Southern California Bight 2013
Regional Monitoring Program

Contaminant Impact Assessment Synthesis Report

BIGHT '13

Southern California Bight
2013 Regional Monitoring
Program
Volume VIII

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Southern California Bight 2013 Regional Monitoring Program: Volume VIII. Contaminant Impact Assessment Synthesis Report

Bight '13 Contaminant Impact Assessment Planning Committee

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FOREWORD

The 2013 Southern California Bight Regional Monitoring Program (Bight '13) is the continuation of an ongoing effort that provides an integrated assessment of the Southern California coastal zone through cooperative region-scale monitoring. The 2013 survey represents the joint effort of more than 100 organizations and is organized into five technical components: (1) Contaminant Impact Assessment, (2) Shoreline Microbiology, (3) Water Quality, (4) Debris, and (5) Rocky Reefs.

This report presents the results from a synthesis of five technical reports comprising the Contaminant Impact Assessment (CIA) component: (1) Sediment toxicity, (2) Sediment chemistry, (3) Benthic infauna, (4) Demersal fish and megabenthic invertebrates, and (5) Contaminant bioaccumulation.

Copies of all Bight synthesis reports, technical reports, workplans, and guidance manuals are available for download at www.sccwrp.org/Documents/BightDocuments.aspx

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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 supporting forests of Giant kelp and abundant marine life (Hickey 1993). Home to over 2,000 species of fish or invertebrates, the Bight represents the beginning or end of more species ranges than anywhere else along the western coast of North America (Dailey et al. 1993).

With a population exceeding 22 million people, the Bight is also a repository for a variety of waste discharges (Figure 1). The effluents from 18 sewage treatment plants, as well as untreated discharges from thousands of miles of urban storm drains, all wind up in the coastal waters of the Bight (Schiff et al. 2001). Environmental managers have been working hard to reduce the pollutant inputs for decades. For most traditional pollutants such as trace metals, inputs today are a fraction of what they were 30 years ago (Lyon and Stein 2009). However, legacy inputs 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 (Schiff et al. 2015). This collaboration first occurred in 1994 and was reprised four times since, approximately every five years. This document summarizes the findings from Contaminant Impact Assessment of the 2013 Southern California Bight Regional Monitoring Program (Bight '13). Forty-one organizations (Appendix A), including both the 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?*

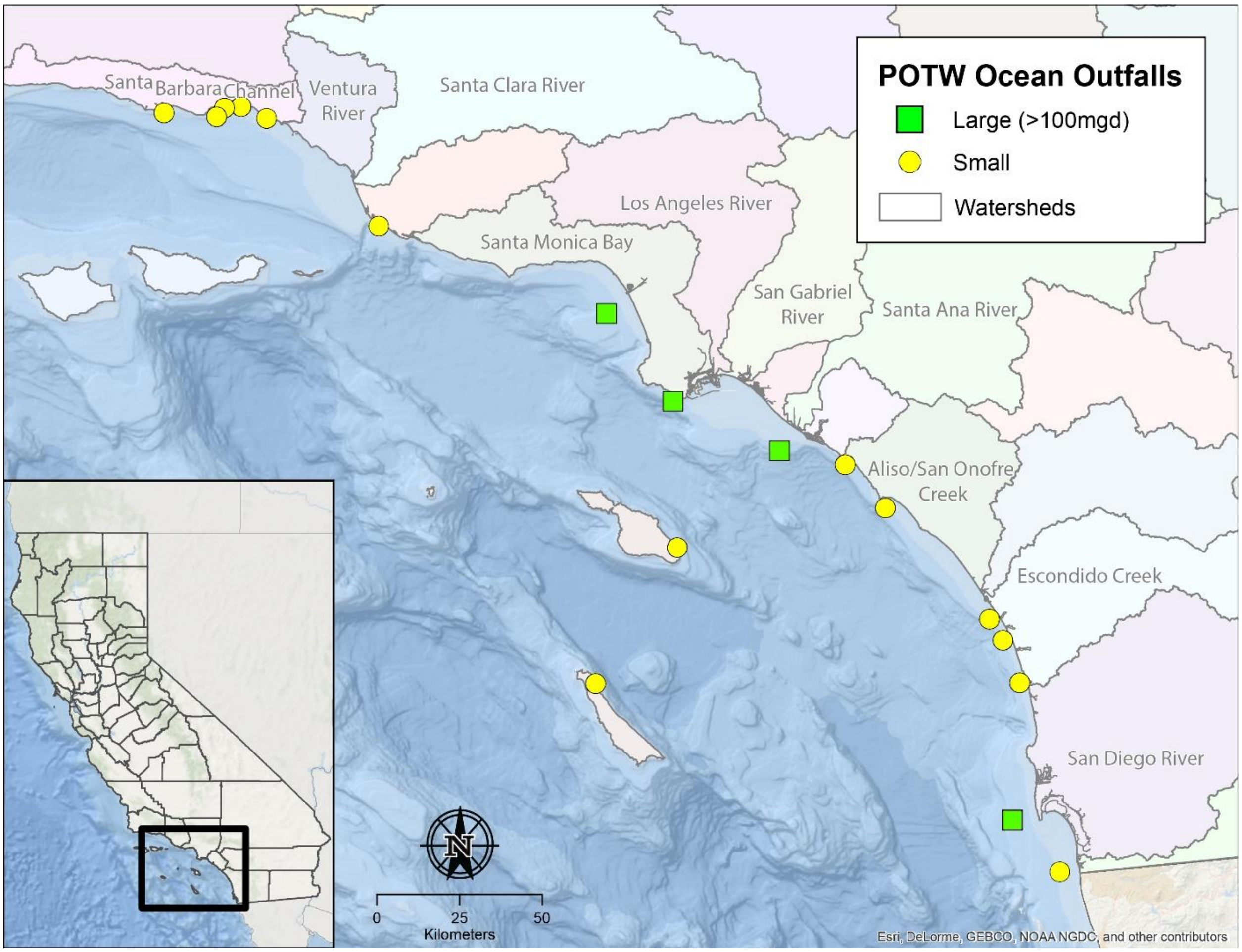

Figure 1. Location of the major coastal watersheds and 18 coastal Publicly Owned Treatment Works (POTWs) that discharge to the Southern California Bight. The POTWs are classified into large (discharge > 100 million gallons per day treated effluent) and small (<100 mgd) facilities.

