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Development of a Model Publicly Owned Treatment Work (POTW) Monitoring Program

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DEVELOPMENT OF A MODEL PUBLICLY OWNED TREATMENT WORK (POTW) MONITORING PROGRAM

Review of Existing Programs

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FOREWORD

More than $10M is expended annually on ocean monitoring in southern California as part of discharger-related monitoring requirements, but most of these programs are poorly integrated, preventing cumulative assessments and comparison of effects among facilities. To address this concern, the Southern California Coastal Water Research Project Authority Commission has requested its staff to develop a model monitoring program for dischargers in the Southern California Bight. The goal of the program is to provide the scientific foundation for coordinating the sampling designs and sampling methods among programs.

Three documents will be produced as part of this program. This document, which is the first, provides a review of the current monitoring programs for the four largest facilities. It is intended to assess the degree of consistency among programs, the effectiveness of the programs at meeting management needs, and the efficiency with which individual agency goals are attained. The second document, which will build from the observations made in this document, will be a program design document. It will provide recommendations about the elements and basic sampling design that should be incorporated in a model program. The third document, which will consist of a series of documents, will be a set of methods manuals. These manuals will provide specific recommended implementation practices with regards to field sampling, laboratory analysis, and information management, and is intended to enhance comparability among programs.

The present document is intended to provide a broad overview of issues that must be addressed to enhance comparability in sampling elements held in common among facilities. This review, as well as the subsequent documents, is not intended to be facility-specific; there are many facility-specific issues that may need to be addressed when building an individual monitoring program. The model monitoring program is intended to provide the fundamental backbone of a monitoring program, upon which individual programs can build and mold, to answer the management questions that are most important to them.

EXECUTIVE SUMMARY

Municipal and industrial dischargers spend more than $10 M annually to monitor the health of the Southern California Bight (SCB). Most of these programs were designed independently and vary in many respects, including the effort expended. Moreover, these programs have changed little in the last 30 years despite an increased understanding of both the marine environment and the potential effects that discharges have on the beneficial uses in receiving waters. This document provides a review of the existing marine programs of the four largest publicly owned treatment work (POTW) dischargers in southern California, which have the largest of the monitoring programs. The review is intended to assess the degree of consistency among programs, the effectiveness of the programs at meeting management needs, and the efficiency with which individual agency goals are attained. This document is part of a larger effort to develop a model monitoring program for dischargers in the SCB.

Consistency Among Monitoring Programs

Five monitoring elements held in common among all programs (effluent, water quality, bacteriological, sediment, and fish monitoring) were assessed for consistency. The level of effort among agencies varied by a factor of at least five-fold for each element, although no agency consistently expended more effort across elements than the other agencies. For example, a seven-fold difference was found in the number of sediment metal constituent analyses, and a five-fold difference was found in the number of microbiology analyses. These differences in effort are the result of inconsistencies in sampling frequency, replication, the number of stations, and the parameters analyzed. In some cases, these differences were attributable to receiving water environment characteristics.

The parameters analyzed differed among programs, particularly in the effluent, sediment chemistry and fish tissue chemistry elements. Although many effluent parameters are measured by all four dischargers, more than 20 parameters are not (e.g., fecal coliforms, aluminum, phenols). In addition, entire sediment analyte classes are analyzed by fewer than four agencies. Volatile organic compounds in sediment, for example, are analyzed by only one agency. Similarly, differences were found in the types and amounts of parameters analyzed in fish tissues. All four agencies analyze trawl-caught fish tissues for a subset of organic contaminants, but the number of metals analyzed ranges from 0 to 17.

Considerable differences were also found in methodological procedures, particularly for chemical analyses. The greatest differences were apparent in chemical analysis reporting limits. Most effluent constituent reporting limits are within a factor of 20, but a 77-fold difference was found in reporting limits for antimony, and a 29-million-fold difference was found in reporting limits for dioxin. A 62-fold difference in reporting limits was found for sediment-associated silver, and a 300-fold difference was found in reporting limits for tissue. These differences occur even though each agency is utilizing EPA approved methodology, meeting quality assurance criteria, and are certified by the State of California

Evaluation of Monitoring Programs

Program effectiveness was evaluated by addressing two questions. First, are the right parameters being measured to evaluate the condition of the SCB? Second, are the sampling designs (i.e., the allocation of samples in time and space) efficient? In general, the existing programs were found to measure the right indicators using acceptable methodologies; however, in most cases, the sampling designs were found to be inefficient for addressing the questions of greatest interest to management.

While most of the indicators presently being collected were found to provide useful and cost-effective information, we oftentimes found that multiple parameters were collected that provided similar data or were not appropriate for the management question. One example is the use of multiple bacterial measures in offshore waters. Bacterial measures are used for two management decision-making purposes. The first purpose is to assess swimmer safety and shellfish areas along the shoreline and in popular diving areas. For this purpose, measurement of multiple indicators is appropriate, since multiple state thresholds are used to assess public safety. The second purpose is to describe plume distribution, with samples taken at depths and locations that would not be visited by swimmers. In this case, the use of multiple bacterial measurements is inappropriate because a single inexpensive indicator would provide virtually the same information about plume distribution. Other examples include sediment and fish tissue constituents (i.e., thallium or volatile organic compounds), for which there are no guidelines for assessing impact; and effluent parameters, for which there is no California Ocean Plan objective, and thus trend information regarding mass emissions would be unimportant.

There were two occasions when new monitoring tools are suggested to improve a programs' ability to answer management questions. The first suggestion was to promote the use of new technology for water quality monitoring. Current sampling designs were capable of helping managers assess where their discharge plumes had not been (i.e. did not cross an inshore transect), but were unable to determine where their plume currently is (i.e. in near real-time). Utilizing *in-situ* sampling technology would help to answer these questions. While this technology is becoming commercially available, it has not been rigorously tested for routine monitoring applications; therefore, we suggest that a test case application (i.e. a strategic process study) occur to evaluate its capabilities. The second monitoring tool we suggest is sediment toxicity. Sediment toxicity would be a useful addition for three reasons. First, sediment toxicity provides a useful interpretation of sediment quality. Sediment quality criteria and benthic biocriteria are not yet available, which requires a weight-of-evidence approach for assessing sediment condition; sediment toxicity provides an additional threshold for evaluation. Second, sediment toxicity provides a means of assurance that unmeasured chemicals are not causing a problem reducing the need to measure a larger array of contaminants in the sediment. Third, sediment toxicity is a standard method used by several national programs, providing context for interpreting local impacts. Sediment toxicity will become even more valuable when sediment toxicity identification evaluations (TIEs) become routinely available enabling mangers to understand the specific constituents that are causing toxicity. We suggest that programs should look for opportunities to phase in sediment toxicity testing, such as regional monitoring or special process studies. The most valuable opportunities will occur at sites where sediment chemistry and benthic infauna data disagree (e.g. chemistry exceeds sediment quality guidelines and benthic infauna data indicated a health community).

Although considerable differences were found in methodology and reporting levels among programs, most of these differences did not hamper program effectiveness on a local scale. There were two exceptions. The first is the level of detection used for measuring some effluent constituents. One goal of effluent monitoring is to assess concentrations relative to permit limits derived from the California Ocean Plan. In some cases, the reporting level exceeded the California Ocean Plan derived effluent limit, meaning that it was possible for an effluent to exceed the limit without being detected. Another goal of effluent monitoring is to estimate mass emissions for comparison to historic discharges and to other dischargers. For some constituents, large differences in reporting limits among facilities, coupled with a high rate of non-detection at facilities with high reporting limits, precluded the meaningful comparison of mass emissions. High reporting limits also hampered assessment of sediment chemistry data for some constituents. Large differences in reporting limits impair managers' ability to compare data among programs or to regional results. Although sediment quality criteria are unavailable, reporting limits occasionally exceed the thresholds used as sediment quality guidelines such as the Effects Range–Low (ERL) (Long *et al.* 1995).

Sampling designs were oftentimes inefficient for addressing the questions of greatest interest to management. One shortcoming is the failure to differentiate which questions are most effectively addressed through regionally coordinated monitoring rather than through site-specific local monitoring. One example is fish monitoring. Since fish are mobile and not acutely sensitive to POTW discharges, they are not good indicators for assessing facility-specific impacts. Fish are, however, good indicators of cumulative impact across facilities. Questions about fish, particularly questions about whether the fish are safe to eat, are cumulative impact questions that are more appropriately addressed through a regional monitoring program rather than through local monitoring. Similarly, most of the monitoring components directed towards addressing concerns of the public, such as "Is it safe to swim?", are better addressed on larger spatial scales.

Developing regional-scale responses to most questions will require more than the compilation of existing data. While programmatic differences in methods do not hamper facility-specific assessments, they do hamper regional assessments. For example, considerable differences were found in fish species and tissue types examined for tissue contaminant levels, with none held in common among all four dischargers. Moreover, sampling efforts from the existing programs are distributed primarily in areas around the outfalls, an area comprising less than 5% of the area in the SCB. Such efforts also require that all of the stakeholders that contribute discharges to the ocean (e.g., stormwater dischargers), and make management decisions affecting these discharges, participate to assess the extent of their impacts. One example includes shoreline monitoring, where stormwater dischargers are conspicuously absent; yet storm drains represent the areas that exceed water quality thresholds most frequently. Developing regional assessments will require an integrated and coordinated sampling effort similar to that of Bight'98.

Even within facility-specific monitoring efforts, opportunities exist for design enhancements. One opportunity is to segregate the monitoring focused on describing spatial patterns from that focused on describing temporal trends. Describing spatial patterns (i.e., mapping) effectively requires gathering data from as many sites as possible, minimizing replication and repeated visits to a single site. Conversely, trend assessments require replication and many repeated visits to the same site. At present, particularly in the sediment monitoring programs for all facilities, the two designs are merged, with many sites receiving repeated visits. A more efficient design would involve dedicating a subset of sites to trend monitoring and increasing the level of repetition at these sites, while dedicating a distinctly separate set of sites to spatial descriptions that do not involve repeated visits.

An opportunity also exists to improve efficiency through the use of power analysis. Power analysis is a statistical modeling tool for assessing the value of incremental sampling effort. Power analysis conducted on effluent monitoring data revealed that the existing sampling effort was often more than twice as frequent as necessary to address the appropriate management questions. At least two additional opportunities were identified for power analysis, particularly for sediment and fish monitoring. The first opportunity is in assessing the desired frequency and replication for trend monitoring. Most of the monitoring programs have a long data history, allowing construction of accurate statistical models. The second is in spatial modeling for creating maps. Accurate spatial patterns require samples that are close enough together to allow meaningful interpolation, but not so close together as to yield duplicative information. Power analysis can be conducted to define the optimal sampling distance among points to develop cost-effective maps. Both of these types of power analyses will be explored further in subsequent Southern California Coastal Water Research Project (SCCWRP) documents.

Finally, the efficiency of all the programs would benefit by greater flexibility in requirements. Existing monitoring programs make measurements at regular intervals and continue to make the same measurements regardless of findings. A more efficient approach would be to respond to monitoring results. Thus, when a lack of impact is demonstrated by repeated measurements, the frequency of measurement should be reduced. Conversely, when an impact or potential impact is found, the level of monitoring effort should increased to better assess the spatial extent and causes of the observed impact. Some of the agencies have increased their respective program's flexibility by incorporating special study elements to address exploratory questions, such as source-tracking, transport or cause-and-effect projects. Other agencies have incorporated flexibility into their respective programs by the exchange of routine effort for special study elements. Such programmatic flexibility has proven cost-effective and is recommended to be encouraged among agencies.

I. INTRODUCTION

Ocean monitoring programs conducted by publicly owned treatment works (POTWs) as part of National Pollutant Discharge Elimination System (NPDES) permit requirements have existed in the Southern California Bight (SCB) for nearly thirty years. In the 1970s, monitoring programs focused upon characterizing the marine environment since our understanding of the ocean environment was still growing. At that time, NPDES discharger impacts on the marine environment were not well understood; many impacts were masked by the state of science and many assessments were confounded by natural variability inherent in the ecosystem. In these early days, the design of ocean monitoring programs were often based upon an analysis of variance (ANOVA) model that compared sites near a single point source to a site, or sites, distant from that source (Tetra Tech 1982, U.S. EPA 1991). The design of ocean monitoring programs has changed very little since 1970, despite our increased understanding of the marine environment and the potential effects that NPDES permittee discharges have on the beneficial uses in receiving waters.

Ocean monitoring in the SCB is costly. Approximately $10 million is spent annually on marine monitoring programs by NPDES permittees in the SCB (NRC 1990a). There is no unified approach to implementing these programs. Since the various facilities lie in separate jurisdictional boundaries governed by different regulatory agencies, most monitoring programs have been designed independently and vary in many respects, including the effort expended. As a result, the data from these different programs are often not comparable due to differences in sampling methodology, analytical procedures, and quality assurance. Even when the data are comparable, they are stored in a series of independent, incompatible electronic storage media that make the data difficult to access, retrieve and summarize. This lack of a unified approach not only limits technical comparability among programs, but it has resulted in inequitable levels of effort and resource expenditures among the various facilities monitoring the SCB.

The needs of ocean monitoring programs have changed over the last 30 years. While the ANOVA-based monitoring design is adequate for addressing some regulatory issues, this model has proven to be insufficient for providing important information required by resource managers, including regulators and permitted dischargers, to enable better decision-making regarding the protection of beneficial uses. These types of information include a more accurate and complete characterization of reference conditions and natural variability, quantification of the spatial extent as well as magnitude of impact, establishment of rates of improvement (or degradation), determination of cumulative impacts from multiple sources that commingle, and establishment of cause/effect mechanisms for identifying sources of problems.

Regional monitoring efforts have been one response to the changing needs of ocean monitoring programs over the last 30 years (NRC 1990b, Cross and Weisberg 1996, SCBPP 1998). Large-scale assessments provide context to resource managers by describing the range of impacts and placing human impacts into the context of variability from natural oceanographic events such as El Niño. Regional monitoring provides a description of regional reference conditions, in part replacing the limited number and different reference sites used by facility-specific programs. Regional monitoring also leads to methods standardization and improved quality control through intercalibration exercises. Maximizing these benefits, though, requires integration between regional monitoring and facility-specific monitoring. Regional monitoring in the SCB is relatively new and it is unclear exactly how, when, and where the integration with local effects monitoring should be accomplished.

Goal of This Document

The goal of this document is to review the existing marine programs of the four largest POTW dischargers in southern California. The review is intended to assess the degree of consistency among programs, the effectiveness of each program in meeting the needs of management, and the efficiency with which management goals are attained. Specifically, this document addresses the following questions:

- What information is not being collected that might be needed in order to answer important management questions?

- What information is collected too frequently or, conversely, not frequently enough to make decisions?

- What measures are not providing useful information or are producing information not being used in the decision-making process?

This document is part of a larger effort to develop a model monitoring program for POTW dischargers in the SCB that integrates facility-specific and regional monitoring activities. The first step in this effort was to define the management questions that a model program should address. These management questions are the basis for the review of existing programs presented in this document; a summary of how these questions were developed is presented in Appendix A. Subsequent documents will provide sampling design recommendations for a model program, largely based upon the conclusions about existing programs developed in this document. This will be followed by a series of methods manuals intended to improve consistency among programs, including manuals for field operations, laboratory operations and information management.

Approach to Reviewing Existing Marine Monitoring Programs

The review of existing programs was achieved in three steps. The first step was to create an inventory of existing monitoring effort by the four largest POTWs in the SCB. The second step was to compare the effort among the different programs. The third step was to evaluate the design of these programs relative to their efficiency in addressing the management questions that they are intended to answer.

The monitoring inventory was compiled using several sources of information. First, each agency's monitoring and reporting requirements for its respective NPDES permits were surveyed. Next, each permit was compared to its respective Annual Report of Waste Discharge (WDR) and Receiving Water Monitoring Report(s). The most recent permits and reports were utilized for these techniques (ca. 1997-98). The inventory documented many monitoring aspects such as the constituents measured; the number of sites sampled, sampling locations, sampling frequency and replication; the methods used to collect and analyze the constituents and the sensitivity of these measurements, among other criteria. Following compilation, the inventory was sent to each agency for review.

Comparisons among programs were conducted at three levels. The first was to compare total effort among facilities. This comparison summed total effort for an entire year, regardless of how the data were collected. Thus, the comparison did not distinguish a program that samples weekly at a single location from a program that samples once per year at 52 locations. The second assessment addressed how that effort was allocated in space and time, including a comparison of the number of sites, sampling frequency, replication, etc. The third assessment compared the constituents measured, as well as the techniques used to conduct the measurements.

Program evaluation focused on three issues. The first, and most important, was an assessment of how effective the programs were in addressing the management questions that had been identified earlier as the primary goal of a model monitoring program (Table 1, Appendix A). The second part of the evaluation was an assessment of whether the sampling designs were efficient (i.e., cost-effective) in achieving these answers. Specifically, we evaluated whether the frequency, sampling locations, etc., were efficiently allocated and whether allocation differences among programs were based upon a solid scientific rationale. Lastly, we evaluated whether the proper indicators were being measured and whether they were measured with a degree of precision appropriate to address the management questions of interest. For this element as well, we paid particular attention to whether a scientific rationale was the basis for differences in approach among programs.

Organization of the Document

The management questions addressed by a model monitoring program include five types of programmatic elements:

- Effluent Monitoring
- Water Quality Monitoring
- Microbiological Monitoring
- Sediment Monitoring
- Fish Monitoring

Accordingly, this document is organized into five chapters, each addressing one of these five elements. Each chapter is organized into three sections. The first section identifies similarities and differences among the ongoing programs. The second section evaluates the effort and designs of the current programs in the context of the appropriate management questions. The third section provides recommendations for improving the efficiency and effectiveness of the current monitoring designs.

TABLE 1.1. Management questions for each of the five programmatic elements of ocean monitoring programs in the Southern California Bight.

Programmatic Element	Management Questions
Effluent Monitoring	• Is the effluent concentration of selected constituents below levels that will ensure public safety and protect aquatic life? • What is the mass of selected materials that are discharged annually? • Is the effluent concentration or mass changing over time?
Water Quality Monitoring	• Are water column physical and chemical parameters within the ranges that ensure protection of the ecosystem? • What is the fate of the discharge plume?
Microbiological Monitoring	• Does sewage effluent reach water contact zones? • Are densities of bacteria in water contact zones below levels that will ensure public safety?
Sediment Monitoring	• Is sediment in the vicinity of the discharge impaired? • If so, what is the spatial extent of sediment impairment? • Is the sediment condition changing over time?
Fish Monitoring	• Is the health of fish communities changing over time? • Is the population of selected species changing over time? • Is fish tissue contamination changing over time? • Are seafood tissue concentrations below levels that will ensure public safety?

II. EFFLUENT MONITORING

Compare and Contrast Among Agencies

The annual number of effluent constituent measurements differed substantially among the four largest POTWs. A 5-fold difference was found in the number of organic constituents analyses conducted and a 7-fold difference was found in the number of metal constituents analyses conducted (Table 2.1).

One reason for the differences in the number of measurements among the four dischargers is that effluent constituents are measured at different frequencies. For example, total coliform concentrations in effluent are analyzed 60 times per year by Hyperion Treatment Plant (HTP), compared to 700 times per year by Los Angeles County Sanitation District's Joint Water Pollution Control Plant (JWPCP) (Table 2.2). Conversely, Orange County Sanitation Districts (OCSD) does not analyze its effluent for total coliforms, while the City of San Diego's Point Loma Wastewater Treatment Plant (PLWTP) analyzes its effluent 12 times per year for total coliforms (even though this constituent is not required in its NPDES permit). A second example of differences in analysis frequency is antimony. Effluent is analyzed quarterly for antimony at HTP and JWPCP, monthly at OCSD, and weekly at PLWTP.

Effluent measurement frequencies vary so widely that only 9% of the general effluent constituents (e.g., BOD, TOC, bacteria) are analyzed with the same frequency by all four dischargers; none of the metal or organic constituent analysis frequencies are common to all dischargers (Table 2.2).

Although many parameters are measured by all four dischargers, more than 20 parameters are not (Table 2.3). Some of these constituents are considered substitutions in the

California Ocean Plan (e.g., total chromium analyses for hexavalent chromium). However, most constituents analyzed by three or fewer agencies have no substitute (e.g., organotins).

