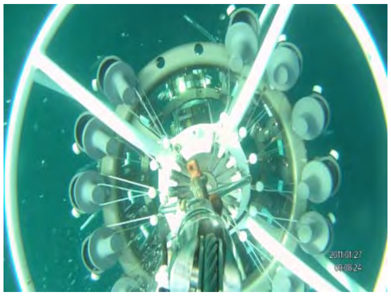
Chapter 3

COASTAL OCEANOGRAPHY AND WATER QUALITY



Chapter 3

COASTAL OCEANOGRAPHY AND WATER QUALITY

INTRODUCTION

To evaluate potential impacts to the marine environment and public health, the Orange County Sanitation District (District) measures physical, chemical, and biological water quality indicators to determine the location and characteristics of its treated effluent after discharge to the ocean. The goals are to assess discharge-influenced changes to water quality and compare them to criteria contained in the California Ocean Plan (COP) and the District's NPDES discharge permit to determine compliance (see box below). This chapter describes results from the July 2012 to June 2013 monitoring year. Chapter 2 (Compliance) has specific compliance evaluation details.

The District's monitoring region extends from Seal Beach to Crystal Cove State Beach, from the shoreline to approximately 12 km offshore and to a water depth of 550 m. The entire sampling area covers approximately 332 km^2 (Figure 3-1). While not part of the Core monitoring program, the District is a member of a regional cooperative sampling effort known as the Central Bight Regional Water Quality Monitoring Program (Central Bight) with the City of Oxnard, City of Los Angeles, and the Los Angeles County Sanitation District. When combined with the District's program, this additional sampling effectively extends the District's monitoring area north to Ventura County and south to Crystal Cove State Beach (Figure 3-2). The Central Bight monitoring provides regional data that enhances the evaluation of water quality changes due to natural or anthropogenic discharges (e.g., stormwater) and provides a regional context for comparisons with the District's monitoring results.

Regional and local changes in ocean conditions strongly influence the water quality in the District's study area on daily, seasonal, and yearly timescales. Large-scale and long-term climatic events, such as the El Niño/Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO), also alter local conditions on multi-year and decadal timescales (Linacre *et al*. 2010; OCSD 2004). These events are notable for producing changes in near coastal water surface temperature and rainfall/runoff in the monitoring area (OCSD 2004). One of the primary differences between ENSO and PDO is that while a typical ENSO event occurs, on average, every 5 years and may last 6–18 months (Chao *et al*. 2000; Mantua 2000), PDO events have cycles of 5–20 years, and may persist for up to 70 years (MacDonald and Case 2005). Upwelling can also strongly influence water quality and productivity in coastal areas by providing a source of additional nutrients to the coastal environment (Fischer *et al*. 1979; Sverdrup *et al*. 1963; Valiela 1995). These natural events modify anthropogenic effects, such as wastewater discharges, dredged material disposal,

Compliance Criteria Pertaining to Water Quality Contained in the District's NPDES Ocean Discharge Permit (Order No. R8-2012-0035, Permit No. CAO110604).

Criteria		Description
V.A.1.a	Total coliform (water contact)	*30-day geometric mean:* Density less than 1,000 per 100 mL *Single Sample:* Density less than 10,000 per 100 mL and density less than 1,000 per 100 mL when FC:TC>0.1
V.A.1.a	Fecal coliform (water contact)	*30-day geometric mean:* Density less than 200 per 100 mL *Single Sample:* Density less than 400 per 100 mL
V.A.1.a	Enterococcus (water contact)	*30-day geometric mean:* Density less than 35 per 100 mL *Single Sample:* Density less than 104 per 100 mL
V.A.1.b	Enterococcus (EPA water contact)	*30-day geometric mean:* Density less than 35 per 100 mL *Single Sample:* Density less than 104 per 100 mL for designated beaches Density less than 158 per 100 mL for moderate use Density less than 276 per 100 mL for light use Density less than 501 per 100 mL for infrequent use
V.A.1.b	Total coliform (Shellfish harvesting standards)	Median total coliform density shall not exceed 70 per 100 mL, and not more than 10 percent of the samples shall exceed 230 per 100 mL.
V.A.2.a	Floating particulates, oils, and grease	Floating particulates, grease, and oil shall not be visible.
V.A.2.b	Water clarity and discoloration	The discharge of waste shall not cause aesthetically undesirable discoloration of the ocean surface.
V.A.2.c	Light transmittance	Natural light shall not be significantly reduced at any point outside the initial dilution zone as a result of the discharge of waste.
V.A.3.a	Dissolved oxygen	The dissolved oxygen concentration shall not at any time be depressed more than 10 percent from that which occurs naturally, as the result of the discharge of oxygen demanding waste materials.
V.A.3.b	Acidity (pH)	The pH shall not be changed at any time more than 0.2 units from that which occurs naturally.
V.A.3.f	Nutrients	Nutrient materials shall not cause objectionable aquatic growths or degrade indigenous biota.

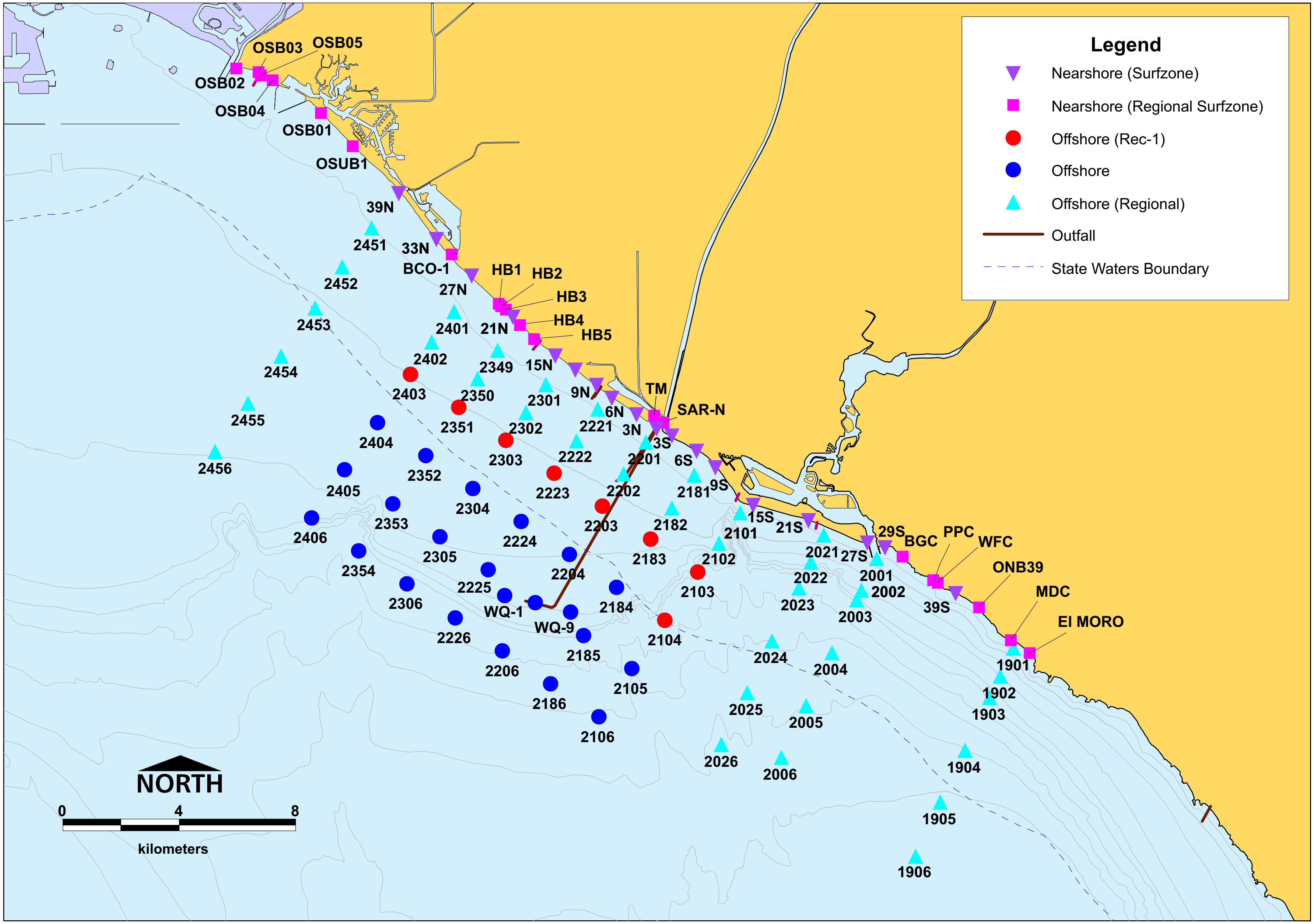


Figure 3-1. Water quality and shoreline monitoring stations for 2012-13.

Orange County Sanitation District, California.

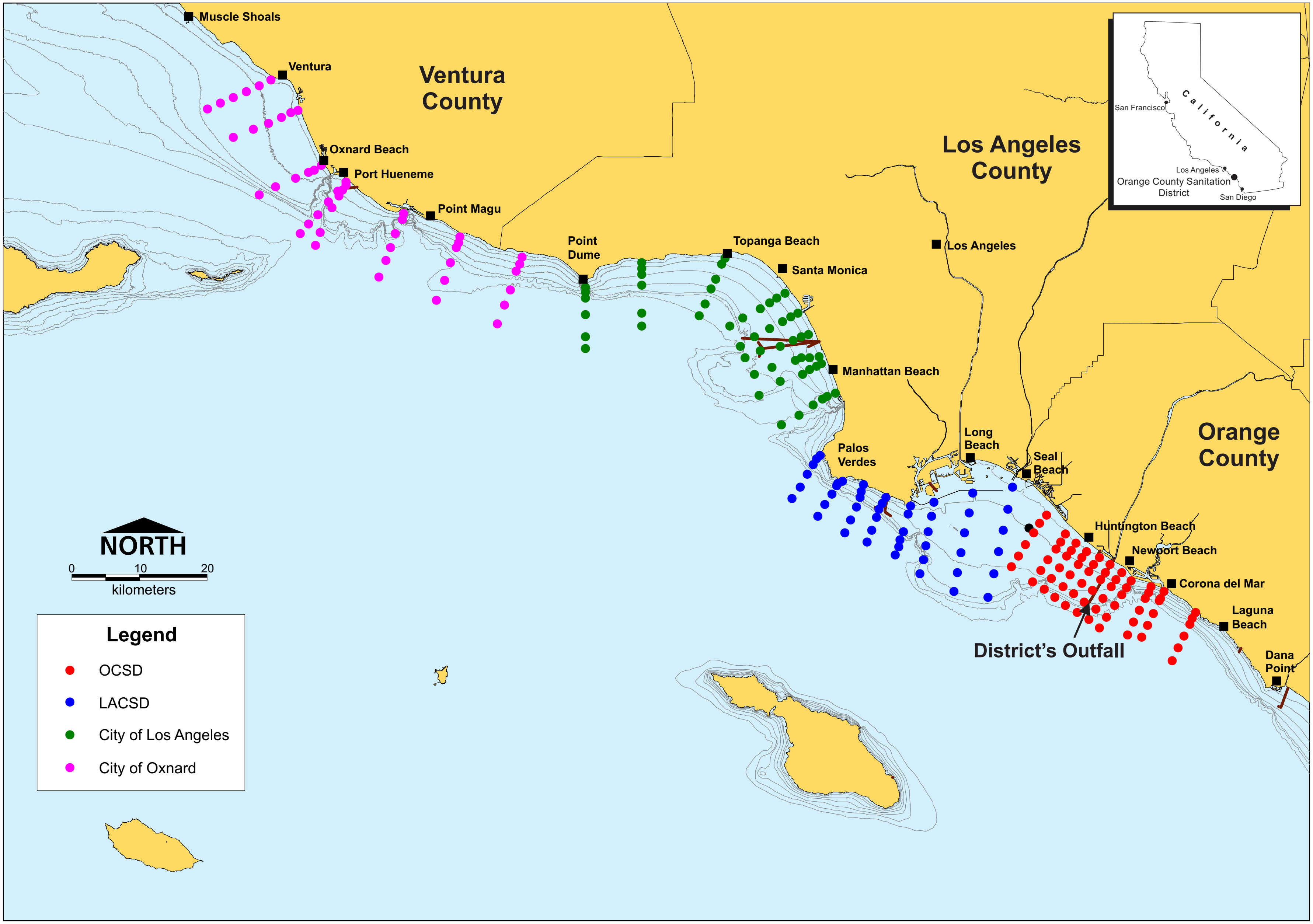


Figure 3-2. Sampling locations for the Central Bight Regional Water Quality Monitoring Program.

Legend denotes agencies responsible for sampling various stations.

Orange County Sanitation District, California.

atmospheric deposition, and runoff from adjacent watersheds. The potential impact of climate change to the coastal ocean could exacerbate human influences by altering water temperature and chemistry (e.g., salinity, dissolved oxygen, and pH), precipitation and associated runoff, and ocean circulation (Howarth *et al*. 2011; Rabalaias, *et al*. 2010; Scavia *et al*. 2002; Tynan and Opdyke 2011; Zhang *et al*. 2010), thereby affecting biologic communities.

Wastewater discharges from the District's outfall dilute quickly by being "jetted" out through 503 discharge portholes located in the last 1.6 km of the outfall pipe. This initial dilution greatly reduces observable differences between the discharged less saline or "fresh" wastewater and seawater. Predicted changes to receiving water quality from the discharge are proportional to the ratio of wastewater mixed with seawater. The initial dilution ratio used in the District's NPDES permit is 180:1 and represents the lower 10^{th} percentile; the mean was 352:1 (Tetra Tech 2008). Using the minimum centerline dilution of 124:1, predicted changes to receiving waters were small (Table 3-1) and fall within typical natural ranges and thereby represent low potential risks to the environment or human health.

Two other factors limit potential discharge effects besides initial dilution. Dynamic mixing with the ocean water and transportation away from the diffuser by prevailing ocean currents further dilutes the effluent. These currents include both large-scale ocean currents (e.g., Southern California Eddy) as well as smaller-scale local currents (Dailey *et al*. 1993; Noble and Xu 2004; Noble *et al*. 2009; OCSD 2010; SCCWRP 1973; SWRCB 1965). Additionally, natural water layering (stratification) by temperature and/or density restricts the upward movement of the wastewater plume toward the surface; stratification off southern California is principally due to temperature (SWRCB 1965). Stratification restricts observable discharge-related changes to below 30–40 m depths during most surveys; plume rise into the upper 10 m of the water column is limited to less than 2 percent of the time (Tetra Tech 2002, 2008). These results were similar to other discharges studied by Petrenko *et al*. (1998) and Wu *et al*. (1994). Previous reports provide detailed analysis of currents (OCSD 1994; SAIC 2009, 2011), comparisons of water quality data with long-term historical trends (OCSD 1992, 1993, 1996a, b, 2004), and summaries of natural seasonal and human-related factors that affect dilution and movement of the wastewater discharge (OCSD 2004).

METHODS

Field Surveys

Core Nearshore

Collection of nearshore water samples for analysis of fecal indicator bacteria (FIB)—total and fecal coliforms and enterococci—were taken at the surfzone in ankle deep water, 1 to 2 days per week at 18 permit-required surfzone stations (Table A-1; Figure 3-1). Stations TM and SAR, located just upstream of the mouths of Talbert Marsh and Santa Ana River outlets, sampled as part of the Regional effort were included with the Core data for historical continuity. These two stations have served to identify potential runoff influence affecting nearby stations (Table A-1).

Table 3-1. Summary of selected final effluent (without disinfection) and receiving water parameters and expected changes compared to natural seawater at 31–45 m depths from the wastewater discharge at a minimum centerline dilution of 124:1.

Orange County Sanitation District, California.

Parameter	Final Effluent Mean	Approx. Natural Mean	Expected Change (%)	COP/AB411* Objectives
Temperature (°C)	25.10	11.39	Increase up to 0.11	Not Applicable
Salinity (psu)	2.25	33.46	Decrease up to 0.25	Not Applicable
Dissolved Oxygen (mg/L)	1.52	5.26	Decrease up to 0.03	<10% decrease
pH	7.20	7.91	Decrease up to 0.01	<0.2 units
Ammonia (mg/L)	30	0.2	Increase up to 0.24	Not Applicable
Total Coliform (MPN/100 mL)	27,393	0	Increase up to 219	10,000 single sample 1,000 geomean
Fecal Coliform (MPN/100 mL)	7,602	0	Increase up to 61	400 single sample 200 geomean
Enterococci (MPN/100 mL)	783	0	Increase up to 6	104 single sample 35 geomean

*COP = California Ocean Plan.
AB411 = State of California Assembly Bill 411, enacted July 1999.

Regional Nearshore

In 2012, four Orange County, CA public agencies collaborated to provide a more integrated and efficient regional microbial ocean water quality monitoring program. Under this program, the District sampled an additional 20 stations, extending its monitoring efforts to include northern Laguna Beach, Sunset Beach, Seal Beach, and Orange County watersheds discharging to receiving waters. As with the District's Core Nearshore monitoring program, sampling frequencies ranged from 1 to 2 days per week (Figure 3-1; Table A-1). When creek/storm drain stations flowed into the ocean, three bacteriological samples were collected at 11 stations: 1) at the source, 2) 25 yards downcoast, and 3) 25 yards upcoast. When flow was absent, a single sample was collected 25 yards downcoast.

Core Offshore

Each quarter (summer, fall, winter, and spring), the District completed three surveys at 28 offshore stations (Table A-1; Figure 3-1). For calculating compliance with state water contact (Rec-1) bacterial standards, three additional surveys were done at a subset of eight stations within 30 days of two of the full-scale grid sampling dates. To define initial FIB conditions at the outfall, most surveys included taking additional bacteriological samples at the outfall (Station 2205) and two nearfield locations (Stations 1 and 9). Table A-2 lists sampling dates and purpose.

A Seabird© electronic sensor package (aka CTD) measured conductivity (used to calculate salinity), temperature, and depth (using pressure). Additional sensors on the package included dissolved oxygen (DO), pH, chlorophyll-*a*, colored dissolved organic matter (CDOM), and three measures of water clarity, light transmission, beam attenuation coefficient (beam-C), and photosynthetically active radiation (PAR); beam-C is a measure of light scattering by suspended particles, such as those found within an effluent plume. Data were collected at a rate of 24 scans/second using Seasoft (2012a) data collection software on both the downcast and upcast, from 1 m below the surface ("surface" sample) to 2 m above the bottom or to a maximum depth of 75 m. Table A-1 lists the subset of stations where discrete samples were collected and Table A-3 lists the collection depths. Sea surface state, wind, and visual observations of floatable materials were also obtained at each station.

Central Bight

Each quarter, the participating Central Bight agencies sampled an expanded station grid (Figure 3-2) using similarly equipped CTDs and comparable field sampling methods. The primary differences between sampling efforts lies in the maximum depth sampled and the number of days each survey took to complete. The District sampled to a maximum of 75 m, while some of the other agencies sampled down to 100 m. The District did not collect discrete water samples at its Central Bight stations (Table A-1).

Data Processing and Analysis

Seasonal and annual tabular and graphic depictions of nearshore and offshore water quality data were compiled using Seasoft (2012b), IGODS (2012), Excel (2010), Deltagraph (2009), Surfer (2010), and/or SYSTAT (2009). Offshore water quality data were grouped into 15-meter depth bins for statistical analysis. Consistent with the District's long-time convention in calculating and reporting 30-day geometric means for FIB, non-detect values for FIB were replaced with either 75% or 125% of the respective lower and upper detection limits (Appendix C); non-detect ammonia (NH3-N) values were handled in the same manner. Algal blooms were defined using definitions from Seubert *et al*. (2013). Pearson correlations were computed on selected variables and reported if significant ($p<0.01$). When variables were very highly correlated (e.g., water temperature and density) discussion will focus on one variable (e.g., temperature).

Appendix A contains more information on the methods used for collection and analysis of the water quality data. Appendix B contains supporting tables and figures. Appendix C is a summary of chemistry and biology quality control and assurance for the year. Compliance determinations with water quality criteria are discussed in Chapter 2 (Compliance).

RESULTS AND DISCUSSION

Regional Water Quality Conditions

This section focuses on summarizing large-scale oceanographic conditions and provides quarterly comparisons for selected parameters from the regional Central Bight program.

<u>Ocean Indices</u>
Several ocean ecosystem indices, such as the PDO, ENSO, and Upwelling Index Anomaly are indicators of ocean conditions for the California Current system and regionally (Figure 3-3). During 2012-13, the strongly negative PDO (-2.21 in September 2012) indicated a continued cool phase regime that began in 2010. The index began to weaken in December 2012 and remained weak through May 2013, whereupon the PDO strengthened again. Overlaid on this cool PDO regime were continuing ENSO neutral conditions for most of the program year with colder-than-average to near-normal sea surface temperatures over the far eastern equatorial Pacific. The Upwelling Anomaly Index, which represents potential productivity along the coast, was consistently positive for the year, with a late spring (April 2013) peak.

<u>Regional Offshore Water Quality</u>

Temperature and Density
Since density and temperature were highly correlated (r = -0.99), results largely mirrored one another so only temperature will be discussed in detail. Temperature and density gradients from the surface to bottom were present at the Central Bight stations throughout the year, with the greatest variability and ranges seen in the upper 30 m of the water column (Table 3-2; Figures 3-4, B-3, B-4, and B-5). Stratification was seen in the summer, fall, and spring quarters, with well-mixed (weakly stratified) waters in winter. Both maximum water temperature and ranges were measured in the summer. The surface waters in the nearshore regions off Ventura and the San Pedro Bay had pockets of cooler water with warmest values seen in Santa Monica Bay and southwest of the Palos Verdes Peninsula. Stratification was evident above 40 m. Fall spatial patterns showed a drop in surface temperatures and a warming of subsurface waters. While maximum fall temperatures dropped 2.3 °C, minimum temperatures were the warmest of the year. This led fall to have the warmest mean depth averaged and binned temperatures. Stratification was again seen above 30 m with maximum delta T between 20 and 40 m. Winter

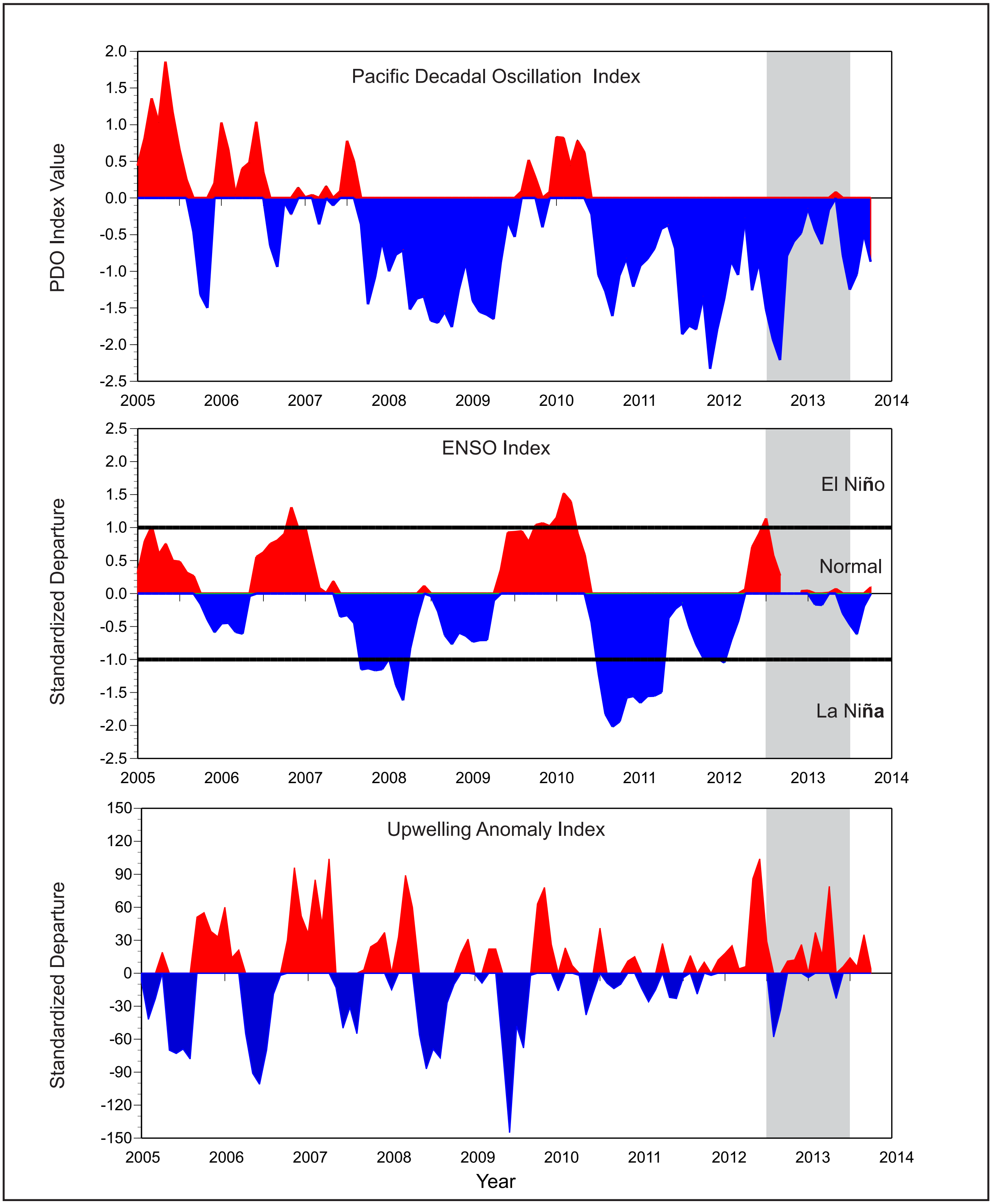


Figure 3-3. Standardized values for the Pacific Decadal Oscillation (PDO), El Niño Southern Oscillation (ENSO), and Upwelling Anomaly indices, 2005–2013.
Current program year denoted in gray. Horizontal lines on ENSO Index represent El Niño/La Niña thresholds.

PDO: http://jisao.washington.edu/pdo/PDO.latest
ENSO: http://www.cdc.noaa.gov/people/klaus.wolter/MEI/mei.htm
Upwelling: ftp://orpheus.pfeg.noaa.gov/outgoing/upwell/monthly/upanoms.mon

Orange County Sanitation District, California.

Table 3-2. Summary of quarterly water quality parameters for the Central Bight Regional Water Quality Monitoring Program by depth strata and season during 2012-13.

Orange County Sanitation District, California.

