SCCWRP Annual Report 1994-1995

Executive Summary

Characteristics of Effluents from Large Municipal Wastewater Treatment Facilities in 1994

Effluents from Hyperion Treatment Plant (HTP; City of Los Angeles), Joint Water Pollution Control Plant (JWPCP; County Sanitation Districts of Los Angeles County), County Sanitation Districts of Orange County (CSDOC), and Point Loma Wastewater Treatment Plant (PLWTP; San Diego) comprise 90% of municipal wastewater discharged directly to the Southern California Bight (SCB). This study summarizes the concentrations of effluent constituents and estimated the mass emissions for these agencies for 1994, and presents trends in mass emissions from 1971 through 1994.

In 1994, the four facilities discharged 1,069 million gallons per day (mgd; 4,046 x 106 L/day) of treated effluent into the SCB. The combined daily volume of effluent discharged from the four facilities did not change significantly from 1993 to 1994 although the proportion of effluent receiving secondary treatment decreased slightly. During this period, the concentrations of 49% of the effluent constituents declined, 24% were unchanged, and 27% increased. The majority (47%) of the metal concentrations decreased, 33% were unchanged, and 20% increased. Most of the decreased metal concentrations occurred at CSDOC. Effluent acute toxicity to fathead minnows (Pimephales promelas) at HTP decreased significantly. None of the combined mass emissions of constituents changed significantly between 1993 and 1994. Most of the constituents showing significant mass emission changes at individual plants during this period decreased. Only copper at HTP and flow and suspended solids at CSDOC showed a significant increase. The combined emissions of DDT decreased 14% between the years. All four dischargers had concentrations of PCBs below detection limits in 1993 and 1994.

From 1971 to 1994, the combined flow from the four facilities increased 15%. The volume of wastewater discharged by CSDOC and PLWTP nearly doubled while the volume decreased 12% at JWPCP and 2% at HTP. During this period, the combined emissions of suspended solids declined 77%, oil and grease declined 69%, and biochemical oxygen demand (BOD) declined 53%. The combined emissions of trace metals declined 95%. Cadmium, chromium, mercury, and lead declined 99%; zinc, copper, and nickel declined 91-96%; and arsenic declined 78%. The combined emissions of chlorinated hydrocarbons declined more than 99%. The decreases in constituent concentrations and mass emissions were the result of improved primary treatment, increased secondary treatment, and improved source control.

Characteristics of Effluents from Small Municipal Wastewater Treatment Facilities in 1994

The 15 small municipal wastewater facilities discharge effluent to the SCB through relatively short, shallow-water outfalls. They treat the sewage to a greater degree prior to discharge than do the large municipal wastewater facilities. This study summarizes the concentrations of effluent

constituents and estimated the mass emissions for the small municipal wastewater facilities for 1994, and presents trends in mass emissions from 1971 through 1994.

In 1994 the 15 small facilities discharged 131 mgd (496 x 106 L/day) of treated effluent into the SCB. They accounted for 11% of the total volume of municipal wastewater discharged to the SCB but only 2% of the suspended solids, oil and grease, and BOD. The small facilities contributed a disproportionately low share of ammonia, arsenic, copper, and DDT, but they contributed most of the inputs of lead and cadmium, and a disproportionately high share of cyanide, chromium, mercury, nickel, silver, and zinc.

The contribution of effluent from the small facilities to the combined municipal wastewater discharge of the large and small facilities was about the same from 1987 (10%) to 1994 (11%), as was their contribution of suspended solids, BOD, and oil and grease, which decreased slightly from 3 to 2%. However, the cyanide contribution from the small facilities increased from 6% of the total discharged in 1987 to 15% in 1994. Contributions of lead increased from 10 to 68%, cadmium from 16 to 56%, silver from 5 to 20%, and chromium from 4 to 19%. Mercury decreased from 31 to 21%.

The annual combined volume of effluent discharged from the small facilities nearly doubled from 1971 to 1994. Ammonia increased 95% but oil and grease decreased 91%, BOD decreased 80%, suspended solids decreased 79%, and cyanide decreased 73%. Estimated mass emissions for other contaminants were not available for 1971. Although the contribution of most constituents from small municipal wastewater dischargers is currently low, their relative contribution may increase in the future as emissions from the large municipal wastewater treatment facilities decrease.

