# Chapter 3. Microbiology

## INTRODUCTION

The City of San Diego performs shoreline and water column bacterial monitoring in the region surrounding the Point Loma Ocean Outfall (PLOO). Bacteriological densities, together with oceanographic data (see Chapter 2), provide information about the movement and dispersion of wastewater discharged through the outfall. Analyses of these data may also implicate point or non-point sources other than the outfall as contributing to bacterial contamination events in the region. The PLOO monitoring program is designed to assess general water quality and demonstrate level of compliance with the 2001 California Ocean Plan (COP) as required by the NPDES discharge permit. The results of bacteriological analyses and individual station compliance data are submitted to the San Diego Regional Water Quality Control Board in the form of Monthly Receiving Waters Monitoring Reports. This chapter summarizes and interprets patterns in bacterial concentration data collected off Point Loma during 2004.

## MATERIALS AND METHODS

### Field Sampling

Water samples for bacteriological analyses were collected at fixed shore and offshore sampling sites throughout the year (**Figure 3.1**). Sampling was performed at eight shore stations (D4, D5, and D7–D12) to monitor bacteria levels along public beaches. Eight stations located in the Point Loma kelp bed were also monitored to assess water quality conditions in areas used for water contact sports (e.g., kelp beds). These stations include three sites (stations C4, C5, C6) located near the inshore edge of the kelp bed along the 9-m depth contour, and five sites (stations A1, A6, A7, C7, C8) located near the offshore edge of the kelp bed along the 18-m depth contour. Samples were taken at three fixed depths for each station (**Table 3.1**). The shore and kelp stations were sampled five times per month according to NPDES permit specifications in order to monitor compliance with COP water contact standards (see **Box 3.1**).

Thirty-six offshore stations (designated F01–F36, Figure 3.1) were sampled quarterly in January, April, July, and October. Sampling at these sites usually takes place over a 3-day period. Three of these stations (F01–F03) are located along the 18-m depth contour, while 33 sites (11 per transect) are located along the 60-m contour (stations F04–F14), the 80-m contour (stations F15–F25), and the 98-m contour (stations F26–F36).

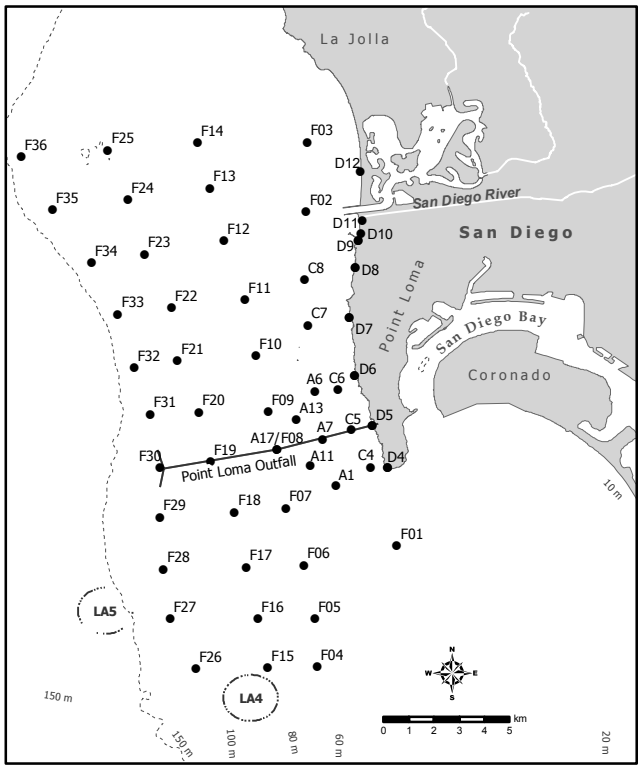


**Figure 3.1**
Locations of water quality monitoring stations where bacterial samples are taken, Point Loma Ocean Outfall Monitoring Program.

