

# Chapter 3

## Water Quality Compliance & Plume Dispersion

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## INTRODUCTION

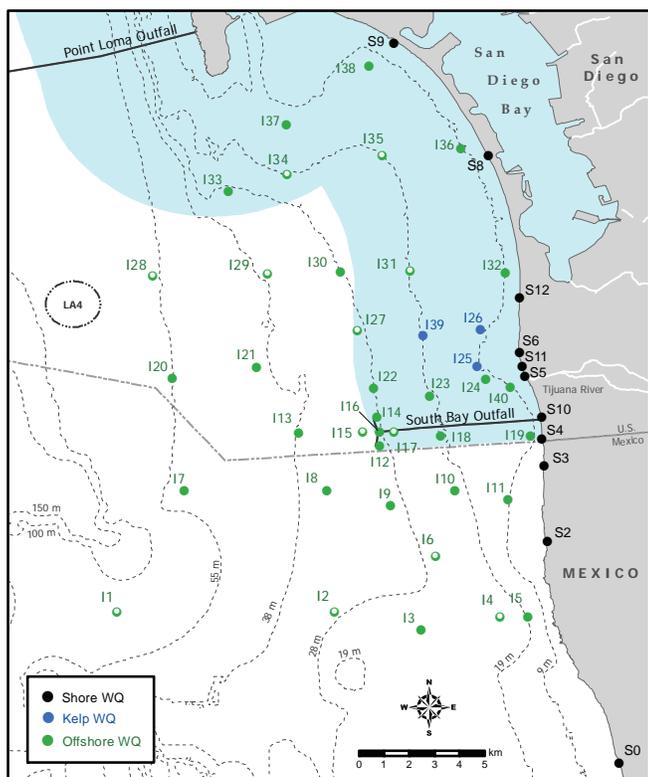
The City of San Diego analyzes seawater samples collected along the shoreline and in offshore coastal waters surrounding the South Bay Ocean Outfall (SBOO) to characterize water quality conditions in the region and to identify possible impacts of wastewater discharge on the marine environment. Densities of fecal indicator bacteria, including total coliforms, fecal coliforms, and *Enterococcus* are measured and evaluated in context with oceanographic data (see Chapter 2) to provide information about the movement and dispersion of wastewater discharged into the Pacific Ocean through the outfall. Evaluation of these data may also help to identify other sources of bacterial contamination in the region. In addition, the City's water quality monitoring efforts are designed to assess compliance with the water contact standards specified in the 2012 California Ocean Plan (Ocean Plan), which defines bacterial, physical, and chemical water quality objectives and standards with the intent of protecting the beneficial uses of State ocean waters (SWRCB 2012).

Multiple sources of potential bacterial contamination exist in the South Bay outfall monitoring region. Therefore, being able to separate any effects or impacts associated with a wastewater plume from the SBOO or other sources of contamination is often challenging. Examples of other sources of contamination include outflows from San Diego Bay, the Tijuana River, and Los Buenos Creek in northern Baja California (Largier et al. 2004, Nezlin et al. 2007, Gersberg et al. 2008, Terrill et al. 2009). Likewise, storm water discharges and runoff from local watersheds during wet weather can also flush contaminants seaward (Noble et al. 2003, Reeves et al. 2004, Griffith et al. 2010, Sercu et al. 2009). Moreover, beach wrack (e.g., kelp, seagrass), storm drains

impacted by tidal flushing, and beach sediments can act as reservoirs for bacteria until released into nearshore waters by returning tides, rainfall, and/or other disturbances (Gruber et al. 2005, Martin and Gruber 2005, Noble et al. 2006, Yamahara et al. 2007, Phillips et al. 2011). Further, the presence of birds and their droppings has been associated with bacterial exceedances that may impact nearshore water quality (Grant et al. 2001, Griffith et al. 2010).

In order to better understand potential impacts of a wastewater plume on water quality conditions, analytical tools based on a natural chemical tracer can be leveraged to detect effluent from an outfall and separate it from other non-point sources. For example, colored dissolved organic material (CDOM) has previously been used to identify wastewater plumes in the San Diego region (Terrill et al. 2009, Rogowski et al. 2012a, b, 2013). By combining measurements of CDOM with additional metrics that may characterize outfall-derived waters (e.g., low salinity, low chlorophyll *a*), multiple criteria can be applied to improve the reliability of detection and facilitate the focused quantification of wastewater plume impacts on the coastal environment.

This chapter presents analysis and interpretation of the microbiological, water chemistry, and oceanographic data collected during calendar year 2014 at water quality monitoring stations surrounding the SBOO. The primary goals are to: (1) document overall water quality conditions in the region; (2) distinguish between the SBOO wastewater plume and other sources of bacterial contamination; (3) evaluate potential movement and dispersal of the plume; (4) assess compliance with water contact standards defined in the 2012 Ocean Plan. Results of remote sensing data for the region are also evaluated to provide insight into wastewater transport and the extent of



**Figure 3.1**

Water quality (WQ) monitoring station locations sampled around the South Bay Ocean Outfall as part of the City of San Diego’s Ocean Monitoring Program. Open circles are sampled by CTD only. Light blue shading represents State jurisdictional waters.

significant events in surface waters during the year (e.g., turbidity plumes).

## MATERIALS AND METHODS

### Field Sampling

#### *Shore stations*

Seawater samples were collected weekly at 11 shore stations to monitor fecal indicator bacteria (FIB) concentrations in waters adjacent to public beaches (Figure 3.1). Of these, stations S4–S6 and S8–S12 are located in California waters between the USA/Mexico border and Coronado and are subject to Ocean Plan water contact standards (see Box 3.1). The other three stations (i.e., S0, S2, S3) are located south of the USA/Mexico border and are not subject to Ocean Plan requirements. Seawater samples were collected from the surf zone at each shore station in sterile 250-mL bottles.

**Table 3.1**

Depths from which seawater samples are collected for bacteriological analysis at the SBOO kelp bed and other offshore stations.

Station Contour	Sample Depth (m)							
	2	6	9/11	12	18	27	37	55
<i>Kelp Bed</i>								
9-m	x	x	x <sup>a</sup>					
19-m	x			x	x			
<i>Offshore</i>								
9-m	x	x	x <sup>a</sup>					
19-m	x			x	x			
28-m	x				x	x		
38-m	x				x		x	
55-m	x				x			x

<sup>a</sup> Stations I25, I26, I32, and I40 sampled at 9 m; stations I11, I19, I24, I36, I37, and I38 sampled at 11 m

The samples were then transported on blue ice to the City of San Diego’s Marine Microbiology Laboratory (CSDMML) and analyzed to determine concentrations of total coliform, fecal coliform, and *Enterococcus* bacteria. In addition, water temperature and visual observations of water color, surf height, human or animal activity, and weather conditions were recorded at the time of collection. These observations were previously reported in monthly receiving waters monitoring reports submitted to the SDRWQCB (e.g., City of San Diego 2014b).

#### *Kelp bed and other offshore stations*

Three stations located in nearshore waters within the Imperial Beach kelp forest were monitored five times a month to assess water quality conditions and Ocean Plan compliance in areas used for recreational activities such as SCUBA diving, surfing, fishing, and kayaking. These included two stations (I25, I26) located near the inner edge of the kelp bed along the 9-m depth contour, and one station (I39) located near the outer edge of the kelp bed along the 18-m depth contour. Three other offshore stations near the terminus of the SBOO (I12, I14, I16) were sampled monthly in conjunction with a kelp sampling event. An additional 22 stations were sampled quarterly (i.e., February, May, August,

### Box 3.1

Water quality objectives for water contact areas, 2012 California Ocean Plan (SWRCB 2012).

