Southern California Bight 1994 Pilot Project:

I. Executive Summary

January 1998

Southern California Coastal Water Research Project
7171 Fenwick Lane Westminster, CA 92683-5218
Phone: (714) 894-2222 • FAX: (714) 894-9699
http://www.sccwrp.org

INTRODUCTION

Ocean-dependent activities contribute $9 billion to Southern California coastal communities

The Southern California Bight (SCB) is a valuable natural resource that contributes to the local economies of the region and enhances the quality of life for those who work in, live in or visit the area. Human uses of the coastline and ocean waters of the Bight include recreation, tourism, aesthetic enjoyment, sport and commercial fishing, coastal development, and industry. Ocean-dependent activities contribute approximately $9 billion to the economies of coastal communities surrounding the SCB and support over 175,000 jobs.

The area bordering the SCB is also home to nearly 20 million people, making it one of the most densely populated shorelines in the United States. With the exception of two small areas (north of Santa Barbara and near Camp Pendleton), the entire California portion of the SCB shoreline has been subject to development, waste discharge, or other forms of resource utilization. These activities have resulted in extensive habitat change and large, varied inputs of contaminants. These changes contribute to concerns about current and potential impacts on the natural resources of the SCB.

What is the Southern California Bight?

A bight is defined as a bend in the coastline, and the Southern California Bight is the 300 km of recessed coastline between Point Conception in Santa Barbara County and Cabo Colnett, south of Ensenada, Mexico. The dramatic change in the angle of the coastline creates a large backwater eddy in which equatorial waters flow north nearshore and subarctic waters flow south offshore. This unique oceanographic circulation pattern creates a biological transition zone between warm and cold waters that contains approximately 500 marine fish species and more than 5,000 invertebrate species.

Less than 5% of the SCB is routinely monitored.

To address these concerns, more than $10 million is spent annually monitoring southern California's coastal water quality. Yet some basic questions about the ocean's condition, such as the level of impact on fisheries and how many acres of ocean bottom are impaired, cannot be answered. The principal limitation is that less than 5% of the area in the SCB is routinely monitored. Moreover, the parameters measured, as well as the frequency and methodology by which they are measured, typically differ among monitoring programs throughout the SCB. These limitations reflect the predominant association of monitoring in southern California with discharge permit requirements that are focused on site-specific, single-source issues. While these programs generally collect high quality data, they are not designed to describe changes that occur on regional scales or to assess cumulative impacts from multiple sources.

Recognizing the need for integrated assessment of the southern California coastal ocean, 12 government organizations, including the 4 largest municipal wastewater dischargers and the 5 agencies regulating discharges in southern California, collaborated to conduct a comprehensive regional monitoring survey in 1994. Called the **Southern California Bight Pilot Project (SCBPP)**, the survey's primary objective was to assess the spatial extent and magnitude of ecological disturbances on the mainland continental shelf of the SCB and to describe relative conditions among different regions of the SCB.

The SCBPP sampled 261 sites in the SCB between July and August, 1994. Sampling sites were limited to the mainland continental shelf (10 to 200 meters water depth) in the U.S. portion of the SCB (Figure 1) and were selected randomly to ensure that they were representative of conditions in the study area. At each site, a series of indicators was selected to address three major attributes of concern to scientists, managers, and the public: 1) the extent of pollutant exposure, or the condition of the physical and chemical environment in which biota live; 2) the status of biological resources, or the existence of healthy, diverse, and sustainable biological communities; and 3) the presence of marine debris, which addresses concerns about aesthetic conditions.

The SCBPP was a cooperative effort of 12 public agencies, with coordination of sampling and analysis among 6 research vessels, 7 chemistry laboratories, and 4 biology laboratories.

Methods Standardization

An important feature of the SCBPP was methods standardization to ensure that data collected by the multiple participating organizations were comparable. This was accomplished in three ways. First, we prepared methods manuals, including a field methods manual, a quality assurance manual, and an information management manual; all of these are publicly available and have been adopted for use beyond the SCBPP by many organizations in southern California. Second, quality assurance officers toured each vessel and laboratory to ensure that the documented practices were being followed. Third, we conducted intercalibration exercises in which the same samples were analyzed by each laboratory; the results of these intercalibrations can be found in the associated technical reports.

The results of the SCBPP provide a "snapshot" of conditions throughout the SCB in 1994. As a pilot study, this project established the feasibility of cooperative regional monitoring in southern California and also identified some of the limitations of interpreting environmental monitoring data.

Volume I, Executive Summary, provides an overview of the findings from the SCBPP and is intended for environmental managers and the general public. Volumes II-VI of this report, which are intended for a scientific audience, provide supporting details for the conclusions presented in this summary. All volumes will be available electronically via the Internet (http://www.sccwrp.org); printed copies can be obtained at a nominal cost by contacting the Southern California Coastal Water Research Project (714-894-2222).

