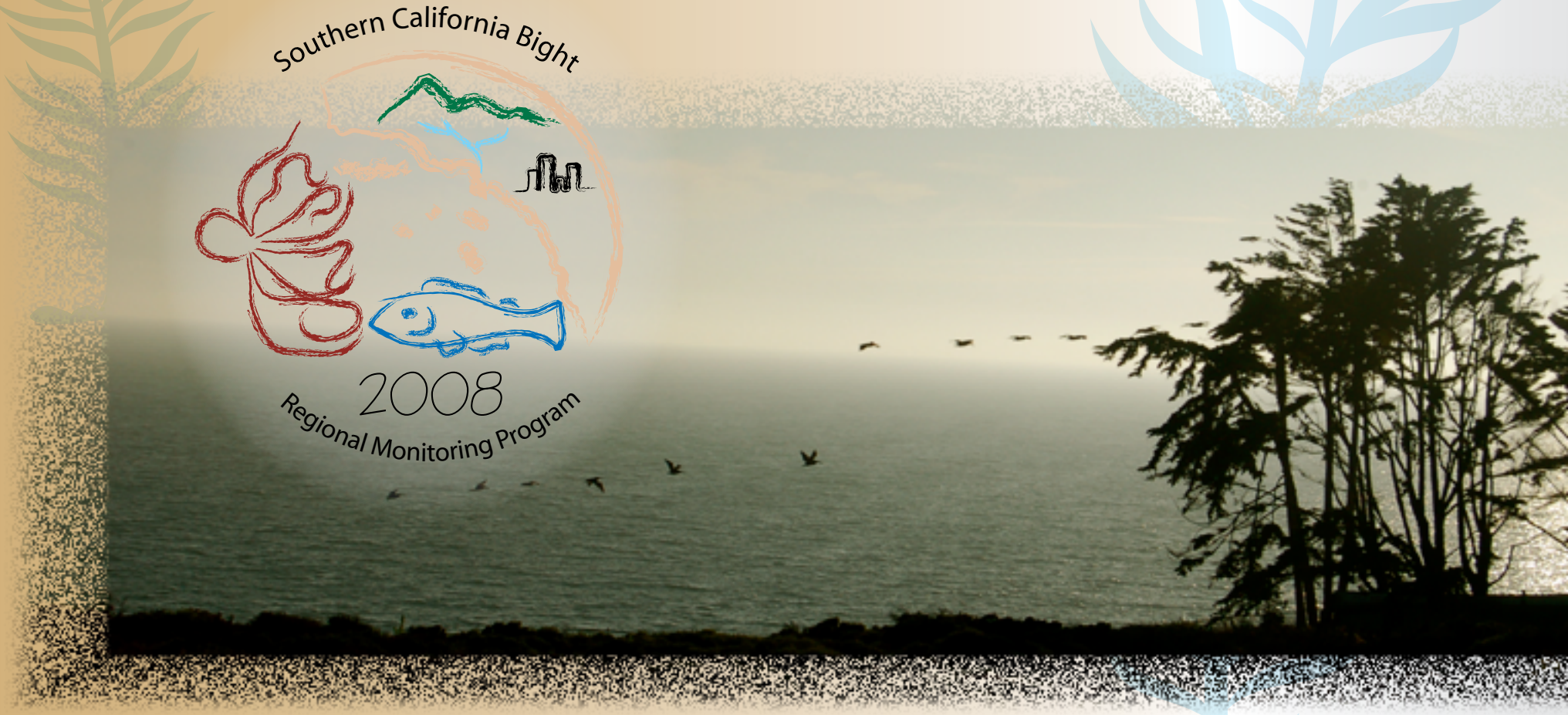
Southern California Bight
2008 Regional Marine Monitoring Program

Coastal Ecology Synthesis Report



Contents

"Working together, environmental managers initiated an integrated collaborative monitoring program designed to understand and protect the unique Bight ecosystems."

Background

The Southern California Bight, the bend in the coastline that extends from Point Conception north of Santa Barbara past the United States-Mexico International Border (Figure 1), is a unique and valuable ecological resource. The Bight is a complex ecosystem where cold, nutrient-rich waters from the north mix with warm, subtropical waters from the south, creating a productive ecosystem that supports giant kelp and abundant marine life. Home to over 2,000 species of fish and invertebrates, the Bight represents the beginning or end of more species' ranges than anywhere else along the western coast of North America.