- A. Bacterial Characteristics – Water Contact Standards; CFU = colony forming units
  - (a) *30-day Geometric Mean* – The following standards are based on the geometric mean of the five most recent samples from each site:
    - 1) Total coliform density shall not exceed 1000 CFU/100 mL.
    - 2) Fecal coliform density shall not exceed 200 CFU/100 mL.
    - 3) *Enterococcus* density shall not exceed 35 CFU/100 mL.
  - (b) *Single Sample Maximum*:
    - 1) Total coliform density shall not exceed 10,000 CFU/100 mL.
    - 2) Fecal coliform density shall not exceed 400 CFU/100 mL.
    - 3) *Enterococcus* density shall not exceed 104 CFU/100 mL.
    - 4) Total coliform density shall not exceed 1000 CFU/100 mL when the fecal coliform:total coliform ratio exceeds 0.1.
- B. Physical Characteristics
  - (a) Floating particulates and oil and grease shall not be visible.
  - (b) The discharge of waste shall not cause aesthetically undesirable discoloration of the ocean surface.
  - (c) Natural light shall not be significantly reduced at any point outside of the initial dilution zone as the result of the discharge of waste.
- C. Chemical Characteristics
  - (a) The dissolved oxygen concentration shall not at any time be depressed more than 10 percent from what occurs naturally, as a result of the discharge of oxygen demanding waste materials.
  - (b) The pH shall not be changed at any time more than 0.2 units from that which occurs naturally.

November) to monitor FIB levels and to estimate the spatial extent of the wastewater plume. These non-kelp offshore stations are arranged in a grid surrounding the discharge site along the 9, 19, 28, 38, and 55-m depth contours (Figure 3.1). Sampling of these offshore stations was completed over a 3-day period each quarter (see Chapter 2).

During quarterly sampling, seawater samples for FIB and total suspended solids (TSS) were collected at three discrete depths at each of the kelp and non-kelp bed stations using either an array of Van Dorn bottles or a rosette sampler fitted with Niskin bottles (Table 3.1). Additional samples for oil and grease (O&G) analysis were collected from surface waters only. Aliquots for each analysis were drawn into appropriate sample containers. FIB samples were refrigerated onboard ship and transported to the CSDMML for processing and analysis. TSS and O&G samples were analyzed

at the City’s Environmental Chemistry Services Laboratory. Visual observations of weather and sea conditions, and human and/or animal activity were also recorded at the time of sampling. Oceanographic data were collected from these stations using a CTD to measure temperature, conductivity (salinity), pressure (depth), chlorophyll *a*, CDOM, dissolved oxygen (DO), pH, and transmissivity (see Chapter 2).

#### Laboratory Analyses

The CSDMML follows guidelines issued by the United States Environmental Protection Agency (USEPA) Water Quality Office and the California Department of Public Health (CDPH) Environmental Laboratory Accreditation Program (ELAP) with respect to sampling and analytical procedures (Bordner et al. 1978, APHA 2005, CDPH 2000, USEPA 2006). All

bacterial analyses were performed within eight hours of sample collection and conformed to standard membrane filtration techniques (APHA 2005).

Enumeration of FIB density was performed and validated in accordance with USEPA (Bordner et al. 1978, USEPA 2006) and APHA (2005) guidelines. Plates with FIB counts above or below the ideal counting range were given greater than (>), less than (<), or estimated (e) qualifiers. However, these qualifiers were dropped and the counts treated as discrete values when calculating means and determining compliance with Ocean Plan standards.

Quality assurance tests were performed routinely on seawater samples to ensure that analyses and sampling variability did not exceed acceptable limits. Bacteriological laboratory and field duplicate samples were processed according to method requirements to measure analyst precision and variability between samples, respectively. Results of these procedures were reported under separate cover (City of San Diego 2015a).

## Data Analyses

### *Bacteriology*

FIB densities were summarized as monthly means for each shore station and by depth contour for the kelp bed and other offshore stations. During non-quarterly months offshore station means included only the three 28-m depth contour stations I12, I14, and I16. TSS and O&G concentrations were also summarized by quarter for the offshore stations. To assess temporal and spatial trends, the bacteriological data were summarized as counts of samples in which FIB concentrations exceeded benchmark levels. For this report, water contact limits defined in the 2012 Ocean Plan for densities of total coliforms, fecal coliforms, and *Enterococcus* in individual samples (i.e., single sample maxima, see Box 3.1 and SWRCB 2012) were used as reference points or benchmarks to distinguish elevated FIB values. Bacterial densities were compared to rainfall data from Lindbergh Field, San Diego, CA (see NOAA 2015). Chi-squared Tests ( $\chi^2$ ) were

conducted to determine if the frequency of samples with elevated FIB counts differed at the shore and kelp bed stations between wet (October–April) and dry (May–September) seasons, and to determine if elevated FIB counts differed between the three outfall stations and the other stations located along the 28-m depth contour. Satellite images of the San Diego coastal region were provided by Ocean Imaging of Solana Beach, California (Ocean Imaging 2015) and used to aid in the analysis and interpretation of water quality data (see Chapter 2 for remote sensing details). Finally, compliance with Ocean Plan water-contact standards was summarized as the number of times per month that each of the eight shore stations located north of the USA/Mexico border, the three kelp bed stations, and the other offshore stations located within State jurisdictional waters (i.e., within 3 nautical miles of shore) exceeded the various standards.

### *Wastewater Plume Detection and Out-of-range Calculations*

The potential presence or absence of the wastewater plume was determined at each station using a combination of oceanographic parameters. All stations along the 9-m depth contour were excluded from analyses due to a strong CDOM signal near shore, which was likely caused by coastal runoff or nearshore sediment resuspension (Appendix B.1). Previous monitoring has consistently found that the SBOO plume is trapped below the pycnocline during seasonal water column stratification, but may rise to the surface when stratification breaks down (City of San Diego 2010–2014a, 2015b, Terrill et al. 2009). Water column stratification and pycnocline depth were quantified using calculations of buoyancy frequency ( $\text{cycles}^2/\text{min}^2$ ) for each quarterly survey (see Chapter 2). For the purposes of the plume dispersion analysis, buoyancy frequency calculations included data from those stations that would be most likely to demonstrate the potential plume trapping depth (i.e., all stations located along the 19, 28, 38, and 55-m depth contours). If the water column was stratified (i.e., maximum buoyancy frequency  $>32 \text{ cycles}^2/\text{min}^2$ ), subsequent analyses were limited to depths below the pycnocline. Identification of a potential plume signal at a station

was based on: (1) high CDOM; (2) low salinity; (3) low chlorophyll *a*; (4) visual interpretation of the overall water column profile. Detection thresholds were adaptively set for each quarterly sampling period according to the following criteria: CDOM exceeding the 95<sup>th</sup> percentile, chlorophyll *a* below the 90<sup>th</sup> percentile, and salinity below the 40<sup>th</sup> percentile. The threshold for chlorophyll *a* was incorporated to exclude CDOM derived from marine phytoplankton (Nelson et al. 1998, Rochelle-Newall and Fisher 2002, Romera-Castillo et al. 2010). It should be noted that these thresholds are based on regional observations of ocean properties and are thus constrained to use within the SBOO region only. Finally, water column profiles were visually interpreted to remove stations with spurious signals (e.g., CDOM signals near the sea floor that were likely caused by resuspension of sediments). Exclusion of stations using the chlorophyll *a* and salinity criteria was confirmed as part of the visual interpretation of the profiles.