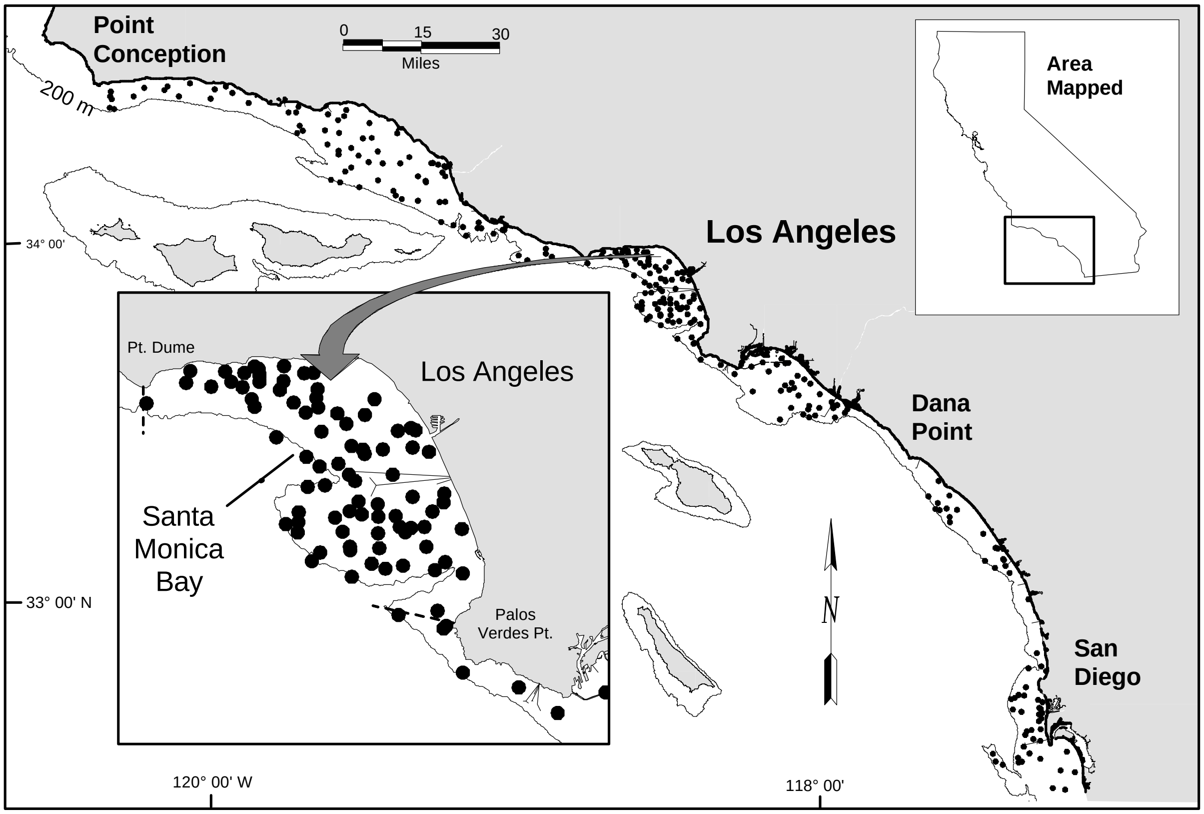

Figure 1. Station locations for the Southern California Bight Pilot Project (coastal shelf at 10-200 m depth). Inset shows the boundaries (dashed lines) for the Santa Monica Bay region.

POLLUTANT EXPOSURE

Humans introduce contaminants into the ocean through various sources, including industrial and sewage outfalls, stormwater runoff, overboard disposal from boats, and atmospheric deposition. Once in the ocean, these materials may affect water quality or settle to the seafloor and affect the quality of the mud in which many important marine food web organisms live. Alternatively, introduced contaminants may flow out of the SCB through ocean circulation, be degraded by organisms, or be diluted below levels of concern. Pollutant exposure indicators measure the fate of introduced materials and the extent to which these materials affect the natural physical and chemical environment. Two types of pollutant exposure indicators, sediment quality and water quality, were measured in the SCBPP.

Contaminants accumulate in sediments which provide an important route of exposure for marine life.

Sediments, or the mud and sand of the ocean bottom, were selected for study because many introduced contaminants bind to particles that eventually sink to the seafloor. Sediments also provide a habitat for many organisms that are important members of ocean food chains, such as worms and clams. Humans can affect these organisms by adding pollutant exposure or by altering their physical habitat, such as the size of particles in the sediment.

The **sediment quality** portion of the SCBPP studied the physical (grain size) and chemical characteristics of bottom sediments. Samples were collected using a 0.1 m^2 Van Veen grab sampler. Chemical characterizations included organic matter (total organic carbon, or TOC), individual metals, pesticides, PCBs and petroleum-related hydrocarbons (PAHs).

Sediment grain size varied widely throughout the SCB. Samples ranged from very coarse (all sand and gravel) to very fine grained (all mud). The muddiest sediments were found in the deepest waters. Sediments became increasingly coarse as water depth decreased; and sandy sediments dominated inshore zones, where wave action limits the deposition of fine material. Overall, the average mud content for SCB sediments was 42%.

Metal Enrichment

One of the challenges of assessing the magnitude of sediment contamination is differentiating metals that occur naturally in the earth's crust from those that are added from human activities. This differentiation was accomplished by normalizing metal concentrations to iron, which acts as a tracer of naturally occurring metal concentrations. Iron is an effective tracer because it naturally occurs at high concentrations that usually far exceed the effect of human influence. Details about these normalization relationships are presented in Volume III of this report.

Contaminants were found in 89% of the SCB sediments.

Chemicals introduced by human activities were present in 89% of the SCB. The pesticide DDT was

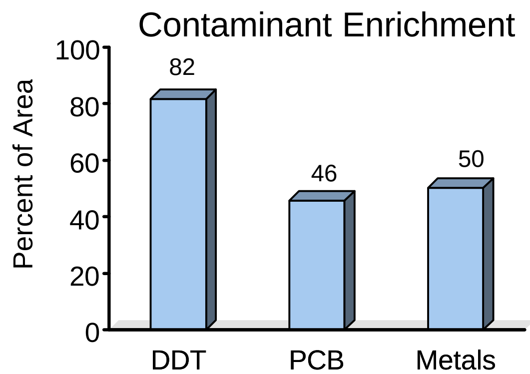

Figure 2. Percent of the SCB with elevated organic or metal contaminants in sediments.

A remnant of historical discharges, DDT was the most prevalent contaminant found in sediments.

the most widespread contaminant; it was found in 82% of the SCB sediments (Figure 2). The highest concentrations of DDT were located on the Palos Verdes Shelf. A stable compound, DDT degrades very slowly in the marine environment. Most of the DDT found in the SCB is the result of large historical discharges; the use of DDT was banned in 1972 and present discharges are usually undetectable.