Differences among the facilities are also apparent in effluent constituent reporting limits (Table 2.4). Although most constituent reporting limits are within a factor of 20, antimony and dioxin show a 77-fold difference in reporting limits (0.3-23 µg/L) and a 29-million-fold difference in reporting limits (0.0017-50,000 ng/L), respectively.

Evaluation of Existing Effort

The management question "*Is the effluent concentration of selected constituents below levels that will ensure public safety and protect aquatic life?*" is effectively being answered by all four dischargers for most effluent constituents. The majority of effluent constituent concentrations and toxicity test results are consistently below California Ocean Plan objective-based effluent limits (Table 2.5). A few constituents have analytical reporting limits above California Ocean Plan objective-based effluent limits; therefore, the management question for these chemicals cannot be answered. However, these problems are the result of a technical inability to reach extremely low levels (e.g., dioxins) rather than a specific facility's ineffectiveness.

While dischargers are answering the management question effectively for the majority of constituents, they are not answering the question in the most cost-efficient manner. There has already been acceptance that daily data are not required to ensure compliance with water quality thresholds. However, little or no justification is evident in the current sampling designs to validate the required frequencies for most of the analytes. Most of the frequencies were set at pre-determined intervals without considering the risk of exceeding the threshold. The risk-based approach assumes that a greater number of samples should be required when there is a greater chance of a threshold being exceeded. This would occur when the data are highly variable, or when effluent concentrations are close to exceeding their prescribed limit

(Figure 2.1). Conversely, when there is less risk of exceeding a threshold, such as when data are not variable or are distant from the threshold, frequencies may be decreased.

Risk-based approaches are contingent upon statistical predictions of likelihood of exceedence. Our ability to predict the likelihood of exceedence, or in statistical terms "confidence," is evaluated using power analysis. Power analysis can determine the optimal number of analyses required for a desired amount of confidence that an exceedence has not occurred by examining the variability associated with historical data. This method is essentially the reverse of predicting a confidence interval, where estimated confidence is determined from a known number of analyses and the associated variability of the data.

Power analysis was used with historical effluent concentration data from 1989-96 for each large POTW to determine the optimal number of samples necessary to be confident that California Ocean Plan objective-based effluent limits (Table 2.6) or permit performance goals (Table 2.7) will not be exceeded. As an example, we used power analysis to determine the relationship between the number of samples per year and confidence that lead concentrations will not exceed their respective six-month median threshold (Figure 2.2). The JWPCP and HTP must analyze one sample per year to be 99% confident they will not exceed the California Ocean Plan objective-based effluent limit, whereas OCSD and PLWTP need to analyze two samples per year to achieve the same result (Figure 2.2). This difference among facilities reflects higher variability or values closer to the threshold for effluent lead concentrations for OCSD and PLWTP compared to JWPCP and HTP.

The overall evaluation of frequency using the risk-based approach concludes that all POTWs typically analyze samples more frequently than necessary to maintain an acceptable level of confidence that they are not exceeding a threshold of concern (Table 2.6). Most constituents require less than two samples per year to be 99% confident the effluent is below permit limits. The most notable exception is total DDT (although most POTWs routinely report below reporting limits for this constituent). The divergence stems from the reporting limit being so close to the respective permit limit (Table 2.5). When reporting limits are close to or above the permit limit, power analysis is not able to resolve appropriate frequency regardless of desired confidence.

Most managers rely upon two criteria when assessing desired levels of confidence. The first criterion hinges upon the importance of the management action that follows from answering the monitoring question. If the action is dramatic or costly, managers often need a high level of confidence before they proceed. For example, if large infrastructure expenditures are required based upon the monitoring results, then managers will expend additional resources to collect more samples to be sure that the construction is necessary. If the management action is small, for instance triggering additional sampling periods, then a lower level of confidence is required. The second criterion for assessing desired confidence is cost efficiency. Figure 2.2 demonstrates that effort and confidence are not linear. The inflection point of this power curve represents the most efficient frequency for monitoring. It is at this point where maximum confidence is obtained for the fewest number of samples. More samples do not buy significantly greater returns in confidence, and a disproportional amount of confidence is lost when fewer samples are collected. We used these two mechanisms to select the 99% confidence level. There was a need to be strongly confident that concentrations remained below water quality thresholds to minimize risk, while significantly more samples obtained only marginally greater confidence that thresholds were not exceeded.

The next management question for effluent monitoring pertains to mass emissions. Each agency has effectively addressed this management question within their facility by demonstrating dramatic reductions in mass emissions over the last 30 years. This management question also has a regional component, however, wherein managers want to know the cumulative and relative mass emissions for all facilities. The current programs are less effective at assessing regional mass emissions. This is primarily due to a number of constituents that are below reporting limits; hence, mass emissions cannot be accurately evaluated from the existing data. Constituents below the reporting limit can either be considered not present in the effluent and therefore assigned a value of zero, or they can be handled in a more conservative approach by considering them equal to the reporting limit.

Certainly, using estimated values will greatly increase the estimated load. Most programs, including SCCWRP's annual summaries of effluent characteristics, treat non-detectable quantities as zero.

The problems associated with assigning non-detectable quantities as zero for estimating mass emissions are compounded by the fact that most of the constituents monitored by the POTWs have dissimilar reporting limits (Tables 2.4 and 2.8). The result is that the agencies that work harder at lowering their limits of detection are penalized. Agencies with higher reporting limits result in non-detectable quantities; hence, their mass emissions are zero. Agencies with lower reporting limits find trace quantities and report some level of emissions. The effect of treating non-detectable quantities as zero or the reporting limit for mass emission estimation is exemplified by mercury (Figure 2.3) and lead (Figure 2.4). In the case of mercury, PLWTP contributes an estimated 76% of the mass emissions to the SCB by large POTWs when non-detectable quantities are treated as zero, compared to 29% when non-detectable quantities are treated as the reporting limit. Conversely, JWPCP contributes 0% when non-detectable quantities are treated as zero, and 37% when non-detectable quantities are treated as the reporting limit. For lead emissions, the contribution by PLWTP changes from 0% when non-detectable quantities are treated as zero to 65% when non-detectable quantities are treated as the reporting limit. The lead contribution by OCSD drops from 52% when non-detectable quantities are treated as zero to 0% when non-detectable quantities are treated as the reporting limit.

The third management question for effluent monitoring pertains to trends. Current programs have been effective at tracking trends in effluent quality, particularly for tracking changes in mass emissions. However, the efficiency of the effluent monitoring program could be improved for detecting trends. The ability to detect trends in mass emissions is a function of sampling frequency, amount of change, and confidence. Similar to the effluent evaluation, however, we have not observed a justification for the frequency that is currently used to track trends. Likewise, a consistent level of change or confidence has not been expressed by POTWs or regulators during our interviews and discussions. Therefore, we used power analysis to determine the percent of change in mass emissions that each discharger can detect using current frequencies (Table 2.9). Based upon data from each of the POTWs from 1989-96, we determined that each agency is able to detect a 25% or smaller change in effluent mass emissions over five years for most constituents. Each agency is able to detect changes of less than 10% for approximately half of the constituents examined.

The one constituent that required an increase in effort to detect a 25% change in mass emissions over five years was total DDT (Table 2.9). Current mass emissions are at low levels, approximately 1.4 kg from all four POTWs combined in 1996. In this case, managers need to evaluate if a 25% change is a meaningful trend for decision-making. This same evaluation should be applied to every effluent constituent in order to allocate the appropriate level of effort for addressing management questions.

Recommendations

The effluent monitoring programs at all four agencies are, for the most part, effectively answering the management questions concerning effluent. Constituents are routinely below California Ocean Plan objectives and permit limits. Effluent monitoring has demonstrated that reductions in mass emissions from POTWs have been dramatic over the last 30 years; on average, there has been a 75% reduction of solids, 95% reduction in trace metals, and >99% reduction in trace organic constituents. The reductions have been so dramatic that other sources, such as stormwater, are now considered the primary source for most constituents. Now that levels are currently low, improvements in effluent monitoring design are appropriate to improve efficiency and lower costs within facilities, as well as maximize comparability among programs to provide integrated assessments. These recommendations are given below.

- *Frequency of monitoring should be proportional to the potential risk of exceeding a water quality threshold. Power analysis to assess potential risk can dramatically improve efficiency of effluent monitoring.*

Comparing effluent concentrations or toxicity to thresholds such as water quality objectives and permit limits is a useful management tool to assess potential risk. Our evaluation of current monitoring programs, however, indicated that many agencies are sampling more frequently than is necessary to maintain an acceptable level of confidence (i.e., 99% confidence) that they are not exceeding a threshold of concern. Our recommendation is that the frequency of effluent sampling should be proportional to the potential risk of exceeding that threshold. We further recommend that the potential risk of exceeding a threshold be defined using power analysis and historical performance of effluent concentrations. In this way, the greatest sampling frequency is allocated to those constituents or facilities that have the greatest potential of exceeding a threshold. Agencies that are unlikely to exceed a threshold because they are so far below the limit or their variability is so small should sample less frequently.

- *Develop a common list of reporting limits so that mass emission estimates among facilities are comparable.*

Mass emissions are an important element of effluent monitoring because they enable resource managers to compare contribution of constituents among different facilities or groups of facilities. Our evaluation of monitoring programs, however, indicated that many facilities have dissimilar reporting limits. The dissimilarities in reporting limits lead to inconsistencies in estimating mass emissions when concentrations are below reporting limits.

Our recommendation is that a common list of reporting limits be developed so that mass emission estimates among facilities would be comparable. This list of reporting limits need not include every constituent, but only those that are of concern due to their toxic or bioaccumulative nature, particularly on large regional scales. The reporting limits that are developed should be achievable with the current technology.

The State Water Resources Control Board is currently developing a reporting limit evaluation based upon a survey from a subset of accredited laboratories. A ranking approach is being used whereby the reporting limits of each laboratory are ranked and the 20^{th} percentile will be established as the reporting limit to which the remaining 80^{th} percentile must conform. This is one potential approach that could be evaluated.

TABLE 2.1. Number of effluent constituent measurements per year. HTP = L.A. City Hyperion Treatment Plant; JWPCP = LACSD Joint Water Pollution Control Plant; OCSD = Orange County Sanitation Districts; PLWTP = City of San Diego Point Loma Wastewater Treatment Plant.

Constituent	HTP	JWPCP	OCSD	PLWTP
General	4487	4227	1239	3270
Metals	172	132	148	988
Organics	244	268	528	1212
Toxicity				
Acute	12	12	4	12
Chronic	12	12	12	12

TABLE 2.2. Effluent constituent analysis frequency.

	Daily	Weekly	Monthly	Quarterly
General				
Suspended solids, Total BOD	HTP JWPCP OCSD PLWTP	-	-	-
Turbidity	HTP JWPCP PLWTP	-	OCSD	-
Floating particulates	PLWTP	-	HTP	-
Oil and Grease	JWPCP PLWTP	HTP	OCSD	-
Total dissolved solids	PLWTP	HTP	-	-
Volatile susp. solids	PLWTP HTP	-	-	JWPCP
TOC	-	HTP JWPCP	-	-
Residual Cl^-	HTP JWPCP	-	-	-
Ammonia-N	-	OCSD PLWTP	HTP JWPCP	-
Nitrate-N	-	PLWTP	HTP JWPCP	-
Nitrite-N	-	-	JWPCP	-
Phosphate	-	PLWTP	JWPCP	-
Total phosphorus	-	-	HTP	-
Cyanide	-	PLWTP	HTP JWPCP OCSD	-
Total coliforms	JWPCP	HTP	PLWTP	-
Enterococcus	JWPCP	HTP	-	-
Fecal coliforms	-	HTP JWPCP	-	-

TABLE 2.2 (Continued)

	Daily	Weekly	Monthly	Quarterly
Metals				
Al, Ba, Co, Fe, Mn, V	-	PLWTP	-	HTP
Sb, Be	-	PLWTP	OCSD	HTP JWPCP
As, Hg, Cd, Cu, Pb Ni, Se, Ag, Zn	-	PLWTP	HTP JWPCP OCSD	-
Total Cr	-	PLWTP	HTP JWPCP	-
Hexavalent Cr	-	-	HTP OCSD	-
Th	-	PLWTP	-	HTP JWPCP OCSD
Organics				
DDTs, PCBs, Chlor. phenols	-	PLWTP	JWPCP OCSD	HTP
Nonchlor. phenols, Other Cl^- pesticides	-	PLWTP	OCSD	HTP JWPCP
Organotins	-	-	PLWTP	HTP JWPCP
PAHs, Benzidines, Acrolein, Dioxin, Acrylonitrile,Other VOCs, Purg. aromatics, Other base/neutral extractables	-	-	OCSD JWPCP PLWTP	HTP
Toxicity				
Acute	-	-	HTP JWPCP PLWTP	OCSD
Chronic	-	-	HTP JWPCP OCSD PLWTP	-

TABLE 2.3. Effluent constituents measured by 3 or fewer POTWs.

General
Residual total chlorine Volatile suspended solids Total dissolved solids Floating particulates Carbonaceous BOD COD TOC Nitrate-N Nitrite-N Organic-N TKN as nitrogen Phosphate Total phosphorus Total coliforms Enterococcus Fecal coliforms Alpha radiation
Metals
Al Ba Co Fe Mn V Total Cr Hexavalent Cr
Organics
Organotins Phenols Total halogenated organics

TABLE 2.4. Effluent constituent reporting limits.

	HTP	JWPCP	OCSD	PLWTP
Metals (µg/L)				
Aluminum	100	-	-	50
Antimony	5	0.3	4	23
Arsenic	1	0.4	2	0.18
Barium	10	-	-	10
Beryllium	0.3	0.5	0.6	0.39
Cadmium	2	0.8	0.1	1
Hexavalent chromium	10	-	-	-
Total chromium	4	20	1	5
Cobalt	2	-	-	4
Copper	10	4	1	4
Iron	20	0.4	-	30
Lead	3	8	1	18
Manganese	10	-	-	4
Mercury	0.3	0.04	0.2	0.27
Molybdenum	10	-	2	-
Nickel	5	10	2	14
Selenium	1	0.1	2	0.4
Silver	0.4	4	2	6.6
Thallium	5	30	4	40
Vanadium	5	-	-	7
Zinc	10	15	2	4
Organics				
Organotins (µg/L)	0.005	0.098	-	0.1
Phenols (µg/L)	-	2-19	5	-
Chlorinated phenols (µg/L)	1-7	2-16	3.3-6.9	1.6-6.1
Nonchlorinated phenols (µg/L)	1-34	2-19	2.6-11	1.8-6.1
DDT (µg/L)	0.002-0.01	0.01-0.03	0.02	0.02-0.04
PCB (µg/L)	0.025-0.065	0.08-0.9	0.3	0.07-0.6
Purgeable aromatics (µg/L)	0.04-0.08	0.3-1.0	0.18-0.58	1-2.9
Benzidines (µg/L)	2, 14	0.101	20	40, 170
PAHs (µg/L)	1	0.015-0.42	1-10	0.8-7.8
Dioxin (ng/L)	0.0008-0.0017	3,000	50,000	0.0008-.008

TABLE 2.5. Ocean Plan objective based effluent limitations and discharger effluent reporting limits. Underlined values indicate reporting limits greater than the Ocean Plan objective based effluent limit.

	Ocean Plan Objective based effluent limit (μg/L)				Reporting Limit (μg/L)			
Constituent	**HTP**	**JWPCP**	**OCSD**	**PLWTP**	**HTP**	**JWPCP**	**OCSD**	**PLWTP**
endrin	0.168	0.332	0.296	0.408	0.004	0.02	0.007	30
aldrin	0.002	0.004	0.003	0.004	0.008	0.01	0.004	0.02
benzidine	0.006	0.011	0.010	0.014	47	0.1	20	40-170
chlordane	0.002	0.004	0.003	0.005	0.005	0.01-0.04	0.27-0.06	0.048
3,3-dichlorobenzidine	0.680	1.345	1.199	1.652	2	0.14	20	40
dieldrin	0.003	0.007	0.006	0.008	0.006	0.02	0.005	0.04
hexachlorobenzene	0.018	0.035	0.031	0.043	1	1	4	1.4
PAHs	0.739	1.461	1.302	1.795	1-2	0.015-0.42	1-10	0.8-7.8
PCBs	0.002	0.003	0.003	0.004	0.025-0.065	0.08-0.9	0.3	0.07-0.6
TCDD equivalents	$3x10^{-7}$	$6x10^{-7}$	$6x10^{-7}$	$8x10^{-7}$	0.0003-0.001	1	50	0.000093
toxaphene	0.018	0.035	0.031	0.043	0.113	0.3	0.23	0.24
DDT	0.014	0.028	0.025	0.035	0.002-0.010	0.01-0.03	0.007-0.039	0.02-0.04

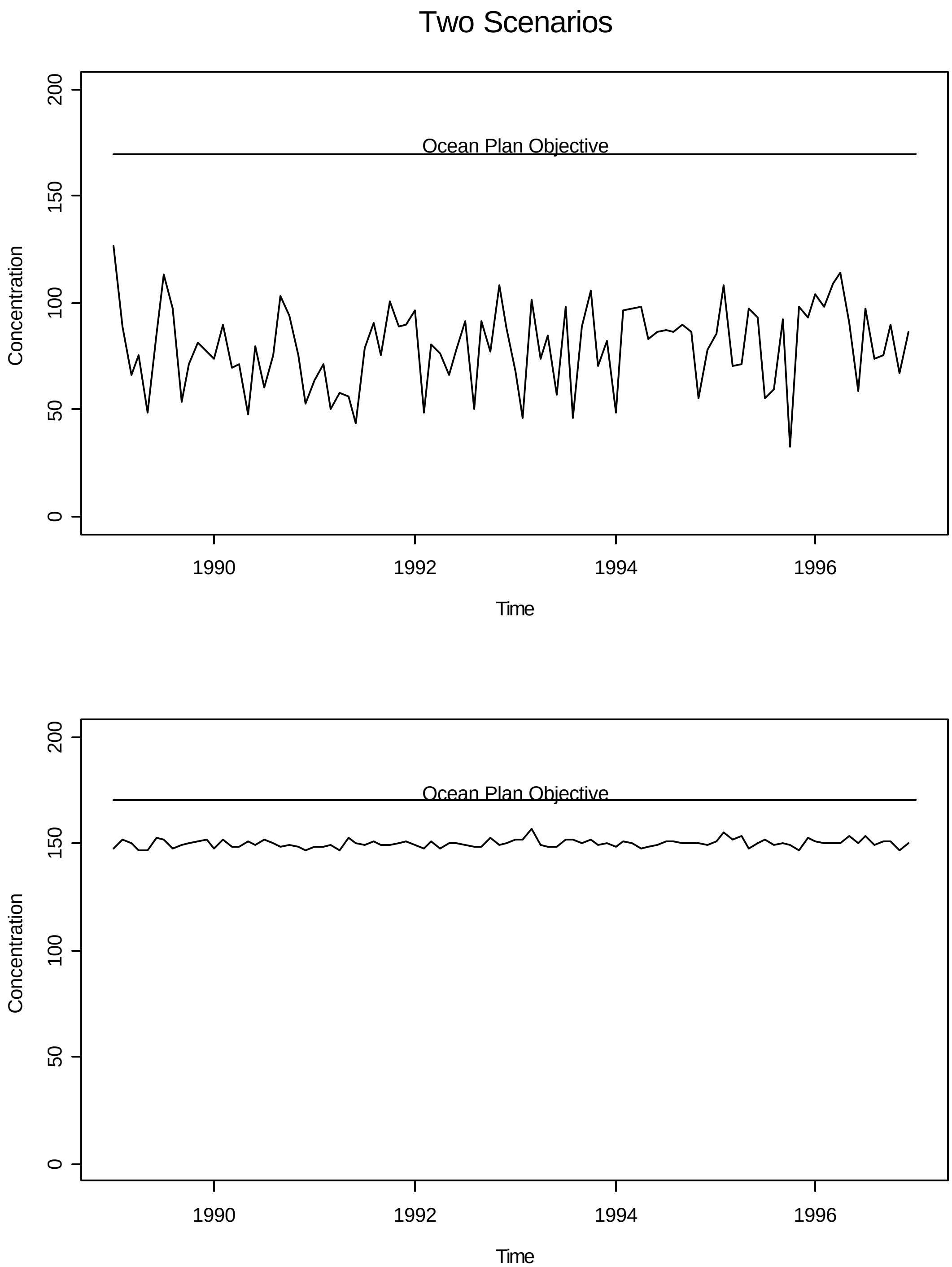


FIGURE 2.1. Effluent constituent variability relative to California Ocean Plan objective based effluent limits. Increases in variability are more tolerable with distance from the objective.

