6.3 Summary of human health factors applied by EPA and other states to protect water quality or in risk assessments

PURPOSE/SOURCE	SOURCE OF CSF	CR	BASIS FOR CR	ARL	BASIS FOR ARL
EPA Methodology for Deriving Ambient Water Quality Criteria (EPA, 2000a)	EPA IRIS	General population - 17.5 g/d Subsistence fishers 142.4 g/d	Default Value is the 95th percentile upper bound estimate of consumption in general population by FDA from 1994-1996. (USEPA 2000a). States should use state or regional data if available.	10^{-4} to 10^{-6}	States may use 10^{-4} to 10^{-6}. Sensitive populations should not exceed an increased cancer risk of 10^{-4} (USEPA, 2000a).
National Toxics Rule* (EPA 1992)	EPA IRIS	6.5 g/d	See CTR	10^{-5} or 10^{-6}	Specific to state and waterbody
EPA Risk Assessment Guidance for Superfund (EPA, 2001)	EPA IRIS	95th percentile Nat Data or 90th percentile local or Reg. Data	Risk Assessment applied to site or regional Areas, suggest consumption rate be based upon local population.	10^{-4} to 10^{-6}	States may use 10^{-4} to 10^{-6} or lower value. 10^{-6} used as point of departure.
Oregon DEQ Sediment Bioaccumulation Assessment Guidance (Oregon DEQ, 2007)	EPA IRIS	General population - 17.5 g/d Subsistence fishers 142.4 g/d	CRs used to calculate screening values for sport fishers and subsistence fishers	10^{-6}	Default Value
Michigan WQC (Michigan DEQ 2006)	EPA IRIS	3.6 g/d - TL3 11.4 g/d - TL 4	CRs used to calculate HH criteria differ by trophic level	10^{-5}	None provided in Rule
Montana WQC	EPA IRIS	6.5 g/d	See CTR. Proposed 0.0175 Kg/d and awaiting EPA approval	$10^{-5}/10^{-3}$ for Arsenic	High level applied because arsenic occurs naturally.

CR = Consumption Rate
g/d = Grams per day
IRIS = Integrated Risk Information System
Reg = Regional
ST =Sediment Target
SV = Screening Value

TA =Tissue Advisory
T&ST =Tissue and Sediment Targets
TMDL =Total Maximum Daily Load
TT =Tissue Target
WQC = Water Quality Criteria

6.3 Development of Indirect Assessment Tools

In order to answer the second assessment question (is sediment contamination at a site a significant contributor to chemical concentrations in prey tissue?) a link needs to be established between the sediment and prey tissue. A variety of empirical tools and models can be applied independently or in combination to establish and quantify the relationship. However the utility of these tools is highly dependent upon the contaminant properties, and the quantity and quality of the field data. This section describes technical tools and frameworks that will be considered in the development of proposed amendments to Part 1.

6.3.1 Indicators and Tools

Sediment Chemistry
Sediment chemistry is a measure of the potential contaminant uptake through the food web. Uptake in this case represents the transfer of contaminants from site sediment to benthic invertebrates to seafood foraging on benthic invertebrates at the site. This indicator provides a linkage between site contamination and the accumulation in seafood and provides a basis for estimating site contribution. However, many additional factors, such as bioavailability of sediment-associated contaminants, structure of the food web, home range of fish and the size of the site, affect the flux of contaminants from the site to higher trophic levels.

Interpretation of the sediment chemistry data for assessing the influence of the site on seafood contaminant levels requires the development of a model that describes the bioaccumulation rate. A variety of models can be used, ranging from a relatively simple **bioaccumulation factor*** based on analyses of tissue samples, to a complex mechanistic model with equations representing key uptake and elimination processes of the organism. The relationship between sediment contamination and seafood bioaccumulation is very complex and models must make a variety of simplifications and assumptions in order to estimate the bioaccumulation of contaminants into seafood. As a result, the model may underestimate or overestimate the contribution of site sediments to seafood contamination, which creates uncertainty in the use of this information for determining whether the SQO is being met.

Tissue Chemistry
The relationship between seafood tissue contamination and risk to consumers was described previously in Section 6.1. From this relationship, tissue chemistry could be applied independently to determine if the SQO is being met. For example, if tissue concentrations are low and pose little or no risk, the fishing-related beneficial use is protected and the Human Health (HH) SQO is met. However, for this to be an appropriate conclusion, the seafood collected must be:

- Representative of the area of interest;
- Routinely consumed; and
- Foraging predominately on benthic invertebrates.