APPROACH

A total of 385 sites were sampled during Bight '13 encompassing approximately 15,911 km^2. Sites were selected via a stratified, random sampling design to remove bias and ensure statistical representativeness (Stevens 1997, B'13 CIA Committee 2013a). This type of sampling design is not structured to identify "hot spots". Sites were sampled using a Van Veen grab from 12 different sediment or "soft-bottom" habitats that fall into two broad categories: embayment and offshore habitats (Table 1, Figure 2). Embayments include habitats such as estuaries (mouths of coastal streams and rivers), marinas (small boat harbors), ports (commercial, industrial and naval activity), or other open bay habitats (i.e., open navigation channels like the Los Angeles Outer Harbor and San Diego Bay). Offshore habitats include the mainland continental shelf (5-200 m depth), the northern Channel Islands (30-120 m depth), the continental slope and basins (200-1,000 m depth), and submarine canyons (10-1,000 m depth). All of the samples were collected from soft-bottom sediments where contaminants tend to accumulate, and not from rocky reefs, kelp forests, or other vegetated habitats. All sites were analyzed for 198 sediment chemical contaminants and benthic biological community composition. A subset of sites was analyzed for sediment toxicity or benthic fishes and mega-benthic invertebrates caught using otter trawl. Guidance Manuals specifying methods and quality assurance were created for each aspect of Bight '13 (B'13 CIA Committee 2013a, B'13 CIA 2013b, B'13 Field and Logistics Committee 2013, and B'13 Benthic Committee 2013).

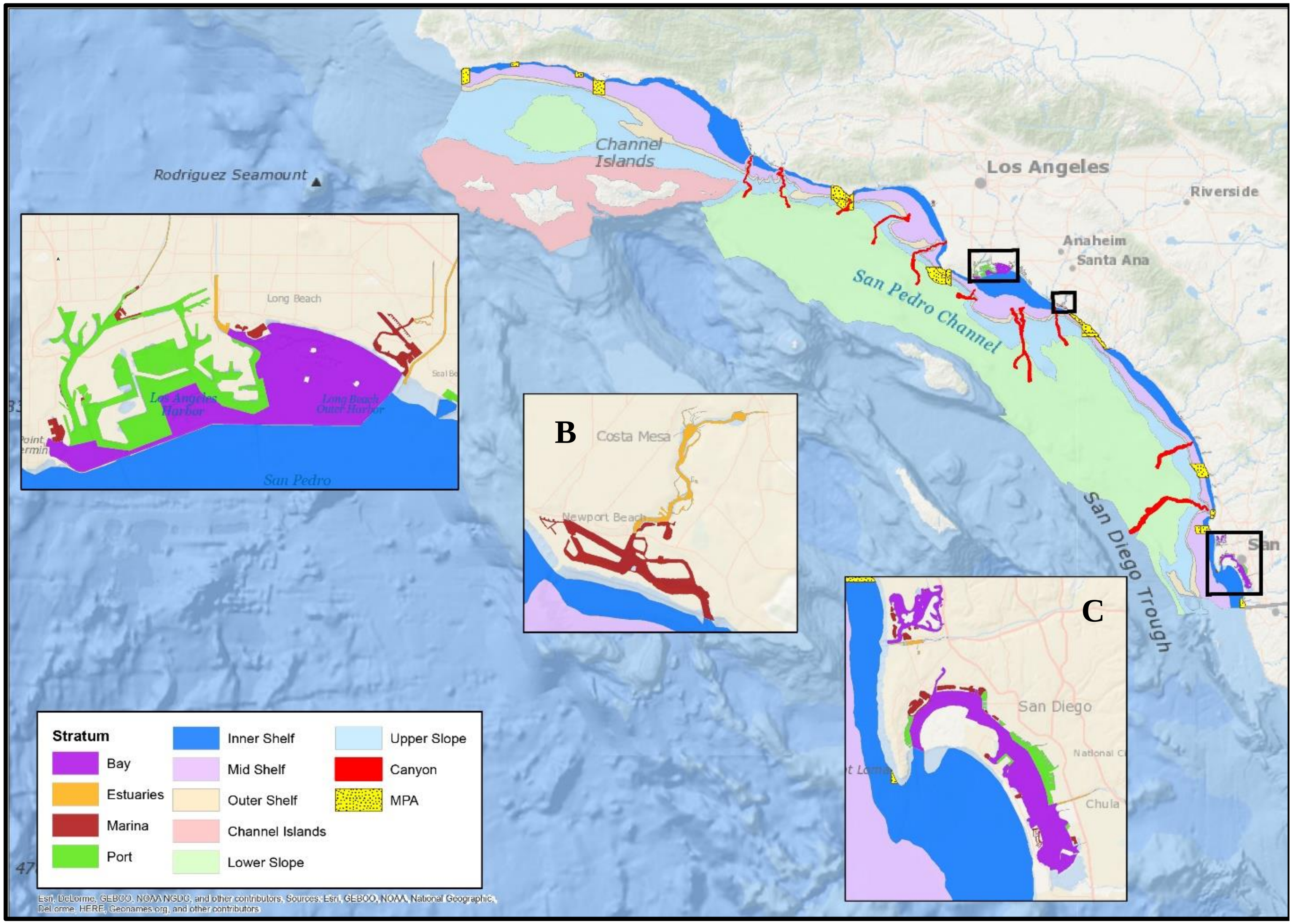

Figure 2. Map of the Southern California Bight delineating the 12 sample strata used in the survey. Insets show the details of: A) Ports of Long Beach/Los Angeles and San Pedro Bay, B) Newport Bay, and C) San Diego Bay.

Table 1. List of sampled habitats, sample size for various environmental indicators and their combined multiple lines of evidence assessment.

Habitat Stratum	Multiple Lines of Evidence[d]	Sediment Toxicity	Sediment Chemistry	Benthic Infauna	Benthic Fish
Embayment – Marina	34	43	35	34	0
Embayment – Estuary	40	44	40	41	0
Embayment – Port	30	45	30	30	0
Embayment – Bay	31	38	31	34	26
Continental Shelf[a]	31	31	112	90	107
Slope and Basin[b]	0	0	66	61	32
Submarine Canyon[c]	0	26	35	30	0
Channel Islands	0	0	0	15	

[a] Includes inner (5-30 m), middle (30-120 m) and outer (120-200 m) Continental Shelf depths
[b] Includes Upper Slope (200-500 m) and Lower Slope and Basin (500-1,000 m) depths
[c] Up to 1,000 m depth
[d] Multiple lines of evidence is a combination of sediment toxicity, sediment chemistry, and benthic infauna; assessment tools for scoring all three lines of evidence do not extend below 200 m depth

In order to provide a more comprehensive understanding of sediment quality in the Southern California Bight, three primary indicators (lines of evidence) of sediment quality were integrated: sediment chemistry, sediment toxicity, and benthic community structure. This integration followed a 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 fraction that is tightly bound to sediment and that which is biologically available. Toxicity tests may integrate the effects of multiple contaminants, but are conducted under laboratory conditions using species that may not occur naturally at the site. Benthic community condition directly measures the organisms at risk from sediment contamination, but can also be affected by non-human physical or habitat related changes. Integration of these three lines of evidence assured that the overall assessment and conclusions were not biased by factors unrelated to pollutant impacts.

