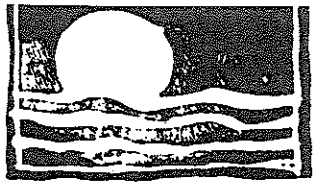


Executive Summary

SOURCES

Characteristics of effluents from large municipal wastewater treatment facilities in 1990 and 1991.

We summarize the concentrations of effluent constituents and estimates of effluent mass emissions for Hyperion Wastewater Treatment Plant, Joint Water Pollution Control Plant (JWPCP, County Sanitation Districts of Los Angeles County), County Sanitation Districts of Orange County (CSDOC) Wastewater Treatment Plants 1 and 2, and Point Loma Sewage Treatment Plant for 1990 and 1991. The trends in the mass emission of contaminants to the Southern California Bight over the past two decades are also examined.

The volume of effluent discharged from the four municipal wastewater treatment facilities declined by 12% from 1989 to 1991, perhaps as a result of water conservation efforts during the recent drought. The amount of effluent receiving secondary treatment increased from 43% of combined emissions in 1989 to 47% in 1991, while the concentrations of most effluent constituents declined. The combined emissions of suspended solids declined 5%, BOD declined 14%, and oil and grease declined 15%. The combined emissions of lead, cadmium, chromium, and mercury declined by more than 50%. Effluent concentrations of DDT and PCB were below method detection limits in 1991. Declines in constituent concentrations and mass emissions were the result of improved source control, improved primary treatment, and increased secondary treatment.

The combined flow from the four largest facilities increased 27% from 1971 to 1990 as a result of population increases. During that time, the volume of wastewater discharged by CSDOC and Point Loma doubled while the volume discharged by JWPCP and Hyperion increased only slightly. Population growth patterns, water reclamation, and inland discharge accounted for differences among the districts. Despite increases in the volume of wastewater discharged, the mass emissions of most effluent constituents have declined. The combined annual mass emission of suspended solids decreased 73%, BOD decreased 51%, and oil and grease decreased 69%. The combined mass emission of trace metals declined 94% and the combined emissions of chlorinated hydrocarbons declined more than 99% from 1971 to 1991.

Surface Runoff to the Southern California Bight

The concentrations of selected constituents were measured in dry and wet weather samples collected from the eight largest channels in Southern California between 1986 and 1988. We present estimates of the annual load of contaminants delivered to the ocean for the Santa Clara, Los Angeles, San Gabriel, Santa Ana, San Diego, and Tijuana rivers, and Calleguas and Ballona creeks. Most of the flows resulted from winter rains and discharge varied from year to year. The Santa Clara and Santa Ana rivers had no measurable flow during most of the study.

The eight channels sampled contributed about 80% of the total gauged runoff to the Southern California Bight. Annual discharges were, on average, 61% below their long-term means during 1986-87 and 31% below their long-term means in 1987-88. River discharge was a combination of surface and groundwater runoff, releases from control facilities, and inputs of domestic and industrial wastes.

The concentrations of trace metals and chlorinated hydrocarbons were generally correlated with suspended sediment and, to a lesser extent, with river discharge. The Tijuana River had the highest concentrations for most of the constituents measured. The Santa Clara River, a predominantly agricultural watershed, had the highest concentration of total DDT. The San Diego River, which drains a less developed basin, had the lowest concentrations for most of the constituents measured.

The Los Angeles, San Gabriel, and Tijuana rivers had the highest mass emissions, and the Santa Clara and San Diego rivers had the lowest. The mass emission of suspended sediment, trace metals,

and chlorinated hydrocarbons increased from 1986-87 to 1987-88 in proportion to the increase in volume discharged. Most river discharge and contaminant transport in Southern California took place during winter storms that occur intermittently and unpredictably.

Hazardous Spills in the Southern California Bight

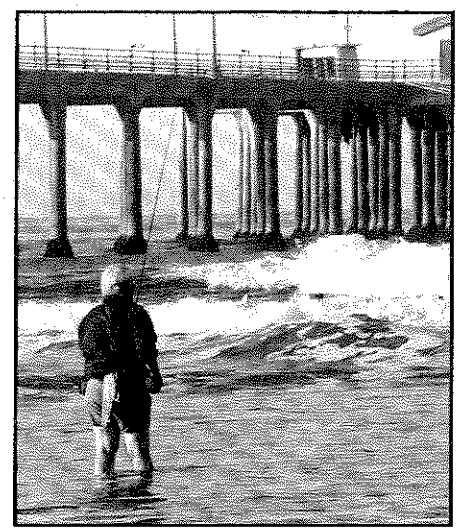
The existing data on hazardous material spills in the Southern California Bight were collected and are summarized in this report. The data were obtained from the U.S. Coast Guard's Pollution Response Branch in Washington, D.C. From 1985 through 1989, 327,115 L of hazardous materials were spilled in 1,102 separate incidents. The amount of hazardous material spilled varied by about an order of magnitude from year to year.