Understanding how these variables affect the accumulation of contaminants in seafood tissue is critical to the development of an indirect effects assessment framework and implementation policy. The accumulation of contaminants in tissue results from the organism's cumulative uptake of contaminants from all areas and exposure routes, and losses through excretion, egestion, and metabolism over the lifetime of the fish. As a result, a species' life history (e.g. foraging area, feeding strategy, habitat) and physiology (e.g., tissue lipid content) are the predominant drivers that determine how much contamination is accumulated from sediments within a specific area. Because this effort focuses on exposure from contaminants in sediment, only tissue from resident seafood with a benthic-based diet (either directly or indirectly through prey fish) would be representative of this exposure route.

Bioaccumulation Tests
Bioaccumulation tests are experiments that measure the bioaccumulation of a contaminant in an organism following exposure to a sediment sample in the laboratory. These tests are widely used for measuring the bioavailability and bioaccumulation potential of sediment associated contaminants for ecological risk evaluations. These tests are usually conducted for periods of 1-2 months and use selected benthic invertebrate species such as worms and clams that burrow into and feed upon the sediment.

Laboratory bioaccumulation tests provide a direct measurement of the transfer of sediment contaminants to the lower levels of the food web. This information is used to estimate the bioavailability of sediment contaminants and is useful for describing part of the transfer of contaminants from sediment through the food web. Bioaccumulation tests have limited utility in describing the linkage between sediment and seafood contamination because they do not represent higher levels of the food web and rarely include key seafood species consumed by humans. These tests are conducted under continuous exposure to the sediment and thus do not account for variations in the forage area of seafood.

Bioaccumulation Models
Sediment bioaccumulation models are used to predict the concentration of a contaminant in an organism as a function of the sediment concentration. Many varieties and levels of model complexity exist, but they can be grouped into two main categories: empirical and mechanistic. Empirical models generally express bioaccumulation as a factor that is calculated using sediment and tissue chemistry data from field surveys. Mechanistic models consist of mathematical functions that represent the key processes influencing contaminant uptake and loss in an organism. These models may use site-specific information, such as sediment organic carbon content, temperature, fish dietary composition, and feeding rate to develop bioaccumulation estimates that vary among sites. Examples of these types of models are described below.

<u>Empirical Models</u>
One of the simplest bioaccumulation models is the **Bioaccumulation Factor*** (BAF) The BAF is the ratio of a chemical compound's concentration in tissue (Ct in mg/kg) to a compound's concentration in water (Cw in mg/L) or in sediment (Cs in mg/kg dry weight); i.e., for sediments:

BAF = Ct/Cs.

BAFs have the advantage of requiring no ancillary data other than biota and sediment contaminant concentrations and thus can be calculated for any area. Empirically measured BAFs integrate all environmental routes of exposure and take into account the bioavailability of the chemical in the system being studied. However, BAF's do not provide the enduser with information that assists in understanding why a given level of bioaccumulation was present, and thus may not be applicable to other locations or species.

The **Biota-Sediment-Accumulation Factor*** (BSAF) is the ratio of biota to sediment contamination concentration, corrected for lipid content of the biota and organic carbon content of the sediment (reviewed in Wong et al. 2001, Burkhard et al. 2004). The ratio is defined by the following equation (U. S. EPA 2000a):

BSAF = (Cl/fl)/(Cs/foc)

whereby

Cl is a compound's concentration in tissue (preferably whole body tissue),
fl is the fraction of lipid in tissue,
Cs is a compound's concentration in sediment, and
foc is the fraction of organic carbon in sediment.

The use of lipid and organic carbon normalization rests on the principle that many contaminants are predominantly associated with these matrices, and that variations in these matrices affect the partitioning of contaminants in sediments and the equilibrium concentrations in tissues (Clark et al. 1988). Organic carbon normalization has been supported by empirical evaluations of contaminant partitioning between sediment and water in multiple datasets (Di Toro and De Rosa 1998). BSAFs are typically derived on a site- and species-specific basis, using empirical data (e.g., Froese et al. 1998, Wong et al. 2001, e.g., Burkhard et al. 2004). Accurate information on organism lipid content and sediment total organic carbon (TOC) content is needed for deriving a BSAF. BSAFs are most useful for systems that are in steady state (thermodynamic equilibrium), which is defined as a condition where chemical concentrations in sediment, water, and organisms do not change as a function of time, especially during the study period (U. S. EPA 2000b and references cited therein).

The empirical models discussed above vary in input data requirements and predictive ability. Both assume that there is a consistent and predictable relationship between biota contaminant concentrations and sediment contaminant concentrations, provided that there are corrections for ancillary data (Clark et al. 1988). When thermodynamic equilibrium is reached, the BSAF typically ranges from 1 to 2. Equilibrium conditions may occur for short-lived benthic invertebrates, but fish and wildlife often exhibit BSAFs above or below these values, reflecting disequilibrium. For fish, BSAF can vary as a result of variation in food web structure, lack of equilibrium between the sediments and water column, variation in benthic-**pelagic*** coupling, and metabolic breakdown of contaminants (Burkhard et al. 2003a, Burkhard et al. 2004). Equilibrium conditions occur in some local studies (e.g., Froese et al. 1998), but BSAFs often differ from equilibrium as a result of these factors (Morrison et al. 1996, Wong et al. 2001, Burkhard et al. 2004).