**Table 3.1**
Depths (m) at which bacteriological samples are collected at the PLOO kelp and quarterly offshore water quality stations.

| | Sample depth | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Station transect | 1 | 3 | 9 | 12 | 18 | 25 | 60 | 80 | 98 |
| 9-m kelp bed | x | x | x | | | | | | |
| 18-m kelp bed | x | | | x | x | | | | |
| 18-m quarterly | x | | | x | x | | | | |
| 60-m quarterly | x | | | | | x | x | | |
| 80-m quarterly | x | | | | | x | x | x | |
| 98-m quarterly | x | | | | | x | x | x | x |

The number of samples taken at each station was depth-dependent and ranged from a minimum of three fixed depths sampled at the 18-m stations to a maximum of five fixed depths sampled at the 98-m stations (Table 3.1).

Seawater samples were collected in sterile 250-mL bottles from the shoreline at each shore station. Visual observations of water color and clarity, surf height, human or animal activity, and weather conditions were recorded at the time of sample collection. The seawater samples were then transported on ice to the City's Marine Microbiology Laboratory and analyzed to determine concentrations of total coliform, fecal coliform, and enterococcus bacteria.

Seawater samples from the kelp bed and quarterly offshore stations were analyzed for the same three bacterial parameters. These samples were collected using either a series of Van Dorn bottles or a rosette sampler fitted with Niskin bottles. Aliquots for each analysis were drawn into appropriate sample containers. The samples were refrigerated aboard ship and then transported to the City's Marine Microbiology Laboratory for bacteriological analysis. Visual observations of weather and water conditions were also recorded for each sampling event.

Monitoring of the San Diego and neighboring coastline also included satellite and aerial remote sensing performed by Ocean Imaging Corporation (OI) (see Chapter 2). These surveys assist in the detection of the turbidity signature from the PLOO plume, while also differentiating between the outfall plume and coastal discharges. Such data help distinguish between bacterial contamination events caused by the PLOO discharge from those attributable to other point and non-point sources (e.g., river and bay discharges).

### Laboratory Analyses and Data Treatment

All bacterial analyses were performed within eight hours of sample collection and conformed to the membrane filtration techniques outlined in the City's Quality Assurance Plan (City of San Diego in prep). The Marine Microbiology Laboratory follows guidelines issued by the EPA Water Quality Office, Water Hygiene Division and the California State Department of Health Services (CS-DHS), Water Laboratory Approval Group with respect to sampling and analytical procedures (Bordner, et al. 1978; Greenberg, et al. 1992).

Colony counting, calculation of results, data verification and reporting all follow guidelines established by the EPA (see Bordner et al. 1978). According to these guidelines, plates with bacterial counts above or below permissible counting limits were given greater than (>), less

## Box 3.1

Bacteriological compliance standards for water contact areas, 2001 California Ocean Plan (CSWRCB 2001). CFU = colony forming units.

(1) *30-day total coliform standard* — no more than 20% of the samples at a given station in any 30-day period may exceed a concentration of 1000 CFU per 100 mL.

(2) *10,000 total coliform standard* — no single sample, when verified by a repeat sample collected within 48 hrs, may exceed a concentration of 10,000 CFU per 100 mL.

(3) *60-day fecal coliform standard* — no more than 10% of the samples at a given station in any 60-day period may exceed a concentration of 400 CFU per 100 mL.

(4) *geometric mean* — the geometric mean of the fecal coliform concentration at any given station in any 30-day period may not exceed 200 CFU per 100 mL, based on no fewer than five samples.

than (<), or estimated (e) qualifiers. However, these qualifiers were dropped and the counts were treated as discrete values during the calculation of compliance with COP standards and in various statistical analyses.