Each line of evidence was represented by a four-category response level that was based on the interpretation of multiple indicators (e.g., two toxicity tests, two chemical indices, four benthic indices). Details of the specific measures, categories, and thresholds used for each line of evidence are provided in Bay et al. (2013). Each line of evidence was then integrated using the State of California sediment quality assessment framework to determine the level of sediment quality impact with respect to sediment contamination for each site (State Water Board 2009). The response-level categories within each of the three lines of evidence resulted in 64 possible combinations of outcomes. The relationship between each line of evidence combination and site condition was established using a conceptual model that related the severity of biological effects (i.e., sediment toxicity and benthic community disturbance) to the level of chemical exposure (sediment chemistry and toxicity). The integration resulted in the classification of each site into one of the following five 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.

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

Bight ’13 represents the most comprehensive region-wide sampling and application of California's multiple lines of evidence framework for embayments. While this framework was adopted to implement sediment quality objectives within all embayments, we utilized this framework for continental shelf (5-200 m depth) sediments as well. To apply this framework to continental sediments, several 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; 2) a single toxicity test was used (amphipod 10-day survival test) rather than the two used for embayments (amphipod 10-day survival and mussel embryo sediment-water interface tests); and 3) the same two sediment chemistry assessment indices developed for embayments were used even though these indices have not been calibrated or validated for continental shelf sediments. Though these assumptions are not ideal, we chose to extrapolate this tool to continental shelf 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 lines of evidence assessment framework in continental shelf sediments has no State of California regulatory implications. We chose not to extrapolate to depths greater than 200 m, or roughly 63% of the Bight area, because no assessment tools exist to comprehensively evaluate these deep, offshore habitats.

Benthic fish communities were assessed using the Fish Response Index (Allen et al. 2001). Similar to the Benthic Response Index, the Fish Response Index utilizes a pollution-weighted fish assemblage score to assess whether fish communities at a sampling site are similar to scores observed at reference sites. The Fish Response Index is calibrated to depths between 5 and 200 m depth.

Results and Discussion

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

Bight '13 found 93.8% of the Southern California Bight assessed during this survey not impacted by sediment contaminants. The multiple lines of evidence framework classified 87.8% of the Southern California Bight sampling area (embayments plus continental shelf) as Unimpacted and another 6.0% was classified as Likely Unimpacted (Figure 3). Of the remaining 6.2% of contaminant-impacted sediments in the Southern California Bight, 6.0% 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 % of the total area was classified as Likely Impacted, and no sample was classified as Clearly Impacted, where all three lines of evidence indicated contaminant effects.

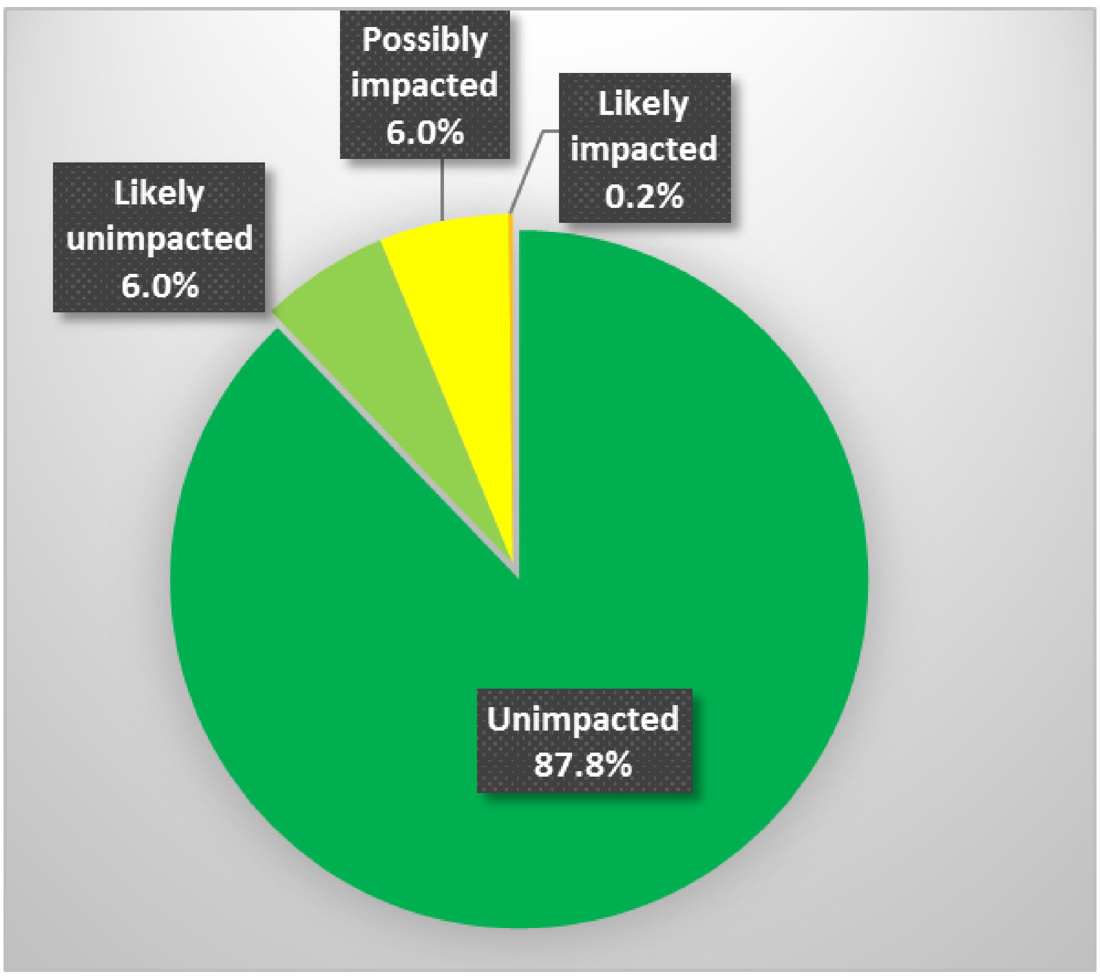

Figure 3. Extent of area in the Southern California Bight in the five different categorical classifications for the entire SCB. No site was classified as Clearly Impacted.

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 (Figures 4, 5). Five percent (5%) of continental shelf sediments in the Southern California Bight were considered contaminant-impacted using the multiple lines of evidence framework; 89% of the area on the continental shelf was classified as Unimpacted and the remaining 6% was classified as Likely Unimpacted. Fish community composition, which is not integrated into the multiple lines of evidence approach, also illustrated lack of contaminant-related impacts on the continental shelf. Ninety-three percent (93%) of the continental shelf area had soft-bottom fish communities in reference condition and 99.3% of the more than 75,000 fish examined did not have lesions, tumors or fin rot, all indications of potentially stressed individuals (Walther et al. *in prep*).