TABLE 2.6. Annual samples necessary to achieve 99% confidence that effluent is within Ocean Plan objective based effluent limit.

Constituent	HTP	JWPCP	OCSD	PLWTP
Silver	2	<1	2	<1
Arsenic	<1	<1	<1	<1
Cadmium	<1	<1	<1	<1
Cyanide	52	2	<1	<1
Chromium	<1	2	<1	<1
Copper	<1	<1	2	2
Mercury	<1	2	52	2
Ammonia - N	<1	<1	<1	<1
Nickel	<1	<1	<1	2
Lead	<1	<1	2	2
Selenium	<1	<1	<1	<1
Zinc	<1	<1	<1	<1
Acute Toxicity	84	180	12	180
Grease & Oil	36	24	12	360
Total DDT	Huge #	Huge #	Huge #	Huge #

TABLE 2.7. Annual effluent samples necessary for 99% confidence in attaining permit performance goals.

Constituent	HTP	JWPCP	OCSD	PLWTP
Silver	9	13	2	1
Arsenic	2	1	8	25
BOD	20	10	25	184
Cadmium	4	1	3	1
Cyanide	17	12	1	21
Chromium	4	2	3	1
Copper	2	1	1	7
Mercury	2	1	1	2
Nitrogen – Ammonia	7	1	7	6
Nickel	3	1	3	1
Lead	1	1	1	1
Selenium	2	42	15	250
Zinc	2	9	2	267
Oil & Grease	5	319	15	52
Total DDT	1	2	1	1
Chlorinated Phenols	1	1	1	1
Suspended Solids	154	60	23	115

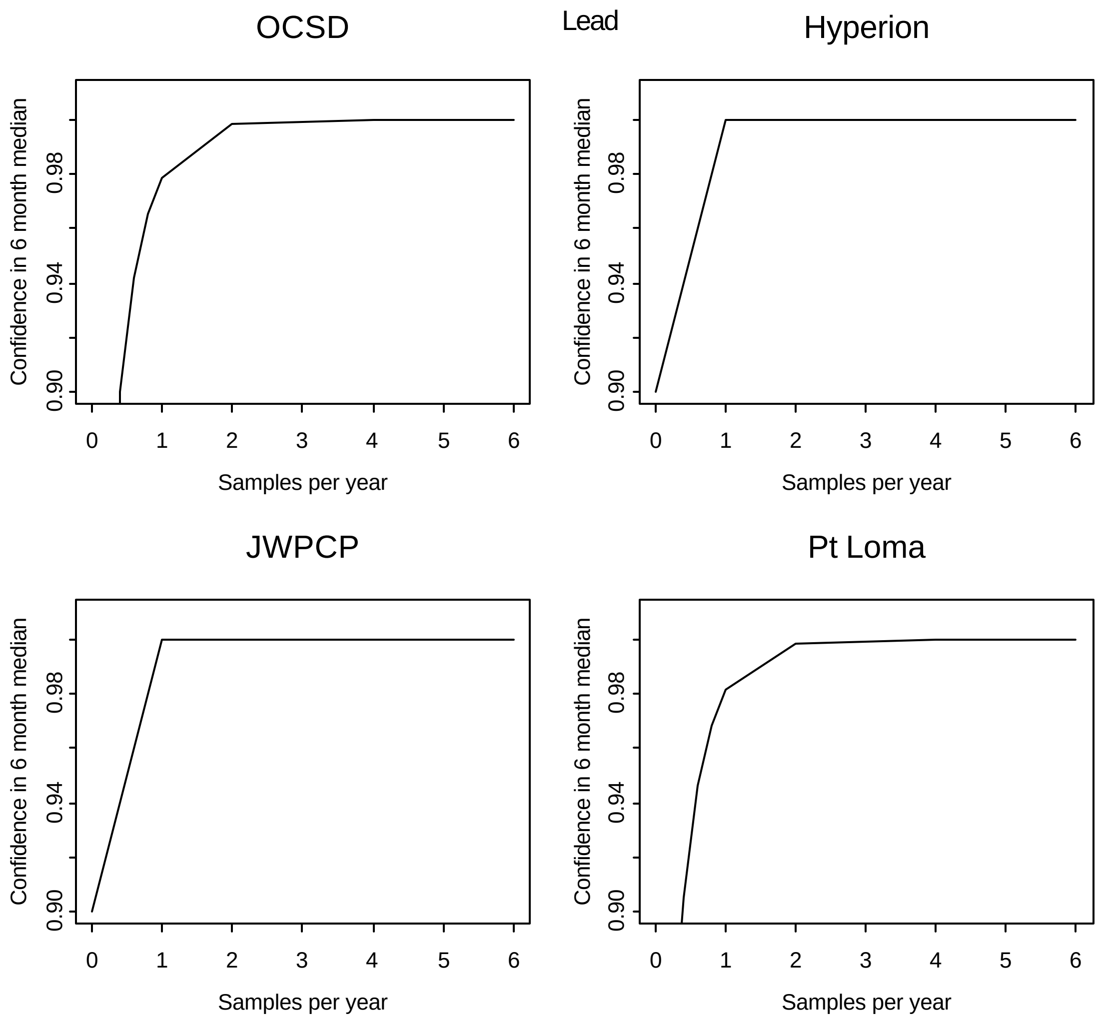
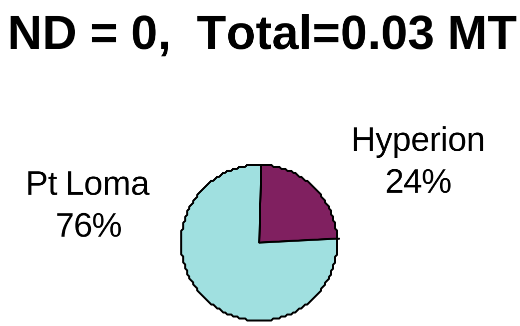


Figure 2.2. Sampling effort required to achieve an acceptable level of confidence for lead effluent concentrations. Power analysis was used with the historical discharge data from 1989-1996 for each of the four dischargers.

Figure 2.3. Proportion of total mercury annual mass emissions. Differences in reporting limits and treatment of nondetects as 0 or at the reporting limit affects the proportion of mercury mass emissions among the four agencies.



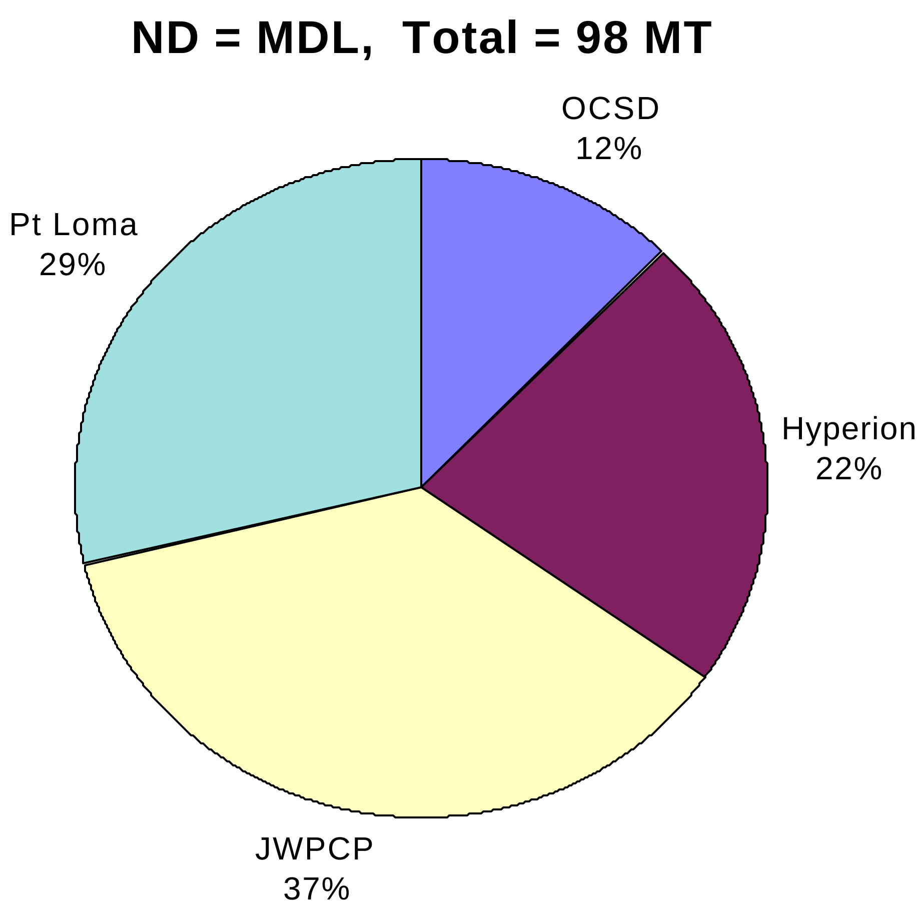
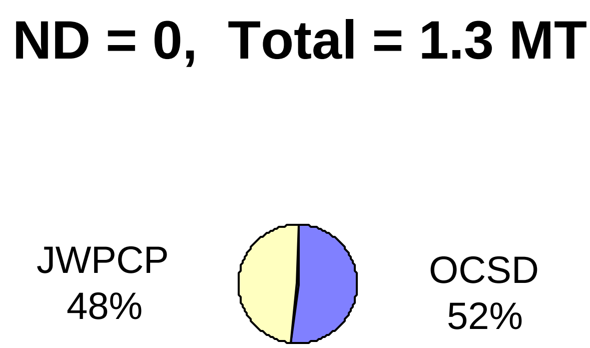


Figure 2.4. Proportion of total lead annual mass emissions. Differences in reporting limits and treatment of nondetects as 0 or equal to the reporting limit affects the proportion of mercury mass emissions among the four agencies.



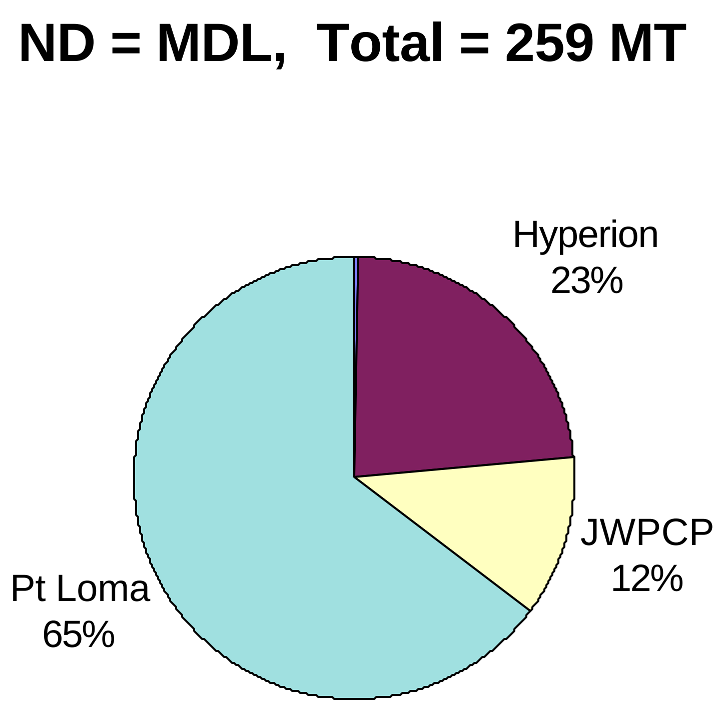


TABLE 2.8. Mass emission estimates treating nondetects as 0, and as the reporting limit.

	OCSD		**HTP**		**JWPCP**		**PLWTP**	
	ND=0	ND = RL	ND=0	ND = RL	ND=0	ND = RL	ND=0	ND = RL
Silver (MT)	0.7	0.7	2.4	2.4	2.6	2.6	0	72
Arsenic (MT)	0.4	3.4	1.8	2.2	1.4	1.4	0.4	0.4
Cadmium (MT)	0.2	0.2	0.2	11.2	0.2	15.2	0.1	20.1
Cyanide (MT)	0.2	1.3	6.7	9.7	3.8	4.8	0.9	0.9
Mercury (MT)	0.0	12.0	0	22.0	0	36.0	0	28.0
Nickel (MT)	5.8	5.8	5.1	5.1	16.3	16.9	0.6	13.4
Lead (MT)	0.7	0.7	0	60	0.6	30.6	0	168
Selenium (MT)	0.4	5.4	0	33	6.7	6.7	0.3	0.3
Total DDT (Kg)	0	0.5	0	0.2	2.1	2.2	0	0.5

TABLE 2.9. Detectable % change in mass emissions over five years with current sample frequency.

	HTP	JWPCP	OCSD	PLWTP
Silver	9	44	12	5
Arsenic	13	19	42	9
BOD	4	3	2	3
Cadmium	12	19	17	6
Cyanide	32	26	8	11
Chromium	31	35	10	5
Copper	6	6	7	1
Mercury	20	16	16	11
Ammonia-N	2	3	2	2
Nickel	16	6	5	12
Lead	18	15	37	6
Selenium	9	3	25	30
Zinc	18	7	6	13
Grease & Oil	4	3	3	4
Total DDT	58	22	71	77
Solids	4	2	2	7

III. WATER QUALITY MONITORING

Compare and Contrast Among Agencies

The level of effort expended on water quality monitoring differs substantially among agencies. Prior to 1998, when some of the programs were modified, sampling effort among agencies varied by a factor of three (Table 3.1). This difference was due to inconsistencies in the number of stations sampled and the number of water quality parameters analyzed. Sampling frequency did not contribute to the differences in effort, since each agency sampled at monthly intervals. However, differences in receiving water environments (i.e. width of shelf) may contribute to the differences in number stations.

The number of sampling stations varied by a factor of three among agencies. The number of water quality parameters analyzed by each agency varied from two to five. CTD casts were the only measurements common to all four agencies. Seven other parameters were measured by three or fewer dischargers, including ammonia, transparency, PAR, fluorescence (an estimator of chlorophyll), TSS, oil and grease, and currents (Table 3.2).

In mid-1998, three of the dischargers (HTP, LACSD, and OCSD), as well as the City of Oxnard, coordinated and extended the spatial scale of their water quality monitoring programs to better understand the interactions among their plumes and the interaction of their plumes with other land-based freshwater sources. This cooperative effort , referred to as the Central Bight Cooperative Program (CBCP), was a replacement of the previous program for HTP and LACSD, while it was added as new element to the OCSD program. The PLWTP still maintains its original water quality program .

The CBCP dramatically increased the level of consistency in sampling activities among the participating agencies by requiring comparable sampling methods, measurement parameters, and sampling frequencies (Tables 3.3 and 3.4). The design increased the amount of area monitored in both longshore and offshore directions by increasing the number of stations (Figure 3.1), but reduced the frequency of monitoring from monthly to quarterly. Cooperating agencies coordinate transect locations and sampling periods to maintain continuity in space and time, and have developed an information management system to share data.

Evaluation of Existing Effort

Water quality monitoring addresses two basic management questions: 1) Do the receiving waters near the outfall meet Ocean Plan water quality objectives, and 2) What is the fate of the discharge plume. The first question is intended to assess ecosystem protection, while the second question primarily addresses a human health issue (the likelihood of the plume reaching water contact zones).

Ecosystem Protection

The historical programs have effectively addressed the management question about ensuring protection of the [water column] ecosystem, all of the programs have demonstrated for more than 15 years that they consistently meet Ocean Plan objectives for pH, dissolved oxygen (D.O.), and transmissivity. When local alterations in these parameters have been noted, they have been attributable to natural phenomena unrelated to outfall discharge (e.g., storms, upwelling), or are identified to be within the range of natural variability (Conversi and McGowan 1994). With most facilities increasing their levels of treatment, and thereby reducing their discharge of BOD and suspended solids, there is little likelihood of future declines in D.O. or transmissivity. The recent reduction of most programs from monthly to quarterly as part of the CBCP seems appropriate.

The increased spatial scales monitored by the CBCP provide a clearer picture of factors that lead to anomalies near their outfalls. The enhancement in the longshore and offshore direction improves a managers' ability to assess large-scale natural phenomenon and identify other anthropogenic plumes that encroach into their discharge zones. In particular, plumes from surface runoff are currently being identified as potential large-scale phenomenon, even during non-rain time periods.

While historical monitoring designs have effectively determined that D.O., pH, and transmissivity consistently do not exceed water quality objectives, they are not designed to address nutrient impacts as a potential stimulator of phytoplankton growth. With reduced discharges of BOD and TSS, nutrient enrichment becomes the most likely mode of potential water quality impact from POTW outfalls. Several studies during the 1970's suggested that upwelling was a larger source of nutrient enrichment than POTWs (Eppley 1986), but little routine nutrient or phytoplankton monitoring has been conducted since that time by any of the four agencies. The POTWs have recently begun to address this issue by adding fluorescence (an estimator of chlorophyll) measurements as part of the CBCP, while nutrients were measured during Bight '98 and in OCSD's special studies. These data should be examined as they become available to determine whether additional nutrient related measurements are appropriate. For instance, preliminary indications from the OCSD special studies suggest that differences in nitrogen speciation may prove useful for differentiating between discharge plumes and natural upwelling effects on oxygen concentration. .

Plume Location

Our evaluation of the question concerning where the discharge plume goes addressed three temporal scales, including the ability of monitoring programs to: 1) hindcast (where has the plume been), 2) determine where the plume currently is (near real-time), or 3) predict where the plume will go under certain conditions (forecasting).

Given the importance the public places on this question, particularly with regards to beach closures, a successful program should be able to address all three temporal scales.

To date, none of the programs have attempted to address either of the latter two time scales. With regards to the hindcasting, the programs have effectively demonstrated that for most of the year and under typical oceanographic conditions, POTW plumes remain submerged and far from shore (Conversi and McGowan 1992). However, the historical monitoring programs have not been effective at assessing where the plume is located in the offshore environment, or under what conditions the plume is likely to move towards shore.

The primary reason that managers are unable to answer questions about where the plume is located under typical oceanographic conditions is because the existing data are underanalyzed. Tremendous effort has been expended to collect spatial information over the last 20 years, but most analysis has focused on a spatial description of single events; the data have not been integrated to create a map that delineates isoclines of plume occurrence (e.g. Figure 3.2). Moreover, little data analysis has been attempted to link correlative variables (i.e. wind, waves, tide, temperature, barometric pressure, etc.) to assess when conditions exist that move the plume in atypical directions.

The primary reason that managers cannot predict where a POTW plume goes during atypical oceanographic conditions is because these conditions have not been well sampled. Episodic events are not well-characterized by a monitoring strategy that samples at infrequent, preset intervals. An alternative strategy would be to recognize the success in demonstrating that the plume is typically submerged and to reallocate effort towards periods when the plume is most likely to move towards surface or shore. Doing so would require switching the sampling schedule from calendar-driven to event-driven.

Recommendations

Our recommendations focus on exchanging inefficient effort from historical monitoring towards producing a predictive water quality model that managers need. Our recommendations for achieving that goal follow a four-step path: 1) reduce monitoring frequency and reallocate the effort more effectively; 2) analyze existing data; 3) promote the use of new technology to improve monitoring in a test case application; and 4) find cooperative interactions among POTW programs, other monitoring agencies, and researchers to develop a predictive model.

- *Reduce the frequency of monitoring that addresses questions regarding water quality impairments and reallocate that effort to address questions regarding plume location.*

The monthly water quality monitoring that has been conducted by all of the large POTWs was providing redundant information regarding water quality impacts; more than 15 years have effectively demonstrated that discharge plumes do not cause exceedences in water quality thresholds. A more efficient reallocation of effort would be to reduce the monthly frequency in favor of monitoring designs that address other questions, such as plume location. This has already begun to occur as part of the CBCP where the monitoring frequency has been reduced to quarterly sampling. The tradeoff in effort has been an increase in spatial extent to assess the impact of other land-based plumes.

