Executive Summary

Characteristics of Effluents from Large Municipal Wastewater Treatment Facilities in 1992

We estimated mass emissions for effluents from Hyperion Wastewater Treatment Plant (City of Los Angeles), the Joint Water Pollution Control Plant (JWPCP, County Sanitation Districts of Los Angeles County), County Sanitation Districts of Orange County (CSDOC), and Point Loma Sewage Treatment Plant (City of San Diego) for 1992. Wastewaters from these facilities composed 90% of municipal effluents discharged to the ocean. We also examined trends in contaminant mass emissions from 1971 to 1992.

The volume of effluent discharged, and amount receiving secondary treatment, were unchanged from 1991 to 1992. The concentrations of 40% of the effluent constituents declined, 30% were unchanged, and 30% increased in 1992. Notably, the combined emissions of trace metals decreased 11%. Effluent mass emissions were related to flow; JWPCP had the highest flow and generally the highest constituent mass emissions.

From 1971 to 1992, the combined flow from the four facilities increased 12%. The volume of wastewater discharged by CSDOC and PLWTP doubled during this time, while the volume discharged by HTP and JWPCP decreased about 10%. Population growth patterns, water reclamation, and inland discharge account for differences among the agencies.

Despite increases in population and the volume of wastewater discharged during the past two decades, the mass emissions of most effluent constituents declined. The combined mass emissions of suspended solids decreased 73%, BOD decreased 52%, and oil and grease decreased 69%. The combined emissions of trace metals declined 94% and the combined emissions of chlorinated hydrocarbons declined more than 99%. Decreases in contaminant mass emissions are the result of increased source control and land disposal of sludge, improved sludge and primary treatment, and increased secondary treatment.

Estimated Discharges from Offshore Oil Platforms in the Southern California Bight in 1990

The oil fields off Southern California are among the largest domestic oil reserves in the US. Offshore facilities discharge drilling muds and cuttings, produced water, and sanitary wastes during development and production. We estimated direct inputs to the ocean from platforms off Southern California in 1990.

Platforms in state waters are permitted to discharge to the ocean, but most discharges are sent to onshore facilities. Platforms in federal waters can either discharge to the ocean or send their discharges to shore for treatment and disposal. In 1990, only a third of the platforms in federal waters discharged drilling muds and cuttings. The discharges varied greatly among platforms due to differences in platform location, drilling phase, stage of platform development, and type of mud used.

Because of low discharge volumes, platforms in federal waters were a minor source of contaminants to the coastal ocean. The mass emissions of drill cuttings, mud solids, and mud additives were 9% of the mass emission of suspended solids from the four largest municipal wastewater treatment facilities in Southern California. The mass of most of the constituents in drilling muds and cuttings was low except for barium. The volume of produced water discharged from platforms was 0.3%, and the volume of

sanitary wastes was 0.004%, of effluent volume discharged from the four largest municipal facilities. The mass emission of contaminants in produced water was <1% of the combined emissions for the same constituents from the four largest municipal facilities.

Congener-specific Analysis of Polychlorinated Biphenyls by GC/ECD and GC/MS: Characterization of an Aroclor Mixture

Polychlorinated biphenyls (PCBs) were manufactured and marketed under the trade name Aroclor until 1977. Aroclors are mixtures that contain 50-80 of the 209 theoretically possible PCB congeners. Traditionally, PCB-contaminated samples have been analyzed by measuring one or several PCB congeners and subjectively matching the chromatographic pattern to one of the Aroclors. This method relies heavily on the experience of the analyst. However, it is important to measure individual PCB congeners because they have different physical and chemical properties, they are degraded and metabolized at different rates, and some congeners are more toxic than others.

Since PCBs have been supplied and disposed mostly as Aroclors, the practical approach to congener-specific analysis would be to choose PCB congeners commonly encountered in the environment for calibration standards. Mixtures of Aroclors fit this purpose and the question becomes how to separate and quantify Aroclors that can be used as daily calibration standards.