Elevated levels of PCB and trace metals were found in approximately half of the SCB sediments. The highest sediment metal concentrations were typically found in fine grained sediments from locations where inputs of these constituents were highest, such as Santa Monica Bay.

Sediment Quality Guidelines
Sediment quality criteria for contaminants are being developed by the United States Environmental Protection Agency (EPA), but are not yet available. The ERL and ERM guidelines developed by NOAA were used in the SCBPP as screening level thresholds to identify areas of potential biological effect. The ERM represents the concentration of a contaminant frequently associated with adverse effects in field and laboratory studies. The SCBPP data were also evaluated using other threshold values, the results were similar and appear in Volume III.. The database resulting from the SCBPP can be used to reevaluate sediment contamination levels when the Federal criteria are issued.

Contaminants exceeded biological effect screening levels in 12% of the SCB sediments.

Two screening level thresholds developed by the National Oceanic and Atmospheric Administration (NOAA) were used to assess the potential biological effects from sediment contamination: Effects Range Low (ERL) and Effects Range Median (ERM). Biological impacts are not expected at sediment contaminant concentrations below the ERL. Contaminant values above the ERM are expected to have some biological impact. The ERM was exceeded in 12% of the SCB (Figure 3), with most exceedences resulting from DDT contamination. Approximately

Contaminant Thresholds

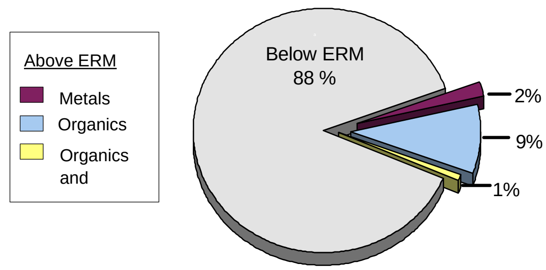

Figure 3. Percent of SCB area exceeding NOAA guidelines (ERM) for biological effects.

55% of the SCB had contaminant concentrations between the ERL and ERM, a range where the potential for biological effects are uncertain.

Contaminant levels in the SCB were similar to those in other areas of the country.

Sediment contaminant levels in the SCB were similar to those observed nationwide in NOAA's National Status and Trends (NS&T) Program. Exceptions included antimony, PCB, and PAH, which were lower in the SCB; and cadmium, silver, and DDT which were higher in the SCB. The NS&T database includes offshore areas similar to those sampled in the SCBPP, as well as harbors and estuaries.

Water quality is important to the health of both water column and bottom-dwelling organisms. Some characteristics, such as dissolved oxygen and water clarity, are of fundamental importance to the health of marine life. The California Ocean Plan, developed by the State Water Resources Control Board, has established objectives for these parameters in areas receiving waste discharge. Other water column parameters, such as temperature and salinity, provide information about circulation patterns within the SCB; these factors can also influence organisms and contaminant fate.

The water quality survey for the SCBPP utilized electronic profilers to measure temperature, salinity, dissolved oxygen, and light transmittance. The most important factor affecting surface water properties was latitude; the northern portion of the SCB was colder, less saline, and higher in dissolved

Precision of Estimates

One of the goals of regional monitoring is to provide estimates of status with a known and acceptable degree of confidence. This was accomplished by selecting stations randomly and including a sufficient number of stations within each region of interest to provide the desired level of accuracy. Confidence levels for the assessments can be found in Volumes II-V of this report.

oxygen than the southern portion. Depth was the most important factor influencing bottom water properties. Temperature and dissolved oxygen concentrations decreased and salinity increased with water depth. Near-bottom water properties did not vary with latitude.

More than 99% percent of the SCB met the California Ocean Plan objectives for dissolved oxygen and water clarity

Water quality was good throughout the SCB. Almost all of the surface waters were fully saturated with oxygen and more than 99% of the SCB met California Ocean Plan water quality objectives for dissolved oxygen and water clarity. The measured reductions in dissolved oxygen were slight (maximum 14% deviation from background conditions). Areas of reduced water clarity were mostly located in shallow water, and probably resulted from the natural resuspension of bottom sediments.

Water Quality Objectives

The California Ocean Plan provides water quality objectives for areas receiving waste discharge. The objectives for water clarity and dissolved oxygen specify allowable deviations from "background" conditions (no significant reduction in natural light, no more than 10% reduction in oxygen). Comparison of SCBPP data to these objectives presented two challenges: determining background conditions and distinguishing between changes due to waste discharge or other events, including natural fluctuations. The technical approaches used to make these comparisons are described in volume II of this report.

BIOLOGICAL RESOURCES

While pollutant exposure provides a measure of human influence on the marine environment, it is the effect of this exposure on biological resources that determines the significance of the influence, and provides the threshold upon which most management decisions hinge. The effects of exposure were assessed in this study using three indicators: one that measured the condition of bottom-dwelling (benthic) invertebrate communities collected at the site; one that measured the response of benthic animals exposed under laboratory conditions to sediment from a site (toxicity testing); and a third that measured the status of bottom-dwelling fish populations.

The status of biological resources was assessed using studies of bottom-dwelling organisms.

Benthic infauna are worms, clams, and other non-fish animals that live in the sediments; these animals have many characteristics that make them useful indicators of environmental quality. Because benthic infauna live in and often feed upon sediment, they are exposed to sediment contamination and are likely to be affected by toxic chemicals. Studies around the world have shown that benthic infauna are sensitive indicators of environmental conditions. They are also good integrators of habitat conditions because they are relatively long-lived (several years) and usually remain in one place throughout their lives.

Sediment grab samples were collected for analysis of benthic infaunal community composition. Individuals of each species were counted and the weights of major groups were measured. An average of 85 species were present at each station. Approximately 50% of the organisms were annelid worms; 19, 13, and 10% were arthropods, brittlestars, and mollusks, respectively.