- *Analyze existing data to create isocline maps of plume occurrence*

The first step in our recommendation is to analyze existing data to improve hindcasting ability. A tremendous quantity of data has been accumulated over the years that could be used to create maps of plume occurrence; contours would represent the proportion of time a plume may occur within its boundaries (Figure 3.2). Spatial statistics will likely play a role in this mapping component. For example, key data sets will need to be identified so that spatial covariance can be assessed and interpolations between data points can be verified. Separate maps might be produced depending upon prevailing oceanographic conditions such as thermocline present or absent. Similar maps could also be created in vertical space (e.g. water column cross-section) or even three dimensions. This recommendation could be undertaken immediately and accomplished in a relatively short time frame of one to three years.

- *Promote the use of new technology to capture data regarding episodic events that are not well-characterized with existing monitoring, but are likely important oceanographic driving factors influencing plume movement towards shore. The new technology should be applied in a test case to demonstrate its effectiveness and improved efficiency prior to becoming routine monitoring.*

The second step in our recommendation is to promote the use of new technology to improve monitoring. Examples of new technology that could be applied include moorings of current meters and/or thermisters, autonomous profiling vehicles (APVs), or autonomous underwater vehicles (AUVs). They're advantageous because each of these new technologies are *in-situ* sampling devices that can record water quality information in near-continuous modes. This new technology enables two improvements to current designs. The first advantage is they will be able to capture the atypical, episodic events that are not well-characterized now, but without having to deploy field crews in continuous, costly and perhaps unsafe conditions. Their second advantage is that they can be telemetered to shore-based facilities. If shown to be reliable monitoring tools, these devices can trigger a variety of adaptive monitoring strategies, such as when field crews could be deployed to obtain spatial information that moorings, APVs, or AUVs cannot collect. All of these new technologies are only now becoming commercially available, but have not been rigorously tested for routine monitoring applications. Therefore, this recommendation should be attempted in a test-case application that could easily occur within a one to five-year time period.

- *Find cooperative interactions among POTW monitoring programs, other monitoring programs, and researchers to effectively develop predictive models of plume dynamics.*

The third step in our recommendation is to find cooperative interactions among POTW programs and researchers to develop a predictive model. The predictive model is the ultimate goal managers need to answer questions regarding where the POTW plume is going. Applications for such a model might include chlorination schedules, awareness of plume intrusions to water contact zones, and assessing proposed increases in discharge volume. However, developing such a model requires unique experience and expertise that is rarely found in the oceanographic community and typically beyond the expectations of monitoring program personnel. In fact, this type of model is beyond the scope of a single facility and will likely require integration of many facilities to understand the large-scale processes that drive oceanographic forcing. This integration has already begun for several POTW agencies (e.g. CBCP), and should be facilitated among additional local agencies, local research institutions, and National Programs. Several local research institutions exist within the SCB with such expertise and desire including UC Santa Barbara, University of Southern California, UC San Diego (Scripps Institute of Oceanography), and the US Geological Survey. Moreover, these institutions have ongoing research projects that may overlap, or may launch off of existing effort, to better understand ocean dynamics, plume dispersion, and transport. Other monitoring agencies also exist within the SCB that need to address plume dynamics. In particular, stormwater management agencies need to assess the fate of their discharges in the marine environment. Finally, there are a series of National Programs that are being developed on the east coast of the U.S. that desire local participation to become effective tools for decision-making purposes.

Table 3.1 Water quality sampling effort among facilities before July 1998. The number of samples per year reflects the number of sites, number of parameters, and sampling frequency.

	HTP	*JWPCP*	CSDOC	PLWTP
# Samples/year	1,776	856	1,764	2,016
# Sites	32	28	16	46
Frequency	monthly	monthly	monthly	monthly
Areal Coverage (km^2)	248	55	72	180
Transect depths (m)	18 30 45 55 60 80 150	18 30 60 305	20 30 40 60 110 120 140 180 280 310	10 18 50 60 90 100 115

Table 3.2 Number of water quality analyses per year before July 1998.

Parameter	HTP	JWPCP	CSDOC	PLWTP
CTD	384	420	192	552
Transparency	384	-	-	552
PAR	-	84	192	-
Fluorescence	-	-	192	-
TSS	-	-	-	684
Ammonia	1,008	252	1,188	-
Oil & Grease	-	-	-	228
Currents	continuous	-	-	-

Table 3.3 Water quality sampling effort among facilities after July 1998. The number of samples per year reflects the number of sites, number of parameters, and sampling frequency following initiation of the Central Bight Cooperative Project.

	HTP	JWPCP	CSDOC	PLWTP
# Samples/year	748	474	812	2,016
# Sites	54	48	42	46
Frequency	quarterly	quarterly	quarterly	monthly
Approx. Areal Coverage (km^2)	400	400	300	180

Table 3.4 Number of water quality analyses per year after July 1998.

Parameter	**HTP**	**JWPCP**	**CSDOC**	**PLWTP**
CTD	216	192	168	552
Transparency	-	-	-	-
PAR	-	-	-	-
Fluorescence	216	192	168	552
TSS	-	-	-	684
Ammonia	336	90	476	-
Oil & Grease	-	-	-	228
Currents	-	-	-	-

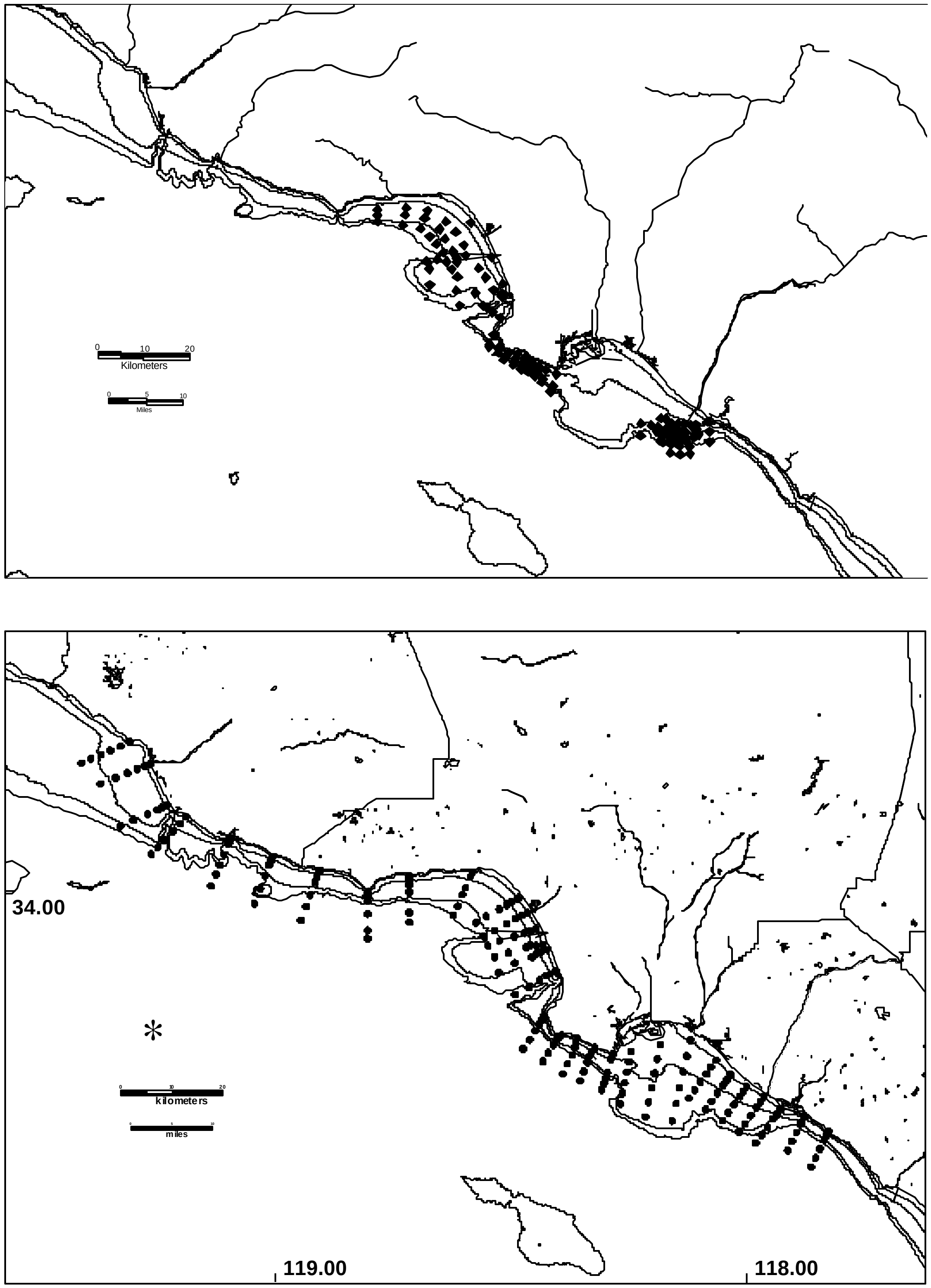


Figure 3.1 Map of station locations sampled before (top) and after (below) July, 1998. The water quality monitoring programs were adjusted in 1998 as part of the Central Bight Cooperative Project. Stations now extend from Ventura to Laguna.

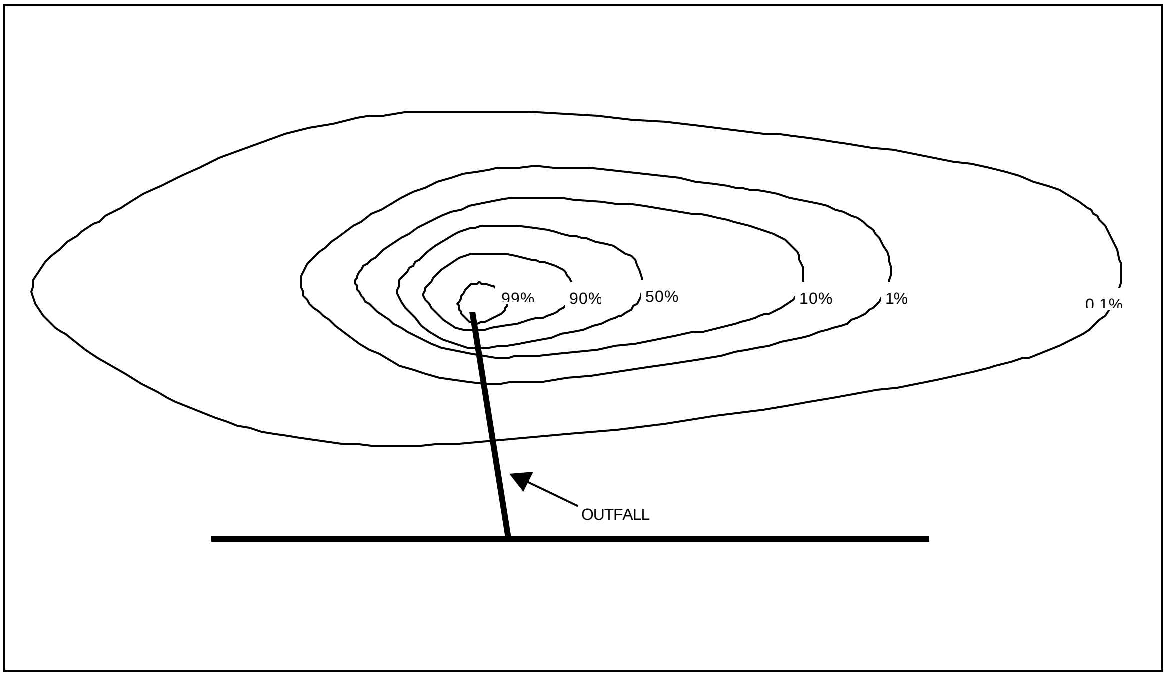


Figure 3.2 Hypothetical isocline map of plume occurrence. Each isocline represents the proportion of time that the plume may occur at that location. Separate maps could be constructed for varying oceanographic conditions.

IV. MICROBIOLOGICAL MONITORING

Compare and Contrast Among Agencies

Comparison Among POTW Programs

The level of microbiological monitoring is disproportionate among agencies. A five-fold difference was found in the number of analyses conducted per year (Table 4.1), which reflects differences in sampling frequency, number of stations sampled, and number of indicators measured. In addition, each agency allocates sampling effort between shoreline, nearshore, and offshore stations differently.

Sampling frequency at shoreline stations varies from daily (5-7 times per week) to biweekly sampling. The PLWTP samples weekly from May to October, and once every two weeks from November to April. The OCSD samples weekdays (5 times per week) from May to September and twice per week from October to April. In contrast, HTP and JWPCP conduct daily monitoring. The sampling frequency at nearshore stations ranges from 1 to 10 times per month. The sampling frequency of offshore stations ranges from less than 1 to 4 times per month.

While the number of analyses differs among agencies, the microbiological indicators and methods are consistent for shoreline stations. All POTW programs measure fecal coliform, total coliform and *Enterococcus*. Nearshore and offshore analyses are less consistent. The PLWTP and JWPCP analyze for total coliform, fecal coliform and *Enterococcus* at nearshore stations, while HTP analyzes exclusively for total coliform, and OCSD targets fecal coliforms.

The number of shoreline stations sampled are somewhat comparable among agencies, differing by a factor of only two. The number of nearshore and offshore stations are not comparable; cumulatively, they differ by a factor of eight. This lack of comparability is also reflected in allocation of effort between shoreline and nearshore and offshore monitoring. The OCSD allocates most of its effort (86%) to shoreline microbiological monitoring, while PLWTP allocates a much smaller proportion (30%) of its effort shoreline monitoring. [Note: PLWTP monitors at least 40 additional shoreline stations, but they are not required under their NPDES permit and are arranged through supplemental agreements.] Moreover, the number of analyses each agency allocates to shoreline monitoring each year is disproportionate to the length of shoreline it monitors. A five-fold difference was found among facilities in the number of analyses per mile of monitored shoreline, ranging from 77 to 384 analyses each year per mile of shoreline (Table 4.2).

Comparison Between POTWs and County Health Programs

Each county in southern California maintains a shoreline microbiological monitoring program to protect human health to which the POTWs contribute data. The number of annual analyses the four largest POTWs conduct along the shoreline is almost twice the number of analyses as the county health departments (Table 4.3). Part of this difference is that POTWs analyze more indicators than the health departments (Table 4.4). Most POTWs measure all three indicators while, historically, most health departments have rarely measured more than two. This is largely the result of different decision criteria. The POTWs address thresholds from the California Ocean Plan objectives whereas health departments mostly address coliform standards. The decision criteria for public health departments are changing as AB411 is being implemented, which is leading to an increase in the numbers of indicators they are required to measure.

While POTWs process more samples, they tend to sample fewer stations than their health department counterparts. This reflects a difference in sampling frequency among the two groups. County health departments sample each site weekly to monthly, whereas POTWs sample most sites multiple times per week (Figure 4.1).

The POTWs and health departments also differ in the methodologies they use for processing samples (Table 4.4). The POTWs rely almost exclusively on membrane filtration methods, whereas health departments have historically relied on multiple tube fermentation. Both methods are approved by the State of California. More recently, health departments have transitioned to the use of chromogenic substrate tests, which cost 75% less than the other two techniques. The POTWs have continued to rely on membrane filtration since the chromogenic substrate tests are not yet approved by the Environmental Protection Agency.

Evaluation of Existing Effort

Microbiological monitoring is conducted for two purposes. First, offshore monitoring is used to track the effluent plume. Bacteria are a sensitive tracer of the effluent plume in offshore areas because there are no other sources of these bacteria in the offshore marine environment. In contrast, shoreline monitoring, which was originally designed to survey for waste plumes encroaching on the beach and for tracking spills into the storm drain system, is now relied upon to assess public water-contact safety. The county health departments, which have responsibility to close or post beaches in response to high bacterial counts, have grown dependent upon the POTW shoreline monitoring data. Nearshore monitoring serves both plume tracking and water-contact safety purposes. For one agency, nearshore monitoring also serves to address shellfish safety purposes.

Offshore microbiological sampling has been conducted routinely, at least monthly for most agencies, for many years. During this time, the data have been effective at confirming what managers learned as part of the water quality monitoring program: plumes typically stay submerged and far from shore the vast majority of the year. Plumes only represent risk for water contact recreation when they surface or move towards the shore. Therefore, the fixed-grid sampling designs at infrequent, predetermined intervals that comprise most offshore monitoring programs do not provide much new information for management decisions.

Offshore microbiological sampling for the purpose of plume tracking is currently ineffective because little new information is gained from this effort. The focus of the offshore monitoring should be on those rare events when the plume may surface and/or come towards shore. Once per month sampling is unlikely to detect these rare events. The offshore programs are further inefficient because multiple indicators are measured using high-cost methods. If the goal of this monitoring is to track plumes, then a single indicator using less expensive methods is warranted. This would not apply in those areas, such as kelp beds, where offshore monitoring is used to assess human water-contact safety or shellfish standards.

Shoreline monitoring has dual purposes. The first purpose is to assess whether overflows, infiltrations and cross-connections into the storm drain system are affecting the shoreline. The second purpose is to assess whether water quality objectives are being achieved in water-contact zones. Stations designated to achieve the first purpose are clustered near storm drains and collection system infrastructure, while stations designated to achieve the second purpose are predominantly located on high-use beach areas.

Shoreline monitoring to detect sanitary sewer contributions into storm drain systems is effective, but this type of monitoring is inefficient because costs appear misallocated. Sanitary sewer incursions are not the only, and in many cases not even the primary, source of bacteria to storm drains. Although the stormwater NPDES permittees in the SCB have the responsibility to maintain storm drain systems and check for illicit connection and illegal discharges, none conduct shoreline monitoring. Not only does this represent an inappropriate allocation of costs, but without the storm drain managers present in the monitoring program, no formal mechanism exists to identify and resolve problems that are discovered. For example, sanitary surveys may be an appropriate adaptive monitoring strategy when chronic bacterial exceedences occur near a storm drain outlet. However, the management framework among POTWs and storm drain managers does not exist to perform these surveys and efficiently identify or resolve any water quality problems.

The public health portion of the shoreline monitoring effort is not well integrated with the county health department monitoring and, as a result, is inefficient in most cases. The POTWs sample more frequently, measure more indicators and use more expensive methods than the health departments, even though the data are being placed into a common data set for a common purpose. If the POTWs were to adopt the same sampling frequency (weekly) and methods (chromogenic substrate) used by most Public Health Agencies, the cost for the shoreline program would decrease by over 90%. If the purpose of monitoring sites away from storm drains is primarily to provide data to the county health department to make decisions, then monitoring design should be integrated and comparable among POTWs, county health departments, and stormwater dischargers. The integration process, focusing on data needs and management decision-making, is most advanced in Santa Monica Bay where HTP, JWPCP, and Los Angeles County Health Department have coordinated their programs in terms of sampling locations and frequency, but even there the dischargers are required to use different and more expensive laboratory analysis methods (membrane filtration) than the County Health Department (chromogenic substrate).

Nearshore monitoring often represents a fence-line strategy that has been effective at providing a warning to managers should the plume move toward shore and, alternatively, provides confirmation that offshore discharges are not the source when elevated bacterial counts are detected onshore. This design is inefficient for many of the same reasons described for offshore monitoring. Years of water quality monitoring have already established that plumes stay submerged offshore the vast majority of the year. Nearshore monitoring, when conducted on an infrequent basis (weekly to monthly), is ineffective at capturing the rare events when plumes might move onshore. Allocating resources towards a plume location and persistence monitoring program, with an adaptive trigger to measure microbiological indicators, would efficiently enable managers to answer questions regarding plume location. This strategy is focused upon where the plume is located, rather than where the plume is not located.

Recommendations

The POTWs in the SCB conduct more microbiological monitoring than any state in the nation including Hawaii, Florida or New Jersey. The monitoring programs in the SCB have effectively answered the two distinct management questions for this program element (plume tracking and water-contact safety). Managers now have a very good assessment of the quality of water along our beaches, how often plumes encroach on the shoreline and the public is well protected for those instances or locations where the water quality is diminished. However, the efficiency and cost-effectiveness of current monitoring programs could be improved. Our recommendations are presented separately for plume tracking and water contact safety below.