Depth (m)	Summer 2012				Fall 2012				Winter 2013				Spring 2013				Annual			
	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev
Temperature (°C)																				
1-15	13.42	18.23	21.71	1.44	15.08	17.81	19.39	0.66	12.13	13.34	15.10	0.41	13.01	17.57	19.94	1.31	12.13	16.74	21.71	2.24
16-30	11.85	15.10	19.62	1.43	12.97	15.51	18.57	1.13	10.71	12.84	13.91	0.50	11.10	14.58	18.80	1.73	10.71	14.52	19.62	1.64
31-45	11.03	13.07	16.36	0.93	12.50	13.55	16.23	0.51	10.36	12.04	13.72	0.62	10.36	11.69	16.35	0.77	10.36	12.59	16.36	1.04
45-60	10.59	12.17	14.46	0.78	11.83	12.71	13.64	0.31	9.57	11.40	12.74	0.61	10.13	10.76	12.14	0.33	9.57	11.76	14.46	0.92
61-75	10.35	11.52	13.41	0.69	11.34	12.06	12.78	0.27	9.34	10.97	12.17	0.56	9.94	10.35	11.21	0.22	9.34	11.23	13.41	0.79
76-90	10.23	11.40	13.03	0.68	10.91	11.58	12.11	0.23	9.43	10.99	11.69	0.35	9.67	10.11	10.60	0.15	9.43	11.02	13.03	0.70
91-100	9.94	11.14	12.53	0.60	10.64	11.15	11.51	0.18	10.22	10.72	11.23	0.17	9.61	9.92	10.19	0.13	9.61	10.73	12.53	0.60
All	9.94	14.68	21.71	2.90	10.64	14.86	19.39	2.41	9.34	12.33	15.10	1.05	9.61	13.74	19.94	3.17	9.34	13.90	21.71	2.71
Density (kg/m^3)																				
1-15	23.22	24.05	25.11	0.33	23.55	24.17	24.70	0.14	24.12	25.16	25.45	0.10	23.15	24.31	25.28	0.30	23.15	24.42	25.45	0.50
16-30	23.71	24.72	25.43	0.31	24.01	24.64	25.15	0.23	25.05	25.27	25.85	0.12	24.03	24.95	25.61	0.36	23.71	24.89	25.85	0.36
31-45	24.49	25.13	25.59	0.22	24.51	25.04	25.26	0.11	25.08	25.45	25.98	0.16	24.60	25.54	25.89	0.15	24.49	25.29	25.98	0.27
45-60	24.81	25.33	25.76	0.20	25.03	25.24	25.43	0.07	25.28	25.62	26.25	0.18	25.45	25.76	26.00	0.09	24.81	25.49	26.25	0.26
61-75	25.04	25.50	25.84	0.18	25.22	25.40	25.59	0.07	25.40	25.76	26.32	0.17	25.61	25.91	26.07	0.07	25.04	25.64	26.32	0.24
76-90	25.13	25.53	25.88	0.18	25.37	25.53	25.72	0.07	25.55	25.76	26.29	0.10	25.83	26.01	26.18	0.06	25.13	25.71	26.29	0.23
91-100	25.24	25.60	25.93	0.17	25.56	25.66	25.80	0.05	25.72	25.85	26.00	0.05	25.98	26.10	26.23	0.05	25.24	25.80	26.23	0.22
All	23.22	24.80	25.93	0.63	23.55	24.79	25.80	0.52	24.12	25.40	26.32	0.27	23.15	25.14	26.23	0.69	23.15	25.03	26.32	0.61
Salinity (psu)																				
1-15	33.23	33.49	33.63	0.06	33.15	33.51	33.60	0.04	32.63	33.50	33.61	0.04	32.47	33.62	33.67	0.04	32.47	33.53	33.67	0.07
16-30	33.16	33.41	33.60	0.07	33.26	33.42	33.56	0.05	33.28	33.51	33.74	0.04	33.37	33.58	33.70	0.03	33.16	33.48	33.74	0.08
31-45	33.18	33.39	33.53	0.07	33.20	33.40	33.49	0.04	33.33	33.54	33.83	0.07	33.30	33.57	33.74	0.06	33.18	33.47	33.83	0.10
45-60	33.26	33.42	33.60	0.07	33.28	33.43	33.51	0.04	33.40	33.62	34.01	0.09	33.34	33.64	33.82	0.07	33.26	33.53	34.01	0.12
61-75	33.33	33.48	33.65	0.07	33.38	33.48	33.58	0.03	33.51	33.69	34.05	0.09	33.46	33.73	33.87	0.05	33.33	33.60	34.05	0.13
76-90	33.37	33.49	33.73	0.08	33.44	33.54	33.62	0.04	33.58	33.70	34.03	0.06	33.70	33.82	33.95	0.05	33.37	33.64	34.03	0.14
91-100	33.39	33.52	33.70	0.08	33.54	33.60	33.67	0.03	33.63	33.75	33.85	0.04	33.79	33.89	33.99	0.04	33.39	33.69	33.99	0.15
All	33.16	33.45	33.73	0.08	33.15	33.46	33.67	0.07	32.63	33.56	34.05	0.10	32.47	33.64	33.99	0.09	32.47	33.53	34.05	0.11

Table 3-2 continues.

Table 3-2 continued.

Depth (m)	Summer 2012				Fall 2012				Winter 2013				Spring 2013				Annual			
	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev
Dissolved Oxygen (mg/L)																				
1-15	6.24	7.83	9.10	0.51	6.41	7.60	8.41	0.35	5.03	8.00	9.82	0.58	5.73	8.08	9.12	0.32	5.03	7.88	9.82	0.49
16-30	5.66	7.98	9.54	0.60	5.88	7.52	8.30	0.45	3.83	7.10	8.60	0.84	4.14	7.47	9.23	1.02	3.83	7.52	9.54	0.82
31-45	4.90	7.12	8.78	0.77	5.50	6.74	8.19	0.48	3.46	5.83	8.29	0.95	3.54	5.26	8.15	0.81	3.46	6.24	8.78	1.06
45-60	4.63	6.20	7.83	0.72	4.93	6.04	7.00	0.35	2.48	4.96	7.14	0.83	3.07	4.24	5.95	0.55	2.48	5.36	7.83	1.03
61-75	4.00	5.54	6.90	0.64	4.62	5.50	6.44	0.34	2.40	4.37	5.90	0.60	2.58	3.83	5.04	0.48	2.40	4.81	6.90	0.91
76-90	3.66	5.29	6.64	0.56	4.12	4.89	6.06	0.32	2.56	4.22	5.23	0.37	2.55	3.43	4.50	0.34	2.55	4.45	6.64	0.82
91-100	3.68	5.00	6.07	0.47	3.87	4.40	5.04	0.24	3.45	3.91	4.60	0.25	2.79	3.12	3.66	0.18	2.79	4.11	6.07	0.76
All	3.66	7.09	9.54	1.17	3.87	6.80	8.41	1.03	2.40	6.37	9.82	1.61	2.55	6.18	9.23	1.94	2.40	6.61	9.82	1.52
Dissolved Oxygen Saturation (%)																				
1-15	78.82	101.42	114.69	6.38	81.69	97.74	109.24	4.19	58.25	94.25	116.35	7.40	68.28	103.55	114.45	4.18	58.25	99.24	116.35	6.72
16-30	66.03	97.38	114.24	8.21	68.66	92.57	102.98	6.42	43.06	82.90	101.95	10.54	46.82	90.57	113.18	14.44	43.06	90.87	114.24	11.58
31-45	55.41	83.38	105.27	10.19	63.90	79.68	98.01	6.36	38.36	66.99	98.39	11.71	39.62	59.99	97.39	10.00	38.36	72.51	105.27	13.58
45-60	51.50	71.35	92.66	9.23	56.55	70.21	82.46	4.27	27.36	56.20	83.10	10.08	33.82	47.39	66.92	6.18	27.36	61.30	92.66	12.67
61-75	44.46	62.88	80.37	8.03	52.43	63.13	73.48	4.08	26.17	49.06	67.87	7.28	28.37	42.40	55.75	5.23	26.17	54.36	80.37	10.97
76-90	40.68	59.89	77.06	7.09	46.18	55.56	68.38	3.76	27.88	47.39	59.55	4.32	28.06	37.80	49.44	3.77	27.88	50.10	77.06	9.79
91-100	40.85	56.26	69.95	5.86	43.09	49.54	56.83	2.77	38.24	43.61	51.63	2.79	30.47	34.28	40.20	2.03	30.47	45.97	69.95	8.90
All	40.68	86.37	114.69	17.59	43.09	83.06	109.24	15.68	26.17	73.91	116.35	20.01	28.06	74.75	114.45	27.22	26.17	79.53	116.35	21.27
pH (pH units)*																				
1-15	8.08	8.23	8.35	0.06	8.05	8.19	8.32	0.04	7.86	8.09	8.26	0.08	7.98	8.18	8.31	0.05	7.86	8.17	8.35	0.08
16-30	7.99	8.20	8.36	0.07	7.99	8.16	8.29	0.05	7.72	8.03	8.23	0.09	7.79	8.13	8.30	0.08	7.72	8.12	8.36	0.10
31-45	7.90	8.10	8.34	0.09	7.98	8.09	8.25	0.06	7.68	7.93	8.21	0.09	7.73	7.94	8.20	0.09	7.68	8.00	8.34	0.12
45-60	7.84	8.00	8.28	0.09	7.93	8.03	8.16	0.05	7.64	7.86	8.12	0.08	7.68	7.85	8.01	0.07	7.64	7.92	8.28	0.11
61-75	7.79	7.94	8.22	0.09	7.89	7.98	8.13	0.04	7.62	7.81	7.98	0.07	7.66	7.80	7.94	0.06	7.62	7.88	8.22	0.10
76-90	7.79	7.94	8.15	0.08	7.86	7.92	8.06	0.03	7.63	7.79	7.93	0.05	7.65	7.80	7.86	0.03	7.63	7.87	8.15	0.09
91-100	7.82	7.92	8.09	0.07	7.83	7.88	7.94	0.02	7.72	7.76	7.85	0.03	7.73	7.78	7.83	0.02	7.72	7.84	8.09	0.08
All	7.79	8.12	8.36	0.14	7.83	8.10	8.32	0.11	7.62	7.97	8.26	0.14	7.65	8.02	8.31	0.17	7.62	8.05	8.36	0.15

Table 3-2 continues.

Table 3-2 continued.

Depth (m)	Summer 2012				Fall 2012				Winter 2013				Spring 2013				Annual			
	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev
Chlorophyll-*a* (µg/L)**																				
1-15	0.09	0.82	9.97	1.02	0.07	1.79	20.51	2.06	0.44	3.98	33.85	4.33	0.18	1.40	12.94	1.28	0.07	1.97	33.85	2.74
16-30	0.17	1.77	12.07	1.50	0.16	3.80	17.90	3.07	0.32	2.20	13.99	1.30	0.50	5.68	27.98	5.36	0.16	3.36	27.98	3.53
31-45	0.40	2.56	11.88	1.95	0.37	3.40	19.67	2.47	0.20	1.01	4.49	0.69	0.21	2.90	21.36	2.58	0.20	2.55	21.36	2.27
45-60	0.27	1.47	8.75	1.20	0.29	1.69	8.54	1.06	0.15	0.41	1.12	0.19	0.18	0.81	3.75	0.55	0.15	1.15	8.75	1.02
61-75	0.12	0.81	3.43	0.59	0.17	0.88	3.14	0.50	0.12	0.25	0.72	0.08	0.12	0.44	1.37	0.21	0.12	0.62	3.43	0.49
76-90	0.11	0.52	1.76	0.30	0.05	0.30	2.19	0.26	0.08	0.18	0.48	0.07	0.06	0.21	0.68	0.12	0.05	0.28	2.19	0.23
91-100	0.14	0.32	0.67	0.12	0.01	0.13	0.26	0.04	0.07	0.14	0.31	0.06	0.05	0.14	0.47	0.07	0.01	0.17	0.67	0.10
All	0.09	1.40	12.07	1.47	0.01	2.27	20.51	2.43	0.07	1.92	33.85	2.89	0.05	2.25	27.98	3.40	0.01	1.98	33.85	2.65
Light Transmission (%)																				
1-15	5.40	84.38	91.09	5.41	37.59	85.86	89.93	4.37	5.56	79.72	91.14	8.93	32.12	82.48	89.30	5.12	5.40	83.11	91.14	6.62
16-30	43.40	84.24	91.16	5.68	50.69	85.75	89.64	3.65	13.15	84.54	92.71	6.16	25.24	80.86	88.72	4.63	13.15	83.85	92.71	5.43
31-45	66.08	85.89	91.27	3.23	78.02	87.43	89.87	1.46	72.38	87.66	93.88	2.75	56.25	84.77	89.32	3.94	56.25	86.44	93.88	3.21
45-60	75.81	87.11	91.68	2.88	80.21	88.32	90.42	1.50	60.53	88.13	94.06	3.25	70.25	86.86	89.70	2.55	60.53	87.61	94.06	2.71
61-75	77.31	87.77	91.67	2.78	81.56	88.96	90.50	1.08	81.58	89.24	94.20	2.18	77.59	87.87	89.81	1.75	77.31	88.46	94.20	2.14
76-90	79.92	88.90	91.59	1.78	81.39	89.42	90.60	1.07	83.14	89.06	94.24	1.35	81.42	88.21	89.87	1.37	79.92	88.89	94.24	1.48
91-100	86.08	89.25	91.14	1.20	86.63	89.69	90.62	0.91	85.41	88.89	90.37	1.07	85.67	88.40	89.85	0.91	85.41	89.06	91.14	1.13
All	5.40	85.66	91.68	4.74	37.59	87.01	90.62	3.39	5.56	84.88	94.24	7.06	25.24	84.07	89.87	4.85	5.40	85.41	94.24	5.29

* Summer and fall pH values do not include data from LA City due to a sensor malfunction.
** Winter and spring chlorophyll-*a* values do not include data from LA City due to a switch in sensor type.

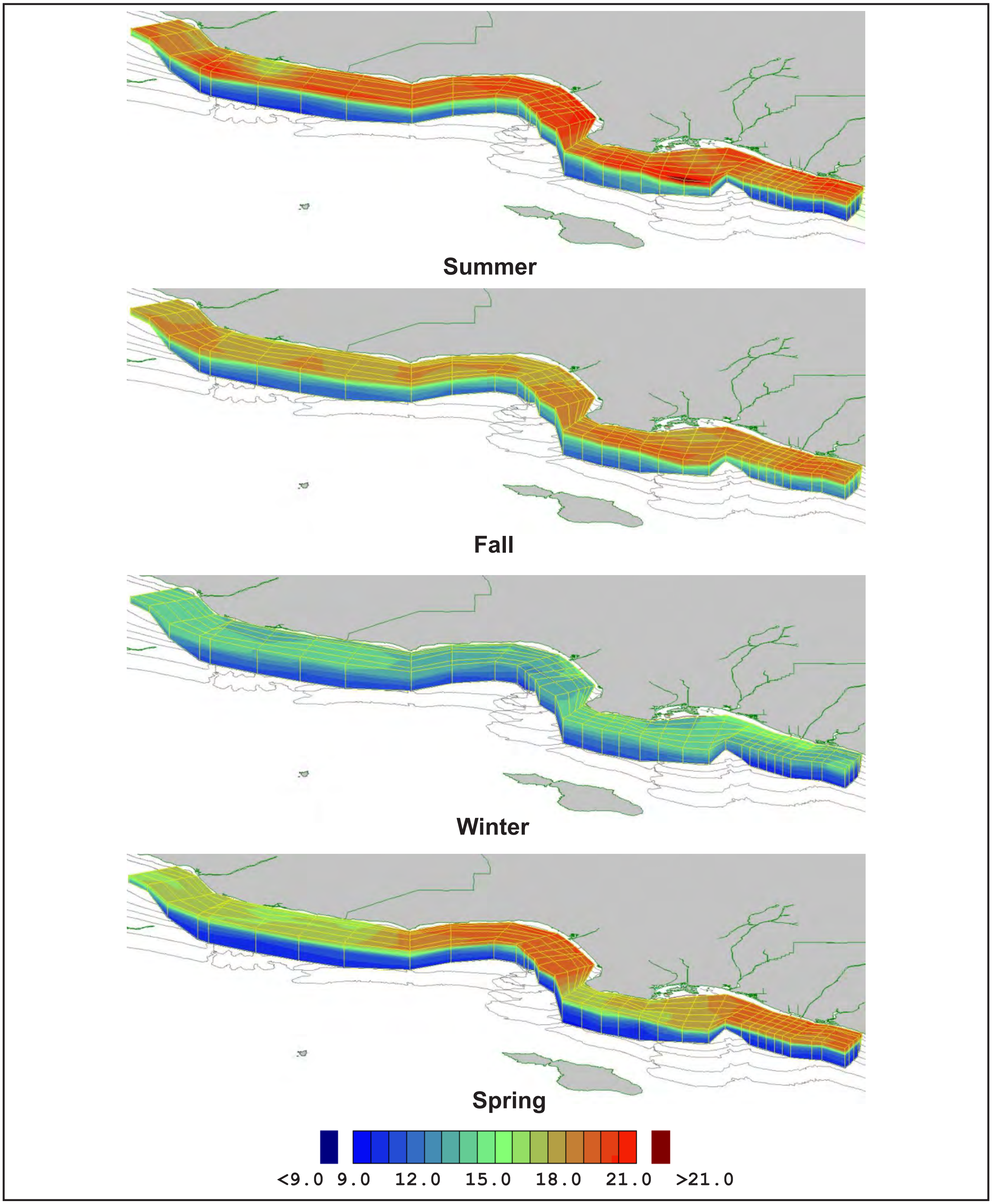


Figure 3-4. **Seasonal patterns of temperature (°C) for summer (August 2012), fall (November 2012), winter (February 2013), and spring (May 2013) for the Central Bight Regional Water Quality Monitoring Program grid.**

Orange County Sanitation District, California.

temperatures were much cooler with a range less than half of that seen in the summer. Waters were well mixed with weak stratification. Spatially, water temperatures were similar throughout the study area. Coldest surface waters were nearshore off Ventura and offshore of Santa Monica Bay and the San Pedro Shelf. Spring surface waters warmed significantly in Santa Monica Bay and on the San Pedro Shelf and stratification set in at depths above 40 m.

Temperature and density values measured within the District's study area diverged from regional values by both season and depth. District temperature and density values were comparable in the upper 30 m in the summer, fall, and winter quarters. Below 30 m, waters off Orange County were colder and denser in the summer, winter, and spring quarters. Spring surface waters (upper 15 m) within the District's study area were warmer and less dense than other areas of the Bight.

Salinity

Across the Central Bight, salinity patterns changed with season and depth (Table 3-2; Figures 3-5 and B-6). Salinity throughout the region fell within a small range (32.47–34.05 psu) with values below 15 m having an even smaller range (33.16–34.05 psu). A notable region-wide feature in the summer and fall was a subsurface lower (blue) salinity layer across the study area. This water mass is subarctic water transported into the area by the California Current at water depths (30–45 m) that coincide with the depth of wastewater plumes after initial dilution and mixing with receiving waters. Prior to the Central Bight regional sampling, discharge agencies sometimes misinterpreted this layer as plume-affected water. A lower salinity surface feature was seen off the Los Angeles/Long Beach Harbors throughout the year, including in the summer (August) when there was no rainfall (see Chapter 1, Figure 1-4); this local feature has been observed consistently since the onset of the Central Bight sampling program in 1998. As was the case the previous year (OCSD 2013), below average rainfall limited freshwater runoff impacts on surface salinity throughout the study area. Winter and spring had elevated subsurface salinities below 60 m throughout the study area that, unlike the previous year, were not upwelled to surface. Salinities off the District's study area were higher in the summer and winter, but comparable to regional values in the fall and spring.

Dissolved Oxygen

Dissolved oxygen (DO) concentrations varied spatially, by season and depth with values that ranged from 2.4–9.8 mg/L (Tables 3-2 and 3-3; Figures 3-6, B-7, and B-8). Summer and fall surface concentrations were lowest off Palos Verdes and the northern part of the San Pedro Shelf, while winter values were highest in this region. Spring surface values were highest north of Palos Verdes. Depth gradients greater than 4.5 mg/L were present throughout the year and while all quarters had low DO values (3-5 mg/L) at depth (e.g., > 60 m), low DO values came up to 15 m in the winter and spring. Oxygen concentrations above 5 mg/L are considered necessary to sustain fish populations while values less than 2 to 3 mg/l are considered hypoxic (NOAA 1998; USGS 2006; Vaquer-Sunyer and Duarte 2008). For 2012-13, DO values below 5 mg/L were seen in the upper 40 m in the summer and fall and above 30 m in the winter and spring. Over 93% of summer and fall DO measurements were above 5 mg/L while winter (73%) and spring (63%) were lower. Values of 5 mg/L were seen down to 100 m in the summer and fall, 80 m in the winter, and 60 m in the spring. Oxygen saturation (based on the relationship between oxygen solubility, temperature, and salinity) showed similar seasonal and depth trends.

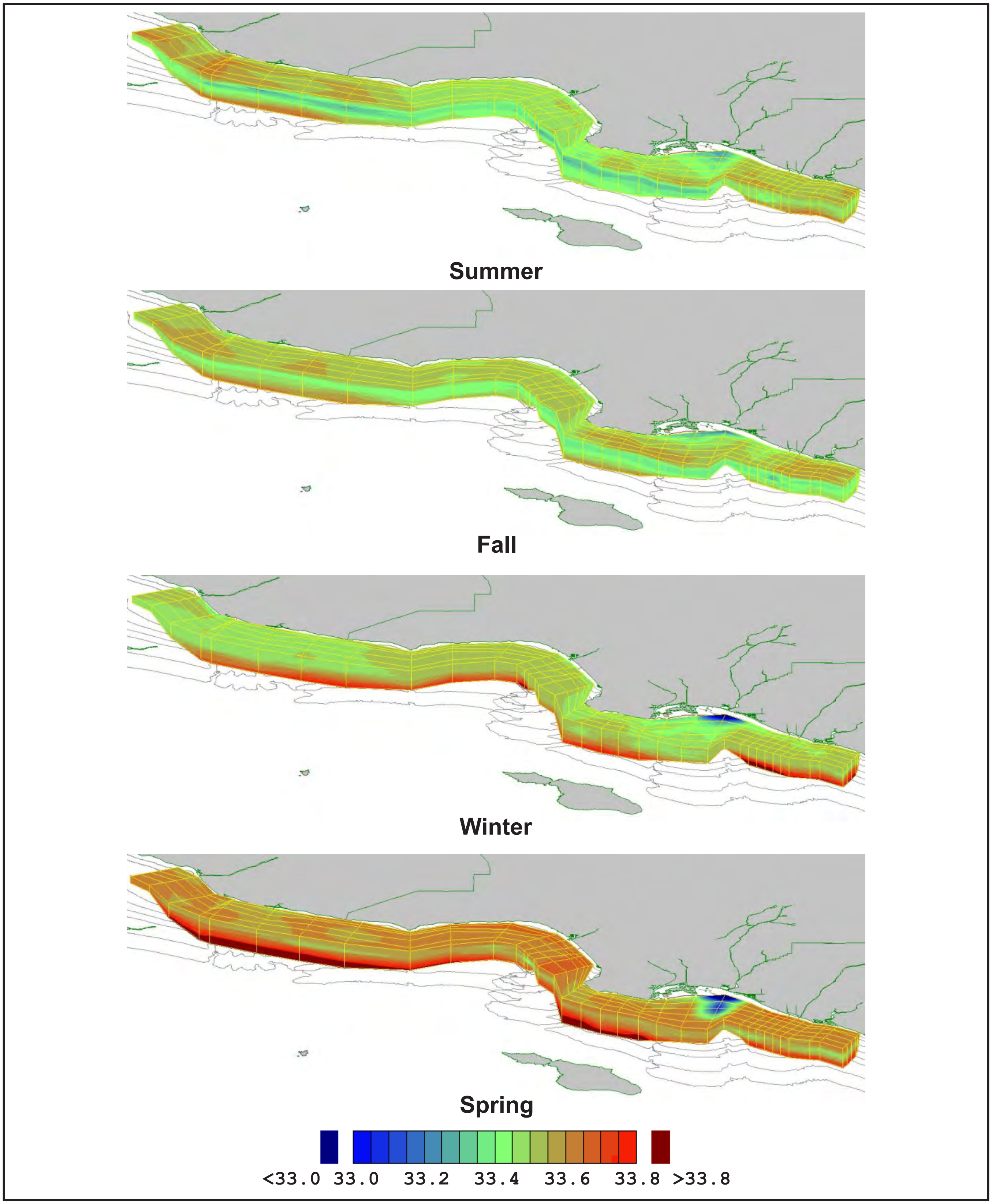


Figure 3-5. **Seasonal patterns of salinity (psu) for summer (August 2012), fall (November 2012), winter (February 2013), and spring (May 2013) for the Central Bight Regional Water Quality Monitoring Program grid.**

Orange County Sanitation District, California.

Table 3-3. Hypoxia levels* based on regional (CBWQ) dissolved oxygen concentrations (mg/L) by season and depth category calculated as percent of total for the Central Bight Regional Water Quality Monitoring Program, August 2012–May 2013.

Orange County Sanitation District, California.

Depth Strata (m)	<3 mg/L	3-5 mg/L	5-8 mg/L	≥8 mg/L	Total	N
			Summer			
1-15	0.00	0.00	17.12	13.34	30.46	3,034
16-30	0.00	0.00	9.97	12.31	22.28	2,219
31-45	0.00	0.01	13.65	2.29	15.95	1,589
46-60	0.00	0.71	12.80	0.00	13.51	1,346
61-75	0.00	2.43	7.17	0.00	9.60	956
76-90	0.00	1.84	3.54	0.00	5.38	536
91-100	0.00	1.43	1.39	0.00	2.81	280
All	0.00	6.42	65.64	27.94	100.00	
N	0	639	6,538	2,783		9,960
			Fall			
1-15	0.00	0.00	27.88	2.54	30.42	3,023
16-30	0.00	0.00	18.81	3.55	22.37	2,223
31-45	0.00	0.00	15.91	0.14	16.05	1,595
46-60	0.00	0.01	13.40	0.00	13.41	1,333
61-75	0.00	0.59	9.05	0.00	9.64	958
76-90	0.00	3.72	1.60	0.00	5.32	529
91-100	0.00	2.74	0.06	0.00	2.80	278
All	0.00	7.06	86.71	6.23	100.00	
N	0	702	8,618	619		9,939
			Winter			
1-15	0.00	0.00	16.48	13.96	30.44	3,023
16-30	0.00	0.55	19.02	2.56	22.13	2,198
31-45	0.00	3.58	12.24	0.18	16.01	1,590
46-60	0.12	7.09	6.42	0.00	13.63	1,354
61-75	0.09	7.61	1.95	0.00	9.66	959
76-90	0.01	5.32	0.06	0.00	5.39	535
91-100	0.00	2.74	0.00	0.00	2.74	272
All	0.22	26.90	56.19	16.70	100.00	
N	22	2,671	5,580	1,658		9,931
			Spring			
1-15	0.00	0.00	13.23	17.25	30.48	3,029
16-30	0.00	0.44	12.97	8.81	22.23	2,209
31-45	0.00	6.31	9.69	0.03	16.03	1,593
46-60	0.00	12.14	1.25	0.00	13.38	1,330
61-75	0.22	9.40	0.01	0.00	9.63	957
76-90	0.41	5.05	0.00	0.00	5.46	543
91-100	0.83	1.96	0.00	0.00	2.79	277
All	1.46	35.30	37.15	26.09	100.00	
N	145	3,508	3,692	2,593		9,938
			Annual			
1-15	0.00	0.00	18.68	11.77	30.45	12,109
16-30	0.00	0.25	15.19	6.81	22.25	8,849
31-45	0.00	2.47	12.87	0.66	16.01	6,367
46-60	0.03	4.98	8.47	0.00	13.49	5,363
61-75	0.08	5.01	4.55	0.00	9.63	3,830
76-90	0.11	3.98	1.30	0.00	5.39	2,143
91-100	0.21	2.22	0.36	0.00	2.78	1,107
All	0.42	18.91	61.43	19.24	100.00	
N	167	7,520	24,428	7,653		39,768

* <3 mg/L = hypoxic; 3-5 mg/L = potential effect; 5-8 mg/L = fish sustained; >8 mg/L = healthy, no impact.