After identifying the stations and depth-ranges where detection criteria suggested the wastewater plume may be present, potential impact of the plume on water quality was determined by comparing mean values of DO, pH, and transmissivity within the possible plume to thresholds calculated for similar depths from reference stations. Any stations with CDOM below the 85<sup>th</sup> percentile were considered outside the plume and were used as reference stations for that quarterly survey (Appendix B.2). Individual stations were determined to be out-of-range (OOR) for DO, pH, and transmissivity if values exceeded the narrative water quality standards for these parameters as defined by the Ocean Plan (Box 3.1). The Ocean Plan defines OOR thresholds for DO as a 10% reduction from that which occurs naturally, while the OOR threshold for pH is defined as a 0.2 pH unit change, and the OOR for transmissivity is defined as dropping below the lower 95% confidence interval from the mean. For the purposes of this report, “naturally” was defined for DO as the mean minus one standard deviation (see Nezlin et al., in prep). February compliance for pH was not calculated due to calibration issues with the instrument (see Chapter 2).

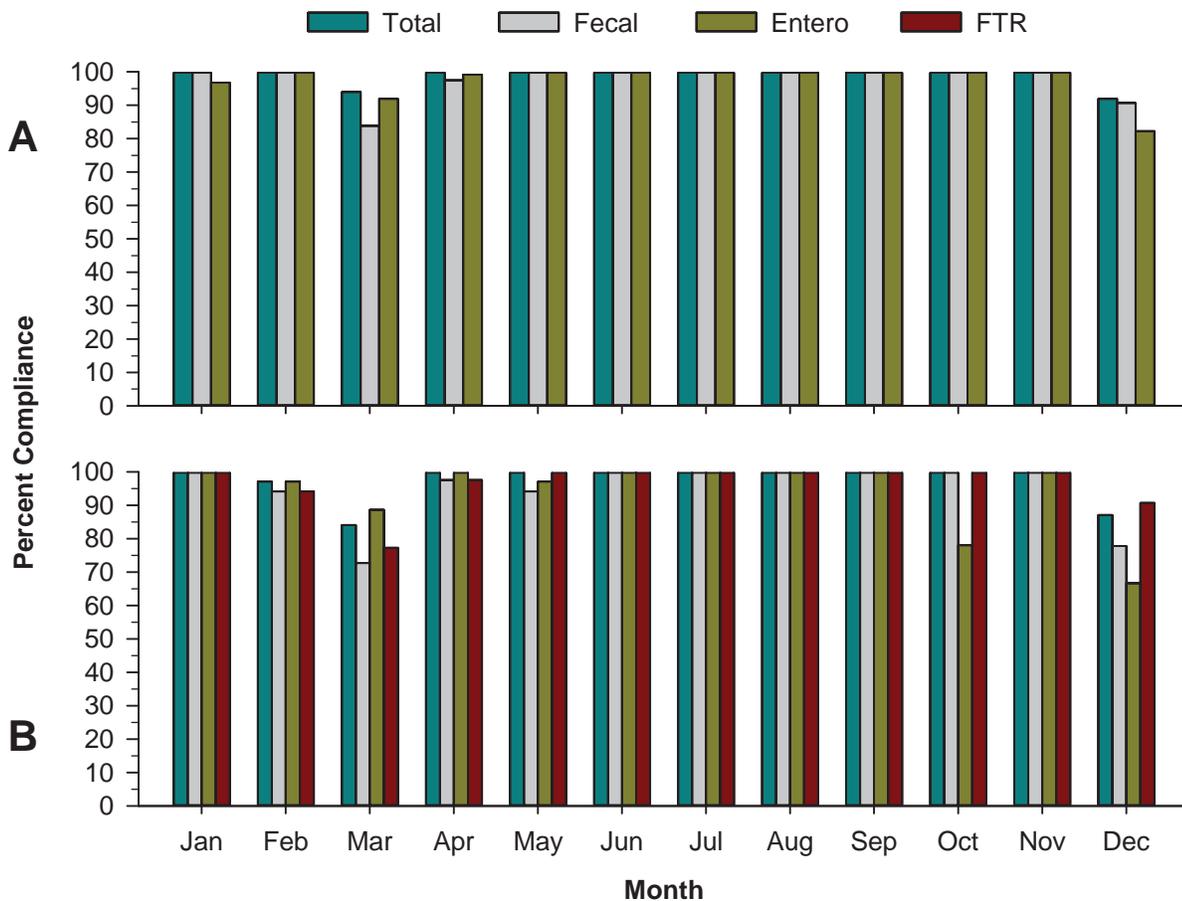
## RESULTS AND DISCUSSION

### Bacteriological Compliance and Distribution

#### *Shore stations*

During 2014, compliance for the 30-day geometric mean standards at the eight shore stations located north of the USA/Mexico border ranged from 92 to 100% for total coliforms, 84 to 100% for fecal coliforms, and 82 to 100% for *Enterococcus* (Figure 3.2A). In addition, compliance with the single sample maximum (SSM) standards ranged from 84 to 100% for total coliforms, 73 to 100% for fecal coliforms, 67 to 100% for *Enterococcus*, and 77 to 100% for the fecal:total coliform (FTR) criterion (Figure 3.2B). However, six of these stations (S4, S5, S6, S10, S11, S12) are located within or immediately adjacent to areas listed as impaired waters and are not expected to be in compliance with water contact standards (SOC 2010). Thus, when these stations are excluded, overall compliance at the remaining two shore stations (i.e., S8, S9) was >99% in 2014. Reduced compliance at shore stations was more prevalent during the wet season, with the lowest values for all standards occurring in either March or December following significant rain events (NWS 2015). In contrast, all standards were in compliance 100% of the time during the dry weather months from June through September.

Monthly mean FIB densities ranged from 6 to 6156 CFU/100 mL for total coliforms, 2 to 2636 CFU/100 mL for fecal coliforms, and 2 to 2451 CFU/100 mL for *Enterococcus* at the individual stations (Appendix B.3). Of the 572 seawater samples collected along the shore during the year (not including resamples), 11% (n=64) had elevated FIB (Appendix B.4), which is slightly higher than the 8% observed in 2013 (City of San Diego 2014a). A majority (83%) of the shore samples with elevated FIB were collected during the wet season when rainfall totaled 7.69 inches, versus 0.08 inches in the dry season (Table 3.2). This general relationship between rainfall and elevated bacterial levels has been evident from water quality monitoring in the region



**Figure 3.2**

Compliance rates for (A) the three geometric mean and (B) the four single sample maximum water contact standards from SBOO shore stations during 2014.

since 1996 (Figure 3.3). For example, historical analyses indicate that a sample with elevated FIB was significantly more likely to occur during the wet than dry season (e.g., 21% versus 7%, respectively;  $n=11,741$ ,  $\chi^2=450.90$ ,  $p<0.0001$ ).

During the wet season in 2014, elevated FIB were primarily detected at stations located close to the mouth of the Tijuana River (S4, S5, S10, S11) as well as in Mexico (S0, S2, S3) (Table 3.2, Appendix B.4). Samples from three of these stations, S0, S2, and S3, also had high FIB counts during dry conditions from May to September, and accounted for 10 of the 11 dry weather samples with elevated FIB. An additional elevated FIB sample was collected during May at station S4 following an unusually late rain event. Results from historical analyses also indicated elevated FIB densities occur more frequently at stations near the Tijuana River and south of the international border near Los Buenos Creek than

at other shore stations, especially during the wet season (Figure 3.4). Over the past several years, high FIB counts at these stations have consistently corresponded to outflows from the Tijuana River and Los Buenos Creek, typically following rain events (City of San Diego 2008–2014). Foam and sewage-like odors were also consistently observed at various shore stations within the SBOO region, with increased occurrences during the wet season. Additionally, storm drain runoff was often observed at all three stations located in Mexico.

***Kelp bed stations***

During 2014, compliance at the three SBOO kelp bed stations was 100% for all water contact standards from January through November. In contrast, compliance rates for the four SSM standards dropped to 78%–98% during December (Figure 3.5), corresponding to a period of high rainfall (i.e., 4.50 inches compared to  $\leq 1.28$  inches

in all other months). Satellite imagery during this time shows numerous turbidity plumes including one originating from the Tijuana River (Figure 3.6).