Plume Tracking

- *Microbiological monitoring for plume tracking should become an adaptive component of a water quality monitoring program. Adaptive strategies represent a cost-effective means of allocating resources to the places and times they contribute the most value.*

Microbiological monitoring, particularly when conducted in areas distant from shore at predetermined intervals, is a costly monitoring element that has provided duplicative information for many years now. Monthly surveys have repeatedly demonstrated that plumes from the large POTWs stay far from shore and are usually submerged, particularly when the water column is stratified (e.g., strong thermocline). The information that would be most useful to resource managers at this point in time is to identify those rare conditions when plumes surface and/or move towards the shore.

Therefore, we recommend that microbiological monitoring for plume tracking become an adaptive component of a water quality monitoring program that provides real-time information about plume location. Offshore and nearshore bacterial sampling should be employed when real-time systems indicate an increased likelihood of plume movement toward shore. As a sensitive plume tracking indicator, bacteria would serve to confirm and refine information about plume location. Thus, offshore and nearshore monitoring would not be conducted on a continual basis, but would be focused only on those periods when bacterial encroachment on areas of human water contact is likely.

- *Use a tiered approach for selecting indicators and methods. Single indicators using inexpensive methods are appropriate for plume tracking when many samples are needed, but multiple indicators coinciding with water quality thresholds should be analyzed at locations or times when body-contact issues are of concern.*

For plume tracking purposes, microbiological data analysis does not focus on comparison to AB411 or California Ocean Plan standards; rather, it is compared to background levels to identify the presence and concentration of the plume. For this purpose, we recommend that the current practice of measuring three indicators with membrane filtration be curtailed to measuring a single indicator using a chromogenic substrate technique. Total coliform is the most sensible of the three indicators since it is not found naturally in the offshore marine environment and is the most concentrated of the three indicators presently measured. However, such monitoring should be adaptive. When the plume is shown to encroach on beneficial-use areas, such as kelp beds, shellfishing zones, or other swimming areas, all three indicators should be measured, allowing comparison to all of the public health thresholds.

Water Contact Safety

- *Effort should be shared equitably among all dischargers of bacteria to assess regional shoreline water quality for protecting public health.*

Assessing health risk to swimmers along the shoreline is a regional question that should be addressed cooperatively among county health departments and all water collection system agencies that potentially release pathogens to the ocean. Notably absent from present efforts are stormwater dischargers, which consistently have high bacterial counts in their discharges, particularly during wet weather. Stormwater dischargers should become part of a stakeholder group that convenes to refine and integrate shoreline monitoring programs.

- *Integrate methods and create regional monitoring designs that focus on quality and efficiency of POTW and county health department programs.*

The primary use of data collected by POTWs on high-use beaches away from discharge sources is to provide a basis for county health departments to keep the public informed about beach safety. The methods and sampling frequency employed by the county health departments to accomplish the same mission on a different set of beaches costs 90% less than POTWs incur on the beaches they monitor. This discrepancy should be resolved in a partnership between these organizations, which would assist both groups in sharing information and delivering an improved assessment for the public. A stakeholder group is evolving to serve as the mechanism to integrate these agencies into a common design using appropriate methods. The Beach Quality Group is developing implementation procedures, including beach posting and closures, for the State of California. Methodological advances provide an additional area for improvement to increase efficiency. If chromogenic substrate kits provide results comparable to methodologies currently used to assess bathing water quality, then efforts should be made to gain approval for these kits by the U.S. Environmental Protection Agency.

TABLE 4.1. Number of microbiological analyses per year.

	Shoreline	Nearshore and Offshore	Total
HTP	14,220	9,000	23,220
JWPCP	2,916	3,020	5,936
OCSD	3,840	624	4,464
PLWTP	1,872	4,320	6,192
Total	22,848	16,964	39,812

TABLE 4.2. Effort relative to distance of shoreline monitored.

	Annual No. Shoreline Analyses	Shoreline Miles Monitored		
		Total	Accessible	Sandy
HTP	14,220	37.0	25.1	25.1
JWPCP	2,916	16.7	9.9	1.7
OCSD	3,840	13.3	13.3	9.9
PLWTP	1,872	24.3	23.8	20.0

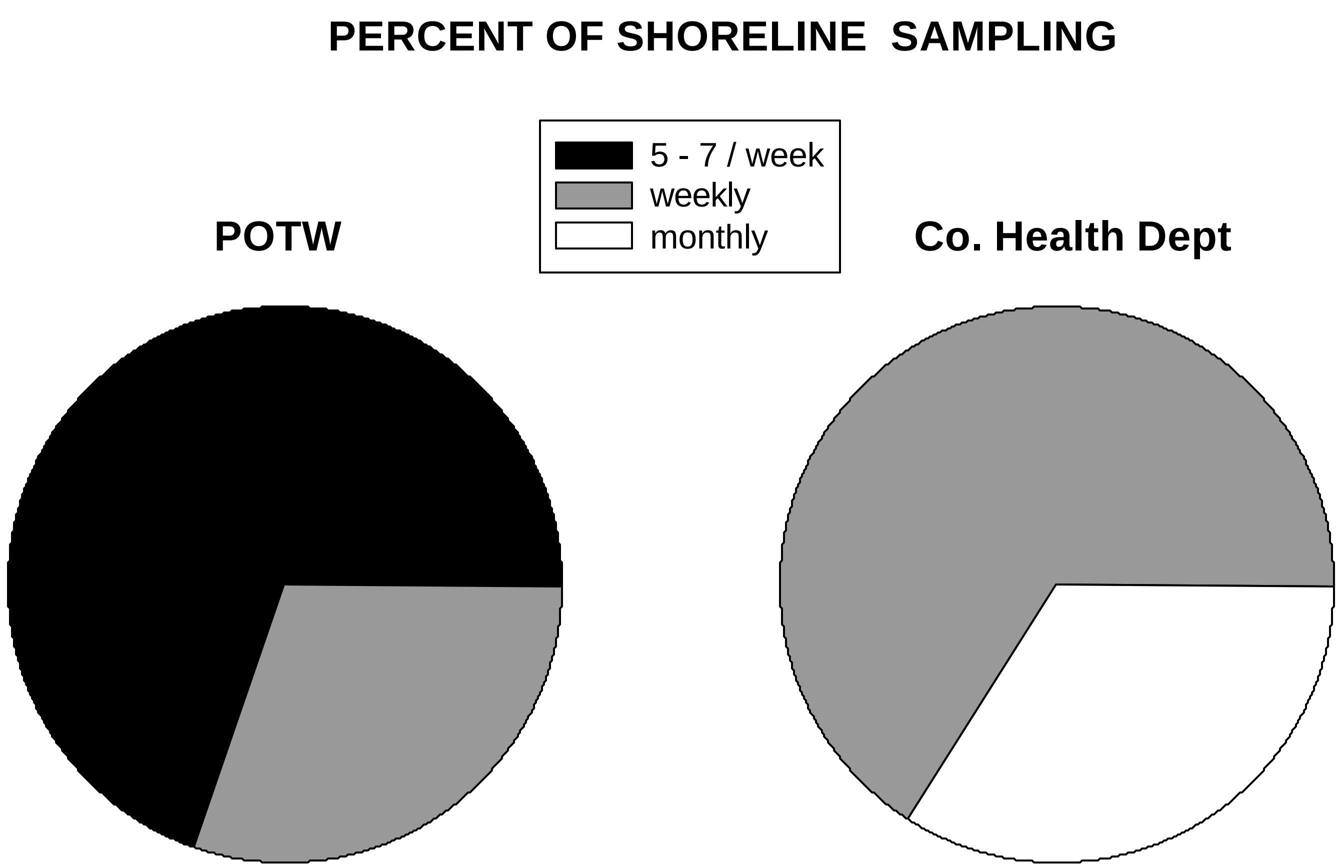
FIGURE 4.3. Comparison of annual effort between POTWs and County Health Departments.

	Shoreline		Near/Offshore	
	Sites	**No. of Analyses Per Year**	***No. of Sites***	**No. of Analyses per Year**
4 Large POTWs	59	22,848	53	16,964
Other NPDES	212	27,423	81	7,116
Health Depts.	171	12,656	-	-
Total	442	62,927	134	24,080

TABLE 4.4. Comparison of methods used for shoreline monitoring between POTWs and Public Health Agencies.

		SCB Public Health Agencies	Large POTWs
Total coliform			
	Mult tube ferm	7,090	3,840
	Membrane filt	468	9,228
	Colilert	728	-
Fecal coliform			
	Mult tube ferm	4,282	-
	Membrane filt	-	7,332
	Colilert	728	-
Enterococcus			
	Mult tube ferm	1,932	-
	Membrane filt	-	7,326
	Enterolert	728	-
	Total	15,956	27,726

FIGURE 4.1. Frequency of shoreline sampling by Publicly Owned Treatment Works (POTWs) and County Health Departments.



V. SEDIMENT MONITORING

Compare and Contrast Among Agencies

Considerable differences were found among the facilities in the level of effort expended on sediment monitoring. The number of sediment chemistry analyses conducted in a one-year period differ 7-fold, although the number of benthic infaunal analyses conducted during the same period differ only 2-fold.

The biggest differences are in sampling frequency (Tables 5.1 and 5.2). The OCSD samples approximately 80% of its sediment chemistry and benthic infaunal stations on an annual basis, and approximately 20% on a quarterly basis. The JWPCP samples approximately 30% of its benthic infaunal stations semi-annually, the remaining 70% of its benthic infaunal stations annually, and all of its sediment chemistry stations biennially. The HTP samples all of its benthic infauna and sediment chemistry stations annually, while PLWTP samples all of its stations for these parameters quarterly.

The degree of station replication for sediment chemistry among agencies varies from 1 to 3 samples (Table 5.2). This same variability also exists for within-agency replicate differences at two facilities. The JWPCP and OCSD analyze three replicates for sediment chemistry at selected sites along the 60-m contour and one sample at all other sites. In contrast, HTP and PLWTP collect one sample at all sediment chemistry sites.

The number of replicates collected for benthic infauna varies from 1 to 5 samples among agencies (Table 5.1). The JWPCP and HTP collect one sample at each site during the winter and five replicate samples along their 60-m contours during the summer. The OCSD collects three replicates for benthic infauna at their 60-m stations on a quarterly basis and one replicate at all other sites on an annual basis. The PLWTP collects 2 replicates at all of its benthic infauna sites.

The number of sediment chemistry and benthic infaunal sampling stations is relatively similar among the agencies (within a factor of two). However, the amount of area over which these stations are distributed varies by a factor of eight, and is unrelated to annual flow or mass loading. Instead, the number and distribution of stations usually appear to be related to the characteristics of the receiving environment. For example, HTP discharges 15,000 metric tons (MT) of suspended solids annually and maintains 40 sediment chemistry stations distributed over approximately 316 km^2, while JWPCP discharges 30,000 MT of suspended solids annually and maintains 41 sediment chemistry stations over approximately 32 km^2. However, the discharge site characteristics for these two agencies are different; HTP discharges into a bay, whereas JWPCP discharges onto a narrow shelf with generally faster ocean currents.

The sediment chemistry constituents analyzed among the agencies differ considerably for organic compounds (Table 5.3). Each discharger analyzes sediment for PCBs and PAHs, but the types of each compound analyzed is different. For example, JWPCP analyzes sediment for 3 PCB Aroclors and 13 PAH derivatives, whereas OCSD analyzes for 44 PCB congeners and 45 PAH derivatives. Entire analyte classes are analyzed by only a subset of the agencies. Volatile organic compounds (VOCs) in sediment, for example, are only analyzed by JWPCP. The OCSD dropped VOC analyses in their 1998 permit because these compounds were consistently not detectable in sediments. The types of sediment metal constituents analyzed are more consistent among facilities. Of the 15 metals, 9 are analyzed by all four agencies, and 11 are analyzed by three or more agencies (Table 5.4).

Most monitoring activities measure constituents for which there are sediment quality guidelines such as Effects Range Low (ERL) and Effects Range Median (ERM) (Long *et al*. 1995). While sediment quality criteria are not yet available, these guidelines represent additional thresholds that managers can use to make assessments about benthic habitat condition and the potential for biological impairments. For the most part, sediment monitoring programs in the SCB can use these guidelines, but for selected constituents the reporting limits are above the threshold of interest, therefore hampering the comparison (e.g., silver).

Evaluation of Existing Effort

Sediment monitoring has been a part of each agency's monitoring program since its inception and has proven to be highly effective. Each of the agencies has been able to demonstrate temporal declines in magnitude of discharge effects; most have also been able to demonstrate declines in the spatial extent of discharge effects. Combined with demonstrated declines in mass emissions, the sediment monitoring data have demonstrated the effectiveness of effluent control programs through improvements in the benthic communities and decreases in sediment chemical concentrations. Sediment data have also provided an important foundation for 301(h) waiver decisions.

While sediment sampling programs have been effective for addressing several management questions, they are inefficient for addressing the two questions that managers have indicated during interviews should be addressed: (1) *is the sediment condition (i.e. contaminant concentration and bioeffects) changing over time?* and (2) *what is the spatial extent of sediment impairment (i.e. a map)?* Present sampling designs fail to distinguish these objectives, which have different design needs, resulting in inefficient allocation of effort.

Describing a spatial pattern requires gathering data from as many sites as possible. To describe a spatial pattern efficiently, the number of replicates collected at a site and the number of repeated visits to the site (e.g., quarterly or annual sampling) should be minimized in favor of sampling more sites. In contrast, trend assessments are more efficiently accomplished through numerous repeated visits to a site and replication during each visit.

At present, most programs commingle these two questions in a common sampling design. A large grid of sampling sites are visited repeatedly over time, often many times per year, and often with replicates. Revisiting each site during every survey favors the trend question, but doing so at all sites appears to provide more trend information than is required to address present management questions. As discharge rates have declined and the affected area around discharge pipes has decreased, the need for trend monitoring at all of the historically monitored sites has declined.

The practice of measuring replicates at every site appears to be an artifact of the historical approach of using an ANOVA model for spatial assessment. In an ANOVA design, the condition at each site is evaluated relative to a reference site(s) and replication is necessary to determine whether sites differ statistically. More recently, though, regional reference conditions and indices that quantify condition of an individual sample relative to regional reference condition (e.g., the Benthic Response Index for benthic infauna, iron normalization curves for metals) have been developed through a cooperative regional monitoring program. This has reduced the need for replication to characterize the condition of individual sites, allowing more efficient allocation of effort toward description of spatial patterns at sites where replication is not needed for trend analysis.

A more efficient design would involve dedicating a subset of sites to trend monitoring and increasing the level of repetition, while dedicating a distinct set of sites to spatial descriptions that do not involve repeated visits. Some programs have already started to adopt such a strategy by identifying their most important trend sites and sampling these at higher frequencies, while surveying the entire grid on a less frequent basis, without replication. In some cases, the sites are located along the 60m isobath and are attempting to identify trends in linear gradients. However, all agencies continue to revisit the same sites from year to year.

An opportunity also exists to improve efficiency through the use of power analysis. The OCSD conducted power analysis and demonstrated that the number of samples allocated to trend analysis could be reduced by more than 50% with minimal loss of trend detection capability; these samples were reallocated to enhancing their detection of spatial pattern. Two types of power analysis might yield additional efficiency for the other sediment monitoring programs. The first is in assessing the desired frequency and replication for trend monitoring. Power analysis would provide needed guidance on whether effort is most efficiently allocated to increased replication on each sampling visit or more visits to the site; it would also provide information about the value/loss of increasing or decreasing total effort at individual sites. The second type of power analysis involves spatial modeling. Accurate depiction of spatial patterns requires samples that are close enough together to allow meaningful interpolation, but not so close together as to yield duplicative information. Power analysis can be conducted to define the optimal sampling distance among points to develop cost-effective maps. Both of these types of power analyses will be explored further in subsequent SCCWRP documents.

The design issues above presuppose that the boundaries for the maps of exposure and effects are well known, which is not the case. The area over which monitoring is conducted varies considerably among dischargers, without apparent rationale for these differences. In most cases, the area sampled is the same as when the programs were initiated 30 years ago. Sampling boundaries would be more appropriately established by quantifying the fate of all discharged material and then selecting the area to be studied based on capturing the vast majority of the deposits. None of the agencies have yet quantified the fraction of their discharge that is retained within the sediments of their sampling grids, but the measurement of linear alkyl benzenes, which are a tracer of sewage effluent, in the Bight'98 cooperative regional monitoring program will soon allow this assessment.

The emphasis of the sediment program evaluation is on sampling design, because that is where the greatest gains in efficiency can be achieved. However, the differences in sediment chemical parameters measured among agencies should be eliminated. All agencies are measuring a common set of chemicals that encompasses all of the parameters measured by the national programs and for which sediment quality guidelines are available (Table 5.4). While differences in PCB parameters still exist, all agencies appear to be moving toward a common set of congeners that is at least as extensive as that measured by the national programs. None of the additional chemicals measured by only a subset of agencies appear to be providing additional management information, though there will always be pressure to add new chemicals of potential concern that are not currently measured (e.g., organophosphate pesticides). A superior alternative to continually adding new chemicals to the list of analytes is to measure sediment toxicity as a means of ensuring that unmeasured chemicals are not having biological effects.

Recommendations

- *Disaggregate the spatial and trend components of the current sediment monitoring sampling designs. Reallocating sampling sites dedicated to addressing each of these distinct management questions will improve efficiency and cost-effectiveness.*

The present programs have a single sampling design intended to address both spatial and temporal trend questions, which leads to inefficiency in sample allocation. A more cost-effective program would involve dedicating a subset of sites that receive a repeated visits to assess trend monitoring, while dedicating a distinct set of sites that do not involve repeated visits to achieve description of spatial pattern.

The number and location of sampling sites dedicated to assessing trends is a facility-specific decision, but one that should factor in the size of the locally affected area and the value of the sites that have been monitored to date. For example, many POTWs have a long history documenting changes in gradients along the 60m isobath. If this provides valuable information, then the trends questions should address gradient analysis. Trend evaluation should also encompass various habitats that are potentially impacted, such as depth-related habitats. Most programs already monitor these types of habitats; we recommend that this practice be continued as a means to increase their value in trend analysis. A dedicated effort should also be made to assess trends in reference conditions in similar habitats unaffected by the discharge. Pooling of effort among dischargers may be an efficient technique for accomplishing some of this reference condition assessment. The desired frequency and replication for sampling all of these trend sites should be assessed through power analysis, but certain factors such as recruitment information should be evaluated.

While we recommend that the number of trend sites be reduced, we are also proposing that the number of sites for describing spatial pattern be increased. Preliminary analysis of chemistry data in Santa Monica Bay suggests that spatial covariance is lost over distances smaller than 4 km. Thus, constructing a defensible map probably requires that all areas within the map boundaries be within 2 km of a measured location, with a more desirable distance being less than that. Further analysis to define the relationship between distance and confidence in derived maps of condition is encouraged.

- *Look for opportunities to incorporate measurements of sediment toxicity to increase the number of thresholds for evaluating impairment. Sediment toxicity will become especially useful when sediment toxicity identification evaluations (TIEs) become routinely available, enabling managers to assess which constituents are responsible for toxicity.*

Currently, no programs in the SCB measure sediment toxicity as part of their routine monitoring programs although OCSD has begun to incorporate sediment toxicity tests as part of their strategic process studies. Sediment toxicity would be a useful addition because of its value in interpretation of sediment quality. Sediment quality criteria for assessing chemistry and biocriteria for assessing benthic infauna data are not yet available. To make these comparisons, each of the agencies can only rely upon sediment quality guidelines (e.g., NOAA’s ERL/ERM concentrations) to interpret chemistry data and locally derived indices (e.g., ITI, BRI) to interpret biological data; however, none of the agency or regulatory personnel we interviewed expressed extensive confidence in these substitutes for criteria. Instead, they emphasized reliance on weight of evidence.

The weight of evidence approach is enhanced by more evidence, which we believe sediment toxicity measurement provides.

Sediment toxicity measurement also provides assurance that unmeasured chemicals are not causing a problem, reducing the need to measure a larger array of contaminants in the sediment. Much as water column toxicity measures are used to screen for unmeasured chemicals in effluent, sediment toxicity screens for unmeasured chemicals accumulated in sediment. Sediment toxicity will become even more valuable when sediment toxicity identification evaluations (TIEs) are further developed because TIEs provide a mechanism for identifying the causative toxic agents, if toxicity is encountered. Sediments near wastewater discharges contain a variety of chemical constituents, many of which exceed sediment quality guidelines. The advantage of the sediment TIEs is that it narrows the list of chemicals to only those which are responsible for toxicity, enabling resource managers to focus their actions on effective remedies.