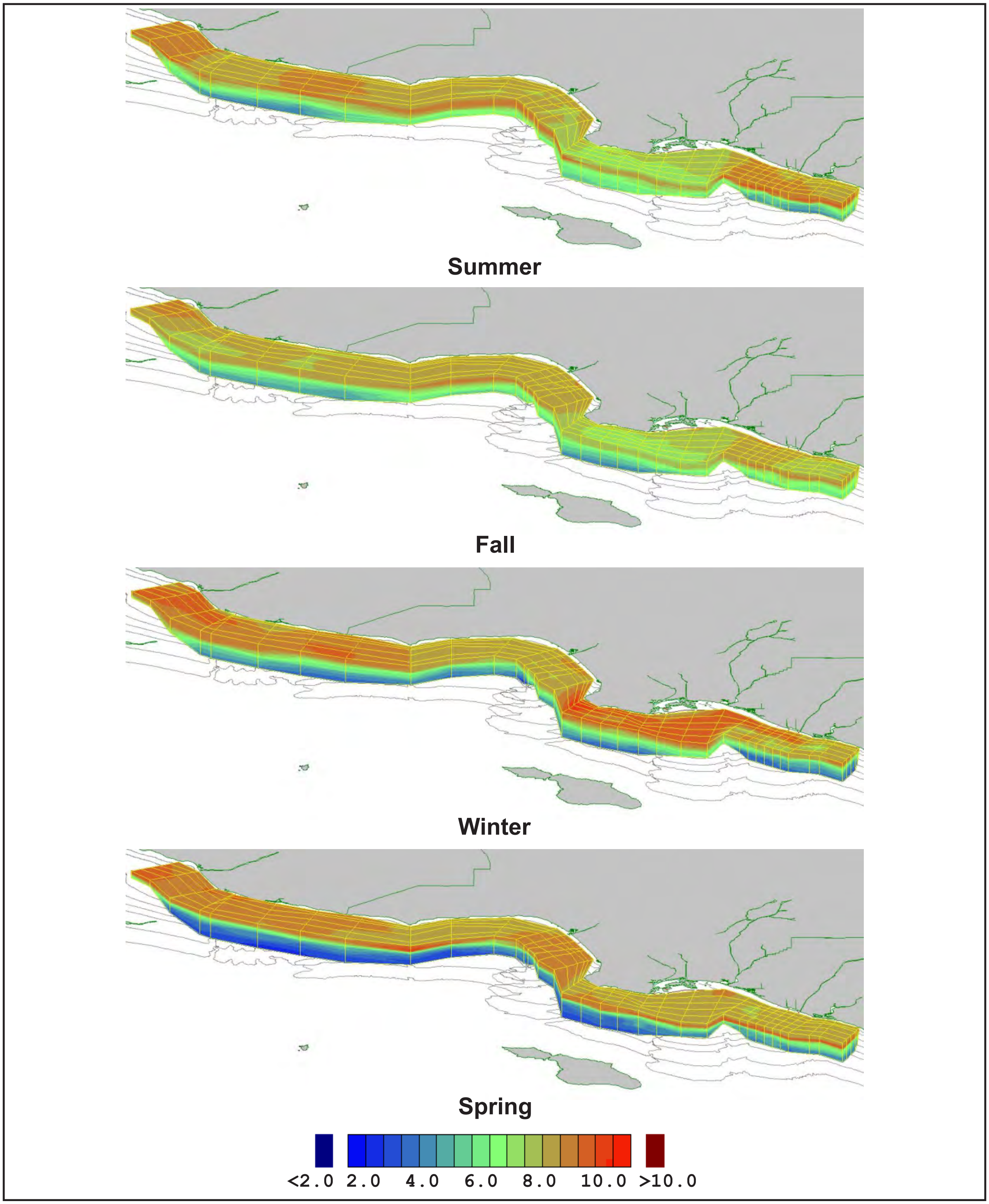


Figure 3-6. **Seasonal patterns of dissolved oxygen (mg/L) for summer (August 2012), fall (November 2012), winter (February 2013), and spring (May 2013) for the Central Bight Regional Water Quality Monitoring Program grid.**

Orange County Sanitation District, California.

Within the District's study area, seasonal and depth oxygen patterns closely followed those noted for temperature above (*r* = 0.76 for oxygen and 0.85 for oxygen saturation). Above 30 m, oxygen values were similar to regional values during all quarters, with the exception of spring when oxygen values off Orange County in the upper 15 m were lower. Below 30 m, waters off Orange County had lower oxygen values and saturation in the summer and winter quarters and higher values in the fall and spring.

pH

The acidity/alkalinity (pH) of receiving waters is an important biologic parameter as it affects the solubility of calcium carbonate, a necessary building material for calcareous organisms. Aragonite concentration is a conventional metric used to evaluate potential impacts to marine organisms with saturation values ≥1 considered necessary for calcium formation. Pre-industrial surface pH has been estimated to be 8.16 and a pH value of 7.75 has been associated with an aragonite saturation of 1 (Bernie 2009; Bijma *et al*. 2009; Feely *et al*. 2008; Orr *et al*. 2005; Pelejero and Hoegh-Guldberg 2010). For 2012-13 pH ranged from 7.62 to 8.36 (Table 3-2; Figure B-9). While over 97% of the measurements were >7.75, both winter (5.3%) and spring (4.3%) quarters had values <7.75; these were primarily seen at depths below 45 m (Table 3-4). District pH values, compared to regional values, were season and depth dependent. Summer pH was comparable in the upper 45 m, but significantly lower below that. Median fall values above 75 m were comparable, with District values below 75 m being higher. Winter median values off Orange County were higher at all depth categories. Spring values were regionally comparable.

Chlorophyll-a

Chlorophyll-*a,* used as a surrogate for phytoplankton biomass, varied widely, by season, region, and depth (Table 3-2; Figures 3-7 and B-10). Chlorophyll concentrations for 2012-13 were very low. The annual average concentration measured for 2012-13 was 31% less than the previous year (2.87 µg/L), which was, in itself, a 45% reduction from the year before that. Maximum concentration (33.85 µg/L) was much less than the 1998–2013 historical value of 122 µg/L. Seubert *et al*. (2013) presented a method of determining whether algal blooms were present based on average chlorophyll values and their standard deviations. For the year, nearly 90% of the samples were indicative of no algal bloom being present, while 6% and 4% of the samples were categorized as minor and major blooms, respectively (Table 3-5). This varied both seasonally and with depth with the largest number of samples representing blooms being in the fall (14.7%) and spring (12.8%). With the exception of elevated near-coast, surface chlorophyll-*a* in Santa Monica Bay, summer and fall showed typical subsurface maximums. This subsurface maximum layer was absent in winter, which showed elevated concentrations primarily at the surface off Orange County. Spring maximum values were again subsurface with the primary area affected being a small region in the very northern portion of the sampling area off Ventura County and from Santa Monica Bay, south to Orange County. District chlorophyll-*a* values were comparable to regional values in the summer, fall, and spring quarters. Winter values off Orange County were much higher at the surface.

Water Clarity

Percent light transmission and beam-C were highly correlated (*r* = -0.89). Regionally, light transmission was consistent both by season and with depth. In general, transmissivity was lowest, with clearer water at depth (Table 3-2; Figures B-11 and B-12). District values were

Table 3-4. Ocean acidification levels* based on regional pH (pH units) by season and depth category calculated as percent of total for the Central Bight Regional Water Quality Monitoring Program, August 2012–May 2013.

Orange County Sanitation District, California.

Depth Strata (m)	<7.75	7.75–8.15	≥8.16	Total (%)	N
Summer					
1-15	0.00	3.31	26.72	30.03	2,277
16-30	0.00	5.20	16.54	21.73	1,648
31-45	0.00	11.13	4.01	15.14	1,148
46-60	0.00	11.88	1.20	13.08	992
61-75	0.00	9.49	0.16	9.65	732
76-90	0.00	6.67	0.00	6.67	506
91-100	0.00	3.69	0.00	3.69	280
All	0.00	51.38	48.62	100	
N	0	3,896	3,687		7,583
Fall					
1-15	0.00	7.47	22.53	30.01	2,273
16-30	0.00	9.15	12.55	21.70	1,644
31-45	0.00	12.53	2.65	15.18	1,150
46-60	0.00	13.00	0.08	13.08	991
61-75	0.00	9.65	0.00	9.65	731
76-90	0.00	6.71	0.00	6.71	508
91-100	0.00	3.67	0.00	3.67	278
All	0.00	62.18	37.82	100	
N	0	4,710	2,865		7,575
Winter					
1-15	0.00	25.52	6.54	32.06	2,843
16-30	0.03	21.68	1.06	22.78	2,020
31-45	0.54	15.43	0.10	16.07	1,425
46-60	1.61	11.82	0.00	13.43	1,191
61-75	1.98	7.25	0.00	9.24	819
76-90	0.45	3.83	0.00	4.29	380
91-100	0.67	1.48	0.00	2.14	190
All	5.29	87.01	7.70	100	
N	469	7,716	683		8,868
Spring					
1-15	0.00	10.20	20.28	30.48	3,029
16-30	0.00	13.53	8.69	22.23	2,209
31-45	0.13	15.79	0.11	16.03	1,593
46-60	1.61	11.77	0.00	13.38	1,330
61-75	2.15	7.48	0.00	9.63	957
76-90	0.24	5.22	0.00	5.46	543
91-100	0.13	2.66	0.00	2.79	277
All	4.27	66.65	29.08	100	
N	424	6,624	2,890		9,938
Annual					
1-15	0.00	12.05	18.63	30.69	10,422
16-30	0.01	12.82	9.31	22.14	7,521
31-45	0.18	13.93	1.55	15.65	5,316
46-60	0.89	12.08	0.29	13.26	4,504
61-75	1.15	8.35	0.04	9.54	3,239
76-90	0.19	5.51	0.00	5.70	1,937
91-100	0.21	2.81	0.00	3.02	1,025
All	2.63	67.56	29.81	100	
N	893	22,946	10,125		33,964

* <7.75 ≈ aragonite saturation level <1; 8.16 ≈ average pre-industrial surface value.

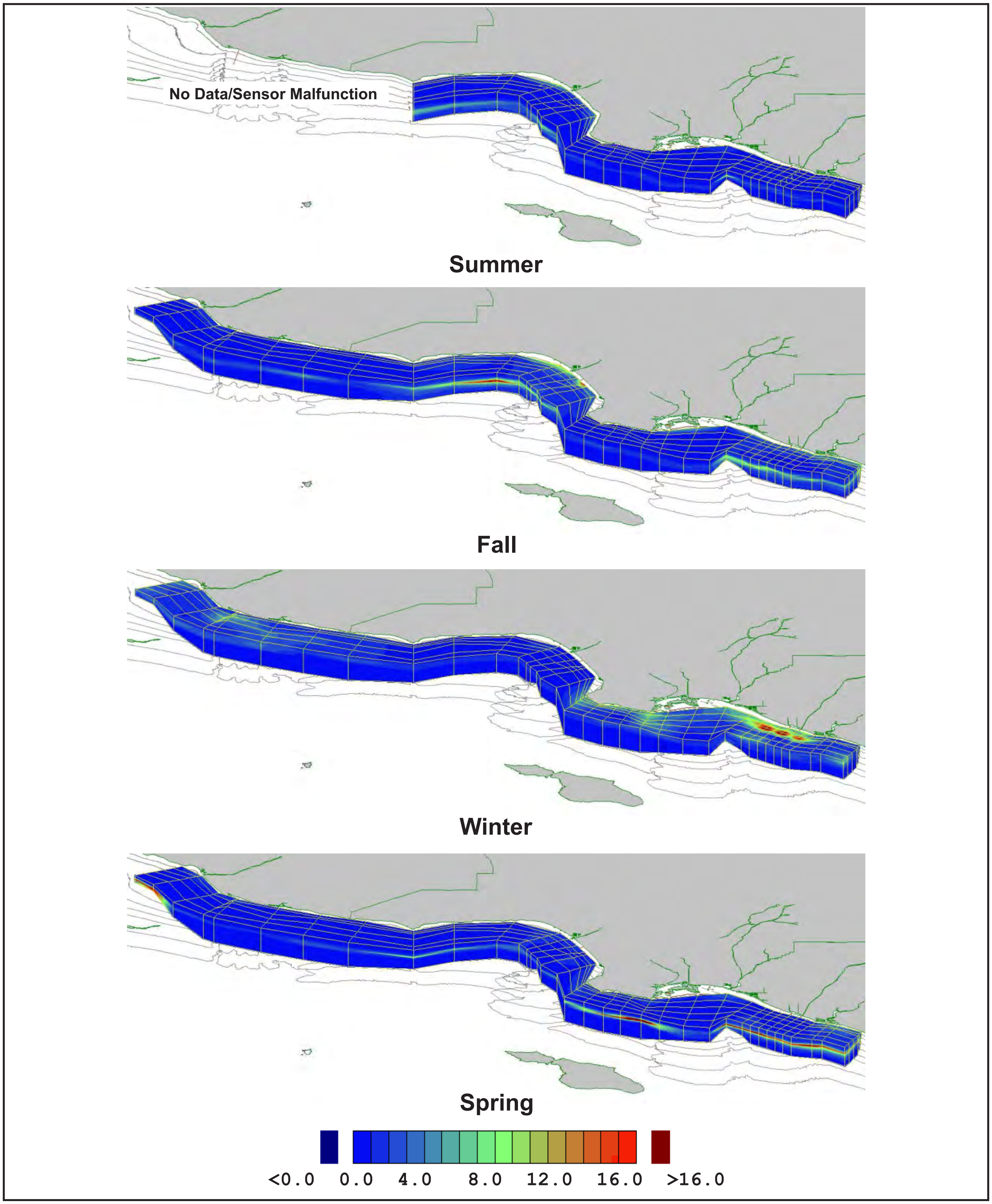


Figure 3-7. **Seasonal patterns of chlorophyll-*a* (µg/L) for summer (August 2012), fall (November 2012), winter (February 2013), and spring (May 2013) for the Central Bight Regional Water Quality Monitoring Program grid.**

Orange County Sanitation District, California.

Table 3-5. Seasonal algal bloom determinations for regional (CBWQ) surveys by depth strata, August 2012–May 2013.

Orange County Sanitation District, California.

Depth Strata (m)	No Bloom	Minor Bloom	Major Bloom	Total	N
Summer					
1-15	29.62	0.36	0.17	30.14	2,367
16-30	21.56	1.10	0.29	22.95	1,802
31-45	14.19	1.99	0.65	16.82	1,321
46-60	13.64	0.29	0.05	13.98	1,098
61-75	9.83	0.00	0.00	9.83	772
76-90	4.24	0.00	0.00	4.24	333
91-100	2.04	0.00	0.00	2.04	160
All	95.11	3.73	1.16	100	
N	7,469	293	91		7,853
Fall					
1-15	27.91	1.88	0.62	30.42	3,023
16-30	14.40	4.40	3.57	22.37	2,223
31-45	12.12	2.84	1.09	16.05	1,595
46-60	13.11	0.29	0.01	13.41	1,333
61-75	9.64	0.00	0.00	9.64	958
76-90	5.32	0.00	0.00	5.32	529
91-100	2.80	0.00	0.00	2.80	278
All	85.30	9.41	5.29	100	
N	8,478	935	526		9,939
Winter					
1-15	23.64	3.43	2.96	30.03	2,261
16-30	20.44	0.88	0.13	21.45	1,615
31-45	15.17	0.00	0.00	15.17	1,142
46-60	13.35	0.00	0.00	13.35	1,005
61-75	9.70	0.00	0.00	9.70	730
76-90	6.69	0.00	0.00	6.69	504
91-100	3.61	0.00	0.00	3.61	272
All	92.60	4.30	3.09	100	
N	6,972	324	233		7,529
Spring					
1-15	29.00	0.82	0.20	30.02	2,269
16-30	12.93	2.69	5.94	21.55	1,629
31-45	12.04	2.01	1.10	15.15	1,145
46-60	13.05	0.00	0.00	13.05	986
61-75	9.67	0.00	0.00	9.67	731
76-90	6.89	0.00	0.00	6.89	521
91-100	3.66	0.00	0.00	3.66	277
All	87.25	5.52	7.24	100	
N	6,594	417	547		7,558
Annual					
1-15	27.59	1.63	0.95	30.17	9,920
16-30	17.15	2.41	2.55	22.11	7,269
31-45	13.29	1.79	0.74	15.82	5,203
46-60	13.28	0.16	0.02	13.45	4,422
61-75	9.71	0.00	0.00	9.71	3,191
76-90	5.74	0.00	0.00	5.74	1,887
91-100	3.00	0.00	0.00	3.00	987
All	89.76	5.99	4.25	100	
N	29,513	1,969	1,397		32,879

lower in the summer above 40 m, but comparable below 40 m and at all depths during the other three seasons.

Local Water Quality Conditions

This section focuses on data collected for both the Nearshore (surfzone) and Offshore sampling programs, and includes seasonal comparisons and determinations of plume impacts.

Core Nearshore (Surfzone) Bacteria

Core surfzone FIB counts were typically low throughout the year. While bacteria counts varied by season, location along the coast, and by indicator bacteria type, a general spatial pattern was associated with the mouth of the Santa Ana River (Table 3-6; Figure 3-8). Seasonal geomeans for three indicator bacteria were typically higher between 9N and TM, and tapered off up- and downcoast. Annually, exceedance rates were ≤2% of total samples at any station by total coliform, <11% by fecal coliform, and <14% by enterococci (Table 3-7). Single sample exceedance by enterococci was absent during summer and spring at stations south of the Santa Ana River, with the exception of one sample at 29S, when total seasonal rainfall was below 1 inch. However, during fall and winter, when total seasonal rainfall was over 2 inches, numerous exceedances were observed between Stations 3S and 21S. A similar pattern in exceedances were observed for fecal coliform, while for total coliform, exceedances were only observed between stations 33N and 0 or during the spring season and between 9N and 3N during the summer season.

Regional Nearshore (Surfzone) Bacteria

Stations HB1, HB2, HB3, HB4, HB5, and EL MORO did not flow during the entire year, while stations PPC and MDC did not flow during the spring or summer seasons, respectively. When flow was not observed at the freshwater-ocean interface, a single sample was collected 25 yards downstream of the source (Table A-1). Geomeans of all three fecal indicator bacteria were typically low during the entire year at Stations OSB01, OSUB1, BCO-1, HB1, HB2, HB3, HB4, and HB5 (Figure 3-9). Comparison of seasonal geomeans showed a general trend of higher concentrations of all three fecal indicator bacteria at the source of Stations BGC, PPC, WFC, and MDC (Table 3-8; Figure 3-9). These results suggest that when these freshwater sources are flowing into the ocean, the discharge serves as a source for bacterial contamination.

Core Offshore Water Quality

Temperature and Density

Water temperature and density were highly correlated (r = -0.99) and shared similar spatial and temporal patterns that varied with depth, month, and season (Table 3-9; Figures 3-10 to 3-12 and B-13 to B-15). For both parameters, the upper 30 m had the biggest seasonal and annual ranges. While winter temperatures and density were the least variable, there were still significant differences in their median values in the upper 30 m as compared to lower depths. Summer patterns showed that in July and August, warmer, less dense water were present from the surface to bottom. Stratification remained strong during the entire season. Fall mean temperatures were warmer and less dense than summer, primarily due

Table 3-6. Summary statistics for surf zone total coliform, fecal coliform, and *Enterococcus* bacteria (CFU/100 mL) by station and seasons during 2012-13.

Orange County Sanitation District, California.

Station	Summer 2012				Fall 2012				Winter 2013				Spring 2013				Annual			
	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev
Total Coliform																				
39N	12.75	27.80	250	2.54	12.75	15.26	33	1.37	12.75	15.77	33	1.42	12.75	22.65	3200	4.74	12.75	21.52	3200	2.55
33N	12.75	19.43	220	1.89	12.75	23.99	540	2.77	12.75	15.48	67	1.58	12.75	16.80	100	1.82	12.75	19.12	540	2.03
27N	12.75	15.41	33	1.31	12.75	21.01	7600	4.65	12.75	13.33	17	1.11	12.75	15.56	33	1.32	12.75	16.12	7600	2.11
21N	12.75	17.35	170	1.76	12.75	16.74	120	1.76	12.75	14.73	83	1.68	12.75	17.56	170	2.11	12.75	16.78	170	1.79
15N	12.75	29.24	270	2.53	12.75	19.75	50	1.71	12.75	18.10	67	1.79	12.75	14.37	17	1.16	12.75	22.21	270	2.14
12N	12.75	32.76	290	2.71	12.75	20.35	67	1.77	12.75	15.48	67	1.58	12.75	14.83	33	1.33	12.75	19.89	290	2.01
9N	12.75	61.86	4000	4.22	12.75	40.98	1800	4.24	12.75	17.8	270	2.11	12.75	22.17	13000	4.06	12.75	35.34	13000	4.05
6N	12.75	43.71	1900	3.82	12.75	67.74	7800	5.66	12.75	36.07	960	3.60	12.75	30.58	15000	5.97	12.75	43.16	15000	4.63
3N	12.75	60.08	18000	6.67	12.75	37.06	620	2.69	12.75	40.69	2600	5.47	12.75	31.88	6500	4.84	12.75	43.63	18000	5.05
0	12.75	21.71	460	2.10	12.75	32.47	1100	3.58	12.75	37.36	200	2.22	12.75	33.32	4800	6.19	12.75	29.03	4800	3.26
SAR-N	12.75	17.98	73	1.77	12.75	42.52	3600	5.76	12.75	27.09	150	2.24	12.75	42.39	2600	5.42	12.75	31.34	3600	3.91
TM	12.75	19.76	150	2.2	12.75	38.79	500	3.56	12.75	35.76	130	2.34	12.75	33.04	9300	5.86	12.75	31.10	9300	3.41
3S	12.75	17.48	180	1.90	12.75	46.55	4000	7.66	12.75	37.71	170	2.96	12.75	14.02	33	1.31	12.75	23.62	4000	3.34
6S	12.75	14.81	33	1.31	12.75	32.05	1900	4.83	12.75	18.46	150	2.33	12.75	15.09	33	1.43	12.75	18.19	1900	2.40
9S	12.75	14.91	50	1.42	12.75	22.93	620	3.60	12.75	20.15	67	1.67	12.75	13.63	17	1.13	12.75	16.93	620	1.99
15S	12.75	14.43	36	1.28	12.75	28.60	860	3.52	12.75	28.45	130	2.18	12.75	16.23	33	1.51	12.75	19.06	860	2.13
21S	12.75	16.29	220	1.88	12.75	21.57	680	2.8	12.75	31.42	130	2.50	12.75	14.99	33	1.31	12.75	19.02	680	2.17
27S	12.75	14.34	100	1.50	12.75	19.91	350	2.48	12.75	16.56	83	1.74	12.75	13.33	17	1.11	12.75	15.57	350	1.75
29S	12.75	21.23	700	2.39	12.75	25.41	180	2.32	12.75	17.02	50	1.52	12.75	20.91	83	2.13	12.75	21.22	700	2.19
39S	12.75	13.87	36	1.26	12.75	16.91	100	1.91	12.75	19.96	280	2.57	12.75	13.33	17	1.11	12.75	15.26	280	1.68

Table 3-6 continues.

Table 3-6 Continued.

Station	Summer 2012				Fall 2012				Winter 2013				Spring 2013				Annual			
	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev
Fecal Coliform																				
39N	12.75	24.18	220	2.09	12.75	14.54	67	1.50	12.75	15.32	33	1.31	12.75	16.11	150	1.97	12.75	18.81	220	1.90
33N	12.75	18.69	83	1.77	12.75	19.94	230	2.12	12.75	14.34	33	1.31	12.75	30.95	3600	5.11	12.75	19.82	3600	2.39
27N	12.75	15.21	36	1.37	12.75	19.40	6200	4.50	12.75	13.04	17	1.08	12.75	21.16	3900	4.82	12.75	16.5	6200	2.61
21N	12.75	15.52	180	1.62	12.75	15.12	50	1.48	12.75	17.14	50	1.61	12.75	26.36	5400	5.53	12.75	17.11	5400	2.25
15N	12.75	26.49	250	2.61	12.75	16.14	33	1.44	12.75	15.24	50	1.56	12.75	23.76	5100	5.13	12.75	21.35	5100	2.64
12N	12.75	22.37	220	2.37	12.75	19.95	100	1.98	12.75	14.24	17	1.16	12.75	22.44	4700	5.01	12.75	19.43	4700	2.63
9N	12.75	55.10	4400	4.25	12.75	39.11	20000	5.44	12.75	16.89	270	2.05	12.75	26.23	3600	4.13	12.75	34.23	20000	4.24
6N	12.75	40.03	1200	3.58	12.75	57.84	5700	5.00	12.75	32.91	500	3.17	12.75	27.94	2900	3.68	12.75	38.85	5700	3.86
3N	12.75	50.04	12000	6.58	12.75	28.66	420	2.58	12.75	43.58	3300	5.18	12.75	26.61	9800	5.2	12.75	37.47	12000	5.02
0	12.75	18.52	330	1.97	12.75	28.55	1100	3.20	12.75	29.05	150	2.32	12.75	20.54	1100	3.12	12.75	22.90	1100	2.59
SAR-N	12.75	15.39	36	1.43	12.75	24.01	560	3.02	12.75	17.11	83	1.93	12.75	18.76	420	2.64	12.75	18.90	560	2.33
TM	12.75	18.93	150	2.11	12.75	21.51	100	1.94	12.75	32.07	130	2.38	12.75	25.09	4700	5.11	12.75	23.65	4700	2.75
3S	12.75	14.73	240	1.67	12.75	29.15	2800	5.26	12.75	25.92	130	2.36	12.75	12.75	12.75	1.00	12.75	18.29	2800	2.59
6S	12.75	13.83	36	1.21	12.75	19.92	230	2.46	12.75	20.52	170	2.23	12.75	13.33	17	1.11	12.75	15.87	230	1.76
9S	12.75	15.26	36	1.41	12.75	19.19	230	2.35	12.75	18.33	120	1.94	12.75	14.34	33	1.31	12.75	16.36	230	1.72
15S	12.75	13.14	17	1.07	12.75	27.10	480	2.83	12.75	23.82	150	2.49	12.75	14.02	33	1.31	12.75	17.12	480	1.98
21S	12.75	16.18	230	1.89	12.75	19.63	420	2.45	12.75	27.32	120	2.22	12.75	13.72	33	1.30	12.75	17.89	420	2.04
27S	12.75	13.76	67	1.33	12.75	14.19	33	1.28	12.75	14.02	33	1.31	12.75	13.04	17	1.08	12.75	13.77	67	1.28
29S	12.75	19.75	330	2.22	12.75	20.93	100	1.93	12.75	16.12	33	1.41	12.75	15.47	50	1.46	12.75	18.58	330	1.93
39S	12.75	12.93	13.5	1.03	12.75	13.19	17	1.10	12.75	19.43	150	2.37	12.75	12.75	12.75	1.00	12.75	13.85	150	1.45

Table 3-6 continues.

Table 3-6 Continued.