The Bight is also an ecosystem at risk. With a nearby population exceeding 17 million people, it serves as a repository for a variety of waste discharges (Figure 1). The effluents from 19 sewage treatment plants and 18 industrial facilities, as well as untreated discharges from thousands of miles of urban storm drains all wind up in the coastal waters of the Bight. Environmental managers have been working hard to reduce pollutant inputs, and for most traditional pollutants, such as trace metals, inputs today are a fraction of what they were 30 years ago. However, legacy pollutants remain and new unmanaged chemicals are being discharged every day.

Working together, environmental managers initiated an integrated collaborative monitoring program designed to understand and protect the unique Bight ecosystems. This collaboration first sampled in 1994 and was repeated in 1998, 2003, and 2008. This document summarizes findings from the 2008 Southern California Bight Regional Marine Monitoring Program (Bight '08) Coastal Ecology component. Thirty-five organizations, including the largest regulated agencies that discharge to the Bight and the State or Federal regulatory agencies that oversee them, joined forces to answer three basic questions:

1. What is the extent and magnitude of environmental impact in the Southern California Bight?
2. How does the extent and magnitude of environmental impact vary among habitats?
3. What are the trends in the extent of environmental impact?

A total of 383 sites were sampled during Bight '08 and classified into two broad categories: (1) embayments such as estuaries, marinas, ports, or bays or (2) offshore habitats such as the mainland continental shelf, the northern Channel Islands, or the continental slope and basins. All sites were analyzed for 198 sediment chemical contaminants and benthic (sea bottom) biological community composition. A subset of sites was analyzed for sediment toxicity and trawl-caught fishes and invertebrates. Some measurements were collected while at sea, but others took over one year to analyze in the laboratory.