Benthic Response Index (BRI)
Benthic animals are good, but complex, indicators, with more than 1500 species occurring in the SCB. These data were interpreted using a newly developed index that combines individual species data into a single value indicating similarity of the assemblage to reference conditions. The magnitude of the BRI also indicates severity of deviation from reference, ranging from slight changes to loss of major species groups. However, the BRI does not identify the cause of the alteration, which may be natural or man-made. Index development is consistent with EPA directives to incorporate biological criteria into assessments of ecological condition, but this index is new to the SCB. A description of how the index was developed, the means that were used in its validation and plans for its continued refinement are presented in Volume IV of this report.

Ninety-one percent of the SCB had communities of bottom-dwelling animals typical of reference areas.

Community composition varied throughout the SCB, primarily in response to different habitat characteristics. Variations in water depth and sediment grain size had the most significant effects on community composition. Ninety-one percent of the SCB contained benthic infaunal communities similar to reference areas (locations within the SCB having minimal human influence). Deviations from reference in the remaining 9% were minor, representing small shifts in species composition (Figure 4). Only 2% of the area of the SCB showed a loss in biodiversity. Most of the

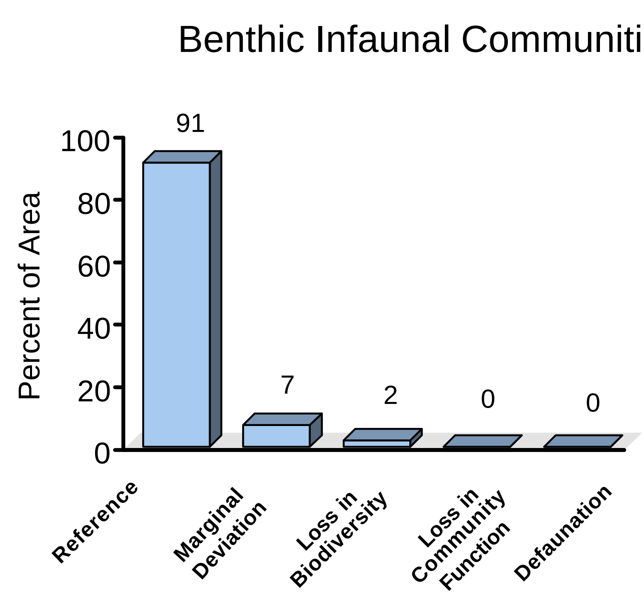

Figure 4. Percent of SCB containing reference or altered communities of bottom-dwelling invertebrates.

stations with altered community composition were located in the Santa Barbara Channel, near the mouths of the Santa Clara and Ventura Rivers, in Santa Monica Bay, and on the Palos Verdes Shelf. Alterations were also found at single stations near the mouths of other large urban rivers and at the head of the La Jolla Submarine Canyon, off San Diego.

The absence of severe alterations in SCB benthic infaunal communities underscores the dramatic improvement in sediment quality that has occurred near some large municipal wastewater outfalls. Monitoring data from the 1970s indicate that much of the Palos Verdes Shelf had degraded benthic communities, characterized by the absence of important animal groups. Similar impacts were also present in Santa Monica Bay. Improvements in benthic infaunal communities since the 1970s correspond to reduced discharges of solids and contaminants by municipal wastewater treatment plants.

Sediment toxicity tests provide a direct measure of the effect of contamination on benthic organisms. These tests complement sediment chemistry measurements by providing a measure of the combined toxic effect of the complex mixture of contaminants often present in sediment. Toxicity test data also aid in the interpretation of benthic community responses, as laboratory tests are less sensitive to noncontaminant environmental variables (e.g., sediment grain size) that affect benthic organisms.

Toxicity tests were conducted on sediment samples from 72 stations. These sites were a subset of those selected for sediment chemistry and benthic animal community analyses. Acute toxicity was measured with a 10-day amphipod (shrimp-like animal) survival test.

Sediment toxicity was not detected in any of the samples.

Toxicity was not detected in any of the sediment samples from the SCB. Results from samples collected from the northern end of the SCB (where there are no large municipal wastewater treatment plant discharges) were similar to results from samples collected from the southern end of the SCB (which is highly urbanized and has several large municipal wastewater discharges). Results from samples collected near municipal wastewater outfalls were similar to results from samples collected at other locations.

Toxicity Tests

Toxicity tests are laboratory experiments in which a sensitive species is exposed to a sample (such as sediment) in order to determine if the contaminants present are capable of causing harmful effects. Sediment toxicity was measured in the SCBPP by exposing the amphipod Ampelisca abdita *to samples of surface sediment for 10 days. Samples in which less than 80% of the amphipods survived were classified as toxic. The 10-day amphipod test is a good measure of short-term (acute) effects of contaminated sediment, although it may not be sensitive to the effects of long-term (chronic) contaminant exposure.*

Sediment quality in the SCB was higher than that in other regions of the country.

The toxicity results from the SCBPP, when compared to results from studies performed in bays and estuaries throughout the United States, indicate that the quality of sediments in the SCB is generally higher than that in other regions of the country. Nationwide, approximately 11% of the sediment area is estimated to be toxic to amphipods. Factors such as good water circulation, few nearby industrial discharges, and improved waste disposal practices have contributed to the low levels of toxicity found in the SCB.

The status of **fish populations** generate intense public interest because of the recreational activities (i.e., fishing and diving) associated with fish, as well as their role as an important food resource for humans and marine animals. The SCBPP studied bottom-dwelling fish because they live and feed in the mud where pollutants accumulate. Studies of bottom-dwelling fish provide an indication of pollution effects resulting from long-term exposure and magnification through the food chain.

The fish portion of the SCBPP assessed communities of bottom-dwelling species, and external anomalies and parasites at 114 sites. In addition, measurements were made for 14 organic contaminants on livers of 3 species from approximately 50% of the sites.

