

2018 SAN DIEGO REGIONAL HARBOR MONITORING PROGRAM

HISTORICAL BACTERIA ANALYSIS - FINAL REPORT

Submitted to:



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And Partner Agencies:

County of Orange, City of Oceanside, and City of San Diego



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FINAL REPORT

December 2020

Prepared for:

The Unified Port of San Diego
City of San Diego
City of Oceanside
County of Orange

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ACRONYMS AND ABBREVIATIONS

303(d) list	California's 2014–2016 List of Impaired Waters
AB411	California Assembly Bill 411
FIB	fecal indicator bacteria
FY	fiscal year
GM	geometric mean
ISWEBE Plan	Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California
MDL	method detection limit
non-detect	below detection limit
OCPW	County of Orange Public Works
Ocean Plan	Water Quality Control Plan for Ocean Waters of California
OCHCA	County of Orange Health Care Agency
OWPP	Ocean Water Protection Program
PCR	polymerase chain reaction PCR
REC-1	water contact recreation beneficial use
RHMP	Regional Harbor Monitoring Program
RHMP Agencies	Port of San Diego, the City of San Diego, the City of Oceanside, and the County of Orange
San Diego Regional Harbors	San Diego Bay, Mission Bay, Oceanside Harbor, and Dana Point Harbor
SDBRPs	San Diego Bay Responsible Parties
SDDEH	County of San Diego Department of Environmental Health
SDRWQCB	San Diego Regional Water Quality Control Board
SSM	single sample maximum
STV	statistical threshold value
SWAMP	State of California Surface Water Ambient Monitoring Program
SWRCB	California State Water Resources Control Board
TMDL	total maximum daily load
WQO	water quality objective

UNITS OF MEASURE

%	percent
<	less than
>	greater than
≥	greater than or equal to
=	equal
C	estimated
cfu	colony forming unit(s)
cfu/100 mL	colony forming unit(s) per 100 milliliters
E	estimated
mL	milliliter(s)
mpn	most probable number
mpn/100 mL	most probable number per 100 milliliters
NR	not reported
ppth	part per thousand

1.0 INTRODUCTION

The Regional Harbor Monitoring Program (RHMP) was developed by the Port of San Diego, the City of San Diego, the City of Oceanside, and the County of Orange (RHMP Agencies) in response to a July 24, 2003, request by the San Diego Regional Water Quality Control Board (SDRWQCB) under Section 13225 of the California Water Code. The RHMP is a comprehensive effort to survey the water quality, sediment quality, and aquatic life in Dana Point Harbor, Oceanside Harbor, Mission Bay, and San Diego Bay (San Diego Regional Harbors) and determine whether beneficial uses are being protected and attained in these harbors. The program is composed of a core chemical, biological, and toxicological monitoring program supplemented by focused special studies. The RHMP takes place once every five years and is designed to address five core questions regarding the status and trends in the harbors:

1. What are the contributions and spatial distributions of inputs of pollutants to the harbors?
2. Do the waters and sediments in the harbors sustain healthy biota?
3. What are the long-term trends in water and sediment quality in the harbors?
4. Are the waters in the harbors safe for body contact activities?
5. Are fish in the harbors safe to eat?

This report aims to address the fourth core question: Are the waters in the harbor safe for body contact activities? To address this question, historical fecal indicator bacteria (FIB) data from the San Diego Regional Harbors from November 1, 2008, through October 31, 2018, were compiled and a post hoc analysis was performed to address the following specific study questions:

- 1) What are the extent and magnitude of FIB concentrations in the receiving waters of the San Diego Regional Harbors?
- 2) What are the historical trends of FIB concentrations throughout the harbors?

FIB concentrations in each San Diego Regional Harbor were compared to water quality objectives (WQOs) for the water contact recreation (REC-1) beneficial use to evaluate whether waters are safe for human body contact.

1.1 Background

During the 2008 RHMP field program, a single set of water samples was collected from each of the 75 stations in the San Diego Regional Harbors. The samples were analyzed for fecal coliform, total coliform, and enterococcus FIB, along with other chemical constituents and toxicity. To address the RHMP core question related to human recreation contact, FIB concentrations were compared with WQOs in accordance with California Assembly Bill 411 (AB411), which mandates weekly testing for FIB during the dry season (April 1 through October 31) for all California beaches with 50,000 visitors or more adjacent to a flowing storm drain. FIB levels did not exceed the AB411 single sample thresholds of 10,000 total coliforms per 100 milliliter (mL), 400 fecal coliforms per 100 mL, or 104 enterococci per 100 mL in any of the samples collected during the 2008 RHMP, and the majority of samples were below detection limits. Total coliforms, fecal coliforms, and

enterococci were detected at only 25, 8, and 4 percent of stations respectively (Weston Solutions, Inc. 2010), all at concentrations below WQO thresholds.

Because of the transient and variable nature of FIB, sampling only once in a 5-year period, as in the 2008 RHMP, does not capture sufficient information to assess the overall water quality in relation to the REC-1 beneficial use. Due to these limitations, the RHMP Agencies and the SDRWQCB agreed to eliminate the FIB testing component of the 2013 RHMP, while directed efforts by the RHMP Agencies in support of total maximum daily loads (TMDLs) and beach water quality monitoring programs continued. These long-term monitoring programs are designed to collect data that more appropriately addresses if waters are safe for human body contact.

In 2018, the SDRWQCB requested that an assessment of human health risk related to REC-1 be reincorporated into the 2018 RHMP. Sampling and analysis of FIB on a regularly scheduled basis provides a much more informative and accurate assessment of extent, magnitude, and trends as compared to a single set of samples collected every 5 years during an ambient monitoring program. To provide a more robust assessment of whether the harbor waters are safe for human body contact, current and historical FIB data collected by the RHMP agencies and others in all four harbors were compiled and are summarized in this report. These data are collected in both dry and wet weather and are focused on beaches and bays throughout southern California where water contact recreation is common. This post-hoc analysis was performed in lieu of collecting a single grab sample for FIB at each sampling location during the RHMP Core Monitoring Program.

2.0 COMPILATION METHODS AND ANALYSIS

2.1 Data Compilation Methods

Historical FIB receiving water data for the San Diego Regional Harbors was extracted from the RHMP Agencies' beach water quality programs for both dry and wet seasons, using the California State Water Resources Control Board (SWRCB) definition of the wet season as November 1 through March 31 and the dry season as April 1 through October 31. As available, FIB data from both wet and dry seasons were compiled from November 1, 2008 through October 31, 2018 to capture the 10-year period through the end of dry season sampling for the 2018 RHMP field season. Although data were compiled for enterococcus, fecal coliform, and total coliform, post hoc analysis focused on enterococcus as the primary indicator to reflect the latest WQOs in the 2018 adoption of the Bacteria Provisions for the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California (ISWEBE Plan; SWRCB 2019) and amendment to the Water Quality Control Plan for Ocean Waters of California (Ocean Plan; SWRCB 2018). These documents identify enterococcus as the most appropriate FIB for the enclosed bays that characterize the San Diego Regional Harbors. Supplemental data analysis of fecal coliform and total coliform is documented in Appendix A of this report.

2.1.1 Data Sources

Data were compiled directly from RHMP Agencies' beach water quality programs. Dana Point Harbor FIB data were obtained from the County of Orange Health Care Agency (OCHCA) Ocean Water Protection Program (OWPP) website (OCHCA 2020b); City of Oceanside data were obtained directly from the City of Oceanside via a data request from the Watershed Protection Program; and Mission Bay and San Diego Bay data were obtained from the SWRCB Beach Monitoring Database (SWRCB 2020). The SWRCB Beach Monitoring Database is the data repository for County of San Diego Department of Environmental Health (SDDEH) Beach and Bay Water Quality Program (SDDEH 2020). The Port of San Diego also provided data directly for San Diego Bay, which were also included in the SDDEH database.

Data from the OCHCA OWPP were compiled by selecting the appropriate monitoring years, downloading the data to Microsoft Excel, and filtering for relevant stations. Data from the SWRCB Beach Monitoring database was obtained by searching the database for "San Diego," "All Stations," "All Parameters," "All Qualifiers," "All Analysis Methods," and "All Years," downloading the data to Microsoft Excel, and filtering for relevant years and stations. Only data from sampling stations located within Dana Point Harbor, Oceanside Harbor, Mission Bay, and San Diego Bay were used for the subsequent data analysis.

In total, 12,275 enterococcus data points were compiled and used in the subsequent analysis. Table 2-1 includes a breakdown of sample sizes by harbor and wet and dry season. Figures 2-1a through 2-1e show the monitoring locations in each harbor from which data were compiled. Note that some stations were monitored for only a portion of the 10-year period included in this analysis. In addition, data was not available for some wet seasons from each harbor, as noted in Table 2-1. Appendix B provides a full breakdown of monitoring locations and coordinates within the San Diego Regional Harbors.

**Table 2-1.
 Enterococcus Sample Size by Harbor**

Harbor	Number of Stations	Dry Season Sample Size	Wet Season Sample Size	Total Sample Size
Dana Point Harbor	12	3,907	1,270 ^c	5,177
Oceanside Harbor	4 ^a	196	129 ^d	325
Mission Bay	23 ^b	4,344	355 ^e	4,699
North San Diego Bay	5	1,259	132 ^f	1,391
South San Diego Bay	3	659	24 ^g	683
All Harbors	47	10,365	1,910	12,275

Notes:

- a. Only 1 sample was collected at Oceanside Harbor station H-4 and latitude and longitude were not recorded, thus station H-4 is not depicted in Figure 2-1b.
- b. Latitude and longitude were not recorded at Mission Bay station MB-200, thus station MB-200 is not depicted in Figure 2-1c.
- c. No data were available for the 2012/2013 wet season in Dana Point Harbor.
- d. No data were available for the 2013/2014 and 2017/2018 wet seasons in Oceanside Harbor.
- e. No data were available for the 2008/2009, 2010/2011, and 2011/2012 wet seasons in Mission Bay.
- f. No data were available for the 2008/2009 through 2013/2014 wet seasons in North San Diego Bay.
- g. No data were available for the 2008/2009, 2009/2010, 2010/2011, and 2013/2014 wet seasons in South San Diego Bay.

Figure 2-1a. Dana Point Harbor Monitoring Locations

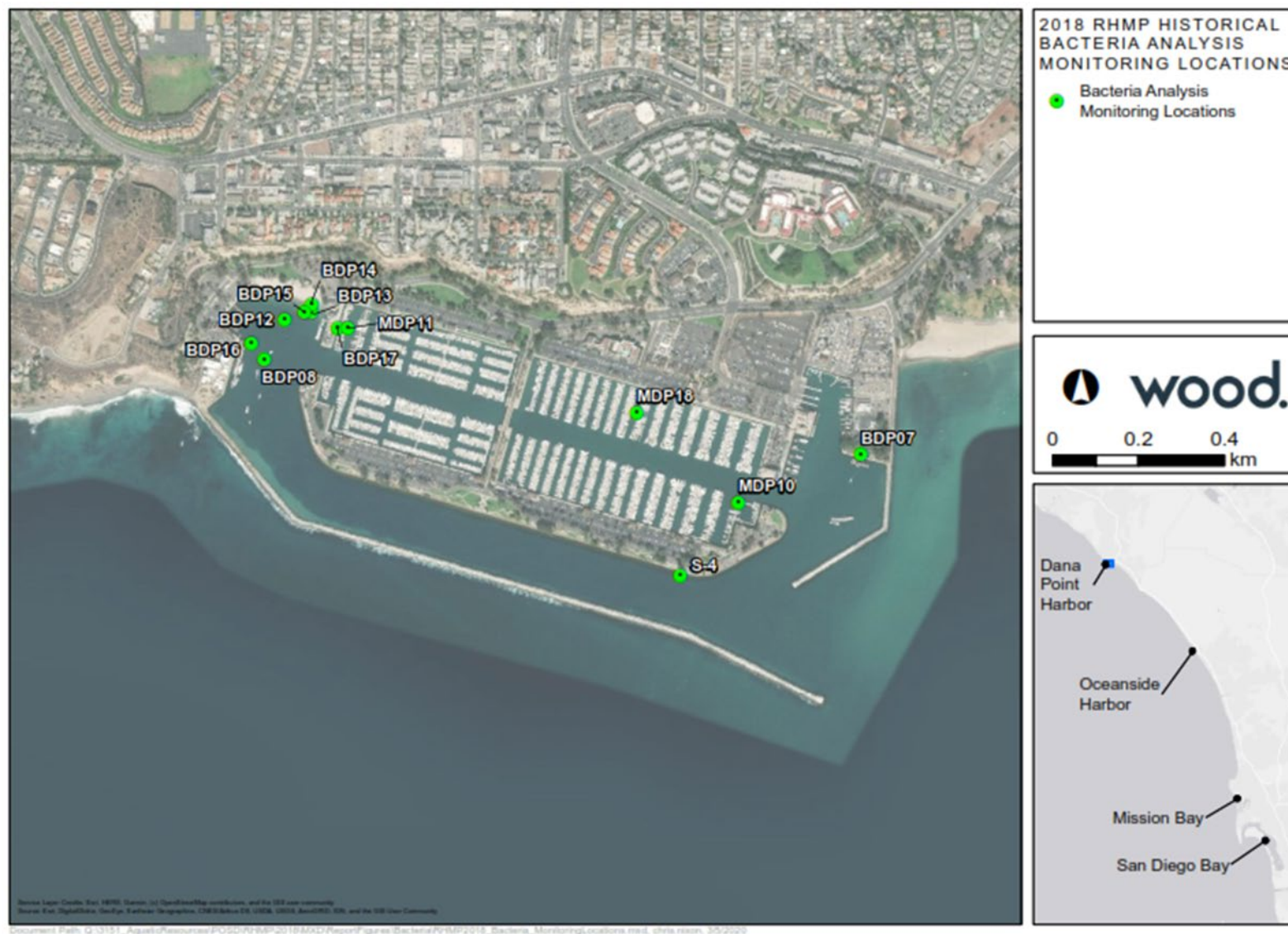
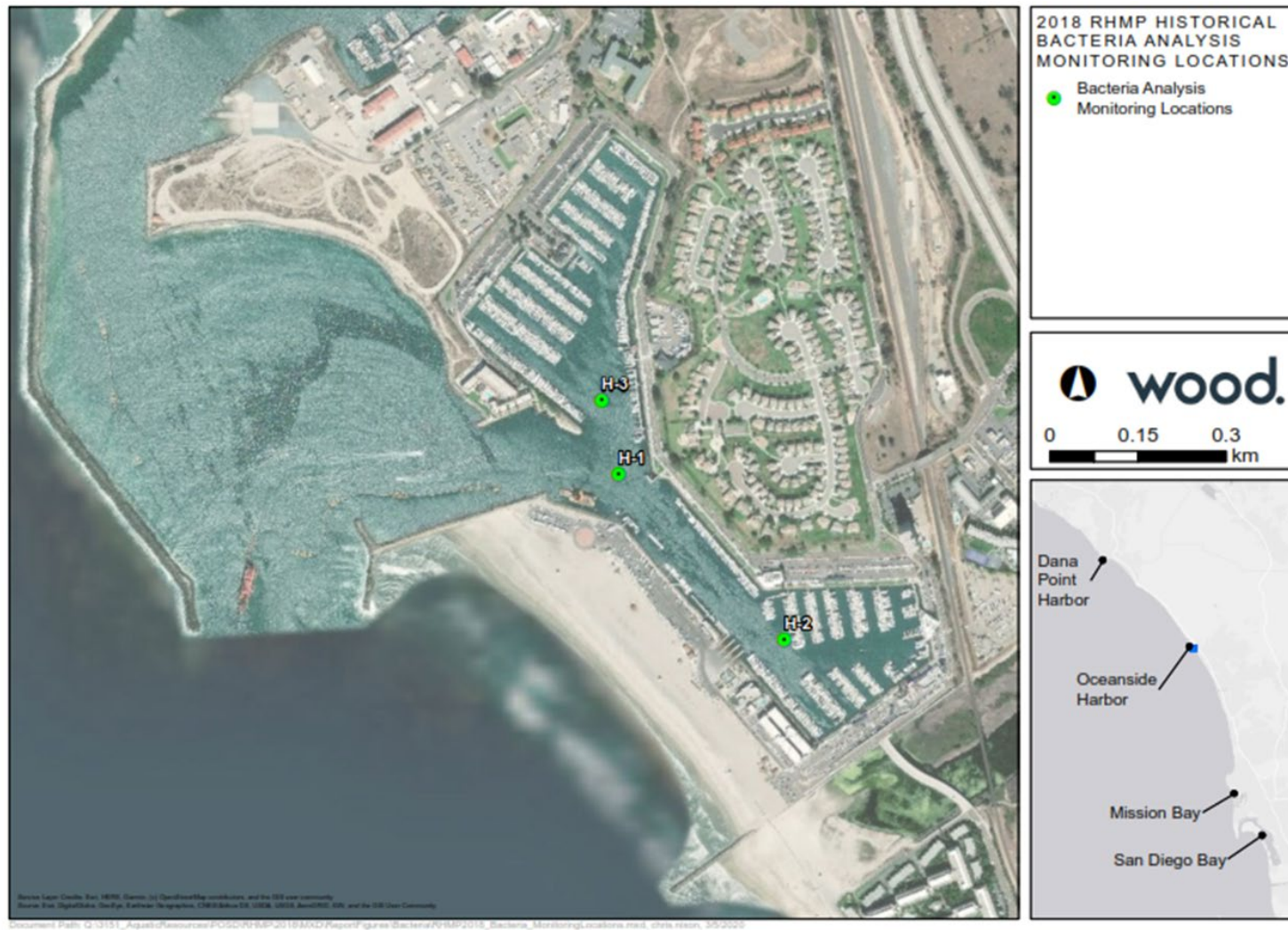
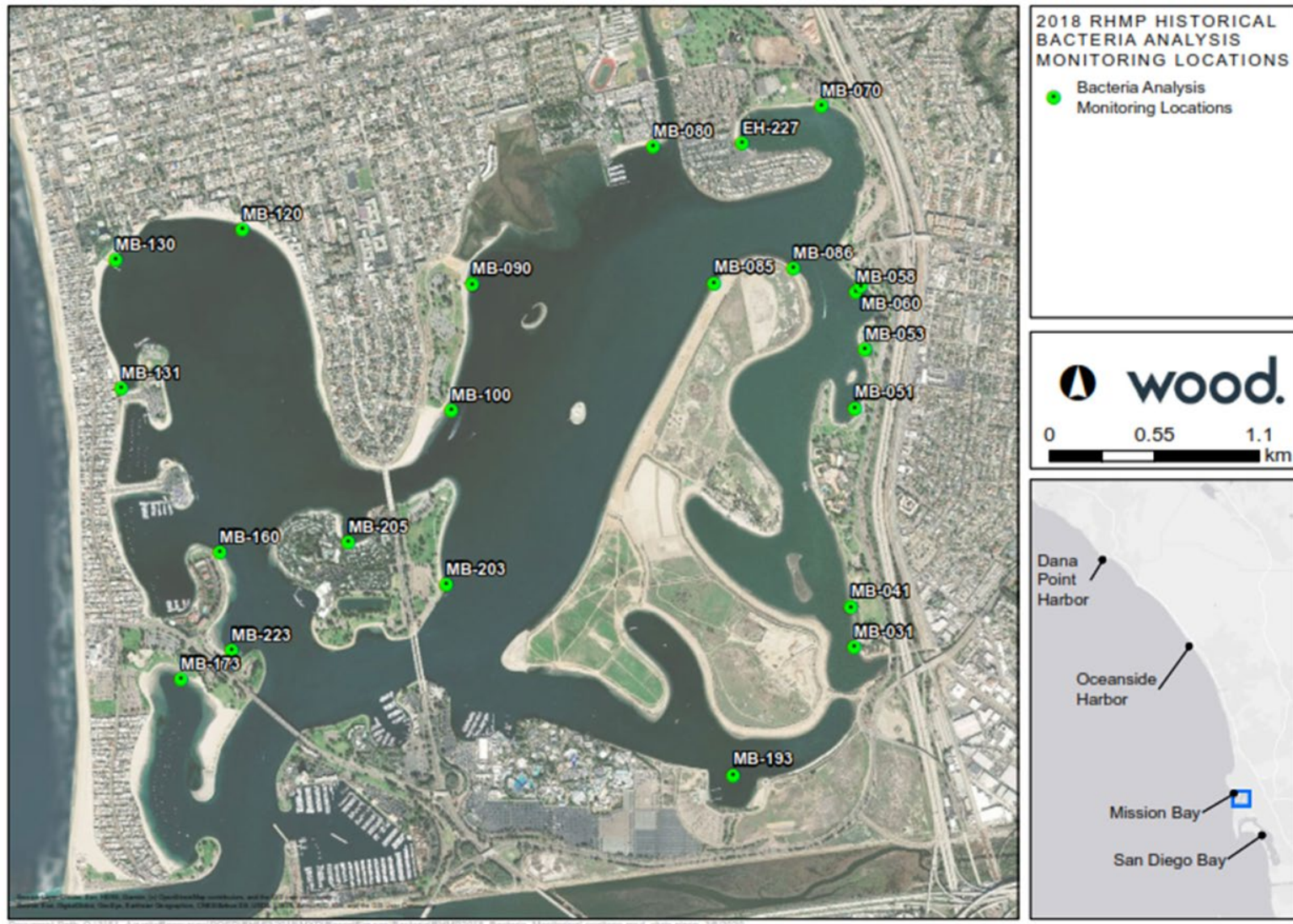


