Microbiological Water Quality at Reference Beaches and an Adjoining Estuary in Southern California during a Prolonged Drought

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EXECUTIVE SUMMARY

Elevated levels of fecal indicator bacteria (FIB) are a common problem in urban surface water and may lead to impairment of beneficial uses, such as swimming or other contact recreation. Once impaired, common regulatory solutions include establishing Total Maximum Daily Loads (TMDLs), and incorporating those TMDLs into National Pollutant Discharge Elimination System (NPDES) permits and other water quality management plans. A reference system approach is a critical element of these TMDLs, where natural sources are documented and a number of exceedance days are allocated based on the frequency at which "reference" sites with natural sources of bacteria exceed established FIB water quality standards. One previous study has documented natural background concentrations of FIB at "reference" beaches. However, the prolonged period of drought in the Southern California region provided an opportunity to characterize FIB concentrations at reference beaches during period of low freshwater input. It also provided an opportunity to intensify sampling effort in the adjoining bar-built estuary to provide the basis for accounting for natural sources of FIB in those naturally productive habitats.

The goal of this study was to characterize the natural background concentrations of *enterococci* (ENT), *E. coli* (EC), fecal (FC) and total coliform (TC) bacteria, and to categorize FIB water quality objective (WQO) exceedance frequency at "reference" recreational beaches and their adjoining estuary or mixing zones. Additionally, samples were analyzed for the HF183 human-associated fecal marker, which is indicative of the presence of human fecal contamination, to confirm that the reference beaches have minimal human impact.

Specific questions addressed in the study were:

1. How does the WQO exceedance frequency for FIB vary between wet weather, summer dry weather and winter dry weather at reference beaches and within the estuary or mixing zone?
2. How does FIB concentration at the beach vary by factors such as presence or absence of an estuary, water temperature, salinity, and number of antecedent dry days?

Reference beaches were selected though geographic information system screening of three criteria: 1) beaches that have minimal human impact were defined as open beaches with breaking waves, 2) the beach receives freshwater runoff from either a creek or an estuary, and 3) the runoff originates from undeveloped watersheds (>93% open space). In addition to these criteria, preference was given to sites in San Diego County. Two sites met these criteria: San Onofre Creek (San Diego County) and Deer Creek (Los Angeles County). Dry weather sampling was conducted weekly from October 1, 2014- April 30, 2016 within the surf zone, estuary or mixing zone, and contributing creeks. Storm sampling was conducted only in San Onofre Creek from January 1, 2014- April 30, 2016, but only one storm breached the creek mouth and was sampled. An intensification of sampling efforts was conducted within the Estuary of San Onofre Creek in order to quantify the natural background exceedance frequencies of bar-built estuaries. Analysis of samples for HF183 demonstrated that the level of human fecal contamination was low during winter and summer dry weather, supporting the concept that these are reference sites; any data associated with a positive HF183 result were removed from calculations of exceedance frequency.

This study, which coincided with a major drought in Southern California, had five major findings:

1. The winter and summer dry weather ranges of FIB concentrations at both beaches were very low, with WQO exceedance frequencies in the range of 0% -3.5%. Such values are characteristic and comparable to results from previous FIB beach bacteria reference studies that had closed tidal

inlets (such as the San Onofre Creek) or flow to the beach without an estuary (such as Deer Creek). Prolonged drought resulted in intermittent dry weather flow at Deer Creek and no dry weather flow at San Onofre Creek, which provides important context to interpret data on exceedance frequencies.

2. Concentrations of FIB in the estuary or freshwater mixing zone of both San Onofre and Deer Creeks were typically 1-3 in orders of magnitude higher compared to their respective beaches, with the highest WQO exceedance frequencies found in San Onofre Creek. This suggests that dry weather exceedance frequencies at the beach could have been greater had the mouth of the estuary been open to tidal exchange and dispersal to the surf zone.

3. FIB in San Onofre Estuary was characterized by high WQO exceedance rates, ranging from 40% (FC) to 92% (EC) for single samples and 72% (FC) to 100% (EC and ENT) for summer dry weather. During both winter dry sampling periods, single sample WQO exceedances ranged from 3.2% (TC) to 84%-93% (ENT), while geomean WQO exceedances during winter dry weather ranged from ~55% (TC) to 100% (ENT). The higher WQO exceedance frequencies of San Onofre Creek Estuary relative to the mixing zone of Deer Creek could be expected, given the abundance of labile organic matter typical in estuaries that can serve to support microbial growth and the presence of water birds in the estuary that excrete high concentrations of FIB.

4. At both beaches, no significant relationship was found with water temperature, salinity or antecedent dry days. In contrast to San Onofre Beach, where FIB concentrations declined with increasing duration of dry weather, the range and mean FIB concentration in San Onofre Estuary increased with increasing antecedent dry days and salinity, suggesting that freshwater input from the ephemeral channel tended to dilute concentrations, rather than be a source of bacteria to the beach. The slight increase in San Onofre Creek Estuary FIB concentrations as a function of temperature and the lack of surface freshwater input suggests that regrowth may be a factor, which is credible given the organic rich environment of San Onofre Creek estuary.

5. Only one storm was captured during this study because of extreme drought and all samples from that storm were found to be contaminated with a human source of fecal material; therefore, the results cannot be used to inform “natural background” exceedance frequencies.

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INTRODUCTION

The beaches of Orange and San Diego County are important natural resources for the region, providing recreation and a source of revenue from tourism. Increased urbanization of land use in the watersheds over the past century have resulted in increased wet and dry weather runoff to beaches. These changes bring increased loads of fecal indicator bacteria (FIB), and increased concentrations of FIB have been linked through epidemiology studies to an increased public health risk from waterborne illnesses. As a result, many beaches in the region have been placed on the State's 303(d) list for impairment of beneficial uses. Total coliform (TC), *E. coli* (EC), fecal coliform (FC), and *enterococci* (ENT) are used to monitor the water quality of marine beaches because they have been shown to correlate with swimming-related illness and are used as water quality objectives (WQOs) for the protection of recreational uses.

The current regulatory strategy to address these water quality problems is through the promulgation of total maximum daily loads (TMDLs). An important component of a TMDL is the numeric target, which establishes the limit of the contaminant required to achieve beneficial uses. The San Diego Regional Water Quality Control Board (SDRWQCB) issued Resolution No. R9-2010-0001, A Resolution Amending the Water Quality Control Plan for the San Diego Basin (9) to Incorporate Revised Total Maximum Daily Loads (TMDL) for Indicator Bacteria Project I-Twenty Beaches and Creeks in the San Diego Region (Including Tecolote Creek), herein referred to as the Bacteria TMDL (SDRWQCB, 2010). The Bacteria TMDL includes numeric targets for total coliform, fecal coliform, and *enterococci*.

Progress on TMDLs in the SDRWQCB region is currently hampered by the lack of a consistent set of scientifically-defensible numeric targets for beaches and their adjoining estuaries. Existing standards do not fully account for natural background concentrations of FIB at beaches. FIB may originate from natural sources. FIB such as TC, EC, FC and ENT are components of the gut microbiota of all warm-blooded animals, including domesticated dogs and cats, and wild birds and mammals (Grant et al. 2001, Oshiro and Fujioka 1995). Furthermore, FIB may have extended survival or even grow in beach sediments and wrack when favorable conditions prevail (Valiela et al. 1991, Weiskel et al. 1996, Desmarais et al. 2002, City of San Diego/MEC Weston 2004, Anderson et al. 2005). Previous studies have quantified the effect of wet weather and dry weather conditions on beach FIB concentrations at non-human impacted reference beaches (Griffith et al. 2010). However, the prolonged period of drought in the Southern California region provided an opportunity to characterize FIB concentrations at reference beaches during period of low freshwater input.

The potential to support elevated natural background concentrations of FIB may be even higher for the region's bar-built estuaries, which experience periodic or prolonged closure of their tidal inlets in times of low river flow (Largier and Taljaard 1991). Mouth closure increases the residence time of surface waters, enabling the proliferation of primary producers such as benthic and floating algae and aquatic plants (McLaughlin et al. 2013). These organic matter sources provide a rich substrate to support prokaryote production in general, including FIB. Many studies have shown that FIB can survive for long periods or grow attached to sediments and vegetation (Savage 1905, Roper and Marshall 1979, LaBelle et al. 1980, Davies et al. 1995, Desmarais et al. 2002, Sanders et al. 2005). Yet no studies have been undertaken to quantify the natural background concentrations of FIB in "reference" bar-built estuaries.

One approach to developing numeric targets that does account for "natural sources" is to establish the concentrations at beaches and their adjoining estuaries in a minimally disturbed or "reference" condition. In fact, some state regulatory agencies use the level of contributions from undeveloped watersheds as the benchmark for acceptable water quality in developed watersheds in the Los Angeles region (LARWQCB

2002). The goal of this study was two-fold: 1) quantify the concentrations and frequency of exceedance of FIB at two Southern California reference beaches during dry and wet weather, using microbial source identification to assure that FIB samples were not contaminated by human sources; 2) quantify the FIB concentrations at a minimally impacted "reference" bar-built estuary. The intent of the study was to quantify the concentrations and exceedance frequencies: 1) between summer dry, winter dry and wet weather, 2) estuary mouth status (open/closed) during wet and dry weather, and 3) between an estuary, defined as a persistent body of ponded water at the terminus of a creek, or a "mixing zone" where a creek discharges directly onto the beach.

Ultimately, this study was intended to provide a sound scientific basis of FIB WQO exceedance rates in minimally disturbed reference beaches in Southern California in order to support discussions of reasonable and accurate targets for regulating FIB at beaches. Exceedance frequencies reported herein are not intended to be used directly in a regulatory application, since alternative approaches to exceedance calculations exist, and historic data can also be considered for inclusion. Our assumption is that the underlying data generated in this study are available to support stakeholder discussions with regulatory agencies.

METHODS

Two coastal "minimally disturbed" reference beaches in Southern California were selected for assessment of water quality during summer and winter dry weather (San Onofre Creek in San Diego County and Deer Creek in Ventura County, Table 1, Figure 1). These two beaches were selected based on four criteria: (1) each reference beach must be an open beach with breaking waves, (2) each reference beach must have a freshwater input (i.e., drainage inlet or estuary), (3) no fire has occurred within the watershed within three years, and (4) the watershed discharging to the reference beach must be >93% undeveloped.

Table 1. Characteristics of Beach Bacteria Reference Sites

Reference Beach Watershed	Latitude (NAD 83)	Longitude (NAD 83)	Water-shed Size (km^2)	Watershed (%) Undeveloped	Beach Direction	Beach Substrate	Lagoonal System
Deer Creek	34° 03.724' N	118° 59.164' W	3.1	98	SW	Sand	No
San Onofre	33° 22.842' N	117° 34.719' W	110	97	W	Sand and Cobble	Yes

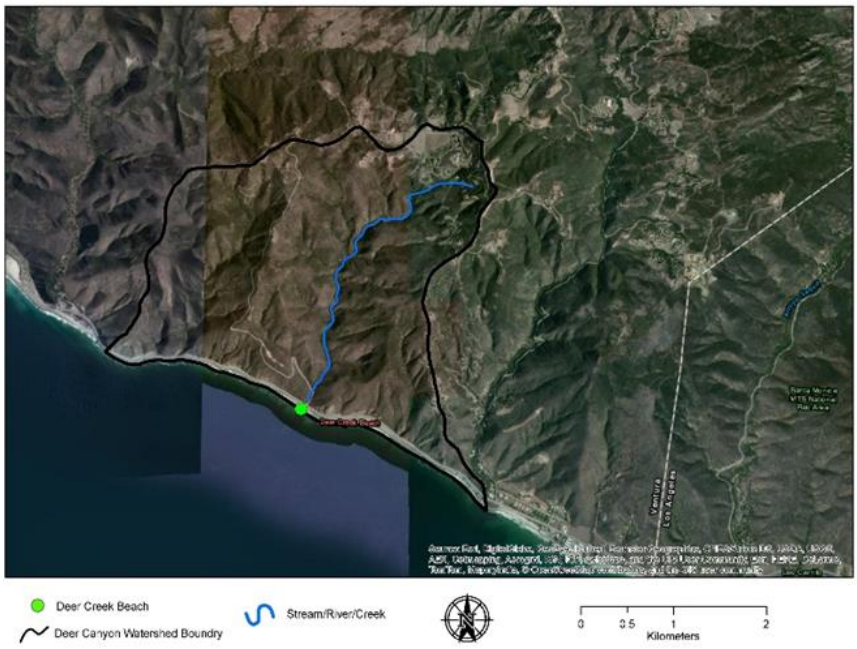

Figure 1. Maps of reference beach sampling sites: Deer Creek Beach in Ventura County (top panel) and San Onofre Beach in San Diego County (bottom panel)

Both San Onofre Creek and Deer Creek reference beaches are open with breaking waves and have freshwater inputs. However, San Onofre Creek Beach is influenced by a bar-built estuary that is intermittently closed to tidal exchange, while Deer Creek only has a "mixing zone" where the creek discharges to the ocean. The two watersheds that discharge to these reference beaches range from 3 to 110 km^2, which is within the 25th and 75th interquartile range of watershed area for all of the watersheds that drain to impacted, urbanized beaches in Southern California. Both watersheds that drain to the reference beaches were greater than 97% undeveloped based on land use data compiled by the U.S. Geological Survey and University of California, Santa Barbara (Davis et al. 1998). Deer Creek was the smallest watershed and has the least amount of human activity (i.e. picnicking, swimming, and fishing), while San Onofre Creek was the largest watershed and has a moderate amount of activity, including Camp Pendleton Marine Corps Base training activities and residential land use (<5%).

Both sites were sampled for dry weather FIB over a 1.5-year period. San Onofre Creek Beach was selected for wet weather sampling, with the intent to gather data as specific as possible to geographic scope of the San Diego Regional Water Quality Control Board.

This study captured conditions of moderate to extreme drought, with rainfall 30-60% of "normal" across the region (Table 2; Appendix Tables C15-C19). San Onofre Creek received 14.15" of rain in water year (WY=Oct. 1-Sept. 30) 2014-2015 and 10.85" rainfall in WY 2015-2016. Deer Creek received 14.15" of rain in WY 2014-2015 and 10.83" rainfall in WY 2015-2016.

Table 2. Percent normal rainfall in southern California during the entire study period. Data generated from National Weather Service.

CLIMATE STATION	Oct 1, 2015 - Apr 30, 2016		Oct 1, 2014 - Apr 30, 2015		Oct 1, 2013 - Apr 30, 2014		Oct 1 - Apr 30	Oct 1 - Sept 30
	Rainfall (inches)	PON[1]	Rainfall (inches)	PON	Rainfall (inches)	PON	Normal Rainfall (inches)	Normal Rainfall (inches)
SANTA BARBARA	10.19	61	9	54	6.49	39	16.61	17.76
LAX INT'L AIRPORT	6.66	56	6.81	57	4.42	37	12	12.82
OCEANSIDE	6.58	53	5.88	47	4.01	32	12.39	13.66

[1]PON is the percent of normal for the period, defined by the National Weather Service as the average annual rainfall during the period of 1981-2010.

Field Sampling

Sampling for wet weather, defined as the day of a rain event plus 72 hours, began in January 2014 and ended April 2016, after drought caused conditions in which few storms met qualifying criteria. Wet weather sampling criteria included an antecedent dry period of three or more days and predicted minimum rainfall estimates of 0.20 inches. Four samples per site were collected over a four-day period: one during the day of the storm (defined as within 24 hours of recorded rainfall), and then one additional sample on each of the three days following recorded rainfall. Due to extreme drought conditions, only one wet weather event successfully breached the mouth of San Onofre Creek during the length of the study period (March 1-3, 2014), a large storm with a total rainfall of 2.74.

Dry weather (both winter and summer) monitoring was conducted to characterize baseline conditions throughout the year. Sampling for dry weather began October 1, 2014 and continued through April 30, 2016, capturing two winter dry (October 1- April 30) and one summer dry weather period (May 1-September 30; Table 3). Bacteria samples were collected weekly, such that five samples would occur within each 30-day period, for the purpose of calculating a 30-day geometric mean (geomean). Dry weather creek sampling occurred when there was measureable flow at a site. Deer Creek began flowing at the end of December 2014 and ceased in early May 2015. The creek never flowed during the 2015-2016 winter dry weather period. From the onset of sampling, San Onofre Creek did not flow during the study period due to the extended drought.

Table 3. Summary of the dry weather sampling (October 1, 2014 through April 30, 2016 (both winter and summer dry weather)) by site.

County	Site	Habitat	Total Weeks Sampled	Total Winter DW Samples	Total Summer DW Samples	Sampling Period (Date)
San Diego	**San Onofre**	Creek[1]	0	0	0	10/2/2014-4/30/2016
		Estuary	71	65	25	
		Beach	71	65	25	
Ventura	**Deer Creek**	Creek	19	21	2	12/9/2014-5/12/2015; 6/9-18/2015
		Mixing Zone[2]	34	35	8	2/3/2015-5/28/2015; 6/9-18/2015; 1/1-4/15/2016, 7/23/2015
		Beach	72	64	25	10/7/2014-4/30/2016
Total				248	85	

[1]San Onofre Creek only flowed one day during the sampling period but samples were not collected since the site was inaccessible. The estuary breached twice (Jan 9th and Mar 7th, 2016). These dates coincided with both storm events and king tides.

[2]Deer Creek ceased flowing in May 2015 however two storm events (early June and mid-July) caused the creek and estuary to briefly flow again. In January 2016, following several winter storms the estuary began to flow again. Deer creek remained unsampleable.

At each reference site, three locations were sampled. The first was in the ocean immediately in front of the drainage inlet or estuary at the "wave wash," where the watershed discharge initially mixes with the ocean waves. All samples were collected between ankle and knee depth on an incoming wave. The second location was in the watershed discharge as it crossed the beach at the closest location that could be sampled prior to mixing with the ocean. A third sampling location was utilized to measure concentrations in the flowing creek prior to mixing with ocean water.