Eighty-seven species of fish were collected in the trawl survey. Pacific sanddab, plainfin midshipman, and slender sole were the most numerous fish collected. Regionally, smaller catches of fish were obtained from the northern portion of the SCB. The central portion of the SCB had lower fish diversity than the other portions, and the southern portion the highest fish abundance. Shallow areas had fewer species and lower diversity; fish catches were larger with increasing depth. Comparison of fish communities in this study to surveys conducted in the early 1970s suggests that minor changes have occurred; these changes are partially due to a warming trend in the coastal ocean waters that began in the 1980s.

Fish communities were healthy; external diseases, which were prevalent 20 years ago, were virtually absent in 1994.

Populations and communities of bottom-dwelling fish were generally healthy in 1994 and their status has noticeably improved over conditions documented in the 1970s. External fish diseases such as fin erosion, which were prevalent in some areas during the 1970s, were virtually absent in fish populations sampled in 1994.

Both DDT and PCB were present in fish livers throughout the SCB, but concentrations were 95% lower than 20 years ago.

Contamination of fish by DDT and PCB was widespread; the livers of virtually all individuals of two species of flatfish (Pacific sanddab and longfin sanddab) contained these chemicals (Figure 5). All samples of a third flatfish (Dover sole) were also contaminated by DDT. The highest DDT and PCB concentrations in all three species were measured in fish collected on or near the Palos Verdes Shelf, an area with highly contaminated sediments that resulted from historical discharge. Tissue concentrations declined to the north of Palos Verdes and were generally lower to the

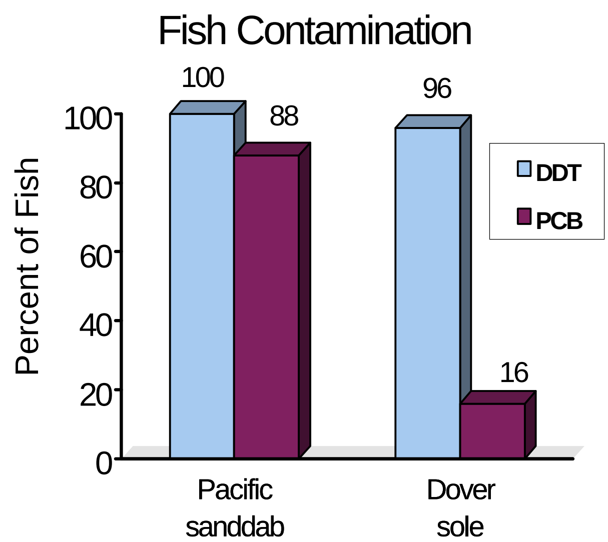

Figure 5. Percent of flatfish containing DDT and PCB organic contaminants in liver.

south, corresponding to patterns in sediment contamination. Dramatic declines in fish liver DDT and PCB concentrations have occurred throughout the SCB. Both DDT and PCB concentrations in fish from reference areas are now less than 5% of levels measured during the last two decades.

No other organic contaminants were detected in fish livers.

Though widespread, contamination of fish in the SCB was restricted to DDT and PCB. None of the liver samples contained detectable concentrations of 12 other organic compounds, which included the pesticides Aldrin, Chlordane, Dieldrin, Endosulfan, Heptachlor, Lindane, and Mirex.

The biological effects of fish contamination in the SCB could not be assessed in this study. While DDT and PCB are toxic compounds that have been implicated in past studies of reproductive effects on fish, sufficient information was not available to establish a tissue threshold of effect for the species examined in the SCBPP.

Is It Safe to Eat the Fish?

The objectives of the fish contamination survey were to determine the relative exposure of fish to contaminants and the potential for biological effects. Contamination was assessed by the analysis of liver tissue for organic chemicals. Livers were analyzed because this organ accumulates high concentrations of contaminants, and data from prior studies were available for comparison. These data cannot be used to assess human health risks from seafood consumption since the species or tissue type (muscle) consumed by people were not analyzed. There are previously published studies which address human health concerns regarding fish consumption.

MARINE DEBRIS

Debris resulting from human activities affects the aesthetic quality of beaches and is one of the primary means by which pollution can be identified by the public. Estimates of the amount of debris contaminating beaches are available through nationally publicized cleanup campaigns, but little is known about the quantity and types of debris that accumulate on the ocean floor. This study, which tabulated debris collected in nets towed along the bottom, is the first to document the amount and types of debris found on the seafloor of southern California's coastal waters.

Debris from human activities was found in 14% of the SCB.

Anthropogenic debris was present in 19 trawl samples, which represented 14% of the SCB study area. Less than 10 items of debris were usually found in a trawl. The debris consisted primarily of cans, glass bottles, and fishing gear (Figure 6). The most unusual items included an inner tube and a shoe.

Debris was most common on the outer shelf, suggesting that marine vessel activity was a primary source.

Most of the debris was found in the central and southern portions of the SCB, near the highly populated areas of San Diego and Los Angeles. Debris tended to increase with depth, occurring mostly on the outer shelf. This trend suggested that much of the material originated from boats, although offshore transport by currents may also be a factor.

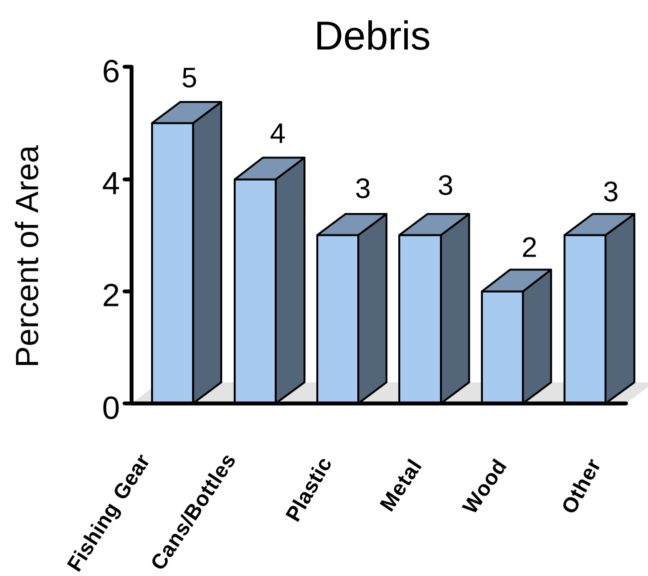

Figure 6. Extent of occurence and types of debris collected in SCB trawl samples. The sum of each category exceeds the total occurrence (14%) because more than one type of debris was present in some samples.