Figure 2-1b. Oceanside Harbor Monitoring Locations



Note: Only 1 sample was collected at station H-4 and latitude and longitude were not recorded, thus station H-4 is not depicted in the figure

Figure 2-1c. Mission Bay Monitoring Locations



Note: Latitude and longitude were not recorded for station MB-200, thus it is not depicted in the figure

Figure 2-1d. North San Diego Bay Monitoring Locations

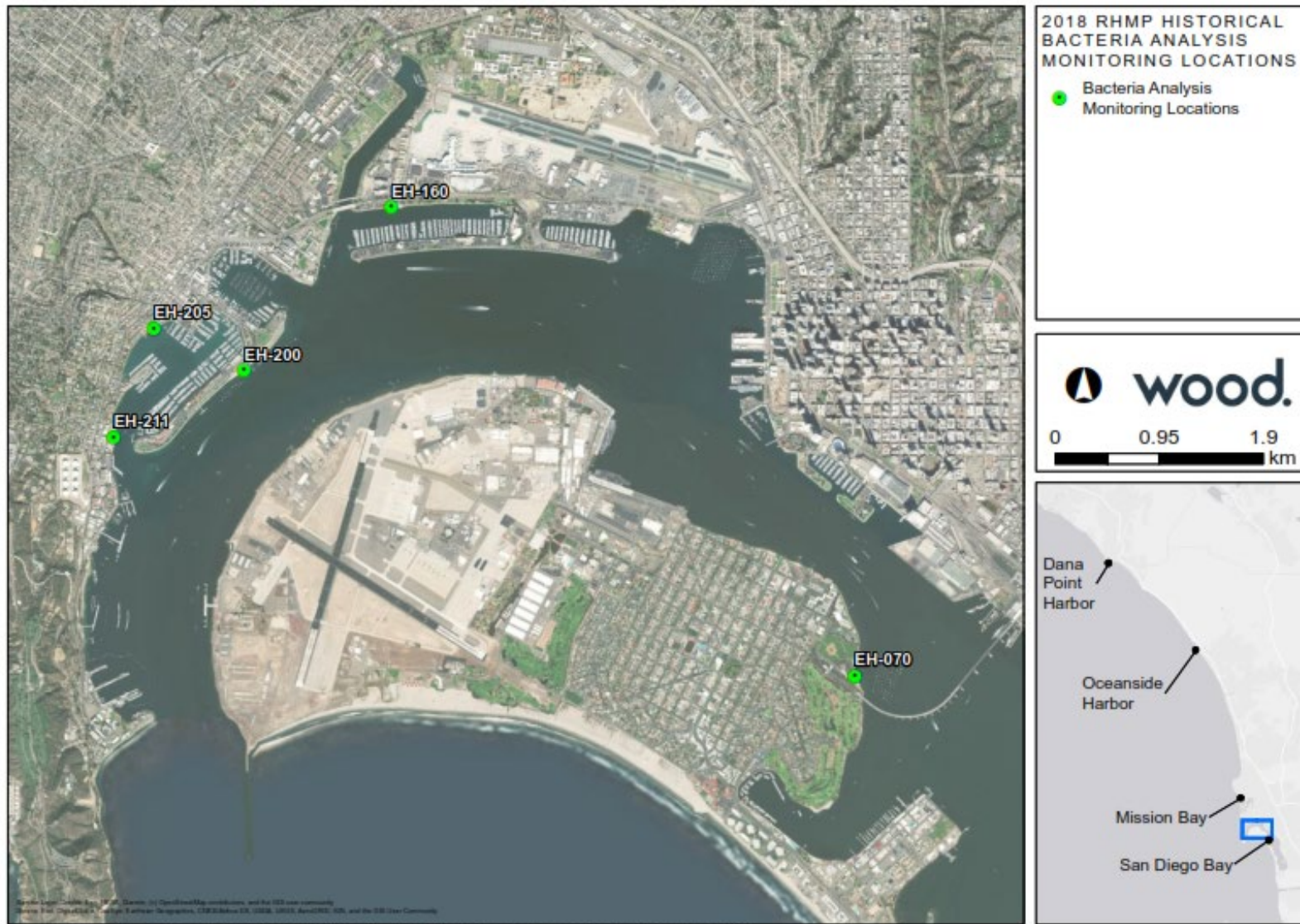


Figure 2-1e. South San Diego Bay Monitoring Locations



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2.1.2 Assumptions

Due to certain discrepancies among data from different sources, several assumptions were made to more effectively process and analyze the data as described in Sections 2.1.2.1 through 2.1.2.5.

2.1.2.1 Units

Bacteria data are commonly reported in either most probable number (mpn) or colony forming units (cfu). The value mpn is a statistical estimate of the most probable number of bacteria and cfu is an actual count of bacterial colony forming units using membrane filtration methods. Historical California regulations for bacteria do not specify or distinguish between units, and the units are assumed to be equivalent for regulatory analysis and compliance.

Approximately half of the historical enterococcus data compiled from the San Diego Regional Harbors were reported in mpn per 100 mL (mpn/100 mL) and the other half were reported in cfu per 100 mL (cfu/100 mL). This analysis adopted regulatory protocol and assumed one mpn/100 mL and one cfu/100 mL to be equivalent. Densities of mpn and cfu were pooled together for analysis and reported as “density.”

2.1.2.2 Non-Detects

All samples with enterococcus densities below the detection limit (non-detects), reported as zero, or accompanied by a less than (<) qualifier, were included in calculations as one-half of the method detection limit (MDL). This method is a commonly adopted data analysis protocol that provides a more conservative approach. Please see the State of California Surface Water Ambient Monitoring Program (SWAMP) methods for additional guidance: https://www.waterboards.ca.gov/water_issues/programs/swamp/docs/cwt/guidance/3413.pdf.

MDLs were not recorded in the Oceanside Harbor dataset. For non-detects in Oceanside Harbor, the most common MDL reported in the compiled historical dataset from all harbors for enterococcus (10 enterococci/100mL) was included and one-half of this value was recorded and used in calculations (5 enterococci/100mL).

2.1.2.3 Other Qualifiers

Qualifiers of “= (equal),” “E (estimated),” “C (estimated),” “> (greater than),” “>= (greater than or equal to),” and “NR (not reported)”¹ were included as the reported value.

2.1.2.4 Stations with Multiple Samples on a Given Date

In some cases, two or more results were reported for a station on a given date. Limited information was available regarding the sample collection methodology (e.g., duplicate, replicate, or follow-

¹ As described in Section 2.1.2.2, non-detects in Oceanside Harbor with “NR” qualifiers were included in calculations as one-half of the most common MDL reported in the compiled historical dataset from all harbors (10 enterococci/100mL).

up samples). Therefore, all results were included in this analysis as reported, unless otherwise noted in the assumptions.

2.1.2.5 Follow-Up Samples

In some cases, follow-up samples were taken if FIB densities exceeded REC-1 WQOs at a given location to determine when waters are safe for contact. As described above, limited information was available regarding sample collection methodology, so it was not possible to identify follow-up samples in the dataset. Therefore, all results, including any potential follow-up samples, were included in this analysis. Note that inclusion of follow-up samples tends to give more weight to samples with elevated FIB densities.

2.2 Analysis Methodology

In 2018, the SWRCB adopted REC-1 beneficial use bacterial characteristics for the ISWEBE Plan and updated and refined bacterial characteristics in the Ocean Plan to reflect recent science. Enterococcus was adopted in the ISWEBE Plan as the only FIB applicable to saline enclosed bays characteristic of the San Diego Regional Harbors. As such, enterococcus is the focus of the following analysis.

Prior to the inclusion of bacterial characteristics in the ISWEBE Plan, beaches and harbors relied on the bacterial characteristics in the Ocean Plan for compliance and AB411 for beach advisory postings. To represent historical extent, magnitude, and trends in FIB, all enterococcus data from 2008–2018 were analyzed with previous Ocean Plan WQOs of a 30-day geometric mean (GM) and single sample maximum (SSM) as reference thresholds. To represent current conditions, enterococcus data from 2017–2018 was also analyzed with the current ISWEBE Plan WQOs of a 6-week GM and Statistical Threshold Value (STV) as reference thresholds. An analysis using both previous and current REC-1 WQOs provides a more comprehensive analysis of historical trends relative to current conditions.

Supplementary historical analysis for total coliform and fecal coliform is documented in Appendix A.

2.2.1 Enterococcus Single Sample Maximum – Historical Objective

Calculations of the SSMs for all data collected from 2008–2018 were based on the following Ocean Plan REC-1 WQO in effect from 2005–2018:

Enterococcus density shall not exceed 104 per 100 mL.

The RHMP FIB database was analyzed in relation to this objective by filtering the database for all samples equal to or greater than (\geq) 104/100 mL.

2.2.2 Enterococcus 30-day Geometric Mean – Historical Objective

Calculations of the 30-day rolling GM for all data collected from 2008–2018 were based on the following Ocean Plan REC-1 WQO in effect from 2005–2018:

Enterococcus density shall not exceed 35 per 100 mL, based on the GM of the five most recent samples from each site.

A GM was calculated for every sample date from November 1, 2008 through October 31, 2018. For the purposes of this report, the analysis included all data 30 days before the sample date, regardless of sample size. Geometric means were calculated regardless of whether or not fewer than 5 samples were available within the prior 30-day period.

2.2.3 Enterococcus Six-week Geometric Mean – Current Objective

Calculations of the six-week rolling enterococcus GMs were based on the following ISWEBE Plan REC-1 WQO currently in effect:

For all waters where the salinity is greater than 1 part per thousand (ppt) more than 5 percent of the time during the calendar year: a six-week rolling GM of enterococci is not to exceed 30 cfu/100 mL, calculated weekly.

A GM was calculated for every sample date from November 1, 2017 through October 31, 2018. For the purposes of this report, the analysis included all data collected 6 weeks prior to the sample date, regardless of sample size.

2.2.4 Enterococcus Statistical Threshold Value – Current Objective

Calculations of the enterococcus STVs were based on the following ISWEBE Plan REC-1 WQO currently in effect:

For all waters where the salinity is greater than 1 ppt more than 5 percent of the time during the calendar year: a STV of 110 cfu/100 mL is not to be exceeded by more than 10 percent of samples collected in a calendar month, calculated in a static manner.

For the purpose of this analysis, the percent of samples that exceeded the STV was calculated for each station monitored from 2017–2018 by season (wet or dry), rather than by calendar month. The resulting seasonal value was calculated by dividing the number of sample results exceeding 110 cfu/100 mL for a station in the 2017–2018 wet or dry season by the total number of samples collected at the station during that season. This approach provides a more representative assessment over time accounting for month to month variability.

2.3 Data Presentation

Enterococcus data is presented in boxplots for each harbor showing the median value (horizontal line), 25th, and 75th percentiles (represented by the colored box), and minimum and maximum values (represented by whiskers). The 30-day geometric mean WQO objective (or 6-week geometric mean WQO for the latest year of data where applicable) are plotted as horizontal dotted lines on all figures for comparison. For each individual harbor, boxplots compare historical annual enterococcus densities over the past 10-years to assess trends. To visually depict the most recent 2017/2018 data spatially, maps are provided for each harbor that show the average seasonal 6-week geometric mean (i.e., the average of all 6-week geometric means for the 2017/2018 dry season or wet season) enterococcus densities at each sampling location as a bubble plot, with

larger bubbles representing greater mean densities. The lowest data bin break for each map represents the 6-week geometric mean WQO in the ISWEBE, with sites with densities below the WQO colored green.

3.0 RESULTS

San Diego Regional Harbors results were analyzed as a single large dataset across harbors and as individual assessments for each harbor. San Diego Bay was further divided into North and South sections because of the size and geographic diversity of this large water body. Use of GMs² calculated over a 30-day or 6-week timeframe provides an assessment of the central tendency of a dataset and information about general or seasonal variability for water contact recreation and potential risk to human health. The SSM and STV are included to help identify acute spikes of FIB concentrations, providing information about specific instances in which WQO exceedances occurred. Calculating both the GM and SSM/STV provides an accurate representation of both chronic (GM) and acute (SSM/STV) WQO exceedances of FIB in specific water bodies.

The four harbors monitored under the RHMP are all semi-enclosed embayments located in southern California, but each has its own unique set of characteristics that are important to consider when interpreting data and making comparisons among them. Geography as well as both current and historical uses have considerable influence on water quality conditions. Further descriptions of each of these water bodies are provided in the 2018 RHMP core monitoring report. A brief summary of enterococcus data among all harbors for the most recent data collected in 2017/2018 is provided in Section 3.1, followed by more detailed summaries for each harbor, including historical comparisons in Sections 3.2 through 3.5.

3.1 All Harbors

3.1.1 30-day Geometric Mean and Single Sample Maximum Analysis – Historical Evaluation (2008–2018)

For all stations over the entire 10-year period, 12,275 samples were analyzed for enterococcus, 1,910 during the wet season and 10,365 during the dry season. In total, 91 percent of samples were below the 30-day GM WQO, 94 percent were below the SSM WQO, and 46 percent were below detection limits. Generally, elevated enterococcus densities were observed during the wet season when compared with the dry season. During the wet season, 22 percent of samples exceeded the 30-day GM WQO and 11 percent exceeded the SSM WQO. During the dry season, 6 percent of samples exceeded the 30-day GM WQO and 6 percent exceeded the SSM WQO (Table 3-1). Detailed assessments of each individual harbor are provided in Sections 3.2 through 3.5. A full summary of 30-day GM and SSM WQO exceedances by station is provided in Appendix C.

² The geometric mean is a mean or average, which indicates the central tendency or typical value of a set of numbers by using the product of their values (as opposed to the arithmetic mean which uses their sum). The geometric mean is defined as the n th root of the product of n numbers, i.e., for a set of numbers x_1, x_2, \dots, x_n . The geometric mean is used routinely to summarize bacteria data because these data are so variable as bacteria can grow at an exponential rate very quickly under the right conditions. The geometric mean value will not be overly influenced by large fluctuations from between one data point and the next.

Table 3-1. 30-Day Geometric Mean and Single Sample Maximum WQO Exceedances for Enterococcus Among All San Diego Regional Harbors (2008–2018)

Harbor	Number of Samples (n)		All Seasons			Wet Season		Dry Season	
	Wet Season	Dry Season	% Non-detect	% Over 30-day GM WQO	% Over SSM WQO	% Over 30-day GM WQO	% Over SSM WQO	% Over 30-day GM WQO	% Over SSM WQO
Dana Point Harbor	1,270 ^a	3,907	40	6	5	9	5	4	5
Oceanside Harbor	129 ^b	196	79	2	1	4	2	1	1
Mission Bay	355 ^c	4,344	49	11	8	63	27	7	6
North San Diego Bay	132 ^d	1,259	49	13	9	50	23	9	7
South San Diego Bay	24 ^e	659	56	8	7	50	25	6	6
All Harbors	1,910	10,365	46	9	6	22	11	6	6

Notes:

% = percent; GM = geometric mean; SSM = single-sample maximum; WQO = water quality objective

a. No data were available for the 2012/2013 wet season in Dana Point Harbor.

b. No data were available for the 2013/2014 and 2017/2018 wet seasons in Oceanside Harbor.

c. No data were available for the 2008/2009, 2010/2011, and 2011/2012 wet seasons in Mission Bay.

d. No data were available for the 2008/2009 through 2013/2014 wet seasons in North San Diego Bay.

e. No data were available for the 2008/2009, 2009/2010, 2010/2011, and 2013/2014 wet seasons in South San Diego Bay.

3.1.2 6-week Geometric Mean and Statistical Threshold Value Analysis – Recent Results (2017/2018 Monitoring Year)

Data from November 1, 2017 through October 31, 2018 were analyzed for the 6-week GM and STV in accordance with ISWEBE Plan WQOs adopted in 2018. For all harbors, stations, and seasons, 1,518 samples were analyzed, 395 wet season samples and 1,123 dry season samples, with the exception of Oceanside Harbor during the 2017/2018 wet season, for which no data were available.

Both the 6-week GM and STV analyses indicate wet season densities of enterococcus were generally greater than dry season densities with no apparent trend in densities across harbors (Figures 3-1 and 3-2).

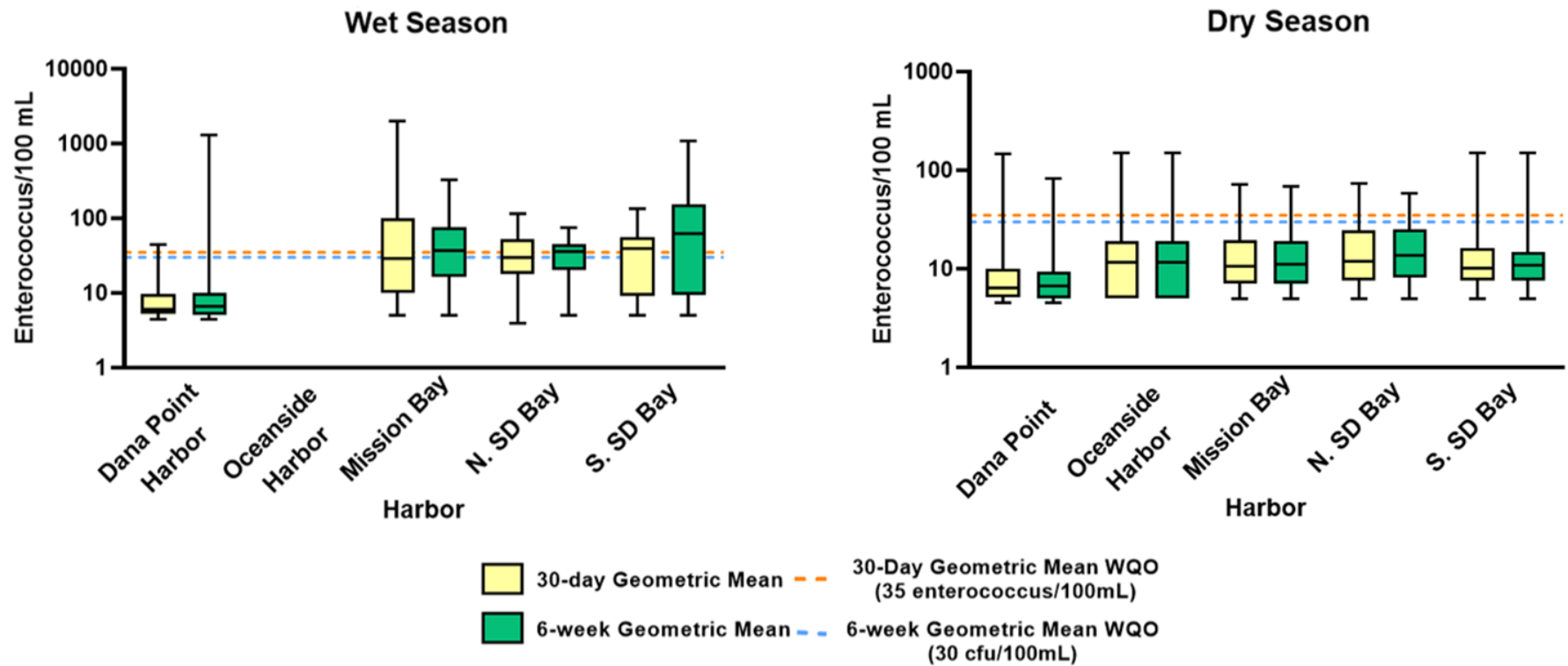
In addition, the 30-day GM was calculated for the 2017/2018 monitoring season and compared with the 6-week GM to assess suitability for historical comparison. Using the historical WQOs, the percent of samples exceeding the 30-day GM during the 2017/2018 wet season ranged from 2% in Dana Point Harbor to 53% in South San Diego Bay. In the 2017/2018 dry season, the percent of samples exceeding the 30-day GM ranged from 3% in South San Diego Bay to 14% in North San Diego Bay (Figure 3-1). Similarly, using the ISWEBE Plan WQOs adopted in 2018, the percent of samples exceeding the 6-week GM during the 2017/2018 wet season ranged from 4% in Dana Point Harbor to 67% in South San Diego Bay. In the 2017/2018 dry season, the percent of samples exceeding the 6-week GM ranged from 3% in South San Diego Bay to 16% in North

San Diego Bay. Both the 30-day GM and 6-week GM showed similar results, indicating that both are suitable for making comparable historical assessments (Figure 3-1).