FIB concentration, temperature (°C), dissolved oxygen (DO) (mg/L), pH, salinity (ppt), and conductivity (µS/cm) using handheld field probes (i.e., Orion 125 and YSI Pro Plus) were measured at the beach and mixing zone locations, while FIB concentration, salinity and flow were measured in the creek. Duplicate samples were collected at both the second and third sites for analysis of the HF 183 human-associated fecal marker to assess the presence of human contributions of fecal pollution.

Samples were collected in 1.5 L sterile high-density polyethylene (HDPE) sample bottles (bacterial analysis, salinity analysis) following Standard Methods 1060 protocol for aseptic sampling techniques (APHA 1995). A replicate water sample was collected in the same way after completion of the initial water sample for approximately 10% of the samples. A field blank sample was collected at each site once a month. Collected water samples were immediately placed on ice and transported to the laboratory within 6 hours of sample collection for subsequent analyses. Stream discharge was measured as the product of the channel cross-sectional area and velocity. Channel cross sectional area was measured in the field. Velocity was measured using a Marsh-McBirney Model 2000 meter (Frederick, MD, USA).

Estuary Special Study

The estuary special study expanded on the existing dry weather monitoring conducted at San Onofre beach to better characterize FIB concentrations within an estuary. From October 2014 to October 2015, four additional sites were monitored once per week within San Onofre Estuary. When the estuary was closed, one grab sample was collected at each site. When the estuary was open to tidal exchange, monitoring was extended to collect samples at high and low tides at all sites (freshwater input, estuary, and beach locations). During the first winter dry season, the estuary at San Onofre beach remained closed. During the second winter dry season the creek flowed for one day after large storm events in both December 2015 and March 2016, coinciding with a "king tide" event (7+ ft.); however, no samples were collected because the site was inaccessible. Therefore, the sampling only characterizes concentrations during a closed mouth condition.

Laboratory Analyses

Water quality samples were analyzed for four bacteria indicators at Orange County Public Health Laboratory (OCPHL) in Newport Beach, CA: EC, ENT, FC and TC. EC and TC were measured using Colilert®-18 (IDEXX, Westbrook, ME). ENT was measured using Enterolert® (IDEXX, Westbrook, ME). Both IDEXX methods were performed following the manufacturer's instructions using the Quanti-tray system. FC were measured by APHA Method 9222 D (APHA 2005).

For each sample, an additional 100 ml of water was vacuum-filtered through 47-mm diameter, 0.4-um pore-size polycarbonate filters, flash-frozen in liquid nitrogen, and stored at -80° C for later analysis for the human-associated fecal marker HF183. Samples were analyzed for HF183 only if EC or ENT exceeded the Region 9 Basin Plan single sample maximum WQO (i.e., EC > 235 MPN/100 ml, or ENT > 61 MPN/100 ml).

For those samples that exceeded EC or ENT WQOs, the HF183 Taqman assay (Layton et al. 2013) was used to determine whether a human-associated fecal signal was present. Each 25 µl qPCR reaction contained 900 nmol l-1 of each primer, 250 nmol l-1 of the probe, and 2 µl of sample DNA, plus 1x Taqman Universal PCR Master Mix (Applied Biosystems, Carlsbad, CA) and 0.2 mg ml-1 bovine serum albumin (Sigma, St. Louis, MO). The reaction was conducted on a CFX96 (Bio-Rad, default ramping speed of 3.3ºC s-1) using the following thermal conditions: 10 min at 95ºC, followed by 40 cycles of 15s at 95ºC and 60s at 60ºC.

After sampling was initiated, the human-associated HF183 MST marker (Layton et al. 2013) was used to confirm that the sites had no putative human fecal contamination. The HF183 genetic marker is used to identify human-associated *Bacteroidales*, a type of anaerobic bacteria that is in the gastrointestinal tract of mammals and that survive poorly outside of their host. Thus, the detection of HF183 is a reliable marker for a human input of fecal contamination into the system. Samples with FIB results that exceeded the Bacteria TMDL numeric targets (Table 2) were selected for further molecular analyses to identify the potential source(s) of bacteria. As part of the preliminary data assessment, FIB results were compared to bacteria TMDL numeric targets to calculate the exceedance frequency of samples during wet and dry weather.

Laboratory FIB samples met quality control (QC) requirements, including: 10% for field blanks, field duplicates, and replicates (Appendix Table A), holding time requirements, and data quality objectives for accuracy, precision and completeness (Appendix Tables A2 -A5). Negative controls were all within the expected "no growth" zone for bacteria. Median blind field blanks were at the minimum reported value of 2 CFU/100ml for all bacteria. Lab variability was well within the 25% method quality objective (MQO) established for this study. Field mean variability (precision) was 90%-94% during wet and winter dry seasons.

Data Analyses

Calculation of Baseline Concentrations and Exceedance Frequencies

First, the storm event grab concentrations (dry weather single sample or 30-d geomean concentrations, variances, and ranges of concentrations) were calculated to provide an estimate of baseline bacterial levels in the creeks, mixing zone or estuary, and beaches. Calculations were summarized by wet weather, winter and summer dry weather.

Dry weather concentration data were used to calculate exceedance frequency. WQOs were based on both single sample grabs and the geomean of five samples. They were compared to the Bacteria TMDL numeric targets, which are based on California State Assembly Bill AB411 public health standards for marine bathing beaches and the California Ocean Plan (Table 4). For this study, 30-d geomean concentrations were calculated by calendar month. When the number of samples was four (e.g., sampling postponed due to wet weather events), then all field duplicates from that month were regarded as individual samples to ensure at least 5 samples within the calendar month were available for the analyses[1]. Months for which there were less than four samples were dropped from geomean calculations.

[1] The decision to use field replicates as one of 5 samples for a geomean calculation was made by the stakeholder workgroup, including the San Diego Regional Water Board, in the San Diego Stream FIB Reference study.

Cumulative frequency distributions (CFDs) were produced to compare observed bacterial concentrations to the WQOs and to calculate accumulated relative exceedance percentages.

Table 4. Bacteria TMDL Numeric Targets for Beaches. Dry weather days defined as days with less than 0.2 inches of rainfall observed during each of the previous three days. Wet weather days defined as days with rainfall events of 0.2 inches or greater and the following three days.

Parameter	30-d Geomean WQO (MPN/100mL) [a]	Single Sample Max WQO (MPN/100mL)
E. coli	235	126
Enterococcus	35	104
Fecal Coliform	200	400
Total Coliform	1,000	10,000

Source: California RWQCB, San Diego Region. Resolution No. R9-2010-0001.

(a) Dry weather numeric objectives based on the 30-day geometric mean water quality objectives in the California Ocean Plan (2005). Compliance with the dry weather TMDLs in the receiving water is based on the frequency that the dry weather days in any given year exceed the dry weather numeric objective. The TMDL set a 0% allowable exceedance frequency of the REC-1 geometric mean WQOs.

(b) E. coli criteria USEPA freshwater bacteriological criteria for water contact recreation (in colonies per 100 mL)

Investigation of the Relationship of FIB Concentrations with Environmental Factors

Factors associated with the variability in FIB concentrations were investigated using two approaches. First, Spearman's rank correlations and regression analyses were used to investigate relationships with other known drivers such as water temperature, salinity (as an indicator of ocean mixing), and number of antecedent dry days. Second, the influence of the freshwater inflow from creek and the presence/absence of an estuary on log-transformed FIB concentrations was investigated. We note that because of the lack of replication in the study, such comparisons are descriptive rather than statistical.

RESULTS AND DISCUSSION

Status of Deer Creek and San Onofre Creek Beaches and Their Respective Estuary/Mixing Zone as Dry Weather Reference Beaches

During the one single, large storm event captured to date at San Onofre Creek, one of the samples collected during the four days exceeded ENT, EC and FC single sample WQOs, while no samples exceeded the TC single sample WQO (Table 5). The concentrations of FIB during the day of the storm were typically the highest, with concentrations declining over Days 2-4. However, the sample that exceeded FIB WQOs tested positive for HF183 (Table 6), thus disqualifying it from analysis as a reference sample.

Table 5. Summary of wet weather storm sampling at San Onofre Beach. Bolded values exceeded single sample maximum water quality objectives (WQOs). Positive HF183 designates human fecal contamination. FIB are in MPN or CFU/100 mL.

Event Date	Storm Size	Season	Rain-fall (in)	Location	Day	EC	ENT	TC	FC	Positive for HF183
						(MPN/100 mL)				
March 1-4, 2014	Large	Mid		Creek	1	**2,100**	**3,980**	9,600	**1,800**	Yes
					2	**1,060**	**2,050**	7,100	**1,010**	Yes
					3	**960**	**2,590**	**15,500**	**720**	Yes
					4	**630**	**2,090**	**10,500**	**429**	Yes
			2.48	Estuary	1	**1,500**	**15,000**	10,000	**1,200**	Yes
			0.18		2	**940**	**2,473**	613	**820**	Yes
			0.08		3	**1,600**	**1,600**	**44,500**	**1,300**	Yes
			0.00		4	**3,540**	**2,800**	**19,000**	**3,250**	Yes
				Beach	1	**920**	**3,600**	9,200	**940**	Yes
					2	5.0	55	45.0	7.0	No
					3	3.5	14	24.5	2.0	No
					4	6.5	8.5	295	4.5	No

A previous study by Griffith et al. (2010) found that 27% of samples collected < 24 hours after rainfall exceeded FIB WQOs for at least one FIB indicator, and the exceedance frequency was among the highest (30%) at San Mateo and San Onofre Creek Beaches (the two of the six beaches in the study that are

located in San Diego). The results of our study cannot contribute to this body of literature informing FIB because the single storm discharge captured was found to be contaminated with a human source of FIB.

Table 6. Microbial source tracking results used to eliminate samples with human fecal contamination during one wet weather event.

Sampling Type	Site	n[1]	% Reactions Positive for HF183	% Sample with both replicates positive	Mean log HF183 copy (include units)
March 1-4, 2014 Storm Event	San Onofre Creek	14	50	43	2.73
	San Onofre Estuary	16	88	75	2.37
	San Onofre Beach	2	100	100	3.31

[1] **n** = number of samples analyzed for HF183, including replicates of duplicate water quality samples.

Despite the positive human fecal contamination evident in the one storm event sampled at San Onofre, MST analyses of dry weather beach, creek and estuary/mixing zone samples showed little to no human fecal contamination over the duration of the study (Table 7), suggesting that both Deer Creek and San Onofre Creek are suitable beach FIB reference sites. The few samples from Deer Creek Beach (winter 2014-15, summer 2014-15) and San Onofre Estuary (winter 2014-15) that tested positive for HF183 were not included in the calculations of concentrations and exceedance frequencies.

Table 7. Samples positive for human fecal contamination during 2014-2015 and 2015-2016 winter dry weather and 2014-15 summer dry weather.

Sampling Type	Site	n[1]	% Reactions Positive for HF183	% Sample with both replicates positive	Mean log HF183 copy
2014-2015 Winter Dry Weather	Deer Creek	10	0	0	-
	Deer Creek Mixing Zone	14	0	0	-
	Deer Creek Beach	4	25	0	1.59
	San Onofre Creek	NA	NA	NA	NA
	San Onofre Estuary	158	2.6	0.9	1.86
	San Onofre Beach	0	0	0	-
2015-2016 Winter Dry Weather	Deer Creek	NA	NA	NA	NA
	Deer Creek Mixing Zone	4	0	0	-
	Deer Creek Beach	0	0	0	-
	San Onofre Creek	NA	NA	NA	NA
	San Onofre Estuary	52	0	0	

	San Onofre Beach	0	0	0	-
2014-2015 Summer Dry Weather	Deer Creek	1	0	0	-
	Deer Creek Mixing Zone	0	0	0	-
	Deer Creek Beach	6	17	17	1.88
	San Onofre Creek	NA	NA	NA	NA
	San Onofre Estuary	44	0	0	-
	San Onofre Beach	8	0	0	-

[1]n = number of samples used for HF183, including replicates of duplicate water quality samples.
NA = not analyzed. San Onofre Creek never flowed during the winter dry weather sampling period.

Reference Beach Winter and Summer Dry Weather Concentrations and WQO Exceedances

At both beaches, the winter and summer dry weather ranges of FIB concentrations were very low and the exceedance frequencies of FIB WQOs were 0% except for ENT at Deer Creek Beach (3.5% and 2.9%; Tables 9-11; Figure 2). In the context of a larger and more varied set of beaches characterized by Griffith et al. (2010), these low exceedance frequencies are characteristic and comparable to the beaches in that study that had the inlets to the estuary blocked (similar to the San Onofre) or are always flowing without an estuary (similar to Deer Creek). During both winter periods, we found that median single sample and 30-day geomean concentrations were less than 10 MPN/100 ml for all FIB analytes, while during the summer dry weather values were less than 5 MPN/100 ml. Detailed median and geomean concentrations and exceedance frequencies are given by month for each creek in Appendix A1.

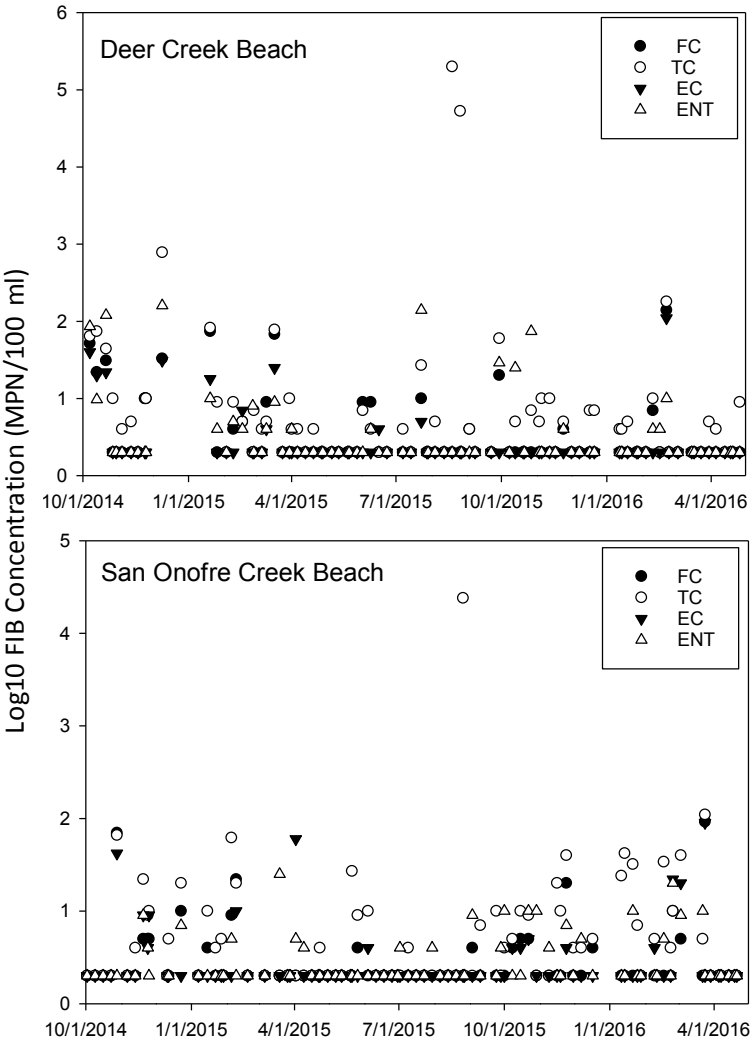

Figure 2. Time series of log 10 transformed dry weather FIB concentrations at San Onofre and Deer Creek Reference Beaches.

Table 8. Summary of 2014-15 Winter Dry Weather FIB Exceedances.

FIB Analytes	Site	Creek					Estuary or Mixing Zone					Beach				
		N	Median (MPN or CFU/100 mL)	Geo-mean (MPN or CFU/100 mL)	% SSM Exceed-ances	% GM Exceed-ances	N	Median (MPN or CFU/100 mL)	Geo-mean (MPN or CFU/100 mL)	% SSM Exceed-ances	% GM Exceed-ances	N	Median (MPN or CFU/100 mL)	Geo-mean (MPN or CFU/100 mL)	% SSM Exceed-ances	% GM Exceed-ances
EC	SOC	0	NA	NA	NA	NA	30	415	334	57	67	30	2	3	0	0
	DC	18	47	23	33	33	15	20	11	0	0	28	2	4	0	0
ENT	SOC	0	NA	NA	NA	NA	28	440	459	84	97	30	2	3	0	0
	DC	18	80	94	42	84	15	110	97	50	75	28	2	4	3.5	11
TC	SOC	0	NA	NA	NA	NA	30	1,200	1,129	3.2	55	30	3	4	0	0
	DC	18	260	327	10	26	15	485	349	0	12	28	7	9	0	0
FC	SOC	0	NA	NA	NA	NA	30	569	475	71	77	30	2	3	0	0
	DC	18	10	30	16	26	15	9.5	10	0	0	28	2	5	0	0

N = number of samples,
SSM = single sample maximum water quality objective,
GM = geomean water quality objective,
SOC = San Onofre Creek,
DC = Deer Creek,
NA = not analyzed. San Onofre Creek never flowed during the winter dry weather sampling period.

Table 8. Summary of 2015-16 Winter Dry Weather FIB Exceedances.