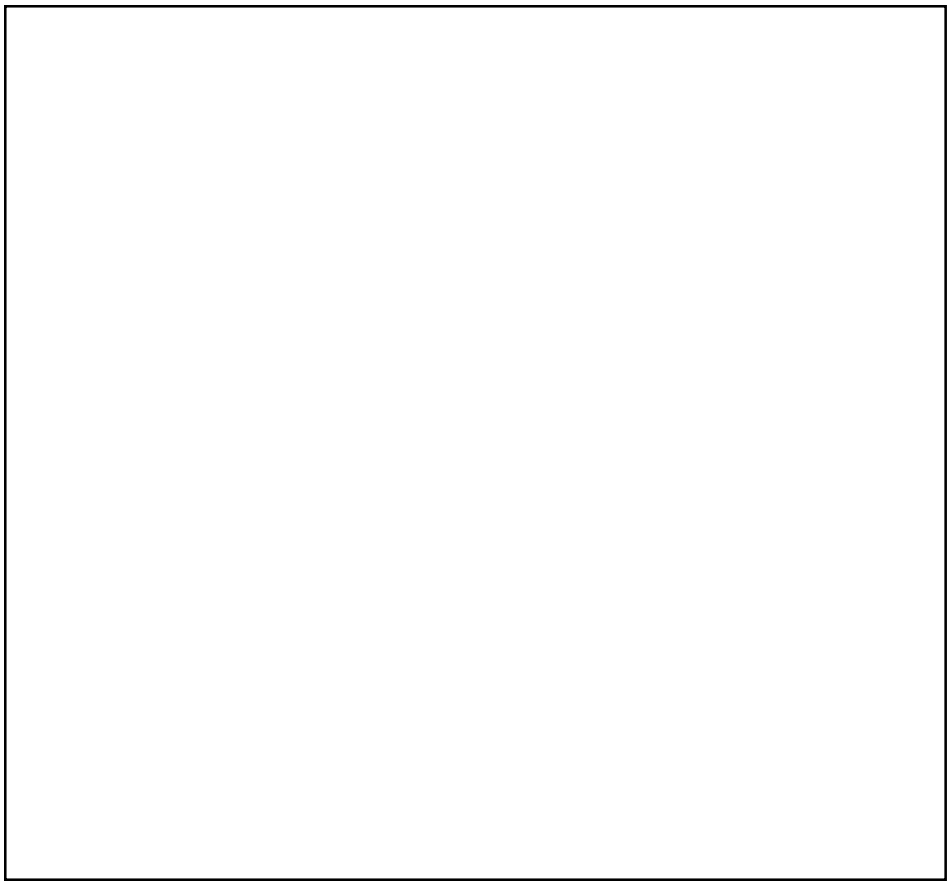
We developed a practical method for PCB congener-specific analysis by GC/ECD. We characterized a mixture of Aroclors 1242, 1248, 1254, and 1260 (1:1:1:1, wt%), called a secondary standard, with 120 PCB congeners (primary standards); peaks were identified and confirmed on GC/MS. The relative retention times and response factors of the PCB congeners were comparable to those obtained by other researchers. Instrument detection limits ranged from 0.05 to 1 ppb (GC/ECD). We will use the Aroclor mixture as a daily calibration standard for congener-specific analyses of PCBs in environmental samples.

SCCWRP Inclinometer Current Meters

Most of our current measurements since 1974 have been made with inclinometer current meters (SICM) with aluminum or polyvinyl-chloride cases. In this report, we describe their design, and we discuss their limitations, calibration in the laboratory, and intercalibration in the ocean. In calm water, the current meter hangs vertically from a swivel. As current speed increases, the meter rotates to face into the current and the tail rises. The angle of the meter from the vertical (tilt) and the orientation of the meter (direction) are related to the current speed and direction. The current meter measures tilt and direction angles at preset intervals.

The relation between tilt angle and current speed was nonlinear in the laboratory calibration. The SICMs worked best at tilt angles between 10^{o}-70^{o}; at higher and lower angles, meter response changed rapidly and the chance for estimation errors increased. The SICM measurements were sensitive to rapid changes in current direction and speed, and to vertical currents associated with surface gravity waves; they were less sensitive to along-axis fluctuations.

Measurements of longshore currents by the SICMs were highly correlated (r=0.96) with measurements by an InterOcean S4 electromagnetic meter. The correlation for cross-shore flows was lower (r=0.76). At water depths greater than 10-15 m, wastefield transport estimated from SICM data collected was comparable to transport estimated from other current meters. The advantage of the SICMs is that they are relatively simple, durable, low cost, and low maintenance, and they are easy to deploy from small boats.



Near-Bottom Currents off Southern California

Near-bottom currents affect the dispersion and fate of natural and effluent particles that settle to the bottom. We report on their properties based on nearly 20 years of measurements on the mainland shelf off Southern California.

The speeds of near-bottom currents were 75-80% of the speeds of midwater flows due to bottom friction; occasionally, near-bottom speeds exceeded midwater speeds. The strength of near-bottom currents varied with season, location, and depth; they had a net offshore component within 5 m of the bottom that was lacking higher in the water column. The strength of the offshore component was comparable to the strength of the longshore component.