Characteristics of Effluents from Power Generating Stations in 1994

Fifteen power generating stations discharge effluent and cooling water to the Southern California Bight through relatively short, shallow-water outfalls. Fourteen of these are conventional thermal plants that use fossil fuels during power generation but the San Onofre Nuclear Generating Station (SONGS) uses nuclear power. Each discharges a small volume of treated in-plant wastes into a stream of once-through cooling water (seawater) that circulates through the plant, cooling the condensers, before being discharged into the ocean. This study summarizes effluent flows, constituent concentrations, and estimated mass emissions for the coastal power generating stations of Southern California for 1994.

In 1994 the 15 power plants discharged 7,233 mgd (27.4 x 109 L/day) of cooling water but only 3 mgd (11 x 106 L/day) of treated in-plant wastes. Discharge temperatures ranged from 16 to 51o C. Emissions varied greatly between generating stations. Long Beach Generating Station had the highest emission of suspended solids; Ormond Beach Generating Station of oil and grease; Encina Power Plant of chromium and nickel; and SONGS of copper, lead, and zinc. The combined annual volume of cooling water discharged by power plants increased 30% between 1970 and 1994.

Although power generating stations accounted for 86% of the water discharged to the ocean from point sources (excluding industrial dischargers), their in-plant waste is not an important source of contaminants to the SCB. The in-plant flow of the power generating stations accounted for 0.04% of treated effluent flow and <0.001 to 7% of the mass emissions of individual constituents discharged to the SCB, with most contributions being less than 1%. The highest percent contributions by the plants were for copper and lead; however, they still made up less than 10% of the input of these individual constituents to the SCB. Although the contribution of in-plant waste from power generating stations is currently low, their relative contribution may increase in the future as constituent emissions from the large municipal wastewater treatment facilities decrease.

Compositional Indices of Polycyclic Aromatic Hydrocarbon Sources off San Diego, California

Hydrocarbons enter the marine environment via municipal and industrial waste discharge, surface runoff, accidental spills, aerial fallout, or natural biochemical processes. Little is known about the relative importance of these sources in contributing organic contaminants to the coastal marine environment of Southern California. Polycylic aromatic hydrocarbons (PAHs) are sensitive indicators of petrogenic and pyrogenic (i.e., petroleum-derived and combustion-derived) inputs of hydrocarbons. PAHs from petrogenic sources are abundant as alkylated homologues of the parent compounds whereas those from pyrogenic sources lack these alkylated homologues. This study uses compositional indices to identify sources of PAHs to the marine environment off San Diego, California.

Samples of the sea surface microlayer, water-column particulates, and sediments were taken from four sites: 1) a reference site; 2) a PLWTP outfall site; 3) a San Diego Bay site; and 4) a site near the mouth of the Tijuana River. Total suspended solids, total organic carbon (TOC), and total nitrogen (TN) were determined for each sample and moisture was determined for sediment and sediment trap particulates. PAH compounds were quantified using gas chromatography/mass spectrometry. These analyses measured 26 PAH compounds. Two PAH assemblages were identified: 1) a low molecular weight assemblage (2,3-ring PAHs dominant) derived from petroleum found in PLWTP effluent, Tijuana River runoff, and microlayer particulates near the mouth of the Tijuana River; and 2) a higher molecular weight assemblage (4,5-ring PAHs dominant) derived from combustion in San Diego Bay..

PAH contamination to the coastal waters off San Diego have decreased greatly during the past decade, probably as a result of better wastewater treatment and source control. PAH levels in the PLWTP sediments and effluents in 1994 were 33 and 1%, respectively, of 1979 levels. Thus, PAHs in the sea surface microlayer, sediments, and on water-column particulates were derived primarily from nonpoint sources. PAHs in the microlayer near the mouth of the Tijuana River are apparently derived from runoff. Those in the microlayer and sediments in San Diego Bay were primarily derived from combustion rather than from accidental spills. A trend of increasing TOC, TN, and PAH concentrations from bottom sediments to water-column particulates may be the result of sediment resuspension or rapid degradation of sewage-derived organic materials in the water column. Settling of resuspended particles may enhance the flux of organic materials near the sea floor.