In contrast to the continental shelf, 18% of the sediments from embayments of the Southern California Bight were classified as contaminant impacted (Figure 5). Thirteen percent (13%) of the area was classified as Possibly Impacted; 5% was classified as Likely Impacted and no site was classified as Clearly Impacted. Likewise, 17% of the embayment area had soft-bottom fish communities in non-reference condition.

The relative extent of contaminant impacted sediments within embayments was not similar among habitats (Figure 5). Nearly half of the area in marinas (48%) and about one-third (35%) of the estuaries were impacted by sediment contaminants compared to less than one-seventh of the area in ports (13%) and bays (11%). Unlike the contaminant-impacted sediments of ports and bays, the majority of the contaminant impacted sediment condition in estuaries (20%) and marinas (25%) was classified as Likely Impacted.

In general, sediment quality in the Southern California Bight was a reflection of proximity to pollutant sources. For example, copper and other biocides are frequently used in vessel bottom paints to retard the growth of fouling organisms (Schiff et al. 2007). This likely resulted in marinas having the highest sediment copper concentrations of any habitat in the Bight (Dodder et al. 2016). 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 (Dodder et al. 2016). Zinc, PAH and current use pesticides originate from land-based activities (i.e., automobiles or home applications) and are washed off during storm events (Tiefenthaler et al. 2008, Stein et al. 2006, Schiff and Sutula 2004).

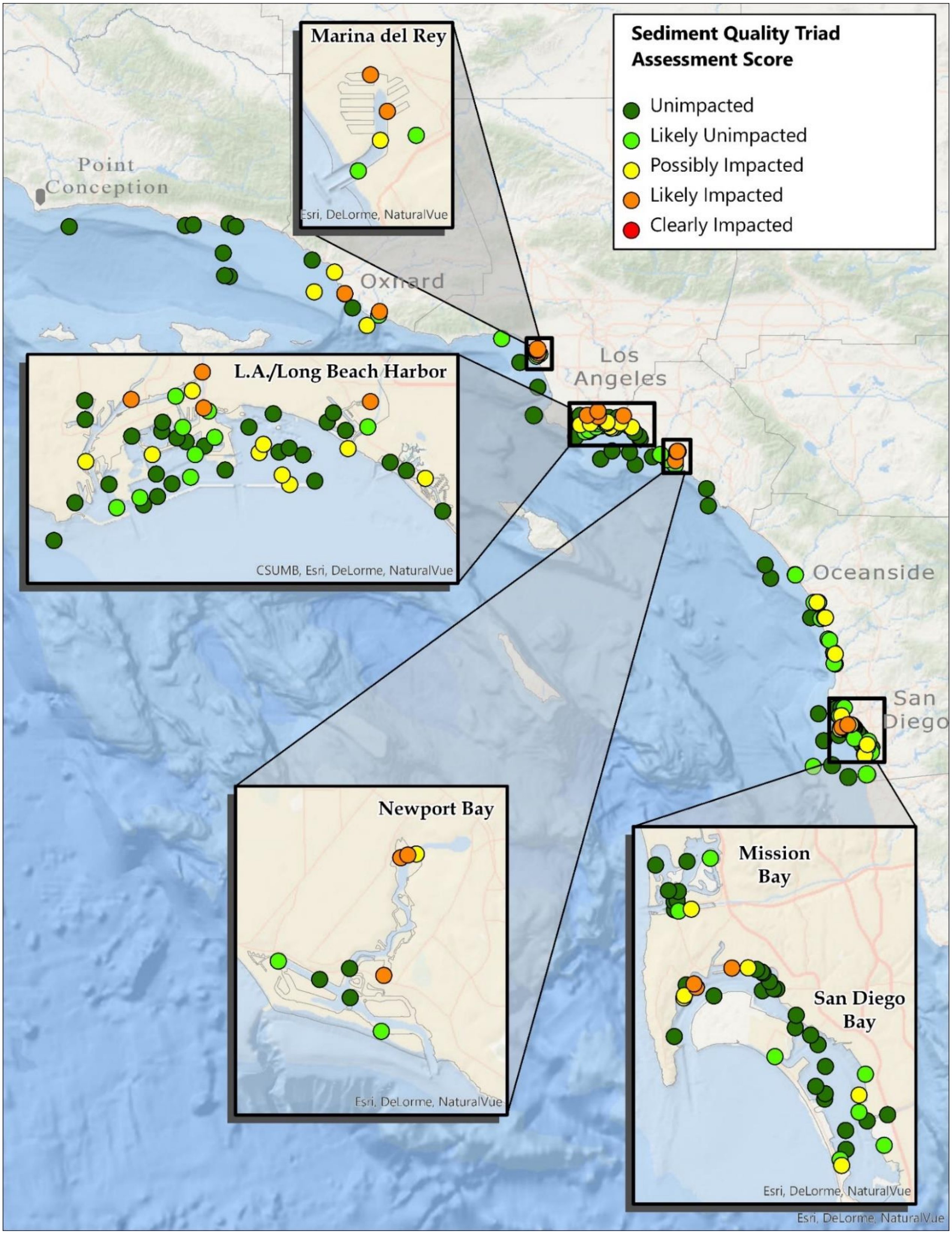

Figure 4. Map of sediment condition classification by site in Bight ’13.

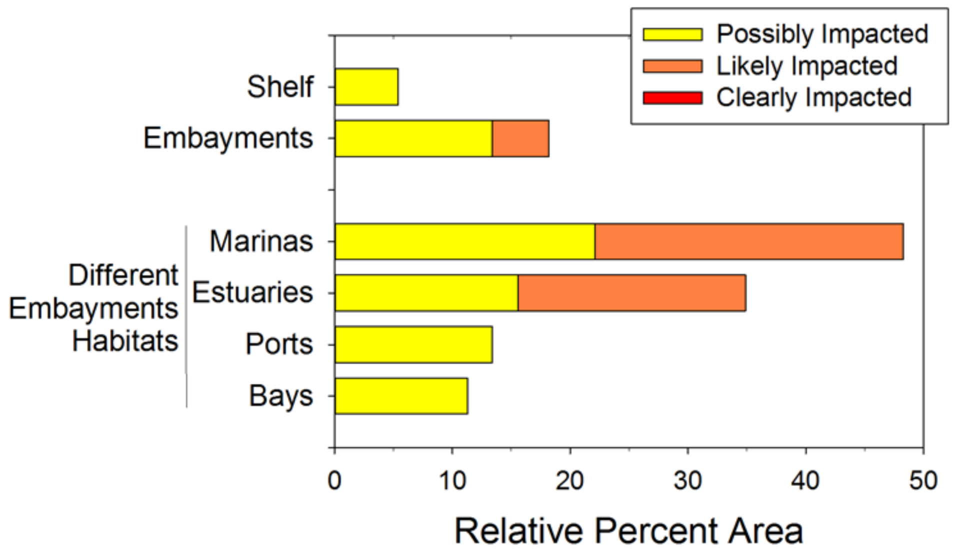

Figure 5. Extent of contaminant impacted sediments by habitat defined by multiple lines of evidence (sediment chemistry, sediment toxicity, benthic community structure) during Bight '13.