Spatial and temporal patterns in bacteriological contamination were determined from mean densities of total coliform, fecal coliform, and enterococcus bacteria. These data were analyzed by station, month, and depth, and evaluated relative to (a) monthly rainfall and climatological data collected at Lindbergh Field, San Diego, CA, (b) oceanographic conditions (see Chapter 2), and (c) other events identified through satellite and aerial sensing data (e.g., stormwater flows, nearshore and surface water circulation patterns). Shore and kelp bed station compliance with COP bacteriological standards was summarized according to the number of days per month that each station exceeded the four standards (see Box 3.1). Bacteriological data for offshore stations data are not subject to COP standards; however, these data were used to examine spatio-temporal patterns in the dispersion of waste field. Bacteriological benchmarks for receiving waters discussed in this report are ≥ 1000 CFU/100 mL for total coliform values, ≥ 400 CFU/100 mL for fecal coliforms, and ≥ 104 CFU/100 mL for enterococcus bacteria. These benchmarks were used as reference points to distinguish elevated bacteriological values. Generally, contaminated waters were identified by samples with total coliform concentrations ≥ 1000 CFU/mL and a fecal:total (F:T) ratio ≥ 0.1 (see CS-DHS 2000). Offshore station water quality samples that met these criteria were used as indicators of the waste field.

Quality assurance tests were performed routinely on water samples to ensure that sampling variability did not exceed acceptable limits. Duplicate and split field samples were collected according to method requirements and processed by laboratory personnel to measure intra-sample and inter-analyst variability, respectively. Results of these procedures were reported in the Quality Assurance Report (City of San Diego 2005).

## RESULTS AND DISCUSSION

### Compliance with California Ocean Plan Standards – Shore and Kelp Bed Stations

Compliance with COP bacterial standards at the shore and kelp stations were generally high, despite heavy rainfall that periodically affected nearshore water quality (see Chapter 2 and below). Water quality samples from the shoreline

## Table 3.2

Summary of compliance with California Ocean Plan water contact standards for PLOO shore stations during 2004. The values reflect the number of days that each station exceeded the 30-day total and 60-day fecal coliform standards. Shore stations are listed left to right from south to north.

**30-Day Total Coliform Standard**

| *Month* | # days | D4 | D5 | D7 | D8 | D9 | D10 | D11 | D12 |
|---|---|---|---|---|---|---|---|---|---|
| January | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| February | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| March | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| April | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| May | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| June | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| July | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| August | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| September | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| October | 31 | 0 | 0 | 0 | 15 | 0 | 0 | 3 | 0 |
| November | 30 | 0 | 0 | 0 | 26 | 0 | 0 | 21 | 0 |
| December | 31 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Compliance (%) | | 100% | 100% | <100% | 89% | 100% | 100% | 93% | 100% |

**60-Day Fecal Coliform Standard**

| *Month* | # days | D4 | D5 | D7 | D8 | D9 | D10 | D11 | D12 |
|---|---|---|---|---|---|---|---|---|---|
| January | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| February | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| March | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| April | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| May | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| June | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| July | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| August | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| September | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| October | 31 | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 0 |
| November | 30 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 0 |
| December | 31 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 |
| Compliance (%) | | 100% | 100% | 100% | 83% | 100% | 100% | 100% | 100% |

stations were over 80% compliant with the 30-day total and 60-day fecal coliform standards and 100% compliant with the 10,000 total coliform and geometric mean standards. Similarly, samples from the kelp stations were compliant with the 30-day total coliform standard over 95% of the time, and approximately 100% of the time with the other COP standards (**Tables 3.2, 3.3**). The few exceptions occurred in October, November, or December. During this time, water quality samples exceeded the 30-day total coliform standard at stations D8 and D11 (October–November) and Station D7 (December). Samples collected at station D8 also exceeded the 60-day fecal coliform during all three months. In addition, a few samples collected at kelp stations A1, A7, and C4 during November and at most kelp stations in December caused these sites to exceed the 30-day total coliform standard. Stations C4 and C5 exceeded the 10,000 total coliform standard once each in December, and station C4 also exceeded the 60-day fecal coliform standard once in December. Generally, these incidences of non-compliance followed periods of excessive rainfall (see Chapter 2, and below). For example, exceedences of the 10,000 coliform standard at stations C4 and

## Table 3.3

Summary of compliance with California Ocean Plan water contact standards for PLOO kelp bed stations during 2004. The values reflect the number of days that each station exceeded the 30-day total and 60-day fecal coliform standards. Kelp stations are listed left to right from south to north by depth contour.