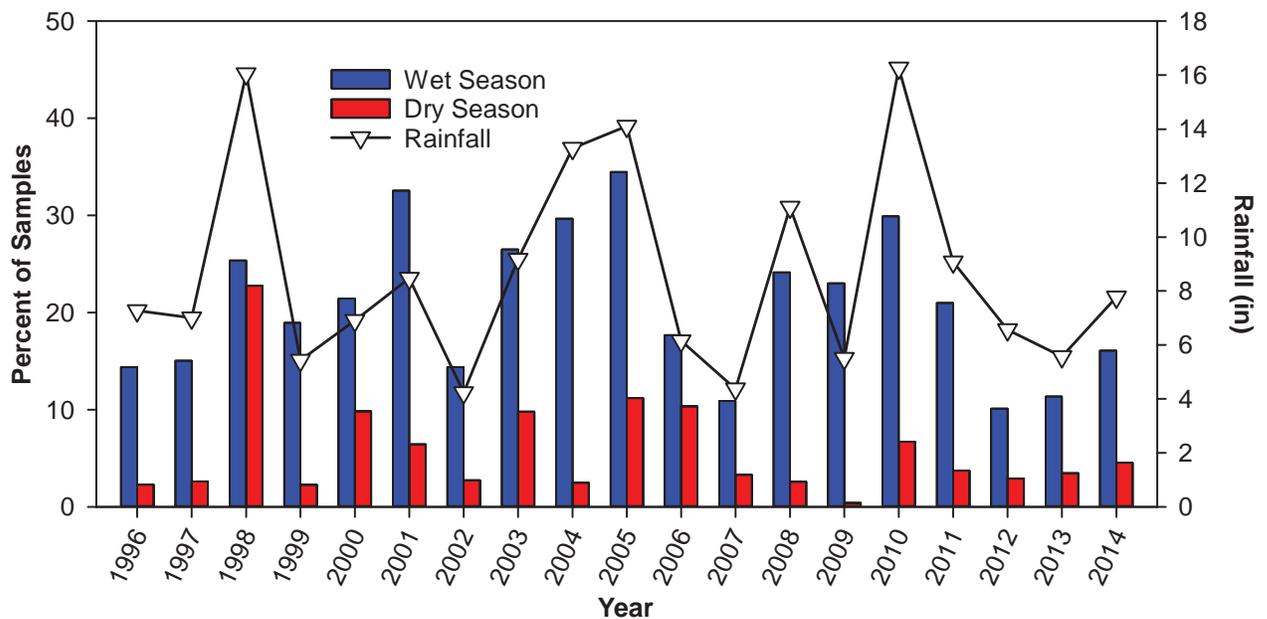
Monthly mean FIB densities at the kelp bed stations were lower than those at shore stations, ranging from 2 to 950 CFU/100 mL for total coliforms, 2 to 110 CFU/100 mL for fecal coliforms, and 2 to 71 CFU/100 mL for *Enterococcus* (Appendix B.5). Nothing of sewage origin was observed at these stations. Of the 531 kelp bed samples analyzed during the year (not including resamples), 2% (n=11) had elevated FIB, all of which were collected in December (Appendix B.6). Due to fewer high-rainfall events, coastal runoff from the Tijuana Estuary was low in 2014 compared to previous years (Svejkovsky 2015) and contributed to the low incidence of elevated FIB detections throughout the year (Table 3.3). Historical water quality monitoring data for the region (Figure 3.7) indicate that elevated FIB were significantly more likely to occur during the wet season than during the dry season (7% versus 1%, respectively; n=9035,  $\chi^2=206.77$ ,  $p<0.0001$ ).

No seawater samples collected from the kelp bed stations in 2014 contained detectable levels of O&G

**Table 3.2**

Number of samples with elevated FIB (eFIB) densities collected from SBOO shore stations during wet and dry seasons in 2014. Rain data are from Lindbergh Field, San Diego, CA. Stations are listed north to south from top to bottom.

Station	Seasons		% Wet
	Wet	Dry	
<i>North of USA/Mexico Border</i>			
S9	2	0	100
S8	0	0	—
S12	1	0	100
S6	2	0	100
S11	2	0	100
S5	7	0	100
S10	6	0	100
S4	4	1	80
<i>South of USA/Mexico Border</i>			
S3	5	2	71
S2	4	3	57
S0	20	5	80
<b>Rain (in)</b>	7.69	0.08	99
<b>Total eFIB</b>	53	11	83
<b>Total Samples</b>	330	242	58



**Figure 3.3**

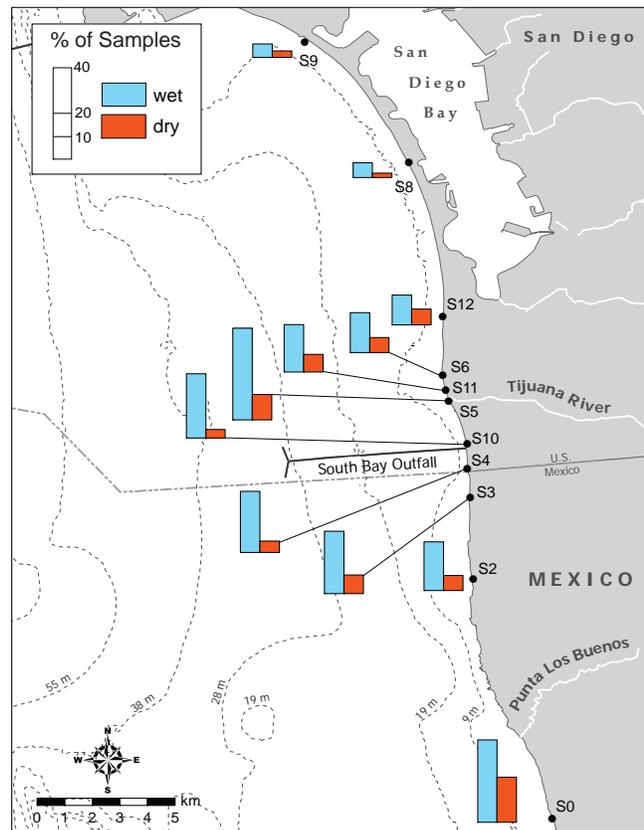
Comparison of annual rainfall to the percent of samples with elevated FIB densities in wet versus dry seasons at SBOO shore stations from 1996 through 2014. Rain data are from Lindbergh Field, San Diego, CA. Data from 1995 were excluded as sampling did not occur the entire year.

(detection limit=0.2 mg/L; Appendix B.7). Detection rates for TSS were higher, ranging from 0% in November to 100% in May, with concentrations  $\leq 8.0$  mg/L. Only one seawater sample had an elevated TSS concentration of 8.0 mg/L. There were no elevated FIB densities associated with this sample.

### Non-kelp bed stations

Compliance with the SSM water contact standards at the 14 offshore stations located within State jurisdictional waters (i.e., I12, I14, I16, I18, I19, I22–I24, I32, I33, I36–I38, I40) was  $\geq 89\%$  during 2014 (Figure 3.8). Monthly mean FIB concentrations in seawater samples collected from these and the other 11 non-kelp bed offshore stations ranged from 2 to 1386 CFU/100 mL for total coliforms, 2 to 238 CFU/100 mL for fecal coliforms, and 2 to 32 CFU/100 mL for *Enterococcus* (Appendix B.5). Only five (~1%) of the 372 samples collected within State waters had elevated FIB, three of which were collected from stations I19 and I40 located along the 9-m depth contour following a rain event (Appendix B.6). These two sites, in combination with the three kelp bed stations, were the only non-outfall stations with elevated FIB throughout the year in the SBOO region (Figure 3.9). Given the proximity of these stations to shore, coastal runoff may be responsible for these elevated FIB levels (see Chapter 2).