Station	Summer 2012				Fall 2012				Winter 2013				Spring 2013				Annual			
	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev
Enterococcus																				
39N	2.0	21.11	214	3.44	1.5	5.61	28	2.63	1.5	3.35	32	2.57	1.5	3.19	10	2.21	1.5	8.59	214	3.87
33N	1.5	10.52	92	3.43	1.5	9.81	156	3.93	1.5	5.73	48	3.30	1.5	7.65	34	2.96	1.5	8.88	156	3.42
27N	1.5	5.74	36	2.70	1.5	3.79	500	4.30	1.5	3.49	12	2.45	1.5	7.52	58	3.00	1.5	5.06	500	3.08
21N	1.5	5.71	68	2.57	1.5	3.73	46	2.83	1.5	8.24	64	3.73	1.5	9.86	130	5.05	1.5	6.06	130	3.26
15N	1.5	10.09	100	3.55	1.5	3.72	30	2.58	1.5	4.05	42	3.34	1.5	5.84	46	2.95	1.5	6.40	100	3.41
12N	1.5	7.30	94	3.48	1.5	6.57	46	3.07	1.5	4.73	36	3.09	1.5	4.57	32	3.07	1.5	5.67	94	3.13
9N	1.5	22.06	500	5.19	1.5	11.90	308	5.32	1.5	7.05	88	4.07	1.5	5.36	28	2.93	1.5	11.36	500	4.91
6N	1.5	16.53	500	5.28	1.5	17.59	500	6.03	1.5	15.51	280	4.24	1.5	7.53	70	3.68	1.5	14.07	500	4.95
3N	1.5	14.30	500	5.92	1.5	12.17	206	3.08	1.5	14.71	500	5.08	1.5	5.62	320	3.87	1.5	11.43	500	4.75
0	1.5	4.92	82	3.18	1.5	6.36	500	5.17	1.5	9.23	96	3.61	1.5	3.84	34	2.51	1.5	5.64	500	3.63
SAR-N	1.5	5.00	18	2.77	1.5	6.13	500	6.17	1.5	5.20	72	4.26	1.5	3.68	18	2.28	1.5	5.00	500	3.87
TM	1.5	7.19	20	2.49	1.5	8.84	74	3.44	1.5	17.07	102	3.33	1.5	4.91	18	2.20	1.5	8.54	102	3.08
3S	1.5	2.18	12	1.81	1.5	6.10	316	5.43	1.5	14.93	90	3.62	1.5	2.51	8	2.03	1.5	3.82	316	3.56
6S	1.5	2.25	8	1.79	1.5	4.80	366	5.30	1.5	6.26	272	4.83	1.5	2.82	18	2.52	1.5	3.25	366	3.27
9S	1.5	3.13	68	2.38	1.5	4.40	144	5.23	1.5	7.95	58	3.77	1.5	2.97	10	2.06	1.5	3.89	144	3.22
15S	1.5	2.31	8	1.80	1.5	5.59	500	5.51	1.5	13.51	96	4.74	1.5	2.22	4	1.53	1.5	3.71	500	3.57
21S	1.5	2.47	58	2.50	1.5	4.75	152	4.39	2	9.85	248	4.81	1.5	2.45	20	2.13	1.5	3.57	248	3.50
27S	1.5	2.13	20	1.92	1.5	3.09	66	3.16	1.5	2.50	34	2.53	1.5	2.92	14	2.26	1.5	2.50	66	2.34
29S	1.5	4.33	60	2.87	1.5	3.92	48	2.99	1.5	4.46	132	3.55	1.5	3.07	42	3.14	1.5	4.02	132	3.00
39S	1.5	2.13	8	1.73	1.5	2.13	12	1.88	1.5	2.55	42	2.84	1.5	1.60	2	1.13	1.5	2.09	42	1.89

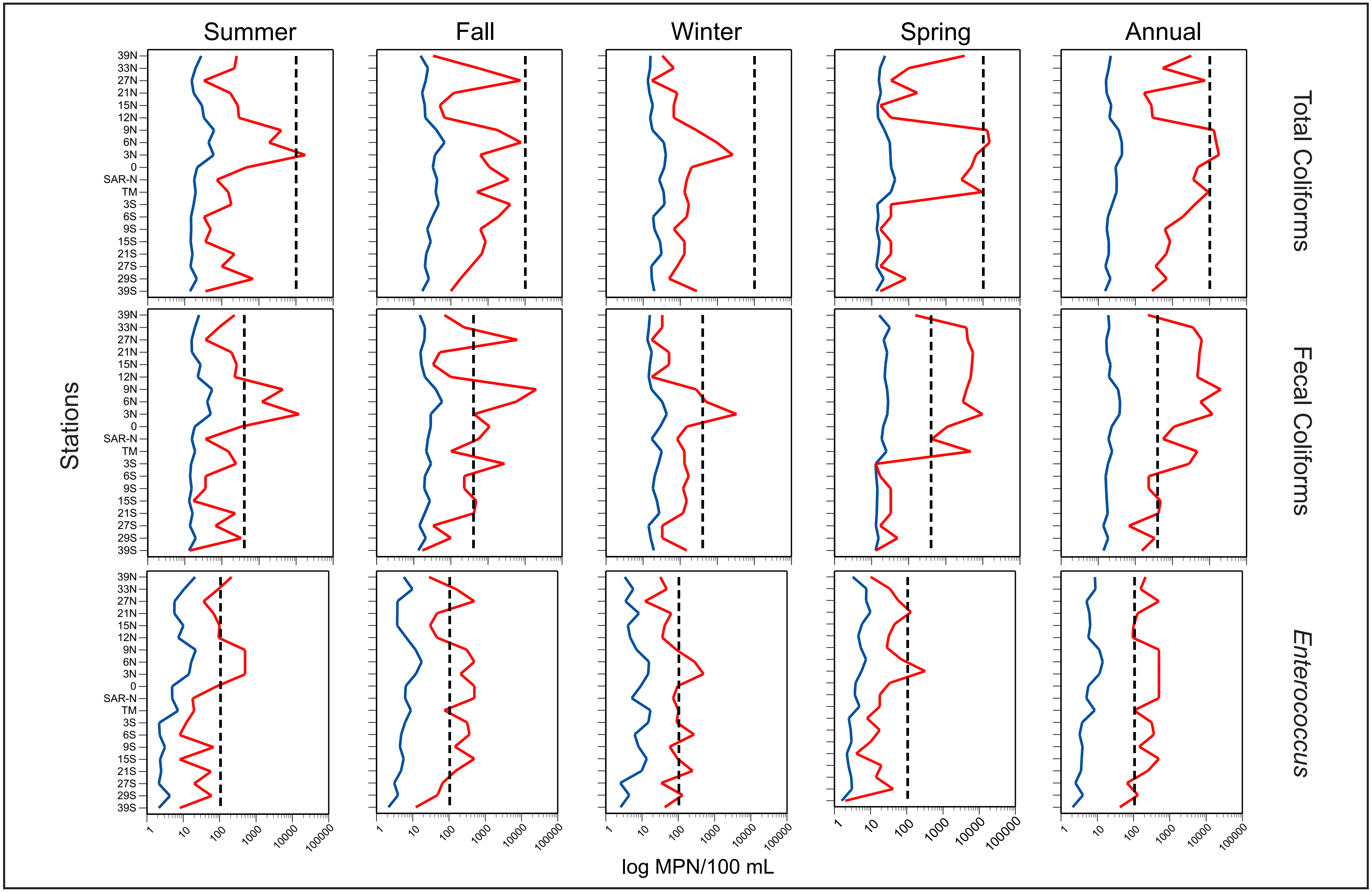


Figure 3-8. Seasonal distribution of total coliform, fecal coliform, and *Enterococcus* bacteria at the District's core nearshore (surfzone) water quality stations for July 1, 2012 to June 30, 2013.

Blue line = geometric mean for the season, red line = maximum value during the season, dashed vertical line = single sample limit.

Table 3-7. Spatial and temporal exceedance statistics of surfzone indicator bacterial data to California AB411 recreational water quality standards, July 2012 through June 2013.

Orange County Sanitation District, California.

	39N	33N	27N	21N	15N	12N	9N	6N	3N	0	SAR	TM	3S	6S	9S	15S	21S	29S	27S	39S	∑
Annual Exceedances by California AB411 Recreational Water Quality Standards																					
Total Coliform																					
Exceedance	0	1	1	1	1	1	2	1	2	0	0	0	0	0	0	0	0	0	0	0	10
No. of Samples	51	51	51	51	51	51	103	103	104	103	51	51	51	51	51	51	51	51	51	51	1229
% Exceedance	0.0%	2.0%	2.0%	2.0%	2.0%	2.0%	1.9%	1.0%	1.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%
Fecal Coliform																					
Exceedance	0	1	2	1	1	1	5	11	11	2	2	1	2	0	0	1	1	0	0	0	42
No. of Samples	51	51	51	51	51	51	104	105	105	103	51	51	51	51	51	51	51	51	51	51	1233
% Exceedance	0.0%	2.0%	3.9%	2.0%	2.0%	2.0%	4.8%	10.5%	10.5%	1.9%	3.9%	2.0%	3.9%	0.0%	0.0%	2.0%	2.0%	0.0%	0.0%	0.0%	3.4%
Enterococcus																					
Exceedance	3	1	1	2	0	0	7	14	12	1	1	0	2	2	2	2	3	1	0	0	54
No. of Samples	51	51	51	51	51	51	104	105	105	103	51	51	51	51	51	51	51	51	51	51	1233
% Exceedance	5.9%	2.0%	2.0%	3.9%	0.0%	0.0%	6.7%	13.3%	11.4%	1.0%	2.0%	0.0%	3.9%	3.9%	3.9%	3.9%	5.9%	2.0%	0.0%	0.0%	4.4%
Seasonal Exceedances by California AB411 Total Coliform Recreational Water Quality Standards																					
Summer (∑Rainfall = 0.08 inches)																					
Exceedance	0	0	0	0	0	0	1	3	5	0	0	0	0	0	0	0	0	0	0	0	9.0
No. of Samples	16	16	16	16	16	13	26	26	27	26	16	16	16	16	16	16	16	16	16	16	358
% Exceedance	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.8%	11.5%	18.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%
Fall (∑Rainfall = 2.48 inches)																					
Exceedance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
No. of Samples	14	14	14	14	14	12	26	26	26	26	14	14	14	14	14	14	14	14	14	14	326
% Exceedance	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Winter (∑Rainfall = 3.96 inches)																					
Exceedance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
No. of Samples	13	13	13	13	13	13	25	25	25	25	13	13	13	13	13	13	13	13	13	13	308
% Exceedance	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Spring (∑Rainfall = 0.63 inches)																					
Exceedance	0	1	1	1	1	1	2	2	3	3	0	0	0	0	0	0	0	0	0	0	15.0
No. of Samples	13	13	13	13	13	13	27	27	27	27	13	13	13	13	13	13	13	13	13	13	316
% Exceedance	0.0%	7.7%	7.7%	7.7%	7.7%	7.7%	7.4%	7.4%	11.1%	11.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.7%

Table 3-7 continues.

Table 3-7 continued.

	39N	33N	27N	21N	15N	12N	9N	6N	3N	0	SAR	TM	3S	6S	9S	15S	21S	29S	27S	39S	∑
Seasonal Exceedances by California AB411 Fecal Coliform Recreational Water Quality Standards																					
Summer (∑Rainfall = 0.08 inches)																					
Exceedance	0	0	0	0	0	0	1	4	5	0	0	0	0	0	0	0	0	0	0	0	10.0
No. of Samples	16	16	16	16	16	13	27	28	28	26	16	16	16	16	16	16	16	16	16	16	362
% Exceedance	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.7%	14.3%	17.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.8%
Fall (∑Rainfall = 2.48 inches)																					
Exceedance	0	0	1	0	0	0	2	4	0	1	1	0	2	0	0	1	0	0	0	0	12.0
No. of Samples	14	14	14	14	14	12	26	26	26	26	14	14	14	14	14	14	14	14	14	14	326
% Exceedance	0.0%	0.0%	7.1%	0.0%	0.0%	0.0%	7.7%	15.4%	0.0%	3.8%	7.1%	0.0%	14.3%	0.0%	0.0%	7.1%	0.0%	0.0%	0.0%	0.0%	3.7%
Winter (∑Rainfall = 3.96 inches)																					
Exceedance	0	0	0	0	0	0	0	2	4	0	0	0	0	0	0	0	1	0	0	0	7.0
No. of Samples	13	13	13	13	13	13	25	25	25	25	13	13	13	13	13	13	13	13	13	13	308
% Exceedance	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.0%	16.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.7%	0.0%	0.0%	0.0%	2.3%
Spring (∑Rainfall = 0.63 inches)																					
Exceedance	0	1	1	1	1	1	2	1	2	1	1	1	0	0	0	0	0	0	0	0	13.0
No. of Samples	13	13	13	13	13	13	27	27	27	27	13	13	13	13	13	13	13	13	13	13	316
% Exceedance	0.0%	7.7%	7.7%	7.7%	7.7%	7.7%	7.4%	3.7%	7.4%	3.7%	7.7%	7.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.1%
Seasonal Exceedances by California AB411 *Enterococcus* Recreational Water Quality Standards																					
Summer (∑Rainfall = 0.08 inches)																					
Exceedance	2	0	0	0	0	0	3	5	5	0	0	0	0	0	0	0	0	0	0	0	15.0
No. of Samples	16	16	16	16	16	13	27	28	28	26	16	16	16	16	16	16	16	16	16	16	362
% Exceedance	12.5%	0.0%	0.0%	0.0%	0.0%	0.0%	11.1%	17.9%	17.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.1%
Fall (∑Rainfall = 2.48 inches)																					
Exceedance	1	0	1	0	0	0	4	6	2	1	1	0	2	1	2	1	1	0	0	0	23.0
No. of Samples	14	14	14	14	14	12	26	26	26	26	14	14	14	14	14	14	14	14	14	14	326
% Exceedance	7.1%	0.0%	7.1%	0.0%	0.0%	0.0%	15.4%	23.1%	7.7%	3.8%	7.1%	0.0%	14.3%	7.1%	14.3%	7.1%	7.1%	0.0%	0.0%	0.0%	7.1%
Winter (∑Rainfall = 3.96 inches)																					
Exceedance	0	1	0	0	0	0	0	2	4	0	0	0	0	1	0	1	2	0	0	0	11.0
No. of Samples	13	13	13	13	13	13	25	25	25	25	13	13	13	13	13	13	13	13	13	13	308
% Exceedance	0.0%	7.7%	0.0%	0.0%	0.0%	0.0%	0.0%	8.0%	16.0%	0.0%	0.0%	0.0%	0.0%	7.7%	0.0%	7.7%	15.4%	0.0%	0.0%	0.0%	3.6%
Spring (∑Rainfall = 0.63 inches)																					
Exceedance	0	0	0	2	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	5.0
No. of Samples	13	13	13	13	13	13	27	27	27	27	13	13	13	13	13	13	13	13	13	13	316
% Exceedance	0.0%	0.0%	0.0%	15.4%	0.0%	0.0%	0.0%	3.7%	3.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.7%	0.0%	0.0%	1.6%

Rainfall data represents information from rain gauge located in Westminster, CA. Data was obtained from National Weather Service provided by NOAA.

CA AB411 exceedances are based on maximum single sample limits of 104 CFU/100mL for enterococci, 400 CFU/100mL for fecal coliform, and 10,000 CFU/100mL for total coliform. All stations were sampled weekly, with the exception of stations 9N 6N, 3N, and 0, which were sampled twice a week.

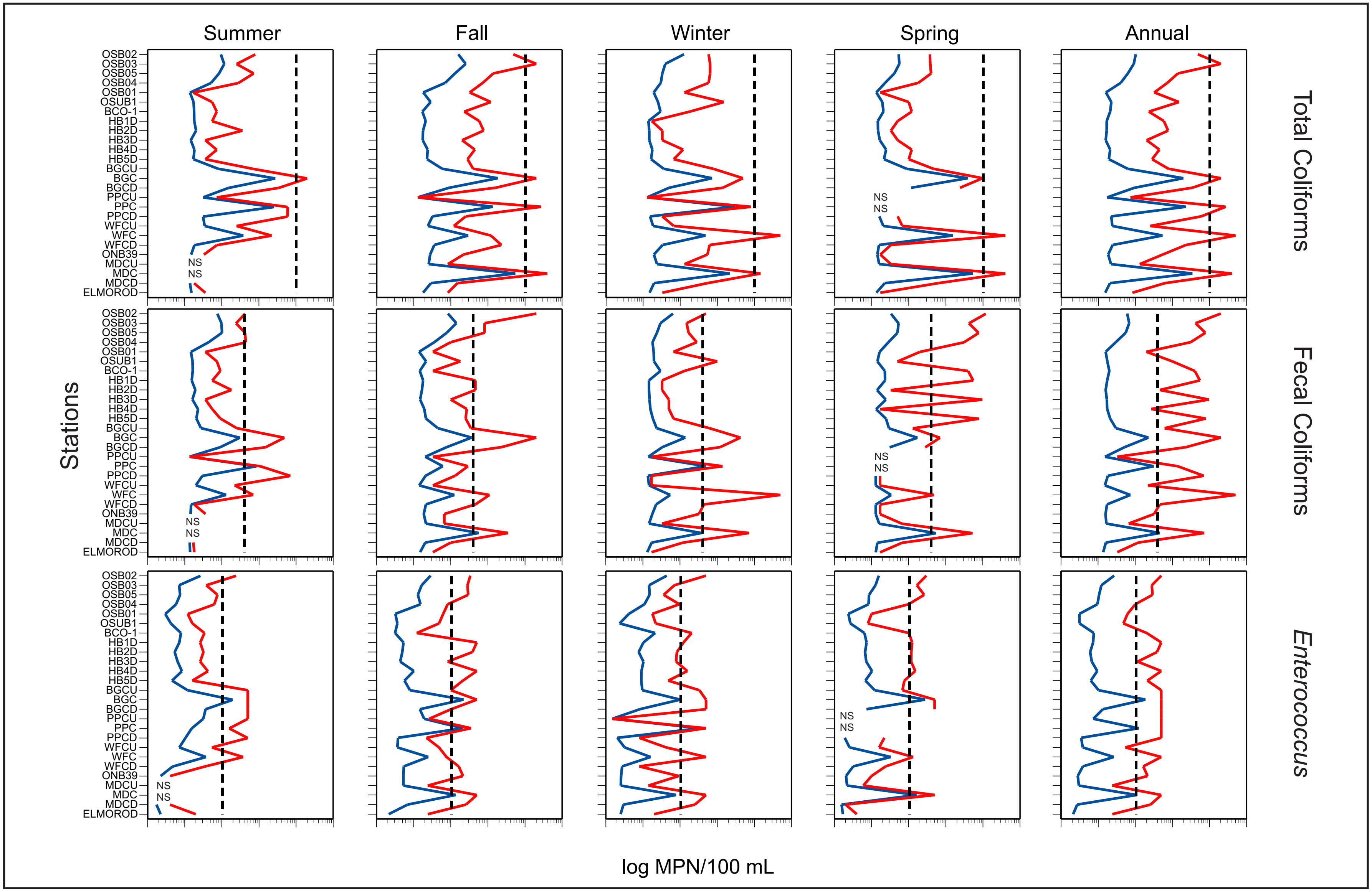


Figure 3-9. **Seasonal distribution of total coliform, fecal coliform, and *Enterococcus* bacteria at the District's regional nearshore (surfzone) water quality stations for July 1, 2012 to June 30, 2013.**

Blue line = geometric mean for the season, red line = maximum value during the season, dashed vertical line = single sample limit.

Orange County Sanitation District, California.

Table 3-8. Summary statistics for regional stations* of surfzone total coliform, fecal coliform, and *Enterococcus* bacteria (CFU/100 mL) by station and seasons during 2012-13.

Orange County Sanitation District, California.

Station	Summer 2012				Fall 2012				Winter 2013				Spring 2013				Annual			
	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev
Total Coliform																				
OSB02	12.75	94.37	800	3.08	12.75	158.17	4800	6.09	17.00	125.70	580	2.78	12.75	53.31	370	3.09	12.75	101.32	4800	3.88
OSB03	33.00	116.55	250	2.10	17.00	250.11	20000	7.12	12.75	39.75	640	3.17	12.75	55.57	380	3.37	12.75	90.42	20000	4.44
OSB05	17.00	84.86	720	3.02	12.75	128.37	1400	3.42	12.75	32.87	640	2.85	12.75	40.64	400	3.32	12.75	62.27	1400	3.47
OSB04	13.50	50.91	280	2.37	12.75	70.00	720	4.06	12.75	30.02	580	3.18	12.75	22.90	180	2.18	12.75	39.99	720	3.12
OSB01	12.75	13.86	17	1.10	12.75	17.97	320	2.47	12.75	19.34	130	1.97	12.75	13.33	17	1.11	12.75	15.92	320	1.78
OSUB1	12.75	17.41	55	1.56	12.75	28.51	1200	4.44	12.75	25.11	1500	3.64	12.75	19.40	100	2.09	12.75	22.18	1500	2.90
BCO-1	12.75	17.98	73	1.78	12.75	17.02	230	2.21	12.75	29.26	180	2.68	12.75	20.75	120	2.22	12.75	20.76	230	2.24
HB1D	12.75	18.15	55	1.76	12.75	20.90	580	3.06	12.75	13.93	17	1.15	12.75	14.63	50	1.49	12.75	16.72	580	1.95
HB2D	12.75	20.33	360	2.58	12.75	17.85	760	3.10	12.75	14.66	33	1.31	12.75	14.83	33	1.33	12.75	16.80	760	2.14
HB3D	12.75	14.62	36	1.32	12.75	17.50	200	2.28	12.75	14.66	33	1.31	12.75	16.62	50	1.56	12.75	15.79	200	1.65
HB4D	12.75	18.38	73	1.76	12.75	23.76	440	2.85	12.75	17.81	120	1.88	12.75	24.40	120	2.29	12.75	20.81	440	2.18
HB5D	12.75	17.19	36	1.40	12.75	22.67	280	2.60	12.75	16.45	67	1.76	12.75	21.36	100	1.96	12.75	19.20	280	1.94
BGCU	12.75	80.63	680	4.36	12.75	58.70	400	2.82	12.75	35.66	780	3.37	12.75	86.83	460	3.51	12.75	61.87	780	3.55
BGC	580.00	2760.89	20000	2.43	720.00	1847.33	20000	2.38	280.00	724.19	4900	2.22	1700.00	3887.04	9750	1.73	280.00	1946.55	20000	2.70
BGCD	12.75	149.70	3375	6.14	12.75	90.36	1600	4.91	12.75	49.97	1400	4.75	12.75	115.10	2400	4.57	12.75	93.92	3375	5.10
PPCU	13.50	31.39	73	3.30	12.75	12.75	12.75	1.00	12.75	12.75	12.75	1.00	-	-	-	-	12.75	17.22	73	2.03
PPC	1100.00	2569.05	6000	3.32	67.00	1344.99	27000	69.54	700.00	2995.55	8000	3.61	-	-	-	-	67.00	2280.65	27000	7.25
PPCD	12.75	31.39	5900	5.11	12.75	31.92	250	2.74	12.75	15.43	33	1.42	12.75	16.09	50	1.66	12.75	22.33	5900	2.83
WFCU	13.50	34.51	250	2.94	12.75	23.94	120	2.37	12.75	18.50	67	1.78	12.75	20.50	67	1.94	12.75	23.66	250	2.29
WFC	100.00	382.57	2200	2.42	15.00	293.60	1200	4.20	11.25	484.57	50000	6.01	150.00	1547.05	40000	4.62	11.25	538.68	50000	4.69
WFCD	12.75	18.32	73	1.72	12.75	35.63	2300	4.78	12.75	33.67	620	3.70	12.75	15.77	33	1.42	12.75	24.26	2300	3.00
ONB39	12.75	14.92	33	1.30	12.75	27.53	220	2.58	12.75	19.55	540	2.81	12.75	14.24	17	1.16	12.75	18.39	540	2.11
MDCU	-	-	-	-	12.75	25.26	83	2.08	12.75	23.72	130	2.34	12.75	15.86	33	1.42	12.75	21.84	130	2.06
MDC	-	-	-	-	400.00	5453.62	40000	5.85	260.00	2161.48	14600	3.20	1000.00	5386.85	40000	4.84	260.00	3425.23	40000	4.32
MDCD	12.75	13.86	18	1.13	12.75	29.09	150	2.79	12.75	19.76	540	2.99	12.75	22.48	625	3.29	12.75	20.57	625	2.63
ELMOROD	12.75	15.29	36	1.33	12.75	17.87	83	1.81	12.75	14.99	33	1.31	12.75	13.33	17	1.11	12.75	15.28	83	1.44

Table 3-8 continues.

Table 3-8 Continued.

Station	Summer 2012				Fall 2012				Winter 2013				Spring 2013				Annual			
	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev
Fecal Coliform																				
OSB02	17.00	75.62	420	2.66	12.75	83.60	20000	5.62	12.75	64.53	500	3.26	12.75	33.64	12000	3.87	12.75	61.22	20000	3.92
OSB03	33.00	97.86	240	1.87	50.00	142.05	820	2.48	12.75	29.83	150	2.43	12.75	53.82	4200	5.03	12.75	68.73	4200	3.33
OSB05	18.00	100.24	420	3.05	17.00	77.96	820	2.77	12.75	24.06	170	2.18	12.75	50.07	7700	5.61	12.75	55.39	7700	3.65
OSB04	12.75	43.59	440	2.87	17.00	36.26	100	1.88	12.75	18.18	280	2.37	12.75	28.48	3100	4.73	12.75	30.08	3100	3.00
OSB01	12.75	14.62	36	1.33	12.75	14.02	33	1.31	12.75	19.47	67	1.82	12.75	16.47	200	2.13	12.75	16.01	200	1.68
OSUB1	12.75	16.14	73	1.60	12.75	21.66	180	2.72	12.75	19.92	1000	3.27	12.75	14.48	50	1.46	12.75	17.82	1000	2.28
BCO-1	12.75	16.42	91	1.70	12.75	14.66	33	1.31	12.75	29.76	130	2.15	12.75	22.97	4000	4.91	12.75	20.14	4000	2.58
HB1D	12.75	15.45	55	1.49	12.75	17.95	460	2.67	12.75	14.66	33	1.31	12.75	23.22	5500	5.20	12.75	17.53	5500	2.66
HB2D	12.75	19.25	180	2.15	12.75	16.80	460	2.70	12.75	14.66	33	1.31	12.75	14.14	33	1.32	12.75	16.13	460	1.92
HB3D	12.75	15.98	36	1.33	12.75	14.94	100	1.77	12.75	15.14	50	1.46	12.75	24.42	9700	6.16	12.75	17.23	9700	2.65
HB4D	12.75	22.79	55	1.85	12.75	19.27	270	2.48	12.75	15.82	50	1.45	12.75	13.38	17	1.12	12.75	17.55	270	1.83
HB5D	12.75	20.62	91	1.86	12.75	21.45	250	2.50	12.75	18.50	67	1.78	12.75	24.82	7900	5.88	12.75	21.23	7900	2.88
BGCU	12.75	27.27	250	3.23	12.75	44.82	350	3.22	12.75	23.58	620	3.24	12.75	29.58	130	2.27	12.75	30.39	620	2.97
BGC	18.00	304.73	4800	4.77	11.25	363.88	20000	5.14	11.25	138.52	4200	4.43	15.00	174.31	700	2.90	11.25	227.47	20000	4.34
BGCD	13.50	89.19	1500	4.57	12.75	77.29	2300	5.20	12.75	33.42	1200	3.68	12.75	30.93	280	2.78	12.75	51.67	2300	4.20
PPCU	13.50	13.50	13.5	1.00	12.75	20.51	33	1.96	12.75	14.03	17	1.18	-	-	-	-	12.75	15.47	33	1.42
PPC	640.00	839.05	1100	1.47	12.75	60.81	290	9.11	250.00	491.87	1400	2.51	-	-	-	-	12.75	315.30	1400	4.77
PPCD	12.75	29.82	7000	5.63	12.75	21.02	130	2.16	12.75	13.63	17	1.13	12.75	13.04	17	1.08	12.75	18.27	7000	2.67
WFCU	12.75	19.96	220	2.33	12.75	14.02	33	1.31	12.75	14.56	17	1.16	12.75	13.04	17	1.08	12.75	15.18	220	1.60
WFC	18.00	129.72	700	3.57	12.75	125.03	1100	4.02	11.25	54.34	50000	10.33	11.25	33.94	480	3.99	11.25	73.95	50000	5.49
WFCD	12.75	14.82	18	1.17	12.75	21.34	460	2.93	12.75	22.73	440	3.12	12.75	13.04	17	1.08	12.75	17.50	460	2.23
ONB39	12.75	14.30	36	1.32	12.75	18.63	67	1.85	12.75	17.97	320	2.47	12.75	13.04	17	1.08	12.75	15.81	320	1.77
MDCU	-	-	-	-	12.75	21.49	67	1.88	12.75	14.66	33	1.31	12.75	16.16	67	1.87	12.75	16.76	67	1.65
MDC	-	-	-	-	92.00	562.45	3500	3.46	11.25	375.63	7200	9.42	31.00	550.06	5300	7.90	11.25	463.73	7200	6.71
MDCD	12.75	13.56	17	1.07	12.75	20.59	100	1.96	12.75	17.21	120	2.01	12.75	14.49	67	1.58	12.75	16.24	120	1.73
ELMOROD	12.75	13.86	18	1.11	12.75	14.99	33	1.31	12.75	13.04	17	1.08	12.75	13.04	17	1.08	12.75	13.71	33	1.18

Table 3-8 continues.