**30-Day Total Coliform Standard**

| | | 9-m stations | | | 18-m stations | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **# days** | **C4** | **C5** | **C6** | **A1** | **A7** | **A6** | **C7** | **C8** |
| *January* | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *February* | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *March* | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *April* | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *May* | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *June* | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *July* | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *August* | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *September* | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *October* | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *November* | 30 | 1 | 0 | 0 | 1 | 12 | 0 | 0 | 0 |
| *December* | 31 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| Compliance (%) | | 99% | <100% | <100% | 99% | 96% | 100% | 100% | <100% |

**60-Day Fecal Coliform Standard**

| | | 9-m stations | | | 18-m stations | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month** | **# days** | **C4** | **C5** | **C6** | **A1** | **A7** | **A6** | **C7** | **C8** |
| *January* | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *February* | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *March* | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *April* | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *May* | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *June* | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *July* | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *August* | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *September* | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *October* | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *November* | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *December* | 31 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Compliance (%) | | <100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

C5 occurred on December 30 following a 2-day storm that accumulated 2.9 inches of rain (NOAA/NWS 2005). Since these samples had relatively low fecal coliform values and F:T ratios ≤ 0.1, the origin of the contamination probably was not sewage related.

### Spatial and Temporal Trends – Shore Stations

Bacteriological concentrations along the shoreline in 2004 were generally low, with mean total coliform densities ranging from 2 to 2030 (**Table 3.4**). The greatest concentrations occurred during periods of heavy rainfall (e.g., February,

## Table 3.4

Mean total coliform, fecal coliform and enterococcus bacteria (Entero) densities (CFU per 100 mL) at PLOO shore stations by station, month, and year (2004). Stations are listed left to right in order from south to north. Rainfall (in inches) was measured at Lindbergh Field, San Diego, CA.