Petrogenic and Biogenic Sources of N-Alkanes off San Diego, California

In the previous study, compositional patterns of PAH assemblages were used to assess petrogenic and pyrogenic sources of hydrocarbons found in effluent, sea surface microlayer, water-column particulates, and sediments of the coast near San Diego, California. In this study, compositional patterns and molecular indices of aliphatic hydrocarbons (AHs) are used to identify petrogenic and biogenic sources of hydrocarbons.

Samples of the sea surface microlayer, water-column particulates, and sediments were taken from the four sites mentioned in the previous study. AH compounds were quantified using gas chromatography/flame ionization detection analysis. Total AH concentrations were highest in particulates found in sea surface microlayer, PLWTP effluent, and Tijuana river runoff. Concentrations were lower in water-column particulates and lowest in sediments. Based on the ratio of low to high molecular weight n-alkanes, hydrocarbons in PLWTP effluent are predominantly from a petrogenic source whereas those in Tijuana River runoff are primarily from biogenic (presumably terrestrial plant) sources. The decrease in the mass emission of AHs since 1979 confirms that improved sewage treatment and source control are lowering inputs of organic contaminants to the SCB.

AHs found in the coastal environment near San Diego are probably derived from both biogenic and anthropogenic petroleum sources. Diffusion, solubilization, evaporation, and microbial degradation are probably responsible for differences in concentrations and compositions of AHs in effluent, microlayer, water-column particulates, and sediment. Although the source of the AHs off San Diego is uncertain, at least some petroleum-derived contaminants appear to be derived from anthropogenic sources. Further studies should be conducted to elucidate the relative importance of wastewater discharge, runoff, and aerial fallout as sources of AHs to the coastal zone off San Diego.

Using Linear Alkylbenzenes to Trace Sewage-derived Organic Materials off San Diego, California

The previous two studies used PAHs and AHs to examine the relative contribution of hydrocarbons from petrogenic, pyrogenic, and biogenic sources to the marine environment off San Diego, California. This study assesses the spread of domestic wastes discharged from the PLWTP outfall and provides insight into the transport mechanisms and fates of sewage-derived organic materials using linear alkylbenzene sulfonates (LABs). LABs are surfactants that are used in the manufacture of detergents. While they are not particularly toxic, they are useful tracers of domestic waste due to their limited sources.

Samples of the sea surface microlayer, water-column particulates, and sediments were taken from the four sites mentioned in the previous two studies. Individual LAB compounds were identified by gas chromatography/mass spectrometry using similar procedures as used for PAHs. LAB concentrations were normalized relative to TOC concentrations in particulate fractions but this could not be done for aqueous samples. The isomeric distribution of C12-LABs provide information on the degree of degradation of LABs. Thus, if the ratio of internal to external isomers (i.e. I/E ration) is low, little degradation has occurred whereas a high ratio indicates that

external isomers have been selectively degraded. This ratio is useful in tracing the dispersal of LABs in the marine environment from their source.

LABs were detected in PLWTP wastewater effluent, Tijuana River runoff, sea surface microlayer, water column particulates, and sediments off San Diego in 1994. PLWTP was the primary source of LABs with less entering via the Tijuana River. Total LAB concentrations and the number of LAB compounds were highest in PLWTP and Tijuana River runoff samples and lowest in microlayer samples. The I/E ratios were lowest in PLWTP effluent (indicating less biodegradation) and highest in Tijuana River runoff and water-column particulates. About 30-50% of the LABs were degraded in the water-column particulates and sediments. Other processes such as dilution, evaporation, bioaccumulation, and advection of suspended particles may also be responsible for reducing LAB levels away from the discharge zone. Thus, these three studies demonstrate how the sources, transport, and fates of hydrocarbons in the marine environment can be identified and assessed using compositional indices of LABs, PAHs, and AHs.

Toxicity of Ammonia to Pacific Purple Sea Urchin (Strongylocentrotus purpuratus) Embryos

Interstitial water extracted from sediments at most of the Southern California Bight Pilot Project (SCBPP) stations were toxic to Pacific purple sea urchin (*Strongylocentrotus purpuratus*) embryos. However, most of the toxic interstitial water samples had total ammonia concentrations greater than 4 mg/L, a level that might cause toxicity to sea urchin embryos. The objectives of this study were to determine both the source of the ammonia encountered and whether ammonia was the cause of the toxicity.