Lastly, sediment toxicity is a standard method used by several national and state programs, providing context for interpreting local trends. Amphipod toxicity tests are used routinely in the California Bay Protection and Clean-up Program, EPA's Environmental Monitoring and Assessment Program, NOAA's National Status and Trends Program, and for dredged material evaluations around the country.

Resource managers should begin to look for opportunities to integrate sediment toxicity into their ocean monitoring programs while sediment TIEs are being developed. Some opportunities exist for accomplishing this integration. The first is regional monitoring which will also serve as a good testing ground for sediment TIEs. A second opportunity might be strategic process studies such as those being conducted by OCSD. Special studies will be particularly valuable at those sites where sediment chemistry and benthic infauna data disagree (e.g. chemistry exceeds sediment quality guidelines and benthic infauna data indicated a health community).

- *Institute an archive program to allow for the possibility of unmeasured chemicals.*

A formal archive program should be instituted to enable evaluation of trends in previously unmonitored chemicals. An archival program would enable the monitoring program to go back in time to assess background conditions, determine the beginning of accumulation, and the rate at which accumulations occurred in sediments. Chemicals in the current era for which such history may have been useful include constituents such as methyl-tert-butyl ether (MTBE) and organo-phosphate pesticides (Chlorpyrifos). Both are coming under intense regulatory and legislative scrutiny, yet neither has been sampled historically in order to provide context to new monitoring measurements.

TABLE 5.1. Infaunal assemblage sampling effort.

Agency	# Stations	# Replicates	Frequency
HTP	33	1	semiannually
	7	1 winter, 5 summer	semiannually
JWPCP	15	1	semiannually
	3	1 winter, 5 summer	semiannually
	26	1	annually
OCSD	10	3	quarterly
	39	1	annually
PLWTP	21	2	quarterly

TABLE 5.2. Sediment chemistry sampling effort.

Agency	# Stations	# Replicates	Frequency
HTP	40	1	annually
JWPCP	41	1	annually *
	3	5	annually *
	18 (subset of above)	1	semiannually *
	21	1	biennially
	3	3	biennially
OCSD	10	3	quarterly
	39	1	annually
PLWTP	23	1	quarterly

* general constituents only

TABLE 5.3. Number of sediment constituent analyses per year.

	HTP	JWPCP	OCSD	PLWTP
General (TOC, AVS)	120	248	297	368
Metals	360	135*	1287	1380
Organics				
DDTs	240	90*	594	552
PCBs	280	45*	4356	644
PAHs	520	195*	4455	2208
phenolics	40	15*	-	-
halogenates	40	15*	-	-
others	280	105*	990	1012

* = half of biennial value

TABLE 5.4. Sediment constituent reporting limits. Also included are sediment quality guidelines (Long *et al.* 1995). NA = not available. Dash = not analyzed.

	HTP	JWPCP	OCSD	PLWTP	Effects Range Low	Effects Range Median
Metals (mg/dry Kg)						
Aluminum	-	-	-	5	-	
Antimony	-	0.18-0.35	-	5	-	
Arsenic	0.2	2	0.01	0.08	8.2	70
Beryllium	-	0.1	0.05	0.2	-	-
Cadmium	0.1	0.7-1.0	0.01	0.5	1.2	9.6
Chromium	2	10	0.5	3	81	370
Copper	4	2	0.5	2	34	270
Iron	-	-	0.6	3	-	-
Lead	0.3	2	0.1	5	46.7	218
Mercury	0.03	0.05	0.02	0.047	0.15	0.71
Nickel	1.2	6	0.5	3	20.9	51.6
Selenium	-	0.73-1.2	0.1	0.11	-	-
Silver	0.03	0.2	0.01	3	1.0	3.7
Thallium	-	0.44-0.85	NA	10	-	-
Zinc	4	11	0.5	4	150	410
Organics(µg/dry Kg)						
DDT	0.5-2.0	1-5	0.1-0.4	0.26-0.94	1.58	46.1
PCB	10-20	10-50	2	NA	22.7	180

VI. FISH MONITORING

Three management questions address fish-related beneficial uses in the SCB. The first question pertains to fish community health, whereby managers examine populations and assemblages of fish (and trawl-caught invertebrates that have proved to be useful indicators). This monitoring is conducted by examining bottom fish rather than pelagic fish because of their increased exposure to outfall particulates. The second question pertains to wildlife protection, whereby managers examine concentrations in fish tissues, in particular liver and muscle tissues, that might bioaccumulate up the food chain in higher order predators such as birds and mammals. This monitoring is also conducted by examining bottom fish species that are not necessarily caught by sport or commercial fisheries. The third question addresses human health issues examining concentrations in fish tissues that might be consumed by the public. This monitoring is also conducted by examining bottom fish species, but focuses on muscle tissue and targets species caught by sport and commercial fishermen.

Compare and Contrast Among Agencies

Fish Community Health

The total effort for fish assemblage monitoring is somewhat comparable among agencies. The number of trawls per year for fish assemblage monitoring varies from 38 to 56 (Table 6.1). The number of fish assemblage trawl stations monitored per year ranges from 9 to 12.

Although the total effort is relatively similar among facilities, inconsistencies were found in trawl replication, frequency and spatial extent of assemblage monitoring.

The number of replicate trawls varies from 1 to 3 among agencies. The JWPCP and PLWTP maintain single trawls at all sites, while both HTP and CSDOC conduct multiple trawls at their 60 m contour sites. The HTP conducts 2 trawls at these stations and 1 trawl at all others sites, while CSDOC conducts 3 trawls at most 60 m stations and 2 trawls at all other sites.

Fish assemblage sampling frequency varies from semi-annually to quarterly among agencies (Table 6.1). Only PLWTP has within-agency differences in sampling frequency, with semi-annual sampling at historic 60 m stations and quarterly sampling at 100 m sites.

The area monitored by trawls differs by a factor of six among facilities (Table 6.1). As with sediment chemistry sampling, the difference in area sampled appears to be more affected by the characteristics of the discharge area than by the annual volume of flow or mass loading. For example, both HTP and JWPCP discharged approximately 340 mgd in 1996. However, HTP maintains 9 fish assemblage trawl stations distributed over approximately 186 km^2, while JWPCP maintains 12 stations over approximately 31 km^2.

Wildlife Protection

The total effort for wildlife protection monitoring is not comparable among agencies. The number of tissue samples analyzed per year varies by a factor of three among facilities, ranging from 39 to 120. The number of stations ranges from 2 to 8 among facilities for fish tissue chemistry, and the sampling frequency varies from semi-annual to annual.

Although eight species are targeted for tissue analysis to address wildlife protection, no single species is measured by all agencies (Table 6.2). Five different species are targeted by only a single agency and only one species is measured by three agencies (hornyhead turbot, *Pleuronichthys verticalis*). White croaker (*Genyonemus lineatus*) and bigmouth sole (*Hippoglossina stomata*) are targeted by only two agencies.

There is little consistency in the approach for selecting tissue types to be analyzed for assessing wildlife protection. The JWPCP analyzes muscle tissue for chemical analysis, whereas HTP, CSDOC and PLWTP analyze both liver and muscle tissues. Sample replication is also inconsistent among facilities. The HTP and PLWTP analyze 3 composite samples for both tissue types in each species, CSDOC analyzes tissues in 10 individuals, and JWPCP analyzes 3 composites for one species (Dover sole, *Microstomus pacificus*) and 10 individual samples for another species (white croaker).

A large discrepancy was found in the types of constituents analyzed in fish tissues (Table 6.3). The number of metals analyzed by each agency ranges from 0 to 17. Only two organic analytes, DDTs and PCBs, are common to all agencies. However, some agencies report PCB Aroclors, while others report congeners. Organic constituents that are not analyzed by all four agencies include additional chlorinated pesticides, PAHs, and phenolic compounds.

Human Health

Not all agencies conduct seafood tissue monitoring. Three agencies conduct rig fishing and two of these agencies also conduct invertebrate tissue chemistry analyses. Of the agencies that do conduct seafood monitoring, the annual number of sportfish tissue samples analyzed differs by a factor of five and the number of invertebrate tissue samples analyzed differs by a factor of three. Although the total effort is not similar, there is parity in the number of stations that are sampled for seafood analysis. The HTP and JWPCP collect fish and invertebrates from three zones, and PLWTP collects fish from two locations (Table 6.4).

Among the agencies that conduct seafood analyses, the sampling frequency for sportfish ranges from three times per year to once every two years. Sampling frequency for invertebrate seafood monitoring ranges from twice per year to once every two years.

No species is targeted by all three agencies that analyze sportfish, or by both of the two agencies that analyze invertebrates (Table 6.5). However, rockfishes (*Sebastes*) are targeted by two facilities. The number of species targeted at each site also differs among facilities. The HTP collects three fish species at each site, PLWTP collects one species of rockfish at each site, and JWPCP specifically targets kelp bass (*Paralabrax clathratus*) at each site.

Both between- and within-agency differences were found in the numbers of sample replicates and tissues analyzed. The HTP analyzes muscle tissue on three individuals of each fish species from sites within the zone of initial dilution (ZID), and muscle from six individuals of each species from sites outside of the ZID. The PLWTP analyzes both muscle and liver on three fish composites from each site. The JWPCP analyzes muscle tissue for 10 individual fish, and liver tissue for 2 fish composites from each site. Tissue and replicate types also differ among the facilities for invertebrate analysis. The HTP analyzes three muscle composites on yellow rock crab (*Cancer anthonyi*) from each site, while JWPCP analyzes gonad from 10 individual red sea urchins (*Strongylocentrotus franciscanus*) from each site.

Evaluation of Existing Effort

Fish Community Health

Over the last 30 years, agencies have been conducting fish monitoring programs to assess impacts to specific fish populations and fish assemblages. Although effects on fish communities were conspicuous at some outfalls in the 1970s, little or no effect has been identified at these local scales for the last 10 to 15 years, other than what can be accounted for by shifts in physical factors (e.g., El Niño). Large-scale surveys, such as the 1994 Regional Monitoring Survey, have led to similar observations; little effect was observed near POTWs other than increased biomass and abundance, while the occurrence of lesions and gross pathologies remained low.

The design for trend monitoring is an important and effective tool for management questions. The public will always want to know the status of fish resources, so resource managers still need to be able to answer these questions. Trend monitoring, where fish population and assemblage condition at impacted and reference sites are compared to previous years, is an effective tool to communicate findings to the public. The efficiency of current designs for trend monitoring needs to be evaluated. Replication and frequency of sampling among sites is inconsistent among agencies and only OCSD has conducted power analysis to determine what the appropriate frequency should be. However, the purpose of this power analysis was to detect changes over space and time (repeated measures-ANOVA). Similar analysis needs to be conducted to assess the appropriate frequency for trend monitoring alone.

Current designs by all of the POTWs commingle spatial extent and trend monitoring. The spatial extent monitoring is inefficient, however, because it provides very little information for decision-making. This is partly due to the lack of effects observed over the last 10 to 15 years. No effects have been observed in fish population or assemblages because these parameters are relatively insensitive to current effluent discharges. Variability from haul to haul is naturally high, making differences from site to site difficult to detect on a local scale. Large-scale changes in fish populations, however, are important for environmental decision-making. This is particularly so when managers try to assess the effect of cumulative discharges or attempt to evaluate local changes in relation to widespread changes in abundance that are occurring throughout the SCB.

Sublethal impacts are largely ignored by most POTW monitoring programs. Sublethal impacts, however, are more sensitive and can indicate exposure to pollutant inputs. The OCSD is the only agency that routinely measures histopathology during its fish surveys; it chronically finds differences among fish caught from impacted areas compared to reference conditions. Other investigators, including SCCWRP, have also observed increases in other subcellular biomarkers. Unfortunately, these indicators are not developed to the extent that management decisions can be made from this monitoring data. For example, a link has not been established between histopathology and outfalls as an epicenter for disease. As research in the area of sublethal impacts continues to assess these cause-and-effect relationships, these indicators may become effective tools for evaluating exposure and potential impacts.

Wildlife Protection

The POTW monitoring for wildlife protection has been effective at addressing management questions that assess trends within each agency. Every agency has a historical record for its respective species and tissue types, some dating back more than 20 years. These data sets have shown decreases in tissue concentrations, at times more than an order of magnitude, since the 1970s. These data sets are extremely useful management tools, particularly when combined with reductions in mass emissions and improvements in sediment chemistry and biota.

Although tissue monitoring provides managers with the ability to assess trends, it has been ineffective at assessing spatial extent. This can be attributed, in part, to differences among programs. Integrating monitoring results among agencies is hampered by incomparable monitoring designs. For example, no single species and tissue type was monitored by all agencies.

Current monitoring designs for wildlife protection are not optimal for making assessments of spatial extent due to the lack of sufficient sampling sites at local scales.

Our comparison of programs showed as few as three sites per program. However, the spatial extent of bioaccumulation is not necessarily a local issue and should encompass the cumulative contributions from all sources that discharge to the ocean as well as the large range in tissue concentrations from reference areas. Moreover, large-scale regional estimates of wildlife protection provide useful data to managers for informing the public or for decision-making. Currently, only the regional monitoring program provides these integrated assessments at the proper spatial scale and where the costs are appropriately shared among stakeholders. For example, the 1994 Regional Monitoring Survey demonstrated that only 2 of 14 chlorinated hydrocarbons were detectable in the SCB, but that total DDT and total PCB were widespread in fish tissues. Even if all of the agencies were comparable in design and methodology, integrating the local programs could not have provided this assessment.

Human Health

The seafood monitoring programs have been ineffective at assessing management questions regarding human health. Only three of the four largest POTWs conduct seafood sampling and analysis as part of their routine monitoring. Moreover, no common approach or design has been adopted for making assessments of seafood safety among these three agencies. For example, the programs sample and analyze a variety of species, at dissimilar frequencies, and with different target analytes. This has begun to change, with both HTP and JWPCP working together to jointly design a program for Santa Monica Bay.

The lack of monitoring by some agencies, coupled with inconsistencies among agencies that do monitor, prevent finding an answer to what should be a regional question. *Is the seafood safe to eat?* is a question that needs to be addressed not just near POTW outfalls, but at all locations where fish are caught for consumption. For example, no routine monitoring program has been established for fish that are caught by sport fishermen off commercial passenger fishing vessels, piers or beaches. Not only is seafood monitoring a regional question, but the sources of seafood contaminants need to be more broadly defined and costs appropriated. Although POTWs are not the only contributor of pollutants that can bioaccumulate in seafood, they are the only group of dischargers that conducts routine seafood monitoring.

Perhaps the greatest inefficiency in the seafood monitoring program, however, is that the POTWs are not the managers that make decisions about seafood for human consumption. It is CalEPA's Office of environmental Health Hazard Assessment (OEHHA), not POTW managers, which post fish advisories or closures. Therefore, the primary decision-makers are not integrated into the monitoring design. Once again, this has begun to change in Santa Monica Bay, where OEHHA assisted in the development of the new HTP and JWPCP seafood monitoring design.

Recommendations

- *Focus fish population and community monitoring on trend sites since spatial extent questions are inefficiently addressed through local monitoring. Spatial extent questions for answers to fish population and community impacts should be addressed through regional monitoring.*

Significant effort has been expended in an effort to answer spatial extent questions at local scales. We recommend that monitoring programs focus fish population and community monitoring on addressing management questions regarding trends and that the spatial extent effort be redirected towards large, regional-scale designs that can capture large portions of a species range in the SCB.

Although we recommend that the spatial monitoring effort be reduced, we do not recommend that all fish monitoring be eliminated at local scales. Fish monitoring provides important information that managers need to report to the public. Maintaining a reduced number of core trend sites will fulfill this need. The frequency of this monitoring should be optimized based upon power analysis using historical data. Managers can evaluate whether population or community parameters are increasing, decreasing or remaining stable over time. Similar to our recommendations for sediment monitoring, we propose that different habitats be monitored in areas that could potentially be affected, such as depth-related habitats . Most programs already monitor these types of habitats; we recommend that this practice be continued as a means to increase their value in trend analysis. The remaining sites should be in the same habitats, but located in reference areas unaffected by the discharge. Pooling of effort among dischargers may be an efficient technique for accomplishing some of this reference condition assessment.

- *Fish tissue monitoring for wildlife protection should be divided into two questions: one question for local monitoring to address trends and a second question for regional monitoring to assess spatial extent.*

The POTWs have been conducting fish tissue monitoring for wildlife for many years. During this time, they have effectively developed an extensive history demonstrating decreases commensurate with effluent and sediment reductions. However, the current programs measure a variety of species and tissue types and are so incomparable that they cannot be integrated. Therefore, we recommend that fish tissue monitoring for wildlife protection be divided into two questions. The first question should address trends in fish tissue concentrations at local scales. The second question should address the spatial extent of fish concentrations at regional scales.

Trend monitoring at local scales will enable resource managers to assess whether discharges are accumulating in local biota. The same sites that are sampled for fish populations (see previous recommendation) can be utilized for this element. By monitoring these sites over time, resource managers can assess whether these concentrations are increasing, decreasing or remaining stable over time.

We recommend that existing species and tissue types be sampled for local trend monitoring. In some cases, a 25-year history of tissue concentrations has been amassed that will prove valuable if the target species and tissues remain the same. However, some flexibility should be allowed to make minor additions in the future. Our comparison of programs identified a large discrepancy in the list of analytes that are measured in current programs. We suggest that only substances that bioaccumulate be measured in local fish tissues. These compounds include the chlorinated hydrocarbons (DDTs, PCBs) and few metals (Hg, Se, As). Finally, we suggest that multiple tissues are not required for trend analysis. Our comparison of programs identified that both muscle and liver are measured in most programs. Chlorinated hydrocarbons are approximately 10-fold more concentrated in livers than in muscle. Trends are most useful when detectable levels are consistently measured. Therefore, liver is the preferred target tissue for local trend monitoring, though individual facilities may need to use another tissue type to maintain their historical record.

Regional monitoring can provide answers such as "percent of area with concentrations above thresholds for wildlife consumers" to resource managers. Unfortunately, no single species has a range that covers the entire area of the SCB. Therefore, we recommend that fish guilds be used to gain the necessary large spatial coverage. Fish guilds are a set of fish species that perform similar ecological roles, but live in separate habitats (e.g., depth zones). Recent SCCWRP research suggests that sanddab guild species bioaccumulate chlorinated hydrocarbons at similar rates because of their similarities in exposure to sources such as sediment and sediment-dwelling prey. Secondly, we recommend that whole fish be used for regional assessments. The goal of wildlife protection assessments is to assess whether chemicals present at lower trophic levels endanger consumers that swallow prey whole.

- *Seafood monitoring for public health is a regional question and should be integrated with CalEPA's Office of Environmental Health and Hazard Assessment (OEHHA). This monitoring should be shared equitably among all dischargers to the ocean.*

Resource managers for POTWs need to know if their discharges, in combination with other discharges, are accumulating in seafood and presenting a public health risk. Unfortunately, the resource managers from POTWs are not the main users of data on seafood concentrations. Instead, OEHHA has the jurisdiction for issuing advisories and closures of commercial and recreational harvesting areas. Moreover, POTWs are not the only source of inputs to the ocean of contaminants that can accumulate in seafood; therefore, their resource managers are in no position to take all the actions that need to be taken. We recommend that the current monitoring programs be integrated with OEHHA's monitoring designs to address the management needs for closures and advisories. Furthermore, we recommend that other sources that contribute to accumulations in seafood share in the burden of this monitoring effort. The share of monitoring each discharger should be responsible for should be proportional to the amount of constituent that they have discharged to the ocean.

TABLE 6.1. Fish assemblage trawling effort.

	HTP	JWPCP	OCSD	PLWTP
# Trawls/year	56	48	44	38
Sampling frequency	Quarterly	Quarterly	Semiannually	Quarterly/ Semiannually
Area sampled (km^2)	186	31	36	75
Trawl depths	18 m	23 m	18 m	60 m (semiannual)
	60 m	61 m	36 m	88 m (quarterly)
	150 m	137 m	55 m	104 m (quarterly)
			60 m	
			137 m	

TABLE 6.2. Target species for trawl-caught fish bioaccumulation that can be used for wildlife protection assessments.