| **Month (rainfall)** | **Stations n** | **D4** 42 | **D5** 42 | **D7** 42 | **D8** 43 | **D9** 43 | **D10** 23 | **D11** 23 | **D12** 23 | **All Stations** |
|---|---|---|---|---|---|---|---|---|---|---|
| January | Total | 12 | 24 | 18 | 240 | 16 | 36 | 31 | 5 | 48.7 |
| **(0.34)** | Fecal | 4 | 4 | 13 | 48 | 3 | 10 | 15 | 3 | 12.6 |
| | Entero | 11 | 3 | 2 | 44 | 3 | 18 | 92 | 4 | 22.4 |
| February | Total | 2 | 38 | 18 | 100 | 252 | 355 | 414 | 637 | 232.7 |
| **(2.8)** | Fecal | 2 | 5 | 12 | 41 | 23 | 58 | 26 | 40 | 26.5 |
| | Entero | 2 | 2 | 7 | 39 | 58 | 65 | 56 | 60 | 37.0 |
| March | Total | 9 | 11 | 37 | 57 | 9 | 90 | 11 | 13 | 29.8 |
| **(0.22)** | Fecal | 2 | 3 | 13 | 11 | 2 | 31 | 5 | 8 | 9.4 |
| | Entero | 4 | 2 | 2 | 4 | 2 | 63 | 6 | 4 | 10.8 |
| April | Total | 2 | 44 | 4 | 63 | 49 | 26 | 28 | 9 | 29.0 |
| **(0.6)** | Fecal | 2 | 5 | 3 | 8 | 2 | 10 | 10 | 5 | 5.6 |
| | Entero | 4 | 3 | 3 | 4 | 3 | 3 | 22 | 3 | 5.6 |
| May | Total | 2 | 8 | nd | 74 | 109 | 45 | 48 | 24 | 46.2 |
| **(0.0)** | Fecal | 2 | 2 | nd | 6 | 18 | 13 | 19 | 6 | 9.6 |
| | Entero | 4 | 2 | nd | 3 | 4 | 5 | 6 | 10 | 4.8 |
| June | Total | 86 | 101 | nd | 33 | 143 | 24 | 72 | 43 | 71.4 |
| **(0.0)** | Fecal | 8 | 41 | nd | 7 | 11 | 8 | 59 | 2 | 19.4 |
| | Entero | 12 | 116 | nd | 5 | 4 | 2 | 12 | 4 | 22.1 |
| July | Total | 11 | 11 | nd | 61 | 8 | 66 | 55 | 77 | 40.8 |
| **(0.0)** | Fecal | 2 | 2 | nd | 5 | 3 | 34 | 25 | 6 | 11.0 |
| | Entero | 4 | 2 | nd | 2 | 2 | 12 | 10 | 5 | 5.2 |
| August | Total | 78 | 18 | nd | 47 | 64 | 71 | 30 | 16 | 46.3 |
| **(0.0)** | Fecal | 3 | 4 | nd | 26 | 3 | 18 | 11 | 5 | 10.0 |
| | Entero | 9 | 2 | nd | 5 | 7 | 24 | 9 | 2 | 8.4 |
| September | Total | 77 | 47 | nd | 1129 | 42 | 25 | 27 | 44 | 220.4 |
| **(0.0)** | Fecal | 2 | 9 | nd | 639 | 2 | 5 | 10 | 5 | 108.6 |
| | Entero | 5 | 2 | nd | 6 | 2 | 7 | 4 | 9 | 5.2 |
| October | Total | 135 | 648 | 153 | 2030 | 506 | 498 | 934 | 98 | 685.6 |
| **(4.79)** | Fecal | 36 | 65 | 87 | 684 | 24 | 37 | 84 | 84 | 154.2 |
| | Entero | 13 | 20 | 41 | 1024 | 15 | 22 | 50 | 16 | 177.9 |
| November | Total | 17 | 168 | 40 | 235 | 37 | 40 | 78 | 158 | 93.1 |
| **(0.33)** | Fecal | 7 | 21 | 5 | 151 | 12 | 8 | 18 | 23 | 30.6 |
| | Entero | 4 | 16 | 4 | 72 | 4 | 5 | 193 | 12 | 38.6 |
| December | Total | 62 | 279 | 489 | 63 | 146 | 120 | 63 | 55 | 162.4 |
| **(3.96)** | Fecal | 8 | 70 | 31 | 130 | 36 | 41 | 49 | 29 | 49.6 |
| | Entero | 27 | 306 | 140 | 383 | 132 | 132 | 94 | 40 | 157.5 |
| **Annual mean** | **Total** | 44 | 108 | 107 | 387 | 109 | 111 | 139 | 92 | |
| | **Fecal** | 6 | 18 | 20 | 159 | 11 | 22 | 26 | 17 | |
| | **Entero** | 8 | 36 | 28 | 134 | 17 | 29 | 43 | 13 | |

## Table 3.5

Mean total coliform, fecal coliform and enterococcus bacteria (Entero) densities (CFU per 100 mL) at PLOO shore stations by station, month, and year (2004). Stations are listed left to right in order from south to north. Rainfall (in inches) was measured at Lindbergh Field, San Diego, CA.

| Date | 72-hr rain | Station | Total | Fecal | Entero | F:T |
|---|---|---|---|---|---|---|
| February 23 | 1.39 | D9 | 1200 | 100 | 280 | 0.08 |
| | | D10 | 1600 | 140 | 280 | 0.09 |
| | | D11 | 2000 | 80 | 260 | 0.04 |
| | | D12 | 2200 | 80 | 200 | 0.04 |
| September 29 | 0.00 | **D8** | 5200 | 4400 | 2 | **0.85** |
| October 17 | 0.09 | **D8** | 10000 | 3600 | 6000 | **0.36** |
| October 23 | 0.10 | D11 | 1400 | 20 | 12 | 0.01 |
| October 29 | 3.00 | D5 | 2800 | 260 | 82 | 0.09 |
| | | **D8** | 1200 | 120 | 50 | **0.10** |
| | | D9 | 1800 | 84 | 54 | 0.05 |
| | | D10 | 1600 | 140 | 96 | 0.09 |
| | | **D11** | 3200 | 380 | 220 | **0.12** |
| December 28 | 1.16 | D7 | 2400 | 140 | 680 | 0.06 |