Three experimental studies were conducted on sediments collected from three stations on the Palos Verdes Shelf with similar sediment characteristics to those collected in the SCBPP survey. The first study examined the production of ammonia during sediment storage by tracking ammonia concentrations in interstitial water over time. This study also examined the effect of sediment homogenization on interstitial water ammonia. The second determined the dose-response relationship between ammonia and toxicity to sea urchin embryos using seawater spiked with ammonia. The third determined the relative toxicities of ionized and un-ionized forms of ammonia to sea urchin embryos by exposing them to spiked seawater at varying pH levels.

The results of the studies indicate that ammonia levels of sediments stored at 4o C can increase greatly with time due to microbial activity and thus increase the toxicity of interstitial water samples. Because of this, sediment and interstitial water tests should be conducted as rapidly as possible after sediment collection. Both homogenized and undisturbed sediments reached similar ammonia levels. Purple sea urchin embryos were more sensitive to ammonia than are most adult organisms of other species. Un-ionized ammonia is more toxic to Pacific purple sea urchin embryos than in the ionized form. Un-ionized ammonia becomes toxic at concentrations greater than 0.04 mg/L. Since pH plays a large role in determining the relative abundance of the two forms of ammonia, the pH of interstitial water samples should not be adjusted. Under natural conditions in the marine environment, more than 95% of the total ammonia is in the ionized

form. Knowledge of the un-ionized ammonia concentration and sensitivity of the test organism is essential for evaluating sediment toxicity results.

Impact of Wastewater on Reproduction of Amphiodia urtica

Red brittlestar (*Amphiodia urtica*) is one of the most common benthic invertebrate species on the continental shelf of the SCB. However, although it is typically widespread and abundant, it is rare or absent near municipal wastewater outfalls, even at depths and sediment types where it is typically found. Reproductive effects, such as a reduction in fertility or fecundity may explain its low abundance near wastewater outfalls. However, although the species is a numerically dominant species on the continental shelf, little is known about its life history or reproductive cycle. The objective of this study is to describe the reproductive cycle of female *Amphiodia urtica* and to determine if it has been impacted near a municipal wastewater outfall.

Amphiodia urtica were collected monthly from July 1993 to June 1994 in sediment samples from a reference site and a moderately impacted outfall site near PLWTP. Reproductive studies were conducted on 13-15 large females from each sample. Disk and oral width diameters (both measures of body size) and oocyte diameters were measured for each individual to determine changes in oocyte diameter with body size or season.

Amphiodia urtica is predominantly a seasonal spawning ophiuroid. Although it can produce large oocytes year-round, spawning peaks in winter. Based on size-frequency distributions of 17,600 oocytes from individuals collected near Point Loma, California, gametes grow during September through December and are shed in January and February. A substantial increase in newly recruited brittlestars, *Amphiodia* spp., was observed in the following spring. Reference and outfall areas had similar patterns in size-frequency distributions of oocytes. Although there was a significant increase in the proportion of large oocytes and a one-month lag in oocyte shedding at the impact site, the difference could be due to interpopulation differences, subtle changes in exogenous cues, sampling bias, or treated wastewater discharges. Because previous studies have not shown a similar difference in oocyte development between outfall and reference areas, the reductions in Amphiodia spp. populations near outfalls are apparently not a result of impacts to the female reproductive cycle, such as a reduction in oocyte growth.

Development of Sediment Bioassays using Newly Settled California Halibut (*Paralichthys californicus*)

California halibut (*Paralichthys californicus*) is an important species to recreational and commercial fisheries of Southern California. Although the larvae are planktonic, newly settled benthic juveniles occur in semiprotected bays and harbors. Because of their high surface-to-volume ratio and their direct contact with bottom sediments in this habitat, they are likely to suffer toxic effects from contact with contaminated sediments. Since these nursery areas are being impacted by dredging and urban runoff, it is important to determine if juvenile halibut are being affected by sediment contamination. However, an appropriate toxicity test for juvenile halibut has not been developed. The objective of this study was to develop a long term (28 d) flow-through sediment toxicity test for newly settled California halibut. This test will measure and evaluate the effects of sediments on halibut survival and development.