During 2014, water quality was very high at the three stations closest to the SBOO south diffuser leg (i.e., outfall stations I12, I14, I16). Only two out of 108 samples (~2%) collected from these stations had elevated FIB (Table 3.3, Figure 3.9, Appendix B.6). These two samples were collected from station I12 on April 4. Historically, samples with elevated bacterial levels have been collected more often at the three outfall stations when compared to other stations along the 28-m depth contour (8% versus 2%;  $n = 5417$ ,  $\chi^2 = 100.11$ ,  $p < 0.0001$ ) (Figure 3.10). In the past, samples with elevated FIB levels were predominately collected at a depth of 18 m. Consequently, it appears likely that these FIB densities were associated with wastewater discharge from the outfall. However, the number of samples with elevated FIB collected from outfall stations has dropped to  $\leq 2$  samples



**Figure 3.4**

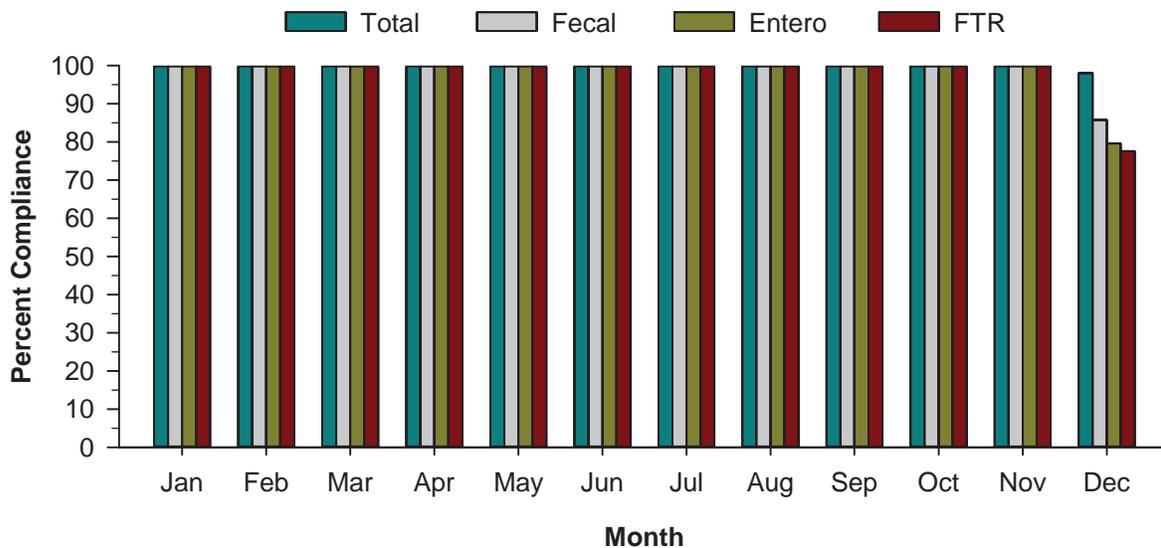
Proportion of samples with elevated FIB densities in wet versus dry seasons at SBOO shore stations from 1995 through 2014.

per year since secondary treatment was initiated at the SBIWTP in January 2011. These results demonstrate improved water quality near the outfall compared to previous years.

Of the 124 samples collected during 2014, three (~2%) contained detectable levels of O&G, with concentrations that ranged from 1.4 to 3.1 mg/L (Appendix B.7). Total suspended solids were detected in 210 of 412 samples (51%), with concentrations that ranged from 2.2 to 18.6 mg/L. None of the seawater samples with elevated TSS concentrations ( $\geq 8.0$  mg/L) corresponded to elevated FIB densities.

### Plume Dispersion and Effects

The dispersion of the wastewater plume from the SBOO and its effects on natural light, DO and pH levels was assessed using the results from 112 CTD profile casts performed during 2014. Based on the



**Figure 3.5**

Compliance rates for the four single sample maximum water contact standards from SBOO kelp bed stations during 2014. See Box 3.1 for details.

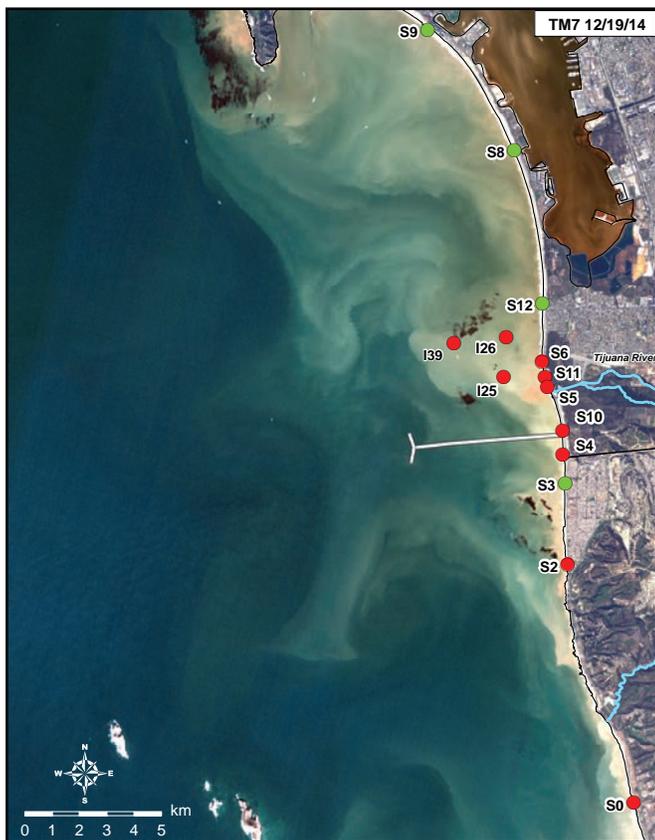
criteria described in the Materials and Methods section, potential evidence of the plume was detected a total of 14 times from 10 different stations throughout the year (Figure 3.11, Table 3.4), while 5–13 stations were identified as reference sites during each quarterly survey (Appendix B.2). No stations were identified with potential plume characteristics in February due to the lack of a salinity signal. Eight of the possible detections (~75%) occurred at stations I12, I16, I23, and I35 in both May and August (Figure 3.11, Appendix B.8). Two of these sites, stations I12 and I16, are located near the outfall wye. The other two stations are located inshore and north of the SBOO along the 19-m contour. The identification of station I35 as having a potential plume signal may be spurious due to its proximity to San Diego Bay and the influence of tidal pumping of organic matter from inside the bay. In November, five stations located south of the USA/Mexico border along the 28 and 19-m contours showed potential plume characteristics. The detection of potential plume at these stations corresponds with near-surface dispersion patterns observed by satellites under typical southward flow conditions (Svejkovsky 2010). However, none of the plume detections were associated with elevated FIB.

The effects of the SBOO wastewater plume on the three physical water quality indicators mentioned

above were calculated for each station and depth where it was detected. For each of these, mean values for natural light (% transmissivity), DO, and pH within the plume were compared to thresholds within similar depths from non-plume reference stations (see Appendix B.8). Of the 14 potential plume detections that occurred during 2014, a total of seven out-of-range (OOR) events were identified at various stations for transmissivity; no OOR events were identified for DO or pH (Table 3.4, Appendices B.9–B.12). Four of these seven OOR events occurred at stations within State jurisdictional waters where Ocean Plan compliance standards apply.