What Are the Trends in The Extent of Environmental Impact?

Although embayments had the greatest relative extent of sediment contamination, this extent has been steadily decreasing over time (Figure 6). Between 1998 and 2013, the extent of contaminated sediments has decreased from 55% to 18% of embayment area. Not only has the extent of sediment contaminant impact decreased over time, but the magnitude of impact has also decreased. In 1998, roughly 5% of the embayment area was classified as Clearly Impacted. In 2013, no site was classified as Clearly Impacted. Fifteen percent (15%) of the embayment area was classified as Likely Impacted in 1998, which has monotonically decreased to 5% in 2013.

This 15-year improvement in sediment quality of Southern California embayments is a reflection of improvements in all three lines of evidence, providing additional confidence in the observed trends (Figure 7, Appendix B). The moderate and high disturbance of infaunal biological communities decreased from 14% of embayment area in 1998 to 7% in 2013. Likewise, moderate and high sediment toxicity decreased from 30% of embayment area in 1998 to 4% in 2013. The largest relative decrease of impacted embayment sediment quality, however, was observed for the sediment chemistry line of evidence. The moderate and high exposure from sediment chemistry decreased from 61% of embayment area in 1998 to 28% in 2013. Further details can be found in Bight Technical Reports for the individual lines of evidence (Bay et al. 2015, Dodder et al. 2016, Gillett et al. 2017).

The relative extent of contaminant impact in continental shelf sediments has remained consistently small between 1998 and 2013, varying between 0 and 5% of the area in this habitat (Figure 6).

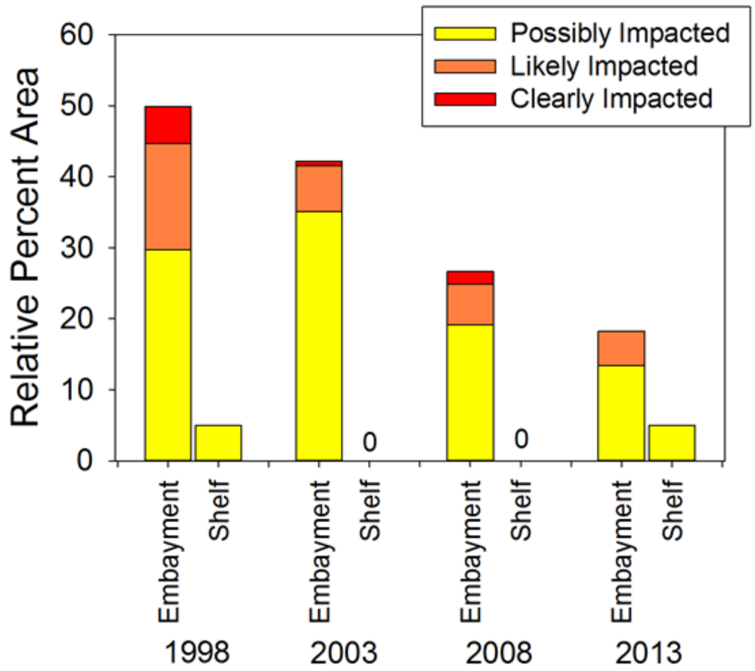

Figure 6. Relative extent of sediment impact in continental shelf or embayment area between 1998 and 2013 based on by multiple lines of evidence (sediment chemistry, sediment toxicity, benthic community structure).

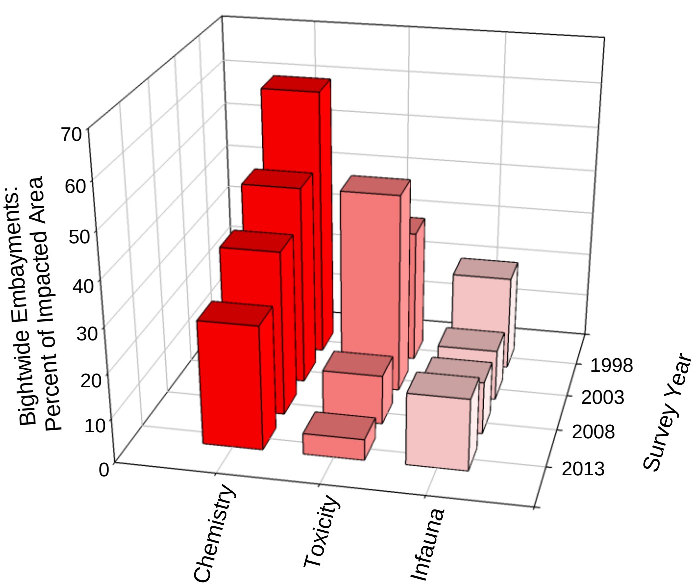

Figure 7. Percent of impacted area in Southern California Bight embayments based on sediment chemistry exposure, sediment toxicity response, and infaunal biological community assemblage during regional surveys between 1998 and 2013.

Bight ’13 Contaminant Impact Assessment Monitoring Program Highlights

Bight ’13 was amongst the largest, most complex regional marine monitoring program to date in the Southern California Bight. Important scientific discoveries, new relationships among partner agencies, and significant regulatory-related impacts all occurred. Below is a partial list of the significant highlights from Bight ’13.

Management Success: Source Control Reduces Ambient Concentrations of Contaminants of Emerging Concern (CECs)

The sediment chemistry element measured not only traditional chemicals, but also contaminants of emerging concern (CECs) such as pyrethroids and polybrominated diphenyl ethers (PBDEs) (Dodder et al. 2016). Pyrethroids are a group of current use pesticides for controlling ants and other terrestrial pests, but are also acutely toxic to non-target freshwater and marine organisms such as crustaceans (Amweg et al. 2005). 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, sea birds, and humans (Kimbrough et al. 2008).

Pyrethroids and PBDEs were found extensively in embayment sediments during Bight ’08 Regional Monitoring (Dodder et al. 2012, Lao et al. 2012). The highest concentrations occurred in estuaries, particularly at the mouths of our most urban watersheds where land-based sources of these contaminants can be washed off during storm events.