SPECIAL HABITATS

The standardized methods used in regional monitoring allow unbiased comparisons of conditions among different areas of the SCB. The sampling effort in the SCBPP was specifically allocated so that comparisons could be made between both geographically defined habitats (e.g., depth and latitude) and habitats potentially influenced by man's activities (e.g., municipal wastewater discharge). Three habitats were examined during the SCBPP to investigate the potential influence of anthropogenic activities: Santa Monica Bay (adjacent to metropolitan Los Angeles), areas near discharges from municipal wastewater treatment plants, and stormwater discharge areas.

Santa Monica Bay, the portion of the coastal shelf lying between Pt. Dume and Palos Verdes Point (Figure 1), includes some of the most highly urbanized coast in southern California. The Bay is used for many activities that have the potential to influence environmental quality, such as industrial and municipal discharge, boating, stormwater discharge, and fishing. The characteristics of this region were compared to data for other regions of the SCB.

All Santa Monica Bay sediments had elevated concentrations of contaminants, with 49% of the area exceeding a threshold for likely adverse effects.

The extent and magnitude of sediment contamination was greater in Santa Monica Bay than in other regions of the SCB (Figure 7). Concentrations of DDT, PCB, eight trace metals, organic carbon, and nitrogen were significantly higher in Santa Monica Bay. All of the Santa Monica Bay sediments were contaminated by at least one chemical. Forty-nine percent of

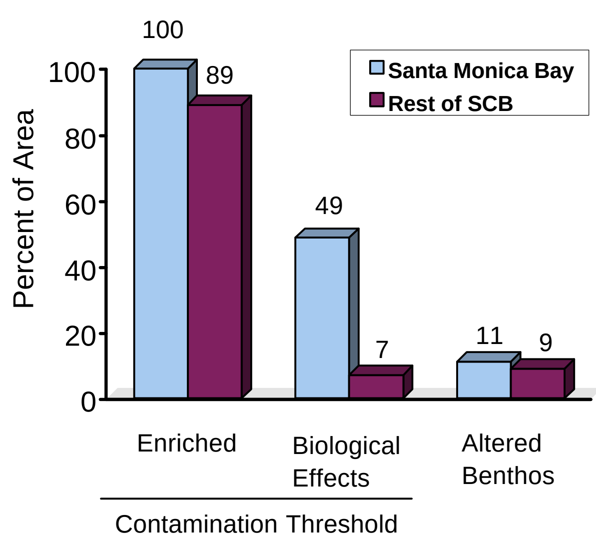

Figure 7. Percent of area exceeding thresholds for sediment contamination or containing altered benthic infaunal communities in Santa Monica Bay or other portions of the SCB.

the Santa Monica Bay sediments exceeded ERM biological effects thresholds for at least one chemical, compared to 7% of the sediments from other regions of the SCB.

Biological resources were in similar condition between Santa Monica Bay and other areas of the SCB.

Despite the higher sediment contamination found in Santa Monica Bay, no significant differences in other indicators were detected between the Bay and other areas of the SCB. Fish and benthic infaunal communities were similar for both regions, and no sediment toxicity was observed in the subset of 16 Bay sites studied. Water column measurements of dissolved oxygen and water clarity were similar between Santa Monica Bay and the other regions of the SCB.

The **municipal wastewater discharge** region was composed of areas surrounding the four largest municipal wastewater discharges. The boundaries of these zones were the areas routinely monitored under discharge permit requirements and included the locations most likely to show impacts from present or past discharges. Comparisons with the other regions of the SCB were constrained to the mid-depth range (25 to 100 m), where these discharges are located.

The relative area with elevated sediment contaminant concentrations was similar in municipal wastewater discharge and nondischarge areas.

The proportion of sediments enriched by anthropogenically introduced contaminants was similar in areas near to and distant from municipal wastewater discharges (Figure 8). However, average surface sediment concentrations of DDT, PCB, copper, mercury, and silver were higher in areas near these discharges, resulting in a higher percentage of area above the thresholds of likely adverse effect. Historic discharges are the source of most of these elevated concentrations. Similar to the other regions of the SCB, 99% of the municipal wastewater discharge area met California Ocean Plan objectives for water clarity and dissolved oxygen.

On the average, flatfish collected from municipal wastewater discharge areas contained higher concentrations of DDT and PCB in their liver tissue than did fish collected from nondischarge areas. The geographic distribution of fish contamination reflected historic discharges of DDT and PCB, with the highest concentrations being present near Palos Verdes.

Bottom-dwelling fish and invertebrate communities were similar near municipal wastewater discharges and in other regions of the SCB.