FIB Analytes	Site	Creek					Estuary or Mixing Zone					Beach				
		N	Median (MPN or CFU/100 mL)	Geo-mean (MPN or CFU/100 mL)	% SSM Exceed-ances	% GM Exceed-ances	N	Median (MPN or CFU/100 mL)	Geo-mean (MPN or CFU/100 mL)	% SSM Exceed-ances	% GM Exceed-ances	N	Median (MPN or CFU/100 mL)	Geo-mean (MPN or CFU/100 mL)	% SSM Exceed-ances	% GM Exceed-ances
EC	SOC	0	NA	NA	NA	NA	31	315	252	52	74	32	2.0	2.9	0	0
	DC	0	NA	NA	NA	NA	18	3.0	5.8	0	0	34	2.0	2.2	0	0
ENT	SOC	0	NA	NA	NA	NA	31	507	414	93	100	32	2.0	3.3	0	0
	DC	0	NA	NA	NA	NA	18	9.0	11	5.6	5.6	34	2.0	2.7	2.9	2.9
TC	SOC	0	NA	NA	NA	NA	31	1,300	1,773	3.2	58	32	5.0	7.0	0	0
	DC	0	NA	NA	NA	NA	18	45	52	0	5.5	34	2.0	3.5	0	0
FC	SOC	0	NA	NA	NA	NA	31	280	308	9.7	61	32	2.0	3.0	0	0
	DC	0	NA	NA	NA	NA	18	9.5	10	0	5.5	34	2.0	2.4	0	0

N = number of samples,
SSM = single sample maximum water quality objective,
GM = geomean water quality objective,
SOC = San Onofre Creek,
DC = Deer Creek,
NA = not analyzed. San Onofre Creek never flowed during the second winter dry weather sampling period

Table 10. Summary of Summer Dry Weather FIB Exceedances.

FIB Analytes	Site	Creek					Estuary or Mixing Zone					Beach				
		N	Median (MPN or CFU/100 mL)	Geo-mean (MPN or CFU/100 mL)	% SSM Exceed-ances	% GM Exceed-ances	N	Median (MPN or CFU/100 mL)	Geo-mean (MPN or CFU/100 mL)	% SSM Exceed-ances	% GM Exceed-ances	N	Median (MPN or CFU/100 mL)	Geo-mean (MPN or CFU/100 mL)	% SSM Exceed-ances	% GM Exceed-ances
EC	SOC	0	NA	NA	NA	NA	25	379	314	92	100	25	2.0	2.0	0	0
	DC	2	97	81	0	50	8	70	53	0	37.5	25	2.0	2.3	0	0
ENT	SOC	0	NA	NA	NA	NA	25	294	268	80	100	25	2.0	2.3	0	0
	DC	2	5,220	2,098	100	100	8	110	97	75	75	25	2.0	4.4	0	0
TC	SOC	0	NA	NA	NA	NA	25	7,308	7,510	40	92	25	2.0	3.4	0	0
	DC	2	350	338	0	0	8	180	232	12.5	37.5	25	2.0	3.3	0	0
FC	SOC	0	NA	NA	NA	NA	25	423	379	54	72	25	2.0	2.2	0	0
	DC	2	88	77	0	0	8	80	104	12.5	37.5	25	2.0	2.8	0	0

N = number of samples,
SSM = single sample maximum water quality objective,
GM = geomean water quality objective,
SOC = San Onofre Creek,
DC = Deer Creek,
NA = not analyzed. San Onofre Creek never flowed during the summer dry weather sampling period

Comparison of Winter and Summer Dry Weather Concentrations and Exceedance Frequencies in San Onofre Creek Estuary and Deer Creek Mixing Zones

Concentrations of FIB were typically 1-3 orders of magnitude higher within San Onofre Creek Estuary and the Deer Creek mixing zone relative to their respective beaches, with the highest geomean WQO and single sample maximum exceedance frequencies at San Onofre Creek (Figure 3). This implies that dry weather exceedance frequencies at the beach had the potential to be higher, had the mouth of the estuary been open to tidal exchange and dispersal of ponded water to the surf zone (Griffith et al. 2010).

Within the San Onofre Estuary, summer dry weather concentrations and exceedance frequencies were only significantly lower than winter dry for ENT and TC (Figure 4). During the summer dry weather, the exceedance frequencies ranged from 40% (FC) to 92% (EC) for single samples, while geomean exceedance frequencies ranged from 72% (FC) to 100% (EC and ENT; Table 10). During both winter dry sampling periods, exceedance frequencies ranged from 3.2% (TC) to 84%-93% (ENT) in 2014-2015 and 2015-2016 (Tables 9 and 10), while geomean exceedance frequencies during winter dry weather ranged from ~55% (TC) to 100% (ENT). No samples were obtained from San Onofre Creek because the creek remained dry, with the estuary mouth closed to tidal exchange throughout the entire period.

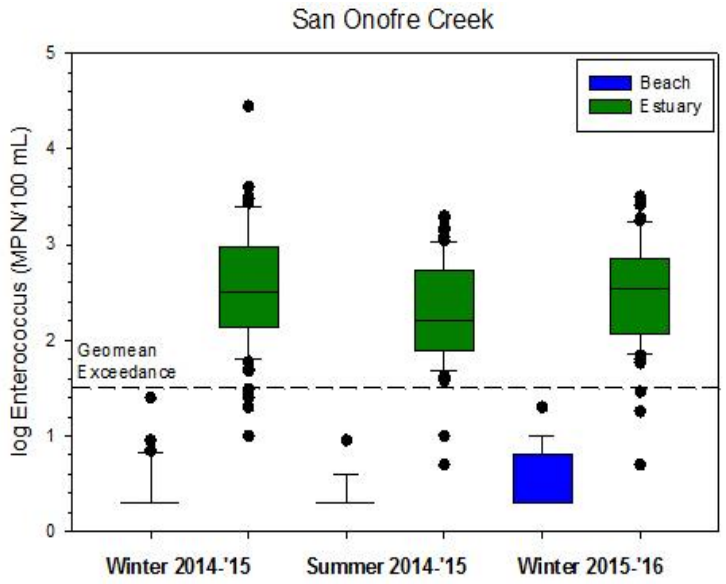

Figure 3. Boxplots of Enterococcus geomean concentrations at San Onofre Beach and Estuary from October 2014 – April 2016. Upper and lower edges of box are 75th and 25th percentile, respectively. Center line is median.

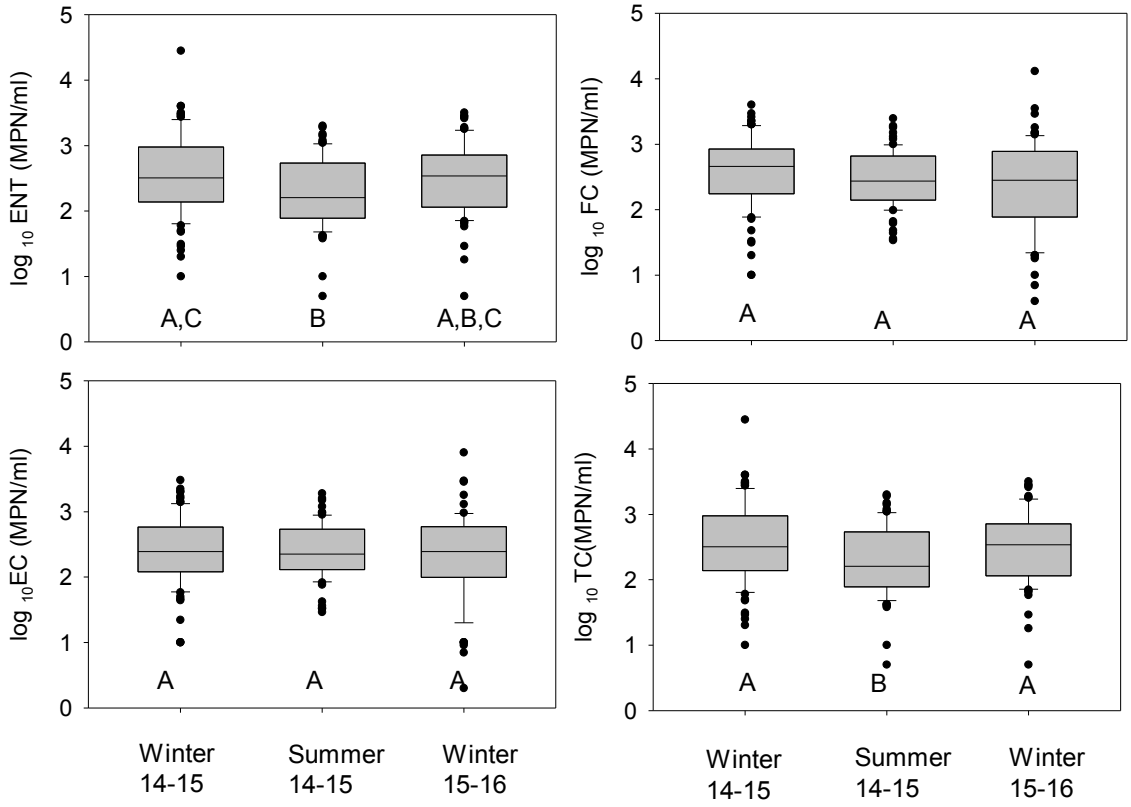

Figure 4. Box and whisker plots of log10 FIB concentrations in San Onofre Estuary by dry weather season and year. Letters under box designate significant difference in non-parametric rank ANOVA, such that the same letter for difference season indicates no significant difference.

Concentrations of FIB in the San Onofre Creek Estuary were 1-2 orders of magnitude higher than the mixing zone of Deer Creek, with much higher WQO exceedance rates. Estuaries are known to be among the most highly productive aquatic habitats (Day et al. 1989), often abundant in labile organic matter sources that provide a rich substrate to support prokaryote production in general, including FIB. It has long been documented that FIB can survive for long periods or regrow attached to sediments and vegetation (Savage 1905, Roper and Marshall 1979, LaBelle et al. 1980, Davies et al. 1995, Desmarais et al. 2002). Such vegetation and organic-rich sediments abound in estuaries. Sanders et al. (2005) showed that estuarine sediments can provide a source of FIB that is exported to beaches. In addition, estuaries serve as habitat for many species of water birds that routinely deposit FIB laden excreta into the water.

The summer dry weather single sample WQO exceedance rates at Deer Creek, which has a mixing zone but no estuary, ranged from 0% (EC) to 75% (ENT) for single samples, while geomean exceedance rates ranged from 38% (EC, FC, TC) to 75% (ENT; Table 10, Figure 5). During both winter dry sampling periods, exceedance rates were generally 0% for FC, TC, and EC for single samples, while geomean exceedance rates for these same FIB ranged from 0-5.5% (Tables 9-10). ENT was more likely to exceed the WQO, with exceedance frequencies of 5.6-50% for single sample and 5.5%-75% for geomean values. Unlike San Onofre Creek, flow was present throughout much of the first winter dry weather and

continued flowing during a limited time during summer dry weather. No samples were obtained from Deer Creek during the second winter dry weather periods because the creek was dry.

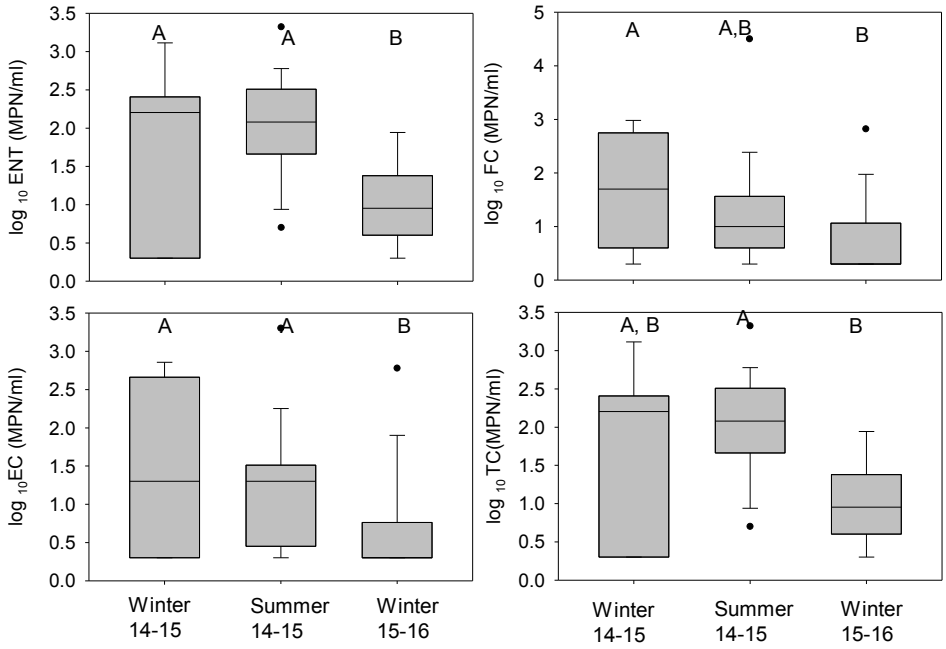

Figure 5. Box and whisker plots of log10 FIB concentrations in Deer Creek mixing zone by dry weather season and year. Letters above box designate significant difference in non-parametric rank ANOVA, such that the same letter for difference season indicates no significant difference.

Factors Influencing Variability in FIB Concentrations at Reference Beaches and San Onofre Estuary

Analysis of spearman's rank correlation of FIB concentrations showed no significant relationship with water temperature, salinity, or antecedent dry days (ADD) for either Deer or San Onofre Creek beaches (p-value> 0.05). Plots of FIB concentration as a function of ADD show a wedge-shaped distribution of data, indicating that wet weather correspond with higher concentrations of FIB, particularly at Deer Creek, within a threshold of ~25-40 ADD (Figure 6). However, because the estuary or mixing zone was typically permanently bermed, with infrequent surface water connectivity with the ocean, beach FIB at these two sites do not appear to be directly influenced by concentrations in the mixing zone or estuary just upstream in this "closed" mouth condition (Figure 7).

Three medium-to-large size storm events (ranging in intensity from 0.77" -1.65") occurred in May, July and September at both monitoring sites (Tables 9-10). These storm events may account for some of the variability in concentrations observed during the summer months.

A previous study by Griffith et al. (2010) found that the degree to which the tidal creek or estuary mouth is open to surface water exchange was a major determinant in the exceedance of WQOs during wet

weather. Our study captured both closed inlet conditions as well as record low inputs of freshwater due to drought conditions. San Onofre Creek never had surface water flow, except for ephemeral flows during storm events. These conditions provide important context for the exceedance frequencies found in this study.

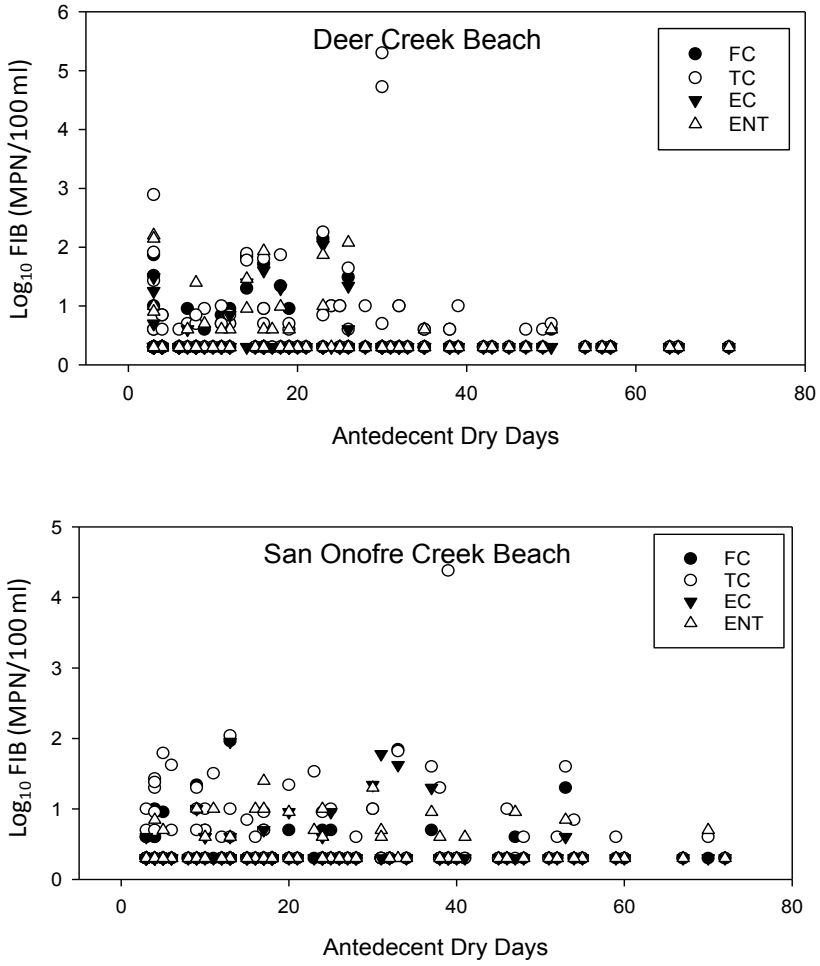

Figure 6. Plots of log 10 transformed FIB concentration data as a function of antecedent dry days for Deer Creek (top panel) and San Onofre Creek (bottom panel).