Table 3-8 Continued.

Station	Summer 2012				Fall 2012				Winter 2013				Spring 2013				Annual			
	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev
Enterococcus																				
OSB02	1.5	26.57	242	3.06	2.0	28.59	336	4.77	2.0	43.69	500	3.52	2.0	15.70	300	3.52	2.0	28.59	336	4.77
OSB03	2.0	7.08	38	2.74	1.5	16.42	280	6.87	2.0	14.70	70	2.37	1.5	12.80	166	3.55	1.5	16.42	280	6.87
OSB05	1.5	7.50	76	3.26	1.5	12.94	292	5.05	4.0	15.13	36	1.94	1.5	8.62	262	4.17	1.5	12.94	292	5.05
OSB04	1.5	5.84	62	2.83	4.0	15.24	82	2.46	2.0	10.96	96	3.68	1.5	8.35	100	2.89	4.0	15.24	82	2.46
OSB01	1.5	2.97	12	2.13	1.5	3.21	62	3.41	1.5	4.18	18	2.34	1.5	2.37	10	2.00	1.5	3.21	62	3.41
OSUB1	1.5	4.24	16	2.68	1.5	3.61	48	3.83	1.5	2.36	22	2.31	1.5	2.68	8	1.94	1.5	3.61	48	3.83
BCO-1	2.0	7.93	34	2.22	1.5	3.13	12	2.23	4.0	21.33	204	3.09	1.5	6.46	102	5.29	1.5	3.13	12	2.23
HB1D	1.5	7.11	26	2.59	1.5	5.31	500	5.51	1.5	10.37	124	4.71	1.5	7.35	124	4.10	1.5	5.31	500	5.51
HB2D	1.5	5.35	32	2.76	1.5	4.95	382	4.70	1.5	7.68	82	4.49	1.5	6.73	118	4.16	1.5	4.95	382	4.70
HB3D	1.5	6.43	26	2.98	1.5	4.33	82	3.20	1.5	10.35	78	3.37	1.5	7.18	116	4.83	1.5	4.33	82	3.20
HB4D	1.5	8.40	42	2.83	2.0	10.14	500	5.21	1.5	9.13	156	4.58	2.0	10.29	150	3.29	2.0	10.14	500	5.21
HB5D	1.5	4.56	16	2.57	1.5	5.63	212	4.72	1.5	9.04	48	3.36	1.5	6.82	76	3.50	1.5	5.63	212	4.72
BGCU	1.5	11.87	500	5.19	1.5	7.91	100	4.15	1.5	9.57	332	5.41	1.5	12.22	68	3.27	1.5	7.91	100	4.15
BGC	26.0	195.59	500	2.16	134.0	220.42	500	1.40	36.0	100.23	500	1.98	118.0	279.18	500	1.69	134.0	220.42	500	1.40
BGCD	1.5	36.39	500	6.23	2.0	14.60	102	3.41	1.5	8.20	500	7.15	1.5	7.26	500	5.54	2.0	14.60	102	3.41
PPCU	2.0	31.62	500	49.61	14.0	19.08	26	1.55	1.5	1.50	1.5	1.00	-	-	-	-	14.0	19.08	26	1.55
PPC	1.5	15.39	158	26.93	128.0	211.05	348	2.03	168.0	347.60	500	1.88	-	-	-	-	128.0	211.05	348	2.03
PPCD	1.5	10.41	500	5.19	1.5	3.77	22	2.73	1.5	2.03	8	1.86	1.5	1.89	22	2.10	1.5	3.77	22	2.73
WFCU	1.5	7.16	54	3.82	1.5	3.61	48	2.70	1.5	3.22	42	3.14	1.5	2.57	16	2.14	1.5	3.61	48	2.70
WFC	6.0	37.13	376	2.91	2.0	24.77	76	2.93	1.5	16.03	500	4.73	8.0	32.78	132	2.76	2.0	24.77	76	2.93
WFCD	1.5	4.67	34	2.67	1.5	5.41	164	5.39	1.5	2.74	8	1.89	1.5	3.20	24	2.45	1.5	5.41	164	5.39
ONB39	1.5	2.24	4	1.62	1.5	5.31	214	4.63	1.5	2.58	92	3.19	1.5	2.06	10	1.82	1.5	5.31	214	4.63
MDCU	-	-	-	-	1.5	5.30	24	2.55	1.5	2.52	14	1.99	1.5	2.19	6	1.77	1.5	5.30	24	2.55
MDC	-	-	-	-	14.0	135.23	500	3.83	14.0	78.01	500	3.22	24.0	162.51	500	3.49	14.0	135.23	500	3.83
MDCD	1.5	1.74	4	1.45	1.5	6.83	256	5.41	1.5	2.98	250	4.37	1.5	1.57	2	1.11	1.5	6.83	256	5.41
ELMOROD	1.5	2.23	20	2.12	1.5	2.12	24	2.10	1.5	2.50	20	2.44	1.5	1.69	4	1.32	1.5	2.12	24	2.10

*Stations designated with a U (25 yards upcoast) or a D (25 yards downcoast) in the station name represent the distance from the nominal station position freshwater-ocean interface. These stations are sampled when creeks/storm drains are flowing. When flow is not observed at the interface, a single sample is collected at the downcoast station.

Table 3-9. Summary of quarterly water quality parameters by depth strata and season during 2012-13.

Orange County Sanitation District, California.

Depth (m)	Summer 2012				Fall 2012				Winter 2013				Spring 2013				Annual			
	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev
Temperature (°C)																				
1-15	12.61	18.02	20.81	1.36	14.64	17.61	19.09	0.73	11.95	13.46	14.67	0.44	13.85	17.56	19.57	1.21	11.95	16.66	20.81	2.12
16-30	11.40	14.32	19.83	1.72	13.09	15.65	18.22	1.08	11.35	12.72	13.85	0.57	10.32	13.78	18.27	1.87	10.32	14.12	19.83	1.76
31-45	10.90	12.34	15.44	1.06	12.35	13.74	16.49	0.69	10.43	11.84	13.55	0.59	9.94	11.11	12.68	0.56	9.94	12.25	16.49	1.22
46-60	10.48	11.65	14.02	0.97	11.83	12.80	14.05	0.42	10.22	11.24	12.56	0.65	9.63	10.38	11.14	0.33	9.63	11.51	14.05	1.08
61-75	10.25	11.24	12.96	0.82	11.34	12.16	13.05	0.39	10.09	10.93	12.14	0.65	9.51	10.06	10.62	0.23	9.51	11.10	13.05	0.94
76-80	10.26	11.12	12.45	0.77	11.31	11.87	12.47	0.35	10.07	10.76	11.85	0.63	9.51	9.99	10.29	0.20	9.51	10.89	12.47	0.87
All	10.25	14.40	20.81	2.96	11.31	15.10	19.09	2.16	10.07	12.37	14.67	1.08	9.51	13.53	19.57	3.19	9.51	13.84	20.81	2.69
delta T (°C)																				
1-15	-0.50	0.21	1.86	0.26	-0.20	0.07	0.75	0.11	-0.25	0.05	0.75	0.08	-0.08	0.14	2.22	0.24	-0.50	0.12	2.22	0.20
16-30	-0.04	0.23	1.52	0.20	-0.06	0.18	1.37	0.17	-0.12	0.06	0.84	0.09	-0.03	0.29	1.76	0.25	-0.12	0.19	1.76	0.20
31-45	-0.07	0.07	0.94	0.09	-0.15	0.09	0.81	0.11	-0.10	0.06	0.59	0.07	-0.27	0.08	0.45	0.08	-0.27	0.07	0.94	0.09
46-60	-0.06	0.03	0.49	0.05	-0.14	0.04	0.28	0.05	-0.10	0.03	0.24	0.04	-0.06	0.03	0.19	0.04	-0.14	0.03	0.49	0.04
61-75	-0.01	0.03	0.33	0.04	-0.07	0.04	0.21	0.04	-0.05	0.02	0.17	0.02	-0.10	0.01	0.14	0.02	-0.10	0.03	0.33	0.03
76-80	-0.01	0.02	0.17	0.03	-0.01	0.02	0.07	0.02	0.00	0.03	0.09	0.03	-0.02	0.01	0.10	0.02	-0.02	0.02	0.17	0.02
All	-0.50	0.15	1.86	0.20	-0.20	0.10	1.37	0.13	-0.25	0.05	0.84	0.07	-0.27	0.14	2.22	0.21	-0.50	0.11	2.22	0.17
Density (kg/m^3)																				
1-15	23.24	24.10	25.27	0.33	23.91	24.22	24.79	0.16	24.67	25.12	25.47	0.12	23.82	24.32	25.14	0.27	23.24	24.44	25.47	0.47
16-30	23.65	24.90	25.55	0.38	24.11	24.62	25.13	0.21	25.03	25.29	25.59	0.12	24.16	25.10	25.85	0.39	23.65	24.98	25.85	0.39
31-45	24.60	25.31	25.67	0.26	24.50	25.01	25.31	0.13	25.12	25.49	25.86	0.14	25.32	25.66	26.00	0.14	24.50	25.37	26.00	0.30
46-60	24.91	25.48	25.81	0.24	25.00	25.24	25.44	0.08	25.33	25.67	26.01	0.17	25.62	25.86	26.12	0.11	24.91	25.56	26.12	0.28
61-75	25.13	25.59	25.87	0.22	25.24	25.41	25.61	0.07	25.45	25.78	26.04	0.18	25.82	25.98	26.19	0.08	25.13	25.69	26.19	0.26
76-80	25.26	25.62	25.88	0.21	25.39	25.49	25.62	0.06	25.52	25.83	26.08	0.19	25.92	26.02	26.19	0.07	25.26	25.75	26.19	0.25
All	23.24	24.88	25.88	0.65	23.91	24.75	25.62	0.46	24.67	25.39	26.08	0.27	23.82	25.17	26.19	0.69	23.24	25.05	26.19	0.60

Table 3-9 continues.

Table 3-9 continued.

Depth (m)	Summer 2012				Fall 2012				Winter 2013				Spring 2013				Annual			
	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev
Salinity (psu)																				
1-15	32.12	33.49	33.58	0.08	32.96	33.50	33.60	0.07	33.21	33.48	33.54	0.06	33.45	33.62	33.67	0.03	32.12	33.52	33.67	0.08
16-30	33.27	33.44	33.55	0.06	33.29	33.44	33.57	0.06	33.43	33.51	33.59	0.02	33.45	33.55	33.78	0.05	33.27	33.49	33.78	0.07
31-45	33.29	33.45	33.56	0.07	33.25	33.41	33.53	0.05	33.43	33.55	33.74	0.05	33.43	33.59	33.78	0.07	33.25	33.50	33.78	0.09
46-60	33.32	33.49	33.64	0.08	33.30	33.46	33.55	0.05	33.48	33.64	33.84	0.08	33.48	33.68	33.88	0.08	33.30	33.57	33.88	0.12
61-75	33.36	33.53	33.68	0.09	33.38	33.51	33.66	0.05	33.53	33.70	33.84	0.09	33.63	33.77	33.92	0.06	33.36	33.63	33.92	0.13
76-80	33.39	33.55	33.73	0.10	33.44	33.56	33.66	0.05	33.53	33.73	33.90	0.10	33.72	33.80	33.92	0.05	33.39	33.66	33.92	0.14
All	32.12	33.47	33.73	0.08	32.96	33.47	33.66	0.07	33.21	33.55	33.90	0.10	33.43	33.62	33.92	0.09	32.12	33.53	33.92	0.11
Dissolved Oxygen (mg/L)																				
1-15	6.68	8.25	9.41	0.44	6.38	7.77	8.56	0.26	5.45	8.34	10.11	0.88	5.81	8.13	12.79	1.04	5.45	8.13	12.79	0.76
16-30	5.39	7.88	9.56	0.88	5.98	7.56	8.39	0.51	4.71	6.94	9.66	0.88	5.02	8.06	10.91	0.98	4.71	7.61	10.91	0.94
31-45	4.79	6.54	8.78	1.06	5.54	6.63	8.02	0.55	3.82	5.56	7.98	0.84	4.03	5.61	7.87	0.80	3.82	6.08	8.78	0.97
46-60	4.25	5.69	7.89	1.01	5.18	5.98	7.00	0.38	3.61	4.76	6.84	0.77	3.74	4.67	5.98	0.39	3.61	5.27	7.89	0.89
61-75	4.00	5.23	7.26	0.92	4.37	5.39	6.44	0.39	3.50	4.37	5.71	0.61	3.54	4.19	4.93	0.29	3.50	4.80	7.26	0.80
76-80	3.66	5.13	6.94	0.93	4.39	5.16	6.06	0.34	3.38	4.22	5.39	0.62	3.47	3.97	4.50	0.22	3.38	4.60	6.94	0.80
All	3.66	7.16	9.56	1.41	4.37	6.98	8.56	0.96	3.38	6.51	10.11	1.70	3.47	6.72	12.79	1.84	3.38	6.84	12.79	1.53
Dissolved Oxygen Saturation (%)																				
1-15	77.56	106.52	116.86	4.67	79.97	99.55	108.14	3.38	62.44	98.56	120.32	11.02	74.98	103.97	161.56	11.72	62.44	102.18	161.56	9.13
16-30	61.15	94.87	115.04	12.66	71.69	93.31	106.36	7.04	53.21	80.85	114.03	11.12	56.43	96.06	137.04	13.61	53.21	91.27	137.04	12.91
31-45	53.61	75.71	101.48	13.90	65.03	78.68	96.67	7.01	42.38	63.66	94.29	10.37	45.03	63.14	90.21	9.40	42.38	70.25	101.48	12.58
46-60	47.18	64.90	93.33	12.89	60.11	69.57	81.54	4.35	39.92	53.80	79.28	9.46	41.38	51.77	66.62	4.38	39.92	59.94	93.33	11.35
61-75	44.46	59.19	84.78	11.47	50.13	61.92	73.48	4.43	38.78	49.12	65.53	7.54	39.04	46.16	54.53	3.20	38.78	54.10	84.78	9.91
76-80	40.68	57.91	80.17	11.41	50.19	58.98	68.38	3.73	37.29	47.26	61.43	7.57	38.34	43.61	49.44	2.33	37.29	51.71	80.17	9.79
All	40.68	86.90	116.86	20.82	50.13	85.62	108.14	14.68	37.29	75.62	120.32	21.16	38.34	80.52	161.56	25.48	37.29	82.15	161.56	21.37

Table 3-9 continues.

Table 3-9 continued.

Depth (m)	Summer 2012				Fall 2012				Winter 2013				Spring 2013				Annual			
	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev
pH (pH units)																				
1-15	7.82	8.14	8.31	0.13	8.02	8.18	8.34	0.07	8.03	8.23	8.40	0.10	8.07	8.19	8.25	0.03	7.82	8.18	8.40	0.10
16-30	7.78	8.05	8.31	0.14	7.92	8.16	8.35	0.08	7.94	8.13	8.36	0.08	7.81	8.12	8.24	0.10	7.78	8.12	8.36	0.11
31-45	7.70	7.91	8.26	0.13	7.88	8.10	8.31	0.10	7.83	8.02	8.24	0.08	7.76	7.89	8.08	0.07	7.70	7.98	8.31	0.13
46-60	7.64	7.82	8.03	0.09	7.86	8.04	8.23	0.08	7.83	7.96	8.13	0.08	7.74	7.83	7.93	0.04	7.64	7.91	8.23	0.12
61-75	7.59	7.76	7.90	0.09	7.80	7.99	8.17	0.08	7.81	7.93	8.06	0.07	7.73	7.80	7.88	0.03	7.59	7.87	8.17	0.12
76-80	7.58	7.73	7.85	0.08	7.78	7.96	8.10	0.08	7.80	7.91	8.01	0.07	7.72	7.78	7.84	0.03	7.58	7.84	8.10	0.11
All	7.58	7.99	8.31	0.19	7.78	8.12	8.35	0.10	7.80	8.09	8.40	0.14	7.72	8.02	8.25	0.17	7.58	8.06	8.40	0.16
Light Transmission (%)																				
1-15	6.58	81.13	85.95	4.25	65.94	86.44	88.86	2.59	63.69	79.87	88.77	6.71	75.45	85.49	89.30	2.15	6.58	83.19	89.30	5.15
16-30	53.47	79.88	86.74	4.53	57.98	84.88	88.72	3.69	68.97	84.26	89.05	3.99	67.90	81.78	87.70	3.49	53.47	82.70	89.05	4.42
31-45	73.39	83.06	88.79	2.85	80.00	86.30	88.60	1.43	75.86	86.05	89.26	1.92	71.91	85.02	88.79	2.35	71.91	85.12	89.26	2.54
46-60	76.38	84.56	89.03	3.06	83.87	87.54	89.45	0.91	82.55	86.36	89.54	1.55	81.45	87.18	89.49	1.76	76.38	86.41	89.54	2.28
61-75	79.53	84.82	89.37	2.76	84.36	87.96	89.62	0.91	82.11	86.91	89.66	1.70	81.23	87.29	89.52	2.11	79.53	86.75	89.66	2.31
76-80	80.07	84.41	89.27	2.61	84.74	87.97	89.60	0.90	83.15	87.16	89.67	1.81	81.40	86.46	89.51	2.61	80.07	86.45	89.67	2.50
All	6.58	82.03	89.37	4.23	57.98	86.33	89.62	2.70	63.69	83.86	89.67	5.17	67.90	84.85	89.52	3.26	6.58	84.26	89.67	4.26
Beam C (1/m)																				
1-15	0.61	0.85	14.94	0.42	0.47	0.58	1.67	0.13	0.48	0.91	1.81	0.34	0.49	0.63	1.13	0.10	0.47	0.75	14.94	0.32
16-30	0.57	0.91	2.50	0.24	0.48	0.66	2.18	0.19	0.46	0.69	1.49	0.20	0.53	0.81	1.54	0.17	0.46	0.77	2.50	0.22
31-45	0.48	0.74	1.24	0.14	0.48	0.59	0.89	0.07	0.46	0.60	1.11	0.09	0.48	0.65	1.32	0.11	0.46	0.65	1.32	0.12
46-60	0.47	0.67	1.08	0.15	0.45	0.53	0.70	0.04	0.44	0.59	0.77	0.07	0.44	0.55	0.82	0.08	0.44	0.59	1.08	0.11
61-75	0.45	0.66	0.92	0.13	0.44	0.51	0.68	0.04	0.44	0.56	0.79	0.08	0.44	0.54	0.83	0.10	0.44	0.57	0.92	0.11
76-80	0.45	0.68	0.89	0.12	0.44	0.51	0.66	0.04	0.44	0.55	0.74	0.08	0.44	0.58	0.82	0.12	0.44	0.58	0.89	0.12
All	0.45	0.80	14.94	0.30	0.44	0.59	2.18	0.13	0.44	0.71	1.81	0.26	0.44	0.66	1.54	0.16	0.44	0.69	14.94	0.24

Table 3-9 continues.

Table 3-9 continued.

Depth (m)	Summer 2012				Fall 2012				Winter 2013				Spring 2013				Annual			
	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev
Photosynthetically Active Radiation (PAR, %)																				
1-15	3.35	21.98	100.00	20.54	2.23	21.51	100.00	15.86	0.53	23.93	100.00	25.75	3.10	26.91	100.00	17.88	0.53	23.57	100.00	20.49
16-30	0.11	3.56	15.57	2.62	0.65	5.07	14.98	2.70	0.07	3.83	38.18	4.65	0.32	5.98	19.12	3.96	0.07	4.61	38.18	3.71
31-45	0.06	0.49	2.60	0.43	0.18	1.17	6.08	0.78	0.06	1.02	7.84	1.09	0.16	0.83	3.44	0.53	0.06	0.88	7.84	0.80
46-60	0.04	0.13	0.49	0.08	0.08	0.42	2.52	0.39	0.05	0.30	1.81	0.28	0.10	0.32	1.12	0.18	0.04	0.29	2.52	0.28
61-75	0.04	0.07	0.19	0.03	0.06	0.27	2.07	0.35	0.03	0.11	0.52	0.08	0.06	0.22	0.63	0.14	0.03	0.17	2.07	0.21
76-80	0.04	0.06	0.21	0.03	0.05	0.23	1.80	0.35	0.02	0.09	0.18	0.04	0.06	0.19	0.57	0.14	0.02	0.14	1.80	0.20
All	0.04	7.85	100.00	14.96	0.05	8.12	100.00	12.57	0.02	8.46	100.00	17.64	0.06	9.89	100.00	15.16	0.02	8.58	100.00	15.22
Colored Dissolved Organic Matter (CDOM, µg/L)																				
1-15	1.07	1.75	22.13	0.94	0.15	1.60	4.66	0.76	0.73	1.71	3.34	0.66	0.17	2.56	4.99	1.35	0.15	1.92	22.13	1.06
16-30	1.07	2.59	4.55	0.60	0.20	2.12	5.00	0.91	0.96	1.69	4.74	0.54	0.57	3.78	7.28	1.74	0.20	2.62	7.28	1.34
31-45	1.86	2.97	5.81	0.61	0.87	2.85	6.64	1.16	1.06	2.08	5.18	0.79	1.05	4.37	8.59	2.13	0.87	3.15	8.59	1.57
46-60	2.19	2.77	5.86	0.64	1.17	2.51	5.85	0.83	1.15	1.71	4.51	0.54	1.01	4.01	7.85	1.95	1.01	2.83	7.85	1.42
61-75	2.19	2.50	3.94	0.22	1.17	2.32	3.05	0.64	1.20	1.51	1.98	0.17	1.09	3.75	5.30	1.73	1.09	2.61	5.30	1.24
76-80	2.21	2.46	2.85	0.14	1.31	2.33	2.90	0.63	1.28	1.51	1.78	0.16	1.16	3.60	5.26	1.78	1.16	2.63	5.26	1.26
All	1.07	2.41	22.13	0.84	0.15	2.17	6.64	0.99	0.73	1.75	5.18	0.63	0.17	3.54	8.59	1.87	0.15	2.53	22.13	1.38
Chlorophyll-*a* (µg/L)																				
1-15	0.19	0.90	17.05	1.07	0.54	2.04	16.39	1.75	0.34	10.46	54.19	12.11	0.58	2.34	13.50	2.07	0.19	3.94	54.19	7.32
16-30	0.25	3.10	24.46	3.49	0.71	4.86	15.79	2.87	0.23	4.35	45.87	5.92	1.36	11.46	75.52	10.73	0.23	5.93	75.52	7.28
31-45	0.40	1.36	6.21	0.78	1.16	4.05	10.86	1.82	0.12	1.34	8.08	0.91	0.61	5.06	68.07	5.52	0.12	2.94	68.07	3.38
46-60	0.25	0.63	1.66	0.24	0.77	1.74	5.00	0.73	0.09	0.66	2.49	0.46	0.31	1.34	3.20	0.65	0.09	1.09	5.00	0.73
61-75	0.17	0.43	1.52	0.20	0.47	0.94	2.51	0.30	0.08	0.42	1.31	0.31	0.27	0.69	1.55	0.30	0.08	0.62	2.51	0.35
76-80	0.17	0.37	0.84	0.16	0.43	0.70	1.11	0.16	0.07	0.32	1.05	0.24	0.28	0.58	1.02	0.23	0.07	0.50	1.11	0.25
All	0.17	1.47	24.46	2.17	0.43	2.98	16.39	2.43	0.07	4.68	54.19	8.37	0.27	4.91	75.52	7.38	0.07	3.51	75.52	5.98

Table 3-9 continues.

Table 3-9 continued.

Depth (m)	Summer 2012				Fall 2012				Winter 2013				Spring 2013				Annual			
	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev
Ammonia (mg/L)																				
1-15	<0.02	0.027	0.990	0.090	<0.02	<0.02	0.030	0.002	<0.02	<0.02	0.090	0.008	<0.02	<0.02	0.060	0.005	<0.02	<0.02	0.990	0.044
16-30	<0.02	<0.02	0.110	0.014	<0.02	<0.02	0.100	0.011	<0.02	0.022	0.170	0.021	<0.02	0.021	0.180	0.021	<0.02	0.020	0.180	0.017
31-45	<0.02	0.030	0.180	0.040	<0.02	0.030	0.170	0.039	<0.02	0.029	0.150	0.032	<0.02	0.031	0.210	0.035	<0.02	0.030	0.210	0.036
46-60	<0.02	0.024	0.180	0.026	<0.02	0.021	0.150	0.021	<0.02	0.019	0.170	0.018	<0.02	0.024	0.130	0.021	<0.02	0.022	0.180	0.022
61-75	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
All	<0.02	0.024	0.990	0.057	<0.02	0.019	0.170	0.018	<0.02	0.020	0.170	0.019	<0.02	0.021	0.210	0.020	<0.02	0.021	0.990	0.032
Total Coliform (MPN/100 mL)																				
1-15	<10	<10	20	1.2	<10	<10	110	1.5	<10	<10	10	1.0	<10	<10	504	1.9	<10	<10	504	1.5
16-30	<10	<10	31	1.4	<10	11	275	2.6	<10	13	1,112	3.2	<10	10	1,071	2.8	<10	11	1,112	2.5
31-45	<10	<10	96	2.0	<10	26	754	6.7	<10	70	1,112	8.6	<10	39	1,780	6.6	<10	28	1,780	6.4
46-60	<10	<10	41	1.6	<10	17	663	3.6	<10	29	1,720	5.4	<10	42	2,603	7.9	<10	20	2,603	4.7
61-75	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
All	<10	<10	96	1.5	<10	12	754	3.0	<10	15	1,720	4.1	<10	14	2,603	4.2	<10	12	2,603	3.2
Fecal Coliform (MPN/100 mL)																				
1-15	<10	<10	<10	1.0	<10	<10	<10	1.0	<10	<10	11	1.1	<10	<10	94	1.5	<10	<10	94	1.2
16-30	<10	<10	11	1.1	<10	<10	81	1.7	<10	<10	336	2.0	<10	<10	156	1.8	<10	<10	336	1.7
31-45	<10	<10	11	1.1	<10	16	217	3.7	<10	32	299	5.0	<10	14	293	3.2	<10	15	299	3.5
46-60	<10	<10	11	1.1	<10	<10	149	2.0	<10	15	234	2.9	<10	17	385	4.0	<10	12	385	2.6
61-75	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
All	<10	<10	11	1.1	<10	9	217	1.9	<10	11	336	2.5	<10	10	385	2.3	<10	9	385	2.0
***Enterococcus* (MPN/100 mL)**																				
1-15	<10	<10	31	1.3	<10	<10	10	1.1	<10	<10	223	1.9	<10	<10	30	1.3	<10	<10	223	1.4
16-30	<10	<10	10	1.1	<10	<10	41	1.4	<10	<10	86	2.0	<10	<10	20	1.2	<10	<10	86	1.5
31-45	<10	<10	10	1.1	<10	<10	20	1.4	<10	16	75	2.5	<10	<10	41	1.6	<10	10	75	1.8
46-60	<10	<10	10	1.1	<10	<10	10	1.1	<10	10	109	1.9	<10	<10	20	1.3	<10	<10	109	1.4
61-75	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
All	<10	<10	31	1.2	<10	<10	41	1.2	<10	10	223	2.0	<10	8	41	1.3	<10	8	223	1.5

ns = No sample.