As shown in Figure 3-2, the percent of samples exceeding the STV of 110 cfu/100 mL for enterococcus ranged from 0 to 27% at any given location during the 2017/2018 dry season and 0 to 43% at any given location during the 2017/2018 wet season. For comparison, the STV is not to be exceeded in more than 10% of the samples in any given calendar month; the dry season includes five calendar months and the wet season includes seven calendar months. Each dot in Figure 3-2 represents a single distinct sampling location. The greatest exceedance frequencies observed among sample locations during this period of time were in Mission Bay and San Diego Bay, particularly during the wet season.

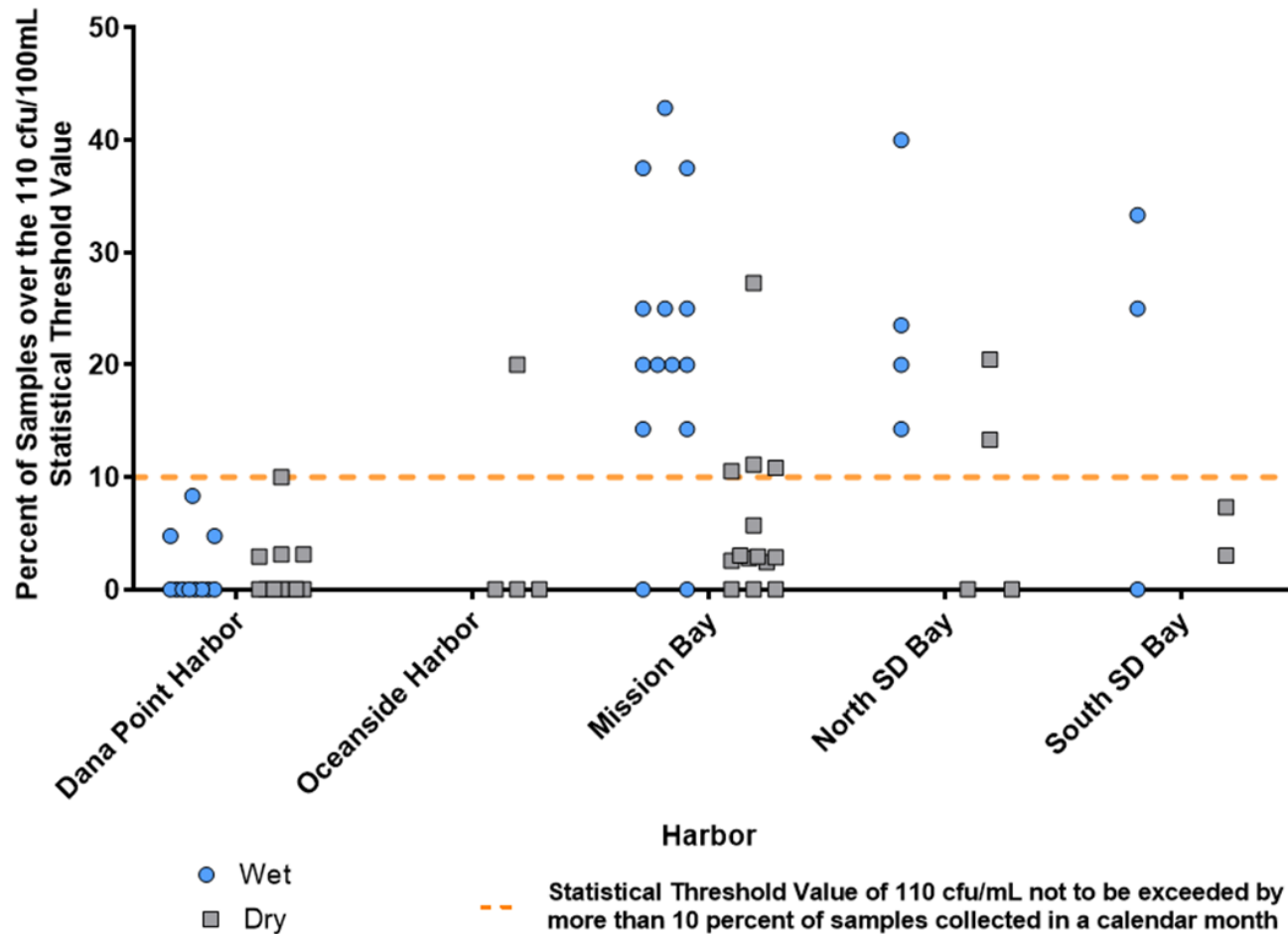
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**Figure 3-1. 30-day vs. 6-week Geometric Mean Densities of Enterococcus in Wet and Dry Seasons
 (November 1, 2017, Through October 31, 2018)**



Notes:
 No data available for Oceanside Harbor during the 2017/2018 wet season
 mL = milliliter(s)
 WQO = water quality objective

Figure 3-2. Percent of Enterococcus Samples Above the Statistical Threshold Value for San Diego Regional Harbors During the 2017/2018 Monitoring Year



Notes: Each data point represents the percent of samples that exceeded the STV during the wet or dry season for a single station
 No data available for Oceanside Harbor during the 2017/2018 wet season
 cfu = colony-forming unit(s)
 mL = milliliter(s)
 SD = San Diego

3.2 Dana Point Harbor

3.2.1 30-day Geometric Mean and Single-sample Maximum Analysis – Historical Evaluation (2008–2018)

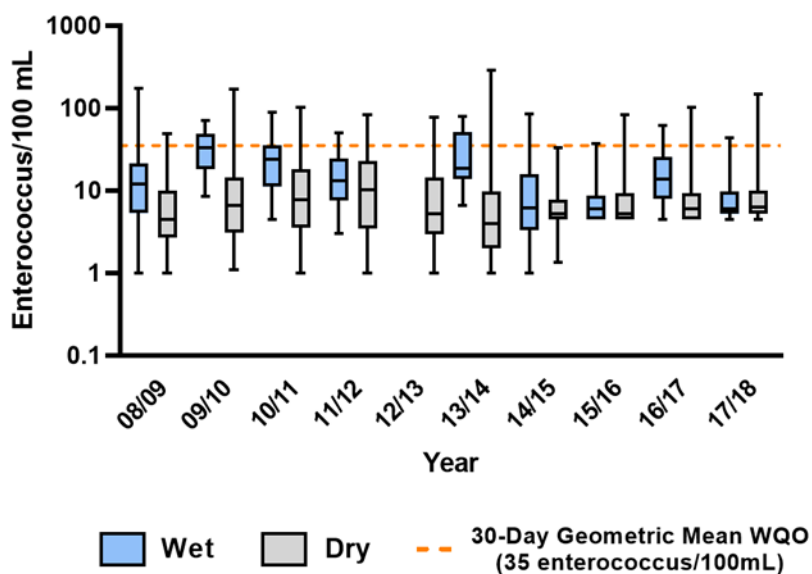
A total of 5,177 samples were compiled from 12 stations within Dana Point Harbor over the 10-year data compilation period. Data were compiled for both wet and dry seasons, with the exception of the 2012/2013 wet season, for which no samples were collected. A total of 3,907 samples were analyzed for the 10 dry seasons and 1,270 samples were analyzed for the nine wet seasons for which data were available.

In general, both 30-day GM and SSM enterococcus densities were below WQOs, with 94 percent of all samples below the 30-day GM WQO and 95 percent below the SSM WQO. Overall, enterococcus densities were slightly higher during the wet season for all years and all stations (Figures 3-3a and 3-3b), with relatively low densities of enterococcus throughout the dry season. During the wet seasons, 9 percent of samples exceeded the 30-day GM WQO and 5 percent exceeded the SSM WQO. During the dry seasons, 4 percent of sample exceeded the 30-day GM WQO and 5 percent exceeded the SSM WQO. Enterococcus densities were below detection limits in 40 percent of samples for all stations and all seasons. A full summary of 30-day GM and SSM WQO exceedances by station is provided in Appendix C.

Across all stations combined, there was a small reduction in variability and median values of enterococcus density through time, with the 2015/2016 through 2017/2018 monitoring seasons showing reduced median values and a more central tendency. Individual stations listed as impaired for the REC-1 beneficial use on the California 2014–2016 List of Impaired Waters (303(d) list) show improvement over time, as noted below for Baby Beach.

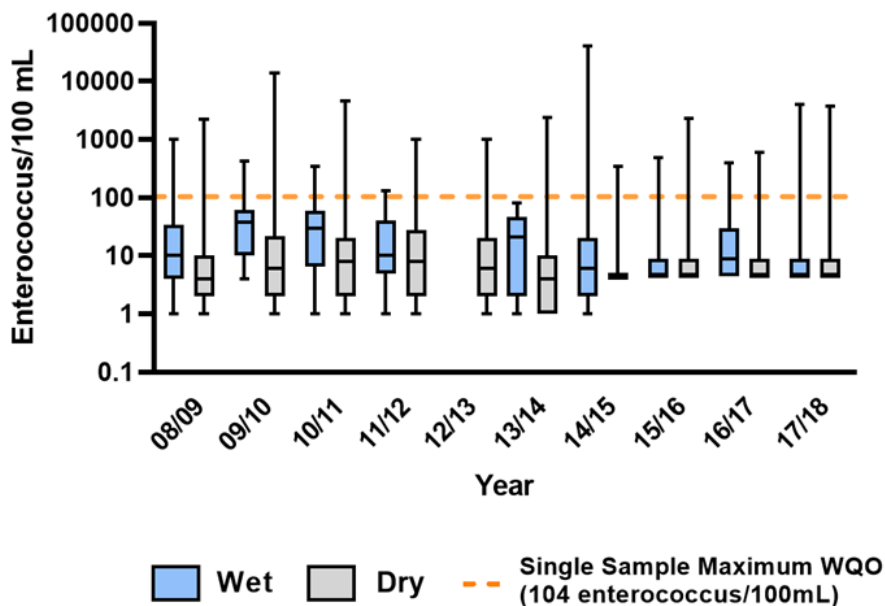
Five of the 12 stations in Dana Point Harbor had very low exceedance rates, with 1 percent or fewer samples exceeding the 30-day GM or SSM WQOs over the 10-year period. The majority of the samples that exceeded WQO thresholds were at the four stations surrounding Baby Beach (BDP12–BDP15) and one station at M Dock (MDP18) in the east basin. At these stations, 8 to 16 percent of samples exceeded the 30-day GM WQO and 7 to 10 percent of samples exceeded the SSM WQO (Appendix C). Baby Beach was previously on the 303(d) list for FIB (including fecal coliform, total coliform, and enterococcus) with a TMDL that went into effect in 2009. Since implementation of the TMDL, Baby Beach has shown improvement (2016 Water Quality Report Card) and has since been removed from the 303(d) list for fecal coliform and enterococcus in the 2010 and 2014/2016 cycles, respectively. The following sources provide information on historical trends, and the extent and magnitude of FIB in Baby Beach and Dana Point Harbor: the County of Orange Public Works (OCPW) Baby Beach website (OCPW 2020), OCHCA Annual Ocean, Harbor, and Bay Water Quality Reports (OCHCA 2020a), the Baby Beach Water Quality Report Card (SDRWQCB 2016), and the Baby Beach Indicator Bacteria TMDL Annual Progress Report Fiscal Year (FY) 2014–2015 (County of Orange and City of Dana Point 2016).

Figure 3-3a. 30-day Geometric Mean Enterococcus Densities for Dana Point Harbor from All 12 Monitored Stations Combined



Notes: No data available for the 2012/2013 wet season
 mL = milliliter(s)
 WQO = water quality objective

Figure 3-3b. Single Sample Maximum Enterococcus Densities in Dana Point Harbor from All 12 Monitored Stations Combined



Notes: No data available for the 2012/2013 wet season
 mL = milliliter(s)
 WQO = water quality objective

3.2.2 6-week Geometric Mean and Statistical Threshold Value Analysis – Recent Results (2017/2018 Monitoring Year)

In Dana Point Harbor, 11 stations and 583 samples were analyzed during the 2017/2018 monitoring year, 229 samples during the wet season and 354 samples during the dry season. Average seasonal enterococcus values for the 6-week GM and STV showed no discernable difference between the wet and dry seasons (Figures 3-1 and 3-2). When results were averaged over the wet season, one of the 11 (9%) stations exceeded the current WQO threshold for the 6-week GM (West end of Baby Beach – BDP12; Figure 3-4a) and no stations (0%) exceeded the STV WQO. When results were averaged over the dry season, no stations exceeded the current WQO for the 6-week GM (Figure 3-4b), and only one of the 11 (9%) stations exceeded the STV WQO, with exactly 10 percent of sampling results exceeding the 110 cfu/100mL regulatory threshold (BDP12). However, none of the prior 303(d) listed sites showed exceedances when analyzed with the 6-week GM WQO and only one of the prior 303(d) listed sites exceeded the STV, again indicating improved current conditions. A summary of the 6-week GM and STV for all stations is provided in Appendix D.

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Figure 3-4a. Average 6-week Geometric Mean Densities of Enterococcus in the 2017/2018 Wet Season for Dana Point Harbor

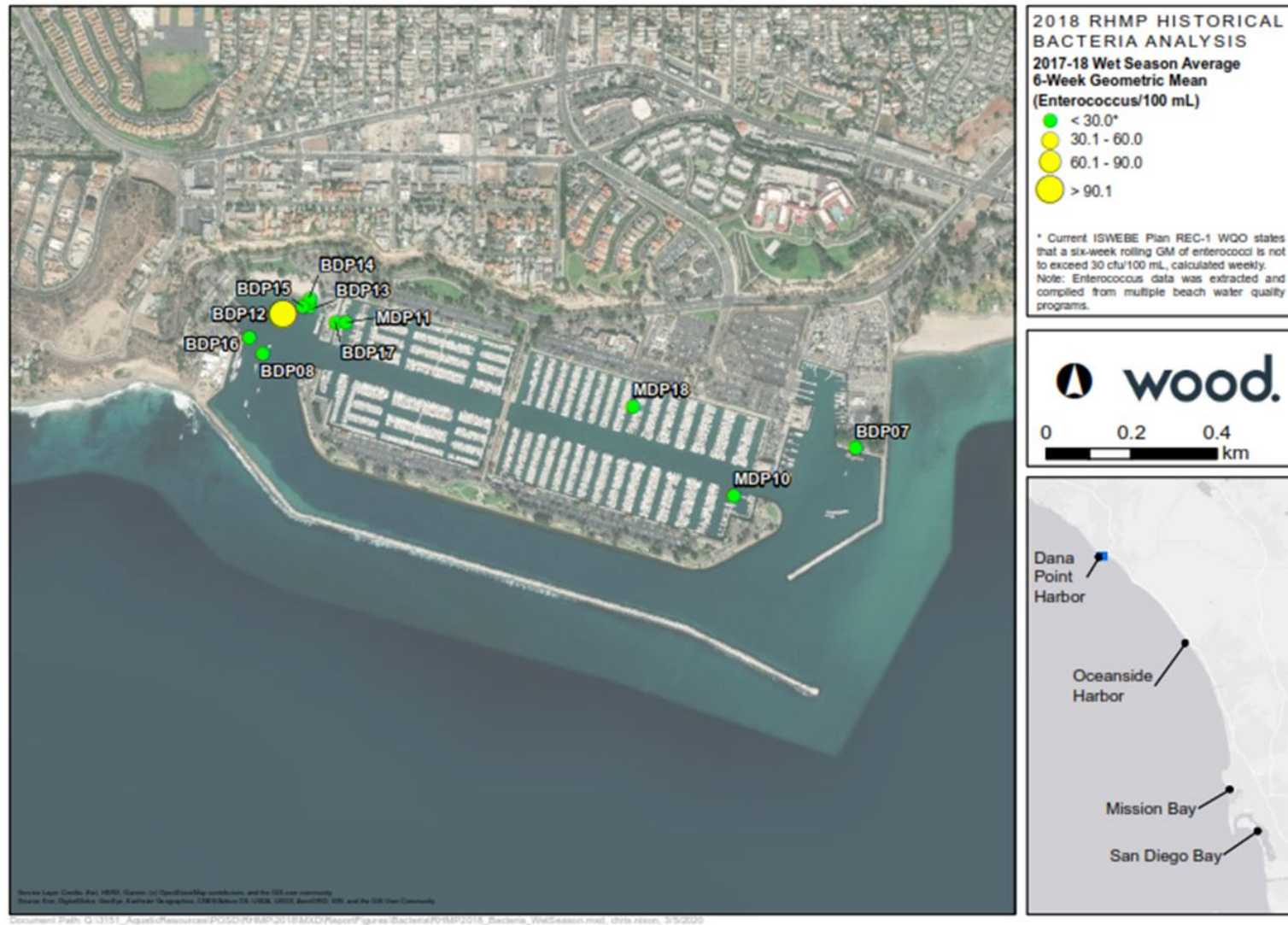
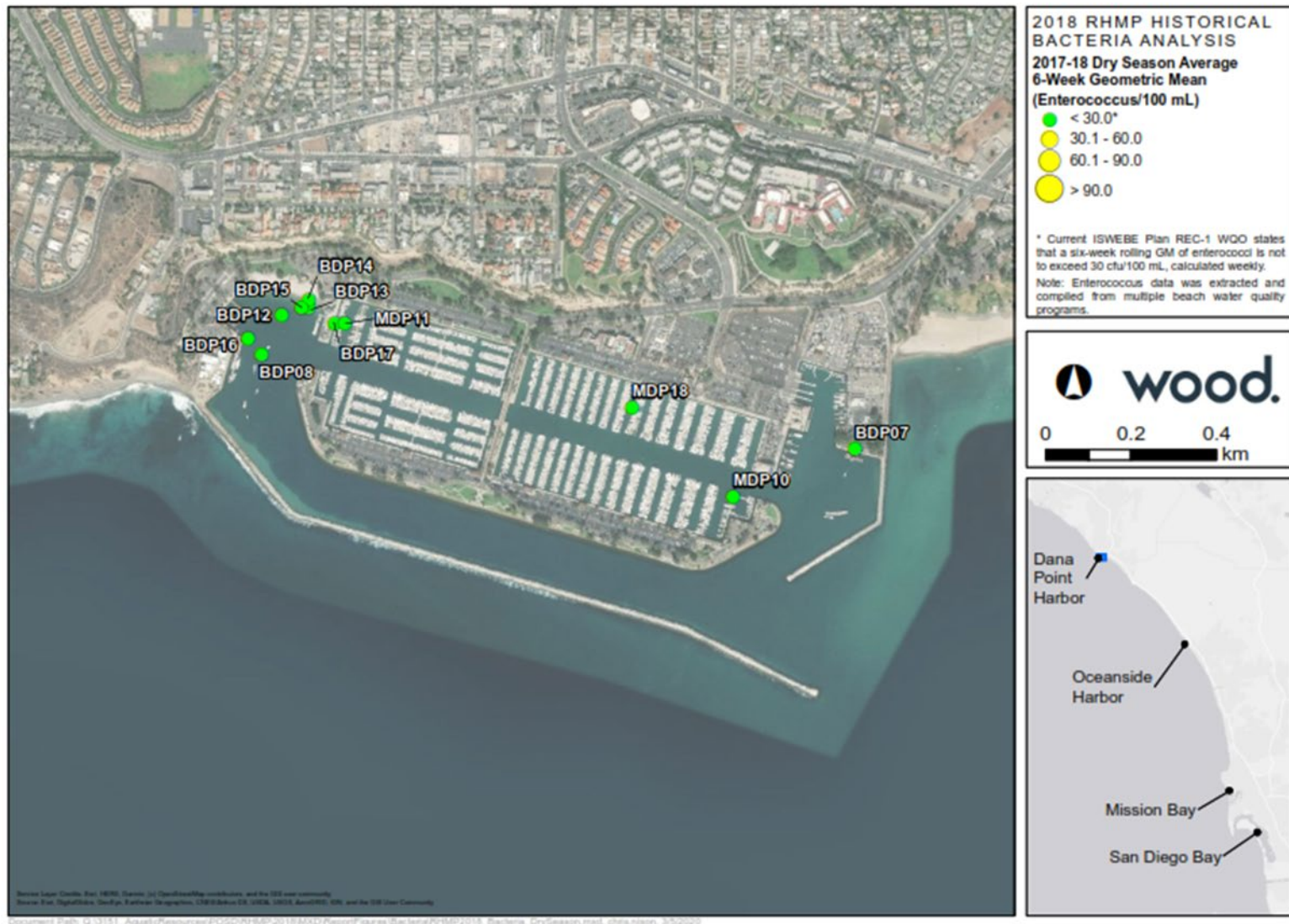