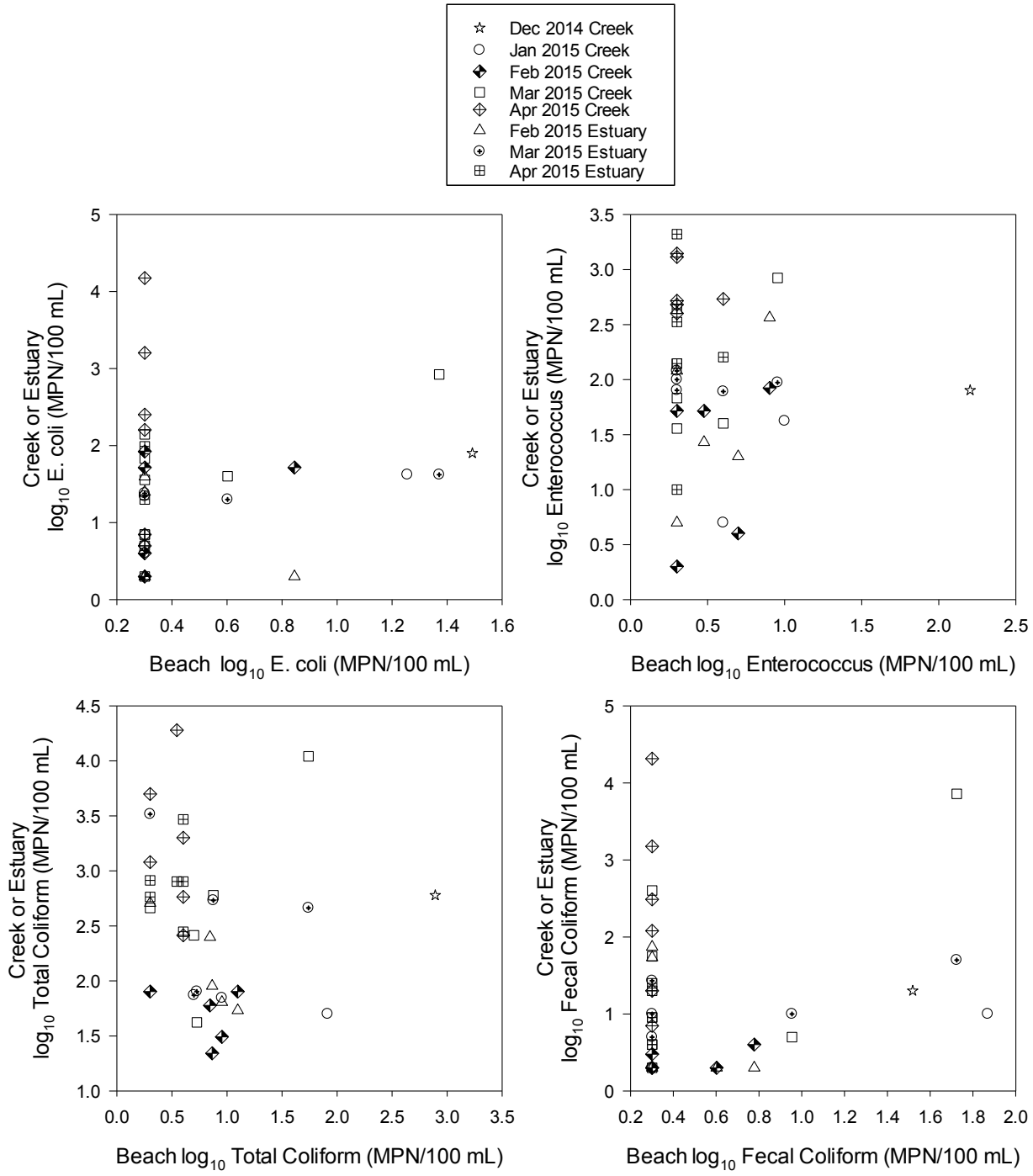

Figure 7. Relationship between log 10 transformed FIB concentrations in Deer Creek, the mixing zone and the beach for each of the four FIB species. The symbols represent corresponding monthly creek, estuary or mixing zone FIB concentrations.

In contrast to San Onofre Beach, where FIB concentrations declined with increasing duration of dry weather, in San Onofre Estuary the range and mean FIB increased with increasing antecedent dry days and salinity (Figure 8), signaling that freshwater input from the ephemeral channel tended to dilute concentrations, rather than be a source. Analysis of spearman's rank correlation showed significant, positive correlations of TC to water temperature, salinity and ADD (p-value<0.05), while EC and FC were positively correlated to salinity (p-value< 0.5). This effect may be in part attributable to the fact that the bed of San Onofre Creek is likely acting as a sand filter for wet weather, removing particulates as flow to the estuary becomes subsurface. Salinity values in the estuary were low throughout the study period, indicating that this estuary is "perched" at a higher elevation relative to mean sea level (MSL) and is infrequently subjected to surface water tidal exchange.

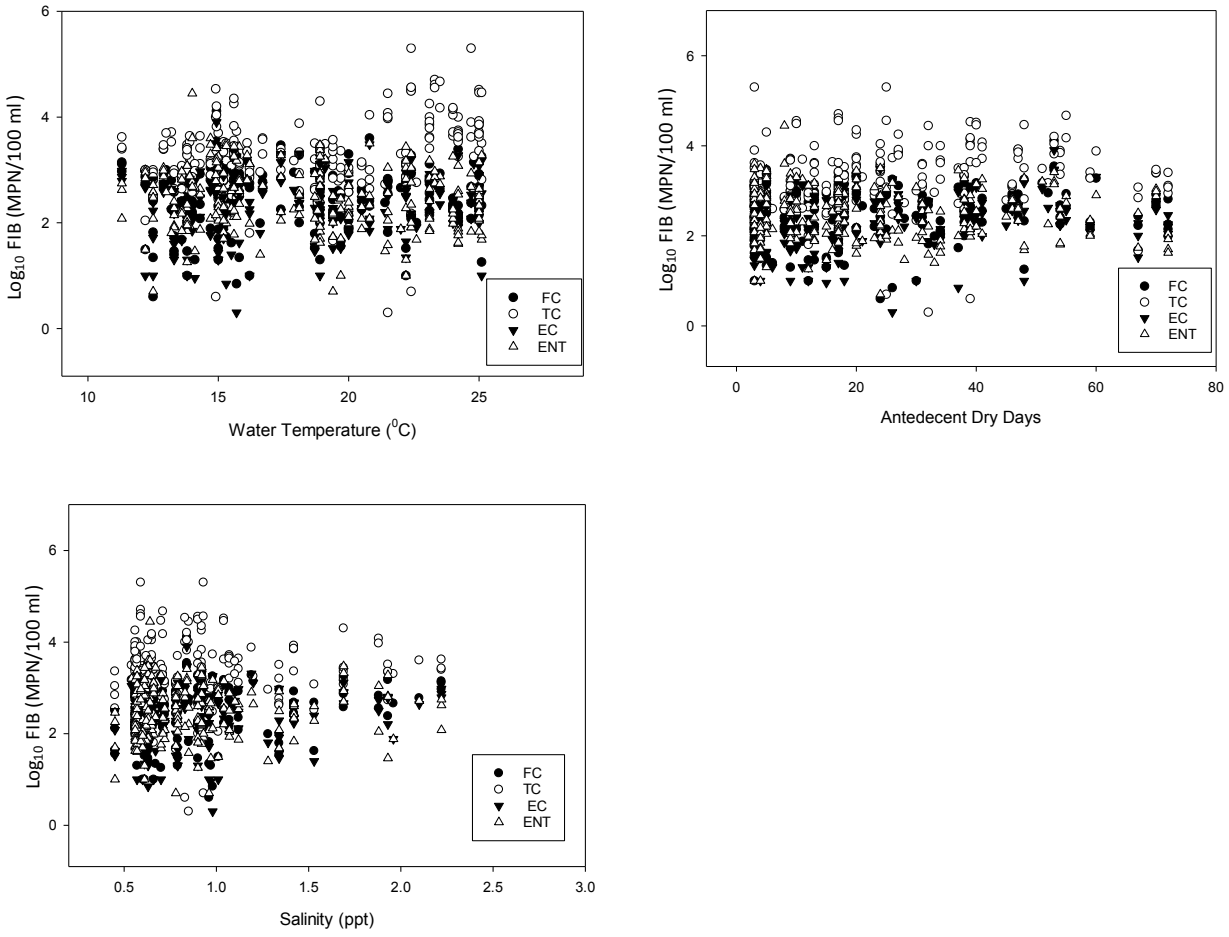

Figure 8. Log 10 transformed FIB concentrations as a function of salinity, water temperature and antecedent dry days in San Onofre Creek Estuary.

The slight increase in some FIB concentrations as function of temperature suggests that growth may be a factor (Figure 8; Hardina and Fujioka 1991, Fujioka et al. 1999), which is credible given the organic rich environment of San Onofre Creek Estuary, which can have phytoplankton concentrations up to 160 µg L^{-1}

in the summertime. Bacteria from the human gut grow well at body temperature (37 C). The ability of bacteria to secrete extracellular polymers and adhere to surfaces as microbial biofilms may be one reason why survival and growth of FIB is enhanced in association with estuarine plants, algae and sediment (Decho 2000).

SUMMARY

The goal of this study was to characterize the natural background concentrations of enterococcus (ENT), *E. coli* (EC), fecal (FC) and total coliform (TC) bacteria conditions, and to categorize FIB water quality objective (WQO) exceedance frequencies at two "reference" recreational beaches and their respective estuary or mixing zone. Additionally, samples were analyzed for HF183, which can indicate the presence of human fecal contamination, to confirm that the reference beaches have minimal human impact.

Specific questions addressed in the study were:

1. How does the WQO exceedance frequency for FIB vary between wet weather, summer dry weather and winter dry weather at reference beaches and within the estuary or mixing zone?
2. How does FIB concentration at the beach vary by factors such as presence or absence of an estuary, water temperature, salinity and number of antecedent dry days?

This study had five major findings:

1. The winter and summer dry weather ranges of FIB concentrations at both beaches were very low and the WQO exceedance frequencies were 0% -3.5%, values that are characteristic and comparable to results from previous FIB beach bacteria reference studies that had the inlets to the estuary blocked (such as the San Onofre Creek) or are always flowing without an estuary (such as Deer Creek). The prolonged drought resulted in intermittent flow at Deer Creek and the complete absence of dry weather flow at San Onofre Creek. These conditions provide important context for the low exceedance frequencies found in this study.

2. Concentrations of FIB were typically 1-3 in order of magnitude higher within San Onofre Creek Estuary and the Deer Creek mixing zone compared to their respective beaches, with the highest WQO exceedance frequencies found in San Onofre Creek. This suggests that dry weather exceedance frequencies could have been greater had the mouth of the estuary been open to tidal exchange and dispersal to the surf zone.

3. Water within San Onofre Estuary was characterized by high WQO exceedance rates, ranging from 40% (FC) to 92% (EC) for single samples and 72% (FC) to 100% (EC and ENT) for summer dry weather. During both winter dry sampling periods, single sample WQO exceedances ranged from 3.2% (TC) to 84%-93% (ENT) in 2014-2015 and 2015-2016, while geomean WQO exceedances during winter dry weather ranged from ~55% (TC) to 100% (ENT). The higher WQO exceedance frequencies of San Onofre Creek Estuary relative to the mixing zone of Deer Creek could be expected, given the abundance of labile organic matter typical in estuaries that can serve to support microbial growth and the presence of water birds in the estuary that excrete high concentrations of FIB.

4. At both beaches, no significant relationship was found with water temperature, salinity or antecedent dry days. In contrast to San Onofre Beach, where FIB concentrations declined with increasing duration of dry weather, the range and mean FIB concentration in San Onofre Estuary increased with increasing antecedent dry days and salinity, suggesting that freshwater input from the ephemeral channel tended to dilute concentrations, rather than be a source of bacteria to the beach. The slight increase in San Onofre Creek Estuary FIB concentrations as a function of

temperature suggests that growth may be a factor, which is credible given the organic rich environment of San Onofre Creek estuary.

5. The single storm captured during this study was found to be contaminated with a human source of fecal material and therefore cannot contribute to the body of literature on reference beach FIB exceedances during wet weather.

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APPENDICES

Appendix A. QA/QC Detailed Results

Table A1a. QAQC Wet Weather and 2014-15' and 2015-16' Winter Dry Weather Sample Collection Summary

Site ID	Primary Sample	Replicate	Field Duplicate	Field Blank
SO-B	**64**	**9**	**10**	**10**
SO-C	**0**	**0**	**0**	**0**
SO-E1-E4	**60**	**6**	**6**	**6**
DC-B	**65**	**12**	**11**	**13**
DC-C	**19**	**4**	**4**	**4**
DC-Mid	**34**	**4**	**4**	**4**
TOTAL	**242**	**35**	**20**	**20**
Percent	**242%**	**14%**	**14%**	**15%**

Site IDs: SO-B =San Onofre Beach, SO-C=San Onofre Creek, SO-E1-E4= San Onofre Estuary sites 1-4, Deer Creek Beach = DC-B, DC-C=Deer Creek, DC-M=Deer Creek Mid

Table A1b. QAQC Summer Dry Weather Sample Collection Summary

Site ID	Primary Sample	Replicate	Field Duplicate	Field Blank
SO-B	**25**	**5**	**5**	**5**
SO-C	**0**	**0**	**0**	**0**
SO-E1-E4	**25**	**5**	**5**	**5**
DC-B	**25**	**5**	**5**	**5**
DC-C	**2**	**1**	**1**	**1**
DC-Mid	**8**	**3**	**3**	**3**
TOTAL	**85**	**19**	**19**	**19**
Percent	**85%**	**22%**	**22%**	**22%**

Site IDs: SO-B =San Onofre Beach, SO-C = San Onofre Creek, SO-E1-E4= San Onofre Estuary sites 1-4, Deer Creek Beach = DC-B, DC-C = Deer Creek, DC-M = Deer Creek Mid

Table A2. Data Quality Objectives and Levels Achieved for Analytical Results for wet weather samples

	Accuracy					Precision			Recovery		Completeness	
Constituent	**DQO**	**Percent Achieved (LCS)[1]**	**DQO**	**Percent Achieved (FB)[2]**	**Percent Achieved (LB)[3]**	**DQO**	**Percent Achieved (FD)[4]**	**Percent Achieved (LD)[5]**	**DQO**	**Percent Achieved (MSS)[6]**	**DQO**	**Percent Achieved**
Bacteria												
E. coli	NA[7]	NA	<TRL[8]	100	100	25% RPD[9]	90	100	NA	NA	90%	100
Enterococcus	NA[7]	NA	<TRL[8]	100	100	25% RPD[9]	90	100	NA	NA	90%	100
Total Coliform	NA	NA	<TRL[8]	100	100	25% RPD[9]	90	100	NA	NA	90%	100
Fecal Coliform	NA	NA	<TRL[8]	100	100	25% RPD[9]	90	100	NA	NA	90%	99

[1]LCS = Laboratory Control; [2]FB = Field Blank; [3]LB = Laboratory Blank; [4]FD = Field Duplicate; [5]LD = Laboratory Duplicate; [6]MSS = Matrix Spike Sample; [7]NA = Not Applicable; [8]TRL = Target Reporting Limit; [9]RPD = Relative Percent Difference

Table A3. Wet Weather Qualified Data for Bacteria

Constituent	Qualified	%Qualified	ND	% ND	DNQ	%DNQ	Total Result Count
Bacteria							
E. coli	0	0.0%	0	0.0%	0	0.0%	7
Enterococcus	0	0.0%	0	0.0%	0	0.0%	7
Total Coliform	0	0.0%	0	0.0%	0	0.0%	7
Fecal Coliform	0	0.0%	0	0.0%	0	0.0%	7

Table A4: Data Quality Objectives and Levels Achieved for Analytical Results for winter 2014-15' and 2015-16' dry weather samples

Constituent	Accuracy					Precision			Recovery		Completeness	
	DQO	Percent Achieved (LCS)[1]	DQO	Percent Achieved (FB)[2]	Percent Achieved (LB)[3]	DQO	Percent Achieved (FD)[4]	Percent Achieved (LD)[5]	DQO	Percent Achieved (MSS)[6]	DQO	Percent Achieved
Bacteria												
E. coli	NA[7]	NA	<TRL[8]	100	100	25% RPD[9]	94	100	NA	NA	95%	100
Enterococcus	NA[7]	NA	<TRL[8]	100	100	25% RPD[9]	94	100	NA	NA	95%	100
Total Coliform	NA	NA	<TRL[8]	100	100	25% RPD[9]	94	100	NA	NA	95%	100
Fecal Coliform	NA	NA	<TRL[8]	100	100	25% RPD[9]	94	100	NA	NA	95%	99

[1]LCS = Laboratory Control; [2]FB = Field Blank; [3]LB = Laboratory Blank; [4]FD = Field Duplicate; [5]LD = Laboratory Duplicate; [6]MSS = Matrix Spike Sample; [7]NA = Not Applicable; [8]TRL – Target Reporting Limit; [9]RPD = Relative Percent Difference

Table A5. 2014-15' and 2015-16' Winter Dry Weather Qualified Data for Bacteria

Constituent	Qualified	%Qualified	ND	% ND	DNQ	%DNQ	Total Result Count
Bacteria							
E. coli	0	0.0%	0	0.0%	0	0.0%	98
Enterococcus	0	0.0%	0	0.0%	0	0.0%	98
Total Coliform	0	0.0%	0	0.0%	0	0.0%	98
Fecal Coliform	0	0.0%	0	0.0%	0	0.0%	98

Table A6. Data Quality Objectives and Levels Achieved for Analytical Results for Summer Dry Weather Samples

	Accuracy					Precision			Recovery		Completeness	
Constituent	**DQO**	**Percent Achieved (LCS)[1]**	**DQO**	**Percent Achieved (FB)[2]**	**Percent Achieved (LB)[3]**	**DQO**	**Percent Achieved (FD)[4]**	**Percent Achieved (LD)[5]**	**DQO**	**Percent Achieved (MSS)[6]**	**DQO**	**Percent Achieved**
Bacteria												
E. coli	NA[7]	NA	<TRL[8]	100	100	25% RPD[9]	95	100	NA	NA	98%	100
Enterococcus	NA[7]	NA	<TRL[8]	100	100	25% RPD[9]	95	100	NA	NA	98%	100
Total Coliform	NA	NA	<TRL[8]	100	100	25% RPD[9]	95	100	NA	NA	98%	100
Fecal Coliform	NA	NA	<TRL[8]	100	100	25% RPD[9]	95	100	NA	NA	98%	99

[1]LCS = Laboratory Control; [2]FB = Field Blank; [3]LB = Laboratory Blank; [4]FD = Field Duplicate; [5]LD = Laboratory Duplicate; [6]MSS = Matrix Spike Sample; [7]NA = Not Applicable; [8]TRL = Target Reporting Limit; [9]RPD = Relative Percent Difference

Table A7. Summer Dry Weather Qualified Data for Bacteria

Constituent	Qualified	%Qualified	ND	% ND	DNQ	%DNQ	Total Result Count
Bacteria							
E. coli	0	0.0%	0	0.0%	0	0.0%	35
Enterococcus	0	0.0%	0	0.0%	0	0.0%	35
Total Coliform	0	0.0%	0	0.0%	0	0.0%	35
Fecal Coliform	0	0.0%	0	0.0%	0	0.0%	35

Appendix B: Detailed Summaries of FIB Concentrations and Exceedance Frequencies

Table B1. Summary of winter 2014-15 dry weather E. coli concentrations and water quality objective (WQO) exceedances at San Onofre Beach, San Diego County and Deer Creek, Ventura County.