Between 2008 and 2013, PBDEs were banned in consumer goods, but there have been few controls for pyrethroid pesticides. As a result, embayment PBDE sediment concentrations dropped by 92% (Figure 8). In contrast, pyrethroid concentrations changed little (Dodder et al. 2016). This illustrates the power of source control to dramatically alter contaminant fate in the environment. Beginning in 2016, limited use regulations have been established for pyrethroid pesticides. Regional Bight monitoring in 2018 will present the next opportunity to document the regional effectiveness of source control, as well as the emergence of replacement pesticides such as nicotinoids.

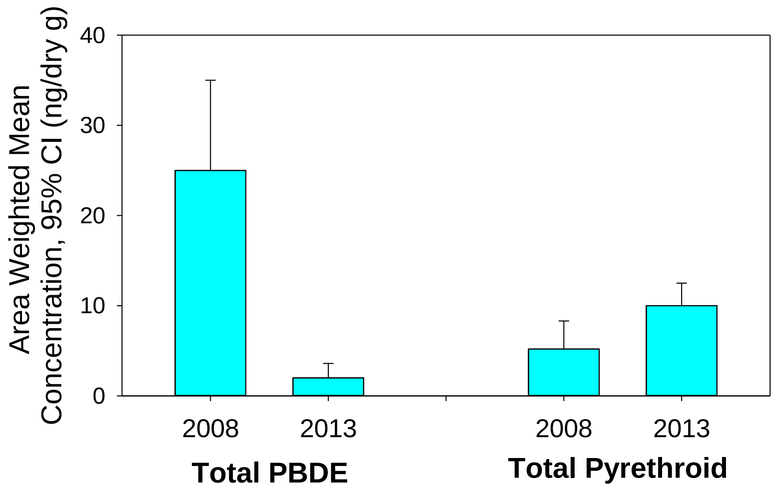

Figure 8. Regional sediment concentrations of polybrominated diphenyl ethers (PBDEs) and pyrethroid pesticides in Southern California Bight embayments from 2008 compared to 2013.

Assessing Wildlife Risk: Bioaccumulation in Sea Bird Eggs

Bight ’13 was the first time a region-wide evaluation of contaminants was measured in sea bird eggs (Clatterbuck et al. 2016). Sea birds are a sentinel indicator of the potential for wildlife risk from sediment contamination. Many contaminants can gradually accumulate as they are passed from prey to predator, and many sea birds are near the top of marine food webs (Bay et al. 2016). Bight ’13 measured the bioaccumulative compounds mercury, arsenic, selenium, PBDEs, PCBs and DDTs in over 100 abandoned or failed to hatch egg samples collected at 16 targeted nesting sites between San Diego and Point Conception from four sea bird species: Western gulls, Double-crested cormorants, Caspian terns, and the endangered California Least tern (B’13 CIA Committee 2013a).

Bioaccumulation of most contaminants in sea bird eggs was consistently detected across species throughout the region, but contaminant levels were generally low (Table 2). While some individual eggs were found to bioaccumulate contaminants at levels above those suspected to cause adverse effects, on average no species met or exceeded lowest-observed adverse effect concentrations (LOAECs). Eggshell thinning, which results from bioaccumulating contaminants such as DDT, was not widely observed during Bight ’13. In fact, eggshell thickness measured in Western gulls during Bight ’13 was approaching measurements taken prior to the widespread use of DDT in the 1940’s and 50’s. While this is the first region-wide assessment of bioaccumulation in sea bird eggs, levels measured during Bight ’13 were steady or declining based on comparison to results from historic site-specific monitoring.

Though bioaccumulation in these four species of sea birds was generally low, we cannot rule out the bioaccumulation of other contaminants not measured, the synergistic effects of multiple contaminants, or the impacts to species not measured.

Table 2. Comparing results of contaminants that bioaccumulate in sea bird eggs to thresholds of concern during Bight '13.

Contaminant	Total Number of Bird Egg Samples	Percent of Samples with Detectable Concentrations	Percent of Samples Exceeding No Effects Thresholds[a]	Percent of Samples Exceeding Lowest Effects Thresholds[b]
PCBs	101	100	0	0
PBDEs	101	100	19	0
DDTs (eggshell thinning)	101	100	61	0
DDTs (reproductive effects)	101	100	18	2
Mercury	99	100	4	2
Selenium	49	100	1	0
Arsenic	49	100	0	0

[a] Concentrations below the No Adverse Effects thresholds are levels where effects are not expected to occur
[b] Concentrations above the Lowest Adverse Effect thresholds are levels where effects may start to occur.

Exploring New Habitats: Sediment Toxicity in Submarine Canyons

Submarine canyons are an important geologic feature offshore in the Southern California Bight. Much like a river carves a canyon on land, submarine canyons cut through the continental shelf creating a pathway for contaminated sediments in shallow water to be transported to, and accumulate in, deeper waters. Frequently, submarine canyons are located near sources of pollutant inputs such as treated wastewater outfalls or large urban watersheds. Bight '13 was the first time a regional survey of all 13 submarine canyons in Southern California was conducted. A total of 26 sediment samples were collected at depths ranging from 63 to 839 m in submarine canyons and analyzed for toxicity in the laboratory using the amphipod *Eohaustorius estuarius*.

Results indicated that 17% of the area at the bottom of submarine canyons exhibited sediment toxicity (Figure 9). The vast majority (14%) of toxic canyon area was defined as highly toxic, where an average of less than 59% of amphipods survived 10 days in canyon sediment samples. In contrast, the extent of sediment toxicity observed on the adjoining continental shelf was only 3% of area, with no sample being highly toxic.

The contaminant(s) responsible for the observed sediment toxicity in submarine canyons remains largely unknown. One toxic canyon sample was subjected to Toxicity Identification Evaluation, which concluded the toxicity could be from an unconfirmed organic chemical (Bay et al. 2015). Examining other lines of evidence to confirm the canyon toxicity was contaminant-related were inconsistent. The canyon sites with the greatest toxicity generally did not have the greatest chemistry concentrations, nor were the biological communities at these sites dramatically different than the assemblages observed at other canyon sites. Unfortunately, there are no rigorous assessment tools for chemistry and benthic communities at the deep water stations most frequently sampled in submarine canyons to provide an integrated multiple lines of evidence assessment similar to what is used on the continental shelf. It is possible that the toxicity observed is not due completely to toxic contaminants, but rather due to non-contaminant issues.