Species	HTP	JWPCP	OCSD	PLWTP
white croaker	–	M	M,L	–
hornyhead turbot	M,L	–	M,L	M,L
bigmouth sole	–	–	M,L	M,L
dover sole	–	M	–	–
barred sandbass	–	–	M,L	–
longfin sanddab	–	–	–	M,L
pacific sanddab	–	–	–	M,L
CA scorpionfish				M,L
speckled sanddab	–	–	–	M,L
kelp bass	-	L	-	-

M = Muscle

L = Liver

TABLE 6.3. Constituent analysis reporting limits for fish and invertebrate tissue samples. Dash = not analyzed.

	HTP muscle	HTP liver	JWPCP muscle & liver	OCSD muscle & liver	PLWTP muscle & liver
Metals (mg/ wet Kg)					
Aluminum	-	-	-	-	2.6
Antimony	0.07	0.25	-	-	3.7
Arsenic	0.1	0.5	-	-	1.4
Beryllium	0.01	0.05	-	-	0.035
Cadmium	0.04	0.04	-	-	0.34
Chromium	0.1	0.08	-	-	0.33
Copper	0.26	0.28	-	-	0.76
Iron	-	-	-	-	1.3
Lead	0.2	0.6	-	-	2.5
Manganese	-	-	-	-	0.2
Mercury	0.02	0.17	-	0.02	0.012
Nickel	0.15	0.5	-	-	0.79
Selenium	0.12	0.6	-	-	0.13
Silver	0.01	0.05	-	-	0.62
Thallium	0.1	0.5	-	-	5.7
Tin	-	-	-	-	4.6
Zinc	0.7	1.2	-	-	0.58
Organics					
DDT (µg/wet Kg)	0.5-2	0.5-2	5	0.1-0.6	8.8-48.4
PCB (µg/wet Kg)	10-20	10-20	20	4.9	4-7
Remaining organochlorine pesticides (µg/wet Kg)	0.5-15	0.5-15	-	0.1-8	0.6-1.9
Total organic halides (mg/wet Kg)	7	-	-	-	-
Base/neutral/acid extractables (mg/wet Kg)	0.16-325	0.16-325		7-25	0.012-0.48

TABLE 6.4. Sportfish sampling effort.

	HTP	JWPCP	OCSD	PLWTP
# Stations	3 zones	3 zones	-	2 zones
# Samples / year	90	18*	-	24
Sampling frequency	triannually	biennially	-	semiannually

* = half of biennial value

TABLE 6.5. Seafood target species.

HTP	JWPCP	OCSD	PLWTP
white croaker	white croaker		Sebastes sp.
CA scorpionfish	kelp bass		
ocean whitefish	red sea urchin		
reef perch			
barred sandbass			
cabezon			
Sebastes sp.			
yellow rock crab			

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APPENDIX A

MONITORING QUESTIONS

Introduction

The first step in creating any monitoring program is to identify why monitoring is needed. In the context of our Model POTW Monitoring Program, we established this need by asking questions. These questions embody the information that resource managers need to make decisions. If the answer to a specific monitoring question is "yes," then the manager makes one decision. If the answer is "no," then an alternative decision is made. If there is no answer, or the answer does not trigger a decision, then the need for that information should be critically evaluated. A monitoring question should always have some decision value.

The audience for monitoring programs is widely varied and so are the questions they ask. At one end of the spectrum are upper level resource managers who typically ask very general questions. These questions include: Is it safe to swim? Is it safe to eat the seafood? Is the ecosystem being protected? The questions are general at this level because they reflect the concerns of the public to whom the managers are ultimately responsible. At the opposite end of the spectrum are scientists who ask very specialized questions. They ask detailed questions because they have a need to define the specifics of how, when and where they will collect and analyze physical, chemical and biological data. One challenge in developing a model monitoring program is to ensure a connection among the questions being asked by the different levels of participants in the monitoring process.

We've made the connection between policy-level and scientist-level needs by creating **Management Questions.** Management questions are those typically asked by mid-level managers who use monitoring information to make decisions. These mid-level managers often serve as the interface between the scientists that collect and analyze monitoring data and the upper level resource managers that must interact with regulatory boards and the public. In most cases, there will be many management questions associated with each policy question and many scientific questions associated with each management question.

Goals of This Document

The goal of this document is to generate a list of management questions for a Model POTW Monitoring Program. Monitoring questions are the single-most important aspect of designing a model monitoring program. The monitoring question, which implies a lack of knowledge, provides the need for a monitoring program. None of the other design or implementation steps that follow can be accomplished if we do not first produce adequate monitoring questions that enable us to focus our effort and resources. If we do not develop the correct questions, or they are framed improperly, the sampling design may not be optimal for the results needed to make important management decisions. This would result in an unnecessary allocation of monitoring effort, eventually increasing the overall cost of a monitoring program.

Undoubtedly, many management questions will need to be answered. However, it will be important to identify the most important questions that the statistical design should address in the next steps of model program development. Our objective, therefore, is to identify the common elements in the monitoring questions and prioritize these for further model program development. Some management questions are site-specific or apply to unique agencies. By focusing on the most universal management questions, we will be able to incorporate designs that all agencies can utilize.

Approach To Developing Monitoring Questions

We spent over one year with upper and mid-level managers and have developed the most important management questions to be answered in a Model Monitoring Program. The questions were derived using three techniques. First, we reviewed existing literature to assess what important monitoring needs have already been identified and what significant findings current monitoring programs have already addressed. Second, we reviewed each of the large and small POTW monitoring permits in the SCB and distilled this information into a series of monitoring questions. Third, we interviewed monitoring specialists from the largest POTW dischargers in southern California and the NPDES permit writers from each of their respective regulatory boards. In these meetings, we asked what the most important policy questions were, what the greatest monitoring information needs were for management and what scientific details were most relevant to their monitoring programs. Finally, we discussed these questions, as a group, on a quarterly basis from 1998 to 1999.

One of the most important attributes of a proper management question is to ensure that the question has decision value. That is, once the monitoring has been accomplished, the results should feed directly into a decision-making process. Therefore, as we developed the list of management questions, we focused on four types of information for each:

- **Management Information Need** - Why does the manager need to know the answer?
- **Decision Criteria** - What criteria will be used for deriving an answer to the question?
- **Expected Product** - How should the answer be expressed?
- **Possible Management Actions** - What actions will be potentially influenced by the answer?

By focusing on these four "decision value" criteria, we ensured that monitoring would provide the information necessary to communicate scientifically technical data to upper management and satisfy the public's need to know.

Design of This Document

We have designed this document to correspond to the five different media that are monitored in the SCB. These media include:

- Effluent
- Water Quality
- Microbiology
- Sediment
- Fish

Within each programmatic element, we list the most important management questions refined through our development process, providing justification, rationale, and decision value for each.

Other media are monitored in the SCB including programmatic elements such as kelp, rocky sub-tidal and rocky intertidal areas, birds and mammals. While these media were partially addressed during our development process, we do not focus on them in this document due to the fact that these media are not held in common among all agencies.

Effluent Monitoring

The most important management questions for effluent monitoring are:

- *Is the effluent concentration of selected constituents below levels that will ensure public safety and protect aquatic life?*
    - *What are the mass emissions of selected materials that are discharged annually?*
- *Is the effluent concentration or mass emissions changing over time?*

- *Is the plant operating efficiently?*

The primary reason for monitoring final effluent concentrations prior to discharge is to assess the potential risk to the receiving water, especially in the water column. Measuring trace quantities of constituents in the water column after discharge has been very challenging technically. However, trace quantities that cannot be measured still have the capability to induce impairments to beneficial uses. Therefore, regulatory agencies have placed water quality objectives on final effluents where concentrations are much higher and are technically easier to sample and measure. Regulatory policies, such as the California Ocean Plan (Ocean Plan) (SWRCB 1997) apply risk-based models to predict harmful concentrations in the environment. The risk-based models are designed for beneficial uses including seafood consumption (public safety) and protection of aquatic life. The local Regional Water Quality Control Boards then apply these water quality objectives using a credit for dilution to back-calculate what concentrations in effluent should be for writing specific discharge permits. In this way, resource managers now have the decision-making tool to evaluate if the concentrations in their discharge have the capability to impair beneficial uses. These monitoring data can be used to trigger source tracking or initiate receiving water monitoring for the potential effects, among other actions.

A second method that is used for predicting risk to aquatic life is the use of toxicity tests. These tests expose sensitive life stages of marine organisms to final effluent (after salinity adjustment) to assess their acute or chronic impact (U.S. EPA 1995). The advantages of these tests are two-fold. First, the risk is directly measured instead of modeled. Second, the toxicity tests can capture toxicity that occurs from unmeasured constituents or from synergistic effects of multiple constituents below their individual water quality objectives. Resource managers can use toxicity monitoring to assess if their discharge is toxic, trigger toxicity identification evaluations (TIE) and track sources or modify the treatment process to reduce environmental risk.

Mass emissions are an important contributor to the effluent monitoring program because they provide resource managers with the tool to compare contributions of constituents from different facilities or groups of facilities (e.g., one POTW versus another POTW or all POTWs versus urban runoff). Identifying which facilities contribute the greatest mass emissions helps managers effectively utilize their resources to reduce inputs. Smaller contributors, where even severe management actions will result in minute changes to the total load, should become a lower priority for concern. Finally, as mass-based regulations become more important, such as total maximum daily loads (TMDLs), mass emission monitoring will become critical in evaluating compliance.

Both mass emission and effluent concentration monitoring enable resource managers to track discharges from a single facility over time. If effluent concentrations or mass emissions from a facility are increasing over time, then resource managers can use this information to carefully consider if management actions are necessary. On the other hand, if a more drastic management action is taken, monitoring for trends in mass emissions of effluent concentration can enable that resource manager to document the improved discharge and reduction in risk to beneficial uses.

Monitoring of effluents for plant performance is another useful program for facility performance. Measurements of common POTW constituents such as suspended and dissolved solids (TSS, TDS), biological oxygen demand (BOD) and others provide invaluable information to facility managers on how well their plant is functioning. Plant performance, however, is not within the scope of this document. Instead, this document focuses on potential impacts to receiving waters in the coastal oceans of the SCB. In reality, facility managers will measure these general constituents at frequencies that address internal operations, regardless of what regulatory agencies may request. Therefore, this document does not address the monitoring question regarding plant performance.

Water Quality Monitoring

The most-important management questions for water quality monitoring are:

- *Are water column physical and chemical parameters within the ranges that ensure protection of the ecosystem?*
- *What is the fate of the discharge plume?*

POTWs design their outfalls to quickly mix and diffuse with receiving waters in the SCB. Most POTWs conduct water quality monitoring to assess if their plume has been sufficiently mixed to maintain protection of the ecosystem in receiving waters. Many water column ecosystems are particularly susceptible to reductions in light or alterations in pH and dissolved oxygen (D.O.). Light reduction can contribute to a decrease in primary production that will have a ripple effect through the ecosystem may eventually leading to reductions in fish abundance and assemblage parameters. Alterations in pH and D.O. can have acutely toxic effects on fish and other invertebrates; D.O. reductions have been responsible for fish kills in other affected ecosystems around the nation.

The California Ocean Plan stipulates numerical water quality objectives for attainment in the receiving waters near the vicinity of a discharge. The water quality objectives are for light transmittance, pH, and D.O. One of the primary management questions is to assess if the levels near the discharge are meeting Ocean Plan objectives and that the ecosystem is being protected.

An equally important, but distinctly different question that managers need to know is where their plume is going. Although light transmittance, pH, and D.O. may be within acceptable limits, there are concerns beyond water column ecosystem health. First, most managers need to know if their plume is moving towards shore where it may encroach upon water contact zones. In this case, human health concerns are of interest and additional water quality thresholds exist for bacteria (*see microbiological monitoring*).

Second, plume direction and mixing has a direct effect on sediment loading. Although, light transmittance may be within acceptable levels for water column assessments, the direction of the plume determines where the discharged particles will eventually settle. Years of accumulations may affect sediments in locations where the plume direction is most consistent. In this case, ecosystem health issues are primary concerns in terms of habitat quality and impairments of benthic communities (*see sediment monitoring*).

Microbiological Monitoring

The most-important management questions for microbiological monitoring are:

- *Does sewage effluent reach water contact zones?*
- *Are densities of bacteria in water contact zones below levels that will ensure public safety?*

The primary motivation for measuring bacteria in receiving waters is for managers to determine if POTW discharges are encroaching upon beneficial use areas such as body-contact recreation zones (i.e., swimming, surfing, diving) and shellfish harvesting grounds. Bacteria are conservative tracers of fecal contamination and are often measurable when other indicators, such as salinity or turbidity, are not sensitive measures. Resource managers can use microbiological monitoring to evaluate if fecal sources are present and, if sampled across a spatial gradient, monitoring can be used to infer sources and/or transport of bacteria.

Resource managers need to assess whether contamination is present and if the levels are high enough to be a public health risk. In the case of three bacteria (total coliform, fecal coliform, and enterococcus), water quality thresholds have been established that set levels of acceptable risk for body-contact recreation and shellfisheries (SWRCB 1997, AB411). By using these thresholds, resource managers have the tool they need, in conjunction with microbiological monitoring, to assess if unacceptable risk is present and whether beach warnings or closures need to occur.

Sediment Monitoring

The most important management questions for sediment monitoring are:

- *Is sediment in the vicinity of the discharge impaired?*
- *If so, what is the spatial extent of sediment impairment?*
- *Is the sediment condition changing over time?*

Sediments integrate constituents that are discharged to the ocean. The particles that come from POTW discharges, and any associated contaminants, will eventually settle to the seafloor where they are incorporated into the existing sediments. Sediments accumulate these particles over the years until the point where sediment quality has degraded and beneficial uses are impaired. The beneficial uses most often associated with sediment quality are aquatic life and public safety (seafood bioaccumulation). Public safety is addressed in the chapter on fish monitoring (although bioaccumulation in invertebrates can also occur). Impairment of sediment quality that can affect aquatic life is monitored by assessing habitat quality such as grain size and organic carbon content, sediment contamination such as anthropogenic constituents, biological communities such as balanced indigenous populations, and interactions among all three components such as sediment toxicity.

Resource managers can utilize sediment monitoring to assess if discharges are affecting receiving waters. Resource managers can use sediment monitoring as a means to evaluate if effluent concentrations or mass emissions are accumulating in receiving water environments, especially if they exceed water quality thresholds. An assessment of magnitude and/or spatial extent of impairment enable resource managers to rank sites and evaluate which locations are most critical for immediate action. Finally, sediment monitoring can be used for beneficial use assessments in other program elements, particularly assessments of impairment to fish.

Answering the management question "*Is sediment near the discharge impaired and, if so, how much is impaired?*" is a two-step process. Resource managers will first want to establish that there is an impact near their discharge before extending their monitoring to greater distances. Alternatively, if there is no impact near the discharge, then additional sampling is unwarranted. This example of adaptive monitoring, whereby resource managers can use the monitoring to establish further need, is an efficient mechanism for minimizing costs and increasing effectiveness of a program.

One of the most effective means for communicating spatial extent is a map. Maps have the capability to add context to interpreting results that long tables of data cannot convey. Maps are easily understood by non-technical audiences. Maps can be especially useful for transmitting magnitude and spatial extent information by the addition of contours. Contours of increasing sediment concentration, contours of numbers(s) of indicators that exceed thresholds, and contours of previous year(s) extent are all insightful tools to relay detailed information in a meaningful format that will provide the appropriate context to decision-makers.

Resource managers can utilize trends in sediment condition to make decisions regarding the need for additional actions. If the trend in sediment condition is improving, then the manager can utilize this information to demonstrate that the actions already undertaken have been effective at reducing risks to beneficial uses. If the trend in sediment condition is getting worse, then little or no action may be necessary if the trend is small or the condition of sediment is already very good. However, if the trend is getting worse and the level is near or above some action level, then the need to take action increases. If there is no trend, then little or no action may be required.

Fish Monitoring

The most important management questions for fish monitoring are:

- *Is the health of fish communities changing over time?*
- *Is the population of selected species changing over time?*
- *Is fish tissue contamination changing over time?*
- *Are seafood tissue concentrations below levels that will ensure public safety?*

Fish monitoring helps to assess impacts to two beneficial uses. The first is aquatic life and the second is public safety (seafood bioaccumulation). The monitoring questions above fall into three categories for resource managers. The first two questions are in response to managers' needs to assess whether populations and assemblages of fish are normal and not degraded. The third question addresses wildlife protection; contaminants can bioaccumulate in fish and harm the fish or its predators after consumption. The fourth question addresses public health; contaminants that bioaccumulate in fish that can harm humans after consumption.

Protection of fish communities and recreational/commercial fishing are among the greatest public concerns of all the receiving water monitoring elements. Managers need to be able to address the public's concern, which is most effectively accomplished by trend analysis. Alterations in communities of fish and important species are easily assessed and communicated to the public by comparing current years to previous years. Moreover, fish populations and community structure can be related to water quality variables such as temperature. Since fish populations extend over wide areas, and water quality variables such as temperatures are wide-scale phenomenon (i.e., El Niño), this essentially becomes a regional question.

Similar to the community and population questions, resource managers can assess wildlife protection questions by assessing fish tissue concentrations over time. Unlike the community and population questions, however, tissue concentration thresholds exist (Environment Canada 1997). This is extremely important because this enables resource managers to answer new questions regarding changes in area and proportion of fish that exceed limits of concern. Assessing the percent of fish or percent of fishing area that exceeds thresholds of concern adds tremendous context to management decisions, especially if these measures of extent are increasing over time. Resource managers should be concerned about contaminants that bioaccumulate in fish because they can induce harm in the fish itself by making them more susceptible to disease or predation. Also, contaminants that bioaccumulate in fish can be passed up the food chain to biomagnify in the higher order wildlife consumers such as birds and marine mammals.

Fish tissue concentrations are a priority for many managers to answer questions regarding human consumption and public health. Strict thresholds have been established by state (CalEPA) and federal (FDA) governments for tissue concentrations of several constituents. Fish tissue monitoring will address managers' needs by assessing if the levels are above or below these thresholds. We phrased the public health question in terms of trends because managers need to know not only if the levels are above or below thresholds, but if they are increasing or decreasing over time. If they are increasing, and near the threshold, then management action may be imminent. If they are increasing, but well below the threshold, then only continued monitoring may be necessary. If they are increasing and above the threshold, then management action is necessary.

Summary of Decision Value Criteria for Priority Management Questions

Management Question	Information Need	Decision Criteria	Expected Product	Potential Action
Effluent Monitoring				
Is the effluent concentration of selected constituents below levels that will ensure public safety and protect aquatic life?	Managers needs to know if effluent concentrations are high enough to represent a potential risk to public or ecosystem health. Risk assessors can estimate the potential for bioaccumulation or toxic exposure in the receiving waters based upon effluent concentrations and predicted dilution. These are the tools used to set numerical criteria for effluent.	Ocean Plan objectives and permit limits, toxicity tests.	Table of constituent concentrations, water quality threshold, and indication of exceedence. Toxic unit summaries.	Examine toxicity test data, look for constituent in ambient monitoring elements, examine trends question. Use an adaptive trigger to increase frequency to reassess data distribution and frequency of exceedence. Use an adaptive trigger to begin a Toxicity Identification Evaluation (TIE). If severe, source ID program.
What are the mass emissions of selected materials that are discharged annually?	Managers need to know the total mass emission of their respective discharge, and what percentage of the total mass emission to the Bight this represents.	Relative to other agencies and sources, relative to influent. Compared to performance goal or waste load allocation for TMDL.	Bar chart or pie chart of combined loads from all sources.	If large piece of pie, then trigger adaptive strategy to improve confidence in load estimate. Examine sediment questions.
Is the effluent concentration or mass changing over time?	A manager wants to know if increases in effluent mass or concentration is an environmental problem they need to address, or alternatively, if the mass is decreasing, have the management actions already been effective.	Historical performance.	Graph of concentration or mass over time.	The relationship between the trend in effluent mass and the total mass emission limit will alter the amount of response required to comply with the limit. If increasing, examine sediment questions.