## SUMMARY

Water quality conditions in the South Bay outfall region were excellent during 2014. Overall compliance with 2012 Ocean Plan water-contact standards was ~98%, which was similar to what was observed during the previous year (City of San Diego 2014a). This continued level of high compliance likely reflects another year of low rainfall, which totaled about 8 inches in 2014, in contrast to 2010, when rainfall totaled about 16 inches and overall compliance was 87% (City of San Diego 2011). Additionally, only ~5% of all water samples analyzed in 2014 had elevated FIB, of



**Figure 3.6**

Rapid Eye satellite image showing stations near the SBOO on December 19, 2014 (Ocean Imaging 2015) combined with bacteria levels sampled at shore and kelp bed stations on December 16 and 19, respectively. Turbid waters from the Tijuana River, caused by several rain events during the month, can be seen overlapping stations with elevated FIB (red circles). See Appendices B.4 and B.6 for bacterial sample details.

which 83% occurred during the wet season. Of these high counts, 80% were from samples collected at the shore stations. This pattern of higher contamination along the shore, especially during the wet season, is similar to that observed during previous years and is likely due to runoff from point and non-point sources (e.g., City of San Diego 2014a). The few samples with high bacteria counts taken during dry weather periods were exclusively at shore stations, most from stations south of the USA/Mexico border.

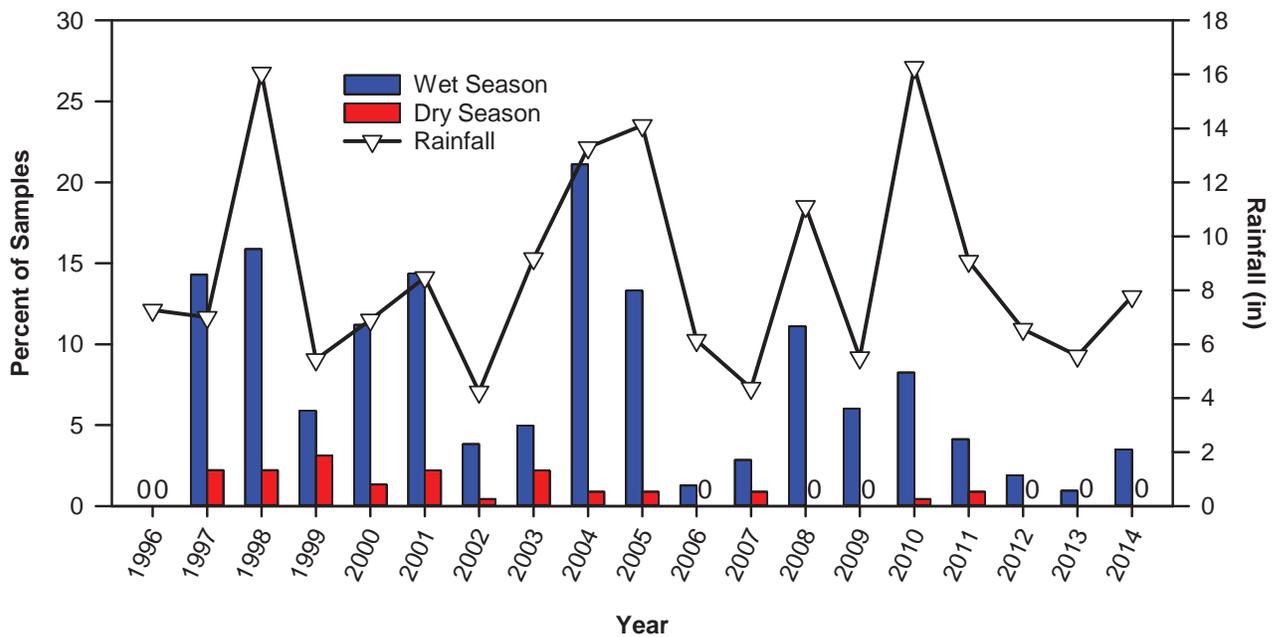
There was no evidence that wastewater discharged to the ocean via the SBOO reached the shoreline during the year. Although elevated FIB were detected at six different stations in the region, these results did not indicate shoreward transport of the plume, a conclusion consistently supported

**Table 3.3**

Number of samples with elevated FIB (eFIB) densities collected at SBOO kelp bed and other offshore stations during wet and dry seasons in 2014. Rain data are from Lindbergh Field, San Diego, CA. Missing offshore stations had no samples with elevated FIB concentrations during 2014.

	Wet	Dry	% Wet
<b>Rain (in)</b>	7.69	0.08	99
<b>Kelp Bed Stations</b>			
<i>9-m Depth Contour</i>			
I25	5	0	100
I26	3	0	100
<i>18-m Depth Contour</i>			
I39	3	0	100
<b>Total eFIB</b>	11	0	100
<b>Total Samples</b>	315	216	
<b>Non-Kelp Bed Stations</b>			
<i>9-m Depth Contour</i>			
I19	1	0	100
I40	2	0	100
<i>28-m Depth Contour</i>			
I12	2	0	100
<b>Total eFIB</b>	5	0	100
<b>Total Samples</b>	195	177	

by remote sensing observations (e.g., Terrill et al. 2009, Svejksky 2010–2015). Instead, other sources such as coastal runoff from rivers and creeks were more likely to impact coastal water quality in the South Bay outfall region, especially during the wet season. For example, the shore stations located near the mouths of the Tijuana River and Los Buenos Creek have historically had higher numbers of contaminated samples than stations located farther to the north (City of San Diego 2008–2014). It is also well established that sewage-laden discharges from the Tijuana River and Los Buenos Creek are likely sources of bacteria during or after storms or other periods of increased flows (Svejksky and Jones 2001, Noble et al. 2003, Gersberg et al. 2004, 2006, 2008, Largier et al. 2004, Terrill et al. 2009, Svejksky 2010). Further, the general relationship between rainfall and elevated bacterial levels in the SBOO region existed before wastewater discharge began in 1999 (see also City of San Diego 2000).



**Figure 3.7**

Comparison of annual rainfall to the percent of samples with elevated FIB densities in wet versus dry seasons at SBOO kelp bed stations from 1996 through 2014. Rain data are from Lindbergh Field, San Diego, CA. Data from 1995 were excluded as sampling did not occur the entire year.

Finally, there was little indication of bacterial contamination in the offshore waters of the SBOO region during 2014, with only about 1% of all samples collected within State jurisdictional waters having elevated FIB. Additionally, these few high counts were generally either from stations located near the Tijuana River and the USA/Mexico border or very close to the active diffuser at the SBOO. The very low number of elevated FIB samples near the outfall is likely related to chlorination of South Bay International Water Treatment Plant effluent (November–April) and the initiation of full secondary treatment that began in January 2011. Further, potential detection of the wastewater plume and its effects on natural water quality indicators was low during the year.