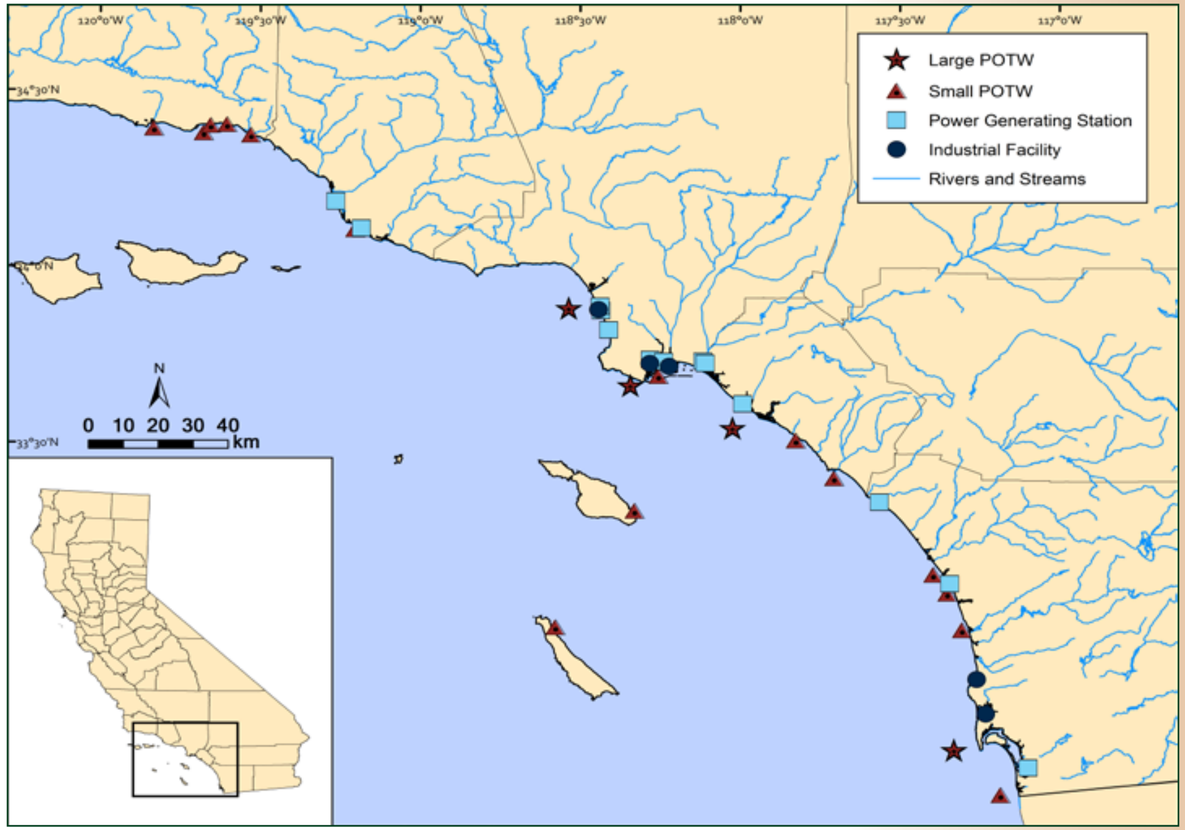


Figure 1. Map of pollutant inputs to the Southern California Bight

Question 1: What is the Extent and Magnitude of Environmental Impact in the Southern California Bight?

In order to provide a more comprehensive understanding of sediment quality in the Southern California Bight, three primary indicators of sediment quality were integrated: sediment chemistry, sediment toxicity, and benthic community structure. This integration followed a methods framework adopted by the State of California to assess sediment quality within enclosed bays and estuaries (State Water Board 2009). Multiple lines of evidence were utilized because each individual line has limitations. For example, chemical concentration data alone fails to differentiate between the chemical fraction that is tightly bound to sediment and that which is biologically available. Toxicity tests integrate the effects of multiple contaminants, but are conducted under laboratory conditions using species that may not occur naturally at the site. The benthic community structure directly measures condition of the organisms at risk from sediment contamination, but can also be affected by non-human related physical or habitat changes. Integration of these three lines of evidence assured that the overall assessment and conclusions were not biased by factors unrelated to pollutant impacts. Ultimately, sites were classified into one of the following six categories:

- **Unimpacted** – Confident that sediment contamination is not causing significant adverse impacts to aquatic life living in the sediment;
- **Likely Unimpacted** – Sediment contamination is not expected to cause adverse impacts to aquatic life, but some disagreement among the three different lines of evidence reduces certainty in classifying the site as unimpacted;
- **Possibly Impacted** – Sediment contamination may be causing adverse impacts to aquatic life, but these impacts are either small or uncertain because of disagreement among the three different lines of evidence;
- **Likely Impacted** – Evidence for a contaminant-related impact to aquatic life is persuasive, even if there is some disagreement among the three different lines of evidence;
- **Clearly Impacted** – Sediment contamination is causing clear and severe adverse impacts to aquatic life; or
- **Inconclusive** – Disagreement among the three different lines of evidence suggests that either the data are suspect or that additional information is needed before a classification can be made.

The State Water Board only considers the first two categories (Unimpacted and Likely Unimpacted) as healthy or representative of conditions undisturbed by sediment pollutants.

Bight '08 represents the first effort to monitor and apply California's newly developed multiple line of evidence framework across the region's embayments. While this framework was adopted to implement California's Sediment Quality Objectives within embayments, we utilized it for offshore sediments as well. To apply the framework to offshore sediments, the following modifications were required: (1) the Benthic Response Index developed for offshore waters (Bergen et al. 2000) was used rather than the four different benthic indices developed for embayments; and (2) a single toxicity test was used (amphipod 10-day survival test) rather than the two tests used for embayments (amphipod 10-day survival and mussel embryo sediment-water interface tests). The same two sediment chemistry assessment indices developed for embayments were used even though these indices have not been calibrated or validated for offshore sediments. Though these assumptions are not ideal, investigators chose to extrapolate this tool to offshore sediments because it is the best approach to assess sediment quality currently available. It is important to note that, unlike bays and estuaries, application of the multiple line of evidence assessment framework in offshore sediments has no regulatory implications in the State of California.

"Bight '08 represents the first effort to monitor and apply California's newly developed multiple line of evidence framework across the region's embayments."