				Habitat									
				Creek			Estuary			Beach			
County	Site	Year	Month	# of Samples	Median	Geomean	%WQO Exceed-ance	# of Samples	Median	Geomean	%WQO Exceed-ance	# of Samples	Median	Geomean	%WQO Exceed-ance
					(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
San Diego	San Onofre	014	Oct.	0	NA[1]	NA[1]	NA[1]	5	82	160	20	5	2.0	3.7	0
			Nov.	0	NA[1]	NA[1]	NA[1]	5	800	814	100	5	4.0	4.2	0
			Dec.	0	NA[1]	NA[1]	NA[1]	3	1065	809	100	3	2.0	2.0	0
		015	Jan.	0	NA[1]	NA[1]	NA[1]	4	162	201	40	5	2.0	2.0	0
			Feb.	0	NA[1]	NA[1]	NA[1]	3	422	366	100	3	4.5	4.5	0
			Mar.	0	NA[1]	NA[1]	NA[1]	3	123	160	25	4	2.0	2.0	0
			Apr.	0	NA[1]	NA[1]	NA[1]	5	610	566	100	5	2.0	2.0	0
Total San Onofre Winter DW				**0**	NA[1]	NA[1]	NA[1]	**28**	**415**	**344**	**67**	**30**	**2.0**	**2.4**	**0**
Ventura	Deer Creek[1]	014	Oct.	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	14	8.4	0
			Nov.	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	2.0	2.0	0

			Dec.	1	36	36	0	0	NA[3]	NA[3]	NA[3]	1	31	NA	0
			Jan.	2	3.0	2.8	0	0	NA[3]	NA[3]	NA[3]	2	10	6.0	0
		015	Feb.	5	2.0	2.6	0	5	14	8.2	0	5	2.0	2.6	0
			Mar.	5	68	80	40	5	22	18	0	5	2.0	3.8	0
			Apr.	5	207	180	67	5	13	10	0	5	2.0	2.0	0
Total Dry Creek Winter DW				**18**	**7.0**	**23**	**33**	**15**	**20**	**11**	**0**	**28**	**2.0**	**3.6**	**0**
Overall Winter DW				**18**	**47.0**	**23**	**33**	**43**	**147**	**101**	**55**	**58**	**2.0**	**3.0**	**0**

[1]NA=San Onofre Creek never flowed during the study period

[2]Reference beach bacteria sampling was suspended at Deer Creek from Dec 10, 2014 to Jan 19, 2015 due to a rock slide that closed Highway 1.

[3]NA= Neither Deer Creek nor the estuary were flowing during the beginning of the winter dry weather sampling period.

Table B2. Summary of winter 2015-16 dry weather E. coli concentrations and water quality objective (WQO) exceedances at San Onofre Beach, San Diego County and Deer Creek, Ventura County.

				Habitat											
				Creek				Estuary				Beach			
County	Site	Year	Month	# of Samples	Median	Geomean	% WQO Exceedance	# of Samples	Median	Geomean	% WQO Exceedance	# of Samples	Median	Geomean	% WQO Exceedance
					(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
San Diego	San Onofre	2015	Oct.	0	NA[1]	NA[1]	NA[1]	5	427	432	100	5	4.0	3.2	0
			Nov.	0	NA[1]	NA[1]	NA[1]	5	620	802	100	5	2.0	2.3	0
			Dec.	0	NA[1]	NA[1]	NA[1]	2	307	248	100	2	2.0	2.0	0
		2016	Jan.	0	NA[1]	NA[1]	NA[1]	4	74	73	25	5	2.0	2.0	0
			Feb.	0	NA[1]	NA[1]	NA[1]	5	144.0	179	60	5	2.0	3.5	0
			Mar.	0	NA[1]	NA[1]	NA[1]	5	135.0	163	60	5	2.0	6.4	0
			Apr.	0	NA[1]	NA[1]	NA[1]	5	315	267	80	5	2.0	2.0	0
Total San Onofre Winter 2015-16 DW				**0**	NA[1]	NA[1]	NA[1]	**31**	**315**	**252**	**74**	**32**	**2.0**	**2.9**	**0**
Ventura	Deer Creek[1]	2015	Oct.	0	NA[2]	NA[2]	NA[2]	0	NA[2]	NA[2]	NA[2]	5	2.0	2.0	0
			Nov.	0	NA[2]	NA[2]	NA[2]	0	NA[2]	NA[2]	NA[2]	5	2.0	2.0	0
			Dec.	0	NA[2]	NA[2]	NA[2]	0	NA[2]	NA[2]	NA[2]	4	2.0	2.0	0
		2016	Jan.	0	NA[2]	NA[2]	NA[2]	5	31	30	0	5	2.0	2.0	0

			Feb.	0	NA[2]	NA[2]	NA[2]	5	2.0	2.8	0	5	2.0	4.4	0
			Mar.	0	NA[2]	NA[2]	NA[2]	5	2.0	2.0	0	5	2.0	2.0	0
			Apr.	0	NA[2]	NA[2]	NA[2]	3	4.0	7.8	0	5	2.0	2.0	0
Total Deer Creek Winter 2015-16 DW				**0**	**NA**	**NA**	**NA**	**18**	**3.0**	**5.8**	**0**	**34**	**2.0**	**2.2**	**0**
Overall Winter 2015-'16 DW				**0**	**NA**	**NA**	**NA**	**49**	**124**	**63**	**74**	**66**	**2.0**	**2.5**	**0**

[1,2]NA= San Onofre Creek never flowed during the study period, Neither Deer Creek nor the estuary were flowing during the beginning of the winter dry weather sampling period.

Table B3. Summary of winter 2014-15 dry weather enterococci concentrations and water quality objective (WQO) exceedances at San Onofre Beach, San Diego County and Deer Creek, Ventura County.

				Habitat											
				Creek				Estuary				Beach			
County	Site	Year	Month	# of Samples	Median	Geo-mean	%WQO Exceed-ance	# of Sam-ples	Median	Geo-mean	%WQO Exceed-ance	# of Sam-ples	Median	Geo-mean	%WQO Exceed-ance
					(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
San Diego	San Onofre	2014	Oct.	0	NA[1]	NA[1]	NA[1]	5	50	75	80	5	2.0	2.0	0
			Nov.	0	NA[1]	NA[1]	NA[1]	5	500	422	100	5	2.0	3.1	0
			Dec.	0	NA[1]	NA[1]	NA[1]	3	1440	2,506	100	3	2.0	3.0	0
		2015	Jan.	0	NA[1]	NA[1]	NA[1]	4	999	1,404	100	5	2.0	2.2	0
			Feb.	0	NA[1]	NA[1]	NA[1]	3	1,025	946	100	3	3.5	3.2	0
			Mar.	0	NA[1]	NA[1]	NA[1]	3	236	201	100	4	2.0	3.9	0
			Apr.	0	NA[1]	NA[1]	NA[1]	5	365	451	100	5	2.0	2.3	0
Total San Onofre Winter DW				**0**	NA[1]	NA[1]	NA[1]	**28**	**440**	**460**	**97**	**30**	**2.0**	**2.7**	**0**
Ventura	Deer Creek[1]	2014	Oct.	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	9.2	12	40
			Nov.	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	2.0	2.2	0
			Dec.	1	80	80	100	0	NA[3]	NA[3]	NA[3]	1	NA	NA	NA
		2015	Jan.	2	24	14	50	0	NA[3]	NA[3]	NA[3]	2	7.0	6.3	0
			Feb.	5	52	18	60	5	27	41	40	5	3.0	3.4	0

			Mar.	5	68	103	100	5	94	93	100	5	2.0	3.1	0
			Apr.	5	530	679	100	5	247	203	100	5	2.0	2.3	0
Total Dry Creek Winter DW				**18**	**80**	**94**	**84**	**15**	**110**	**97**	**75**	**28**	**2.0**	**4.4**	**11**
Overall Winter DW				**18**	**80**	**94**	**84**	**43**	**307**	**270**	**89**	**58**	**2.0**	**3.4**	**5**

[1]NA=San Onofre Creek never flowed during the study period.

[2]Reference beach bacteria sampling was suspended at Deer Creek from Dec 10, 2014 to Jan 19, 2015 due to a rock slide that closed Highway 1.

[3]NA= Neither Deer Creek nor the estuary were flowing during the beginning of the winter dry weather sampling period.

Table B4. Summary of winter 2015-16 dry weather enterococci concentrations and water quality objective (WQO) exceedances at San Onofre Beach, San Diego County and Deer Creek, Ventura County.

				Habitat										
				Creek				Estuary				Beach			
County	Site	Year	Month	# of Samples	Median	Geomean	% WQO Exceedance	# of Samples	Median	Geomean	% WQO Exceedance	# of Samples	Median	Geomean	% WQO Exceedance
					(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
San Diego	San Onofre	2015	Oct.	0	NA[1]	NA[1]	NA[1]	5	367	287	100	5	10.0	5.2	0
			Nov.	0	NA[1]	NA[1]	NA[1]	5	825	741	100	5	2.0	2.9	0
			Dec.	0	NA[1]	NA[1]	NA[1]	2	520	297	100	2	3.5	3.2	0
		2016	Jan.	0	NA[1]	NA[1]	NA[1]	4	567	427	100	5	2.0	2.8	0
			Feb.	0	NA[1]	NA[1]	NA[1]	5	588	441	100	5	2.0	4.1	0
			Mar.	0	NA[1]	NA[1]	NA[1]	5	440	399	100	5	2.0	3.7	0
			Apr.	0	NA[1]	NA[1]	NA[1]	5	245	359	100	5	2.0	2.0	0
Total San Onofre Winter 2015-16 DW				**0**	NA[1]	NA[1]	NA[1]	**31**	**507**	**414**	**100**	**32**	**2.0**	**3.3**	**0**
Ventura	Deer Creek[1]	2015	Oct.	0	NA[2]	NA[2]	NA[2]	0	NA[2]	NA[2]	NA[2]	5	2.0	6.8	20
			Nov.	0	NA[2]	NA[2]	NA[2]	0	NA[2]	NA[2]	NA[2]	5	2.0	2.2	0
			Dec.	0	NA[2]	NA[2]	NA[2]	0	NA[2]	NA[2]	NA[2]	4	2.0	2.0	0
		2016	Jan.	0	NA[2]	NA[2]	NA[2]	5	31	30	0	5	2.0	2.0	0
			Feb.	0	NA[2]	NA[2]	NA[2]	5	7.0	7.4	0	5	4.0	3.6	0

		Mar.	0	NA[2]	NA[2]	NA[2]	5	7.0	5.8	0	5	2.0	2.0	0
		Apr.	0	NA[2]	NA[2]	NA[2]	3	4.0	8.9	33	5	2.0	2.0	0
Total Deer Creek Winter 2015-16 DW			**0**	**NA**	**NA**	**NA**	**18**	**9.0**	**11**	**5.6**	**34**	**2.0**	**2.7**	**2.9**
Overall Winter 2015-'16 DW			**0**	**NA**	**NA**	**NA**	**49**	**168**	**107**	**65**	**66**	**2.0**	**3.0**	**1.5**

[1]NA=San Onofre Creek never flowed during the study period

[2]NA= Neither Deer Creek nor the estuary were flowing during the beginning of the winter dry weather sampling period.

Table B5. Summary of winter 2014-15 dry weather total coliform concentrations and water quality objective (WQO) exceedances at San Onofre Beach, San Diego County and Deer Creek, Ventura County.

				Habitat										
				Creek				Estuary				Beach			
County	Site	Year	Month	# of Samples	Median	Geomean	%WQO Exceed-ance	# of Samples	Median	Geomean	%WQO Exceed-ance	# of Samples	Median	Geomean	%WQO Exceed-ance
					(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
San Diego	San Onofre	2014	Oct.	0	NA[1]	NA[1]	NA[1]	5	870	998	40	5	2.0	4.0	0
			Nov.	0	NA[1]	NA[1]	NA[1]	5	1885	2,668	100	5	9.0	7.4	0
			Dec.	0	NA[1]	NA[1]	NA[1]	3	2310	2,279	67	3	5.0	5.8	0
		2015	Jan.	0	NA[1]	NA[1]	NA[1]	4	700	770	20	5	4.0	3.8	0
			Feb.	0	NA[1]	NA[1]	NA[1]	3	1,420	1,480	67	3	20	13	0
			Mar.	0	NA[1]	NA[1]	NA[1]	3	200	235	0	4	2.0	2.3	0
			Apr.	0	NA[1]	NA[1]	NA[1]	5	2,035	1,455	67	5	2.0	2.3	0
Total San Onofre Winter DW				**0**	NA[1]	NA[1]	NA[1]	**28**	**1,200**	**1,129**	**55**	**30**	**2.5**	**4.4**	**0**
Ventura	Deer Creek[1]	2014	Oct.	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	42.0	22.4	0
			Nov.	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	5.0	5.1	0
			Dec.	1	600	600	0	0	NA[3]	NA[3]	NA[3]	1	780	NA	0
		2015	Jan.	2	60	59	0	0	NA[3]	NA[3]	NA[3]	2	45.5	27.2	0
			Feb.	5	60	48	0	5	90	132	0	5	7.3	6.5	0

			Mar.	5	460	506	20	5	460	344	20	5	5.3	7.4	0
			Apr.	5	1600	1803	67	5	800	794	17	5	3.8	3.1	0
Total Dry Creek Winter DW				**18**	**260**	**327**	**26**	**15**	**485**	**349**	**12**	**28**	**9.0**	**10.7**	**0**
Overall Winter DW				**18**	**260**	**327**	**26**	**43**	**800**	**782**	**60**	**58**	**4.0**	**6.2**	**0**

[1]NA=San Onofre Creek never flowed during the study period.

[2]Reference beach bacteria sampling was suspended at Deer Creek from Dec 10, 2014 to Jan 19, 2015 due to a rock slide that closed Highway 1.

[3]NA = Neither Deer Creek nor the estuary were flowing during the beginning of the winter dry weather sampling period.

Table B6. Summary of winter 2015-'16 dry weather total coliform concentrations and water quality objective (WQO) exceedances at San Onofre Beach, San Diego County and Deer Creek, Ventura County.

				Habitat										
				Creek				Estuary				Beach			
County	Site	Year	Month	# of Samples	Median	Geomean	% WQO Exceed-ance	# of Samples	Median	Geomean	% WQO Exceed-ance	# of Samples	Median	Geomean	% WQO Exceed-ance
					(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
San Diego	San Onofre	2015	Oct.	0	NA[1]	NA[1]	NA[1]	5	3,133	3,646	100	5	5.0	5.1	0
			Nov.	0	NA[1]	NA[1]	NA[1]	5	2,625	2,862	100	5	10.0	9.1	0
			Dec.	0	NA[1]	NA[1]	NA[1]	2	2,657	2,657	100	2	4.5	4.5	0
		2016	Jan.	0	NA[1]	NA[1]	NA[1]	4	1,618	1,096	50	5	24.0	13.5	0
			Feb.	0	NA[1]	NA[1]	NA[1]	5	681	667	0	5	10.0	11.2	0
			Mar.	0	NA[1]	NA[1]	NA[1]	5	870	981	40	5	5.0	10.2	0
			Apr.	0	NA[1]	NA[1]	NA[1]	5	820	762	40	5	2.0	2.0	0
Total San Onofre Winter 2015-16 DW				**0**	NA[1]	NA[1]	NA[1]	**31**	**1,300**	**1,773**	**58**	**32**	**5.0**	**7.0**	**0**
Ventura	Deer Creek[1]	2015	Oct.	0	NA[2]	NA[2]	NA[2]	0	NA[2]	NA[2]	NA[2]	5	2.0	3.1	0
			Nov.	0	NA[2]	NA[2]	NA[2]	0	NA[2]	NA[2]	NA[2]	5	5.0	5.5	0
			Dec.	0	NA[2]	NA[2]	NA[2]	0	NA[2]	NA[2]	NA[2]	4	4.5	3.7	0
		2016	Jan.	0	NA[2]	NA[2]	NA[2]	5	90	103	0	5	4.0	3.2	0
			Feb.	0	NA[2]	NA[2]	NA[2]	5	26	21	0	5	2.0	6.8	0

			Mar.	0	NA[2]	NA[2]	NA[2]	5	29	35	0	5	2.0	2.2	0
			Apr.	0	NA[2]	NA[2]	NA[2]	3	53	151	33	5	2.0	2.3	0
Total Deer Creek Winter 2015-16 DW				**0**	**NA**	**NA**	**NA**	**18**	**45**	**52**	**5.5**	**34**	**2.0**	**3.5**	**0**
Overall Winter 2015-'16 DW				**0**	**NA**	**NA**	**NA**	**49**	**645**	**402**	**39**	**66**	**4.0**	**4.9**	**0**

[1]NA=San Onofre Creek never flowed during the study period

[2]NA= Neither Deer Creek nor the estuary were flowing during the beginning of the winter dry weather sampling period.

Table B7. Summary of winter 2014-'15 dry weather fecal coliformconcentrations and water quality objective (WQO) exceedances at San Onofre Beach, San Diego County and Deer Creek, Ventura County.