Particles settling from the surface waters are carried along by mid water currents that flow predominantly along the mainland shelf, so settling particles tend to be deposited along isobaths. Sediment trap and transmissometer studies near the bottom suggest that these particles are resuspended many times. The thickness of the near-bottom turbidity layer was nearly the same as the thickness of the near-bottom currents. Since near-bottom currents have a significant net offshore component, they may be important in moving particles off the mainland shelf and into the nearshore basins.

Temperature Variations in the Water Column off Point Loma

Most people are aware of the motions of waves on the sea surface and the rise and fall of the tides. Similar vertical motions occur below the sea surface. These internal waves or tides can be observed by measuring the rise and fall of surfaces of constant temperature or constant density. We used temperature measurements from the ocean off San Diego to describe these motions. Internal waves and tides caused 10-20 m, and occasionally 35-40 m, vertical excursions of surfaces of constant density in 55-70 m of water.

Internal waves and tides can affect the transport of wastewater plumes. If the wastefield is confined below the maximum depth in a protected area, wastewater intrusions can be prevented. Since vertical mixing appears small on the mainland shelf, the top of the wastefield will stay at the same isothermal surface as at the end of initial dilution. Internal waves and upwelling can raise the top of the wastefield to depths shallower than the maximum depth of the protected area.

Internal waves may distort the spatial distribution of water quality parameters in hydrocast surveys, unless sampling is done in less than half the semidiurnal tidal period (<<6 h). Within an area or along a transect, the vertical motions associated with internal waves do not always move up and down as a unit and hydrocast surveys may not be appropriate for detecting upwelling or downwelling; time-series temperature measurements from moorings are probably necessary.

Preliminary Study of Seasonal Variation of Carbon and Nitrogen in Sediments off Point Loma

We investigated the seasonal variation in total organic carbon (TOC) and total nitrogen (TN) in surface sediments in a pre-discharge study off San Diego. The TOC and TN concentrations were typical of marine-dominated, nearshore sediments (mean TOC=0.53%; TN=0.038%); the carbon/nitrogen ratios (mean C/N=15.4) were similar to marine humic material.

The TOC and TN measurements separated the stations into three groups: sites with coarse sediments and highly variable TOC and TN; sites near a dredge material dumpsite with low TOC and TN; and the remaining stations near the recently extended Point Loma outfall with similar TOC and TN. Sediments in the first two groups were generally poor in nitrogen, and thus had higher C/N ratios.

The TOC concentrations were relatively constant at most stations throughout the year, while TN concentrations were higher in summer and fall compared to winter and spring. Seasonality may be associated with marine microbial activities occurring in the water column before organic particles are deposited, or occurring in the sediments after particle deposition. This study provided baseline data for TOC and TN against which the effects of future municipal wastewater discharge from the recently extended outfall can be measured.

Contamination of Recreational Seafood Organisms off Southern California

We provide information on contaminant levels in the edible tissues of white croaker (*Genyonemus lineatus*) and yellow rock crab (*Cancer anthonyi*) collected from Santa Monica Bay, the Palos Verdes Shelf, and Dana Point. We also review the historical data on seafood contamination near Los Angeles.

White croaker from the Palos Verdes Shelf had higher levels of PCBs, DDT, and other chlorinated pesticides than elsewhere. Yellow rock crab from the Palos Verdes Shelf had higher concentrations of PCBs and DDT than those from Dana Point, but crabs from Dana Point had higher levels of other chlorinated pesticides and selenium. The concentrations of DDT and PCBs in white croaker were several times higher than concentrations in yellow rock crab.

White croaker was the only seafood species that was examined from the 1970s into the 1990s. They had the highest levels of DDT and PCB of all bony fishes at every location in all surveys. The concentrations of DDT in white croaker from the Palos Verdes Shelf and Santa Monica Bay declined over the last two decades; PCB levels decreased on the Palos Verdes Shelf but not in Santa Monica Bay.

Levels of PCBs and DDT in surface sediments on the Palos Verdes Shelf have declined since the mid-1970s as contaminated sediments were progressively buried by cleaner particles. Nevertheless, the concentration of DDT and PCBs in surface sediments are higher on the Palos Verdes Shelf than elsewhere in Santa Monica Bay. Historic deposits of contaminated sediments on the Palos Verdes Shelf are the primary source of DDT and PCBs.