When considering the entire Southern California Bight, 99% was unimpacted by sediment contaminants. The new multiple line of evidence framework classified 95.5% of the Southern California Bight area (offshore plus embayments) as Unimpacted and another 3.7% as Likely Unimpacted (Figure 2). Of the remaining 1% of contaminant-impacted sediments in the Southern California Bight, 0.6% was classified as Possibly Impacted, a category representing limited confidence as a result of low responses and/or disagreement among the individual lines of evidence. Only 0.2 % and 0.1% of the total area was classified as Likely Impacted or Clearly Impacted, respectively.

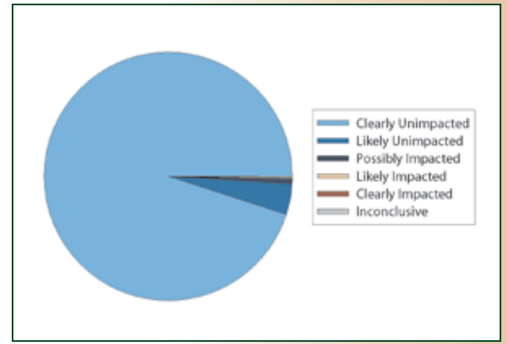


Figure 2. Extent of sediment contaminant impacts in the Southern California Bight

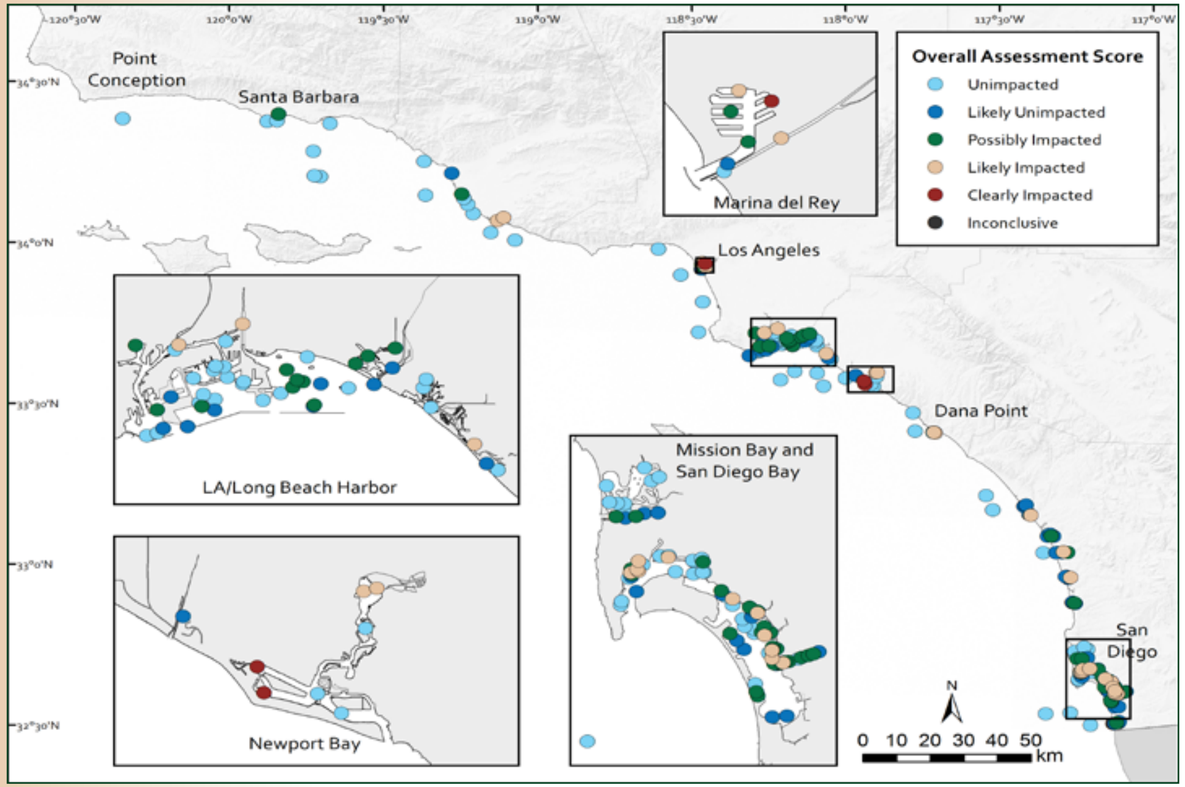


Figure 3. Map of sediment condition classification by site in Bight '08

Question 2: How does the Extent and Magnitude of Environmental Impact Vary among Habitats?