Figure 3-4b. Average 6-week Geometric Mean Densities of Enterococcus in the 2017/2018 Dry Season for Dana Point Harbor



3.3 Oceanside Harbor

3.3.1 30-day Geometric Mean and Single-Sample Maximum Analysis – Historical Evaluation (2008–2018)

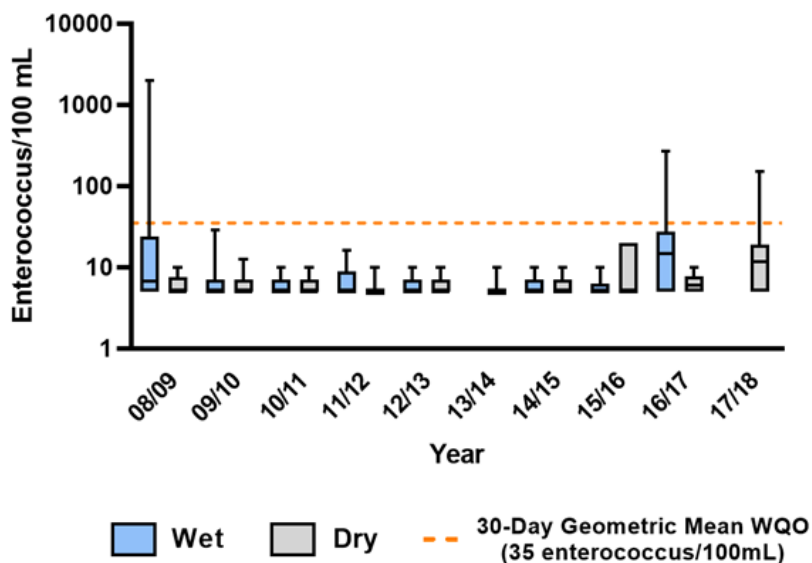
A total of 325 samples were compiled from four stations within Oceanside Harbor over the 10-year data compilation period. Data were compiled for both wet and dry seasons, with the exception of the 2013/2014 and 2017/2018 wet seasons, for which no samples were collected. A total of 196 samples were analyzed for the 10 dry seasons and 129 samples were analyzed for the 8 wet seasons for which data were available.

In general, both the 30-day GM and SSM were below WQOs, with 98 percent of samples below the 30-day GM WQO and 99 percent below the SSM WQO. Enterococcus densities were similar for both the wet season and dry season, with a few exceptions (Figures 3-5a and 3-5b). The 30-day GM was slightly higher during the 2008/2009 and 2016/2017 wet seasons and the 2015/2016 dry season. For the 10-year period, 4 percent of samples exceeded the 30-day GM WQO and 2 percent exceeded the SSM WQO during the wet season, and less than 2 percent of samples exceeded either GM or SSM WQO thresholds during the dry season. Densities of enterococcus were below detection limits in 79 percent of samples for all stations and all seasons.

On a station-by-station basis, one station (H-4) had only one data point. Of the remaining three stations for which multiple samples were collected, only one station (H-3, located in the northern section of the harbor) had more than one WQO exceedance of the 30-day GM or SSM WQOs. A full summary of 30-day GMs and SSMs by station is provided in Appendix C.

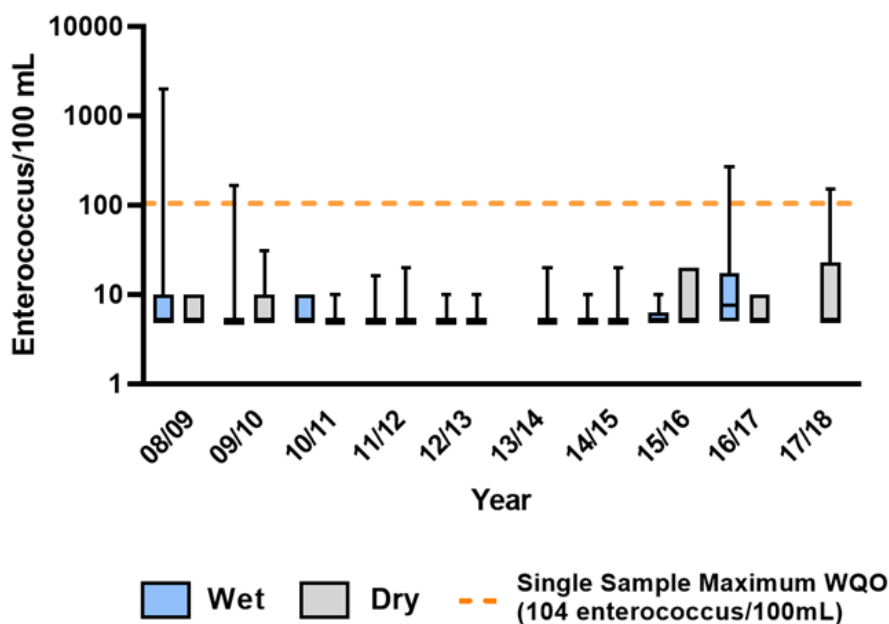
Enterococcus densities were generally low, and no obvious temporal trends were apparent for FIB densities in Oceanside Harbor among all stations combined over the past 10 years.

Figure 3-5a. 30-day Geometric Mean Enterococcus Densities in Oceanside Harbor Data from All 4 Monitored Stations Combined



Notes: No data available for the 2013/2014 and 2017/2018 wet seasons
 mL = milliliter(s)
 WQO = water quality objective

Figure 3-5b. Single-sample Maximum Enterococcus Densities in Oceanside Harbor Data from All 4 Monitored Stations Combined



No data available for 2013/14 and 2017/18 wet seasons

Notes: No data available for the 2013/2014 and 2017/2018 wet seasons
 mL = milliliter(s)
 WQO = water quality objective

3.3.2 6-week Geometric Mean and Statistical Threshold Value Analysis – Recent Results (2017/2018 Monitoring Year)

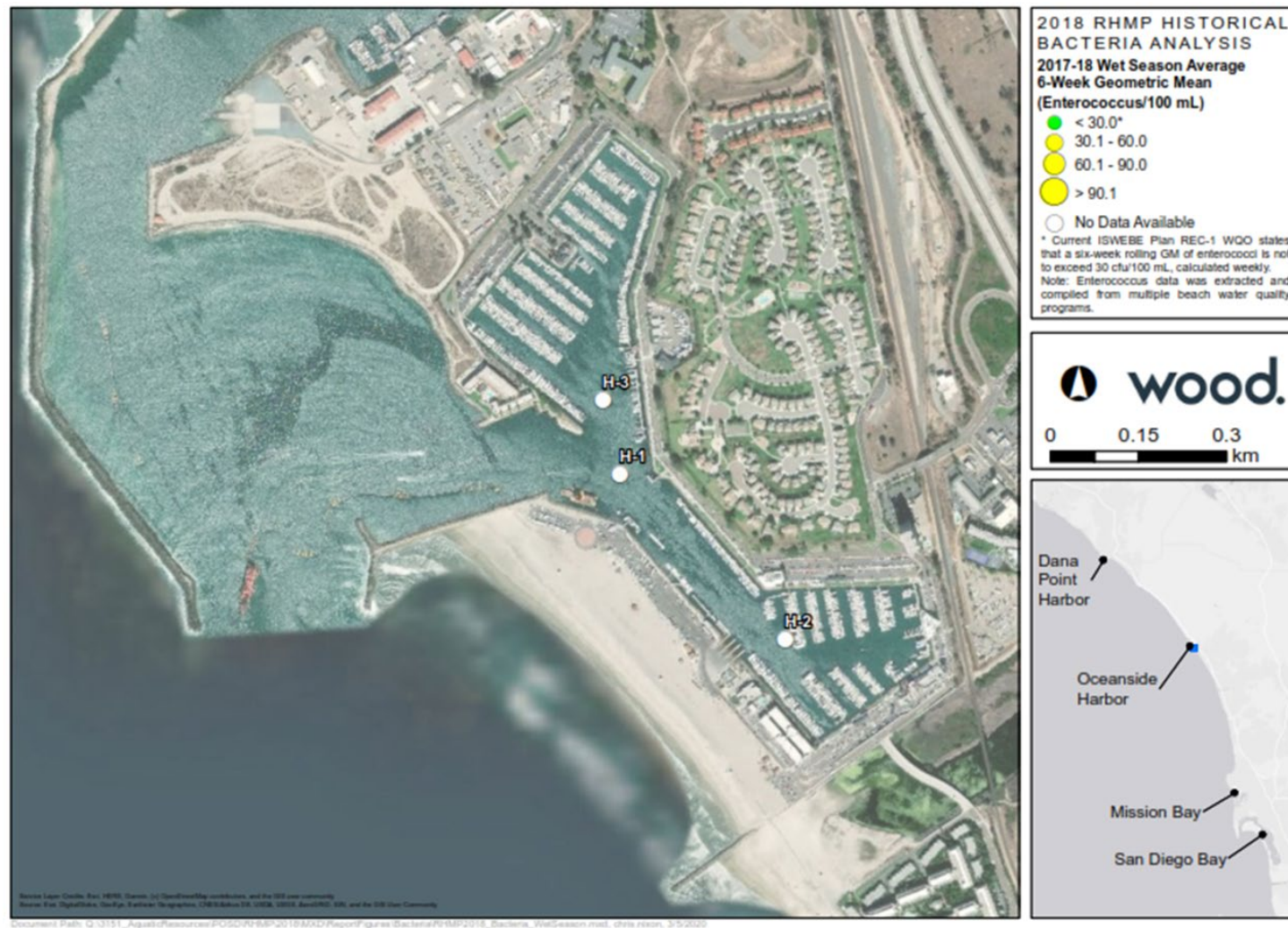
During the 2017/2018 monitoring year, Oceanside Harbor collected no wet season samples (Figure 3-6a) and limited dry season samples. During the dry season, four stations were sampled, with 10 samples collected. Three of the four stations had a sample size of two or fewer;³ the remaining station had only five samples.

The dry season seasonal average for the one station with five samples exceeded WQOs for both the 6-week GM and the STV (H3, Figure 3-6b). A summary of the 6-week GM and STV for all stations is provided in Appendix D.

³ Calculation of the 6-week GM and STV normally requires a minimum of 5 samples. For consistency and to include as much data as possible for the purposes of this report these calculations were performed regardless of sample size using all available data and should thus be interpreted with this caveat noted.

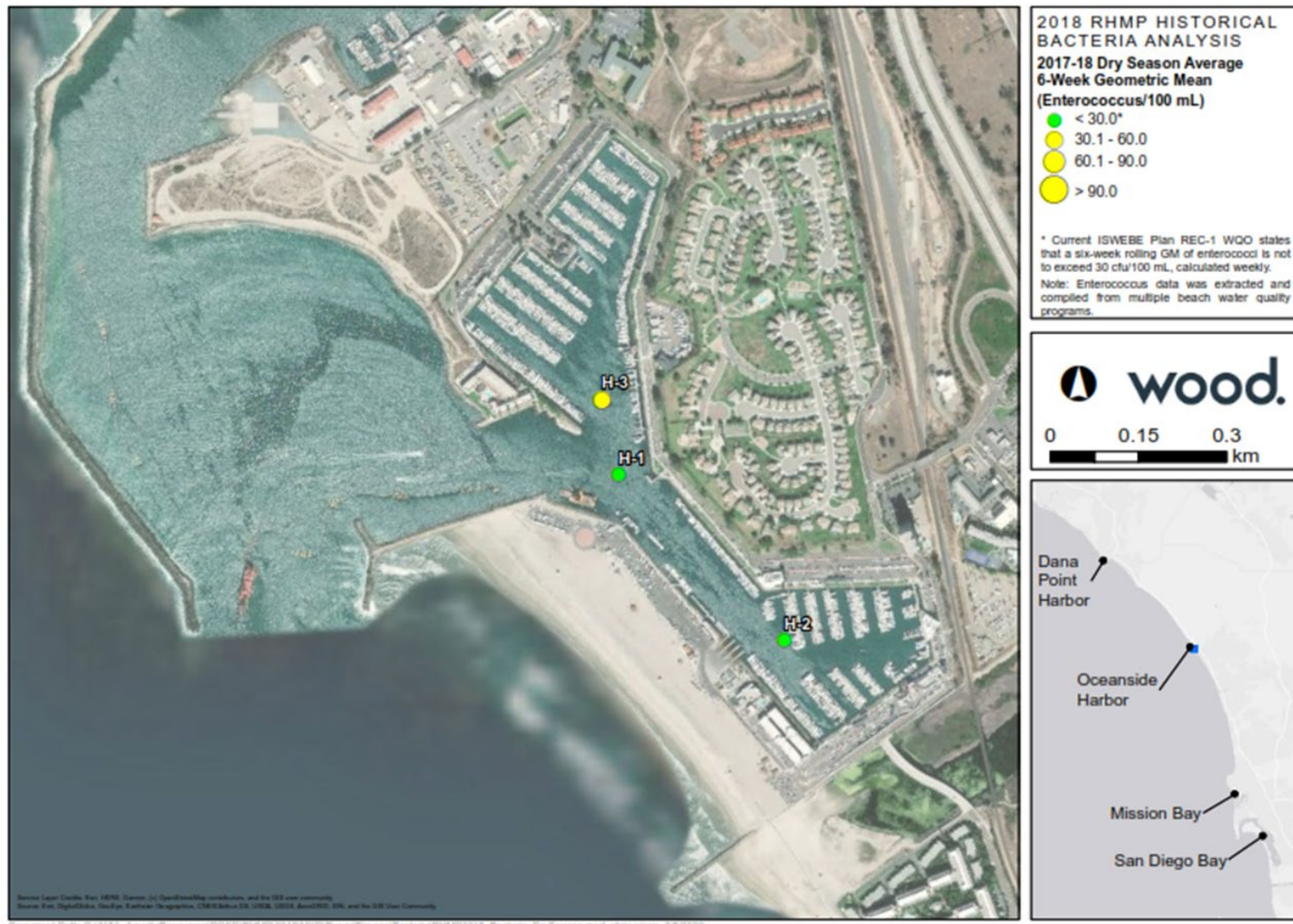
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Figure 3-6a. Average 6-week Geometric Mean Densities of Enterococcus in the 2017/2018 Wet Season for Oceanside Harbor



Note: Only 1 sample was collected at station H-4 and latitude and longitude were not recorded, thus station H-4 is not depicted

Figure 3-6b. Average 6-week Geometric Mean Densities of Enterococcus in the 2017/2018 Dry Season for Oceanside Harbor



Note: Only 1 sample was collected at station H-4 and latitude and longitude were not recorded, thus station H-4 is not depicted

3.4 Mission Bay

3.4.1 30-day Geometric Mean and Single Sample Maximum Analysis – Historical Evaluation (2008–2018)

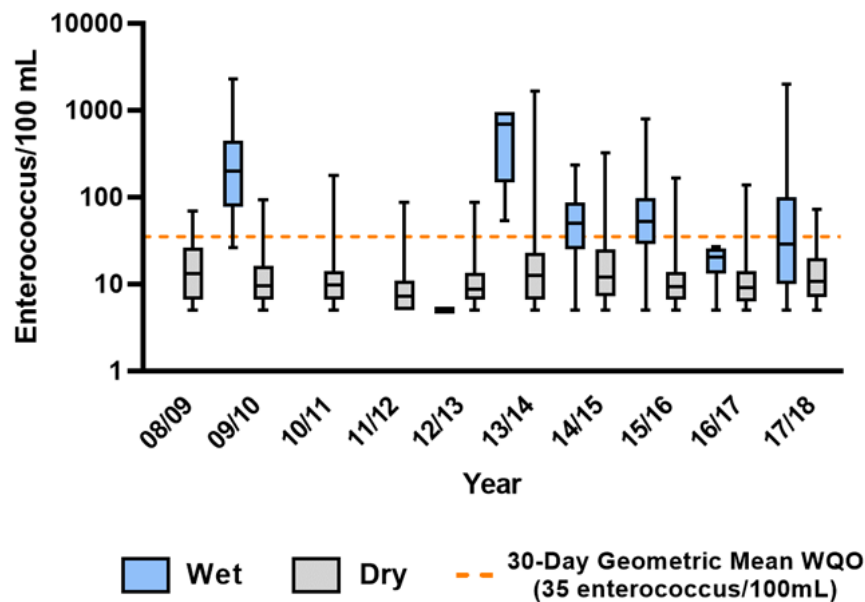
A total of 4,699 samples were compiled from 23 stations within Mission Bay over the 10-year data compilation period. Data were compiled for both wet and dry seasons, with the exception of the 2008/2009, 2010/2011, and 2011/2012 wet seasons, for which no samples were collected. A total of 4,344 samples were analyzed for the 10 dry seasons and 355 samples were analyzed for the 7 wet seasons for which data were available.

In general, 30-day GM and SSM densities were below WQOs during the dry season and were elevated during the wet season (Figures 3-7a and 3-7b). Among all stations for all seasons, 89 percent of the samples were below the 30-day GM WQO and 92 percent were below the SSM WQO. During the wet season, 63 percent of samples exceeded the 30-day GM WQO, and 27 percent exceeded the SSM WQO, with the 2009/2010 and 2013/2014 wet seasons experiencing noticeably elevated levels of enterococcus. During the dry season, 7 percent of samples exceeded the 30-day GM WQO and 6 percent exceeded the SSM WQO. Densities of enterococcus were below detection limits in 49 percent of samples for all stations and all seasons.