October, December). For example, mean concentrations of the three indicator bacteria peaked in October as a result of samples collected during the October 23 and 29 surveys; these surveys were completed over a 12 day period when 4.8 inches of rain accumulated (NOAA/NWS 2005). In addition, of the 13 samples with total coliforms ≥ 1000 CFU/100 mL, 10 were collected within 72-hour periods of rain events that exceeded 1.0 inch, including four samples in February, five samples in October, and one sample in December (**Table 3.5**). However, it appears that none of these samples were related to sewage contamination. For example, the two samples collected at stations D8 and D11 on October 29 had a F:T ratio ≥ 0.1, but had fecal coliform densities below the benchmark of 400 CFU/100 mL. These low fecal coliform values suggest that the source of contamination was likely related to storm discharge. In contrast, two samples collected at station D8 on September 29 and October 17 had total and fecal coliform densities well above their respective benchmark values, but occurred when there was little to no rain. Visual observations recorded during both sampling events indicated large amounts of kelp, trash, and the presence of dogs, all of which are likely contributors to the source of the elevated coliform densities (see City of San Diego 2004a, b).

### Spatial and Temporal Trends – Offshore Stations

Of the 564 bacteriological samples collected at the offshore quarterly stations in 2004, four samples had total coliform densities that were uncountable due to overgrowth of non-coliform bacteria, and 67 (12%) had total coliform densities ≥ 1000 CFU/mL and an F:T ratio ≥ 0.1 (**Appendix A.1**). Total coliform concentrations in surface and subsurface waters (1–25 m) ranged from non-detectable levels to 400 CFU/100 mL throughout the year. Moreover, all surface and subsurface fecal coliform densities were <160 CFU/100 mL. In contrast, total coliform concentrations in relatively deep waters (60–98 m) ranged between 2 and 22,000 CFU/100 mL. Each of the 67 samples with total coliform densities ≥ 1000 CFU/mL and F:T ratios ≥ 0.1 came from this depth range (**Figure 3.2A**), suggesting that the stratified water column restricted the plume to

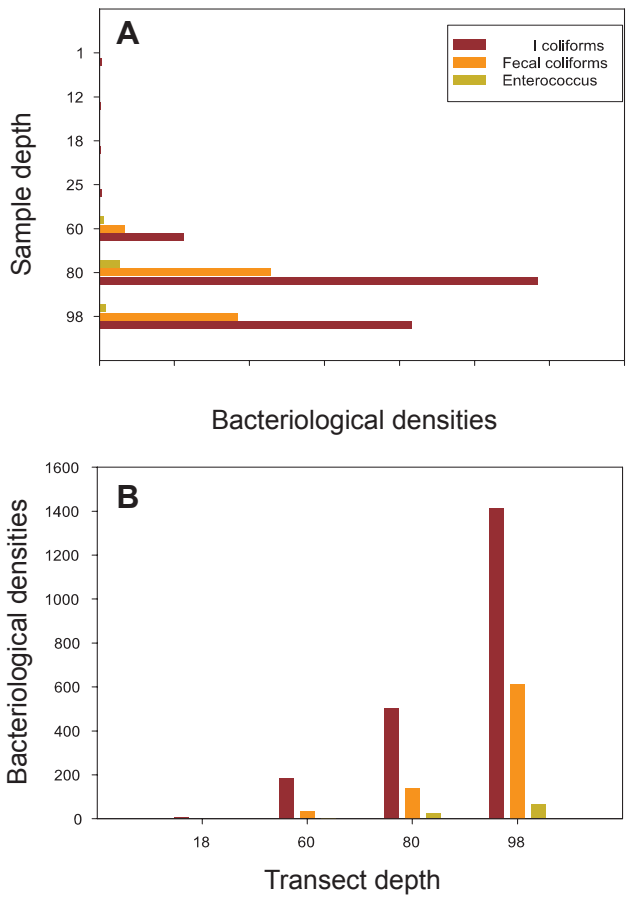


**Figure 3.2**
Mean total coliform, fecal coliform, and enterococcus bacteria densities (CFU/100 mL) at PLOO quarterly sampling stations by sample depth (A) and transect depth (B). Depths are in meters.

mid- and deep-water depths throughout the year (see Chapter 2).