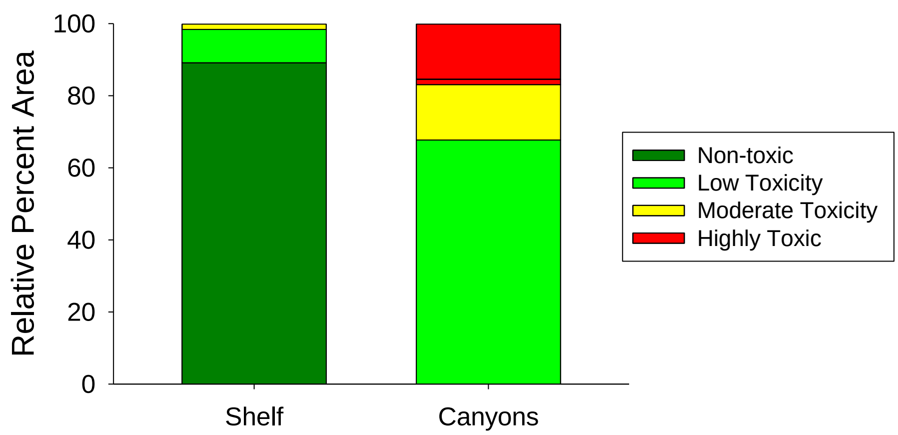

Figure 9. Extent of amphipod sediment toxicity in Submarine Canyons compared to the Continental Shelf during Bight '13.

Setting the Baseline for Success: Regional Monitoring in Marine Protected Areas

In December 2012, the State of California protected 350 square miles of the Bight by promulgating 50 Marine Protected Areas (MPAs). These MPA regulations limit fishing and, in some cases, limit pollutant discharges to provide harvest refugia and maintain environmental integrity along the southern California coastline. Bight '13 created a stratum specifically for measuring the status of MPAs and to create a baseline of condition for future MPA performance evaluations.

Ultimately, fish and invertebrate populations inside MPAs were not distinguishable from populations outside of MPAs during Bight '13 (Williams and Pondella 2015). Along with the hundreds of sample locations collected since 1998, this data set is amongst the largest of any data set to be used for judging MPA effectiveness in future surveys.

Potential Future Issue: Reduced Biological Integrity of Channel Islands Infauna

Bight '13, like the regional monitoring iterations before it, collected samples surrounding the Channel Islands National Marine Sanctuary. The Sanctuary is composed of the five most northern, and perhaps most environmentally protected, Channel Islands.

From Bight '98 to Bight '08, infaunal biological communities at nearly every site scored exceptionally well, producing reference-like assessment scores using the Benthic Response Index (Figure 10). In Bight '13, however, the assessment of Channel Islands benthic infaunal communities appeared to be changing; over one-quarter (27%) of the island infauna switched from Reference to Low Disturbance Conditions (Gillett et al. 2017). While Low Disturbance is still considered an acceptable condition category, some managers are concerned that this change in condition may portend future reductions of biological integrity. The cause of the observed changes in infaunal biological condition at the Channel Islands during Bight '13 – be it sediment quality, natural variability, or some other cause – remains unknown because chemistry and toxicity were not measured in this stratum.

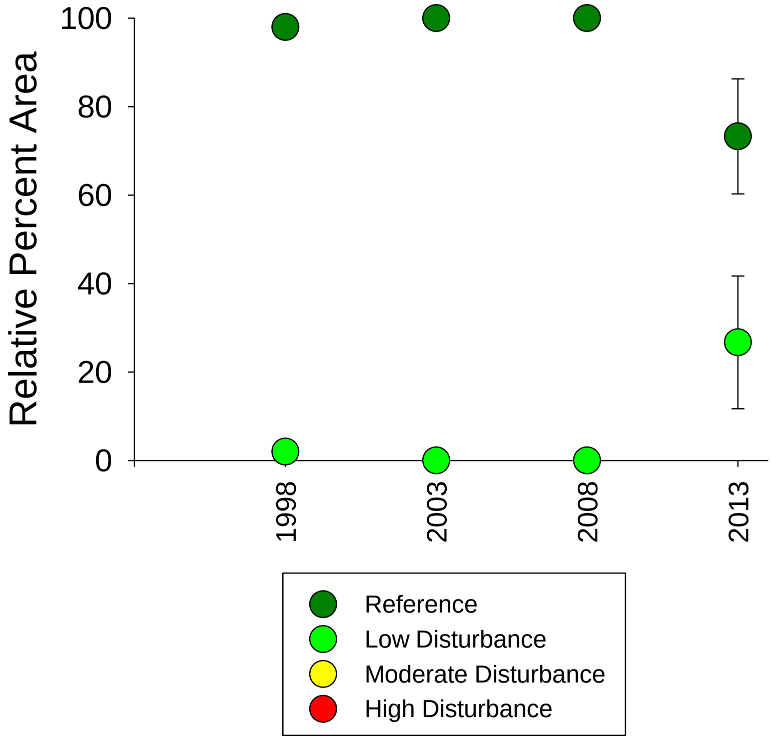

Figure 10. Trend in infauna biological community assessment scores (95% confidence intervals) at the Channel Islands between 1998 and 2013. Reference and Low Disturbance condition categories are considered acceptable, but Moderate and High Disturbance is not acceptable.

NEW CHALLENGES FOR BIGHT '18

While Bight '13 answered many questions and provided many highlights, there are still a number of challenges that face managers and scientists as the next round of regional monitoring approaches in 2018. These challenges fall into two general areas: developing new assessment tools and conducting causal assessments.

Assessment tools are the key to translating complex environmental quality information into easy-to-understand categories of impacted and not impacted condition. Bight '13 utilized a multiple lines of evidence approach to assess sediment quality condition including tools for sediment chemistry, sediment toxicity, and benthic infauna. These assessment tools have been rigorously calibrated and validated for marine and estuarine embayments, and are now part of the State's regulatory framework. However, assessment tools and the multiple lines of evidence approach are not fully vetted for other important Bight habitats including the continental shelf, continental slope and basin, and less saline estuaries. Moreover, Bight participants agree that assessment tools for benthic fish and invertebrates need updating and improvement. The good news is that all of the necessary data for calibrating and validating new assessment tools is already collected as part of Bight Regional Monitoring. For example, a new tool for infaunal community condition of the continental slope and basin is currently under development. The bad news is that developing any new assessment tool, and consensus regarding the meaning of assessment tool scores, is a lengthy process that has both technical and sociopolitical challenges to overcome.

Bight Regional Monitoring is amongst the premier monitoring programs in the nation for assessing status and trends. Because of its focus on regional condition, it does not delve into site-specific concerns such as causes of sediment quality degradation. For example, Bight '13 observed a relative increase in the extent and magnitude of sediment toxicity collected from submarine canyons, but the specific contaminant(s) responsible for the toxicity is unknown. Further site-specific investigations, such as toxicity identification evaluations, would be required to ascertain this information. Likewise, Bight '13 observed a decrease in infaunal community composition surrounding the Channel Islands, but the cause of the decrease is also unknown. Once again, site-specific investigations are necessary to determine if these impacts are being caused by contaminant or non-contaminant factors. Identifying the specific causative agents is crucial for managers to target effective remediation.