Mechanistic models

Mechanistic models use equations to quantify the specific contaminant uptake and loss processes (e.g., respiration, feeding, absorption, and excretion), in order to predict concentrations in biota of a specific ecosystem (Mackay and Fraser 2000). A number of mechanistic models have been developed to represent food web trophic transfer of trace organic compounds (e.g., Connolly 1991, e.g., Thomann et al. 1992).

The Gobas model is a steady state model developed to assess transfer of non-polar organic contaminants through food webs (Gobas 1993). This model simulates organic contaminant transfer from sediments and water through a multi-species food web by combining contaminant kinetics in biota (e.g., uptake and elimination) and food web dynamics (Gobas 1993, U. S. EPA 2000a). The model is appropriate for evaluation of non-polar organic contaminants, such as PCBs, legacy pesticides, dioxins, and PBDEs. It is not appropriate for evaluation of metals or organometals, such as mercury, tin or selenium.

The Gobas model has been used in a wide range of research and regulatory applications, by multiple agencies and scientists. It can provide an estimate of the uptake of a particular chemical into an organism from the water column versus directly from the sediment and porewater. However, additional models and data would be required to contrast the amount of contaminant exposure due to resuspended sediments within the water column vs. other sources. More complex kinetic models would also be required to incorporate time or age-dependant changes in biota concentrations or bioaccumulation processes (e.g., Borgmann and Whittle 1992)

6.3.2 Assessment Frameworks

There exists a variety of approaches that have been applied to assess the contribution of contaminants from site sediments to health effects from consuming seafood. These range from relatively straight forward sediment chemical thresholds derived from large sediment and tissue databases to relatively complex and resource intensive site specific assessments conducted under CERCLA/Superfund.

Chemical Specific Thresholds

Chemical specific thresholds are sediment concentrations that define an acceptable human health risk from consuming seafood. These thresholds are usually created by back calculating a sediment threshold from health risk equations and assumptions regarding the bioaccumulation of the contaminant at the site (e.g., BAF). Application of simple thresholds results in a straight forward binary conclusion. Sediment concentrations can be directly compared to threshold values to determine if the sediment meets the narrative SQO.

Statewide chemical specific sediment thresholds have been developed by the Oregon Department of Environmental Quality (ODEQ) for the regulated community to use in the evaluation of bioaccumulative compounds in sediments (ODEQ, 2007). These *non regulatory* guidance thresholds were developed from existing tissue and sediment chemistry databases and are used to screen site sediments for bioaccumulation potential. If site sediments exceed the thresholds, the guidance describes additional methods and data that could be collected to better assess site-specific bioaccumulation potential. In highly urbanized waterbodies, where contamination may be present from many sources, ODEQ suggest that responsible parties consult with ODEQ staff to evaluate a site's bioaccumulation potential. Washington also initiated the development of human health-based, chemical-specific sediment criteria or standards in the 1990's, following a tiered approach similar to that used by Oregon as guidance. Washington has not yet adopted human health-based sediment criteria.

The SQO Scientific Steering Committee voiced concerns against relying solely on a chemical threshold approach because the assumptions used in the development of statewide thresholds must be very conservative to be protective for the diverse types of conditions within California. As a result, such thresholds would likely be highly overprotective for many water bodies and limit the utility and accuracy of the assessment for subsequent management actions.

Site Specific Risk Assessment

This approach is used by U.S. EPA, U.S. Army Corps of Engineers and many state agencies to evaluate sites where elevated levels of contaminants are present in site sediments. The risk assessment process is a framework composed of the following basic elements (U.S. EPA, 2000):

- Hazard identification;
- Dose-response assessment;
- Exposure assessment; and
- Risk characterization.

Although U.S. EPA and other federal and state agencies provide guidance on how to conduct risk assessments, the process is intended to be flexible to enable the investigators to respond to any situation encountered and to scale the resources applied to data collection relative to the size and complexity of the site. As a result, this framework performs equally well when applied to small simple sites as it does to large complex National Priorities List (NPL) Sites. However, this process also requires a high degree of best professional judgment both in planning and analysis, which affects consistency in application, utility, and ease of use. In addition, projects involving risk assessments require a high level of communication and negotiation amongst the regulators, responsible parties, and the affected population throughout the process.