Similarly, there was little evidence that discharged wastewater impacted nearshore waters in 2004. Mean bacterial levels along the 80 and 98-m depth transects stations were much higher than those closer to shore (i.e., 18 and 60-m transects) (**Figure 3.2B**). Sixty-five of the sixty-seven samples with total coliform densities ≥ 1000 CFU/mL and F:T coliform ratios ≥ 0.1 came from the 80 and 98-m depth transects. The other two samples occurred along the 60-m transect, both at station F08. In addition, mean bacterial concentrations at the kelp bed stations were similar to the 18-m quarterly stations for every month except October (**Table 3.6**). The October kelp station values were relatively high because of elevated bacterial densities found in samples collected during the October 21 and 29 surveys (see above). Bacteriological densities at the quarterly stations were lower because these surveys occurred before the rains began. It is also possible that persistent northward surface currents helped drive storm-related contamination from more southern sources in to the waters off Point Loma (see Chapter 2). For example, even after a storm-related sewage overflow at the Point Loma Wastewater Treatment Plant on October 27 caused 2.2 MG of sewage to flow into the ocean, kelp station samples collected offshore of the treatment plant on October 29 were relatively low. The only samples with elevated bacterial densities were collected at southern kelp stations A1 (1-m sample) and A7 (1 and 12-m samples), but all had low fecal coliform values and were likely a result of stormwater contamination from San Diego Bay and the Tijuana River (see Chapter 2; Ocean Imaging 2005). In addition, maximum total and fecal coliform densities in samples from the kelp and the 18-m quarterly stations were all below their respective benchmarks during every month except October and December when stormwater runoff and possibly northward flowing currents affected nearshore water quality.

Bacteriological data from offshore stations suggested that the waste field was detected at stations around the PLOO discharge site to approximately 13 km (8.2 mi) to the north. Samples indicative of the possible waste field intrusion were only occasionally collected up to 5.9 km (3.7 mi) to the south of the PLOO. For example, approximately 88% of the samples with total coliform densities ≥ 1000 CFU/mL and F:T ratios ≥ 0.1 were collected at sites within approximately 2 km of the PLOO (i.e., stations F19, F29, F30, and F31) or to the north at stations F20–25 and F32–36 (see Appendix A.1). In contrast, about 9% were found to the south at stations F15–F18 and F26–F28. Collectively, these data suggest that the wastewater plume was limited primarily to depths greater than 60 m within the vicinity of the

## Table 3.6

Mean bacteria densities (CFU/100 mL) for January, April, July, and October sampling at PLOO quarterly offshore stations and kelp bed stations, by transect.

| Month | Station | Total | Fecal | Entero |
|---|---|---|---|---|
| *January* | 9-m kelp bed | 3 | 2 | 2 |
| | 18-m kelp bed | 15 | 3 | 2 |
| | 18-m quarterly | 4 | 2 | 2 |
| | 60-m quarterly | 94 | 18 | 5 |
| | 80-m quarterly | 483 | 230 | 37 |
| | 98-m quarterly | 982 | 437 | 79 |
| *April* | 9-m kelp bed | 3 | 2 | 2 |
| | 18-m kelp bed | 34 | 8 | 3 |
| | 18-m quarterly | 12 | 3 | 2 |
| | 60-m quarterly | 575 | 102 | 6 |
| | 80-m quarterly | 483 | 230 | 37 |
| | 98-m quarterly | 2114 | 752 | 75 |
| *July* | 9-m kelp bed | 3 | 2 | 2 |
| | 18-m kelp bed | 12 | 2 | 3 |
| | 18-m quarterly | 4 | 2 | 2 |
| | 60-m quarterly | 38 | 7 | 3 |
| | 80-m quarterly | 79 | 21 | 5 |
| | 98-m quarterly | 2180 | 963 | 80 |
| *October* | 9-m kelp bed | 227 | 32 | 11 |
| | 18-m kelp bed | 159 | 20 | 12 |
| | 18-m quarterly | 3 | 2 | 2 |
| | 60-m quarterly | 41 | 6 | 2 |
| | 80-m quarterly | 374 | 68 | 10 |