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APPENDIX A: LIST OF CONTAMINANT IMPACT ASSESSMENT COMMITTEE MEMBERS

Member Name	Participating Agency
Geremew Amenu	Los Angeles County Public Works
Shelly Anghera	Anchor QEA
Matt Arms	Port of Long Beach
Steve Bay	Southern California Coastal Water Research Project (Co-Chair Toxicity Committee)
Chris Beegan	State Water Resources Control Board
Brent Bowman	City of San Diego Public Utilities Department
Don Cadien	County Sanitation Districts of Los Angeles County
Doug Campbell	ENCINA Wastewater Authority
Mariela Carpio-Obeso	State Water Resources Control Board
Michele Castro	Eurofins
Janice Chen	County Sanitation Districts of Los Angeles County
Adrienne Cibor	Nautilus Environmental
Wanda Cross	Santa Ana Regional Water Quality Control Board
Kathryn Curtis	Port of Los Angeles
Dario Diehl	Southern California Coastal Water Research Project (Co-Chair Field Operations Committee)
Nate Dodder	Southern California Coastal Water Research Project (Chair Chemistry Committee)
Terrence Fleming	US Environmental Protection Agency, Region IX
David Gillett	Southern California Coastal Water Research Project (Co-Chair Benthic Committee)
Rich Gossett	Physis Environmental Laboratories (Co-Chair Chemistry Committee)
Joe Gully	County Sanitation Districts of Los Angeles County
Sheila Holt	Weston Solutions
Andrew Jirik	Port of Los Angeles

Member Name	Participating Agency
Scott Johnson	Aquatic Bioassay and Consulting Laboratories
Ami Latker	City of San Diego Public Utilities Department (Co-Chair Trawl Committee)
Rebecca Lewison	San Diego State University
Larry Lovell	County Sanitation Districts of Los Angeles County (Co-Chair Benthic Committee)
Michael Lyons	Los Angeles Regional Water Quality Control Board
Rachel McPherson	Port of San Diego
Michael Mengel	Orange County Sanitation District
Eric Miller	MBC Applied Environmental
Pamela Neubert	EcoAnalysts
Canh Nguyen	Orange County Sanitation District
Dean Pasko	Dancing Coyote Ranch
Jian Peng	Orange County Public Works
Dawn Petschauer	City of Los Angeles
Greg Piniak	National Oceanic and Atmospheric Administration
Bruce Posthumus	San Diego Regional Water Quality Control Board
Leo Raab	Weck Laboratories
Terri Reeder	Santa Ana Regional Water Quality Control Board
John Rudolph	Amec Foster Wheeler
Ken Schiff	Southern California Coastal Water Research Project (Chair)
Tim Stebbins	City of San Diego Public Utilities Department
Steve Steinberg	Southern California Coastal Water Research Project (Co-Chair Toxicity Committee)
Chris Stransky	Amec Foster Wheeler
Kelly Tait	Port of San Diego

Member Name	Participating Agency
Chris Trees	San Elijo Joint Powers Authority
James Vernon	Port of Long Beach
Shelly Walther	County Sanitation Districts of Los Angeles County (Co-Chair Trawl Committee)
JoAnn Weber	San Diego County Environmental Health
Regina Wetzer	Los Angeles Natural History Museum
Lan Wiborg	City of San Diego Public Utilities Department (Co-Chair Toxicity Committee)
Catherine Zeeman	US Fish and Wildlife Service

APPENDIX B: INDIVIDUAL LINES OF EVIDENCE AREAL ESTIMATES (% OF AREA IN EACH STRATUM) AND 95% CONFIDENCE INTERVALS (CI) ACROSS REGIONAL SURVEYS IN 1998, 2003, 2008, AND 2013.

SEDIMENT TOXICITY	Strata	Nontoxic	95% CI	Low Toxicity	95% CI	Moderate Toxicity	95% CI	High Toxicity	95% CI
Bight '13	Embayment	74.6	7.3	21	6.4	3.8	4.1	0.5	0.6
	Shelf	89.2	9.4	9.2	8.8	1.6	2.9	0	0
Bight '08	Embayment	49.8	9.6	39.1	9.1	9.9	5.2	1.2	1.3
	Shelf	77	14.8	23	14.8	0	0	0	0
Bight '03	Embayment	51.8	13.9	3.3	4.9	30.8	12.5	14.1	8.5
	Shelf	83.3	12.9	0	0	16.7	12.9	0	0
Bight '98	Embayment	38.1	11.4	31.8	11	23.8	9.8	6.3	3.4
	Shelf	72.8	8.4	10.5	5.7	16.2	7.1	0.5	0.6
SEDIMENT CHEMISTRY	**Strata**	**Minimal Exposure**	**95% CI**	**Low Exposure**	**95% CI**	**Moderate Exposure**	**95% CI**	**High Exposure**	**95% CI**
Bight '13	Embayment	4	2.1	68.1	7.7	23.7	7.5	4.1	2.3
	Shelf	62.3	10.7	26.2	13.8	11.5	9.6	0	0
Bight '08	Embayment	8.4	4.5	54.7	8.8	30.6	7.8	6.4	3.7
	Shelf	78.4	12.9	20	13	1.6	2.9	0	0
Bight '03	Embayment	12.2	8.9	52.9	13.2	32.9	11.7	1.9	1.5
	Shelf	50	11.7	45.8	12	4.2	7.1	0	0
Bight '98	Embayment	8.9	6.5	30.5	10.2	43.4	10.3	17.2	7.5
	Shelf	53.8	9.2	39.4	9	6.4	4.2	0.4	0.5
BENTHIC INFAUNA	**Strata**	**Reference**	**95% CI**	**Low Disturbance**	**95% CI**	**Moderate Disturbance**	**95% CI**	**High Disturbance**	**95% CI**
Bight '13	Embayment	19.3	7.8	64.6	8.8	13.7	5.7	2.4	1.3
	Shelf	78.2	11.7	21.8	11.7	0	0	0	0
Bight '08	Embayment	31.3	8.6	56.8	9.2	10.2	3.2	1.6	1.2
	Shelf	82.6	11.9	17.4	11.9	0	0	0	0
Bight '03	Embayment	27.2	11.8	61.4	12.3	9.8	5.1	1.6	1.3
	Shelf	95.8	7.3	4.2	7.3	0	0	0	0
Bight '98	Embayment	23.2	8.9	55.6	11.3	14.8	7.9	6.5	4.6
	Shelf	82.4	6.6	14.3	5.8	3.3	3.5	0.1	0.1