While the extent of contaminant-impacted sediments was low throughout the Southern California Bight as a whole, not all habitats were in equivalent condition (Figure 3). Virtually none of the offshore sediments in the Southern California Bight were considered contaminant impacted using the new multiple line of evidence framework; 97% of the area on the continental shelf was classified as Unimpacted and the remaining 3% was classified as Likely Unimpacted. Fish community composition, which is not integrated into the multiple lines of evidence approach, also illustrated a lack of contaminant-related impacts on the continental shelf. Ninety-six percent (96%) of the continental shelf had fish communities in reference condition.

In contrast to the continental shelf, approximately one-quarter of sediments in embayments of the Southern California Bight were considered contaminant impacted. Nineteen percent (19%) was classified as Possibly Impacted, and 6% and 2% of the area was classified as Likely Impacted and Clearly Impacted, respectively.

The relative extent of contaminant-impacted sediments within embayments differed among habitats (Figure 4). At least half of the area in Marinas (55%) and Estuaries (50%) was impacted by sediment contaminants, compared to less than one-quarter of the area in Ports (23%) and Bays (20%). Categorization of impact within the contaminant-impacted sediments (Possibly Impacted, Likely Impacted, or Clearly Impacted) also varied. Unlike Ports and Bays, much of the sediment condition in Estuaries (32%) and Marinas (31%) was classified as either Likely Impacted or Clearly Impacted.

In general, sediment quality in the Southern California Bight reflected proximity to pollutant sources. For example, copper and other biocides are frequently used in vessel bottom paints to retard the growth of fouling organisms. This resulted in Marinas having the highest sediment copper concentrations of any habitat in the Bight. Similarly, estuaries are a sink for the untreated wet and dry weather discharges from the urban runoff generated within their contributing watersheds. As a result, some of the region's greatest zinc, polynuclear aromatic hydrocarbon (PAH), and current use pesticide concentrations were observed in estuaries. These constituents all originate from land-based activities (i.e., automobiles or home applications) and are flushed off the land during storm events.

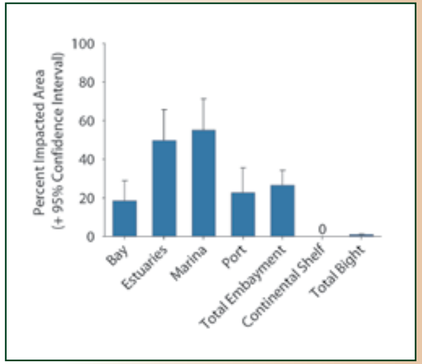


Figure 4. Extent of impacted sediments by habitat as defined by multiple lines of evidence (sediment chemistry, sediment toxicity, benthic community structure)

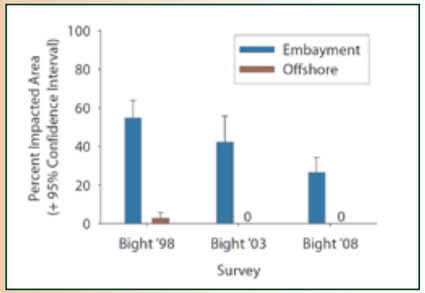


Figure 5. Relative extent of sediment impact in offshore or embayment area over the last decade based on multiple lines of evidence (sediment chemistry, sediment toxicity, benthic community structure)

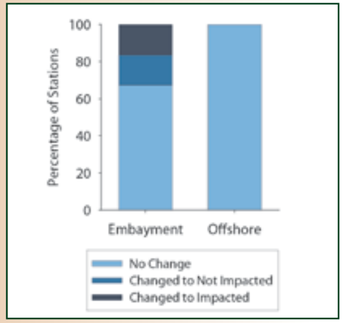


Figure 6. Changes in sediment impact found in site revisits from previous surveys over the last 10 years based on multiple lines of evidence (sediment chemistry, sediment toxicity, benthic community structure)

Question 3: What are the Trends in the Extent of Environmental Impact?

The relative extent of contamination in offshore sediments has remained consistently small over the last decade, varying between 0% and 3% of the continental shelf area.