Management Question	Information Need	Decision Criteria	Expected Product	Potential Action
Water Quality Monitoring				
Are water column physical and chemical parameters within the ranges that ensure protection of the ecosystem?	Managers need to demonstrate that the discharge is not adversely affecting the physical and chemical characteristics of ocean waters within the waste field where initial dilution occurs. In order to protect the ecosystem, managers must verify that the POTW is meeting the numerical and narrative water quality objectives.	Ocean Plan Objectives for light transmittance, pH, dissolved oxygen. Levels relative to reference condition.	Table of number of days that exceeded thresholds by parameter.	If exceed threshold, assess spatial extent and frequency of exceedences.
What is the fate of the discharge plume?	Is the plume moving towards shore. Managers should be able to tell public where the plume goes. What is the extent of water column alterations.	Use conservative tracer of plume such as salinity or indicator bacteria for determining where the plume is going. Use Ocean Plan criteria for exceedences.	Plume map with isoclines estimating the frequency of occurrence at different distances. Table of volume-days that exceed water quality thresholds.	If large area, trigger adaptive strategy to assess biological impacts and incorporate other measures (i.e. nutrients and chlorophyll). If moving into water contact areas, trigger additional microbiological monitoring

Management Question	Information Need	Decision Criteria	Expected Product	Potential Action
Microbiological Monitoring				
Does sewage effluent reach water contact zones?	Water-contact zones adjacent to POTWs are often influenced by more than one anthropogenic source. Therefore, the POTW manager must know if the effluent is contributing to the degraded water quality at water-contact zones. The manager needs information not only concerning effluent incursions from the discharge zone, but also about sewer line breaks and overflows into the stormwater system.	Comparison of bacteria levels to reference condition.	Plume location map. Table or map of affected sites.	If there is an indication that the plume is reaching the water-contact zone, this justifies the need for further management action such as triggering an adaptive strategy to increase frequency or spatial extent
Are densities of bacteria in water contact zones below levels that will ensure public safety?	Once a plume intrusion has occurred, the manager needs to know if the severity, both in magnitude and duration, represents a potential health risk.	Ocean Plan Objectives, AB411 Standards.	Table or map of densities at specific locations, Table of number of days that exceed thresholds.	If above standards, contact Public Health Agencies. If near drain, notify stormwater agencies. If chronic, trigger a special study to track upstream sources.

Management Question	Information Need	Decision Criteria	Expected Product	Potential Action
Sediment Monitoring				
Is sediment in the vicinity of the discharge impaired?	A manager needs to know if the discharge has accumulated in the environment and is impairing ecological health.	Comparison of indicators to reference condition.	Table or chart of chemistry, biology, toxicity relative to reference conditions for sites near the outfall.	If impaired, trigger spatial extent questions. Examine mass emissions question. Examine Fish question.
If so, what is the spatial extent of sediment impairment?	Once the sediment is known to be impacted, the manager needs to know how big of an area is affected. The severity in the spatial distribution will guide the extent of possible management actions.	Comparison of indicators to sediment quality guidelines/criteria, Biological indices/criteria, and magnitude of toxicity endpoints.	Map of impacted area. Contours can add context.	Examine trends question. Examine plume extent question. Trigger special studies to examine cause-and-effect.
Is the sediment condition changing over time?	Increases in the area or magnitude of sediment impairment justifies the need for action. Alternatively, if the area or magnitude of concentrations are decreasing, the manager will know that previous actions have been effective. The relationship between the trend of sediment contamination near the outfall, and conditions at a reference site will alter the amount of response required.	Relative to magnitude or spatial extent over time.	Graphs of various indicators over time. Maps with shrinking/growing contours.	If getting bigger and worse, examine effluent mass and fish question. Trigger special studies to address fate-and-transport including other potential sources.

Management Question	Information Need	Decision Criteria	Expected Product	Potential Action
Fish Monitoring				
Is the health of fish communities changing over time?	Communities of indigenous species need to be balanced.	Ocean Plan Narrative Standards. Assemblage parameters, guidelines/biocriteria	Table of assemblage parameters relative to regional condition. Graph of assemblage parameters at discharge location and reference condition over time.	If communities are declining relative to reference condition, trigger adaptive strategy to assess spatial extent. Evaluate tissue accumulation.
Is the population of selected species changing over time?	Selected populations need to be healthy and sustainable.	Ocean Plan Narrative Standards. Density and catch per unit effort for selected species. Gross extemal pathologies.	Table of population parameters relative to regional condition. Graph of population parameters at discharge location and reference condition over time.	If populations are declining relative to reference condition, trigger adaptive strategy to assess spatial extent. Evaluate tissue accumulation. Trigger special studies to assess cause-and-effect.
Is fish tissue contamination changing over time?	Fish tissue contaminant concentrations are to be below levels that would adversely affect the fish or their consumers. Numerical quality objectives are not available in the Ocean Plan, but predator protection limits are available in the scientific literature.	Ocean Plan narrative standards. Predator protection limits. Ecological risk assessment benchmarks from Cal EPA or others.	Table of tissue contaminant concentrations at POTW site, reference condition, and predator protection limit. Estimate of percent of area and percent of fish that exceed limit. Create map showing locations of exceedences and magnitude.	If increasing, examine population and community structure. Evaluate sediment levels. Trigger an adaptive program that evaluates biomarker or biochemical impairment. Trigger special study to assess accumulation mechanisms and evaluate if higher-order consumers are being affected.
Are seafood tissue concentrations below levels that will ensure public safety?	Fish tissue contaminant concentrations are to be below levels that would adversely affect human consumers.	FDA action limits.	Table of tissue contaminant concentrations at POTW site, reference condition, and action limit. Create map showing locations of exceedences and magnitude.	If near or above limits, contact CalEPA. Increase trend monitoring program. Trigger a special study for sources.

APPENDIX B

COMMISSIONS' TECHNICAL ADVISORY GROUP RESPONSE LETTER

January 18, 2000

Memo to: The SCCWRP Commission---

Art Coe, Regional Water Quality Control Board, San Diego Region; Commission Chair
Judith Wilson, City of Los Angeles Bureau of Sanitation; Commission Vice-Chair
Charles Carry, Los Angeles County Sanitation Districts
Dennis Dickerson, Regional Water Quality Control Board, Los Angeles Region
Robert Ghirelli, Orange County Sanitation District
Janet Hashimoto, US Environmental Protection Agency, Region IX
Alan Langworthy, City of San Diego Metro Wastewater Dept.
Stan Martinson, California State Water Resources Control Board
Gerard Thibeault, Regional Water Quality Control Board, Santa Ana Region

From: CTAG, the Commission's Technical Advisory Group

Re: Development of a Model POTW Monitoring Program: Review of Existing Programs (Nov. 22, 1999)

Attached are abbreviated CTAG comments on SCCWRP's independent review of existing NPDES monitoring programs for the four largest Southern California POTWs: City of Los Angeles, Los Angeles County Sanitation Districts, Orange County Sanitation District, and City of San Diego. Although this first phase of the development of a model monitoring program is a "Review of Existing Programs", SCCWRP relies heavily on recommendations to summarize its assessment of current programs. Therefore, CTAG has focussed on these recommendations made for effluent, water quality, microbiology, sediment and fish monitoring.

Regulators generally agree with SCCWRP's recommendations, and therefore did not provide specific comments. POTWs have significant reservations with the proposals. To POTWs, it is an important issue whether a particular program recommendation is for routine compliance monitoring, research, research on monitoring, or regional monitoring. POTWs have also voiced concerns for the cost and feasibility of implementing these recommendations. The scale of some of the proposals markedly exceeds those of current NPDES requirements. The recommendations are not prioritized.

These differences in viewpoint are difficult to resolve without exploring the details of the program changes that are only implied by the recommendations. It is time to move on to the next phase, recognizing there is still much work to be done to reach the optimum program. CTAG looks forward to a continuing dialog with SCCWRP, as model POTW programs evolve to improve monitoring of the Southern California Bight.

Jan Stull
Los Angeles County Sanitation Districts
CTAG Chair

January 18, 2000

CTAG COMMENTS ON SCCWRP'S RECOMMENDATIONS

Development of a Model POTW Monitoring Program:

Review of Existing Programs (November 22, 1999)

SCCWRP's charge from its Commission was to develop independent recommendations for a model POTW monitoring program for the four largest Southern California POTWs (City of Los Angeles, Los Angeles County Sanitation Districts, Orange County Sanitation District, and City of San Diego). In turn, the Commission has requested that CTAG (the Commission's Technical Advisory Group) prepare a written response to the SCCWRP review of existing monitoring programs. While this initial report is characterized as a "Review of Existing Programs", it has in fact broached a number of monitoring recommendations as an entrée to the second phase of the model monitoring program project. The next phase will develop much more specific recommendations for changes to monitoring programs. Discussions between CTAG members and SCCWRP staff at that time will permit an exploration of the differences between member agencies' positions.

CTAG requests that this letter to the SCCWRP Commission be referenced in the executive summary of the document. CTAG has significant concerns that need to be considered in the next phase of the project.

The following comments focus on the recommendations portion of the review of existing programs. Overall comments are made first, and then each of the monitoring elements are separately reviewed.

A. GENERAL COMMENTS

(1) SCCWRP should identify each recommendation as falling into one of three monitoring categories.

Each element should be clearly linked to core compliance monitoring, regional monitoring or special developmental projects. Those elements which cannot be clearly associated with any of these categories should be viewed as a potential SCCWRP or external research project.

> **Core monitoring** includes compliance monitoring, which is associated with specific regulatory requirements or limits, and is intended to be conducted for many years. POTWs negotiate such programs independently with their regulators (SCCWRP has no role), as there are legal and political issues, in addition to technical matters, to be addressed.
>
> **Regional monitoring** includes cooperative studies which provide a larger scale view of conditions in the Southern California Bight. It can be used to assess the cumulative results of anthropogenic and natural effects on the Southern California Bight environment, and to place POTW and other agencies' monitoring in perspective. Regional monitoring is the best way to identify those issues or parameters which appear to be related to POTW discharges. Further investigation during subsequent regional monitoring or by special projects would clarify that relationship and suggest those components which could rationally be moved to core monitoring programs.
>
> **Special projects** include developmental research, designed to move monitoring science and policy forward. These can be used to demonstrate the value of particular analyses, to illustrate ways in which data can be used, or to develop new skills. They may be conducted by the POTWs, or SCCWRP, or by contract. Some projects are beyond the power of individual permittees, and may require central coordination.

CTAG also suggests that the forthcoming design document should specifically identify those program elements which are unnecessary.

(2) Development of program details may change the recommendations.

CTAG is assured by SCCWRP that the design recommendations in the report are preliminary, and the details must be subjected to more critical review of the details during the next phase. Such close scrutiny may reveal serious or fatal flaws which will call into question entire individual recommendations. For example, the review of existing programs implies that less frequent chemical analyses will be necessary for effluents. However, critical details have yet to be explored, including specific analytical constituents and reporting limits. Until such details are fully explored, it is not clear that the recommendations will result in fewer analyses as the report suggests (see B, effluent, below).

(3) POTW programs differ for good reasons.

The comparisons in the report sometimes imply that the programs should be uniform among POTWs. In comparing existing POTW programs, the document does not identify the regulatory framework for the monitoring. Regulatory requirements contribute significantly to program differences, and the regulatory document which drives each program or element should be identified. These include the California Ocean Plan, the Basin Plans, and 301(h) guidance for waivers from full secondary treatment. The future program design document should identify areas where these regulatory foundations are weak. Differences in discharge receiving environments (e.g., shallow broad plain vs narrow shelf), also account for many of the differences among programs and design recommendations should acknowledge and reflect this.

B. EFFLUENT. SCCWRP recommends: *(1) Frequency of monitoring should be proportional to the potential risk of exceeding a water quality threshold. Power analysis to assess potential risk can dramatically improve efficiency of effluent monitoring. (2) Develop a common list of reporting limits so that mass emission estimates among facilities are comparable.*

(1) The water quality thresholds should be identified (including the Ocean Plan and facility specific dilution factors). The risk of remaining out of compliance (e.g., for running averages) should be factored in to the calculations of monitoring frequencies. Some of the projected sampling frequency "savings" may exist only on paper. While the sampling frequency needed to meet discharge requirements may indeed be lower than current levels, the calculated frequency needed to detect changes in mass emissions could actually be much higher than at present. For many metals, the laboratory effort is similar whether one, two, or six metals are concurrently analyzed. The same applies to the groups of trace organics. Power analyses should be conducted for groups of chemicals which are analyzed together. It is important to remember that statistics are not the only driving forces for monitoring: there are regulatory, political and practicality issues. While the tables generated by power analysis were an interesting exercise, they sometimes lead to irrational implications. For example, a huge number of DDT samples are necessary each year to achieve 99% confidence that the effluent is within the Ocean Plan objective, and <1 to 2 mercury analyses are necessary for three of the four POTWs (Table 2.6).

(2) The POTWs strongly contend that *risk* is the operative issue, not mass. Reporting limits should *not* be lowered just for the sake of detection. The recommendation should clearly specify that it applies only to toxic or bioaccumulated chemicals with associated human or ecological risks.

C. WATER QUALITY. SCCWRP recommends: *(1) Reduce the frequency of monitoring that addresses questions regarding water quality impairments and reallocate that effort to address questions regarding plume location. (2) Analyze existing data to create isocline maps of plume occurrence. (3) Promote the use of new technology to capture data regarding episodic events that are not well-characterized with existing monitoring, but are* *likely important oceanographic driving factors influencing plume movement towards shore. The new technology should be applied in a test case to demonstrate its effectiveness and improved efficiency prior to becoming routine monitoring. (4) Find cooperative interactions among POTW monitoring programs, other monitoring programs, and researchers to effectively develop predictive models of plume dynamics.*

The POTWs feel that the water quality recommendations are too generic for the diversity that exists among discharges and receiving waters. The wastefields behave differently, the receiving environments are different, the treatment levels are not the same, and even the controlling regulatory environment varies. This variability makes development of a prescriptive program inappropriate.

(1) CTAG agrees that monitoring frequency for water quality should be reduced. However, the POTWs disagree with the second half of SCCWRP's recommendation, which states: "reallocate that effort to address questions regarding plume location." This is not compliance monitoring. Plume monitoring is an important tool as an intermediate step if there is a problem such as incursions by the wastefield into water contact sports zones. While daily modeling or measurement is generally not supported by the POTWs, the Orange County Sanitation District suggests that a description of the general plume location is needed to satisfy the public's concerns. Nutrient and phytoplankton enhancement studies are special research which can be done using airborne and satellite imagery. This should be pursued only if it can be shown by regional studies that POTW discharges are a focus of enhancement.

(2) The POTWs agree that existing data should be analyzed to create general isocline maps of plume occurrence. The phrase "and to identify most appropriate periods for characterizing oceanographic seasons" should be added to the recommendation. It is already generally understood where the plumes occur. While a study to develop a description of the local oceanographic seasons would be useful for interpreting unusual water quality findings, a large scale effort over many years would not be productive or efficient. The POTWs can provide data for the analyses, but this should be a SCCWRP project.

(3) Item 3 should not presume an untested technology will lead to routine monitoring, as implied by the phrase "prior to becoming routine monitoring". This is a research plan. The POTWs believe compliance monitoring should include only identified, cost effective technology that may increase POTW efficiency in water quality monitoring, and their ability to explain POTW discharges in a regional and local perspective. POTWs support remote sensors as a means of keeping boats and field crews onshore. Where possible, cooperative approaches with vendors are recommended, to assure that equipment development is tailored to POTW needs.

(4) This is a research project. Predictive modeling should be site specific, and only if there are relevant parochial interests (the need varies with the specifics of each discharge and receiving environment).

D. MICROBIOLOGY. SCCWRP recommends: *(1) Microbiological monitoring for plume tracking should become an adaptive component of a water quality monitoring program. Adaptive strategies represent a cost-effective means of allocating resources to the places and times they contribute the most value. (2) Use a tiered approach for selecting indicators and methods. Single indicators using inexpensive methods are appropriate for plume tracking when many samples are needed, but multiple indicators coinciding with water quality thresholds should be analyzed at locations or times when body-contact issues are of concern. (3) Effort should be shared equitably among all dischargers of bacteria to assess regional shoreline water quality for protecting public health. (4) Integrate methods and create regional monitoring designs that focus on quality and efficiency of POTW and county health department programs.*

(1) Even though bacteria are considered conservative plume indicators (within limits), some POTWs cannot use bacteria for plume tracking because their effluent is chlorinated. For most POTWs, shoreward transport is not a concern because it has been demonstrated through years of monitoring that it does not occur. Adaptive monitoring would not necessarily demonstrate compliance with nearshore water contact and shellfish standards, and would create enormous staffing problems.

(2) Any bacterial indicator would be sufficient for plume tracking (although several POTWs do not recommend it unless there's an identified problem). The Ocean Plan requires multiple indicators for compliance with bathing water and shellfish standards. Chromogenic methods which are recommended as inexpensive substitutes have not been certified for marine waters by EPA or ELAP, which may discourage some Regional Boards from approving their use.

(3) This recommendation is good in concept, but the basis for equitable sharing must be defined by the regulators.

(4) The POTWs recommend that choices for analytical methods in bathing waters and shellfish areas be performance based. The methods and data must be comparable.

E. SEDIMENTS. SCCWRP recommends: *(1) Disaggregate the spatial and trend components of the current sediment monitoring sampling designs. Reallocating sampling sites dedicated to addressing each of these distinct management questions will improve efficiency and cost-effectiveness. (2) Look for opportunities to incorporate measurements of sediment toxicity to increase the number of thresholds for evaluating impairment. Sediment toxicity will become especially useful when sediment toxicity identification evaluations (TIEs) become routinely available, enabling managers to assess which constituents are responsible for toxicity. (3) Institute an archive program to allow for the possibility of unmeasured chemicals.*

(1) SCCWRP has not demonstrated that disaggregation is more efficient and cost effective. CTAG disagrees that current programs have "blended" spatial/temporal patterns, although temporal and spatial programs do augment each other. There are also temporal gradient analyses, which combine both space and time; monitoring of changes in gradients emanating from the outfall zone should be continued. There are serious concerns about sediment program design, since very large numbers of samples can be proposed if there were rigid, blind application of power analysis. It is important to carefully watch the assumptions used in power analyses, as they often drive the results. Also, repeated visits over time give greater power than does replication at a particular time. Finally, if the POTWs' reference sites are within the range of variability of the regional monitoring surveys, then the POTWs recommend that local "controls" be used, unless it can clearly be shown that more distant sites provide more useful information.

The POTWs are not convinced of the need for mapping as described in the document, without defined confidence levels. A "shotgun" approach to defensible maps isn't needed: parameters requiring the greatest resolution and precision, both near and distant from the discharge, must be defined first. In many cases, general distribution patterns have been identified, and available maps suffice.

(2) Sediment toxicity tests are clearly a research issue which demands rigorous demonstration before use as a monitoring tool. If no problem is demonstrated by regional monitoring in the POTW subpopulation, then sediment toxicity tests are not recommended for routine monitoring. If there is no effluent toxicity but there are toxic sediments, there is typically no associated management action to be taken. For sediment toxicity, both methods and results vary, and the meaning of the results is often unclear. TIEs have not been used effectively in sediments (even for water quality, TIEs are often not clear).

(3) Sediment archiving is not supported by the POTWs, who see very little utility to such a program. Holding times would be exceeded for most chemicals (except metals). SCCWRP's examples illustrate some of the problems: MTBE is volatile, and chlorpyrifos (and some other organics) are designed to have short shelf lives.

F. FISH. SCCWRP recommends: *(1) Focus fish population and community monitoring on trend sites since spatial extent questions are inefficiently addressed through local monitoring. Spatial extent questions for answers to fish population and community impacts should be addressed through regional monitoring. (2) Fish tissue monitoring for wildlife protection should be divided into two questions: one question for local monitoring to address trends and a second question for regional monitoring to assess spatial extent. (3) Seafood monitoring for public health is a regional question and should be integrated with CalEPA's Office of Environmental Health and Hazard Assessment (OEHHA). This monitoring should be shared equitably among all dischargers to the ocean.*

(1) POTWs see a need for continued local monitoring of population trends in fish *and invertebrates*. These data are needed for 301(h) permits, for demonstrating the lack of discharge related impacts to the public and for gradient analysis. Regional monitoring should be used for concurrently assessing Bight-wide, local and reference conditions.

(2) POTWs support the continued use of historical species and tissues, as possible.

(3) CTAG supports integration of seafood monitoring with OEHHA. Monitoring results are already shared with this agency.