Seven of the 23 stations within Mission Bay were sampled for only a single year or season, with sample sizes ranging from 1 to 28 samples. Of the 16 stations that were sampled over multiple years, two stations in east Mission Bay near Cudahy Creek exceeded the 30-day GM WQO (Sites MB-058 and MB-060) and one of these stations also exceeded the SSM WQO (Site MB-058) more than 20 percent of the time during the dry season. Fourteen of the 16 stations that were sampled over multiple years exceeded the 30-day GM WQO and 9 stations exceeded the SSM WQO more than 20 percent of the time during the wet season. A full summary of 30-day GMs and SSMs by station is provided in Appendix C.

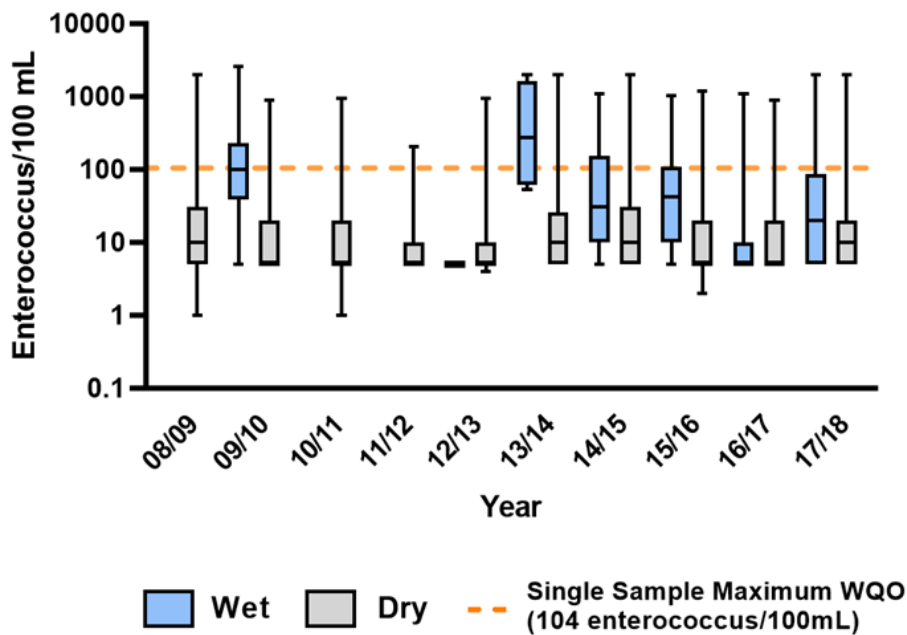
Based on a combined assessment of all stations, the 2013/2014 wet season had particularly elevated levels of enterococcus, but no other obvious temporal trends were apparent for enterococcus densities in Mission Bay over the past 10 years.

Figure 3-7a. 30-day Geometric Mean Enterococcus Densities in Mission Bay Data from All 23 Monitored Stations Combined



Notes: No data available for the 2008/2009, 2010/2011, and 2011/2012 wet seasons
 mL = milliliter(s)
 WQO = water quality objective

Figure 3-7b. Single-sample Maximum Enterococcus Densities in Mission Bay Data from All 23 Monitored Stations Combined



Notes: No data available for the 2008/2009, 2010/2011, and 2011/2012 wet seasons
 mL = milliliter(s)
 WQO = water quality objective

3.4.2 6-week Geometric Mean and Statistical Threshold Value Analysis – Recent Results (2017/2018 Monitoring Year)

In Mission Bay, 14 stations and 597 samples were analyzed for the 2017/2018 monitoring year, 79 samples for the wet season and 518 for the dry season. Average seasonal values were elevated during the wet season as compared with the dry season (Figures 3-1 and 3-2). Seasonal averages for the wet season exceeded the 6-week geometric mean WQO at 10 of the 14 (71%) stations (Figure 3-8a) and the STV WQO at 12 of the 14 (86%) stations. During the dry season, seasonal averages exceeded the 6-week GM WQO at no stations (0%) (Figure 3-8b) and exceeded the STV WQO at four of the 14 (29%) stations. Spatially, wet season enterococcus densities were greater in the eastern side of Mission Bay, which is less exposed to tidal mixing compared with the western side of Mission Bay. The more enclosed character of the eastern side of the bay and other known and documented sources of bacteria such as birds have been found to contribute to elevated levels of FIB observed in Mission Bay (City of San Diego 2004 and 2005). A summary of the 6-week GM and STV for all stations is provided in Appendix D.

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Figure 3-8a. Average 6-week Geometric Mean Densities of Enterococcus in the 2017/2018 Wet Season for Mission Bay

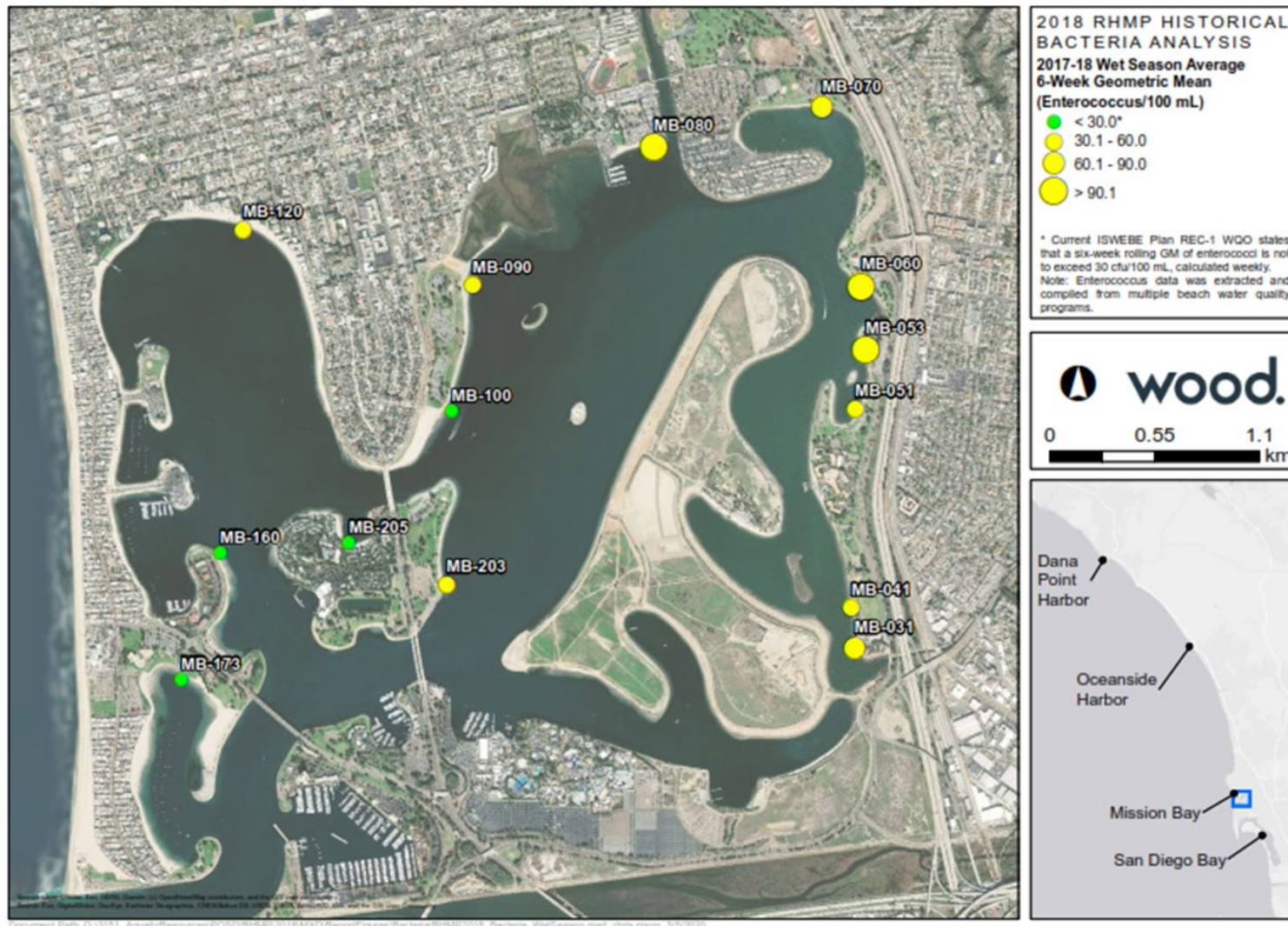
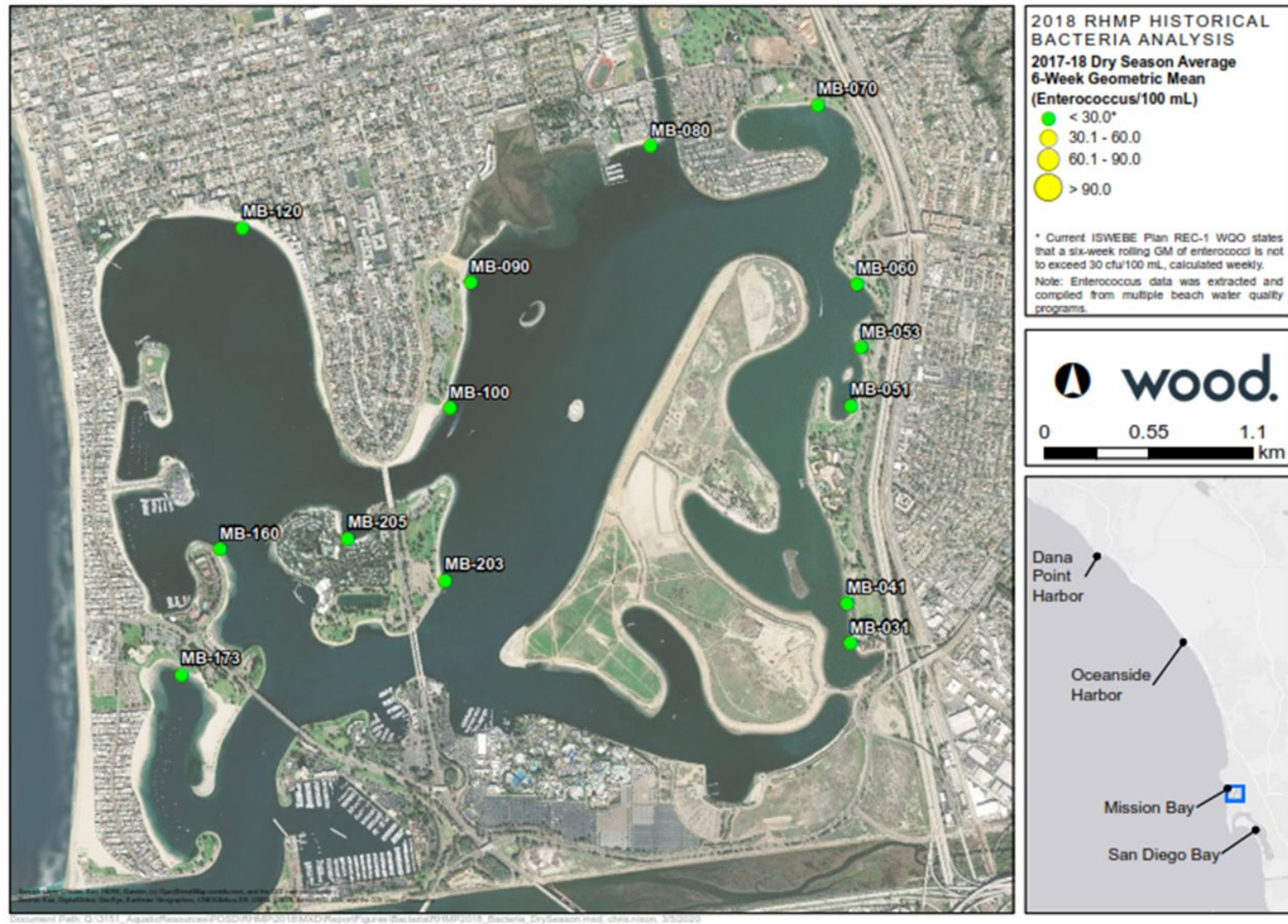


Figure 3-8b. Average 6-week Geometric Mean Densities of Enterococcus in the 2017/2018 Dry Season for Mission Bay



3.5 San Diego Bay

For the analysis of FIB, San Diego Bay was divided into north and south sections⁴ because of unique hydrodynamic and geographic conditions that affect flushing, temperature, and other physical and chemical characteristics of this large and diverse water body. North San Diego Bay included all stations north of the Coronado Bridge and South San Diego Bay included all stations south of the Coronado Bridge.

3.5.1 North San Diego Bay

3.5.1.1 30-day Geometric Mean and Single Sample Maximum Analysis – Historical Evaluation (2008–2018)

A total of 1,391 samples were compiled from 5 stations within North San Diego Bay over the 10-year data analysis period. Data were compiled for both wet and dry seasons, with the exception of the 2008/2009 through 2013/2014 wet seasons, for which no samples were collected. A total of 1,259 samples were analyzed for the 10 dry seasons and 132 samples were analyzed for the 4 wet seasons for which data were available.

In general, both SSM and 30-day GM enterococcus densities were below WQOs during the dry season, and enterococcus densities were elevated during the wet season (Figures 3-9a and 3-9b) in North San Diego Bay. For all stations and all seasons, 87 percent of samples were below the 30-day GM WQO, 91 percent were below the SSM WQO, and 49 percent were below detection limits. During the wet season, 50 percent of samples exceeded the 30-day GM WQO and 23 percent exceeded the SSM WQO. During the dry season, 9 percent of samples exceeded the 30-day GM WQO and 7 percent exceeded the SSM WQO.

One of the five stations in North San Diego Bay (EH-205, near Bessemer Beach) was sampled during only a portion of a single year (April – July of 2009) with a sample size of 3. Of the four stations sampled for multiple years, two stations showed a greater relative WQO exceedance frequency, Tidelands Park (EH-070) and Shelter Island Shoreline Park (EH-200)⁵. At these stations, 14 and 27 percent of samples exceeded the 30-day GM WQO and 10 and 17 percent of samples exceeded the SSM WQO, respectively. At the other two stations sampled over multiple years, samples exceeded WQOs 3 percent or less over the 10-year data compilation period. All stations had elevated enterococcus densities during the wet seasons.

The two stations that showed greater exceedance rates, Shelter Island Shoreline Park and Tidelands Park, are currently on the 303(d) list for indicator bacteria for the REC-1 beneficial use. A TMDL went into effect in 2009 for Shelter Island Shoreline Park (SDRWQCB 2008) and is still in effect. Tidelands Park is identified as a Focused Priority Condition for Swimmable Waters under

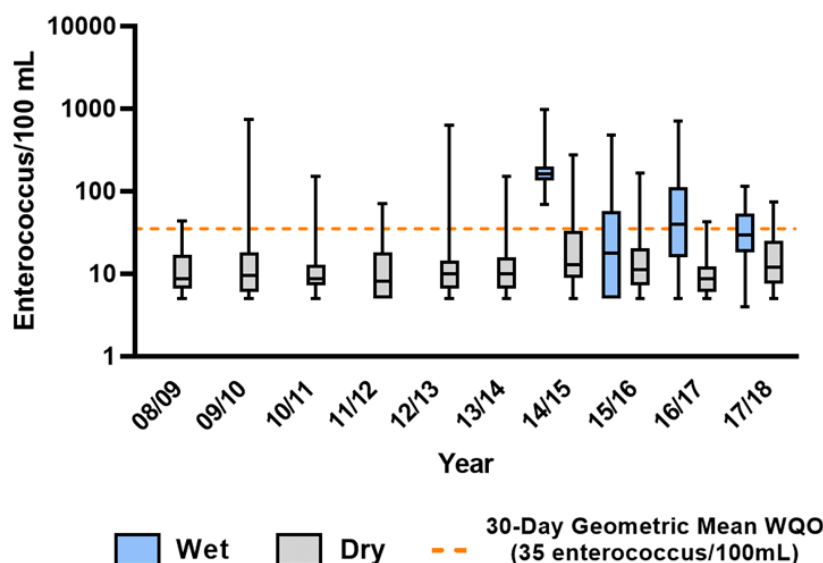
⁴ In the RHMP core monitoring report, San Diego Bay was divided into three sections (north, central, and south). However, due to the limited number of stations sampled for bacteria in Central San Diego Bay (one station in Glorietta Bay, EH-080), stations south of the Coronado Bridge were categorized as “South San Diego Bay” for the purposes of this historical bacteria analysis.

⁵ Note that sample sizes for Tidelands Park (EH-070) and Shelter Island Shoreline Park (EH-200) are greater than those for other sites in North San Diego Bay due to more robust monitoring programs, which may skew results.

the San Diego Bay Watershed Management Area (WMA) Water Quality Improvement Plan (WQIP). The San Diego Bay WMA WQIP FY 2019 Annual Report (San Diego Bay Responsible Parties [SDBRPs] 2020) provides more information on historical trends, current status, and extent and magnitude of FIB within these sites and throughout San Diego Bay.

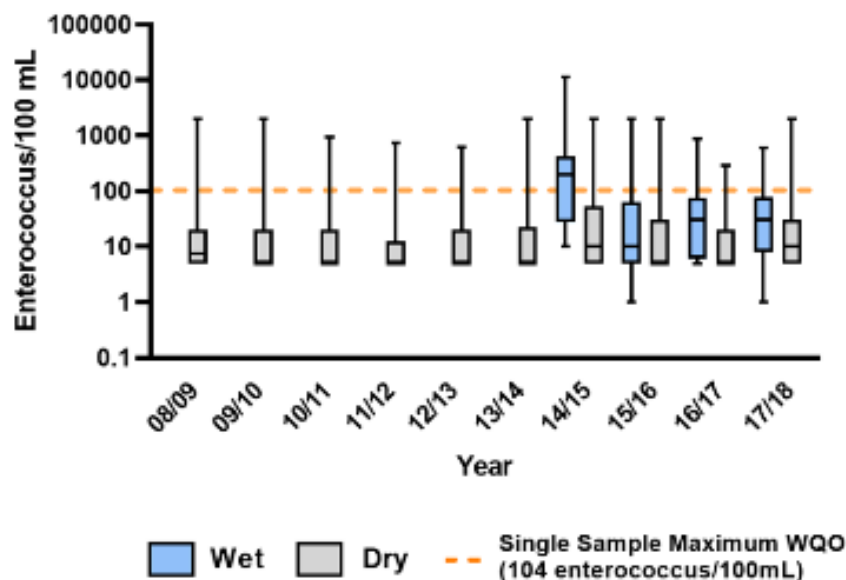
Based on a combined assessment of all stations in North San Diego Bay, no obvious temporal trends were apparent in enterococcus densities. However, evaluating sites on an individual basis may better assist in identifying trends at individual sites. A full summary of 30-day GMs and SSMs by station is provided in Appendix C.

**Figure 3-9a. 30-day Geometric Mean Enterococcus Densities in North San Diego Bay
 Data from All 5 Monitored Stations Combined**



No data available for the 2008/2009 through 2013/2014 wet seasons
 mL = milliliter(s)
 WQO = water quality objective

Figure 3-9b. Single-Sample Maximum Enterococcus Densities in North San Diego Bay from All 5 Monitored Stations Combined



No data available for the 2008/2009 through 2013/2014 wet seasons
 mL = milliliter(s)
 WQO = water quality objective

3.5.1.2 6-week Geometric Mean and Statistical Threshold Value Analysis – Recent Results (2017/2018 Monitoring Year)

In North San Diego Bay, 4 stations and 239 samples were analyzed for the 2017/2018 monitoring year, 72 samples during the wet season and 167 samples during the dry season. Average seasonal enterococcus densities were generally higher during the wet season than the dry season (Figures 3-1 and 3-2). During the wet season, the seasonal average for two of the four (50%) stations exceeded the 6-week GM WQO (EH-200 at Shelter Island Shoreline Park and EH-211 near Lawrence Street outlet; Figure 3-10a) and all four (100%) stations exceeded the STV WQO. During the dry season, no stations (0%) exceeded the 6-week GM WQO (Figure 3-10b) and two of the four (50%) stations exceeded the STV WQO (Tidelands Park [EH-070] and Shelter Island Shoreline Park [EH-200]), with the remaining two stations (Spanish Landing [EH-160] and Lawrence Street outlet [EH-211]) at a zero percent exceedance rate for the STV WQO. As previously mentioned, a TMDL went into effect in 2009 for Shelter Island Shoreline Park (SDRWQCB 2008 and is still in effect. Tidelands Park is identified as a Highest Priority Condition for Swimmable Waters under the San Diego Bay WMA WQIP. As a result, long-term monitoring programs are established at both locations. A summary of the 6-week GM and STV for all stations is provided in Appendix D.