Although embayments had the greatest relative extent of sediment contamination, this extent has been steadily improving over time (Figure 5). Between 1998 and 2008, the extent of contaminated sediments has decreased from 55% to 27% of embayment area. This decade-long improvement reflects improvements in all three lines of evidence, providing additional confidence in the observed trends. For example, the relative extent of sediments that produced moderate or high chemical exposure decreased from 60% to 37% of embayment area between 1998 and 2008. The relative extent of sediments that produced moderate or high toxicity decreased from 36% to 11% of embayment area between 1998 and 2008. Lastly, the relative extent of sediments that produced moderately or highly disturbed benthic communities decreased from 25% to 12% of embayment area between 1998 and 2008.

A new design element incorporating site revisits from previous surveys (N=88) was instituted during Bight '08 specifically to better evaluate trends over time (Figure 6). Approximately half of the revisited sites were matched to Bight '98 and the other half were matched to Bight '03. All revisited sites were placed into one of three categories: (1) no change in status between surveys, (2) status changed from impacted to not impacted based on the multiple line of evidence approach, or (3) status changed from not impacted to impacted.

In offshore habitats, no sites experienced a change in sediment contamination status. All of the sites remained unimpacted, supporting the areal trend estimates observed for this habitat type. In embayments, approximately two-thirds of the sites did not change sediment contamination status. Of the remaining sites that did change status, an equal fraction switched from contaminated to not contaminated or vice versa. This change in status of embayment sites didn't exactly match areal estimate expectations, which predicted either no change or perhaps some improvement over time. Consistent with the predictions, though, the embayment sites with the greatest decline in sediment quality were located in estuaries and marinas.

Other Highlights from the 2008 Regional Monitoring Program

Bight '08 was the largest, most complex regional marine monitoring program to date in the Southern California Bight. It brought important scientific discoveries, new relationships among partner agencies, and significant regulatory-related impacts. Below is a partial list of additional highlights from Bight '08.

"Bight '08 was the largest, most complex regional marine monitoring program to date..."

Incidence of Contaminants of Emerging Concern (CECs)

The sediment chemistry monitoring element measured not only traditional chemicals, but also two types of contaminants of emerging concern (CECs): pyrethroids and polybrominated diphenyl ethers (PBDEs). Pyrethroids are a group of current use pesticides for controlling ants and other terrestrial pests, which are acutely toxic to non-target freshwater and marine organisms such as crustaceans. PBDEs are flame retardants found in clothing, furniture, and electronics. Although PBDEs are less acutely toxic than pyrethroids, they can bioaccumulate in higher level predators such as fish, marine mammals, seabirds, and humans.

Both pyrethroids and PBDEs were found extensively throughout the Southern California Bight during Bight '08. Pyrethroids were only sampled in embayments, but were detected across over a third of the embayment area. The highest concentrations occurred in estuaries, particularly at the mouths of the most urban watersheds such as Ballona Creek, Los Angeles River, and Upper Newport Bay. Two estuary sites with observed toxicity were subjected to toxicity identification evaluations to evaluate causal factors, and both toxic samples were due, at least in part, to pyrethroid pesticides.

PBDEs were detected in 95% of all Southern California Bight sediments, and 100% of embayment area sediments. Once again, the greatest concentrations occurred in estuaries, particularly at the mouths of the most urban watersheds. Though PBDE bioaccumulation was not measured in Bight '08, southern California tissue samples ranging from the California mussel to the California sea lion have consistently been found by others to have the greatest PBDE concentrations in the nation (Kimbrough et al. 2008, Meng et al. 2009).

Bioaccumulation in Sportfish

Over eight million sportfish were landed by recreational anglers in the Southern California Bight in 2008; however, no Bight-wide tissue monitoring of sportfish has occurred in more than 20 years, and NPDES monitoring programs are so distinctly different that compilation of local programs throughout southern California is not possible. This data gap exists even though the State of California warns anglers about seafood consumption on the Los Angeles margin.