				Habitat										
				Creek				Estuary				Beach			
County	Site	Year	Month	# of Samples	Median	Geomean	% WQO Exceed-ance	# of Samples	Median	Geomean	% WQO Exceed-ance	# of Samples	Median	Geomean	% WQO Exceed-ance
					(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
San Diego	San Onofre	2014	Oct.	0	NA[1]	NA[1]	NA[1]	5	242	295	60	5	2.0	4.1	0
			Nov.	0	NA[1]	NA[1]	NA[1]	5	960	1,069	100	5	5.0	3.5	0
			Dec.	0	NA[1]	NA[1]	NA[1]	3	1320	1,008	100	3	2.0	3.4	0
		2015	Jan.	0	NA[1]	NA[1]	NA[1]	4	460	361	80	5	2.0	2.3	0
			Feb.	0	NA[1]	NA[1]	NA[1]	3	438	598	100	3	7	7	0
			Mar.	0	NA[1]	NA[1]	NA[1]	3	150	211	25	4	2.0	2.0	0
			Apr.	0	NA[1]	NA[1]	NA[1]	5	598	584	83	5	2.0	2.0	0
Total San Onofre Winter DW				**0**	NA[1]	NA[1]	NA[1]	**28**	**569**	**475**	**77**	**30**	**2.0**	**3.0**	**0**
Ventura	Deer Creek[1]	2014	Oct.	0	NA2	NA2	NA2	0	NA2	NA2	NA2	5	21	10	0
			Nov.	0	NA2	NA2	NA2	0	NA2	NA2	NA2	5	4.0	3.9	0
			Dec.	1	20	20	0	0	NA2	NA2	NA2	1	33	NA	0
		2015	Jan.	2	6	4	0	0	NA2	NA2	NA2	2	38	12.2	0
			Feb.	5	2	2	0	5	2	8	0	5	2.0	2.9	0

			Mar.	5	56	69	20	5	10	15	0	5	2.0	5.2	0
			Apr.	5	214	233	50	5	9	9	17	5	2.0	2.0	0
Total Dry Creek Winter DW				**18**	**10**	**30**	**26**	**15**	**9.5**	**10**	**0**	**28**	**2.0**	**4.6**	**0**
Overall Winter DW				**18**	**10**	**30**	**26**	**43**	**239**	**132**	**51**	**58**	**2.0**	**3.7**	**0**

[1]NA=San Onofre Creek never flowed during the study period

[2]Reference beach bacteria sampling was suspended at Deer Creek from Dec 10, 2014 to Jan 19, 2015 due to a rock slide that closed Highway 1.

[3]NA= Neither Deer Creek nor the estuary were flowing during the beginning of the winter dry weather sampling period.

Table B8. Summary of winter 2015-16 dry weather fecal coliform concentrations and water quality objective (WQO) exceedances at San Onofre Beach, San Diego County and Deer Creek, Ventura County.

				Habitat										
				Creek				Estuary				Beach			
County	Site	Year	Month	# of Samples	Median	Geomean	% WQO Exceedance	# of Samples	Median	Geomean	% WQO Exceedance	# of Samples	Median	Geomean	% WQO Exceedance
					(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
San Diego	San Onofre	2015	Oct.	0	NA[1]	NA[1]	NA[1]	5	773	581	100	5	4.0	3.3	0
			Nov.	0	NA[1]	NA[1]	NA[1]	5	887	1,083	100	5	2.0	3.2	0
			Dec.	0	NA[1]	NA[1]	NA[1]	2	371	286	50	2	3.0	2.8	0
		2016	Jan.	0	NA[1]	NA[1]	NA[1]	4	134	102	50	5	2.0	2.0	0
			Feb.	0	NA[1]	NA[1]	NA[1]	5	178	198	40	5	3.0	3.3	0
			Mar.	0	NA[1]	NA[1]	NA[1]	5	137	194	20	5	2.0	5.0	0
			Apr.	0	NA[1]	NA[1]	NA[1]	5	322	290	60	5	2.0	2.0	0
Total San Onofre Winter 2015-16 DW				**0**	NA[1]	NA[1]	NA[1]	**31**	**280**	**308**	**61**	**32**	**2.0**	**3.0**	**0**
Ventura	Deer Creek[1]	2015	Oct.	0	NA[2]	NA[2]	NA[2]	0	NA[2]	NA[2]	NA[2]	5	2.0	2.0	0
			Nov.	0	NA[2]	NA[2]	NA[2]	0	NA[2]	NA[2]	NA[2]	5	2.0	2.3	0
			Dec.	0	NA[2]	NA[2]	NA[2]	0	NA[2]	NA[2]	NA[2]	4	2.0	2.0	0
		2016	Jan.	0	NA[2]	NA[2]	NA[2]	5	6.0	9.6	0	5	2.0	2.0	0
			Feb.	0	NA[2]	NA[2]	NA[2]	5	2.0	4.3	0	5	3.5	6.7	0

			Mar.	0	NA[2]	NA[2]	NA[2]	5	2.0	2.0	0	5	2.0	2.0	0
			Apr.	0	NA[2]	NA[2]	NA[2]	3	5.0	19	20	5	2.0	2.0	0
Total Deer Creek Winter 2015-16 DW				**0**	**NA**	**NA**	**NA**	**18**	**2.0**	**10**	**5.5**	**34**	**2.0**	**2.4**	**0**
Overall Winter 2015-'16 DW				**0**	**NA**	**NA**	**NA**	**49**	**143**	**71**	**41**	**66**	**2.0**	**2.7**	**0**

[1]NA=San Onofre Creek never flowed during the study period

[2]NA= Neither Deer Creek nor the estuary were flowing during the beginning of the winter dry weather sampling period.

Table B9. Summary of summer dry weather E. coli concentrations and water quality objective (WQO) exceedances at San Onofre Beach, San Diego County.

				Habitat											
				Creek				Estuary				Beach			
County	Site	Year	Month	Number of Samples	Median	Geomean	% WQO Exceed-ance	Number of Samples	Median	Geomean	% WQO Exceed-ance	Number of Samples	Median	Geomean	% WQO Exceed-ance
					(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
San Diego	San Onofre	2014	October	0	NA[1]	NA[1]	NA[1]	5	82	160	20	5	2.0	3.7	0
			November	0	NA[1]	NA[1]	NA[1]	5	800	814	100	5	4.0	4.2	0
			December	0	NA[1]	NA[1]	NA[1]	3	1065	809	100	3	2.0	2.0	0
		2015	January	0	NA[1]	NA[1]	NA[1]	4	162	201	40	5	2.0	2.0	0
			Febuary	0	NA[1]	NA[1]	NA[1]	3	422	366	100	3	4.5	4.5	0
			March	0	NA[1]	NA[1]	NA[1]	3	123	160	25	4	2.0	2.0	0
			April	0	NA[1]	NA[1]	NA[1]	5	610	566	100	5	2.0	2.0	0
	Total San Onofre Winter DW			**0**	NA[1]	NA[1]	NA[1]	**28**	**415**	**344**	**69**	**30**	**2.0**	**2.4**	**0**
		2015	May	0	NA[1]	NA[1]	NA[1]	5	124	182	100	5	2.0	2.0	0
			June	0	NA[1]	NA[1]	NA[1]	5	425	349	100	5	2.0	2.2	0
			July	0	NA[1]	NA[1]	NA[1]	5	357	350	100	5	2.0	2.0	0
			August	0	NA[1]	NA[1]	NA[1]	5	533	451	100	5	2.0	2.0	0
			September	0	NA[1]	NA[1]	NA[1]	5	360	302	100	5	2.0	2.0	0
	Total San Onofre Summer DW			**0**	**NA[1]**	**NA[1]**	**NA[1]**	**25**	**379**	**314**	**100**	**25**	**2.0**	**2.0**	**0**

[1]NA=San Onofre Creek never flowed during the study period

Table B10. Summary of summer dry weather E. coli concentrations and water quality objective (WQO) exceedances at Deer Creek, Ventura County.

				Habitat											
				Creek				Estuary				Beach			
County	Site	Year	Month	Number of Samples	Median	Geomean	% WQO Exceed-ance	Number of Samples	Median	Geomean	% WQO Exceed-ance	Number of Samples	Median	Geomean	% WQO Exceed-ance
					(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
Ventura	Deer Creek[2]	2014	October	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	13.5	8.4	0
			November	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	2.0	2.0	0
			December	1	36	36	0	0	NA[3]	NA[3]	NA[3]	1	31	31	0
		2015	January	2	3.0	2.8	0	0	NA[3]	NA[3]	NA[3]	2	10.0	6.0	0
			Febuary	5	2.0	2.6	0	5	13.5	8.2	0	5	2.0	2.6	0
			March	5	68.0	62.2	20	5	22.0	17.8	0	5	2.0	3.8	0
			April	5	207	180	67	5	13.5	10.2	20	5	2.0	2.0	0
	Total Deer Creek Winter DW			**18**	**7.0**	**23**	**33**	**15**	**20**	**11**	**0**	**28**	**2.0**	**3.6**	**0**
		2015	May	2	97	81	50	5	460	165	60	5	2.0	2.2	0
			June	0	NA[3]	NA[3]	NA[3]	2	61	15	0	5	2.0	2.7	0
			July	0	NA[3]	NA[3]	NA[3]	1	2	2	0	5	2.0	2.4	0
			August	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	2.0	2.0	0
			September	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	2.0	2.0	0
	Total Deer Creek Summer DW			**2**	**97**	**81**	**50**	**8**	**70**	**53**	**20**	**25**	**2.0**	**2.3**	**0**

[2]Reference beach bacteria sampling was suspended at Deer Creek from Dec 10, 2014 to Jan 19, 2015 due to a rock slide that closed Highway 1.

[3]NA= Neither Deer Creek nor the estuary were flowing during the beginning of the winter dry weather sampling period.

Two storm events in both early June and mid July caused the estuary at Deer Creek to flow but the creek remained unsamplable.

Table B11. Summary of summer dry weather enterococcus concentrations and water quality objective (WQO) exceedances at San Onofre Beach, San Diego County.

				Habitat											
				Creek				Estuary				Beach			
County	Site	Year	Month	Number of Samples	Median	Geomean	% WQO Exceedance	Number of Samples	Median	Geomean	% WQO Exceedance	Number of Samples	Median	Geomean	% WQO Exceedance
					(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
San Diego	San Onofre	2014	October	0	NA[1]	NA[1]	NA[1]	5	50	75	80	5	2.0	2.0	0
			November	0	NA[1]	NA[1]	NA[1]	5	500	422	100	5	2.0	3.1	0
			December	0	NA[1]	NA[1]	NA[1]	3	1,440	2,506	100	3	2.0	3.0	0
		2015	January	0	NA[1]	NA[1]	NA[1]	4	999	1,404	100	5	2.0	2.2	0
			Febuary	0	NA[1]	NA[1]	NA[1]	3	1,025	946	100	3	3.5	3.2	0
			March	0	NA[1]	NA[1]	NA[1]	3	236	201	100	4	2.0	3.9	0
			April	0	NA[1]	NA[1]	NA[1]	5	365	451	100	5	2.0	2.3	0
	Total San Onofre Winter DW			**0**	NA[1]	NA[1]	NA[1]	**28**	**440**	**460**	**97**	**30**	**2.0**	**2.7**	**0**
		2015	May	0	NA[1]	NA[1]	NA[1]	5	108	162	100	5	2.0	2.0	0
			June	0	NA[1]	NA[1]	NA[1]	5	346	277	100	5	2.0	2.0	0
			July	0	NA[1]	NA[1]	NA[1]	5	363	307	100	5	2.0	2.5	0
			August	0	NA[1]	NA[1]	NA[1]	5	613	397	100	5	2.0	2.2	0
			September	0	NA[1]	NA[1]	NA[1]	5	294	249	100	5	3.0	3.1	0
	Total San Onofre Summer DW			**0**	**NA[1]**	**NA[1]**	**NA[1]**	**25**	**294**	**268**	**100**	**25**	**2.0**	**2.3**	**0**

[1]NA=San Onofre Creek never flowed during the study period

Table B12. Summary of summer dry weather enterococcus concentrations and water quality objective (WQO) exceedances at Deer Creek, Ventura County.

				Habitat											
				Creek				Estuary				Beach			
County	Site	Year	Month	Number of Samples	Median	Geomean	% WQO Exceedance	Number of Samples	Median	Geomean	% WQO Exceedance	Number of Samples	Median	Geomean	% WQO Exceedance
					(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
Ventura	Deer Creek[1]	2014	October	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	9.2	12.5	40
			November	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	2.0	2.2	0
			December	1	80	80	100	0	NA[3]	NA[3]	NA[3]	0	0	0	0
		2015	January	2	24	14	50	0	NA[3]	NA[3]	NA[3]	2	7.0	6.3	0
			Febuary	5	52	18	60	5	27	41	40	5	3.0	3.4	0
			March	5	68	103	100	5	94	93	83	5	2.0	3.1	0
			April	5	530	679	100	5	247	203	100	5	2.0	2.3	0
	Total Deer Creek Winter DW			**18**	**80**	**94**	**84**	**15**	**110**	**97**	**75**	**27**	**2.0**	**4.4**	**11**
		2015	May	2	5,220	2,098	100	5	207	224	100	5	2.0	2.0	0
			June	0	NA[3]	NA[3]	NA[3]	2	651	51	50	5	2.0	2.3	0
			July	0	NA[3]	NA[3]	NA[3]	1	2	NA[3]	0	5	2.0	2.0	0
			August	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	2.0	2.0	0
			September	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	2.0	3.9	0
	Total Deer Creek Summer DW			**2**	**5,220**	**2,098**	**100**	**8**	**183**	**80**	**50**	**25**	**2.0**	**2.3**	**0**

[2]Reference beach bacteria sampling was suspended at Deer Creek from Dec 10, 2014 to Jan 19, 2015 due to a rock slide that closed Highway 1.

[3]NA= Neither Deer Creek nor the estuary were flowing during the beginning of the winter dry weather sampling period.

Two storm events in both early June and mid July caused the estuary at Deer Creek to flow but the creek remained unsamplable.

Table B13. Summary of summer dry weather total coliform concentrations and water quality objective (WQO) exceedances at San Onofre Beach, San Diego County.

			Habitat											
			Creek				Estuary				Beach			
Site	Year	Month	Number of Samples	Median	Geomean	% WQO Exceedance	Number of Samples	Median	Geomean	% WQO Exceedance	Number of Samples	Median	Geomean	% WQO Exceedance
				(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
San Onofre	2014	October	0	NA[1]	NA[1]	NA[1]	5	870	998	40	5	2.0	4.0	0
		November	0	NA[1]	NA[1]	NA[1]	5	1,885	2,668	100	5	9.0	7.4	0
		December	0	NA[1]	NA[1]	NA[1]	3	2,310	2,279	67	3	5.0	5.8	0
	2015	January	0	NA[1]	NA[1]	NA[1]	5	700	770	20	5	4.0	3.8	0
		Febuary	0	NA[1]	NA[1]	NA[1]	3	1,420	1,480	67	3	20	13	0
		March	0	NA[1]	NA[1]	NA[1]	4	200	235	0	4	2.0	2.3	0
		April	0	NA[1]	NA[1]	NA[1]	5	2,035	1,455	67	5	2.0	2.3	0
Total San Onofre Winter DW			**0**	NA[1]	NA[1]	NA[1]	**30**	**1,200**	**1,129**	**55**	**30**	**2.5**	**4.4**	**0**
		May	0	NA[1]	NA[1]	NA[1]	5	1,332	1,203	60	5	2.0	4.4	0
	2015	June	0	NA[1]	NA[1]	NA[1]	5	6,050	5,080	100	5	2.0	2.4	0
		July	0	NA[1]	NA[1]	NA[1]	5	11,100	11,240	100	5	2.0	2.3	0
		August	0	NA[1]	NA[1]	NA[1]	5	41,000	50,972	100	5	2.0	2.8	0
		September	0	NA[1]	NA[1]	NA[1]	5	6,933	6,622	100	5	8.5	7.3	0
Total San Onofre Summer DW			**0**	**NA[1]**	**NA[1]**	**NA[1]**	**25**	**7,308**	**7,510**	**92**	**25**	**2.0**	**3.4**	**0**

[1]NA=San Onofre Creek never flowed during the study period

Table B14. Summary of summer dry weather total coliform concentrations and water quality objective (WQO) exceedances at Deer Creek, Ventura County.

			Habitat											
			Creek				Estuary				Beach			
Site	Year	Month	Number of Samples	Median	Geomean	% WQO Exceedance	Number of Samples	Median	Geomean	% WQO Exceedance	Number of Samples	Median	Geomean	% WQO Exceedance
				(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
Deer Creek[1]	2014	October	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	42.0	22.4	0
		November	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	5.0	5.1	0
		December	1	600	600	0	0	NA[3]	NA[3]	NA[3]	1	780	NA	0
	2015	January	2	60	59	0	0	NA[3]	NA[3]	NA[3]	2	45.5	27.2	0
		Febuary	5	60	48	0	5	90	132	0	5	7.3	6.5	0
		March	5	460	506	20	5	460	344	20	5	5.3	7.4	0
		April	5	1600	1803	67	5	800	794	17	5	3.8	3.1	0
Total Deer Creek Winter DW			**18**	**260**	**327**	**26**	**15**	**485**	**349**	**12**	**28**	**7.0**	**8.8**	**0**
	2015	May	2	350	338	0	5	2310	1396	60	5	2.0	2.4	0
		June	0	NA[3]	NA[3]	NA[3]	2	102	28	0	5	2.0	3.0	0
		July	0	NA3	NA[3]	NA[3]	1	2	NA[3]	0	5	3.0	4.4	0
		August	0	NA3	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	2.0	2.4	0
		September	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	3.0	5.6	0
Total Deer Creek Summer DW			**2**	**350**	**338**	**0**	**8**	**180**	**232**	**37.5**	**25**	**2.0**	**3.3**	**0**

[2]Reference beach bacteria sampling was suspended at Deer Creek from Dec 10, 2014 to Jan 19, 2015 due to a rock slide that closed Highway 1.

[3]NA= Neither Deer Creek nor the estuary were flowing during the beginning of the winter dry weather sampling period.

Two storm events in both early June and mid July caused the estuary at Deer Creek to flow but the creek remained unsamplable.

Table B15. Summary of summer dry weather fecal coliform concentrations and water quality objective (WQO) exceedances at San Onofre Beach, San Diego County.