Tiered Decision Framework

A tiered decision framework is being developed by the SQO technical team in consultation with the Scientific Steering Committee. This tiered decision framework is intended to include the benefits associated with the chemical threshold and site specific assessment approaches described previously while minimizing the problems associated with each. Both sediment and seafood tissue chemistry data from the site is used in conducting an assessment under the tiered approach (Figure 5.1). The tissue chemistry data is interpreted using health risk calculations based on standardized exposure parameters to determine the level of human health risk associated with consumption. The sediment chemistry data is interpreted using bioaccumulation models to estimate the human health directly associated with the site sediments. The decision framework consists of three tiers (Figure 5.2). Each tier represents an increasing level of complexity in order to enable the assessment to match variations is data availability, site complexity, and study objectives. Tier I consists of a preliminary evaluation of either tissue data or sediment data to determine whether there appears to be a potential hazard to human health. In Tier I evaluations, sediment or tissue chemical concentration data are interpreted using standardized conservative assumptions to evaluate the potential hazard to human consumers of seafood. If Tier I indicates a potential hazard exists, then the analysis would proceed to Tier II. Tier II consists of an evaluation of both tissue data and sediment data to determine potential hazard to human health, using available site-specific information. As in Tier I, chemical concentration data are used for the evaluation. However, in Tier II, some default assumptions and parameters are replaced with more realistic parameters and assumptions that are relevant to the site characteristics. For example, variations in seafood trophic level, forage area, and sediment characteristics are incorporated into the assessment. The resulting estimates of consumption risk (from tissue data) and site sediment contribution (from sediment data) are compared to classify the site condition. If Tier II results indicate an acceptable condition, the sediment would meet the human health SQO. If Tier II results indicate an unacceptable condition (e.g., hazard), there are two alternative outcomes: (1) determine that the SQO is not met; or (2) proceed with Tier III analysis.

The Tier III assessment is intended to be used when it is determined that the Tier II assessment is unreliable due to site specific conditions such as other sources of contamination, temporal variability, inadequate data, or the desire to investigate various management alternatives. The specifics of the Tier III assessment method are determined on a site-specific basis and might require the collection of additional data and use of alternative data analysis methods. Some examples of information that could be applied within Tier III include; (1) incorporating information on preferential foraging areas based upon gut content and the distribution of benthic invertebrate prey in the assessment, or (2) incorporating information from beyond the area of interest to better understand contaminant contribution through out the water body. Application of a tiered decision framework requires consistency in study design and data analysis methods in order to achieve comparability in the assessment results among water bodies and user agencies. This consistency would be achieved partly through the development of a decision support tool (DST) to guide data analysis. This DST is expected to include an integrated set of data analysis tools that would apply the bioaccumulation models, health risk calculations, and assessment criteria in a consistent manner without requiring a high level of user technical expertise. Technical guidance on study design would also be developed to help achieve consistency in the assessment.