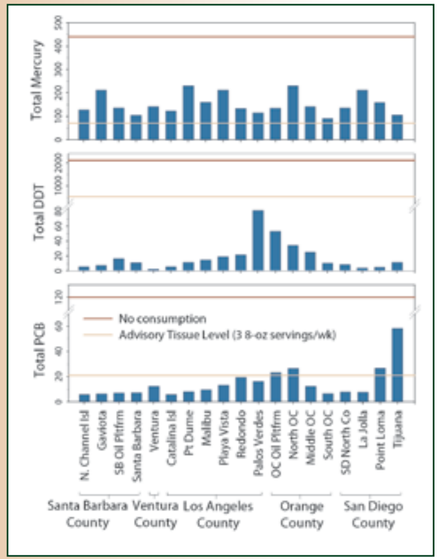


Figure 7. Bioaccumulation of mercury, PCB, and DDT in kelp bass, one of the most frequently caught sportfish in the Southern California Bight

In partnership with California's Surface Water Ambient Monitoring Program (www.waterboards.ca.gov/SWAMP), the Bight '08 program collected over 900 sportfish comprising five different species across 27 fishing zones from San Diego to Santa Barbara, including the offshore islands. Edible tissues were measured for the three pollutants thought to carry the most risk to seafood consumers: mercury, PCBs, and DDTs.

Sportfish tissue contamination was moderate but widespread (Figure 7). In general, sportfish in embayments carried higher pollutant burdens than fish in the offshore zones. Using kelp bass as an example, mercury exceeded sportfish consumption thresholds most often. All zones exceeded the lowest mercury threshold, which recommends consuming less than three meals per week for children and women of childbearing age. However, no zone exceeded the highest threshold recommending no consumption. Total PCBs were the next most pervasive tissue contaminant. Four zones exceeded the three meal per week threshold, but no zone exceeded the no consumption threshold. Finally, total DDT was the least pervasive tissue contaminant, for which no zone exceeded the three meal per week threshold.

Sediment Toxicity

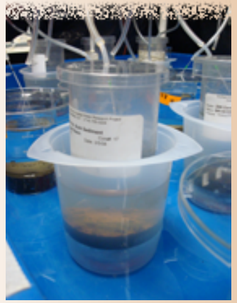
Bight '08 was the first effort utilizing multiple sediment toxicity methods for southern California regional monitoring, consistent with the State's regulatory sediment quality assessment framework. The framework requires the use of at least two toxicity tests, one acute and one sub-lethal. The amphipod (*Eohaustorius estuarius*) 10-day survival test and a mussel (*Mytilus galloprovincialis*) embryo development test with a sediment-water interface exposure were used at 180 embayment stations in Bight '08. The tests agreed as to whether toxicity was observed at 137 (76%) of the stations, and 131 stations were considered not toxic for both tests.

The State's assessment framework places sites in one of four categories with regard to toxicity. Approximately three quarters (76%) of the stations were placed in the same category by both methods (Table 1). Most agreement occurred in the non-toxic category. Where there was disagreement, the amphipod test typically indicated a category of greater toxicity; this occurred at more than half of the stations with disagreement.

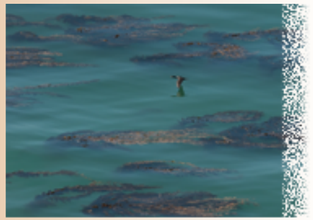
The use of two toxicity methods allowed for a higher degree of confidence in the results, since the two species are not equally sensitive to all sediment contaminants. Thus, if both tests agreed a station was non-toxic, there was a higher degree of confidence in the result than if only one test was performed. The differences that did occur provide clues as to the toxicant of concern. For example, amphipods are generally more sensitive to pesticides than mussels, and for the toxicity identification evaluations that were conducted, pesticides were responsible for at least part of the toxicity observed.

Table 1. Contingency table indicating the percent agreement in toxicity among the two test species (n=180)

		Amphipod	
		Not Toxic	Toxic
Mussel Embryo	Not Toxic	72.2%	10.0%
	Toxic	14.4%	3.3%



Continental Slope and Basin



The upper continental slope (200-500 meters) and lower slope and basins (500-1,000 meters) are some of the deepest waters in the Southern California Bight. These unique habitats are rarely sampled by ongoing monitoring programs and little is known about their ecology. The Bight '08 program sampled these deep waters to ascertain if anthropogenic activities in shallow water can affect more remote habitats.