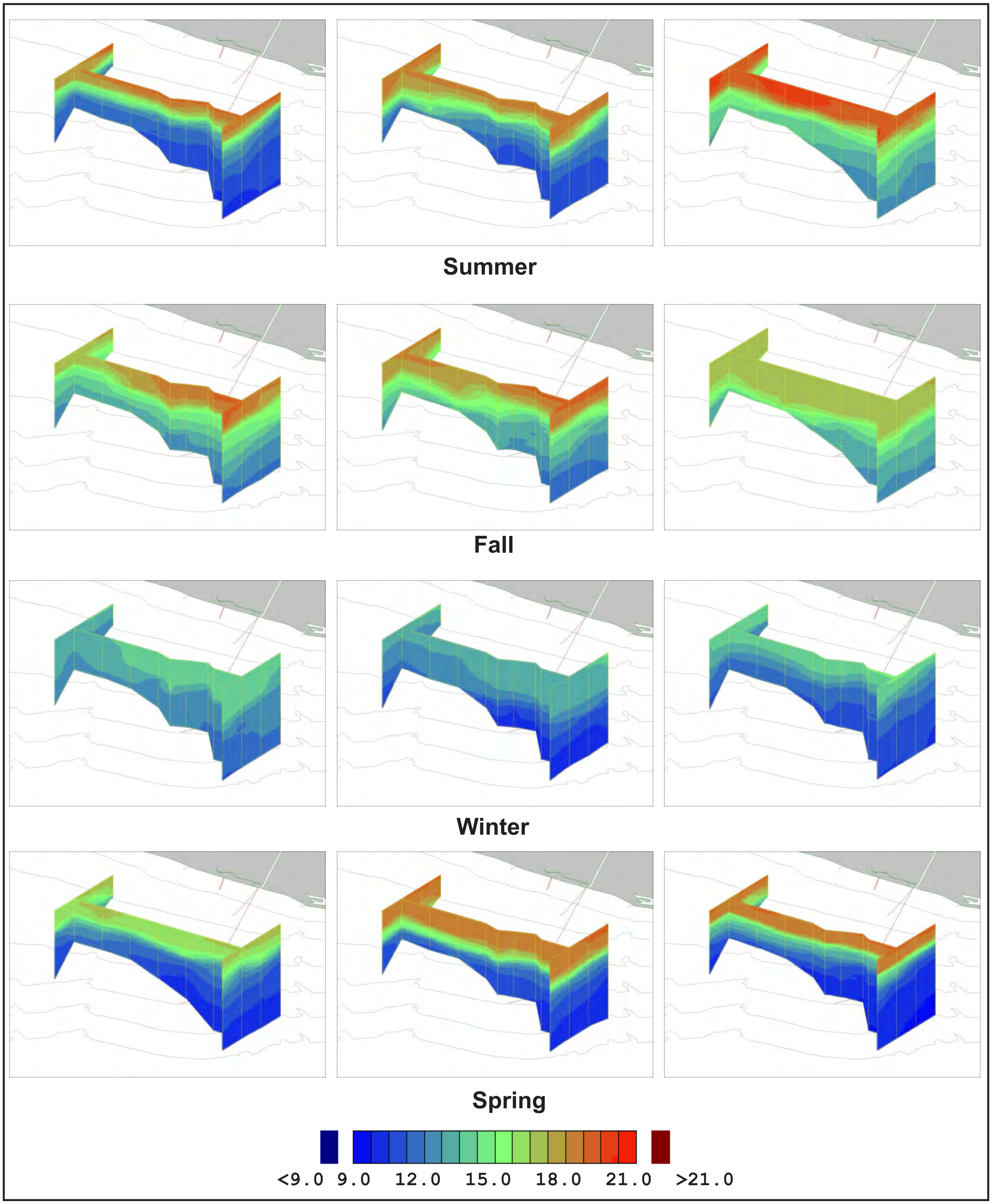


Figure 3-10. **Seasonal patterns of temperature (°C) for summer (July 19, August 7, and September 19, 2012), fall (October 30, November 6, and December 4, 2012), winter (January 30, February 26, and March 11, 2013), and spring (April 29, May 20, and June 13, 2013).**

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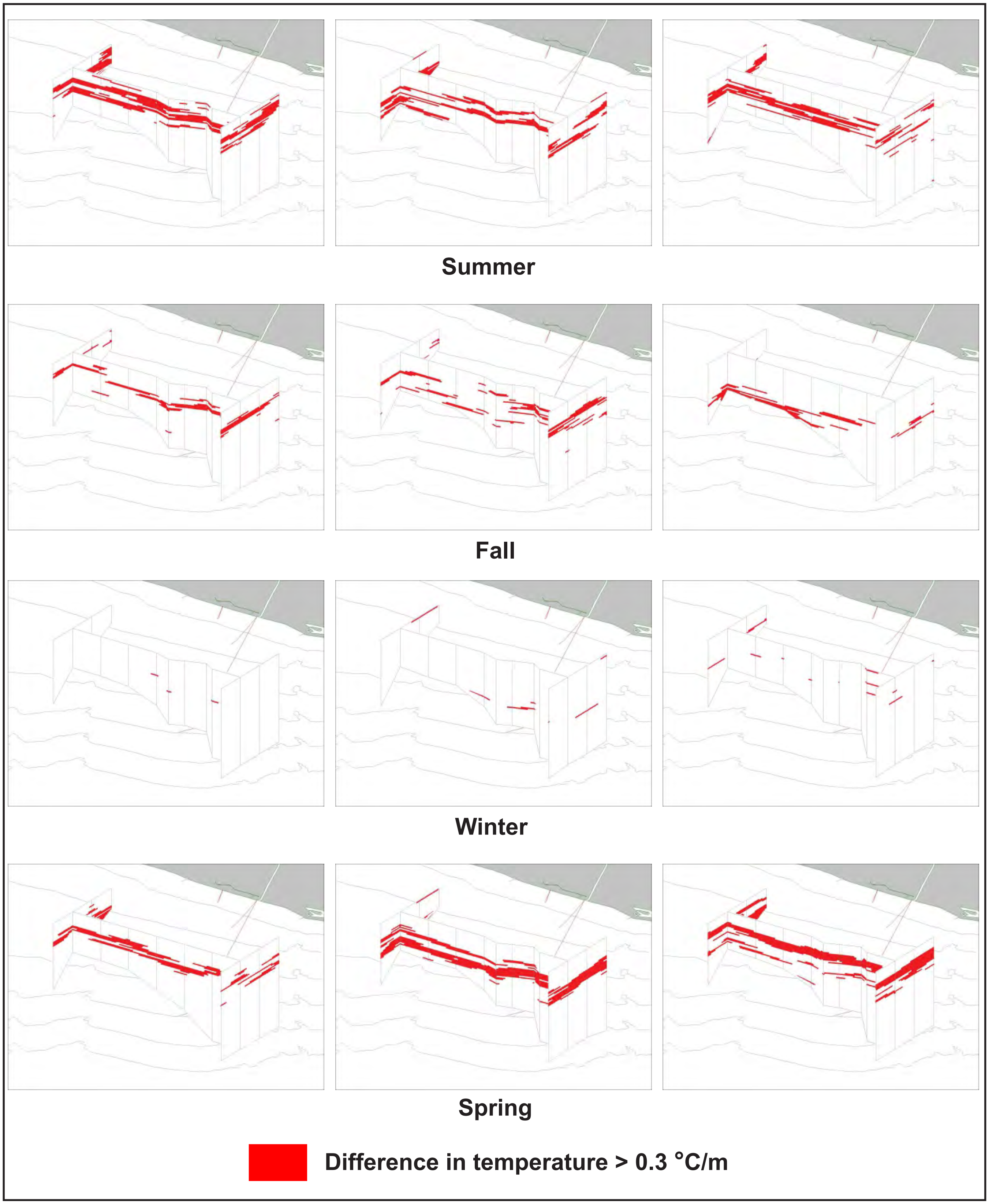

Figure 3-11. **Seasonal patterns of thermocline depth for summer (July 19, August 7, and September 19, 2012), fall (October 30, November 6, and December 4, 2012), winter (January 30, February 26, and March 11, 2013), and spring (April 29, May 20, and June 13, 2013).**

The thermocline is defined as change in temperature >0.3 °C/m.

Orange County Sanitation District, California.

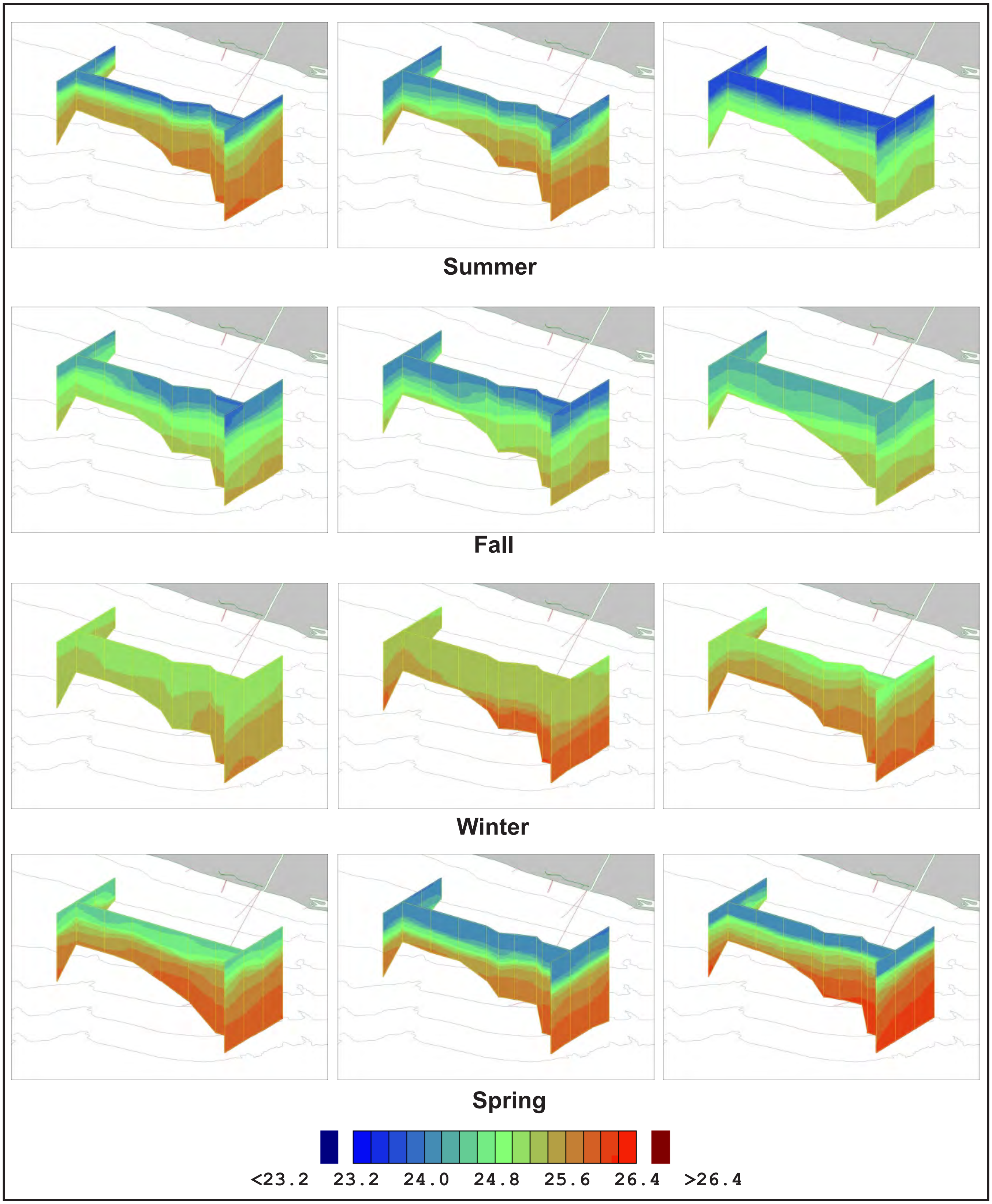

Figure 3-12. **Seasonal patterns of density (kg/m^3) for summer (July 19, August 7, and September 19, 2012), fall (October 30, November 6, and December 4, 2012), winter (January 30, February 26, and March 11, 2013), and spring (April 29, May 20, and June 13, 2013).**

Orange County Sanitation District, California.

to differences seen at depths below 30 m. Stratification, though, remained strong throughout the season. By January, stratification had ended and remained so for the remainder of the season. Temperature and density showed small surface to bottom variability, compared to the previous two seasons. By April, stratification was re-established, which was reflected in both temperature and density values above 30 m.

The predicted plume impact would be a slight increase in water temperature and a decrease in density after mixing. These direct effects might be offset by the entrainment of colder, denser water as the buoyant plume rises in the water column. Profiles for outfall Station 2205 all fell within measured values from stations not impacted by the discharge (Figures B-13 and B-15) and the calculated temperature change (Table 3-1) was within natural variability. However, median values for temperature/density, were slightly lower/higher below 30 m for each season indicating that entrainment might be affecting water conditions near the outfall.

Overall, for temperature and density, the ranges, mean values, and spatial and temporal patterns for 2012-13 were typical of long-term District observations (OCSD 1996b, 2004; SAIC 2009).

Salinity
For 2012-13, salinity values had a narrow range with minimum and maximum values of 32.12 and 33.92 psu, respectively (Table 3-9). A prominent feature from July to November was the presence of a layer of lower salinity water between 15 and 45 m (Figure 3-13). This water is a combination of discharged effluent and regional, subarctic water described above. By January, this layer was no longer present and higher salinity water, associated with colder, denser waters, was seen at depth. The subsurface low salinity feature reformed in April, while the higher salinity waters at depth remained in place. Other features seen throughout the year included reductions in surface salinity in March, most likely due to runoff from land.

The plume is essentially a freshwater source discharged into saline waters, so a primary plume signature is the reduction in salinity after initial dilution (Table 3-1). Discharge-related decreases in salinity were apparent each quarter below the pycnocline or at mid-depth (e.g., Figure 3-13, October survey). Except during fall, at depths below 30 m, changes were not significantly different from non-outfall stations (Figure B-16).

As was the case for temperature, the general patterns and ranges for salinity were consistent with long-term monitoring (e.g., summarized in OCSD 1996b, 2004).

Dissolved Oxygen
Water temperature, salinity, depth, and biological activity all influence dissolved oxygen concentrations. Nearly 84% of the annual DO values were above 5 mg/L with no hypoxic conditions (Table 3-10). While the average and median seasonal DO values generally decreased with depth for all seasons (Table 3-9; Figures 3-14, B-17, and B-18), a feature often seen is a subsurface oxygen maximum around 25 m. This was apparent in the summer, less so in the fall, and not present in the winter. The subsurface maximum re-established in spring and was strongest in June. Variability in summer oxygen values was driven by the change seen in September when oxygen below 30 m increased by up to 2 mg/L. Fall surveys were comparable with the exception of higher oxygen values seen

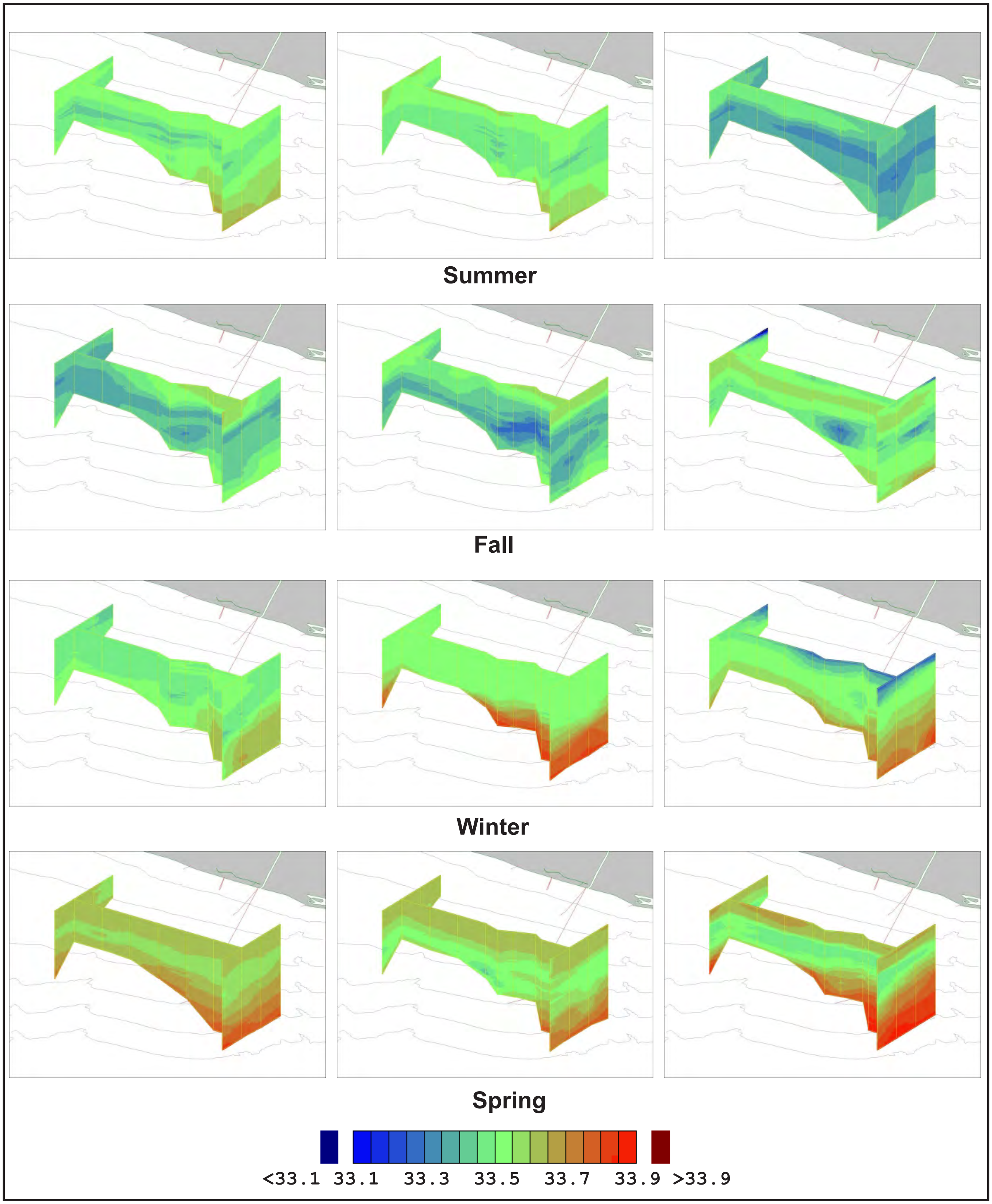

Figure 3-13. **Seasonal patterns of salinity (psu) for summer (July 19, August 7, and September 19, 2012), fall (October 30, November 6, and December 4, 2012), winter (January 30, February 26, and March 11, 2013), and spring (April 29, May 20, and June 13, 2013).**

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Table 3-10. Hypoxia levels* based on Core dissolved oxygen concentrations (mg/L) by season and depth category calculated as percent of total for the District's Water Quality Monitoring Program, July 2012–June 2013.

Orange County Sanitation District, California.

Depth Strata (m)	<3 mg/L	3-5 mg/L	5-8 mg/L	≥8 mg/L	Total	N
Summer						
1-15	0.00	0.00	7.69	23.27	30.96	1,426
16-30	0.00	0.00	9.51	16.76	26.27	1,210
31-45	0.00	0.22	16.17	1.43	17.82	821
46-60	0.00	4.15	9.23	0.00	13.37	616
61-75	0.00	6.19	3.84	0.00	10.03	462
76-80	0.00	0.91	0.63	0.00	1.54	71
All	0.00	11.46	47.07	41.47	100.00	
N	0	528	2,168	1,910		4,606
Fall						
1-15	0.00	0.00	24.63	5.44	30.07	1,365
16-30	0.00	0.00	20.40	6.23	26.63	1,209
31-45	0.00	0.00	18.02	0.04	18.06	820
46-60	0.00	0.00	13.61	0.00	13.61	618
61-75	0.00	1.30	8.88	0.00	10.18	462
76-80	0.00	0.40	1.06	0.00	1.45	66
All	0.00	1.70	86.59	11.72	100.00	
N	0	77	3,931	532		4,540
Winter						
1-15	0.00	0.00	11.60	18.59	30.19	1,395
16-30	0.00	0.17	23.46	2.47	26.10	1,206
31-45	0.00	6.04	12.25	0.00	18.29	845
46-60	0.00	9.48	4.59	0.00	14.07	650
61-75	0.00	7.55	2.45	0.00	10.00	462
76-80	0.00	1.08	0.28	0.00	1.36	63
All	0.00	24.32	54.62	21.06	100.00	
N	0	1,124	2,524	973		4,621
Spring						
1-15	0.00	0.00	13.85	16.21	30.06	1,365
16-30	0.00	0.00	9.34	17.11	26.45	1,201
31-45	0.00	4.10	13.98	0.00	18.08	821
46-60	0.00	10.88	2.62	0.00	13.50	613
61-75	0.00	10.17	0.00	0.00	10.17	462
76-80	0.00	1.74	0.00	0.00	1.74	79
All	0.00	26.89	39.79	33.32	100.00	
N	0	1,221	1,807	1,513		4,541
Annual						
1-15	0.00	0.00	14.40	15.92	30.32	5,551
16-30	0.00	0.04	15.69	10.63	26.36	4,826
31-45	0.00	2.59	15.10	0.37	18.06	3,307
46-60	0.00	6.13	7.50	0.00	13.64	2,497
61-75	0.00	6.31	3.79	0.00	10.09	1,848
76-80	0.00	1.03	0.49	0.00	1.52	279
All	0.00	16.11	56.97	26.92	100.00	
N	0	2,950	10,430	4,928		18,308

* <3 mg/L = hypoxic; 3-5 mg/L = potential effect; 5-8 mg/L = fish sustained; >8 mg/L = healthy, no impact

between 20–40 m in October. Winter showed considerable within season variability with the lowest subsurface values seen in January and the highest surface values in March. Spring oxygen values were comparable with the exception of the large subsurface spike seen in June between 10–15 m.

The major DO spatial patterns were not plume related, but coincided with deeper, colder, and denser water impinging onto the shelf, or elevated chlorophyll-*a*. Localized decreases in median DO at the outfall below 15 m were probably due to entrainment of low oxygen waters caused by the rising plume (e.g., Figure 3-14, October). Values at outfall Station 2205 fell within the range of values seen within the study area and, overall, there were few instances of a >10% depression of DO values relative to background conditions and compliance with criterion V.A.3.a was above 97.7% (Chapter 2).

The 2012-13 DO patterns and values were consistent with long-term monitoring results (summarized in OCSD 1996b, 2004).

pH

While oxygen and pH were correlated (r = 0.66) and showed similar depth related patterns, there were differences seen both spatially and temporally (Table 3-9; Figures 3-15 and B-19). Mean values decreased from the surface to the bottom with the highest average pH during fall. Summer had the lowest pH values of the year with August having the lowest values below 30 m and September having the lowest values above 30 m. Fall showed a general increase in pH at all depths with an almost 0.4 unit increase from September to October. Winter showed considerable change month to month with a general decrease of pH at all depths from January to February, followed by an increase at all depths from February to March. Monthly spatial and depth patterns were consistent in spring.

As noted above, pH values less than 7.75 have been associated with aragonite saturation levels of <1. While 3% of the values in 2012-13 fell below this value (Table 3-11), no values were below 7.5, a level at which slight reductions in hatching and survival of juvenile copepods and euphausids have been measured (Peterson *et al*. 2010).

As was the case with oxygen, the major pH spatial patterns were not plume related, but coincided with deeper water impinging onto the shelf. Ranges and median values at the outfall (Station 2205) were similar to non-outfall stations, with the exception of waters between 15–30m, where pH was lower in the fall, winter, and spring seasons. Overall the pH criterion (V.A.3.b) was met >100% this year (Chapter 2).

Water Clarity

Percent light transmission and beam-C were highly correlated (r = -0.98). Overall, light transmission for the year was high (mean values >84%) at all depths (Table 3-9; Figures 3-16, B-20, and B-21). The most consistent feature was the reduced light transmittance seen in the Newport Canyon during all surveys. Lower values were also seen in surface and mid-water depths during most surveys. The low surface values seen throughout the study area in March were associated with lower surface salinities and elevated oxygen and chlorophyll-*a* concentrations. The spring subsurface minimum values were associated with elevated oxygen and elevated chlorophyll-*a*.