The majority of spills involved petroleum products, primarily diesel, fuel oil, jet fuel, and kerosene. The volume of individual spills was generally small; the median spill was 15 L for facilities and 19 L for vessels.

Spills from facilities accounted for 40% of the total number of spills and 60% of the total volume of material spilled. Most of the facility spills originated on land; a smaller proportion originated at offshore oil platforms and pipelines.

Spills from vessels accounted for 60% of the total number of spills and 40% of the total volume of material spilled. Most of the vessel spills originated with recreational boats, freighters, and tankers, although the largest volume of spills came from the U.S. Navy and towboats.

About 80% of the vessel spills and 50% of the facility spills occurred in harbors and bays. Los Angeles and Long Beach harbors were the site of more facility and vessel spills than any other waterbody.



Estimates of Ocean Disposal Inputs to the Southern California Bight

Currently, only approved dredged materials can be dumped at ocean disposal sites off Los Angeles (LA-2), Newport Beach (LA-3), and San Diego (LA-5). We estimated the total mass of dredge material and contaminants dumped at these sites between 1984 and 1991. The data were obtained from dredge permit files of the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency Region IX, and local port authorities.

Fifty-three projects disposed nearly 6,000,000 yd^3 of dredge materials in the bight between 1984 and 1991. The total annual volume of dredge materials dumped ranged from 72,000 to 2,354,000 yd^3; more than 80% of the material was dumped at LA-5 and LA-3. Most of the projects dumped small quantities of materials. The smallest projects dredged sand from private docks and marinas. Six projects accounted for 58% of all dredge materials dumped. The largest project was the deepening of Newport Harbor Back Bay completed in 1987. It contributed 70% of the material dumped at LA-3 and 22% of the volume dumped at all sites during the study.

Chemistry data were reported for 37 dredge projects that represented about 90% of the total volume dumped in the bight during the study. Dredge materials from the large industrialized harbors had the highest concentrations and largest concentration ranges. The annual mass input of most constituents to the bight was correlated with the annual mass input of solids.

Total Organic Carbon and Total Nitrogen in Marine Sediments, Sediment Trap Particles, Municipal Effluents, and Surface Runoff

We report on a method adopted in our laboratory for the analysis of total organic carbon (TOC) and total nitrogen (TN) in marine sediments, effluent particles, and similar matrices. Effluents were collected from the Joint Water Pollution Control Plant (JWPCP, County Sanitation Districts of Los Angeles County), the County Sanitation Districts of Orange County Wastewater Treatment Plant (CSDOC), and the City of San Diego Point Loma

Treatment Plant (PLTP). Sediment trap particles were collected near each of their ocean outfalls. Surface sediments were collected near the CSDOC and PLTP outfalls.

There were no significant differences in concentrations of TOC (25-40%) and TN (2.5-6.0%) among effluent samples from the wastewater treatment plants. The C/N ratios of effluent particles (7.1-8.4) were comparable to C/N ratios of effluents from other treatment plants. The concentrations of organic carbon and nitrogen on effluent particles have not changed in nearly two decades, while the concentrations of suspended solids have declined 60-70% since 1978.

The organic content of sediment trap particles was about 5-10% of the organic content of effluent particles from the corresponding sites. The C/N ratios of sediment trap particles (9.1-10.3) were higher than the C/N ratios of effluent particles. The lower TOC and TN concentrations, and higher C/N ratios, of sediment trap material suggest that effluent particles undergo rapid biodegradation, and perhaps dilution with plankton and terrestrial particles, upon discharge to the marine environment.

The organic content of surface sediments off Orange County and Point Loma was 1-2% of the organic content of effluent particles from the same site. The organic content of sediments at both sites was at or below levels of TOC and TN in surface sediments at the 60-m Reference Survey stations. However, the TOC and TN concentrations in surficial sediments were generally higher at stations close to the outfall and lower at stations farther away.

Sediment Model Verification

We examined the ability of two models (DECAL and SED2D) to simulate the characteristics of sediments around ocean outfalls off Point Loma (City of San Diego), Huntington Beach (County Santitation Districts of Orange County), and the Palos Verdes Peninsula (County Santitation Districts of Los Angeles County). The study investigated the sensitivity of model predictions to the input data and the consistency of the predictions. It also provided site specific predictions based on the consequences of particle aggregation.

Both models predicted areas of high sedimentation rates near the ocean outfalls; these zones were surrounded by areas of lower rates of sedimentation. There were, however, substantial uncertainties in the predictions of the fates of wastewater particles. Interestingly, the models also predicted an increase in the sedimentation of natural particles as a result of particulate-free discharges.