Newly settled halibut were obtained from a local halibut hatchery and kept in tanks with different sediment types, ranging from artificial to potentially contaminated. Experiments were conducted for 28 d with 12:12 h light:dark periods with water at about 15o C. Standard lengths (SL) of the fish were measured at the beginning and end of the experiments. The test end point was mortality. Growth was defined as an increase in SL during the test. Based on experimental results, sediments were renewed after 14 d and artificial sediments were chosen as reference sediments. Although survival of control halibut was also low, there was a significantly lower survival in halibut living on potentially contaminated sediments (based on historical contaminant levels from the sites). However, until contaminant levels in the exposure sediments are analyzed, the source of the decreased survival cannot be determined.

Thus, sediment testing using newly settled California halibut is technically feasible. The halibut are tolerant of a wide range of sediment particle sizes (<0.004-2.00 mm). Artificial sediment is a suitable substrate for maintaining California halibut to 28 d of exposure. The test showed promise because halibut survival differed significantly between sediments thought to be clean and those assumed to be contaminated. However, further study is needed to determine causes of this difference and to improve the test methodology.

Age and Growth in the Hornyhead Turbot (*Pleuronichthys verticalis*) off Orange County, California

The hornyhead turbot (*Pleuronichthys verticalis*) is benthic-feeding flatfish that occurs commonly on the mainland shelf of Southern California. Individuals of the species from Santa Monica and San Pedro Bays sometimes have high levels of DDE in their livers. Although hornyhead turbot is a target species for contaminant bioaccumulation studies in several receiving-water programs in the area, little is known of its life history. In particular, it is not known about how long contaminated individuals may have been exposed to contaminated sediments. Understanding the age structure of the population, coupled with reproductive information from previous studies, should provide insight into the length of time a turbot could potentially be accumulating contaminants. The objective of this study is to describe the age and growth of hornyhead turbot as part of a larger study on the life history of this species.

Live hornyhead turbot were injected with oxytetra-cycline (OTC) for age validation; their otoliths were removed after a year and examined under ultraviolet light to validate that a growth ring on an otolith represented a year's growth. Additional fish were collected for age determination. Sagittal otoliths were removed from these fish and their standard lengths (nearest millimeter) were measured. Sagittal otoliths were prepared for examination using cross sections through the nucleus. Age readings of a subset of the otoliths were checked by expert readers in a double blind test. Several growth equations were applied to the age and length data to determine which gave the best fit.

The results of the study showed that hornyhead turbot growth is slow and almost linear. Although the logistic model best describes the growth data, it is not significantly better than the more commonly used von Bertalanffy model. The species grows to at least 370 mm SL and can live to at least 25 yr. Because of its relatively long life span, the high levels of contaminants in

hornyhead turbot in some areas may be the result of bioaccumulation over a relatively long period of time.

Comparison of Methods for Obtaining Group Biomass Measurements of Trawl-caught Fishes

Demersal fish near municipal wastewater outfalls are regularly monitored to determine impacts of the discharge. Although most of the analytical emphasis is on abundance and length-frequency distributions, biomass provides another important measure of the populations. However, field conditions (e.g., boat movement, slime accumulation) may affect the accuracy of bulk (i.e., by species) biomass measurements. Calculation of bulk biomass from size-class data using predetermined mean biomass per size class information is an alternative approach that may provide more accurate weights and reduce fish mortality associated with field weighing procedures. The objective of this study was to determine the accuracy of three different methods for obtaining species biomass measurements (field bulk weights, laboratory bulk weights, and weights calculated from size-class data) relative to actual weights and to evaluate the potential value of calculating bulk weights from size-class data to produce species biomass estimates.

Demersal fish collected by trawl from June to November 1995 were identified, measured to standard length by centimeter size class, weighed by species in the field to the nearest 0.1 kg to obtain a field bulk weight, frozen, and returned to the laboratory. After thawing, they were weighed in the same manner as in the field to obtain a laboratory bulk weight. Each fish was then measured to the nearest millimeter and weighed to the nearest 0.01g. Individual fish weights for a species in a sample were summed, giving an actual weight (summed group weight). Mean weights per size class were calculated for each species, using data collected from all stations. Species weights were then calculated using size-class data to obtain a calculated bulk weight for a station. Field and laboratory bulk weights differed significantly from the calculated group weights and actual weights, which did not differ significantly. Thus the calculated group weight provided a more accurate estimate of the biomass than did the field or laboratory bulk weights. The lack of difference between field and laboratory bulk weights may be due to the calm seas during the field surveys.