Pollutants discharged in shallower waters do tend to make their way to the slope and basins. Legacy contaminants such as DDT and PCB were routinely detected in these deep sediments, at times in greater concentrations than observed elsewhere in the Bight. Average concentrations of many trace metals were greater on the slope than on the shelf. Moreover, it was evident that discharged pollutants continue to find their way to deep waters since PBDEs, a current use flame retardant, were also detected in slope and basin sediments. Pollutants eventually settling into these deep water habitats have little to no chance of removal by dispersion or burial since currents and deposition at these cold, still depths is minimal.

The slope and basin also has unique biological communities not found in shallower waters. In fact, 34 new species were detected in regional surveys while sampling the slope and basins. Even for species that also occur on the continental shelf, abundance and relative proportions are vastly different in the slope and basin environments.

Despite the unique biology observed on the continental slope and basins, and the potential risk posed by contaminants migrating from shallower water, it remains difficult to ascertain if there are any pollutant-related impacts to these deep-water communities. No assessment tools, like the multiple line of evidence developed for embayments, exist for these depths. The data collected during Bight '08 will be extremely useful in developing assessment tools if in the future managers consider regulatory actions in these deep water habitats.

Method Standardization and Quality Assurance

Quality assurance activities are crucial during the Bight '08 program because so many agencies participate. To combine the data for interpretation, it is critical that each collaborator produces comparable values. Comparability training and evaluations often begin six months prior to field efforts, and every participating agency is required to pass some form of pre-survey quality assurance exercise(s).

Successes in quality assurance observed in the Bight program live on well after the survey has been completed. For example, chemistry intercalibrations using unknown samples took three iterations in 1998 to achieve adequate comparability and quality, but results were as good (or better) in 2008 after a single intercalibration exercise. Similarly, the participating toxicity laboratories generated a numeric scoring system for intercalibrations using reference toxicants and unknown samples, and all participating laboratories scored between 80 and 100%. Finally, the trawl element has introduced a new method for presenting data (as fish/meter^2). This will enable better integration with fisheries-based management programs such as the new system of Marine Protected Areas slated for Southern California in the upcoming year. Finally, the data quality objectives used for identification and enumeration of benthic organisms in Bight '08 is now being considered for use as a statewide standard by the State Water Resources Control Board.

"Successes in quality assurance observed in the Bight program live on well after the survey has been completed."

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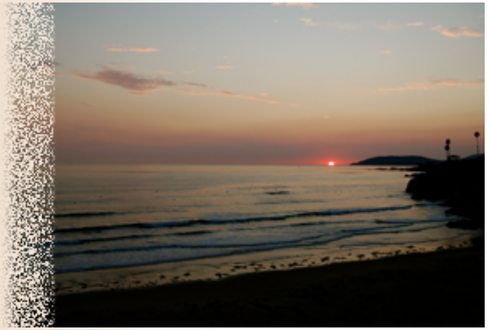

Bight '08 Coastal Ecology Study - Participating Agencies

Aquatic Bioassay and Consulting Laboratories
California State University, Long Beach
California Department of Fish and Game
Channel Islands National Marine Sanctuary
Chevron USA Products Company
City of Los Angeles Environmental Monitoring Division
City of Oceanside
City of Oxnard
City of San Diego
CRG Marine Laboratories
Encina Wastewater Authority
Los Angeles County Department of Beaches & Harbors
Los Angeles County Sanitation Districts
Los Angeles Department of Water and Power
Marine Pollution Studies Laboratory - Granite Canyon
Marine Pollution Studies Laboratory - Rancho Cordova
MBC Applied Environmental Consultants
Natural History Museum of Los Angeles County
Nautilus Environmental
NES Energy, Inc.
National Oceanic and Atmospheric Administration
NRG Energy, Inc.
Orange County Sanitation District
Port of Long Beach
Port of Los Angeles
Port of San Diego
Reliant Corporation
San Elijo Joint Powers Authority
South Orange County Wastewater Authority
Southern California Coastal Water Research Project
State Water Resources Control Board
US EPA Office of Research and Development
US Geological Survey
Vantuna Research Group, Occidental College
Weston Solutions

Components of the 2008 Bight Regional Monitoring Program (Bight '08):

- Coastal Ecology
- Shoreline Microbiology
- Offshore Water Quality
- Areas of Special Biological Significance
- Rocky Reef
- Coastal Wetlands and Estuaries

Additional Bight '08 reports are available at:
http://www.sccwrp.org/Documents/BightDocuments.aspx

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