Uncertainties in the predictions came from questions about the aggregation of particles in the water column, the lack of data on vertical mixing within the wastefield, a poor understanding of sediment resuspension processes, and the lack of estimates of the decay rate of organic material in the water column and sediments. Until these uncertainties are addressed, it will be difficult to assess the validity of the predictions of the two models and the process representations contained within them. However, the models provide qualitative insight into the dynamics of the interaction of a wastefield and natural waters, and the localized effects on sedimentation from the discharge of wastewater effluents.

Potential Extension of the Point Loma Outfall

The application of body contact standards for bacterial concentrations to kelp beds in 1983 doubled the depth of the protected waters off Point Loma, and decreased the distance between the outer boundary of the protected area and the outfall diffuser. These changes substantially reduced the isolation of the wastefield from areas where body contact standards must be met and resulted in violations of the standard. An extension of the existing outfall into deeper water offshore is one way to meet bacterial standards in the kelp bed.

We examined the characteristics of water column density stratification and the properties of currents with current meter and thermistor data collected by Engineering Science, Inc. between March and September 1990 near the Point Loma outfall. The results were incorporated into time-dependent models of initial dilution and transport of wastewater by ocean currents.

In simulations based only on density stratification of the water column, potential intrusions of the wastefield into the kelp beds were predicted for 18-38% of the time for an outfall in 83 m, and for 4-12% of the time for an outfall in 95 m. When ocean currents were added to the model, wastewater intrusions into the kelp bed peaked at 15% of the time 1-2 km upcoast from an outfall in 83 m of

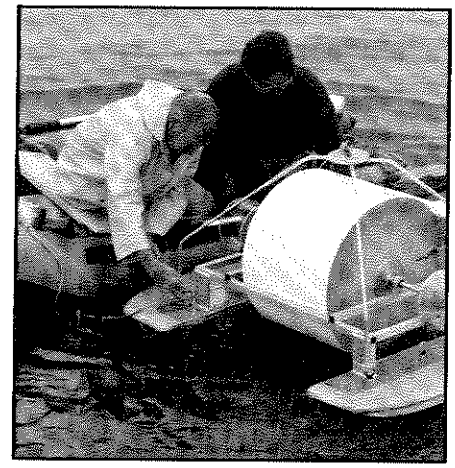
water; actual intrusions were predicted for about 40% of potential intrusions. Wastewater intrusions peaked at 7.5% of the time 4 km upcoast from an outfall in 95 m of water; actual intrusions were predicted for about 60% of potential intrusions. The increased upcoast displacement for the deeper discharge is the result of increased wastefield transport time from the diffuser to the kelp bed.

Response of Dover Sole to Termination of Sludge Discharge in Santa Monica Bay

We examined the response of Dover sole, a common deepwater flatfish, to the termination of sludge discharge by the Hyperion municipal wastewater treatment plant. The discharge of solid waste into the outer part of Santa Monica Bay ceased in November 1987 and resulted in changes in the biology of the macrofauna near the 7-mile sludge outfall.

Dover sole were most abundant in the contaminated zone near the outfall, and declined in abundance with increasing distance from the sludge outfall. The incidence of epidermal tumors and fin erosion decreased with distance from the outfall. There was little or no disease among fish collected in the reference area. The abundance of Dover sole and the incidence of disease in the contaminated zone declined after the termination of sludge discharge.

The decrease in Dover sole abundance and disease incidence after termination of solid waste discharge indicates that benthic conditions were improving near the outfall. The decline in abundance is probably related to the decreased organic content and prey abundance in the sediments. The organic content of surface sediment was significantly higher near the outfall and declined after termination of waste discharge. Sediments with high organic content support large populations of deposit feeders such as polychaetes, which are the primary prey items of Dover sole.



Temporal and Spatial Changes in Sediment Toxicity in Santa Monica Bay

We describe the temporal changes in sediment toxicity in the outer part of Santa Monica Bay following termination of sludge discharge by Hyperion wastewater treatment plant in 1987. The toxicity of sediments was tested in the laboratory with the amphipod, *Grandidierella japonica*.

The laboratory tests indicated that the toxicity of sediments in the sludge field decreased during a period of marked changes in animal species composition and abundance in the field. This suggests that the laboratory toxicity tests included the relevant sediment qualities that were important to organisms living in Santa Monica Bay.

Changes in the concentration of hydrogen sulfide, total organic carbon, and total nitrogen were related to the changes in toxicity. Low molecular weight petroleum aromatic hydrocarbons may have also played a role in the reductions in toxicity of sediments collected close to the 7-mile outfall.