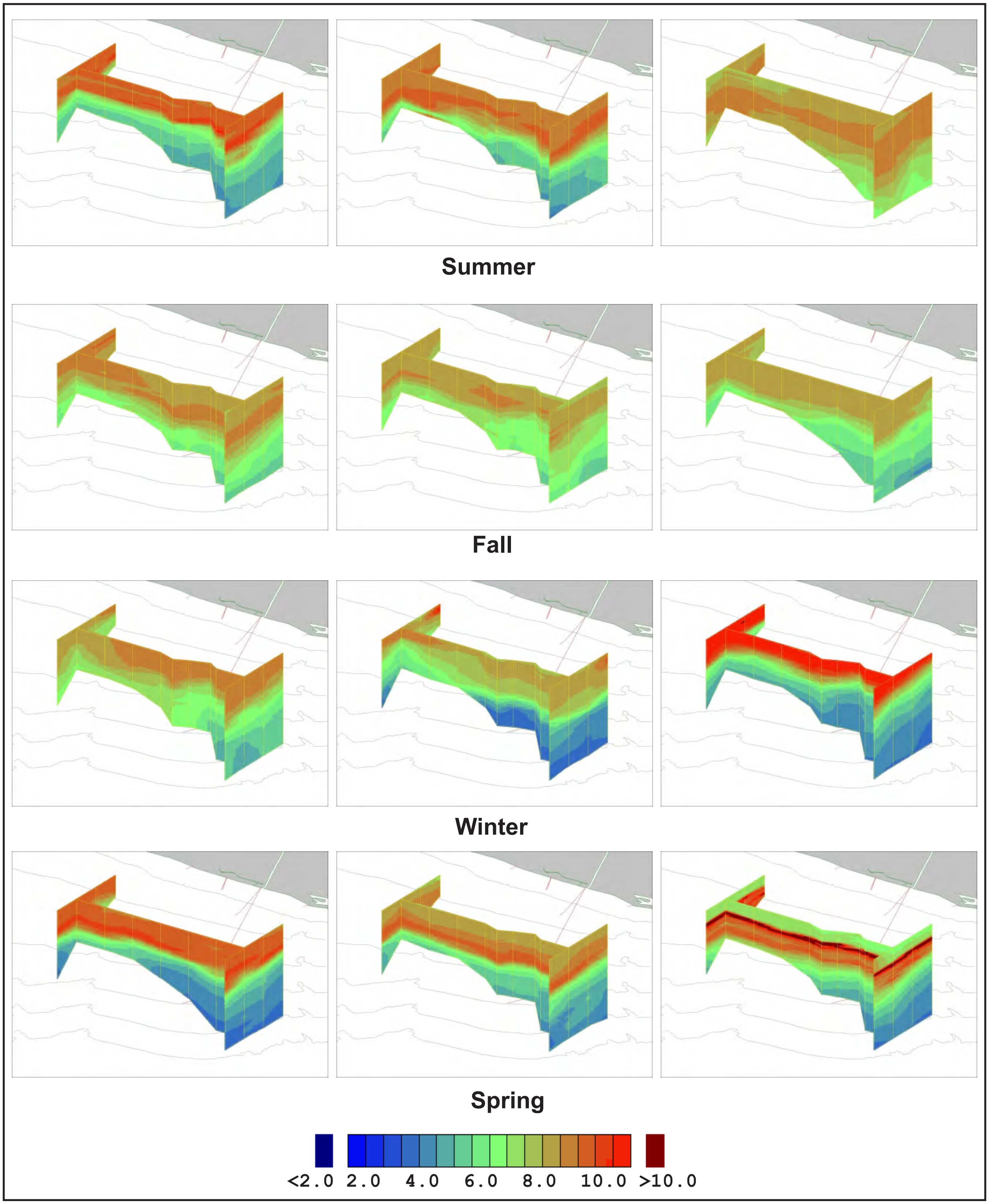

Figure 3-14. Seasonal patterns of dissolved oxygen (mg/L) for summer (July 19, August 7, and September 19, 2012), fall (October 30, November 6, and December 4, 2012), winter (January 30, February 26, and March 11, 2013), and spring (April 29, May 20, and June 13, 2013).

Orange County Sanitation District, California.

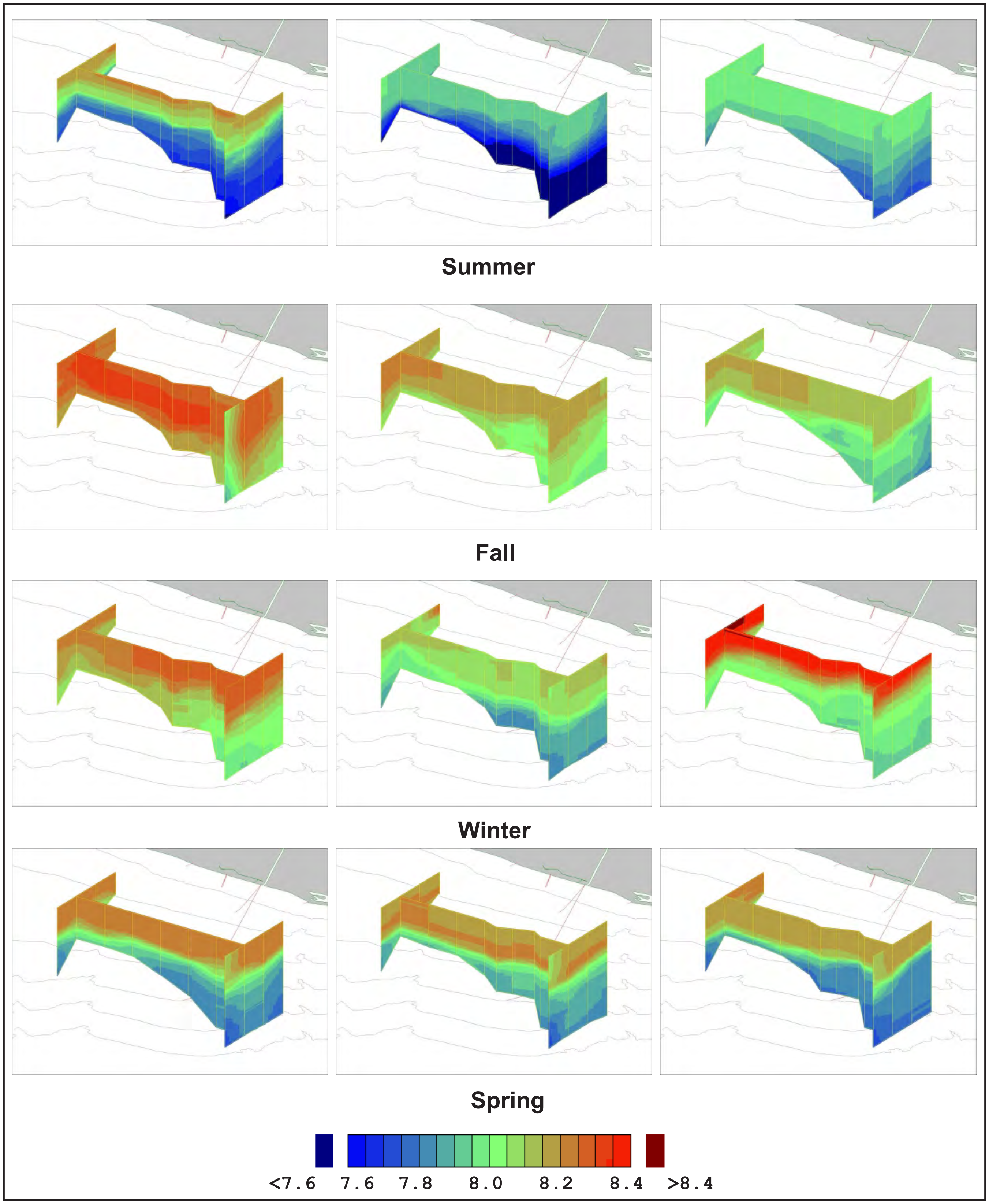

Figure 3-15. **Seasonal patterns of pH for summer (July 19, August 7, and September 19, 2012), fall (October 30, November 6, and December 4, 2012), winter (January 30, February 26, and March 11, 2013), and spring (April 29, May 20, and June 13, 2013).**

Orange County Sanitation District, California.

Table 3-11. Ocean acidification levels* based on Core pH (pH units) by season and depth category calculated as percent of total for the District's Water Quality Monitoring Program, July 2012–June 2013.

Orange County Sanitation District, California.

Depth Strata (m)	<7.75	7.75–8.15	≥8.16	Total (%)	N
Summer					
1-15	0.00	14.16	16.80	30.96	1,426
16-30	0.00	18.26	8.01	26.27	1,210
31-45	1.02	15.89	0.91	17.82	821
46-60	4.41	8.97	0.00	13.37	616
61-75	4.21	5.82	0.00	10.03	462
76-90	0.96	0.59	0.00	1.54	71
All	10.59	63.68	25.73	100	
N	488	2,933	1,185		4,606
Fall					
1-15	0.00	11.61	18.46	30.07	1,365
16-30	0.00	13.59	13.04	26.63	1,209
31-45	0.00	12.80	5.26	18.06	820
46-60	0.00	12.00	1.61	13.61	618
61-75	0.00	10.04	0.13	10.18	462
76-90	0.00	1.45	0.00	1.45	66
All	0.00	61.50	38.50	100	
N	0	2,792	1,748		4,540
Winter					
1-15	0.00	9.15	21.03	30.19	1,395
16-30	0.00	16.62	9.48	26.10	1,206
31-45	0.00	17.49	0.80	18.29	845
46-60	0.00	14.07	0.00	14.07	650
61-75	0.00	10.00	0.00	10.00	462
76-90	0.00	1.36	0.00	1.36	63
All	0.00	68.69	31.31	100	
N	0	3,174	1,447		4,621
Spring					
1-15	0.00	3.08	26.98	30.06	1,365
16-30	0.00	14.69	11.76	26.45	1,201
31-45	0.00	18.08	0.00	18.08	821
46-60	0.04	13.46	0.00	13.50	613
61-75	1.01	9.16	0.00	10.17	462
76-90	0.29	1.45	0.00	1.74	79
All	1.34	59.92	38.74	100	
N	61	2,721	1,759		4,541
Annual					
1-15	0.00	12.05	18.63	30.69	10,422
16-30	0.00	12.82	9.31	22.14	7,521
31-45	0.26	13.93	1.55	15.65	5,316
46-60	1.12	12.08	0.29	13.26	4,504
61-75	1.31	8.35	0.04	9.54	3,239
76-90	0.31	5.51	0.00	5.70	1,937
All	3.00	67.56	29.81	100	
N	549	22,946	10,125		33,964

* <7.75 ≈ aragonite saturation level <1); 8.16 ≈ average preindustrial surface value

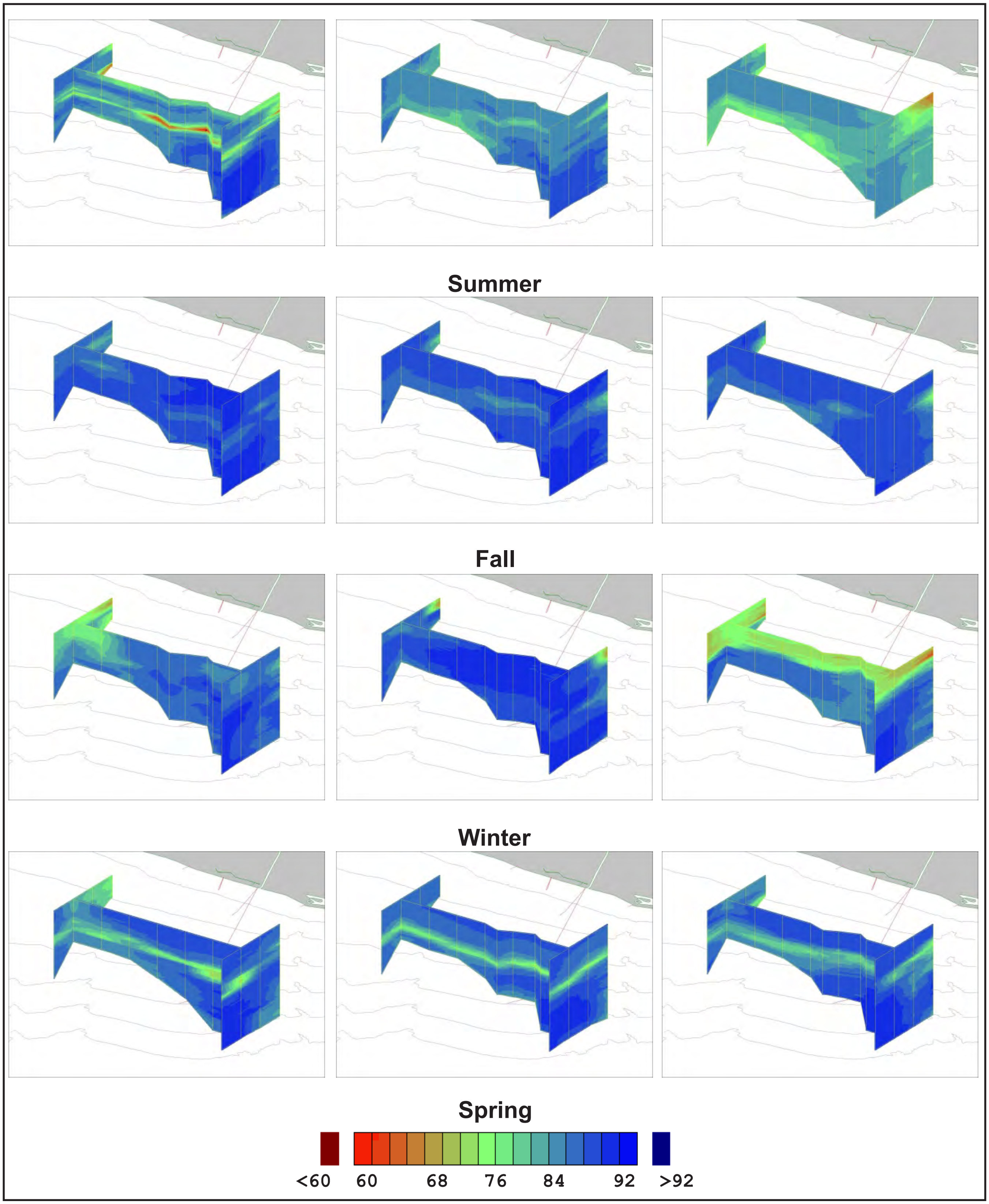

Figure 3-16. **Seasonal patterns of light transmission (%) for summer (July 19, August 7, and September 19, 2012), fall (October 30, November 6, and December 4, 2012), winter (January 30, February 26, and March 11, 2013), and spring (April 29, May 20, and June 13, 2013).**

Orange County Sanitation District, California.

Plume-related changes in light transmission were not identified. No patterns were associated directly with the discharge and values seen at Station 2205 all fell within measured ranges for the year. With the exception of clearer (more transparent) water seen between 45 and 60 m, the median values for Station 2205 were not different from the other stations. Decreased subsurface values generally corresponded with increased chlorophyll-*a*. Compliance with criterion V.A.2.c was above 99% (Chapter 2) and the overall effect on the "natural" light penetration criterion was, therefore, minimal and not ecologically significant (see Chapter 2).

Photosynthetically Active Radiation (PAR)
Light levels rapidly decreased within the upper 10 m of the water column (Figures 3-17 and B-22). The range of depths for the 10% light level was between 1–25 m (Table 3-9). While the 1% light level (euphotic zone depth) exceeded 75 m in the fall, on average, it was limited to the upper 30 m of the water column. Spring had the clearest surface and depth averaged light penetration.

Quarterly spatial patterns of the 1% light levels showed considerable spatial and temporal variability (Figure 3-18). However, general patterns showed shallower penetration closer to the coast, especially upcoast (northwest) of the outfall. Water clarity was typically highest downcoast (southeast) of the outfall off the San Pedro Shelf.

A plume impact would include changes in water clarity that diminishes light penetration such that it would have an effect on phytoplankton by reducing photosynthesis and inhibiting growth. However, no plume-related patterns were seen (Figures 3-17 and 3-18).

Colored Dissolved Organic Matter (CDOM)
While there are other sources of CDOM, such as rivers, zooplankton, and bacteria (Kowalczuk *et al*. 2003, Steinberg *et al*. 2004), its use has proven to be a reliable effluent plume tracer in southern California (Jones *et al*. 2011, Rogowski *et al*. 2011). Plume-related CDOM effects matched well with subsurface salinity (Figures 3-19 and B-23). Changes were mostly limited to depths below 20 m, with the highest values at depths between 31–45 m (Table 3-9).

As the primary source of subsurface CDOM, there was a strong outfall signal measured during most surveys.

Phytoplankton
Chlorophyll-*a* fluorescence, used as a surrogate to collecting discrete samples for phytoplankton, is an indicator of phytoplankton abundance and biomass in coastal waters. While chlorophyll-*a* does not distinguish between the source of chlorophyll (terrestrial versus marine) or plankton species, high concentrations typically indicate high phytoplankton biomass and reflect a potential response to nutrient loads. For 2012-13, spring had the highest maximum and depth-averaged mean values, with a strong subsurface maximum peak at around 30 m (Table 3-9; Figures 3-20 and B-24). Winter also had elevated chlorophyll values, but maximum values were higher in the water column (above 15 m). Phytoplankton blooms were present each quarter (Table 3-12) but not each month (Table 3-13). Only in the spring did values exceed bloom criteria in 15% or more of the samples collected each month. Otherwise, about 90% of the samples collected were

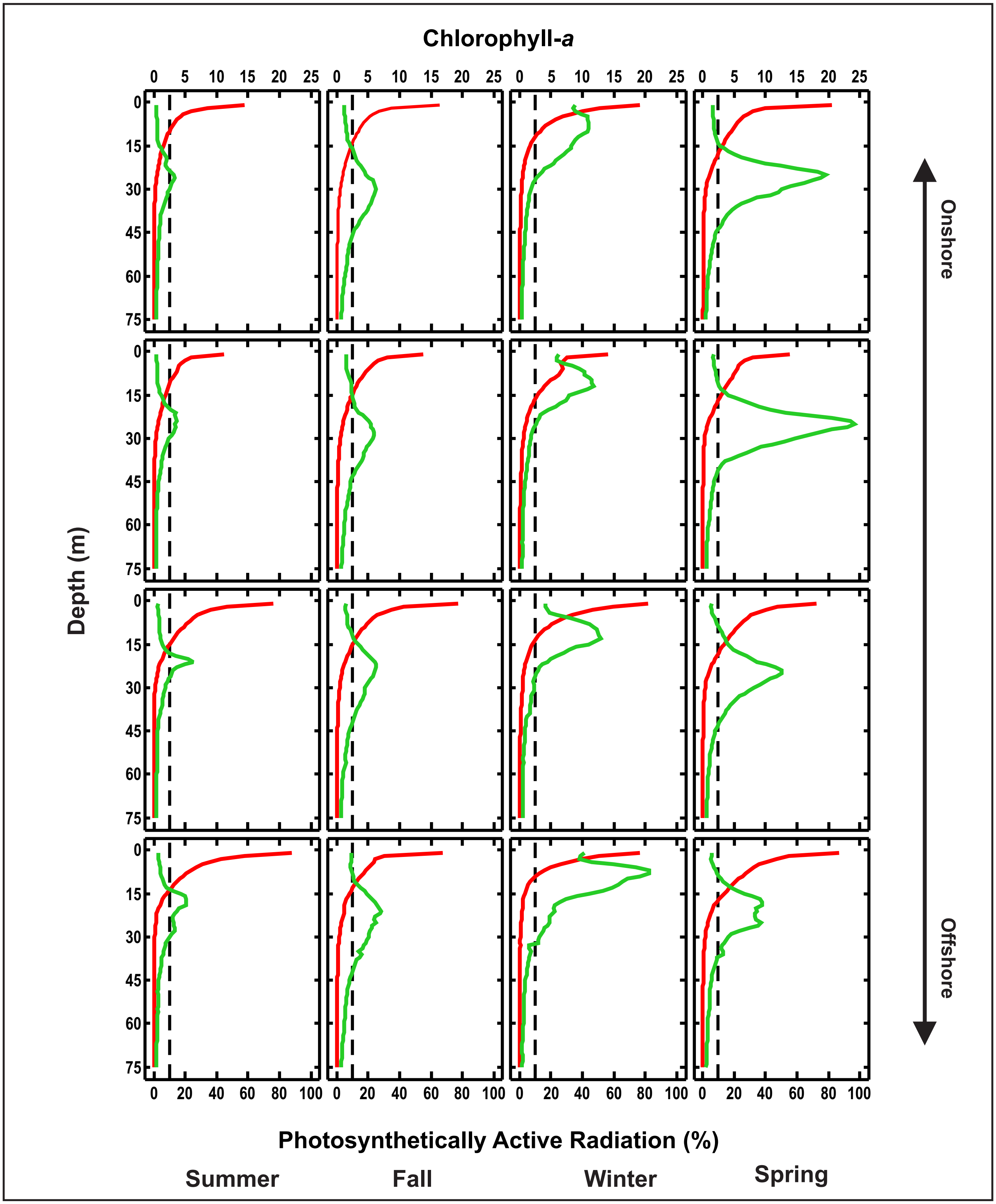

Figure 3-17. **Quarterly average chlorophyll-*a* fluorescence (µg/L; green line) and photosynthetically active radiation (PAR; %; red line) with depth for summer (July 19, August 7, and September 19, 2012), fall (October 30, November 6, and December 4, 2012), winter (January 30, February 26, and March 11, 2013), and spring (April 29, May 20, and June 13, 2013).**

Black vertical dashed line represents the 10% light penetration level.

Orange County Sanitation District, California.

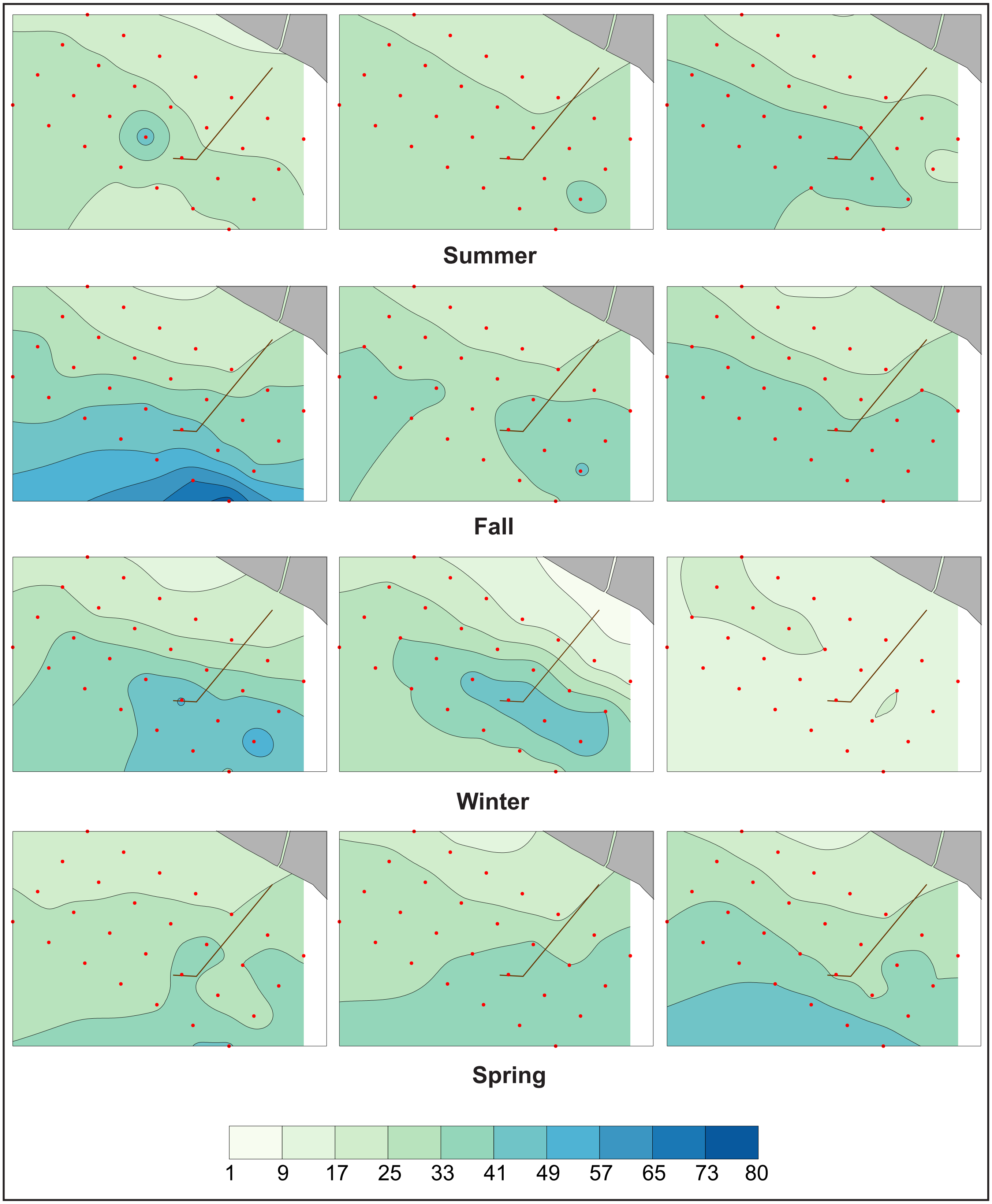

Figure 3-18. Seasonal patterns of 1% PAR depth (m) for summer (July 19, August 7, and September 19, 2012), fall (October 30, November 6, and December 4, 2012), winter (January 30, February 26 and March 11, 2013), and spring (April 29, May 20, and June 13, 2013).

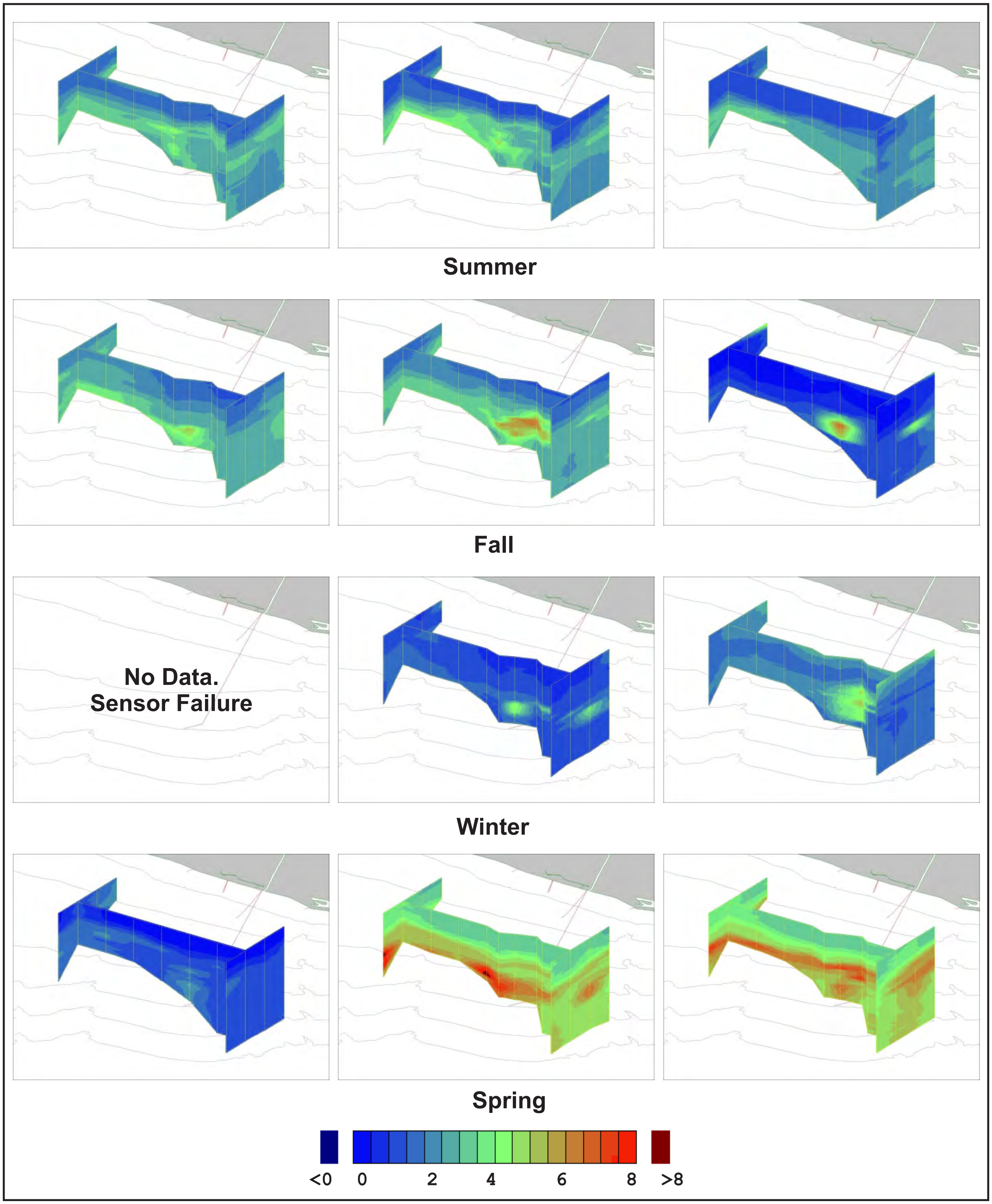

Figure 3-19. **Seasonal patterns of color dissolved organic matter (CDOM, µg/L) for summer (July 19, August 7, and September 19, 2012), fall (October 30, November 6, and December 4, 2012), winter (January 30, February 26, and March 11, 2013), and spring (April 29, May 20, and June 13, 2013).**

Orange County Sanitation District, California.