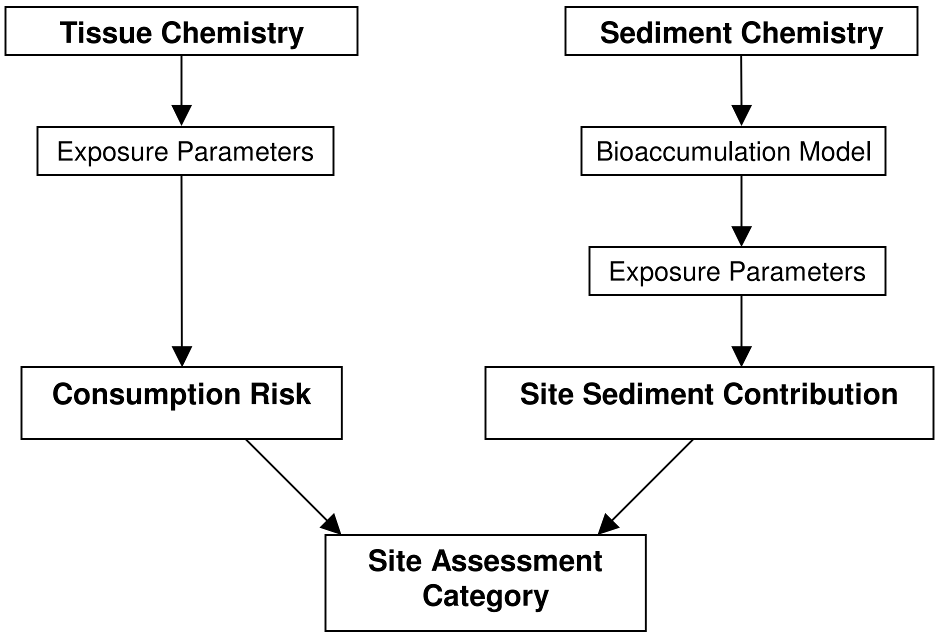

Figure 6.1. Schematic of proposed approach for data interpretation

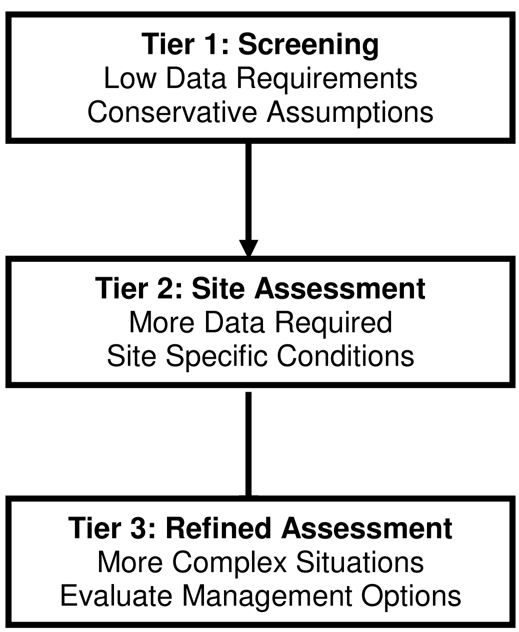

Figure 6.2. Proposed tiered decision framework.

Results Interpretation

Regardless of the assessment framework used to evaluate the SQO, the results will need to be interpreted using either a binary pass/fail system or an ordinal category system. This system should retain sufficient scientific information needed to inform subsequent management decisions.

The direct effects assessment framework included in Part 1 used factors such as magnitude of effects and agreement among indicators to differentiate categories of impact. A study by Barnett (et al, 2008) demonstrated the utility of using multiple categories for assessing sediment quality. These categories facilitated the description of spatial patterns in the results and also aided in the calculation of the percent area of impacts within different portions of the State. Categories for indirect effects could be developed based upon risk and/or consumption rates.

6.3.3 Critical Factors Affecting Assessment Outcome

This section describes some of the critical factors related to assessment that, in addition to the human health factors discussed in Section 6.2, can significantly affect the outcome of the assessment.

Assumption Regarding Scale and Site Area
As described in Section 4.2.2, the tissue contaminant concentration reflects the cumulative exposure over the entire home range of the seafood species. The contribution of site sediment contaminants to an organism tissue burden is proportional to the site area relative to the home range assuming all other variables are equal. As a result, a smaller area will contribute less to overall tissue burden than a larger area. The issue of area is addressed differently depending upon the goals and objectives of the specific project or program. Differences between sediment concentration targets developed for human health risk-based TMDLs and human health-based cleanups are often a function of contaminant contribution from the site relative to the forage area of the key seafood species. The effect of area size is one of the key differences between cleanup targets developed for CERCLA sites and average sediment concentrations estimated to result in no significant risk to seafood consumers across the water body. There are several alternatives for accounting for variations in site area:

1. <u>All exposure occurs at site.</u>
   The site area is assumed to encompass the entire home range area of target species and reflects the total exposure to the fish. If the site area is approximately equal in size to that of the home range, the scenario may reflect actual conditions. If the site and waterbody exhibit similar concentrations, this exposure would approximate the exposure across the target species home range.
   Advantages:
   - Need only site sediment chemistry
   - Size of site (area) does not affect results
   - Waterbody contribution not necessary

   Disadvantages:
   - Conservative for small sites, resulting in potential overestimate of contribution of site sediment to tissue contamination

   Application:
   TMDL development where site represents large reaches or segments.

2. <u>Portion of total exposure occurs at site. Offsite exposure set to zero.</u>

Site exposure is proportional to site area divided by target species home range area. All offsite exposure is assumed to be zero. As a result, smaller sites would contribute less to tissue burden than larger sites, given the same contaminant concentration.

Advantages:

- Considers the extent to which the site would actually contribute to the total seafood **body burden*** and associated risk to consumers
- No offsite sediment chemistry data needed
- Accounts for scale-dependant nature of contaminant exposure

Disadvantages

- Difficult to accurately characterize actual contribution of local site, due to uncertainties and variability in foraging area of species

Application:

U.S. EPA Superfund/CERCLA Risk Assessment

3. Only portion of total exposure occurs at site. Offsite exposure is set to reflect offsite conditions.

Advantages:

- More realistic model results; gives more useful planning information
- Provides more options for interpretation of percentage site contribution

Disadvantages

- Difficult to accurately characterize actual contribution of local site, due to uncertainties and variability in foraging area of species
- Requires more chemistry data and more complex modeling

Application:

U.S. EPA Superfund/CERCLA Risk Assessment

Target Species Selection

The species selected for tissue chemical analysis or bioaccumulation modeling will affect the outcome of the analysis. Many species-specific factors strongly influence the accumulation of contaminants in fish tissue including diet, foraging range, and lipid content (Kidd et al 1998). Whether the approach adopted by the State Water Board relies on estimated tissue concentrations from food web models or actual tissue concentrations measured in fish, the assessment approach could include features to assure that relevant parameters were included. Proposed amendments to Part 1 could:

1. Specify which species of fish should be targeted when collecting samples for tissue analysis. Because the SQO relates to seafood consumed by humans, fish or shellfish not routinely consumed by humans would not provide appropriate data to assess hazard.
2. Specify the species or biological parameters to be used for bioaccumulation modeling. Estimating the bioaccumulation of multiple species requires greater model complexity and more information about life history traits. Default model parameters for a selected number of species could be specified in the model, or it may be beneficial to develop sets of model parameters that represent a range of realistic bioaccumulation scenarios.

6.4 Development of Amendments Supporting Indirect Effects

Staff expects to develop proposed amendments addressing the program of implementation for indirect effects. This section would describe how the SQOs will be used in various programs, and how the results are interpreted, and what would constitute a violation. Staff will make every effort to model the proposed amendments after the basic principles contained in Part 1. These include:

- Utilize the SQOs to assess ambient surficial sediment quality in regional monitoring programs.
- Utilize the SQOs as receiving water limits within permits if conditions warrant the need.
- Encourage permittees, responsible parties, and stakeholders to form regional monitoring coalitions.
- Require regional monitoring coalitions to collect representative high quality data throughout the water body.
- Require regional monitoring coalitions to collect additional data within areas of concern to better characterize the hazard or risks associated with these areas or hotspots and sources.
- Provide this data and information to the State and Regional Water Boards so that regulators and resource managers can more effectively evaluate the risks, stressors, and sources associated with the affected sediments, and assess the need for corrective action and effectiveness.

The potential contents and organizational structure of the proposed amendments to Part 1 is presented below

Anticipated contents of Phase 2 amendments associated with indirect effects

I. INTENT AND SUMMARY
- A. Intent of Part 1
- B. Summary of Part 1

II. USE AND APPLICABILITY OF SQOS
- A. Ambient Sediment Quality
- B. Relationship to other narrative objectives
- C. Applicable Waters
- D. Applicable Sediments
- E. Applicable Discharges

III. BENEFICIAL USES

IV. SEDIMENT QUALITY OBJECTIVES
- B. Seafood Consumption and Human health

VI. APPROACH TO INTERPRET THE OBJECTIVE
- A. Basis for Framework
- B. Linking sediment and tissue chemistry
  - 1. Indicators and Tools
  - 2. Interpretation Framework
- D. Study Design
  - 1. Conceptual Model
  - 2. Site Definition
  - 3. Minimum Data Requirements
- F. Methods
  - 1 Sampling
  - 2 Chemical Analysis
  - 3 Bioaccumulation
- G. Hazard and Risk Calculations
  - 1. Exposure Point Equations
  - 2. Cancer Slope factors/Reference Does Values
  - 3. Population and Consumption Rates
- H. Assessment
  - 1. Tier 1
  - 2. Tier 2
  - 3. Tier 3
- I. Interpretation
  - 1. Interpreting the categorical results
  - 2. Exceedence of the narrative objective
  - 4. Spatial and Temporal Considerations
  - 5. Offsite Contribution and Sources

VII. PROGRAM OF IMPLEMENTATION
- A. Relationship to Direct Effects SQO
- B Dredge Materials
- C NPDES Permits
  - 1. Conventional Point Sources
  - 2. Stormwater
- D. Exceedance of Receiving Water Limit
- E Receiving Water Limits Monitoring Frequency
- F. Regional Sediment Monitoring Considerations
- G. Site Assessment/Corrective Action
- H. Cleanup and Abatement

VIII. GLOSSARY

7.0 CEQA Analysis and Water Code Factors

7.1 CEQA Analysis

When developing water quality objectives and water quality control plans, the State Water Board must comply with the California Environmental Quality Act (CEQA), Public Resources Code § 21000 et. seq. The objectives of CEQA are to: 1) inform the decision makers and public about the potential significant environmental effects of a proposed project, 2) identify ways that environmental damage may be mitigated, 3) prevent significant, avoidable damage to the environment by requiring changes in projects, through the use of alternatives or mitigation measures when feasible, and 4) disclose to the public why an agency approved a project if significant effects are involved. (Cal. Code Regs., tit. 14, § 15002(a).)