By 1989, sediment quality at 100 m in the contaminated zones was similar to sediment quality in the reference zone. However, assemblages of benthic macrofauna in the contaminated zones were still adversely affected in 1990. Sediment toxicity tests with *G. japonica* were a less sensitive indicator of sediment quality in Santa Monica Bay than the composition of the benthic macrofauna in the field.

Long-Term Trends in Trawl-Caught Fishes Off Point Loma, San Diego

Information on long-term trends in demersal fish populations on the mainland shelf off Southern California is uncommon. This study examined temporal and spatial changes in trawl-caught fishes at six stations along the 60 m isobath off Point Loma from 1982 to 1991. Nearly 27,000 individuals from 57 species (28 families) were collected during a decade of semi-annual trawling.

The composition and abundance of trawl-caught fishes were similar among the six stations, although catches were lowest at the control station. Plainfin midshipman, longspine combfish, yellowchin sculpin, California tonguefish, and longfin sanddab

occurred in over 90% of the trawls and accounted for 55% of the individuals collected. The 10 most abundant species accounted for 83% of the fish captured.

There were seasonal and long-term differences in trawl catches that were correlated with water temperature. Longfin sanddab, California lizardfish, and hornyhead turbot were more abundant in the winter, while Dover sole, Pacific sanddab, and rockfish were more abundant in the summer. The number of species, individuals, and biomass declined following the 1982-83 El Niño. In general, more species of fish were collected when bottom water temperatures were lower.

The similarity of trawl fish abundance and composition among the six stations, and the similarity in abundance and composition between this study and the 1990 Reference Survey, suggest that the effects of wastewater discharge on the structure of the fish assemblage off Point Loma are minimal.

1990 Reference Survey

We recently completed the third survey of chemical and biological conditions in reference areas on the mainland shelf off Southern California in the last 15 years. Seven stations along the 30, 60, and 150 m isobaths were sampled in summer 1990. We report estimates of sediment characteristics, contaminant concentrations, and biological conditions from the least impacted areas on the mainland shelf.

Shelf sediments were predominantly sandy silt. The sand content decreased, and the clay and organic content increased, with increasing water depth. Trace metal concentrations were low at all stations and were similar among depths. Sediment concentrations of DDT, PCB, and polynuclear aromatic hydrocarbons were higher at the northern stations.

The macrobenthic (>1 mm) organisms collected in grab samples were variations of the *Amphiodia urtica-Spiophanes missionensis* assemblage that inhabits the Southern California mainland shelf. Amphipods (*Amphideutopus oculatus* and *Ampelisca brevisimulata*) dominated the samples from 30 m. The brittlestar, *Amphiodia urtica*, and the polychaete, *Myriochele* sp. M., dominated samples collected at 60 m. The 150 m stations were dominated by polychaetes (*Spiophanes fimbriata* and *Myriochele* sp. M) and *Amphiodia urtica*.

Trawl catches of large, motile invertebrates (megabenthos) and fish increased with increasing depth. The asteroid, *Astropecten verrilli*, dominated collections at 30 m. The sea urchin, *Lytechinus pictus*, and the prawn, *Sicyonia ingentis* dominated collections at 60 m. The sea urchins, *Allocentrotus fragilis* and *Lytechinus pictus*, dominated the 150 m stations. Fish catches at 30 m were dominated by speckled sanddab and longfin sanddab. Pacific sanddab and longfin sanddab dominated trawl catches at the 60 m stations. Slender sole and plainfin midshipman dominated trawl catches at the 150 m stations.

The assemblages of macrobenthos, megabenthos, and demersal fishes collected in 1990 were similar to the assemblages collected in the 1977 and 1985 reference surveys.

Toxicity of Dry Weather Flow in Ballona Creek

Ballona Creek is one of the few flood control channels that flows throughout the year into Santa Monica Bay. During dry weather, it receives discharges from a variety of sources including groundwater pumping and decontamination, swimming pool drainage, and dehumidifier condensate. We determined the toxicity of dry weather flow in Ballona Creek to purple sea urchin gametes (fertilization) and embryos (development) and examined the variability in toxicity over different time scales.

Dilutions of Ballona Creek samples collected in winter 1990 and winter 1991 were toxic to sea urchin sperm and embryos, although the fertilization test was more strongly affected than the development test. There was little variability in toxicity among samples collected on the same day, but the 1991 samples were slightly more toxic than the 1990 samples. Most of the receiving water samples collected at the mouth of Ballona Creek were also toxic to sea urchin sperm.

Elevated pH was responsible for much of the toxicity, although other constituents could not be ruled out. The spatial pattern of toxicity suggested that there were upstream (dry weather flow) and downstream (Santa Monica Bay) sources. Sources contributing to the toxicity of the receiving water may be contamination from Marina del Rey or the release of toxicants from Ballona Creek sediments. ■