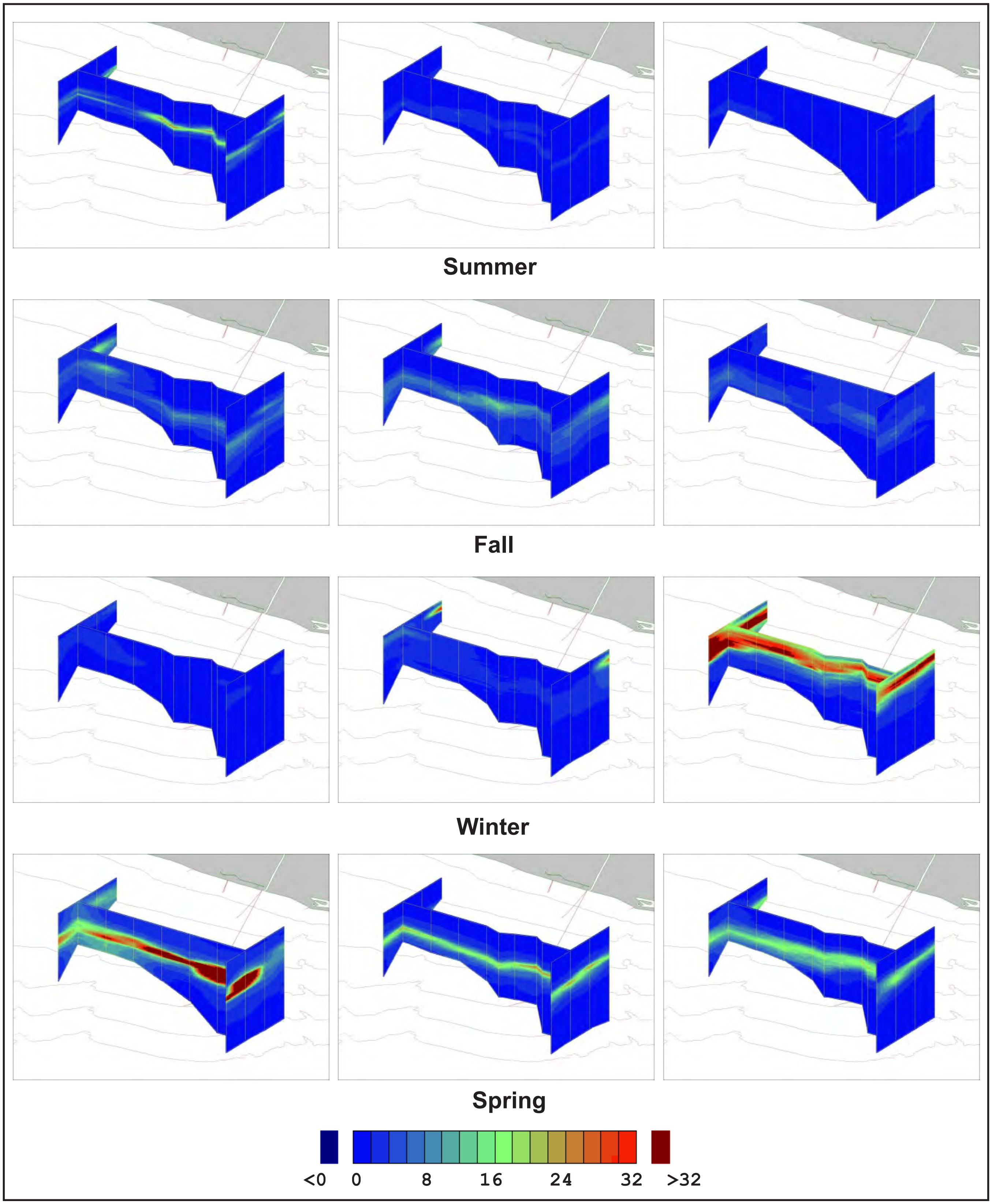

Figure 3-20. **Seasonal patterns of chlorophyll-*a* (µg/L) for summer (July 19, August 7, and September 19, 2012), fall (October 30, November 6, and December 4, 2012), winter (January 30, February 26, and March 11, 2013), and spring (April 29, May 20, and June 13, 2013).**

Orange County Sanitation District, California.

Table 3-12 Seasonal algal bloom determinations for Core surveys by depth strata, July 2012–July 2013.

Orange County Sanitation District, California.

Depth Strata (m)	No Bloom	Minor Bloom	Major Bloom	Total	N
Summer					
1-15	30.83	0.11	0.02	30.96	1,426
16-30	24.12	1.61	0.54	26.27	1,210
31-45	17.82	0.00	0.00	17.82	821
46-60	13.37	0.00	0.00	13.37	616
61-75	10.03	0.00	0.00	10.03	462
76-90	1.54	0.00	0.00	1.54	71
All	97.72	1.72	0.56	100	
N	4,501	79	26		4,606
Fall					
1-15	29.56	0.44	0.07	30.07	1,365
16-30	23.02	3.52	0.09	26.63	1,209
31-45	17.42	0.64	0.00	18.06	820
46-60	13.61	0.00	0.00	13.61	618
61-75	10.18	0.00	0.00	10.18	462
76-90	1.45	0.00	0.00	1.45	66
All	95.24	4.60	0.15	100	
N	4,324	209	7		4,540
Winter					
1-15	18.74	2.55	8.89	30.19	1,395
16-30	22.81	2.10	1.19	26.10	1,206
31-45	18.26	0.02	0.00	18.29	845
46-60	14.07	0.00	0.00	14.07	650
61-75	10.00	0.00	0.00	10.00	462
76-90	1.36	0.00	0.00	1.36	63
All	85.24	4.67	10.08	100	
N	3,939	216	466		4,621
Spring					
1-15	29.07	0.99	0.00	30.06	1,365
16-30	11.23	10.09	5.13	26.45	1,201
31-45	15.66	2.05	0.37	18.08	821
46-60	13.50	0.00	0.00	13.50	613
61-75	10.17	0.00	0.00	10.17	462
76-90	1.74	0.00	0.00	1.74	79
All	81.37	13.12	5.51	100	
N	3,695	596	250		4,541
Annual					
1-15	27.03	1.03	2.27	30.32	5,551
16-30	20.32	4.31	1.73	26.36	4,826
31-45	17.30	0.67	0.09	18.06	3,307
46-60	13.64	0.00	0.00	13.64	2,497
61-75	10.09	0.00	0.00	10.09	1,848
76-90	1.52	0.00	0.00	1.52	279
All	89.90	6.01	4.09	100	
N	16,459	1,100	749		18,308

Table 3-13. Chlorophyll bloom determination by percent for monthly Core water quality sampling, July 2012–June 2013.

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Depth Strata (m)	No Bloom	Minor Bloom	Major Bloom	Total	N
			July		
1-15	29.75	0.32	0.06	30.14	465
16-30	19.83	4.80	1.62	26.25	405
31-45	18.47	0.00	0.00	18.47	285
46-60	13.74	0.00	0.00	13.74	212
61-75	9.98	0.00	0.00	9.98	154
76-80	1.43	0.00	0.00	1.43	22
All	93.20	5.12	1.69	100	
N	1,438	79	26		1,543
			August		
1-15	31.88	0.00	0.00	31.88	511
16-30	26.39	0.00	0.00	26.39	423
31-45	17.59	0.00	0.00	17.59	282
46-60	13.16	0.00	0.00	13.16	211
61-75	9.61	0.00	0.00	9.61	154
76-80	1.37	0.00	0.00	1.37	22
All	100.00	0.00	0.00	100	
N	1,603	0	0		1,603
			September		
1-15	30.82	0.00	0.00	30.82	450
16-30	26.16	0.00	0.00	26.16	382
31-45	17.40	0.00	0.00	17.40	254
46-60	13.22	0.00	0.00	13.22	193
61-75	10.55	0.00	0.00	10.55	154
76-80	1.85	0.00	0.00	1.85	27
All	100.00	0.00	0.00	100	
N	1,460	0	0		1,460
			October		
1-15	28.94	0.90	0.19	30.04	465
16-30	24.55	1.87	0.13	26.55	411
31-45	17.18	1.16	0.00	18.35	284
46-60	13.82	0.00	0.00	13.82	214
61-75	9.95	0.00	0.00	9.95	154
76-80	1.29	0.00	0.00	1.29	20
All	95.74	3.94	0.32	100	
N	1,482	61	5		1,548
			November		
1-15	29.42	0.38	0.00	29.81	465
16-30	18.21	8.40	0.13	26.73	417
31-45	17.56	0.71	0.00	18.27	285
46-60	13.78	0.00	0.00	13.78	215
61-75	9.87	0.00	0.00	9.87	154
76-80	1.54	0.00	0.00	1.54	24
All	90.38	9.49	0.13	100	
N	1,410	148	2		1,560
			December		
1-15	30.38	0.00	0.00	30.38	435
16-30	26.61	0.00	0.00	26.61	381
31-45	17.53	0.00	0.00	17.53	251
46-60	13.20	0.00	0.00	13.20	189
61-75	10.75	0.00	0.00	10.75	154
76-80	1.54	0.00	0.00	1.54	22
All	100.00	0.00	0.00	100	
N	1,432	0	0		1,432

Table 3-13 continues.

Table 3-13 continued.

Depth Strata (m)	No Bloom	Minor Bloom	Major Bloom	Total	N
	January				
1-15	30.02	0.00	0.00	30.02	465
16-30	26.34	0.00	0.00	26.34	408
31-45	18.27	0.00	0.00	18.27	283
46-60	14.01	0.00	0.00	14.01	217
61-75	9.94	0.00	0.00	9.94	154
76-80	1.42	0.00	0.00	1.42	22
All	100.00	0.00	0.00	100	
N	1,549	0	0		1,549
	February				
1-15	24.92	1.88	3.37	30.18	465
16-30	25.50	0.39	0.00	25.89	399
31-45	18.23	0.00	0.00	18.23	281
46-60	14.15	0.00	0.00	14.15	218
61-75	9.99	0.00	0.00	9.99	154
76-80	1.56	0.00	0.00	1.56	24
All	94.35	2.27	3.37	100	
N	1,454	35	52		1,541
	March				
1-15	1.11	5.81	23.45	30.37	465
16-30	16.53	5.94	3.59	26.06	399
31-45	18.29	0.07	0.00	18.35	281
46-60	14.04	0.00	0.00	14.04	215
61-75	10.06	0.00	0.00	10.06	154
76-80	1.11	0.00	0.00	1.11	17
All	61.14	11.82	27.04	100	
N	936	181	414		1,531
	April				
1-15	27.02	2.74	0.00	29.75	435
16-30	6.84	11.83	7.73	26.40	386
31-45	14.16	2.46	1.16	17.78	260
46-60	13.47	0.00	0.00	13.47	197
61-75	10.53	0.00	0.00	10.53	154
76-80	2.05	0.00	0.00	2.05	30
All	74.08	17.03	8.89	100	
N	1,083	249	130		1,462
	May				
1-15	30.16	0.00	0.00	30.16	465
16-30	14.92	6.81	4.54	26.26	405
31-45	15.95	2.27	0.00	18.22	281
46-60	13.62	0.00	0.00	13.62	210
61-75	9.99	0.00	0.00	9.99	154
76-80	1.75	0.00	0.00	1.75	27
All	86.38	9.08	4.54	100	
N	1,332	140	70		1,542
	June				
1-15	29.93	0.33	0.00	30.25	465
16-30	11.71	11.71	3.25	26.68	410
31-45	16.79	1.43	0.00	18.22	280
46-60	13.40	0.00	0.00	13.40	206
61-75	10.02	0.00	0.00	10.02	154
76-80	1.43	0.00	0.00	1.43	22
All	83.28	13.47	3.25	100	
N	1,280	207	50		1,537

below bloom criteria. When blooms did occur, they were predominantly in the upper 30 m of the water column.

Chlorophyll-*a* peaks were below the 10% light level in the summer, fall, and spring quarters, but at, or just above, in winter (Figure 3-17). While the 10% light level generally corresponds to minimum levels needed by phytoplankton for photosynthesis, the subsurface layering patterns also correspond to typical sinking depths for phytoplankton (Hardy 1993).

There were no patterns relative to the outfall for chlorophyll-*a*. Patterns observed were typically seen throughout the study area without an outfall gradient.

Ammonia

Ammonia concentrations (NH3-N) were below detection in 86% of the 1,581 samples collected in 2012-13. Of the 224 samples with detectable ammonia (≥0.02 mg/L), 202 (90%) occurred below 15 m. Seasonally, the highest mean concentrations were seen between 31–45 m (Table 3-9). The highest value recorded for the year was at the surface in September. This sample was collected during the J-112 outfall diversion project at Station WYE, located atop of the 78-inch outfall (Figure 3-21). Minimal differences were seen in seasonal depth averaged mean concentrations (Table 3-9). Spatial distributions reflected probable current transport. Summer saw upcoast and offshore transport in July and August. Discharge in September was from the 78-inch outfall with an evident, but spatially limited surface expression for NH3-N. Fall NH3-N distributions showed no evident transport past 2 km from the outfall. Winter showed upcoast and inshore transport in January and then downcoast and offshore in February and March. Spring had a very low downcoast NH3-N signal in April and then was upcoast in May and June. Values above 30 m at outfall Station 2205 all fell within the range of non-outfall stations (Figure B-25), but the rate of detectable NH3-N was nearly three times higher (44%). Median values below 30 m were
also higher than at non-outfall stations. Taking into account the limited vertical and spatial distribution of NH3-N, lack of coincidence with chlorophyll-*a,* and low probability of toxicity, it was determined that compliance with the nutrient criterion (V.A.3.f) was met.

Bacteria

With continued disinfection of the final effluent, the vast majority (77–88%) of the three FIB counts were below the method detection of 10 MPN/100 mL. All three FIB were significantly correlated ($p<0.01$); only total and fecal coliform counts were strongly correlated (r = 0.92), while the *Enterococcus* r-value was 0.48 and 0.55 for total and fecal coliform bacteria, respectively. All three FIB showed similar spatial distributions throughout the year (Figures 3-22 to 3-24 and B-26 to B-28), so total coliform bacteria, which had the highest counts and fewest samples below detection, is presented as a "worse-case" example of the impact of bacteria to the receiving water. Median counts were higher at the outfall below 45 m. Elevated total coliform bacteria typically occurred below 15 m (Table 3-9; Figure 3-22 and B-26). Spatially, FIB occurred primarily near the outfall with no evidence of impact at the Rec-1 stations along the 20 m isobath. Summer values were low due to the enhanced disinfection process that was in place as a component of the J-112 outfall diversion project. Most total coliform samples (737) were below the detection limit of 10 MPN/100 mL and no samples were greater than the 10,000 MPN/100 mL single sample standard. All offshore criteria for bacteria (V.A.1.a and V.A.1.b) were met.

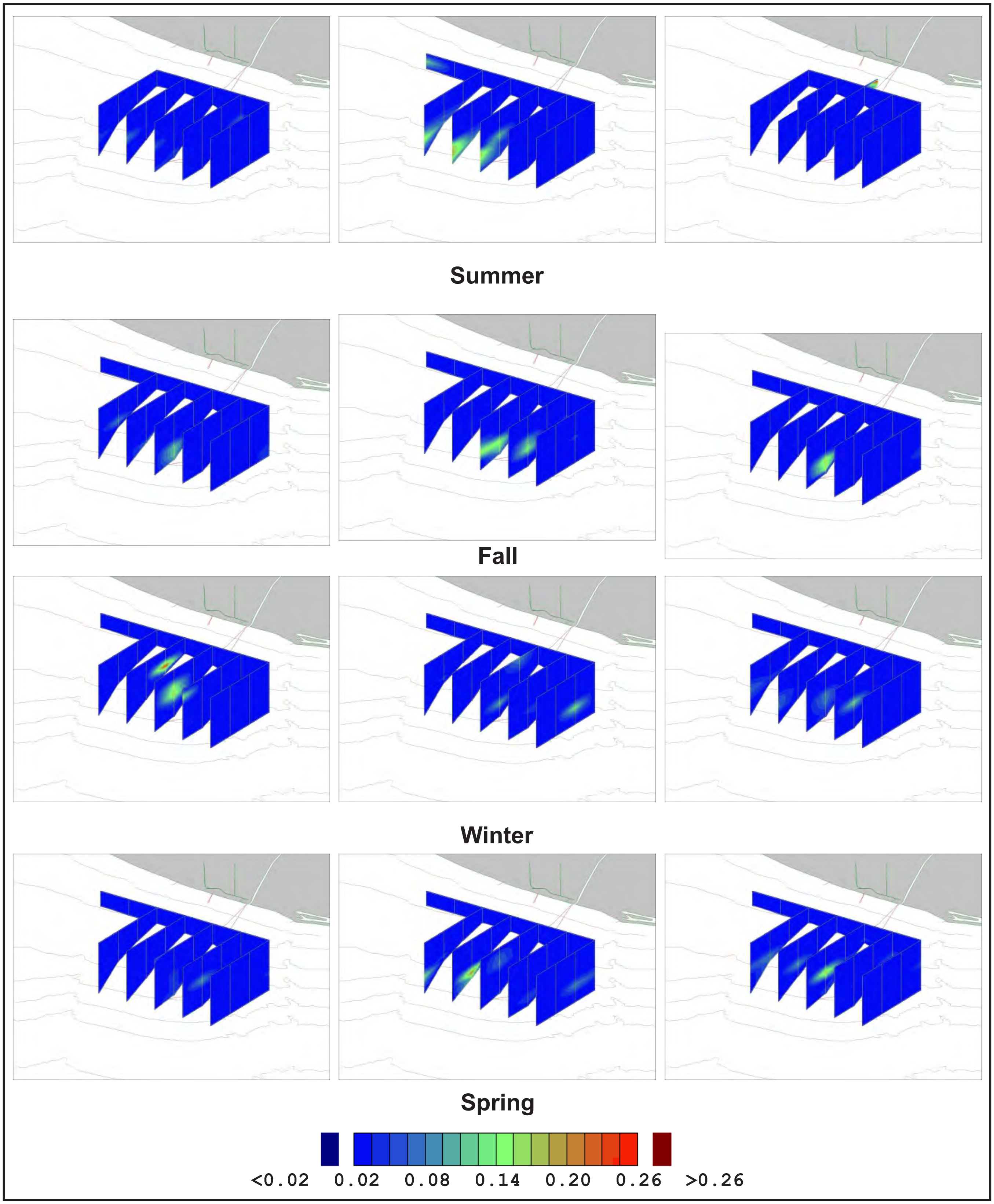

Figure 3-21. **Seasonal patterns of ammonia (mg/L) for summer (July 19, August 7,and September 19, 2012), fall (October 30, November 6, and December 4, 2012), winter (January 30, February 26, and March 11, 2013), and spring (April 29, May 20, and June 13, 2013).**

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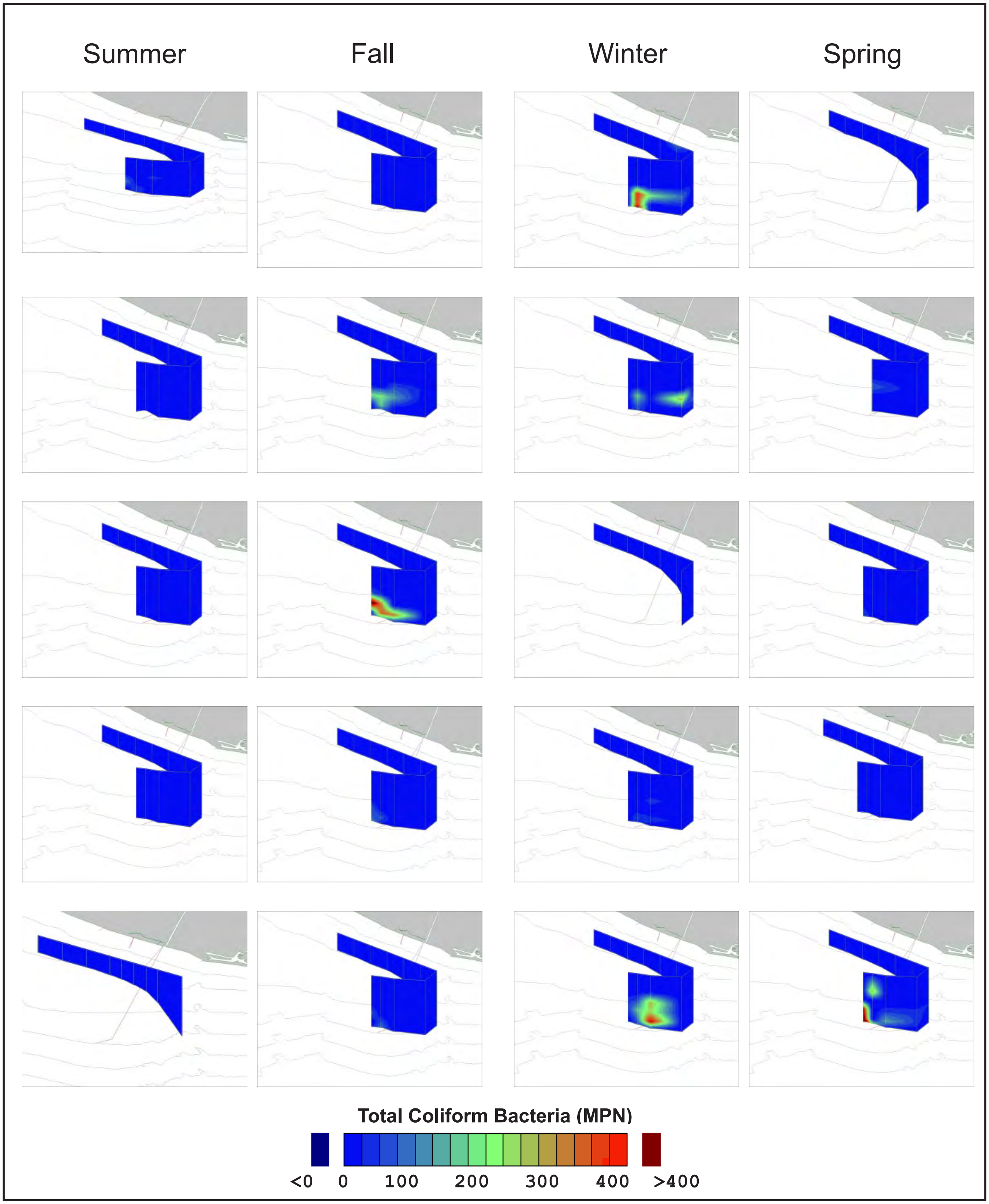

Figure 3-22. **Seasonal patterns of total coliforms (MPN/100mL) for summer 2012 (July 19 and August 2, 6, 7, 9), fall 2012 (October 30 and November 6, 8, 13, 14), winter 2013 (February 14, 26, 27, 28 and March 11), and spring 2013 (April 24, 29 and May 7, 9, 20).**

Orange County Sanitation District, California.

Figure 3-23. Seasonal patterns of fecal coliforms (MPN/100mL) for summer 2012 (July 19 and August 2, 6, 7, 9), fall 2012 (October 30 and November 6, 8, 13, 14), winter 2013 (February 14, 26, 27, 28 and March 11), and spring 2013 (April 24, 29 and May 7, 9, 20).

Orange County Sanitation District, California.

Figure 3-24. **Seasonal patterns of *Enterococcus* bacteria (MPN/100mL) for summer 2012 (July 19 and August 2, 6, 7, 9), fall 2012 (October 30 and November 6, 8, 13, 14), winter 2013 (February 14, 26, 27, 28 and March 11), and spring 2013 (April 24, 29 and May 7, 9, 20).**

Orange County Sanitation District, California.

Floatables
Observations of grease and floatables address the potential effects from the wastewater discharge to offshore surface waters. There were also no offshore observations of floatable material related to the discharge or that affected water clarity (Tables B-5 and B-6). These results demonstrated compliance with criterion V.A.2.a and were consistent with findings from previous years (OCSD 2004–2013).

CONCLUSIONS

Results from the District's 2012-13 water quality monitoring program detected minor changes in measured water quality parameters related to the discharge of wastewater to the coastal ocean, which is consistent with previously reported results (e.g., OCSD 2013). Plume-related changes in temperature, salinity, DO, pH, and transmissivity were measurable beyond the initial mixing zone during some surveys, but usually extended only into the nearfield stations, typically <2 km away from the outfall. None of these changes were determined to be environmentally significant since they fell within natural ranges to which marine organisms are exposed (Allen *et al*. 2005; Chavez *et al*. 2002; Hsieh *et al*. 2005; Jarvis *et al*. 2004; OCSD 1996a and 2004; Wilber and Clarke 2001) and overall compliance with COP criteria remained high (98–100%, Chapter 2).

The spatial extent of the wastewater plume was apparent in subsurface patterns of salinity and CDOM with changes occurring near the outfall during most surveys, but primarily below 15 m water depth. In contrast, levels and patterns in dissolved oxygen, pH, and light transmission primarily responded to natural processes. One exception was the apparent depression in median oxygen concentration at the outfall, perhaps due to the secondary entrainment of deeper lower oxygen water by the rising effluent plume. These results were consistent with predicted changes in DO and pH levels listed in Table 3-1 using a minimum centerline dilution value of 124:1 from Tetra Tech (2008).

Measures of potential climate change effects—low dissolved oxygen and pH—indicated that, while there were a few instances of waters with the potential to affect living organisms encroaching up onto the shelf, the vast majority of the samples, both regionally and locally, were above levels of concern at present. Lower levels of DO and pH were found at depth (typically below 60 m) and probably had advected into the study area.

Direct measures of the wastewater plume were nutrients (NH3-N) and bacteria. With the exception of the surface sample collected at the end of the 78-inch outfall (0.99 mg/L) during the fall J-112 diversion, maximum NH3-N concentrations were 20 times less than COP objective for chronic toxicity to marine organisms (4 mg/L; SWRCB 2005). Average values at all depths and for all seasons were two orders of magnitude lower than this objective. Only 14% of the NH3-N samples were above the detection limit of 0.02 mg/L and the vast majority of these (90%) were below 15 m. The low levels, along with the lack of association with chlorophyll-*a*, suggests that these concentrations were not environmentally significant.

Prior to disinfection, FIB levels were the primary plume tracer of the discharged wastewater plume. Since disinfection began in August 2002, offshore bacterial concentrations have remained low and predominately below measurement detection levels. This was the case for 2012-13 where 77–88% of the samples fell below the lower MDL of 10 MPN/100 mL.

Overall, the measured environmental and public health effects to the receiving water continue to be small, with all values within the ranges of natural variability for the study area and that reflected seasonal and yearly changes of large-scale regional influences. The limited observable plume effects occurred primarily at depth, even during the winter when stratification was weakest. In summary, staff concluded that the discharge is not greatly affecting the receiving water environment and that beneficial uses were protected and maintained based on the 2012-13 water quality monitoring results.

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