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2018 RHMP HISTORICAL BACTERIA ANALYSIS
2017-18 Wet Season Average
6-Week Geometric Mean
(Enterococcus/100 mL)

- < 30.0*
- 30.1 - 60.0
- 60.1 - 90.0
- > 90.1

* Current ISWEBE Plan REC-1 WQO states that a six-week rolling GM of enterococci is not to exceed 30 cfu/100 mL, calculated weekly.

Note: Enterococcus data was extracted and compiled from multiple beach water quality programs.

wood.

0 0.8 1.6 km

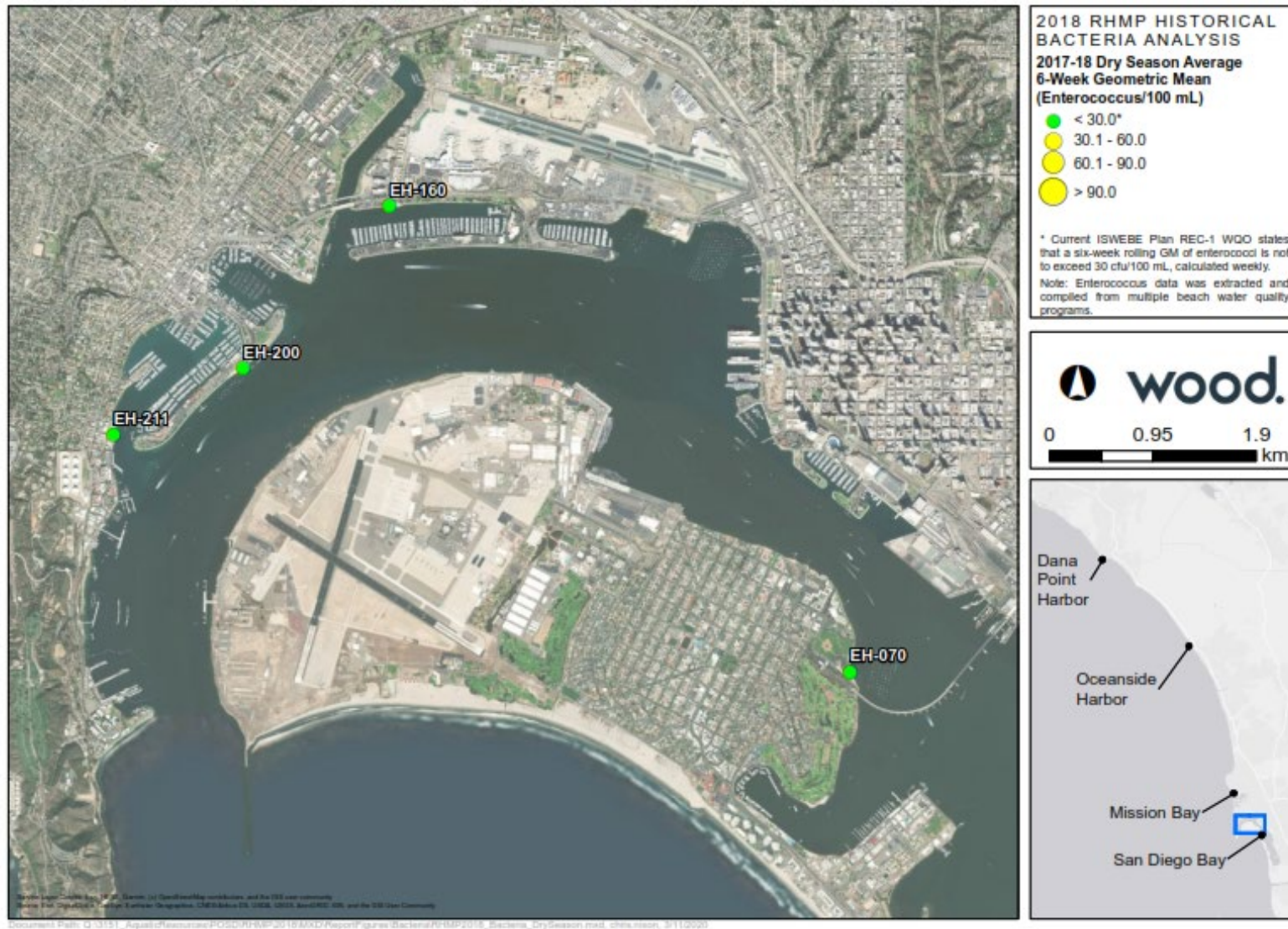
Dana Point Harbor

Oceanside Harbor

Mission Bay

San Diego Bay

Figure 3-10b. Average 6-week Geometric Mean Densities of Enterococcus in the 2017/2018 Dry Season for North San Diego Bay



3.5.2 South San Diego Bay

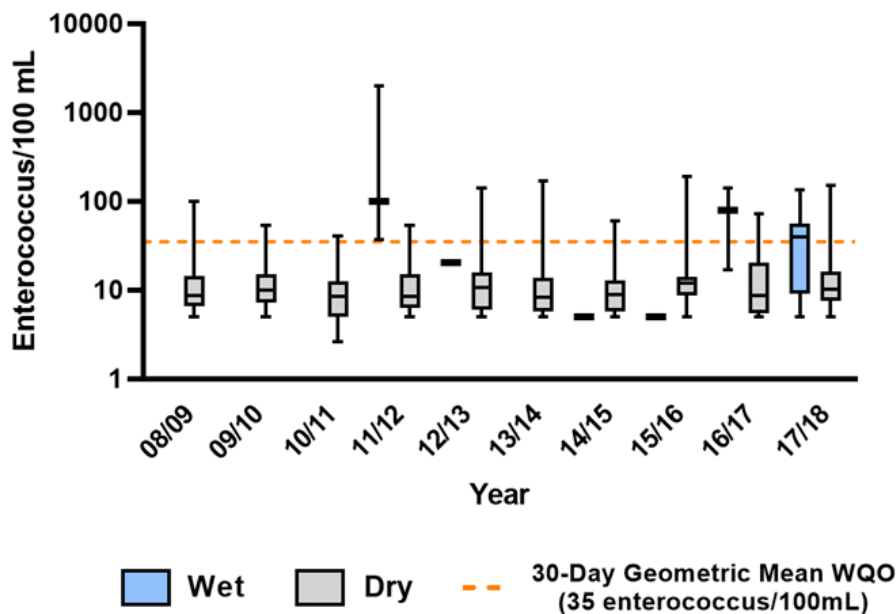
3.5.2.1 30-day Geometric Mean and Single Sample Maximum Analysis – Historical Evaluation (2008–2018)

A total of 683 samples were analyzed from three stations within South San Diego Bay over the 10-year data compilation period. Data were compiled for both wet and dry seasons, with the exception of the 2008/2009, 2009/2010, 2010/2011, and 2013/2014 wet seasons, for which no samples were collected. A total of 659 samples were analyzed for the 10 dry seasons and 24 samples were analyzed for the 6 wet seasons for which data were available. For all stations and all seasons, 92 percent of samples were below the 30-day GM WQO, 93 percent were below the SSM WQO, and 56 percent were below detection limits. In general, both 30-day GM and SSM enterococcus densities were below WQOs (Figures 3-11a and 3-11b). Enterococcus densities were generally elevated during the wet season where 50 percent of samples exceeded the 30-day GM WQO and 25 percent exceeded the SSM WQO. During the dry season, 6 percent of samples exceeded the 30-day GM WQO and 6 percent exceeded the SSM WQO.

At one of the three stations, EH-090 (bayside of the Silver Strand), samples exceeded the 30-day GM WQO 44 percent of the time and the SSM WQO 22 percent of the time during the wet season; no exceedances were observed at this station during the dry season. However, station EH-090 also had a lower sample size, with only 13 samples collected over five years. The other two sites, EH-080 (Glorietta Bay) and EH-120 (Bayside Park at J Street), had greater sample sizes (351 and 319 samples over 10 years, respectively) and lower overall exceedance rates, with 2 and 13 percent of samples, respectively, exceeding the 30-day GM WQO, and 4 and 9 percent of samples, respectively, exceeding the SSM WQO over the 10-year period. Both stations had low exceedance rates during the dry season, with 1 and 12 percent of samples, respectively, exceeding the 30-day GM WQO, and 4 and 9 percent of samples, respectively, exceeding the SSM WQO. Exceedance rates were generally greater during the wet season for EH-080 and EH-120, with 33 and 83 percent of samples, respectively, exceeding the 30-day GM WQO and 22 and 33 percent, respectively, exceeding the SSM WQO during the wet season. A full summary of 30-day GMs and SSMs by station is provided in Appendix C.

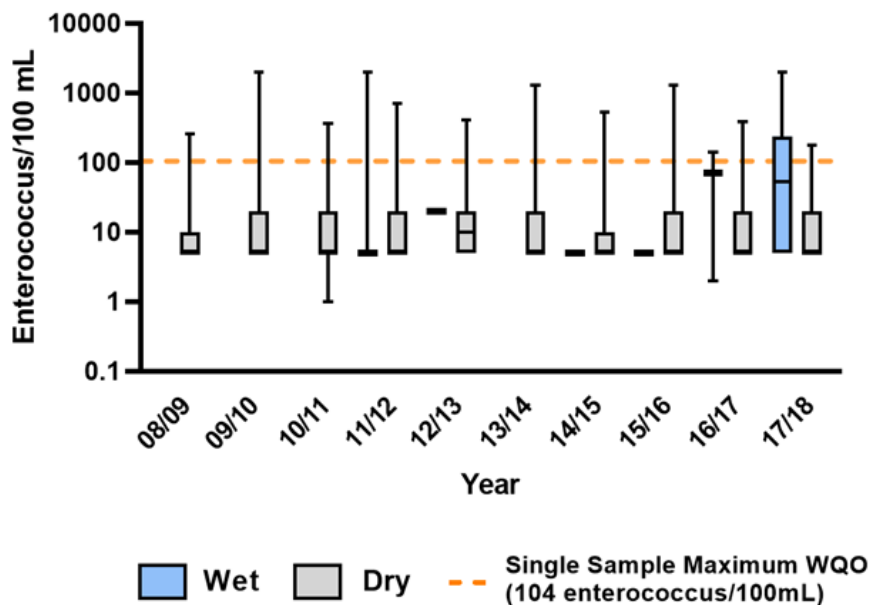
Based on a combined assessment of all stations in South San Diego Bay, no obvious temporal trends were apparent for enterococcus densities over the past 10 years.

Figure 3-11a. 30-day Geometric Mean Enterococcus Densities in South San Diego Bay from All 3 Monitoring Stations Combined



No data available for the 2008/2009 through 2010/2011 and 2013/2014 wet seasons
 mL = milliliter(s)
 WQO = water quality objective

Figure 3-11b. Single-sample Maximum Enterococcus Densities in South San Diego Bay from All 3 Monitoring Stations Combined



No data available for the 2008/2009 through 2010/2011 and 2013/2014 wet seasons
 mL = milliliter(s)
 WQO = water quality objective

3.5.2.2 6-week Geometric Mean and Statistical Threshold Value Analysis – Recent Results (2017/2018 Monitoring Year)

In South San Diego Bay, three stations and 89 samples were analyzed for the 2017/2018 monitoring year, 15 samples for the wet season and 74 samples for the dry season. However, for both wet and dry seasons, one station (EH-090, located on the bayside of the Silver Strand) had only one sample collected for the wet season and no samples collected for the dry season during the 2017/2018 monitoring year. Average values for the wet season were greater than those for the dry season for both 6-week GM and STV. During the wet season, for both stations with more than one sample, analytical results exceeded both the 6-week GM (Figure 3-12a) and STV WQOs. During the dry season, no stations exceeded the 6-week GM (Figure 3-12b) or STV WQOs. A summary of the 6-week GM and STV for all stations is in Appendix D.

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Figure 3-12a. Average 6-week Geometric Mean Densities of Enterococcus in the 2017/2018 Wet Season for South San Diego Bay

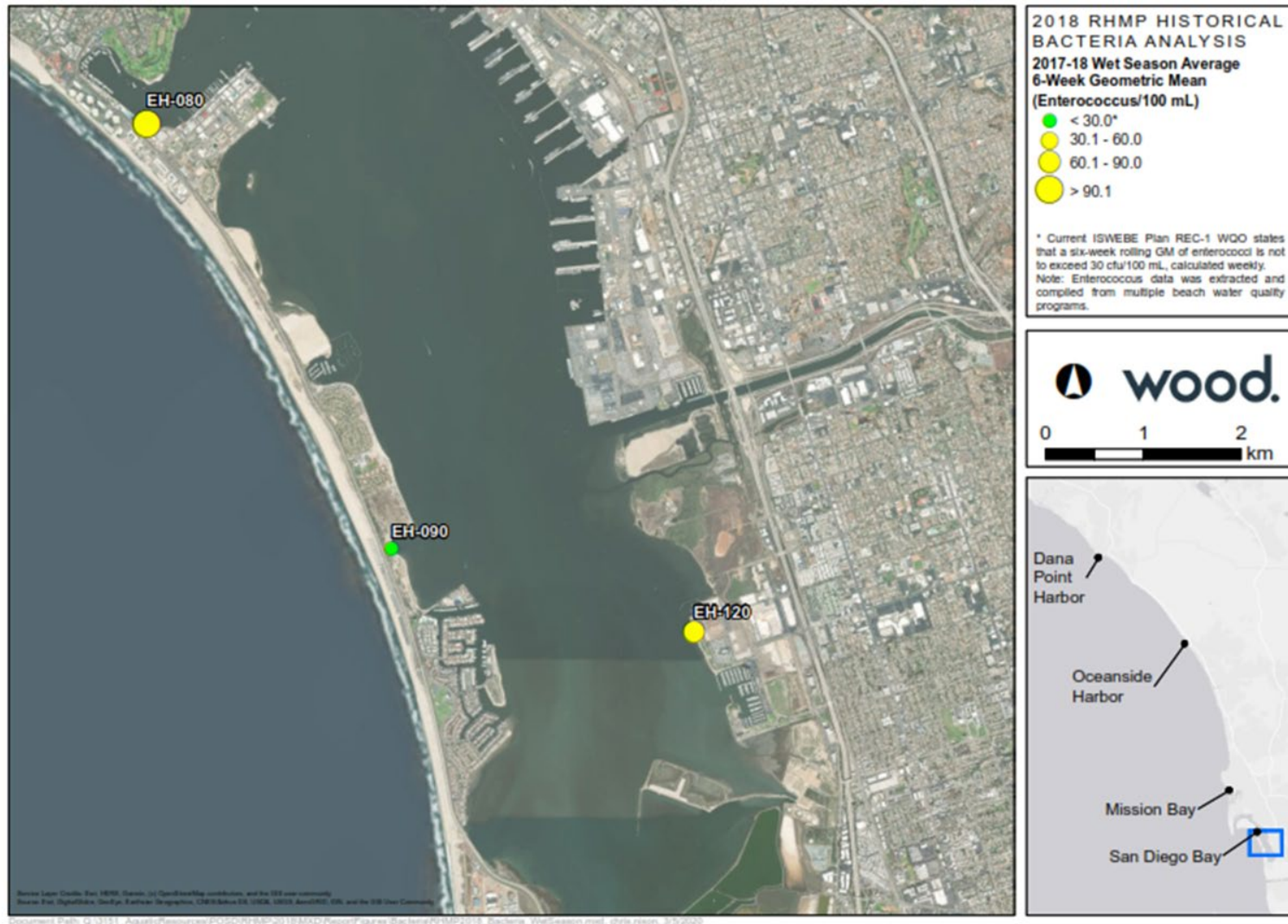
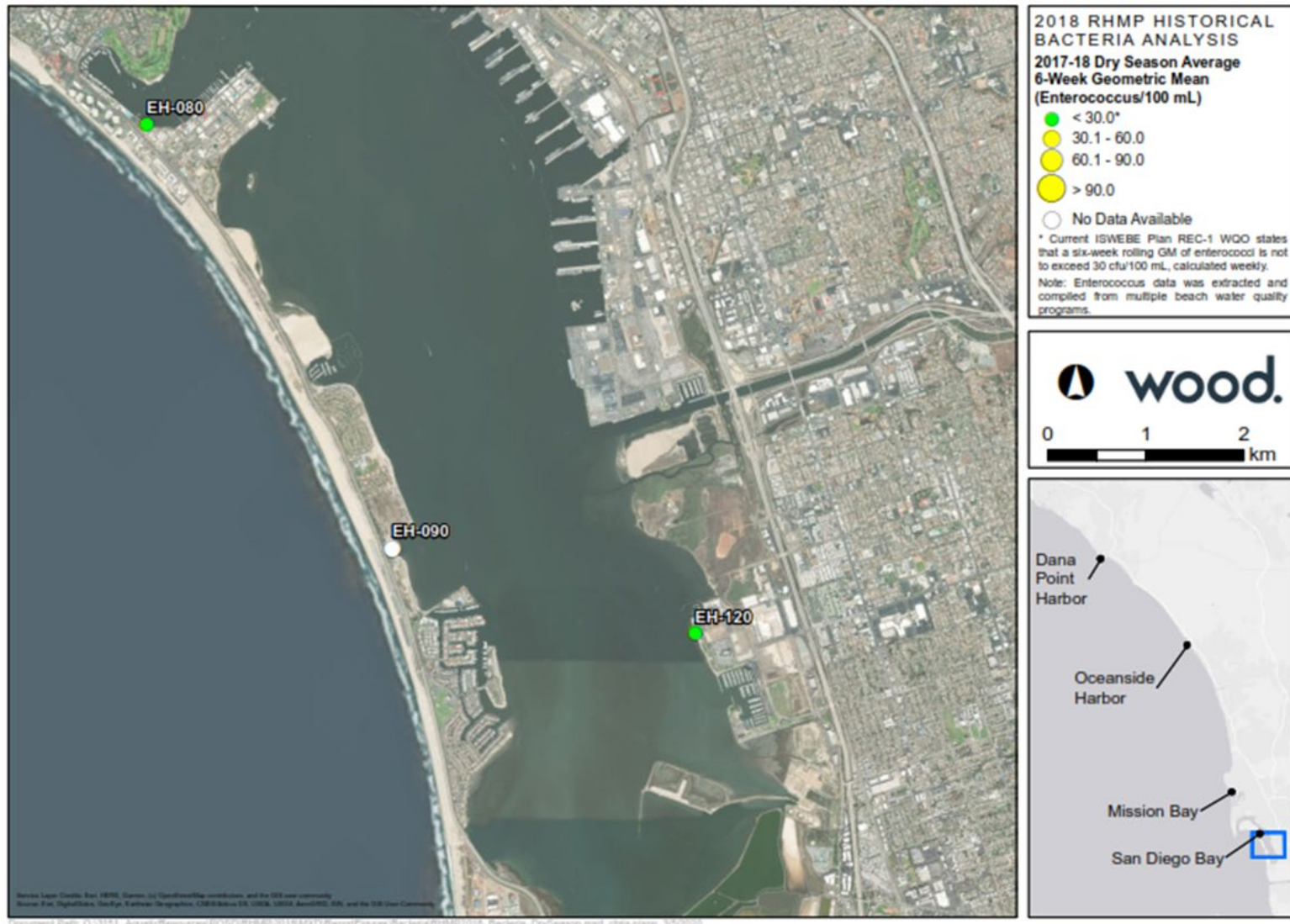


Figure 3-12b. Average 6-week Geometric Mean Densities of Enterococcus in the 2017/2018 Dry Season for South San Diego Bay



4.0 DISCUSSION

4.1 Extent, Magnitude, Historical Trends, and Current Condition

The aim of this historical indicator bacteria analysis was to address the core monitoring question: Are the waters in the harbors safe for body contact activities? To do so, this report evaluated the extent, magnitude, historical trends, and current condition of enterococcus densities throughout the San Diego Regional Harbors. Supplemental data analysis of fecal coliform and total coliform is provided in Appendix A.