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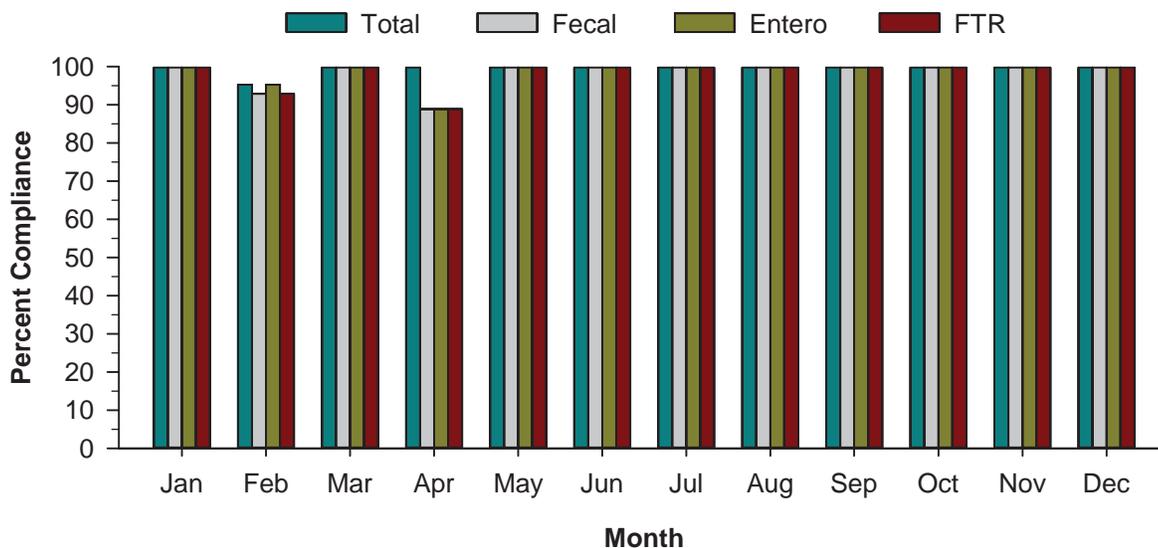
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**Figure 3.8**

Compliance rates for the four single sample maximum water contact standards at SBOO other offshore stations during 2014. See Box 3.1 for details. During non-quarterly months sampling was limited to I12, I14, and I16.

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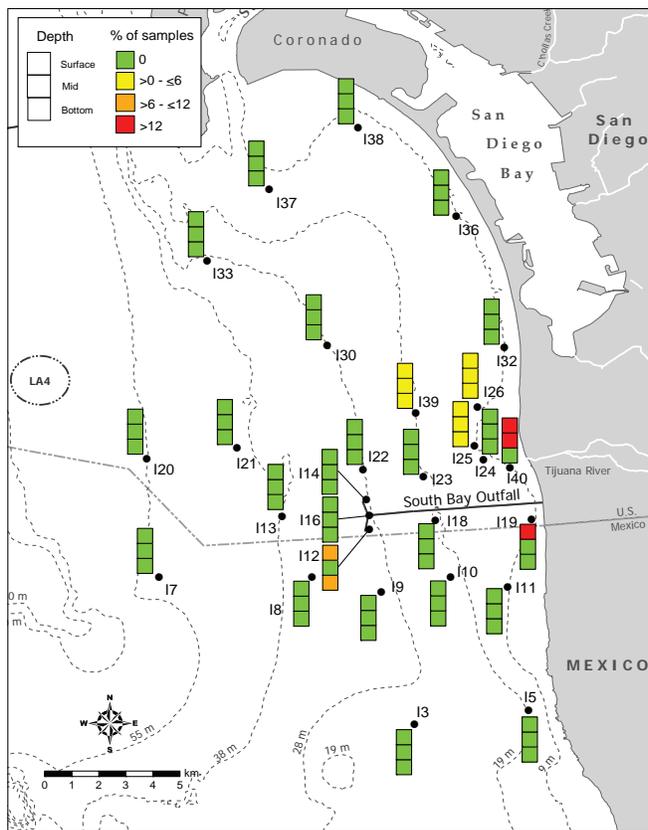
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**Figure 3.9**

Distribution of samples with elevated FIB collected from kelp bed and other offshore stations during 2014. Data are the percent of samples that contained elevated bacteria densities. See text and Table 3.1 for sampling details.

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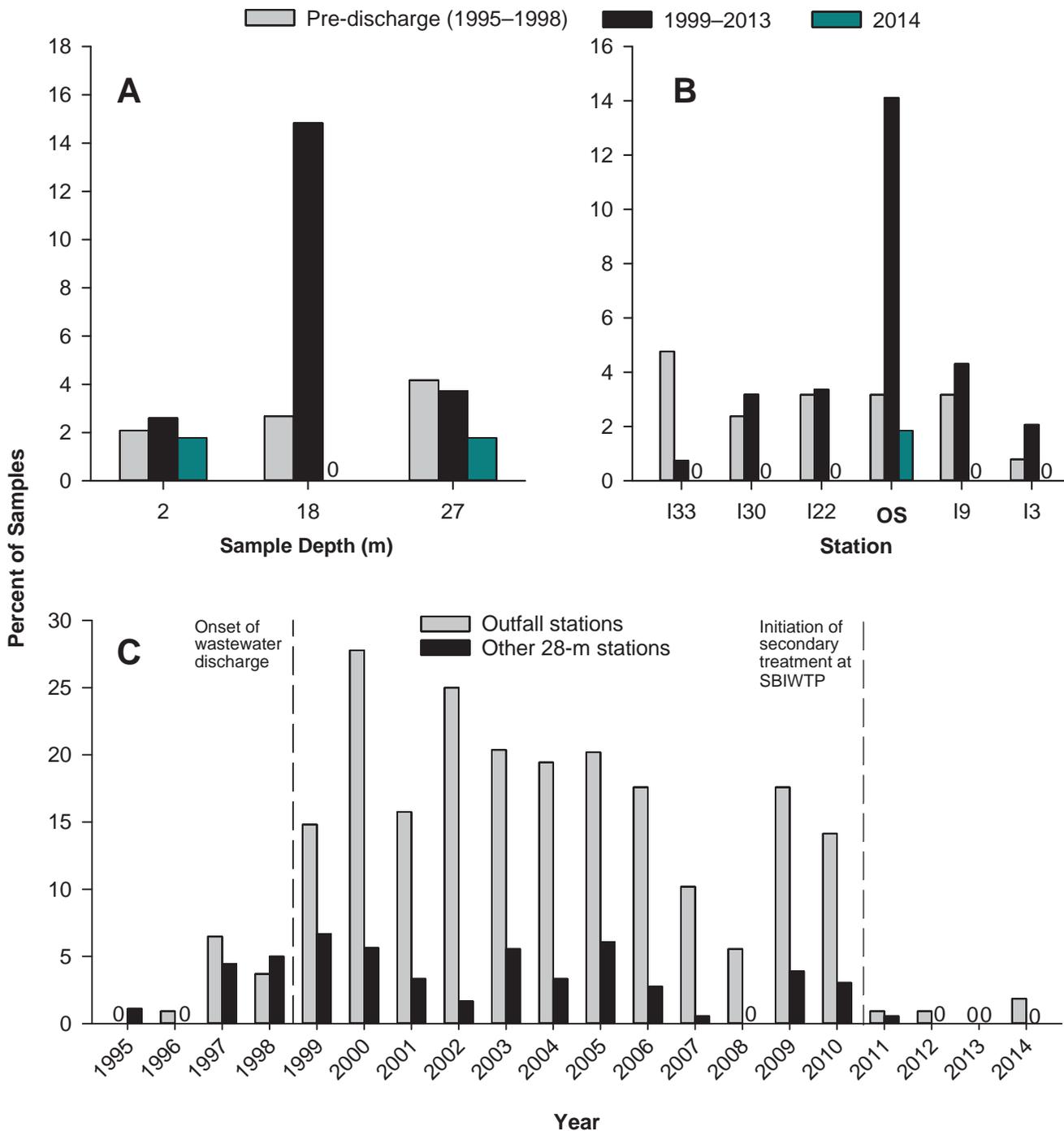
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**Figure 3.10**

Percent of samples collected from SBOO 28-m offshore stations with elevated bacteria densities. Samples from 2014 are compared to those collected from 1995 through 2013 by (A) sampling depth, (B) station listed north to south from left to right, and (C) year. OS=outfall stations (I12, I14, I16).

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**Table 3.4**

Summary of potential wastewater plume detections and out-of-range values at SBOO offshore stations during 2014. Stations within State jurisdictional waters are in bold. DO=dissolved oxygen; XMS=transmissivity.