Staff will prepare a program level environmental analysis. The document will describe the analysis of the reasonably foreseeable environmental impacts associated with reasonably foreseeable methods of compliance with the proposed amendments to Part 1. Reasonably foreseeable environmental impacts will be considered in context to the following factors

Aesthetics

Agricultural resources

Air quality

Biological resources

Cultural resources

Geology and soils

Hazards and Hazardous materials

Hydrology and water quality

Land use and planning

Mineral resources

Noise

Population and housing

Public services

Recreation

Transportation and traffic

Utilities and service delivery systems

• Climate change

7.2 Water Code Sections 13241 and 13242

Chapter 5.6 of the Porter-Cologne Water Quality Control Act requires that the State Water Board adopt SQOs in accordance with the procedures described in the Water Code for adopting and amending water quality control plans. The procedures include notice and a public hearing prior to plan adoption. In addition, Section 13241 of the Water Code requires that the Water Boards consider specified factors when they establish water quality objectives to ensure the reasonable protection of beneficial uses. These factors include:

(a) Past, present, and probable future beneficial uses of water.

(b) Environmental characteristics of the hydrographic unit under consideration.

(c) Water quality conditions that could reasonably be achieved through control of all factors affecting water quality.

(d) Economic considerations.

(e) The need for developing housing within the region.

(f) The need to develop and use recycled water.

Water Code section 13242 requires that the Water Boards formulate a program of implementation for the water quality objective under consideration by the Board. The program of implementation for achieving water quality objectives must include, at least:

(a) A description of the nature of actions that is necessary to achieve the objectives, including recommendations for appropriate action by any entity, public or private.

(b) A time schedule for the actions to be taken.

(c) A description of surveillance to be undertaken to determine compliance with objectives.

8.0 Glossary

Beneficial Uses: As defined in the California Water Code, beneficial uses of the waters of the state that may be protected against quality degradation include, but are not limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves.

Benthic: Living on or in the bottom of the ocean, bays, and estuaries, or in the streambed.

Bioaccumulation: A process in which contaminant concentrations in an organism's tissue exceeds that in its surrounding environment as a result of chemical uptake through all routes of chemical exposure; dietary and dermal absorption and transport across the respiratory surface. Bioaccumulation results from a combination of both **bioconcentration*** and biomagnification (Mackay and Fraser 2000).

Bioaccumulation factor (BAF) – The ratio of a chemical compound's concentration in tissue to a compound's concentration in water or sediment.

Bioavailability: The fraction of a chemical pollutant or contaminant that can be absorbed by an organism through gills or other membranes, potentially causing an adverse physiological or toxicological response. Bioavailability is dependent on the chemical form of the pollutant in the media, the physical and biogeochemical processes within the media, the route and duration of exposure, and the organism's age, metabolism, size and sensitivity.

Bioconcentration: net uptake by an organism of a chemical, as a result of exposure the chemical in water (including sediment-associated porewater). Bioconcentration predominantly occurs via the respiratory surface (Mackay and Fraser 2000).

Bioconcentration Factor (BCF): The ration of the contaminant concentrations in biota to that in the water column. BCF represents water only exposure and uptake.

Biomagnification: Process by which higher chemical concentrations are attained in organisms at higher trophic levels (at higher levels in the food web). At its simplest, biomagnification indicates an increase in chemical concentration in an organism to a level higher than the organism's diet (Mackay and Fraser 2000).

Biota Sediment Accumulation Factor (BSAF): The ratio of contaminant concentrations in biota to that in sediment. For organic pollutants, the BSAF is presented on a lipid and organic carbon normalized basis (Burkhard et al. 2003).

Body Burden: Amount of contaminant that has accumulated in a human or organism

Contamination: An impairment of the quality of the waters of the State by **waste*** to a degree that creates a hazard to the public health through poisoning or through the spread of disease. "Contamination" includes any equivalent effect resulting from the disposal of waste whether or not waters of the State are affected (CWC section 13050(k)).

California Toxics Rule (CTR): Numerical water quality criteria established by U.S. EPA for priority toxic pollutants for California's inland surface waters, enclosed bays, and estuaries.

Contaminants of Emerging Concern: Pollutants that are not typically evaluated in water quality protection programs because the analytical methods were until recently largely unavailable and the biological effects could not be observed in routine short-term bioassays. CECs include polybrominated diphenyl ethers (PBDEs);perfluorinated organic acids; certain pharmaceuticals and personal care products (PPCPs), including drugs such as antidepressants, over-the-counter medications such as ibuprofen, bactericides (e.g., triclosan), veterinary medicines such as antimicrobials, antibiotics, anti-fungals, growth promoters and hormones; endocrine-disrupting chemicals (EDCs), capable of modulating normal hormonal functions and steroidal synthesis in aquatic organisms; (U.S. EPA)

Degradation of sediment quality: Sediment toxicity and changes in benthic community attributes as a result of exposure to toxic pollutants in bedded surficial sediments. Unacceptable risk to human health and wildlife as a result of bioaccumulation from pollutants in bedded surficial sediments that are transported up the aquatic food chain.