			Habitat											
			Creek				Estuary				Beach			
Site	Year	Month	Number of Samples	Median	Geomean	% WQO Exceedance	Number of Samples	Median	Geomean	% WQO Exceedance	Number of Samples	Median	Geomean	% WQO Exceedance
				(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
San Onofre	2014	October	0	NA[1]	NA[1]	NA[1]	5	242	295	80	5	2.0	4.1	0
		November	0	NA[1]	NA[1]	NA[1]	5	960	1,069	100	5	5.0	3.5	0
		December	0	NA[1]	NA[1]	NA[1]	3	1320	1,008	100	3	2.0	3.4	0
	2015	January	0	NA[1]	NA[1]	NA[1]	5	460	361	80	5	2.0	2.3	0
		Febuary	0	NA[1]	NA[1]	NA[1]	3	438	598	100	3	7	7	0
		March	0	NA[1]	NA[1]	NA[1]	4	150	211	25	4	2.0	2.0	0
		April	0	NA[1]	NA[1]	NA[1]	5	598	584	83	5	2.0	2.0	0
Total San Onofre Winter DW			**0**	NA[1]	NA[1]	NA[1]	**30**	**569**	**475**	**77**	**30**	**2.0**	**3.0**	**0**
	2015	May	0	NA[1]	NA[1]	NA[1]	5	167	238	40	5	2.0	2.9	0
		June	0	NA[1]	NA[1]	NA[1]	5	412	413	100	5	2.0	2.0	0
		July	0	NA[1]	NA[1]	NA[1]	5	460	419	80	5	2.0	2.0	0
		August	0	NA[1]	NA[1]	NA[1]	5	436	383	80	5	2.0	2.0	0
		September	0	NA[1]	NA[1]	NA[1]	5	407	362	60	5	2.0	2.2	0
Total San Onofre Summer DW			**0**	**NA[1]**	**NA[1]**	**NA[1]**	**25**	**423**	**379**	**72**	**25**	**2.0**	**2.2**	**0**

[1]NA=San Onofre Creek never flowed during the study period

Table B16. Summary of summer dry weather fecal coliform concentrations and water quality objective (WQO) exceedances at Deer Creek, Ventura County.

			Habitat											
			Creek				Estuary				Beach			
Site	Year	Month	Number of Samples	Median	Geomean	% WQO Exceedance	Number of Samples	Median	Geomean	% WQO Exceedance	Number of Samples	Median	Geomean	% WQO Exceedance
				(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
Deer Creek[1]	2014	October	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	20.5	10	0
		November	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	4.0	3.9	0
		December	1	20	20	0	0	NA[3]	NA[3]	NA[3]	1	33	NA	0
	2015	January	2	6	4	0	0	NA[3]	NA[3]	NA[3]	2	38.0	12.2	0
		Febuary	5	2	2	0	5	2	8	0	5	2.0	2.9	0
		March	5	56	69	20	5	10	15	0	5	2.0	5.2	0
		April	5	214	233	50	5	9	9	17	5	2.0	2.0	0
Total Deer Creek Winter DW			**18**	**10**	**30**	**26**	**15**	**9.5**	**10**	**0**	**28**	**2.0**	**4.6**	**0**
	2015	May	2	88	77	0	5	560	461	60	5	2.0	2.2	0
		June	0	NA[3]	NA[3]	NA[3]	2	56	18	0	5	2.0	3.4	0
		July	0	NA3	NA[3]	NA[3]	1	2	NA[3]	0	5	2.0	3.1	0
		August	0	NA3	NA[3]	NA[3]	0	NA3	NA[3]	NA[3]	5	2.0	2.0	0
		September	0	NA[3]	NA[3]	NA[3]	0	NA[3]	NA[3]	NA[3]	5	3.0	4.2	0
Total Deer Creek Summer DW			**2**	**88**	**77**	**0**	**8**	**80**	**104**	**37.5**	**25**	**2.0**	**2.8**	**0**

[2]Reference beach bacteria sampling was suspended at Deer Creek from Dec 10, 2014 to Jan 19, 2015 due to a rock slide that closed Highway 1.

[3]NA= Neither Deer Creek nor the estuary were flowing during the beginning of the winter dry weather sampling period.

Two storm events in both early June and mid-July caused the estuary at Deer Creek to flow but the creek remained unsamplable.

Table B17. Summary of overall winter and summer dry weather FIB concentrations and water quality objective (WQO) exceedances at Deer Creek and San Onofre Creek during the 2014-2016 study period.

		Habitat											
		Creek				Estuary				Beach			
FIB Analyte	Sampling Period	Number of Samples	Median	Geomean	% WQO Exceedance	Number of Samples	Median	Geomean	% WQO Exceedance	Number of Samples	Median	Geomean	% WQO Exceedance
			(MPN/100 ml)				(MPN/100 ml)				(MPN/100 ml)		
EC	Winter 2014-'15 DW	18	4	10	13	43	147	101	55	58	2.0	3.0	0
	Winter 2015-'16 DW	0	NA[1]	NA[1]	NA[1]	49	124	63	74	66	2.0	2.5	0
	Summer 2014-'15 DW	2	97	81	50	33	339	201	61.9	50	2.0	2.1	0
ENT	Winter 2014-'15 DW	18	80	94	84	43	307	270	89	57	2.0	3.4	4.9
	Winter 2015-'16 DW	0	NA[1]	NA[1]	NA[1]	49	168	107	20	66	2.0	3.0	1.5
	Summer 2014-'15 DW	2	5,220	2,098	100	33	264	202	81	50	2.0	2.1	0
TC	Winter 2014-'15 DW	18	260	327	26	43	800	782	60	58	4.0	6.2	0
	Winter 2015-'16 DW	0	NA[1]	NA[1]	NA[1]	49	645	402	39	66	4.0	4.9	0
	Summer 2014-'15 DW	2	350	338	0	33	5,200	3,150	87	50	2.0	3.3	0
FC	Winter 2014-'15 DW	18	10	30	26	43	239	132	51	58	2.0	3.7	0
	Winter 2015-'16 DW	0	NA[1]	NA[1]	NA[1]	49	143	71	41	66	2.0	2.7	0
	Summer 2014-'15 DW	2	88	77	0	33	397	274	72	50	2.0	2.9	0

Appendix C. Supplemental Graphics

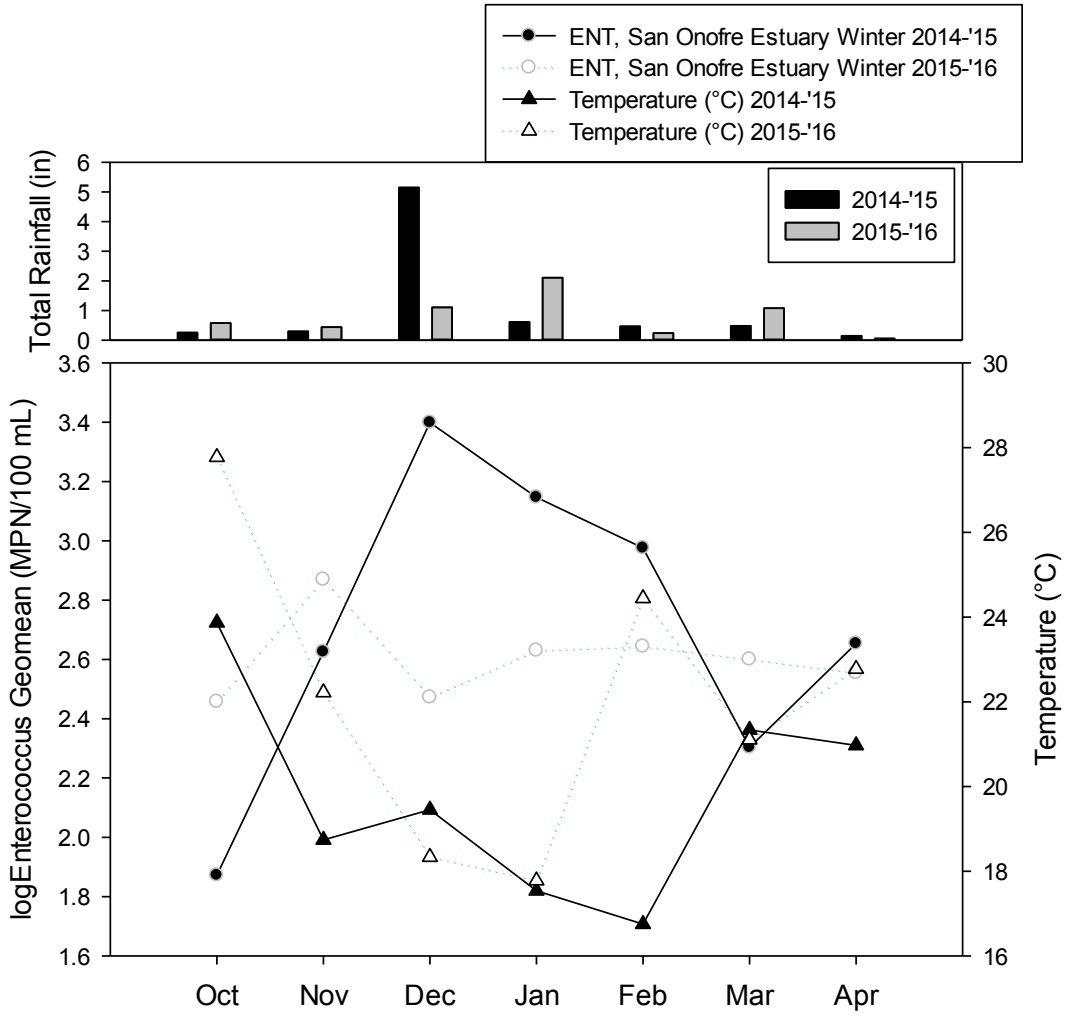

Figure C1. Winter dry weather comparisons of enterococcus geomean concentrations, mean temperature and total rainfall at San Onofre Estuary during the two winter dry weather study periods (Oct 2014 – Apr 2015 and Oct 2015 – Apr 2016).

Table C1. Summary statistics for allwinter 2014-'15 dry weather constituents at San Onofre Beach, San Diego County.

Winter 2014-'15 San Onofre Beach										
	ENT	EC	TC	FC	DO	pH	Salinity	Cond	Temp (°C)	Temp (°C)
	log (MPN/100 mL)				(mg/L		(ppt)	(µs/cm)	Water	Air
No Samples	30	30	30	30	30	30	30	30	30	30
Min	0.30	0.30	0.30	0.30	5.31	7.35	31.56	41,281	15.9	14.4
Max	1.40	1.78	1.82	1.85	8.18	8.24	33.16	48,219	22.8	31.1
Range	1.10	1.48	1.52	1.54	2.87	0.89	1.60	6,938	6.9	16.7
Median	0.30	0.30	0.30	0.30	7.45	7.81	32.69	44,207	18.6	21.1
Mean	0.42	0.47	0.62	0.48	7.32	7.75	32.68	44,171	18.91	21.65
SE.mean	0.05	0.07	0.08	0.07	0.13	0.04	0.06	322	0.37	0.66
CI.mean	0.09	0.14	0.17	0.13	0.26	0.09	0.11	658	0.76	1.36
Var	0.07	0.15	0.22	0.13	0.51	0.06	0.09	3.E+06	4.29	13.67
Std.Dev	0.26	0.39	0.47	0.37	0.72	0.24	0.31	1,794	2.07	3.70
Coef.Var	0.61	0.83	0.75	0.77	0.10	0.03	0.01	0.04	0.11	0.17

Table C2. Summary statistics for allsummer 2015 dry weather constituents at San Onofre Beach, San Diego County.

Summer 2015 San Onofre Beach										
	ENT	EC	TC	FC	DO	pH	Salinity	Cond	Temp (°C)	Temp (°C)
	log (MPN/100 mL)				(mg/L		(ppt)	(µs/cm)	Water	Air
No Samples	25	25	25	25	25	25	25	25	25	25
Min	0.30	0.30	0.30	0.30	3.48	7.26	31.79	4.16E+04	17.20	16.00
Max	0.95	0.60	4.38	0.60	7.61	8.32	32.95	4.96E+04	25.00	32.00
Range	0.65	0.30	4.08	0.30	4.13	1.06	1.16	8,010	7.80	16.00
Median	0.30	0.30	0.30	0.30	4.76	8.01	32.34	4.63E+04	21.85	22.30
Mean	0.37	0.31	0.64	0.33	5.18	7.97	32.29	4.61E+04	21.64	22.71
SE.mean	0.03	0.01	0.18	0.02	0.24	0.05	0.06	524	0.53	0.85
CI.mean	0.07	0.03	0.36	0.04	0.49	0.11	0.12	1,084	1.10	1.75
Var	0.03	0.00	0.74	0.01	1.33	0.07	0.08	6.59E+06	6.81	17.19
Std.Dev	0.16	0.06	0.86	0.08	1.15	0.27	0.28	2.57E+03	2.61	4.15
Coef.Var	0.44	0.20	1.34	0.26	0.22	0.03	0.01	0.06	0.12	0.18

Table C3. Summary statistics for all winter 2015-'16 dry weather constituents at San Onofre Beach, San Diego County.

Winter 2015-'16 San Onofre Beach										
	ENT	EC	TC	FC	DO	pH	Salinity	Cond	Temp (°C)	Temp (°C)
	log (MPN/100 mL)				(mg/L		(ppt)	(µs/cm)	Water	Air
No Samples	32	32	32	32	32	32	32	32	32	32
Min	0.30	0.30	0.30	0.30	4.84	7.68	31.97	4,301	15.4	14.4
Max	1.30	1.95	2.04	1.96	9.37	8.75	35.25	5.E+04	24.7	27.7
Range	1.00	1.65	1.74	1.66	4.53	1.07	3.28	5.E+04	9.3	13.3
Median	0.30	0.30	0.70	0.30	7.41	8.26	34.28	5.E+04	17.65	20.55
Mean	0.51	0.47	0.81	0.46	7.21	8.22	33.88	5.E+04	18.61	20.15
SE.mean	0.06	0.07	0.09	0.06	0.18	0.06	0.19	1,991	0.50	0.56
CI.mean	0.11	0.14	0.19	0.13	0.37	0.12	0.38	4,060	1.02	1.14
Var	0.10	0.14	0.26	0.13	1.03	0.11	1.12	1.E+08	7.97	10.08
Std.Dev	0.32	0.38	0.51	0.36	1.01	0.34	1.06	1.E+04	2.82	3.17
Coef.Var	0.62	0.81	0.64	0.78	0.14	0.04	0.03	0.25	0.15	0.16

Table C4. Summary statistics for allwinter 2014-'15 dry weather constituents at San Onofre Estuary, San Diego County.

Winter 2014-'15 San Onofre Estuary										
	ENT	EC	TC	FC	DO	pH	Salinity	Cond	Temp (°C)	Temp (°C)
	log (MPN/100 mL)				(mg/L		(ppt)	(µs/cm)	Water	Air
No Samples	86	86	86	86	86	86	86	86	86	86
Min	1.00	1.00	1.81	1.00	3.45	6.91	0.54	930	12.20	14.40
Max	4.45	3.48	4.35	3.60	6.31	8.34	1.96	2,070	24.80	28.00
Range	3.45	2.48	2.54	2.60	2.86	1.43	1.42	1,140	12.60	13.60
Median	2.51	2.39	3.00	2.66	4.94	7.41	0.63	1,095	18.10	21.00
Mean	2.55	2.41	3.02	2.57	5.05	7.46	0.81	1,217	17.71	20.28
SE.mean	0.07	0.06	0.05	0.06	0.10	0.04	0.04	27.63	0.33	0.35
CI.mean	0.13	0.11	0.10	0.12	0.20	0.08	0.07	54.93	0.65	0.69
Var	0.39	0.28	0.22	0.29	0.83	0.14	0.12	7.E+04	9.15	10.31
Std.Dev	0.62	0.53	0.47	0.54	0.91	0.38	0.34	256.19	3.02	3.21
Coef.Var	0.24	0.22	0.16	0.21	0.18	0.05	0.42	0.21	0.17	0.16

Table C5. Summary statistics for allsummer 2015 dry weather constituents at San Onofre Estuary, San Diego County.

Summter 2015 San Onofre Estuary										
	ENT	EC	TC	FC	DO	pH	Salinity	Cond	Temp (°C)	Temp (°C)
	log (MPN/100 mL)				(mg/L		(ppt)	(µs/cm)	Water	Air
No Samples	71	71	71	71	71	71	71	71	71	71
Min	0.70	1.46	0.30	1.53	1.7	6.87	0.45	8.14E+02	14.9	17.7
Max	3.30	3.28	5.30	3.39	7.19	8.32	1.88	4.96E+04	25.1	32
Range	2.60	1.81	5.00	1.86	5.49	1.45	1.43	4.88E+04	10.2	14.3
Median	2.20	2.35	3.72	2.44	4.51	7.89	0.65	1,289	23.1	20
Mean	2.28	2.38	3.64	2.46	4.26	7.82	0.80	8,650	22.09	22.27
SE.mean	0.06	0.05	0.11	0.05	0.16	0.05	0.04	2,050	0.32	0.46
CI.mean	0.13	0.10	0.22	0.10	0.33	0.09	0.08	4,088	0.63	0.92
Var	0.29	0.18	0.84	0.18	1.93	0.15	0.11	2.98E+08	7.08	15.14
Std.Dev	0.54	0.42	0.92	0.43	1.39	0.39	0.33	1.73E+04	2.66	3.89
Coef.Var	0.24	0.18	0.25	0.17	0.33	0.05	0.41	2.00	0.12	0.17

Table C6. Summary statistics for all winter 2015-‘16 dry weather constituents at San Onofre Estuary, San Diego County.