Month	Potential	Out of Range			Stations
	Plume Detections	DO	pH	XMS	
Feb	0	0	—	0	
May	4	0	0	0	<b>I12, I16, I23, I35</b>
Aug	5	0	0	4	<b>I12, I16<sup>a</sup>, I23<sup>a</sup>, I35<sup>a</sup>, I39<sup>a</sup></b>
Nov	5	0	0	3	<b>I2, I3, I6<sup>a</sup>, I9<sup>a</sup>, I10<sup>a</sup></b>
<b>Detection Rate (%)</b>	12.5	0.0	0.0	6.2	
<b>Total Count</b>	14	0	0	7	
<b>Total Samples</b>	112	112	84	112	

<sup>a</sup>Out-of-range value for transmissivity

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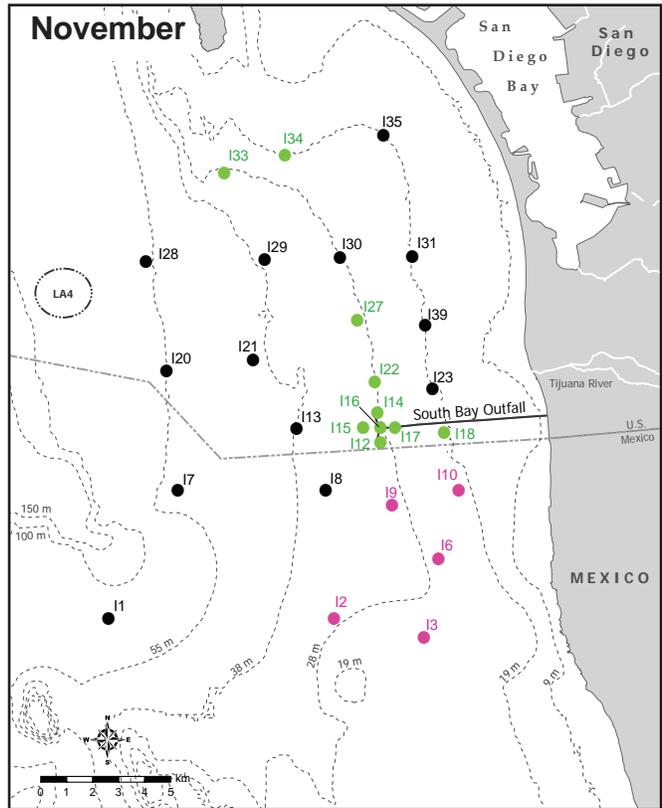
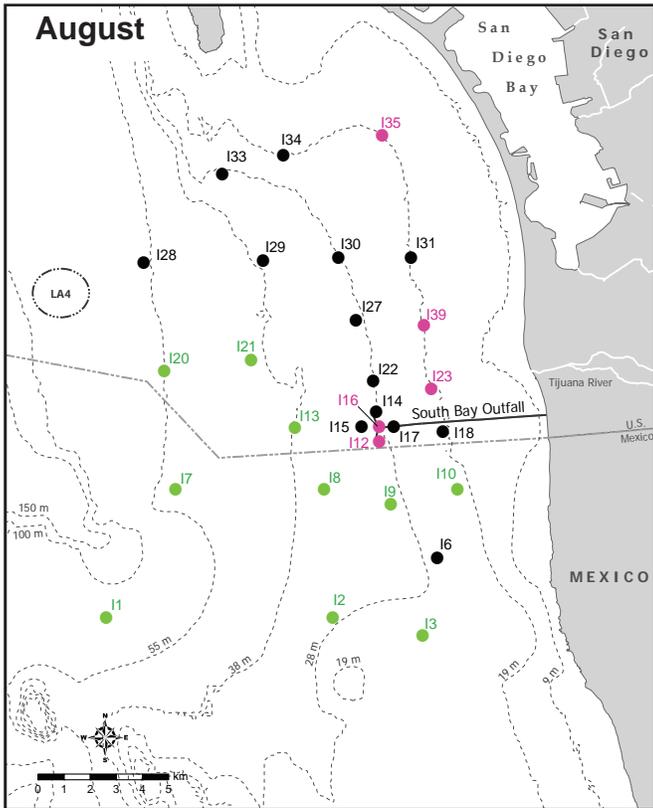
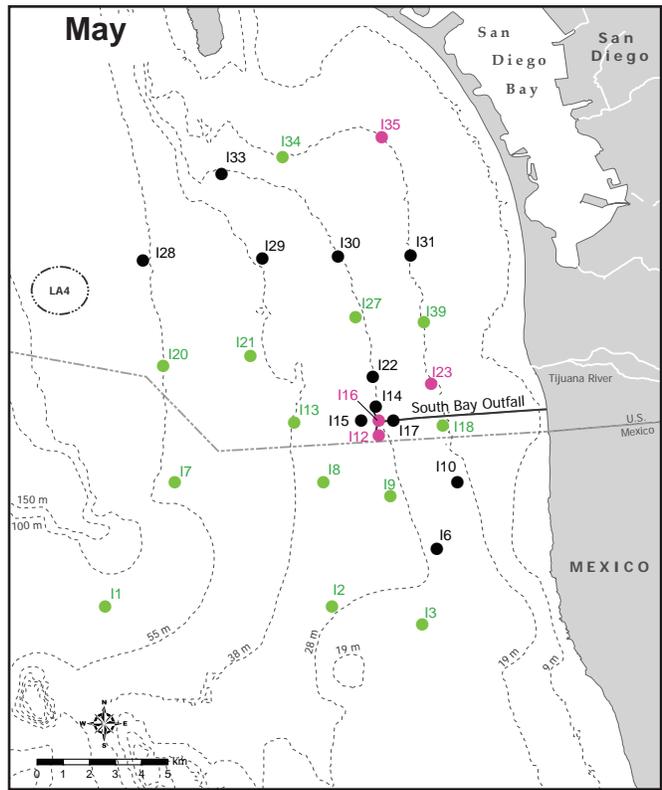
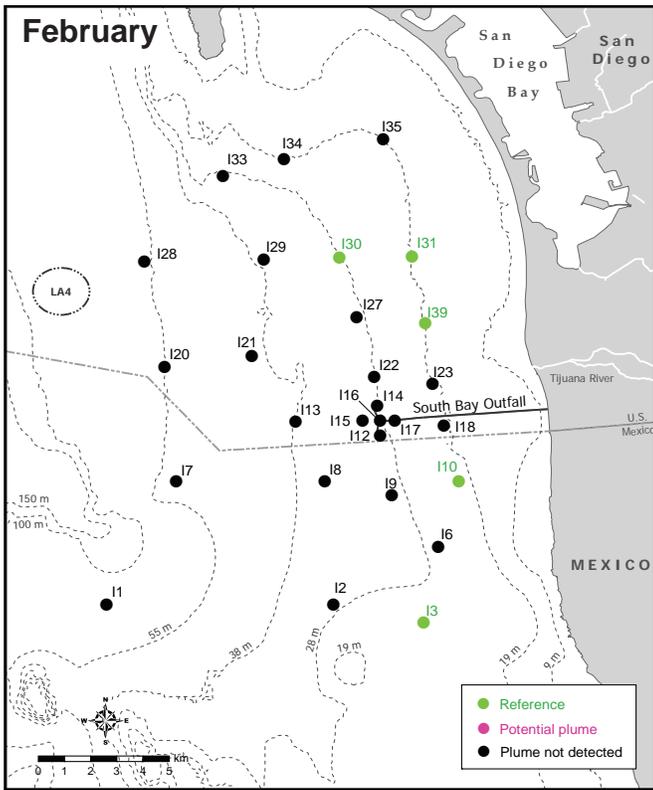
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**Figure 3.11**

Distribution of stations where SBOO plume was potentially detected (pink) and those used as reference stations (green) during quarterly surveys in 2014.

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