Although calculation of bulk weights from size-class data could provide more accurate data (and possibly reduce field costs and fish mortality), more individual fish biomass data are needed for the range of species collected in the monitoring surveys. Future studies should develop a more extensive mean weight-per-size-class table, calculate species-specific weight-length regression equations, and convert length-frequency distributions to weight-frequency distributions to characterize and compare segments of the population (e.g., juveniles and adults).

The Southern California Bight Pilot Project: An Overview

Every year, millions of taxpayer dollars are spent monitoring water quality in the coastal marine environment off Southern California. However, existing compliance monitoring programs do not monitor the environment at the spatial and temporal scales of the important physical and biological processes, nor do they evaluate the cumulative effects of all discharges in the area. The programs frequently differ in sampling designs, parameters measured, methods, and

sampling frequency. Without an accessible data management system, the data collected by these programs cannot be integrated into a regional database. Thus, after two decades, the monitoring programs are not providing the most appropriate data for environmental decision-making. To address these concerns, the Southern California Coastal Water Research Project (SCCWRP) began planning a regional monitoring program in 1993. This article describes the development, focus, technical challenges, and project management of the Southern California Bight Pilot Project (SCBPP).

The SCBPP was intended to demonstrate an integrated, coordinated, regional environmental monitoring program based on existing monitoring programs. The United States Environmental Protection Agency's (USEPA) Environmental Monitoring and Assessment Program (EMAP), provided the framework and design for a regional monitoring program that was appropriate for the SCB. The SCBPP focused on the extent, magnitude, and variability of ecological change on the mainland shelf of the SCB, and whether the change could be associated with identifiable sources of pollution. It differed from existing monitoring programs in that it focused on estimating the areal extent of altered conditions within the SCB. To ensure that comparable data was produced by the participating agencies, the SCBPP developed standard field and laboratory methods, quality assurance protocols, and data management system, and used new data analysis techniques. Project management consisted of a steering committee (with representatives of the 12 local, state, and federal agencies participating in the project) that guided the project, a Project Manager, and task coordinators. The coordinators were supported by technical representatives of each of the agencies.

The success of the SCBPP will provide the impetus and the tools for implementing regional monitoring in the SCB. The future success of regional monitoring, however, will require development of a formal institutional mechanism or memoranda of understanding to integrate existing compliance monitoring programs and their results. Regional monitoring will provide environmental managers with the data they need to evaluate the influence of the various anthropogenic inputs. Ultimately, this will allow managers to select the most cost-effective management strategies.

The Southern California Bight Pilot Project: Sampling Design

The SCBPP is a cooperative sampling effort intended to provide synoptic information about the ecological condition of the mainland shelf of Southern California. This article describes the sampling design used for the 1994 survey. The sampling design was developed by USEPA EMAP. Sampling points were chosen by random placement of a grid of points over the sampling area, followed by random selection of grid points and random placement of stations around the grid points. The grid ensured that the sampling effort was well distributed over the study area while the random placement of the grid and random selection of sampling stations provided randomness needed for statistical inference. Moreover, since the interpoint distance of the grid was known, each sampling point represented a known area so that the amount of area with a particular characteristic can be estimated.

The sampling was designed for assessing ecological conditions in three geographical regions, three depth zones, areas around the four major municipal wastewater outfalls (treated

cumulatively), the areas within 3 km of 11 rivers and storm drains (treated cumulatively), Santa Monica Bay, and the area around the Hyperion Treatment Plant outfall. The assessment of ecological condition will be based on measures of water quality, demersal fish and benthic infaunal assemblages, sediment characteristics, sediment toxicity, fish pathology and bioaccumulation, and marine debris.