The communities of bottom-dwelling animals were similar in organization and health in municipal wastewater discharge and nondischarge areas. In wastewater discharge areas, fish were more abundant and diverse and had higher biomass. The occurrence of external fish diseases such as tumors and fin erosion were low (at background levels) in both areas. For benthic infauna, wastewater discharge areas and the other regions of the SCB were similar in all measures of community structure and function, such as number of species and population size. Approximately 90% of both habitats were classified as healthy and similar to reference sites. Comparison of SCBPP data with prior surveys indicates that animal assem-

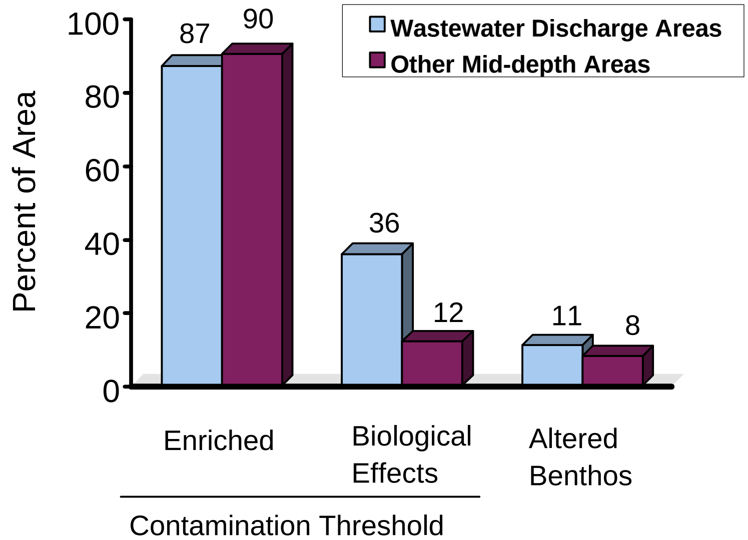

Figure 8. Percent of area exceeding thresholds for sediment contamination or containing altered benthic infaunal communities in municipal wastewater discharge regions or other mid-depth portions of the SCB.

blages near municipal wastewater discharge areas have improved significantly since the 1970s.

The **stormwater discharge** region was defined as the area within a 3 km radius of the mouths of the 11 largest rivers and creeks in the SCB. Stormwater areas were compared to other shallow water areas of the SCB in order to eliminate differences related solely to water depth.

Stormwater Effects

The measurement of stormwater effects in the ocean is complicated by the fact that these discharges are intermittent and highly variable. Most water column impacts of stormwater, such as changes in salinity and water clarity, are short-term and difficult to detect using the SCBPP sampling design. Our goal was to determine whether stormwater discharge produced persistent effects on the characteriscs of the surrounding sediments and changes in biological communities; these effects have the potential to be more biologically significant since they occur year-round.

Sediment contaminants were enriched in 70% of the area near stormwater discharges, but concentrations were below thresholds for adverse effects.

Sediments near stormwater discharges were typically finer and contained more organic carbon than other shallow areas. This trend was also reflected in near-bottom measurements of water quality. Forty-six percent of the area had reduced water clarity, presumably because of natural sediment resuspension. Sediment contaminants were enriched in 70% of the area near stormwater discharges, somewhat less than the percentage for distant areas (Figure 9). Forty-seven percent of the sediment near stormwater discharges was enriched in metals. This occurred at twice the frequency of enrichment that was observed in areas distant from stormwater discharges.

Communities of bottom-dwelling animals were altered in 40% of the stormwater discharge areas, although the degree of change was minor.

Altered communities of benthic infauna were present in 40% of the stormwater discharge areas, approximately three times the extent measured in other shallow areas. However, most of the alterations were minor. It is unclear whether these changes were the result of anthropogenic factors or merely reflect responses to natural disturbances created by river discharges.

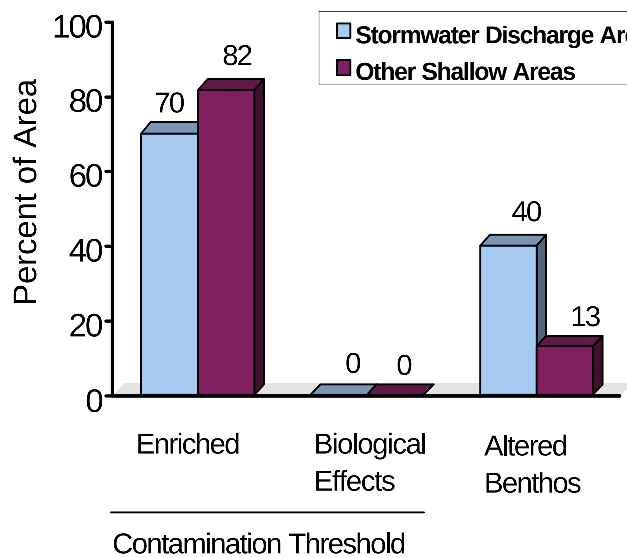

Figure 9. Percent of area exceeding thresholds for sediment contamination or containing altered benthic infaunal communities in stormwater discharge regions or other shallow portions of the SCB.

INTEGRATION

A primary reason for conducting the SCBPP was to assess the extent of anthropogenic impact on the southern California marine environment. A variety of indicators were used to quantify pollutant exposure or biological effects. While both types of information are important, neither alone is sufficient to assess the overall status of the SCB. For example, the area of human influence described by elevated sediment contaminants may not be the same as the area of biological impacts. Both types of information must be integrated to assess the relationship between activities such as waste discharge and environmental effects.

Bioaccumulation of chlorinated hydrocarbons in flatfishes was highly correlated with concentrations of these compounds in adjacent sediments

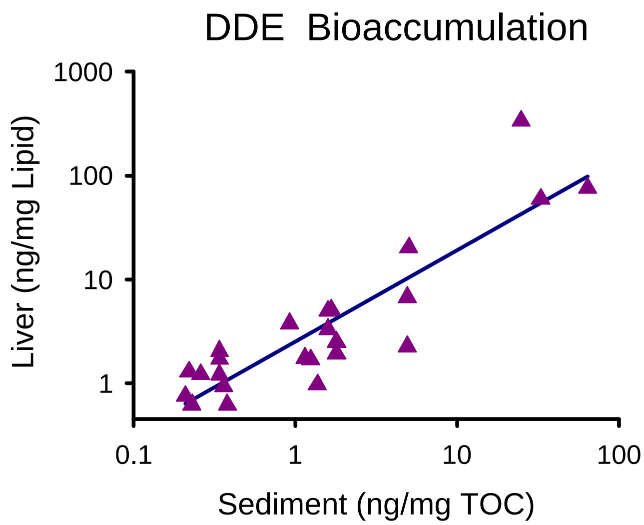

Figure 10. The relationship between DDE (a DDT metabolite) bioaccumulation in longfin sanddab liver and sediment concentration. Concentrations have been normalized to liver fat content and sediment organic carbon content.