Distribution of the Brittlestar *Amphiodia (Amphispina)* Species in the Southern California Bight in 1957-59

Between 1956 and 1959, scientists at the University of Southern California conducted an extensive oceanographic, geological, and biological survey off Southern California. One of the major findings was that the red brittlestar (*Amphiodia urtica*) was the most abundant and widely distributed organism on the mainland shelf. Currently, *A. urtica* is rare or absent near municipal wastewater outfalls and it is used as an indicator of outfall effects. We used the historic data to determine the effect of latitude, depth, and sediment grain size on the abundance of *A. urtica*.

Amphiodia urtica was most abundant in coarse silt to very fine sand between about 50-100 m of water. It was rarely collected in <15 m or >185 m, even where the sediment was suitable. Brittlestars were less abundant north of Ventura, probably due to colder water temperatures and the lack of suitable sediments. Other factors, including food availability, competition and predation, may also affect its distribution.

There is a question of how representative the historic data are of current conditions in the bight. *Amphiodia urtica* abundance ranges from about 500 to 4500/m^2 at control stations in municipal wastewater monitoring programs, which is within the range of abundance in the historic data. However, benthic communities may have changed over the past three decades. The clam *Cyclocardia ventricosa* dominated the infaunal community with *A. urtica* in the historic data. The abundance of *C. ventricosa* decreased between 1959 and 1977, and it no longer dominates.

Population Biology of the Brittlestar *Amphiodia urtica*

Amphiodia urtica is one of the most abundant and widespread invertebrates on the mainland shelf off Southern California, but it is rare or absent near municipal wastewater outfalls. We compared reproduction, growth, mortality, and recruitment of *A. urtica* at moderately-impacted sites near wastewater outfalls and at reference sites in Santa Monica Bay and off San Diego.

The abundance of *A. urtica* was low at the impacted sites, but juveniles and adults were present. The abundance was higher at the reference sites, but more juveniles were collected in Santa Monica Bay than off San Diego. There were no differences in growth rates between impacted and reference stations, but mortality was higher at the impacted stations. *Amphiodia urtica* reproduced throughout the year and males and females matured at the same size. More of the brittlestars off San Diego had regenerated disks suggesting a higher level of disturbance. The differences in population structure between Santa Monica Bay and San Diego could have been caused by differential recruitment, differential survival of juveniles, predation, or something else.

Interestingly, *A. urtica* recruited to the reference and impacted stations. The fact that brittlestars recruited to impacted sites, coupled with the lack of effects on growth and survival of adults in laboratory bioassays with contaminated sediments, suggest that the mechanism(s) resulting in low brittlestar abundance near municipal wastewater outfalls acts during the early juvenile stage.

Sediment Toxicity Test Methods for the Brittlestar *Amphiodia urtica*

There is broad interest in the biology of *Amphiodia urtica* because its abundance is reduced near municipal wastewater outfalls and the cause is unknown. We developed a sediment toxicity test as a tool to help us understand why the brittlestar does not occur around outfalls. We experimentally determined the length of time that brittlestars can be held in laboratory

culture and the optimum exposure period for sediment bioassays. The success of the culturing techniques was judged by brittlestar survival, growth, and reproductive status. In the sediment bioassays, we measured growth and survival, and evaluated growth, arm regeneration, and calcium uptake as indicators of sublethal stresses.

Brittlestar survival was generally high for 69 weeks in laboratory cultures and the animals grew and matured. Growth was most rapid in the first 26 weeks and slowed thereafter. The reduction in growth rate was probably due to a shift in the allocation of energy to reproduction as the animals approached maximum size.

Brittlestar survival was not affected by exposure to contaminated sediments from Los Angeles Harbor or the Palos Verdes Shelf. However, growth, arm regeneration, and calcium uptake were reduced among *A. urtica* exposed to sediments from Palos Verdes; and growth and arm regeneration were reduced among animals exposed to sediments from Los Angeles Harbor. Growth was the most responsive measure, and arm regeneration was the most precise. The growth response of *A. urtica* was one of the most sensitive sublethal measures of sediment quality we have observed in our laboratory.

Response of the Brittlestar *Amphiodia urtica* to an Outfall Gradient

We measured the response of adult *Amphiodia urtica* to sediments collected along outfall gradients in Santa Monica Bay and off Orange County. Its abundance in sediments over the two gradients tested ranged from zero near the outfalls, to levels typical of reference areas in off Southern California.

There was no mortality among *A. urtica* exposed to sediments from Santa Monica Bay during a 28-day experiment. Growth rates of brittlestars exposed to sediments from the outfall stations were not different from the control. There was some mortality among brittlestars exposed to sediments from Orange County during a 56-day experiment, but there was no difference among the stations. Mortality may have been a laboratory artifact that resulted from degradation of sediment quality.