The GM provides a measure of long-term trends in FIB by demonstrating the central tendency of a robust dataset over a longer time period (30 days or 6 weeks). The SSM and STV indicate acute spikes of FIB at a specific time, providing information about specific instances in which the water may be unsuitable for water contact recreation. Calculating both the GM and SSM/STV provides a more robust representation of both chronic exceedance levels and acute exceedances of FIB and the suitability for water contact recreation of specific water bodies over both long-term and short-term instances.

The results indicate the extent and magnitude of enterococcus throughout the San Diego Regional Harbors can be highly variable, with no clear trend in exceedance patterns. Although the range in enterococcus densities was wide at some locations driven by occasional exceedances, densities were generally below WQOs. The wide range of data is not unexpected given the ability of bacteria to grow exponentially when present at source locations under favorable conditions. Densities of enterococcus in all harbors were generally greatest during wet season sampling, likely due to terrestrial runoff and associated bacterial sources entering the receiving waters during rain events.

During the dry season, when all stations were analyzed collectively, less than 10 percent of the samples from 2008 through 2018 exceeded the historical 30-day GM or SSM WQOs, indicating that waters generally meet the standards for water contact recreation during the dry season. During the wet season, exceedances of the historical WQOs were also less than 10 percent over the same 10-year period for collective sampling results from Dana Point Harbor and Oceanside Harbor. However, wet season exceedances for historical WQOs in Mission Bay and San Diego Bay were greater, ranging from 23 to 63 percent of total samples over the same 10-year period. For the 6-week GM analysis for the 2017/2018 monitoring year, 27% and 6% of samples exceeded the 6-week GM in the wet and dry seasons and 7 percent of samples exceeded the 110cfu/mL threshold for the STV WQO.

These findings indicate that both historical and current potential impacts on human health from water contact recreation are limited overall, but risk appears greater during the wet season as compared with the dry season. To mitigate risk of illness from water contact recreation, standard recommendation guidelines should be followed with water contact avoided during wet weather events, and for the 72 hours following a wet weather event. In addition, the public should check San Diego and Orange Counties' Departments of Environmental Health respective water quality websites for current enterococcus levels and advisories.

Based on a combined assessment of all stations, across all harbors, and within the individual harbors, no obvious long-term temporal trends were apparent for enterococcus densities over the

10-year period evaluated. However, when evaluated on a site-by-site basis, data for locations that have been 303(d) listed for FIB and subsequently addressed via TMDLs and WQIP Priority Conditions (e.g., Baby Beach in Dana Point Harbor; Shelter Island Shoreline Park and Tidelands Park in north San Diego Bay) show decreases in enterococcus densities over time. Baby Beach was delisted for enterococcus from the 303(d) list during the 2014/2016 cycle based on the reduced FIB exceedances. Trends in FIB concentrations at Baby Beach are discussed further in the South Orange County WMA WQIP Annual Report (South Orange County WMA Permittees 2020). Trends in FIB concentrations at SISP and Tidelands Park are discussed further in the San Diego Bay WMA WQIP Annual Report (SDBRPs 2020).

To appropriately identify sources of the bacterial indicators described in this report, more specific molecular analyses are necessary. In 2005, an analysis of bacteria in Mission Bay using two microbial source tracking techniques was employed: ribotyping and polymerase chain reaction (PCR) techniques (City of San Diego, 2004 and 2005). The PCR technique takes advantage of host-specific genetic differences in an anaerobic bacterium, *Bacteroides*, a major bacterial resident present in feces of warm-blooded animals (Bernhard and Field 2000). The PCR assay provides a rapid first step in tracking bacterial host origin and allows for determination of the presence or absence of human fecal contamination.

The results of this analysis indicated that birds were the dominant source of the indicator bacteria during this study. Avian sources accounted for 67 percent of all the bacterial isolates collected, followed by unknown sources and canine. The percentage of bacterial isolates that originated from human sources was very small, accounting for less than 10 percent of the measured FIB. More recent microbial source tracking studies performed at both Baby Beach in Dana Point Harbor and Shelter Island Shoreline Park in San Diego Bay produced similar results, with birds identified as the dominant source of indicator bacteria at both locations (County of Orange & City of Dana Point 2019; Weston 2015).

4.2 Data Quality and Availability

Wet season data were not available for all stations and all years. Some stations had data for only specific years, which is likely because of special studies conducted for a single year or a change in regulatory status that either activated or deactivated sample collection. In addition, entire harbors were missing data for some wet seasons, possibly because of regulatory mandates such as AB411, which requires sampling only during the dry season by the DEH. In addition, drought conditions throughout the state of California from 2014 through 2016 may have prohibited wet season sampling during those years because of the lack of rain. Elevated levels of enterococcus during the 2016/2017 season may have resulted from El Niño conditions producing greater rainfall and associated runoff to receiving waters than normal. A wide variety of other natural sources have also been documented to contribute to elevated bacteria counts such as beach wrack (Imamura, 2011) and birds (City of San Diego 2004 and 2005; Weston 2015).

To compare the previous 30-day GM calculation with the recently adopted 6-week GM for enterococcus, the 2017/2018 data were analyzed for both the 30-day and 6-week GM and no discernable difference was found. This indicates both calculations provide a comparable chronic representation of water quality, and both calculations are suitable for historical comparisons.

In addition, the data analysis assumptions used in this report facilitated a better understanding of extent, magnitude, and trends, but not all data used was collected or analyzed under AB411 and ISWEBE data requirements for regulatory compliance. In particular, depending on the station, program requirements of the data collected, and dates, it was not possible in many cases to calculate the GM using the minimum number of samples required. Even so, given the large amount of data available with which to conduct assessments for this evaluation, this deviation is not expected to have a considerable impact on the high-level conclusions.

5.0 CONCLUSION

This historical analysis of bacteria aimed to address the RHMP core monitoring question: Are the waters in the harbors safe for body contact activities? This question was addressed by compiling historical datasets from several long-term bacteria monitoring programs already in place and evaluating concentrations and trends in FIB monitored at numerous locations within the San Diego Regional Harbors over a 10-year period extending from 2008 through 2018. Data were compiled for enterococcus, fecal coliform, and total coliform, but post hoc analysis focused on enterococcus as the primary indicator to reflect the latest WQOs provided in the 2018 adoption of the ISWEBE Plan (SWRCB 2019) and amendment to the Ocean Plan (SWRCB 2018), which identify enterococcus as the most appropriate FIB for the enclosed bays that characterize the San Diego Regional Harbors. Enterococcus densities in each San Diego Regional Harbor were compared to WQOs for the REC-1 beneficial use to evaluate whether waters are safe for human body contact.

Results of this historical analysis indicated that ranges in enterococcus densities throughout the San Diego Regional Harbors are highly variable depending on the sampling date and station location. However, enterococcus densities were generally below WQOs, with most exceedances occurring during wet season sampling. These results indicate that potential impacts on human health from contact exposure are limited overall, particularly during the dry season, and general recommendations from DEH to avoid water contact during or immediately following wet weather events near storm drain or watershed inputs should be followed.

Based on a combined assessment of all stations both across all harbors and within the individual harbors, no obvious temporal trends were apparent for FIB concentrations over the 10-year period evaluated. However, when evaluating data for individual sites on the Clean Water Act Section 303(d) list of water quality impaired segments and addressed via TMDLs and WQIP Priority Conditions, decreases in FIB are apparent for several locations, including Baby Beach in Dana Point Harbor, as well as Shelter Island Shoreline Park and Tidelands Park in north San Diego Bay.

RECOMMENDATIONS

- To eliminate potential sources of bacteria at a site of interest, a holistic approach including assessment of potential sources of FIB along with the use of molecular methods that can more specifically identify the actual source, is important to consider when evaluating and making conclusions about water quality for locations that have WQOs exceedances using standard analysis of FIB.
- RHMP sampling for bacteria occurs once every 5 years during dry weather, offering a brief snapshot in time for bacteria monitoring at sampling locations that are removed from popular swimming beaches. Monitoring programs set up for the long term monitoring of bacteria in high use area are better suited to evaluate if waters are meeting the Rec 1 beneficial use.

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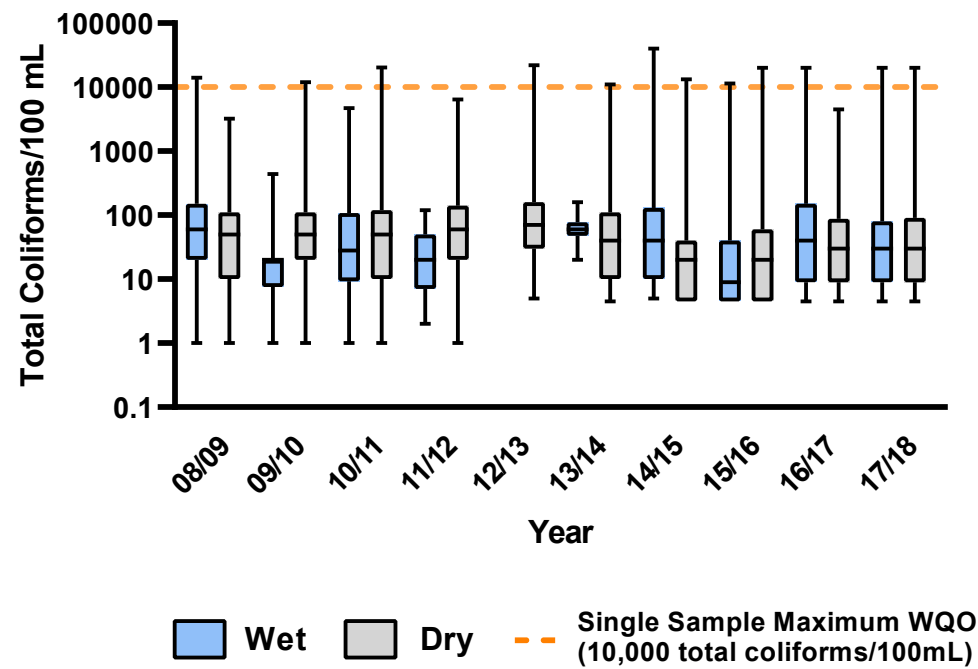
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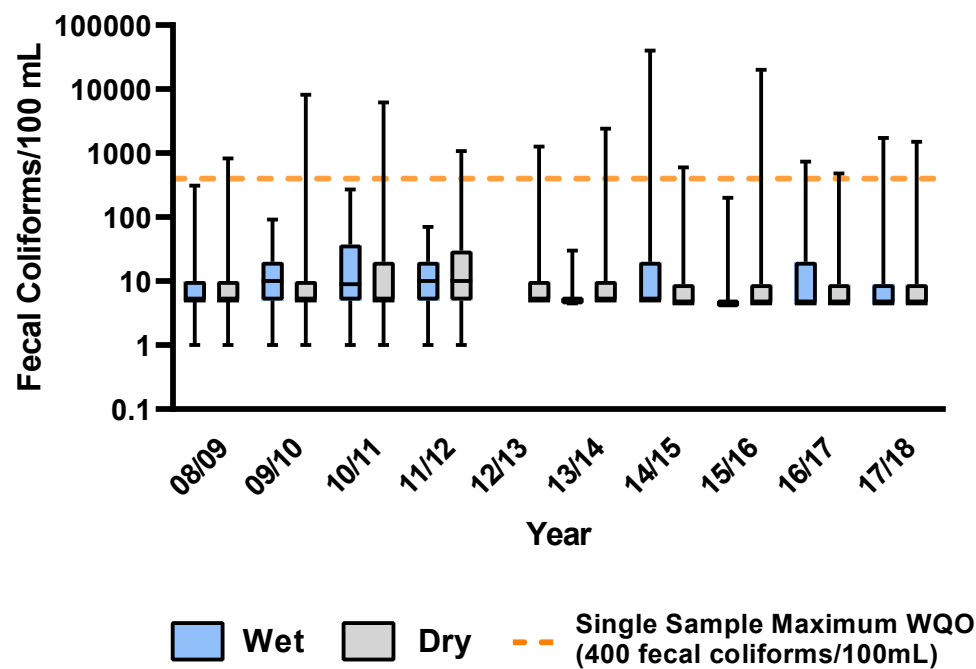
APPENDIX A
TOTAL AND FECAL COLIFORM SUPPLEMENTAL ANALYSIS

Dana Point Harbor Total Coliform Single Sample Maximum



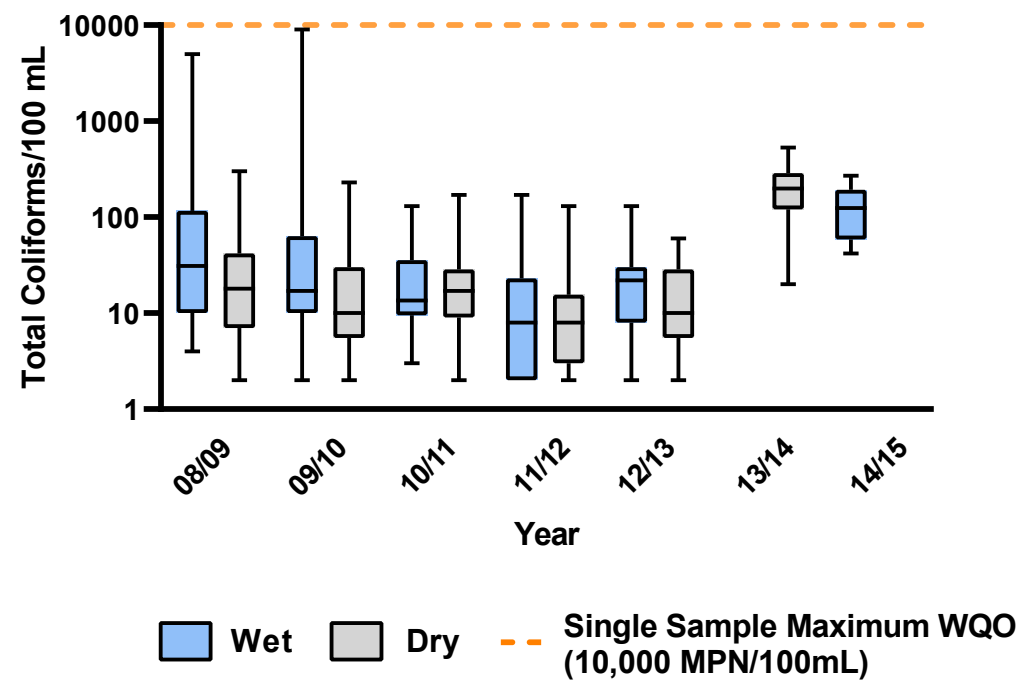
No data available for 2012/13 wet season

Dana Point Harbor Fecal Coliform Single Sample Maximum



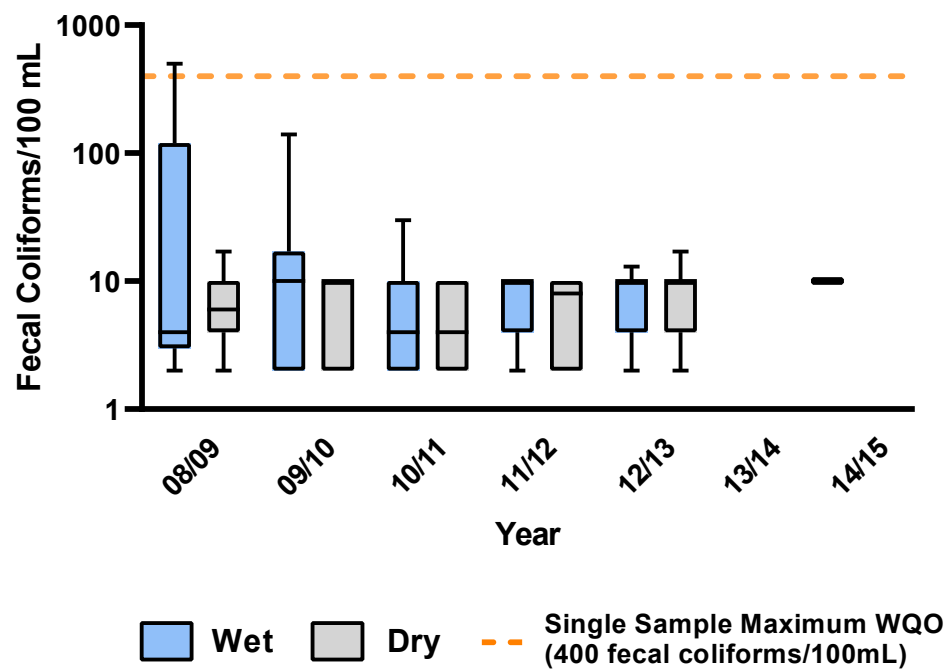
No data available for the 2012/13 wet season

Oceanside Harbor Total Coliform Single Sample Maximum



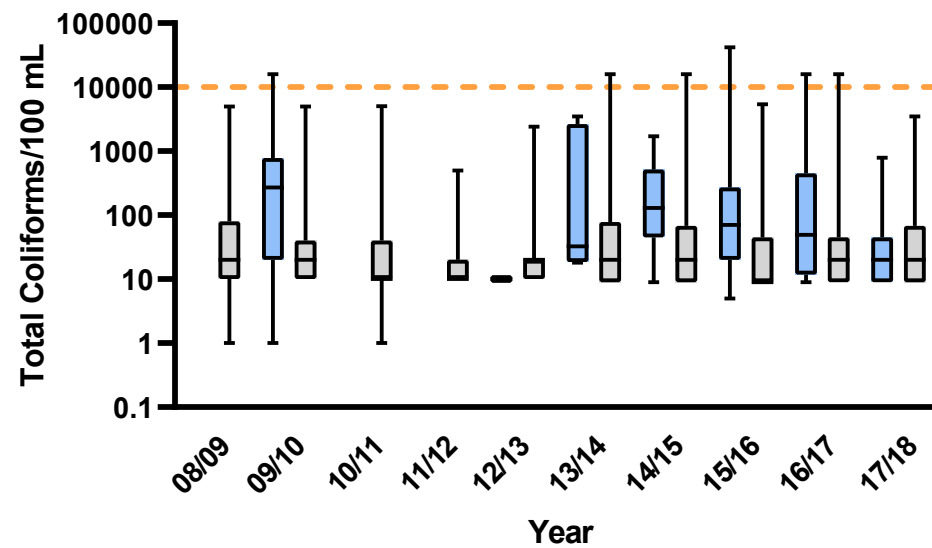
No data available for the 2013/14 wet season, 2014/15 dry season,
and no data collected after 2015

Oceanside Harbor Fecal Coliform Single Sample Maximum



No data available for the 2013/14 wet season, 2014/15 dry season,
and no data collected after 2015