Demersal: Organisms that prefer to spend the majority of their time on or near the bottom of a water body.

Ecotoxicity. The study of toxic effects on nonhuman organisms, populations, or communities.

Enclosed Bays: Indentations along the coast which enclose an area of oceanic water within distinct headlands or harbor works. "Enclosed bays" include all bays where the narrowest distance between headlands or outermost harbor works is less than 75 percent of the greatest dimension of the enclosed portion of the bay. "Enclosed Bays" include, but are not limited to: Humboldt Bay, Bodega Harbor, Tomales Bay, Drake's Estero, San Francisco Bay, Morro Bay, Los Angeles-Long Beach Harbor, Upper and Lower Newport Bay, Mission Bay, and San Diego Bay

Estuaries: Waters, including coastal lagoons, located at the mouths of streams which serve as mixing zones for fresh and **ocean waters***. Coastal lagoons and mouths of streams which are temporarily separated from the ocean by sandbars shall be considered as estuaries. Estuarine waters shall be considered to extend from a bay or the open ocean to a point upstream where there is no significant mixing of fresh water and sea water. Estuarine waters include, but are not limited to, the Sacramento-San Joaquin Delta, as defined in [Water Code] Section 12220, Suisun Bay, Carquinez Strait downstream to the Carquinez Bridge, and appropriate areas of the Smith, Mad, Eel, Noyo, Russian, Klamath, San Diego, and Otay Rivers.

Euhaline: Waters ranging in salinity from 25–32 practical salinity units (psu).

Indirect effects: Adverse effects to humans and wildlife as a result of consuming prey items exposed to polluted sediments.

Infauna: Organisms that live within sediment or substrate.

Inland Surface Waters: All surface waters of the State that do not include the ocean, enclosed bays, or estuaries.

Load Allocation (LA): The portion of a receiving water's total maximum daily load that is allocated to one of its nonpoint sources of **pollution*** or to natural background sources.

Mesohaline: waters ranging in salinity from 5 to 18 psu.

National Toxics Rule: Numerical water quality criteria established by U.S. EPA for priority toxic pollutants for 12 states and two Territories who failed to comply with the section 303(c)(2)(B) of the Clean Water Act.

Nonpoint Sources: Sources are diffused and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. The commonly used categories for nonpoint sources are agriculture, forestry, mining, land disposal, and salt intrusion.

Ocean Waters: Territorial marine waters of the State as defined by California law to the extent these waters are outside of enclosed bays, estuaries, and coastal lagoons. Discharges to ocean waters are regulated in accordance with the State Water Board's California Ocean Plan.

Part 1: Water Quality Control Plan for Enclosed Bays and Estuaries Part 1 Sediment Quality, effective August 25, 2009.

Pelagic: Organisms living in the water column.

Pollutant: Defined in section 502(6) of the Clean Water Act as "dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water."

Pollution: defined in section 502(19) of the Clean Water Act as the "the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water." Pollution is also defined in CWC section 13050(1) as an alternation of the quality of the waters of the State by waste to a degree that unreasonably affects either the waters for beneficial uses or the facilities that serve these beneficial uses.

Polyhaline: Waters ranging in salinity from 18–25 psu.

Seafood: Aquatic animals consumed by humans; i.e., human prey. Seafood may include finfish and shellfish.

Site: an area of management concern to be evaluated for the indirect effects SQO. Based on management needs, "site" could be an entire water body, or a portion of a water body to be evaluated.

Surficial sediments: Those sediments representing recent depositional materials and containing the majority of the benthic invertebrate community

Uncertainty: Uncertainty refers to the difference between a true value, condition or property and the measured or quantified value, condition or property. (U.S. EPA IRIS - http://www.epa.gov/iris/help_gloss.htm)

Variability: Variability refers to true differences in the parameter measured within a population or strata. Variability could represent a biological response to contaminant exposure. These differences may be the result of different body weights, exposure duration and genetic differences (U.S. EPA IRIS - http://www.epa.gov/iris/help_gloss.htm)

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Appendix A
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State Water Board Internet Sources and Information

State Water Board Main Web Page
www.waterboards.ca.gov

State Water Board SQO web page
www.waterboards.ca.gov/water_issues/programs/bptcp/sediment.shtml

Email Subscriptions – Notices, Document Availability, SQO Board Meetings, Hearings and Workshops
www.waterboards.ca.gov/resources/email_subscriptions/
Select "Sediment Quality Objectives"

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Southern California Coastal Water Research Project
www.sccwrp.org

SQO development related web pages
From main page (above) select "Contaminants", then "Sediment Quality Assessment"

San Francisco Estuary Institute
www.sfei.org