There was no relation between the field abundance of *A. urtica* and the mortality or growth of adult brittlestars exposed to sediments from the same site. There were no differences in growth or arm regeneration rates among brittlestars exposed to sediments from outfall and control stations. The absence of effects on growth and survival of adult brittlestars exposed to contaminated sediments, coupled with the fact that brittlestars recruit to impacted sites, suggests that the mechanisms that result in low brittlestar abundance near municipal wastewater outfalls act during the early juvenile stage.

Preliminary Toxicity Identification Evaluation (TIE) of Dry-weather Urban Discharge

Urban surface runoff is a significant source of contaminants to the coastal waters off Southern California. Urban runoff can be toxic, and in some rivers and storm drains, dry-weather flow is more toxic than wet-weather flow. Dry-weather flows can mobilize household, industrial, and construction site wastes; used crankcase oil; and pesticides, and carry them untreated to the ocean through the storm drain system. Approximately one-fourth of the total pollutant loading in the Santa Monica Bay is due to urban runoff and the largest contributor is Ballona Creek. We measured the toxicity of dry-weather flow in Ballona Creek and three other storm drains that discharge to the bay.

Dry-weather flow from the four storm drains was toxic to the early life stages of abalone, sea urchins, and giant kelp. Effluent from Ashland storm drain was usually the most toxic. There was no

difference among toxicity levels of Ballona Creek, Pico-Kenter, and Sepulveda storm drains. Responses of the three test species indicate that no single organism can predict the relative toxicity of dry-weather effluents among storm drains.

The toxicity of dry-weather storm drain flows was spatially and temporally variable, even over the course of one day, indicating that the composition of dry-weather flow was variable. Results of the TIE experiments implicated toxicants with properties of metals, oxidants, and nonpolar organics as causes of toxicity.

Toxic Effects of Elevated Salinity and Desalination Waste Brine

Desalination of seawater is not a common source of potable water in Southern California. The high cost of desalinated water compared to water from other sources has limited the number of desalination projects. However, the recent drought prompted construction of several plants and there are plans for more. The by-product of desalinating seawater is a brine with a salinity about twice that of seawater.

We measured the effects of elevated salinity on amphipods, giant kelp spores, and sea urchin embryos. We also examined the effects of interactions between waste brine and secondary effluent. Samples with elevated salinity were produced in the laboratory. Secondary effluent was obtained from the El Estero treatment plant in Santa Barbara. Waste brine and seawater were obtained from the Diablo Canyon desalination plant in Central California.

Desalination plant brine and elevated salinity did not produce toxic effects on amphipods, kelp spores, or sea urchin fertilization at salinities up to 15% above seawater. Sewage effluent had a significant effect on sea urchin embryo development only at the highest concentration (5.6%). Elevated salinity also had a significant effect on urchin embryo development at concentrations 9% above seawater. Desalination waste brine was not toxic to amphipods, kelp spores, or sea urchin embryos at concentrations expected to occur in the field.

Aspects of the Life History of Hornyhead Turbot, *Pleuronichthys verticalis*, off Southern California

The hornyhead turbot, *Pleuronichthys verticalis*, is a common flatfish on the mainland shelf off Southern California. It is used as an indicator of contaminant bioaccumulation in the monitoring programs of several agencies. The concentrations of chlorinated hydrocarbons in hornyhead turbot tissues is often several magnitudes higher than the concentrations in the sediments on which it lives. Despite its importance in monitoring programs, relatively little is known about the life history of the hornyhead turbot. We determined the reproductive cycle and diet of hornyhead turbot on the mainland shelf off Orange County.

The largest concentrations of adult and juvenile hornyhead turbot were found off Huntington Beach in 30-35 m of water. Males and females grew at the same rate up to about 150 mm, which is the size of sexual maturity for females. Beyond 150 mm, females weighed more than males at the same length; females also grew to a larger size. Males matured at about 100 mm. Spawning apparently took place from late winter to spring, but some spawning may have occurred through the year.

Hornyhead turbot fed mainly at sunrise and consumed relatively few species of sedentary, tube-dwelling polychaetes and bivalves; other taxa were eaten incidentally. Food availability was higher in the summer when fish contained about three times the mass of prey as fish collected in the winter. Future studies will focus on how the hornyhead turbot, a relatively low trophic level fish, accumulates high tissue levels of chlorinated hydrocarbons.