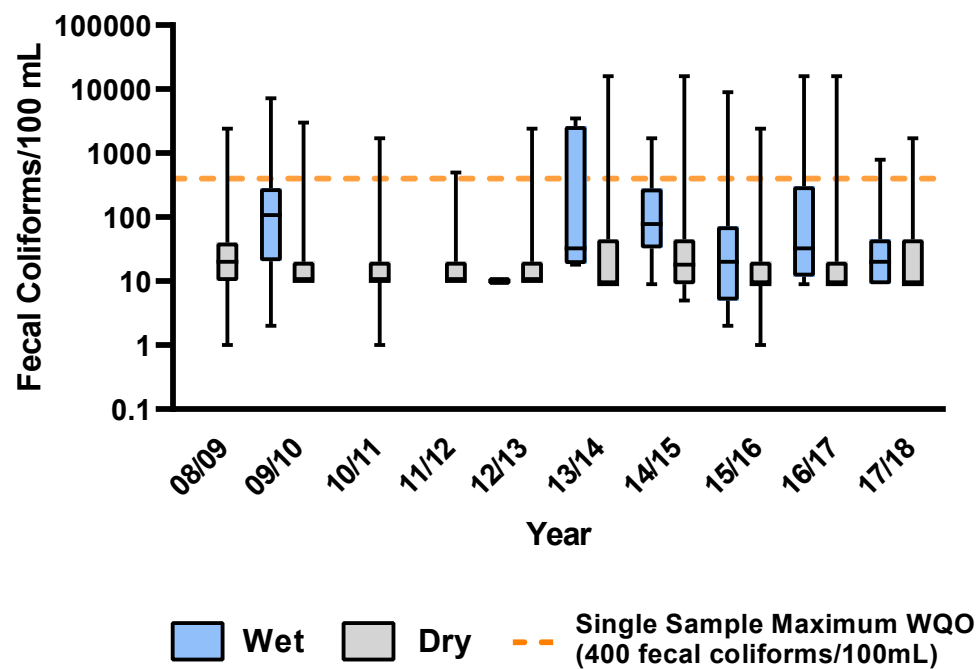
Mission Bay Total Coliform Single Sample Maximum



Wet
 Dry
 Single Sample Maximum WQO (10,000 total coliforms/100mL)

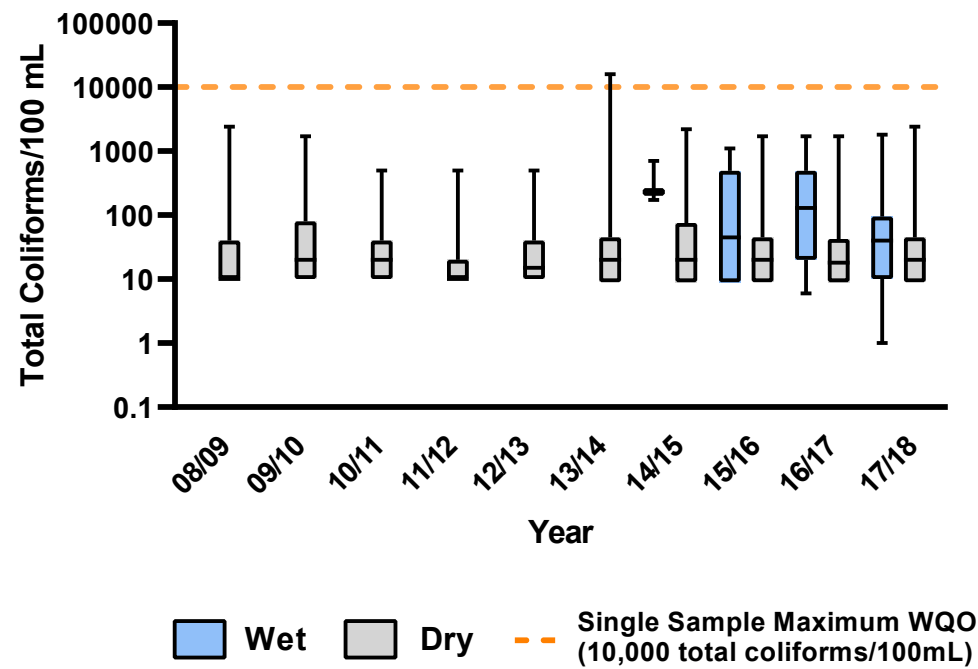
No data available for 2008/09, 2010/11, and 2011/12 wet seasons

Mission Bay Fecal Coliform Single Sample Maximum



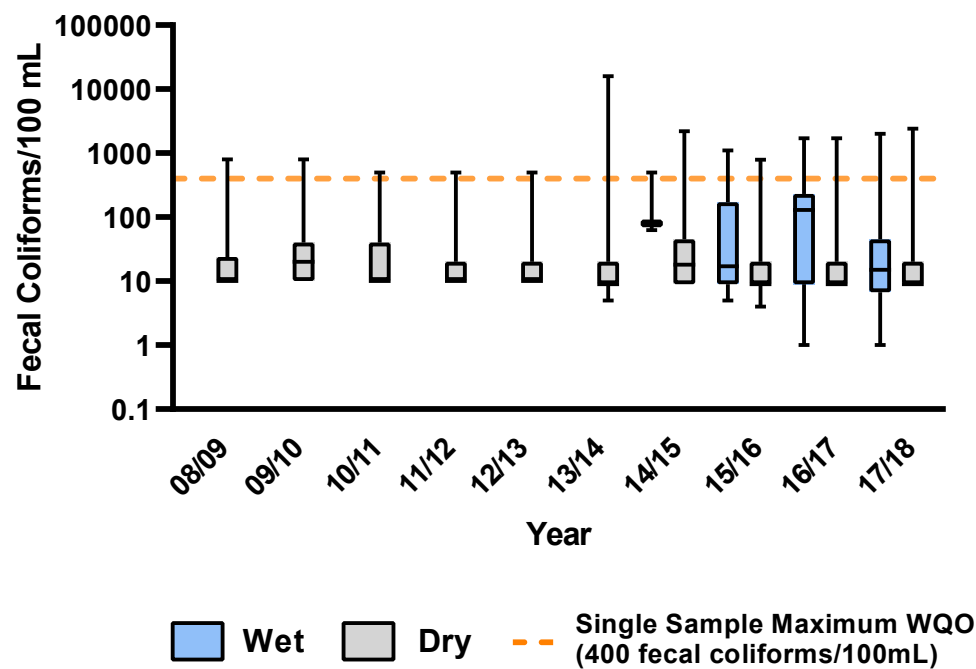
No data available for 2008/09, 2010/11, and 2011/12 wet seasons

North San Diego Bay Total Coliform Single Sample Maximum



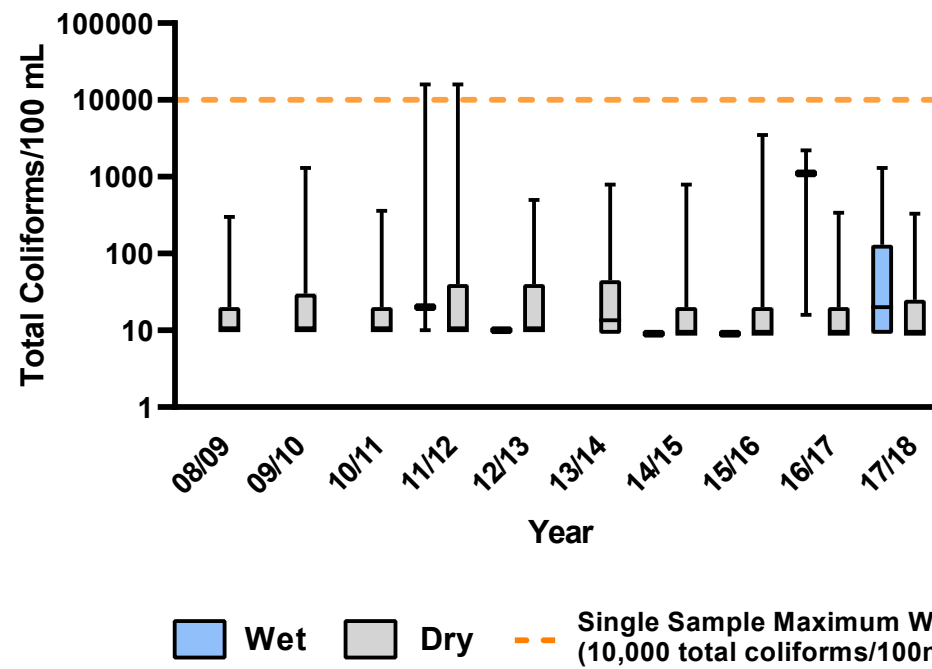
No data available for the 2008/09 through 2013/14 wet seasons

North San Diego Bay Fecal Coliform Single Sample Maximum



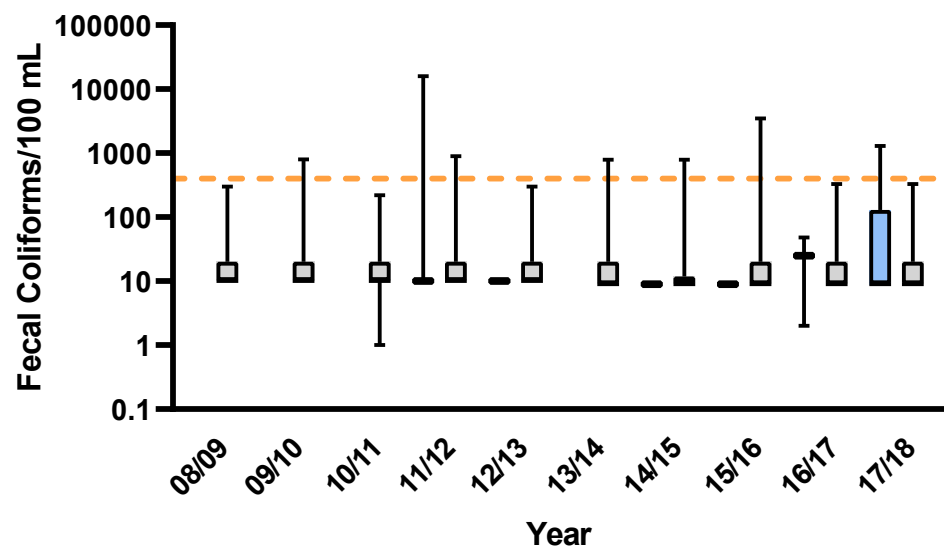
No data available for the 2008/09 through 2013/14 wet seasons

South San Diego Bay Total Coliform Single Sample Maximum



No data available for the 2008/09 through 2010/11 and 2013/14 wet seasons

South San Diego Bay Fecal Coliform Single Sample Maximum



Wet
 Dry
 **Single Sample Maximum WQO
(400 fecal coliforms/100mL)**

No data available for the 2008/09 through 2010/11 and 2013/14 wet seasons

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APPENDIX B

STATION LOCATIONS AND COORDINATES

Historical Bacteria Analysis Station Locations and Coordinates

Harbor	Station	Latitude dd.ddddd°	Longitude ddd.ddddd°	Start Sample Date	End Sample Date
Dana Point Harbor	BDP07	33.45950	-117.69050	11/13/2008	10/29/2018
Dana Point Harbor	BDP08	33.46133	-117.70550	11/13/2008	10/29/2018
Dana Point Harbor	BDP12	33.46216	-117.70500	11/13/2008	10/31/2018
Dana Point Harbor	BDP13	33.46233	-117.70433	11/13/2008	10/29/2018
Dana Point Harbor	BDP14	33.46250	-117.70433	11/13/2008	10/29/2018
Dana Point Harbor	BDP15	33.46233	-117.70450	11/13/2008	10/29/2018
Dana Point Harbor	BDP16	33.46166	-117.70583	11/13/2008	10/29/2018
Dana Point Harbor	BDP17	33.46200	-117.70367	11/13/2008	10/29/2018
Dana Point Harbor	MDP10	33.45845	-117.69355	11/13/2008	10/29/2018
Dana Point Harbor	MDP11	33.46200	-117.70341	11/13/2008	10/29/2018
Dana Point Harbor	MDP18	33.46031	-117.69613	11/13/2008	10/29/2018
Dana Point Harbor	S-4	33.45690	-117.69500	11/4/2008	5/30/2012
Oceanside Harbor	H-1	33.20806	-117.39501	1/13/2009	9/11/2018
Oceanside Harbor	H-2	33.20555	-117.39195	1/13/2009	9/11/2018
Oceanside Harbor	H-3	33.20919	-117.39533	1/13/2009	9/13/2018
Oceanside Harbor	H-4	NR	NR	4/3/2018	4/3/2018
Mission Bay	EH-227	32.79510	-117.21634	11/15/2016	12/13/2016
Mission Bay	MB-031	32.77130	-117.20980	4/7/2009	10/30/2018
Mission Bay	MB-041	32.77320	-117.21000	6/23/2009	10/30/2018
Mission Bay	MB-051	32.78260	-117.20990	4/7/2009	10/30/2018
Mission Bay	MB-053	32.78539	-117.20933	6/23/2009	10/30/2018
Mission Bay	MB-058	32.78809	-117.20987	2/5/2014	5/24/2016
Mission Bay	MB-060	32.78840	-117.20960	4/1/2009	10/30/2018
Mission Bay	MB-070	32.79690	-117.21190	4/7/2009	10/30/2018
Mission Bay	MB-080	32.79490	-117.22130	4/7/2009	10/30/2018
Mission Bay	MB-085	32.78847	-117.21783	9/24/2009	1/20/2016
Mission Bay	MB-086	32.78920	-117.21340	1/15/2016	2/23/2016
Mission Bay	MB-090	32.78830	-117.23140	6/23/2009	10/30/2018
Mission Bay	MB-100	32.78230	-117.23250	6/23/2009	10/30/2018
Mission Bay	MB-120	32.79080	-117.24430	6/23/2009	10/30/2018
Mission Bay	MB-130	32.78930	-117.25140	8/22/2011	8/22/2011
Mission Bay	MB-131	32.78320	-117.25100	6/3/2014	8/25/2015
Mission Bay	MB-160	32.77550	-117.24540	6/23/2009	10/30/2018
Mission Bay	MB-173	32.76950	-117.24750	4/7/2009	10/30/2018
Mission Bay	MB-193	32.76520	-117.21650	10/25/2011	10/25/2011
Mission Bay	MB-200	NR	NR	6/14/2011	8/30/2011
Mission Bay	MB-203	32.77410	-117.23270	6/23/2009	10/30/2018
Mission Bay	MB-205	32.77605	-117.23820	6/23/2009	10/30/2018
Mission Bay	MB-223	32.77088	-117.24468	3/20/2013	3/20/2013
North San Diego Bay	EH-070	32.69012	-117.16440	4/1/2009	10/31/2018
North San Diego Bay	EH-160	32.72834	-117.20994	4/15/2009	10/30/2018
North San Diego Bay	EH-200	32.71477	-117.22416	4/1/2009	10/30/2018
North San Diego Bay	EH-205	32.71820	-117.23300	4/16/2009	7/27/2009
North San Diego Bay	EH-211	32.70921	-117.23684	6/22/2009	10/30/2018
South San Diego Bay	EH-080	32.67521	-117.16818	6/22/2009	10/31/2018
South San Diego Bay	EH-090	32.63631	-117.14110	9/9/2011	3/8/2018
South San Diego Bay	EH-120	32.62880	-117.10809	6/22/2009	10/31/2018

Notes:

ddd/dd.ddddd° = decimal degrees, NR = not reported

APPENDIX C
SUMMARY OF 30-DAY GEOMETRIC MEAN AND SINGLE SAMPLE
MAXIMUM

**2008-2018 Summary of
30-day Geometric Mean and Single Sample Maximum WQO Exceedances:
All Stations**

Harbor/Station	All Seasons			Wet Season		Dry Season	
	% Non-detect	% Over 30-day GM WQO	% Over SSM WQO	% Over 30-day GM WQO	% Over SSM WQO	% Over 30-day GM WQO	% Over SSM WQO
Dana Point Harbor	40	6	5	9	5	4	5
BDP07	55	0	1	1	2	0	1
BDP08	53	0	1	0	3	0	0
BDP12	24	16	9	26	7	13	10
BDP13	29	8	8	5	6	9	8
BDP14	27	9	10	20	8	6	10
BDP15	25	10	7	14	9	9	7
BDP16	51	0	1	0	2	0	1
BDP17	56	0	1	0	2	0	1
MDP10	46	2	4	0	2	3	4
MDP11	52	0	1	0	2	0	0
MDP18	28	11	7	17	10	9	6
S-4	40	7	5	25	13	0	1
Oceanside Harbor	79	2	1	4	2	1	1
H-1	76	0	0	0	0	0	0
H-2	80	1	0	2	0	0	0
H-3	79	4	4	9	7	1	1
H-4	100	0	0	--	--	0	0
Mission Bay	49	11	8	63	27	7	6
EH-227	60	0	10	0	10	--	--
MB-031	57	9	7	85	35	3	5
MB-041	50	5	5	52	20	1	3
MB-051	55	7	3	62	19	3	2
MB-053	37	19	13	71	39	14	11
MB-058	21	61	34	76	38	41	29
MB-060	29	29	18	83	29	21	17
MB-070	50	15	8	84	39	8	5
MB-080	40	15	8	93	43	8	4
MB-085	20	60	20	75	25	0	0
MB-086	36	0	4	0	4	--	--
MB-090	60	2	3	33	20	0	2
MB-100	65	3	3	40	20	2	2
MB-120	55	5	6	20	0	4	6

Harbor/Station	All Seasons			Wet Season		Dry Season	
	% Non-detect	% Over 30-day GM WQO	% Over SSM WQO	% Over 30-day GM WQO	% Over SSM WQO	% Over 30-day GM WQO	% Over SSM WQO
MB-130	100	0	0	--	--	0	0
MB-131	100	0	0	--	--	0	0
MB-160	64	2	7	0	0	2	7
MB-173	44	5	4	25	13	5	4
MB-193	0	100	100	--	--	100	100
MB-200	14	14	0	--	--	14	0
MB-203	57	4	5	57	43	2	4
MB-205	37	24	13	79	27	18	12
MB-223	100	0	0	0	0	--	--
North San Diego Bay	49	13	9	50	23	9	7
EH-070	42	14	10	29	13	12	9
EH-160	58	3	3	45	9	2	3
EH-200	37	27	17	62	30	19	14
EH-205	67	33	0	--	--	33	0
EH-211	65	3	2	27	18	2	2
South San Diego Bay	56	8	7	50	25	6	6
EH-080	63	2	4	33	22	1	4
EH-090	62	31	15	44	22	0	0
EH-120	48	13	9	83	33	12	9
All Harbors	46	9	6	22	11	6	6

Notes:

% = percent, -- = no data available, GM = geometric mean; SSM = single sample maximum; WQO = water quality objective

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APPENDIX D
SUMMARY OF 6-WEEK GEOMETRIC MEAN AND STATISTICAL
THRESHOLD VALUE

**2017/2018 Summary of
Average Seasonal 6-week Geometric Means and Statistical Threshold Values**

Station	2017/2018 Wet Season		2017/2018 Dry Season	
	Average Seasonal 6-week GM (cfu/100 mL)	% Samples over 110 cfu/100 mL	Average Seasonal 6-week GM (cfu/100 mL)	% Samples over 110 cfu/100 mL
Dana Point Harbor				
BDP07	5	0	5	0
BDP08	5	0	6	0
BDP12	95	8	24	10
BDP13	7	0	12	0
BDP14	15	0	10	3
BDP15	12	5	8	0
BDP16	6	0	7	3
BDP17	6	0	5	0
MDP10	5	0	5	0
MDP11	6	0	5	0
MDP18	16	5	9	3
Oceanside Harbor				
H-1	--	--	5	0
H-2	--	--	13	0
H-3	--	--	42	20
H-4	--	--	5	0
Mission Bay				
MB-031	88	25	8	3
MB-041	37	20	7	0
MB-051	52	25	14	6
MB-053	120	38	17	11
MB-060	92	38	26	27
MB-070	62	20	17	2
MB-080	92	14	17	3
MB-090	31	25	8	0
MB-100	22	20	6	3
MB-120	40	0	13	11
MB-160	14	0	8	3
MB-173	29	14	17	0
MB-203	42	43	10	3
MB-205	28	20	21	11
North San Diego Bay				
EH-070	26	14	20	13
EH-160	21	20	7	0
EH-200	44	24	26	20
EH-211	31	40	9	0
South San Diego Bay				
EH-080	317	25	10	3
EH-090	5	0	--	--
EH-120	76	33	18	7

Notes:

% = percent, -- = no data available, cfu = colony forming units, GM = geometric mean; mL = milliliter(s)