Contaminant levels in fish tissues were correlated with contaminant levels in sediments.

(Figure 10). The DDT and PCB concentrations were higher in flatfish livers from areas with high sediment concentrations. In addition, the PCB compounds that were most environmentally abundant were also most frequently accumulated in fish liver tissue. As sediment contamination levels of DDT and PCB decreased at reference sites over the past two decades, liver concentrations decreased by one or two orders of magnitude; these results indicate that sediment contamination is still a dominant factor influencing the contamination of SCB marine life.

Benthic infauna responses and sediment toxicity were poorly related to sediment contamination.

In contrast to fish bioaccumulation, a poor correspondence was found between sediment contamination and effects on benthic infauna. Although 90% of the SCB had evidence of anthropogenic contamination by at least one chemical, 91% of the SCB had apparently healthy benthic infaunal communities. Altered benthic commu-

Natural vs. Anthropogenic Effects

It is often difficult to distinguish between alterations caused by human activities and those due to natural events. For example, alterations in benthic communities near stormwater discharges may be due to natural factors, such as the episodic discharge of freshwater or the deposition of terrestrial organic material. Determining the cause of an effect is an important step in determining the appropriate management response. We attempted to minimize the influence of natural factors in the SCBPP by using assessment tools that partially compensate for natural variability, such as iron-normalization and the Benthic Response Index.

nities were not found consistently at sites with the highest sediment contamination. Sediment toxicity was not detected at any location.

Differences in the impact assessments using biology, toxicity, or chemistry indicators demonstrate that the relationship between pollutant exposure and biological effects is complex. The geographic distribution of the sites with impacted benthos suggests that effects are related to stormwater runoff or municipal wastewater discharge, but the cause may be due to unmeasured or intermittent factors. Understanding the relationship between relatively slight impacts, as found in the SCBPP, and human activities is difficult because of the large variability caused by natural events in the ocean.

FUTURE DIRECTION

The SCBPP data provide a benchmark for comparison with other southern California monitoring data.

The SCBPP was highly successful, yielding the first consistent, region-wide data sets for describing pollution exposure and biological resources within the SCB. These data sets allowed us to achieve two SCBPP objectives: 1) assessing the spatial extent and magnitude of ecological disturbances in the SCB, and 2) describing relative conditions among different regions. The Bight-wide data also provide a benchmark against which local monitoring programs can evaluate the relative condition of their individual sites.

The SCBPP formed a model for achieving regional monitoring cost-effectively through collaboration among multiple agencies. Development of SCBPP methods manuals provided the opportunity for participants to assess and improve the quality of data they produce. The quality assurance procedures provided the feedback mechanisms necessary for achieving comparable data of high quality.

A second cooperative regional study is planned for 1998.

A second cooperative regional survey is planned for 1998. Periodic regional monitoring allows evaluation of whether the overall system is improving or declining. Future regional monitoring will also provide the opportunity to refine assessment tools, such as the Benthic Response Index and iron-normalization curves. Regional monitoring programs also provide the opportunity to create new tools that can only be developed when data from a broader range of sampling locations are available.

Future regional monitoring efforts will provide the opportunity to address a number of questions that were not studied in the SCBPP. Foremost among these is how does the environmental condition of offshore areas (the subject of the SCBPP) compare to that of nearshore areas, such as harbors, bays, and ports, which are closer to human influence. Future studies also provide the opportunity to add new indicators, such as bacteriological measures, that allow assessment of human health questions.

New participants are needed to share costs and increase the types of measures in future surveys.

As new issues and new habitats are added to the regional monitoring program, it becomes increasingly important to involve new participants in the cooperative effort. Adding participants provides additional resources that reduce the cost to all participants and expand the number of sample sites and indicators that can be measured. New participants also provide additional expertise and perspective for selecting questions that should be addressed with regional monitoring. Perhaps of greatest importance, new participants provide the opportunity to achieve a broader consensus about, and an increased audience for, the products of regional monitoring; regional monitoring is only of value if the data are accepted and used for environmental management.

SCBPP STEERING COMMITTEE

Southern California Coastal Water Research Project

Dr. Stephen B. Weisberg (Chair)*	Dr. M. James Allen*
Dr. Jefferey N. Cross (past Chair)	Dr. Mary Bergen (past Chair)*
Steven Bay*	Kenneth Schiff*

U.S. Environmental Protection Agency, Office of Research and Development

Dr. Kevin Summers

U.S. Environmental Protection Agency, Region IX

Terry Fleming*	Janet Hashimoto
Robert K. Hall	

City of Los Angeles, Environmental Monitoring Division

Dr. Masahiro Dojiri*	Dr. John Dorsey

County Sanitation Districts of Los Angeles County

Janet K. Stull*

County Sanitation Districts of Orange County

George Robertson*	Dr. Irwin Haydock
Richard Santangelo	Richard W. Gossett

City of San Diego, Metropolitan Wastewater Department

Patricia M. Vainik*

California State Water Resources Control Board

Linda Rao*	Dr. Francis H. Palmer

Regional Water Quality Control Board, Los Angeles Region

Michael Lyons*

Regional Water Quality Control Board, Santa Ana Region

Steve Mayville*	Gordon Anderson

Regional Water Quality Control Board, San Diego Region

Darcy Jones*	Peter Otis

Santa Monica Bay Restoration Project

Dr. Guang-Yu Wang*	Patricia V. Velez
Dr. Rainer Hoenicke	

* = Present member