discharge site, but carried up to 13.3 km (8.2 mi) northward of the PLOO.

## SUMMARY AND CONCLUSIONS

Bacteriological data from water quality surveys of offshore stations suggest that discharge from the Point Loma Ocean Outfall (PLOO) rarely, if ever, impacted surface or nearshore recreational waters during 2004. Evidence of contamination along the shoreline and within the kelp bed was minimal, and limited primarily to periods associated with heavy rainfall and shore-based discharges. The single exception occurred at shore station D8 during September when this station experienced elevated bacterial counts during a prolonged dry period. However, visual observations recorded at the time of sampling suggest that recreational usage was the most likely cause of elevated counts at this site.

Overall rates of compliance with the four California Ocean Plan (COP) standards were high in 2004 despite the influences of heavy rainfall in February, October, and December. Water quality samples from the shoreline stations were over 80% compliant with the 30-day total and 60-day fecal coliform standards and 100% compliant with the 10,000 total coliform and geometric mean standards. Similarly, samples from the kelp bed stations were compliant with the 30-day total coliform standard over 95% of the time, and 100% of the time with all other COP standards. Incidences of non-compliance were primarily associated with rainfall events. For example, incidences of non-compliance at shore stations D8 and D11, located south of the San Diego River, were limited to October, November, and December following periods of the heaviest rainfall. Similarly, stations within the Point Loma kelp bed had incidents of non-compliance with the 30-day total coliform standard in November and December following particularly heavy rains and during periods of northward current flow. Patterns of bacterial concentration and visible satellite imagery data indicate that land-based sources were likely the cause of shoreline and near shore contamination during the year (see Ocean Imaging 2004, 2005). Sources of nearshore contamination in 2004 likely include discharge from north county lagoons, Mission Bay, the San Diego River, San Diego Bay, and as far south as the Tijuana River and Los Buenos Creek, Mexico. In certain cases (e.g., shore station D8), localized terrestrial runoff, or patterns of coastal recreation usage may also be responsible for sporadic high bacterial counts.

Throughout 2004, moderate and high levels of bacteria (>1000 CFU/100 mL) introduced to offshore waters by the PLOO discharge

were restricted to deep waters far from shore. Bacteriological data from offshore samples indicate that discharged materials were prevalent in the deeper waters immediately surrounding the outfall diffusers, with lateral transport northward. This lateral transport would have been parallel to shore and constrained to deeper waters. Contaminated waters that may be indicative of the waste field were also evident to the south, but were very infrequent. Northward transport of the waste field appeared to be the predominant pattern throughout the year.

In addition to minimal transport shoreward, the bacterial data from 2004 also indicate that the wastewater plume did not reach surface waters, even at stations directly above the outfall diffusers. Although physical characteristics of the water column suggest strong seasonal stratification, the lack of an increase in bacterial concentrations in surface waters during winter months indicates that seasonal stratification was not the primary factor limiting plume influences on local surface waters (see Chapter 2). The depth of discharge (94–98 m) into cold waters may in fact be the strongest factor restricting the wastewater plume to mid- and deep-water depths. Although research shows that vertical displacement of isothermal surfaces within the water column off Point Loma can be as dramatic as 40 m within a 6-hour time period (Hendricks 1994), data from the region do not indicate that such transport ever caused the plume to reach the surface in 2004.

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