Winter 2015-'16 San Onofre Estuary										
	ENT	EC	TC	FC	DO	pH	Salinity	Cond	Temp (°C)	Temp (°C)
	log (MPN/100 mL)				(mg/L		(ppt)	(µs/cm)	Water	Air
No Samples	73	73	73	73	73	73	73	73	73	73
Min	0.70	0.30	2.00	0.60	1.25	6.27	0.6	1.27	11.30	15.55
Max	3.50	3.90	4.20	4.11	8.13	8.82	2.22	4.96E+04	25.10	32.00
Range	2.80	3.60	2.20	3.51	6.88	2.55	1.62	4.96E+04	13.80	16.45
Median	2.54	2.39	3.23	2.45	4.92	8.01	0.84	1,442	14.10	18.89
Mean	2.48	2.28	3.18	2.37	5.00	8.02	0.97	4,127	15.08	19.38
SE.mean	0.06	0.08	0.05	0.08	0.22	0.07	0.05	1,136	0.37	0.39
CI.mean	0.13	0.16	0.11	0.16	0.45	0.14	0.10	2,265	0.74	0.77
Var	0.30	0.47	0.20	0.47	3.66	0.35	0.18	9.42E+07	10.02	10.98
Std.Dev	0.55	0.69	0.45	0.68	1.91	0.59	0.43	9,706	3.17	3.31
Coef.Var	0.22	0.30	0.14	0.29	0.38	0.07	0.44	2.35	0.21	0.17

Table C7. Summary statistics for allwinter 2014-'15 dry weather constituents at Deer Creek Beach, Ventura County.

Winter 2014-'15 Deer Creek Beach										
	ENT	EC	TC	FC	DO	pH	Salinity	Cond	Temp (°C)	Temp (°C)
	log (MPN/100 mL)				(mg/L		(ppt)	(µs/cm)	Water	Air
No Samples	28	28	28	28	28	28	28	28	28	28
Min	0.30	0.30	0.30	0.30	5.71	7.64	30.99	39,774	15.20	11.00
Max	2.20	1.60	2.89	1.87	8.41	8.14	37.65	56,640	21.50	25.00
Range	1.90	1.30	2.59	1.57	2.70	0.50	6.66	16,866	6.30	14.00
Median	0.30	0.30	0.70	0.30	7.54	7.89	33.35	47,471	16.90	18.00
Mean	0.63	0.56	0.91	0.67	7.28	7.89	33.40	47,791	17.57	18.29
SE.mean	0.10	0.08	0.12	0.10	0.13	0.03	0.20	736	0.36	0.78
CI.mean	0.21	0.17	0.25	0.21	0.26	0.06	0.40	1,507	0.74	1.60
Var	0.31	0.21	0.42	0.30	0.47	0.02	1.12	1.57E+07	3.82	17.78
Std.Dev	0.55	0.45	0.65	0.55	0.68	0.15	1.06	3,962	1.96	4.22
Coef.Var	0.88	0.82	0.72	0.82	0.09	0.02	0.03	0.08	0.11	0.23

Table C8. Summary statistics for allsummer 2015 dry weather constituents at Deer Creek Beach, Ventura County.

Summer 2015 Deer Creek Beach										
	ENT	EC	TC	FC	DO	pH	Salinity	Cond	Temp (°C)	Temp (°C)
	log (MPN/100 mL)				(mg/L		(ppt)	(µs/cm)	Water	Air
No Samples	25	25	25	25	25	25	25	25	25	25
Min	0.30	0.30	0.30	0.30	2.55	7.76	31.4	4.16E+04	14.2	16
Max	2.15	0.70	5.30	1.30	7.82	8.35	35.7	5.44E+04	23.1	29.4
Range	1.85	0.40	5.00	1.00	5.27	0.59	4.3	1.28E+04	8.9	13.4
Median	0.30	0.30	0.30	0.30	6.26	8.03	32.53	4.52E+04	19.7	22.78
Mean	0.44	0.33	0.90	0.44	5.90	7.99	32.82	4.58E+04	19.02	22.71
SE.mean	0.09	0.02	0.28	0.06	0.33	0.04	0.18	809	0.51	0.88
CI.mean	0.19	0.04	0.59	0.13	0.68	0.07	0.37	1,678	1.07	1.83
Var	0.20	0.01	1.84	0.09	2.50	0.03	0.72	1.50E+07	6.09	18.00
Std.Dev	0.45	0.10	1.35	0.30	1.58	0.17	0.85	3,879	2.47	4.24
Coef.Var	1.00	0.31	1.50	0.67	0.27	0.02	0.03	0.08	0.13	0.19

Table C9. Summary statistics for allwinter 2015-'16 dry weather constituents at Deer Creek Beach, Ventura County.

Winter 2015-'16 Deer Creek Beach										
	ENT	EC	TC	FC	DO	pH	Salinity	Cond	Temp (°C)	Temp (°C)
	log (MPN/100 mL)				(mg/L		(ppt)	(µs/cm)	Water	Air
No Samples	34	34	34	34	34	34	34	34	34	34
Min	0.30	0.30	0.30	0.30	4.13	7.6	31.57	4,337	15.1	15
Max	1.87	2.04	2.26	2.15	8.22	8.72	35.08	5.29E+04	24.1	25
Range	1.57	1.74	1.95	1.85	4.09	1.12	3.51	4.86E+04	9	10
Median	0.30	0.30	0.30	0.30	6.70	8.18	34.56	4.67E+04	17.9	21.1
Mean	0.43	0.35	0.57	0.38	6.72	8.17	33.83	4.66E+04	18.28	20.85
SE.mean	0.06	0.05	0.07	0.06	0.13	0.06	0.20	1,476	0.41	0.48
CI.mean	0.12	0.10	0.14	0.11	0.27	0.12	0.41	3,003	0.83	0.98
Var	0.12	0.09	0.16	0.11	0.61	0.12	1.39	7.41E+07	5.64	7.88
Std.Dev	0.34	0.30	0.40	0.33	0.78	0.34	1.18	8,606	2.37	2.81
Coef.Var	0.80	0.85	0.69	0.87	0.12	0.04	0.03	0.18	0.13	0.13

Table C10. Summary statistics for allwinter 2014-'15 dry weather constituents at Deer Creek Mixing Zone, Ventura County.

Winter 2014-'15 Deer Creek Mixing Zone										
	ENT	EC	TC	FC	DO	pH	Salinity	Cond	Temp (°C)	Temp (°C)
	log (MPN/100 mL)				(mg/L		(ppt)	(µs/cm)	Water	Air
No Samples	15	15	15	15	15	15	15	15	15	15
Min	0.70	0.30	1.73	0.30	6.92	8.04	0.78	1,373	13.6	11
Max	3.32	1.99	3.52	1.86	9.22	9.1	1.08	2,100	23.1	23.9
Range	2.62	1.69	1.78	1.56	2.3	1.06	0.3	727	9.5	12.9
Median	2.04	1.07	2.67	0.98	8.45	8.23	0.955	1,842	15.15	16.25
Mean	1.98	1.01	2.54	1.01	8.26	8.28	0.95	1,814	16.04	17.30
SE.mean	0.16	0.14	0.14	0.13	0.17	0.06	0.02	42.07	0.62	0.99
CI.mean	0.34	0.30	0.30	0.28	0.37	0.13	0.04	89.66	1.31	2.11
Var	0.42	0.31	0.32	0.27	0.48	0.06	0.00	28,313	6.06	15.74
Std.Dev	0.65	0.56	0.56	0.52	0.70	0.24	0.07	168	2.46	3.97
Coef.Var	0.33	0.55	0.22	0.52	0.08	0.03	0.07	0.09	0.15	0.23

Table C11. Summary statistics for allsummer 2015 dry weather constituents at Deer Creek Mixing Zone, Ventura County.

Summer 2015 Deer Creek Mixing Zone										
	ENT	EC	TC	FC	DO	pH	Salinity	Cond	Temp (°C)	Temp (°C)
	log (MPN/100 mL)				(mg/L		(ppt)	(µs/cm)	Water	Air
No Samples	8	8	8	8	8	8	8	8	8	8
Min	0.30	0.30	0.30	0.30	5.31	7.97	0.80	1,374	14.9	11.5
Max	3.11	3.30	4.51	4.50	8.09	8.22	0.90	1,760	18	18
Range	2.81	3.00	4.21	4.20	2.78	0.25	0.10	386	3.1	6.5
Median	2.26	1.69	2.63	1.87	6.99	8.07	0.86	1,608	16.60	17.05
Mean	1.93	1.73	2.47	2.04	6.63	8.06	0.86	1,575	16.36	16.23
SE.mean	0.37	0.41	0.51	0.48	0.41	0.03	0.01	63	0.33	0.71
CI.mean	0.88	0.98	1.20	1.14	0.98	0.08	0.03	149	0.78	1.69
Var	1.10	1.36	2.04	1.85	1.36	0.01	0.00	3.E+04	0.87	4.07
Std.Dev	1.05	1.17	1.43	1.36	1.17	0.09	0.04	178	0.93	2.02
Coef.Var	0.54	0.68	0.58	0.67	0.18	0.01	0.05	0	0.06	0.12

Table C12. Summary statistics for allwinter 2015-‘16 dry weather constituents at Deer Creek Mixing Zone, Ventura County.

Winter 2015-'16 Deer Creek Mixing Zone										
	ENT	EC	TC	FC	DO	pH	Salinity	Cond	Temp (°C)	Temp (°C)
	log (MPN/100 mL)				(mg/L		(ppt)	(µs/cm)	Water	Air
No Samples	18	18	18	18	18	18	18	18	18	18
Min	0.30	0.30	0.30	0.30	4.64	7.70	0.77	1,373	13.9	15.55
Max	1.94	2.78	3.11	2.82	9.20	9.12	1.51	2,340	23.1	25
Range	1.64	2.48	2.81	2.52	4.56	1.42	0.74	967	9.2	9.45
Median	0.95	0.30	1.65	0.30	7.92	8.80	0.84	1,617	16.85	21.1
Mean	1.02	0.65	1.72	0.75	7.67	8.63	0.92	1,658	17.28	21.06
SE.mean	0.12	0.16	0.15	0.16	0.33	0.10	0.05	62	0.70	0.56
CI.mean	0.26	0.33	0.32	0.35	0.70	0.20	0.11	132	1.47	1.18
Var	0.28	0.44	0.40	0.48	1.99	0.17	0.05	7.E+04	8.73	5.67
Std.Dev	0.52	0.66	0.64	0.69	1.41	0.41	0.22	264	2.95	2.38
Coef.Var	0.51	1.01	0.37	0.93	0.18	0.05	0.24	0	0.17	0.11

Table C13. Summary statistics for allwinter 2014-'15 dry weather constituents at Deer Creek, Ventura County.

Winter 2014-'15 Deer Creek Creek										
	ENT	EC	TC	FC	DO	pH	Salinity	Cond	Temp (°C)	Temp (°C)
	log (MPN/100 mL)				(mg/L		(ppt)	(µs/cm)	Water	Air
No Samples	18	18	18	18	18	18	18	18	18	18
Min	0.30	0.30	1.49	0.30	4.19	7.28	0.88	762	13.8	11
Max	3.15	4.18	4.28	4.31	8.60	8.44	1.21	2,150	18.1	22.8
Range	2.85	3.88	2.79	4.01	4.41	1.16	0.33	1,388	4.3	11.8
Median	1.85	0.85	2.41	1.00	7.23	7.7	0.98	1,820	15.4	15
Mean	1.97	1.47	2.52	1.50	6.92	7.75	0.98	1,732	15.62	15.74
SE.mean	0.19	0.29	0.20	0.29	0.24	0.07	0.02	85	0.27	0.80
CI.mean	0.40	0.61	0.42	0.61	0.51	0.16	0.04	179	0.57	1.68
Var	0.70	1.60	0.74	1.59	1.12	0.11	0.01	1.E+05	1.39	12.16
Std.Dev	0.83	1.26	0.86	1.26	1.06	0.33	0.08	372	1.18	3.49
Coef.Var	0.42	0.86	0.34	0.84	0.15	0.04	0.08	0	0.08	0.22

Table C14. Summary statistics for allsummer 2015 dry weather constituents at Deer Creek, Ventura County.

Summer 2014-'15 Deer Creek Creek										
	ENT	EC	TC	FC	DO	pH	Salinity	Cond	Temp (°C)	Temp (°C)
	log (MPN/100 mL)				(mg/L		(ppt)	(µs/cm)	Water	Air
No Samples	2	2	2	2	2	2	2	2	2	2
Min	2.64	1.64	2.41	1.66	6.52	7.72	0.80	1,630	17.15	16.00
Max	4.00	2.18	2.64	2.11	8.43	8.13	0.86	1,690	17.20	18.00
Range	1.36	0.53	0.23	0.45	1.91	0.41	0.06	60	0.05	2.00
Median	3.32	1.91	2.53	1.89	7.48	7.93	0.83	1,660	17.18	17.00
Mean	3.32	1.91	2.53	1.89	7.48	7.93	0.83	1,660	17.18	17.00
SE.mean	0.68	0.27	0.11	0.23	0.96	0.21	0.03	30	0.03	1.00
CI.mean	8.62	3.38	1.45	2.87	12.13	2.60	0.38	381	0.32	12.71
Var	0.92	0.14	0.03	0.10	1.82	0.08	0.00	1,800	0.00	2.00
Std.Dev	0.96	0.38	0.16	0.32	1.35	0.29	0.04	42	0.04	1.41
Coef.Var	0.29	0.20	0.06	0.17	0.18	0.04	0.05	0	0.00	0.08

Table C15. November-February precipitation totals for San Francisco and Los Angeles for each of the El Niño seasons classified as "strong" or "very strong" by NOAA since 1950.

Total (Nov-Feb) Rainfall (inches)		
Water Year (WY)	**San Francisco**	**Los Angeles**
1957-58	16.89	11.19
1965-66	14.29	17.88
1972-73	25.63	17.9
1982-83	21.67	16.32
1997-98	36.71	22.38
2015-16	**14.53**	**4.54**
Nov-Feb Avg. [1]PQR (1981-2010)	16.68	10.29
El Nino Avg (Excluding 2015-16)	23.04	17.13

[1]PQR = Precipitation Quantification Record - normals are 1981-2010 averages.

Table C16. Summary of 2014-'15 storm events and total precipitation (ppt) at San Onofre Creek (both winter and summer dry weather (DW)).

Month	Day	Year	Total PPT (in)	Comments
October	31	2014	0.25	
November	1	2014	0.22	(2 day event = 0.47")
December	2-4	2014	2.20	(3 day event = 2.47")
December	12	2014	1.94	
December	15-16	2014	0.78	(2 day event = 0.78")
January	10	2015	0.25	
January	11	2015	0.21	(2 day event = 0.46")
January	26-27	2015	0.16	
February	22-23	2015	0.35	
February	28	2015	0.10	
March	1-3	2015	0.46	(4 day event = 0.56")
2014-'15 Winter DW Rainfall Total			**6.92**	
May	6-7	2015	0.43	
May	15-16	2015	0.52	
May	16-17	2015	0.60	(2 day event = 1.12")
May	18	2015	0.04	
May	22	2015	0.07	
June	9	2015	0.01	Trace
June	28	2015	0.02	
July	18	2015	0.40	
July	19	2015	0.37	(2 day event=0.77")
September	14	2015	0.13	
September	15	2015	1.01	(2 day event=1.14")
2014-'15 Summer DW Rainfall Total			**3.60**	
Overall DW Rainfall Total			**10.62**	

Table C17. Summary of 2015-'16 storm events and total precipitation (ppt) at San Onofre Creek (both winter and summer dry weather (DW)).

San Onofre Creek			Total PPT (in)	Comments
Month	Day	Year		
October	4	2015	0.3	
October	5	2015	0.29	(2 day event=0.59")
November	2-3	2015	0.17	
December	13	2015	0.21	
December	20	2015	0.19	
December	22	2015	0.26	
January	5	2016	1.28	
January	6	2016	0.73	**Breached; King Tides**
January	7	2016	0.05	**King Tides**
January	9	2016	0.08	**King Tides**
January	31	2016	0.33	
February	17-18	2016	0.16	
March	4-5	2016	0.38	
March	7	2016	0.42	**Breached; King Tides**
March	11-12	2016	0.51	
March	14	2016	0.13	
April	7	2016	0.11	
April	8	2016	0.29	
April	9	2016	0.12	
2015-'16 Rainfall Total			**5.56**	

Table C18. Summary of 2014-'15 storm events and total precipitation (ppt) at Deer Creek (both winter and summer dry weather (DW)).

Month	Day	Year	Total PPT (in)	Comments
October	31	2014	0.19	
November	1-2	2014	0.20	(2 day event = 0.39")
November	30	2014	1.00	
December	1	2014	0.28	(2 day event = 1.28")
December	2-4	2014	4.58	(3 day event = 4.58")
December	12	2014	2.75	
December	15-16	2014	0.62	(2 day event = 0.62")
January	10	2015	2.37	
January	11	2015	0.20	(2 day event = 2.57")
January	26-27	2015	0.10	
February	7	2015	0.10	
February	22-23	2015	0.58	
Feb-Mar	28-3	2015	1.18	(4 day event = 1.18")
2014-'15 Winter DW Rainfall Total			**14.15**	
May	6-7	2015	0.04	
May	15-16	2015	0.52	
May	16-17	2015	1.13	(2 day event = 1.65")
May	22	2015	0.04	
June	9	2015	0.13	
June	28	2015	0.02	Trace
July	18	2015	0.40	
July	19	2015	0.41	(2 day event=0.81")
September	14-15	2015	1.30	
2014-'15 Summer DW Rainfall Total			**3.99**	
Overall DW Rainfall Total			**18.14**	

Table C19. Summary of 2015-'16 storm events and total precipitation (ppt) at Deer Creek (both winter and summer dry weather (DW)).

Deer Creek			Total PPT (in)	
Month	Day	Year		Comments
October	4	2015	0.1	
October	5	2015	0.19	(2 day event=0.29")
October	19	2015	0.1	
December	13	2015	0.18	
December	20	2015	0.19	
December	22	2015	0.26	
January	5	2016	1.54	
January	6	2016	1.01	King Tides
January	7	2016	1.09	King Tides
January	9	2016	0.08	King Tides
January	19	2016	0.05	
January	20	2016	0.19	
January	31	2016	0.68	
February	1	2016	0.29	
February	17-18	2016	0.58	
March	4-5	2016	0.23	
March	7	2016	2.09	King Tides
March	11-12	2016	0.59	
March	14	2016	0.08	
April	7	2016	0.63	
April	9	2016	0.53	
April	10	2016	0.17	
2015-'16 Rainfall Total			**10.85**	