The survey was conducted by five agencies during July-August 1994. Quality assurance was achieved by standardizing field methods and using performance-based standards for laboratory analysis. The extent and magnitude of change between subpopulations will be measured by developing a cumulative distribution function (CDF) for a parameter and selecting threshold values to distinguish natural from changed areas. Then the percent area that has been changed will be estimated.

Survey results will be presented in a series of reports, including an assessment of ecological conditions on the Southern California mainland shelf and an evaluation of the SCBPP survey design.

Spatial Variability in Southern California Demersal Fish and Invertebrate Catch Parameters in 1994

Municipal wastewater outfalls discharge onto the soft- bottom habitat of Southern California and hence can impact the demersal fish and invertebrate populations found there. Near some outfalls these populations have been monitored for more than two decades for population changes, anomalies, and bioaccumulation of contaminants. However, the background natural variability of the populations has not been adequately described. Understanding the natural variability of the populations is important for interpreting whether population changes near the outfalls are due to the discharge or to natural conditions. The SCBPP survey was conducted to provide much needed information on the extent of environmental change due to the outfalls. However, it also provided an opportunity to describe the natural variability of these populations for the SCB. The objective of this study is to describe variability in demersal fish and invertebrate catch parameters (abundance, biomass, numbers of species, and diversity) in the SCB by region, depth zone, and proximity to outfalls. This analysis is part of a larger study which will describe the extent of environmental change in the demersal fish and invertebrate assemblages of the SCB.

Fish and invertebrate populations were sampled by small (7.6-m headrope) otter trawls from July to August 1994. Trawl samples were collected at 114 stations at depths from 9 to 215 m. Fish and invertebrates were identified to species, counted, weighed, and examined for anomalies; fish lengths were also measured. Area-weighted data were summarized, presented in CDFs, and tested for differences among subpopulations.

Demersal fish and invertebrate populations on the mainland shelf of the SCB varied significantly by region, depth, and proximity to outfalls in 1994. Trawl catch parameters varied more consistently by depth than by region. Catch parameters were generally lower on the inner shelf and higher on the outer shelf. Regional variability occurred in almost all fish and invertebrate catch parameters but the pattern of variability differed greatly by parameter. Outfall areas generally had higher catch parameter values than non-outfall areas. Although this may be due to

stimulation from wastewater discharge, it also may be related to the broader shelf in the vicinity of most outfalls relative to the rest of the SCB. In general, mean fish and invertebrate catch parameters were similar between the SCBPP survey and historical surveys for the mainland shelf of the SCB. However, fish abundance and number of species have apparently increased to the south and fish diversity has increased to the north since the late 1970s.

Sediment Toxicity on the Mainland Shelf of the Southern California Bight in 1994

Most chemical contaminants entering the marine environment have an affinity for particles and thus generally accumulate in sediments. Contaminated sediments may be toxic to benthic or demersal organisms. Because the principal focus of the SCBPP was on the benthic environment, it used various indicators of sediment quality that for evaluating the health of the benthic environment of the SCB. Sediment toxicity tests were conducted on about a quarter of the benthic stations sampled during the SCBPP survey in July-August 1994. This study describes the results of the sediment toxicity survey of the SCBPP.

Two different sediment toxicity tests were used on SCBPP samples. The first measured whole sediment toxicity on a tube-dwelling amphipod, *Ampelisca abdita*, a representative of an ecologically important group of benthic organisms. This test measures amphipod death during a 10-d period and involves little manipulation of the sediment. The second measured interstitial water toxicity during a 72-h period on developing Pacific purple sea urchin embryos. This test measured developmental abnormalities and provided greater sensitivity, and hence better discrimination between sites.

Sediment toxicity testing was successfully carried out on 72 stations in the SCBPP survey, thus demonstrating the feasibility of performing these tests on a regional basis. No acute toxicity was found at any station based on the amphipod bioassay. Most interstitial water samples produced toxic effects in developing sea urchin embryos. However, the interference of ammonia in the interstitial water samples made identification of toxic stations difficult and possibly inaccurate. Correction of the data for ammonia effects resulted in the identification of 15 of 52 stations as toxic at a concentration of 25% interstitial water. Variation in sediment storage and handling methods can influence the results of toxicity tests using bulk sediment or interstitial water. Additional research on sample handling methods is needed to improve toxicity data comparability. In future studies, the storage time of sediments should be reduced.