Chapter 2. Oceanographic Conditions

INTRODUCTION

The City of San Diego monitors oceanographic conditions in the region surrounding the Point Loma Ocean Outfall (PLOO) in order to assess possible impacts from outfall discharge on the environment. Changes in current patterns, temperature, salinity, and density can affect the fate of the wastewater plume. They can also affect the distribution of turbidity plumes produced by non-point sources such as tidal exchange and runoff from San Diego Bay, Mission Bay, and the San Diego and Tijuana Rivers. These factors can either individually or synergistically determine the water quality within the Point Loma region.

The fate of wastewater discharged into deep offshore waters is determined by oceanographic conditions and other events that suppress or facilitate horizontal and vertical mixing. Consequently, measurements of physical and chemical parameters such as water temperature, salinity, and density are important components of ocean monitoring programs because these properties determine water column mixing potential (Bowden 1975). Analysis of the spatial and temporal variability of these 3 parameters as well as transmissivity, dissolved oxygen, pH, and chlorophyll may also elucidate patterns of water mass movement. Taken together, analyses of such measurements for the receiving waters surrounding the PLOO can help: (1) describe deviations from expected patterns, (2) reveal the impact of the wastewater plume relative to other inputs, (3) determine the extent to which water mass movement or mixing affects the dispersion/dilution potential for discharged materials, and (4) demonstrate the influence of natural events such as storms or El Niño/La Niña oscillations.

In the absence of information on deepwater currents, bacterial distributions may provide the best indication of horizontal transport of discharged waters (Picard and Emery 1990; see Chapter 3). Thus, the City of San Diego combines measurements of physical oceanographic parameters with assessments of bacterial concentrations to provide further insight into the transport potential surrounding a discharge throughout the year. This chapter describes the oceanographic conditions that occurred off Point Loma during 2005, and is referred to in subsequent chapters to explain patterns of bacteriological occurrence (see Chapter 3) or other changes in the local marine environment (see Chapters 4–7).

MATERIALS AND METHODS

Oceanographic measurements were collected at fixed sampling sites located in a grid pattern surrounding the PLOO (**Figure 2.1**). Thirty-six offshore stations (designated F01–F36) were

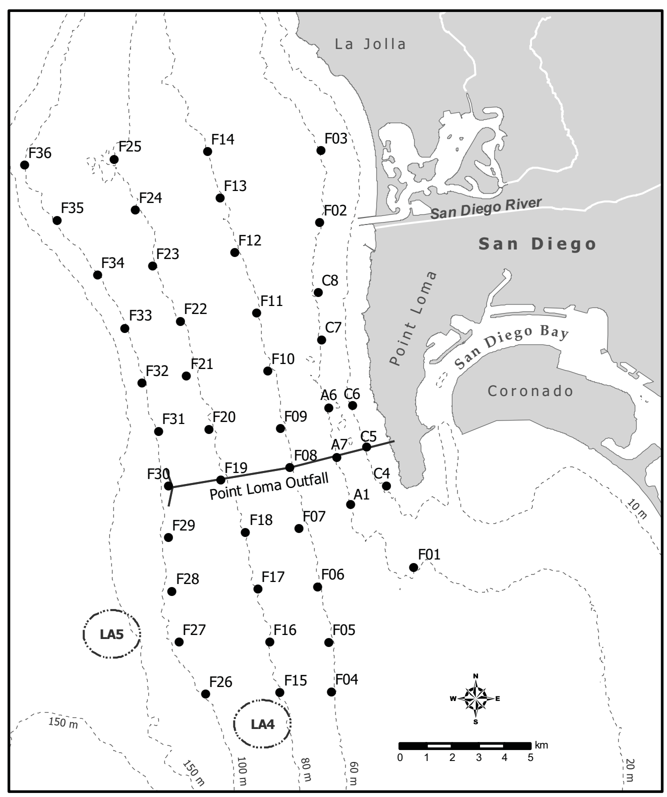

Figure 2.1
Locations of water quality monitoring stations where CTD casts are taken for the Point Loma Ocean Outfall Monitoring Program.

sampled quarterly in January, April, July, and October, usually over a 3-day period. Three of these stations (F01–F03) are located along the 18-m depth contour, while 11 sites are located along each of the following depth contours: 60-m contour (stations F04–F14); 80-m contour (stations F15–F25); 98-m contour (stations F26–F36). Eight additional stations located in the Point Loma kelp bed are subject to the 2001 California Ocean Plan (COP) water contact standards (SWRCB 2001). These stations include 3 sites (stations C4, C5, C6) located along the inshore edge of the kelp bed paralleling the 9-m depth contour, and 5 sites (stations A1, A6, A7, C7, C8) located along the 18-m depth contour near the offshore edge of the kelp bed. To meet the COP sampling frequency requirements for kelp bed areas, sampling at the 8 kelp bed stations was conducted 5 times per month.

Oceanographic measurements of temperature, salinity, density, pH, transmissivity (water clarity), chlorophyll *a*, and dissolved oxygen were collected by lowering a SeaBird conductivity, temperature, and depth (CTD) instrument through the water column. Profiles of each parameter were constructed for each station by batch process averaging of the data values recorded over 1-m depth intervals. This ensured that physical measurements used in subsequent data analyses corresponded with bacterial sampling depths. Further details regarding the CTD data processing are provided in the City's Quality Assurance Plan (City of San Diego in prep). Visual observations of water color and clarity, surf height, human or animal activity, and weather conditions were also recorded prior to each CTD sampling event. Mean chlorophyll *a* data were calculated for depths between surface and 15 meters for water quality stations from the Point Loma and South Bay regions. Maps of average chlorophyll *a* distribution were generated with an inverse distance weighted interpolation algorithm in ArcView.

Monitoring of the PLOO area and neighboring coastline also included aerial and satellite image analysis performed by Ocean Imaging (OI) of Solana Beach, CA. All usable images captured during 2005 by the Moderate Resolution Imaging Spectroradiometer (MODIS) satellite were downloaded, and several high clarity Landsat Thematic Mapper (TM) images were purchased monthly. Aerial images were collected with OI's DMSC-MKII digital multispectral sensor (DMSC). Its 4 channels were configured to a specific wavelength (color) combination which, according to OI's previous research, maximizes the detection of the PLOO plume's turbidity signature by differentiating between the wastewater plume and coastal turbidity. The depth penetration of the sensor varies between 8 and 15 meters, depending on overall water clarity. The spatial resolution of the data is dependent upon aircraft altitude, but is typically maintained at 2 meters. Several aerial overflights were performed each month for a total of 11 flights from January to April and November to December and 6 flights from May to October.

RESULTS AND DISCUSSION

Expected Seasonal Patterns of Physical and Chemical Parameters

Southern California weather can be classified into 2 basic seasons, wet (winter) and dry (spring through fall), and certain patterns in oceanographic conditions track these seasons. Each year, typical winter conditions are present in January and February as shown in a 5 year summary of annual changes in local ocean temperatures (**Figure 2.2**). A high degree of homogeneity within the water column is the normal winter signature for all physical parameters, although storm water runoff may intermittently influence density profiles by causing a freshwater lens within nearshore surface waters. The chance that the wastewater plume may surface is highest during these winter months when there is little, if any, stratification of the water column. These conditions often extend into March, when a decrease in the frequency of winter storms brings about the transition of seasons.

In late March or April, surface waters begin to warm and re-establish the seasonal thermocline and pycnocline to local coastal and offshore waters. Once water column stratification becomes established by

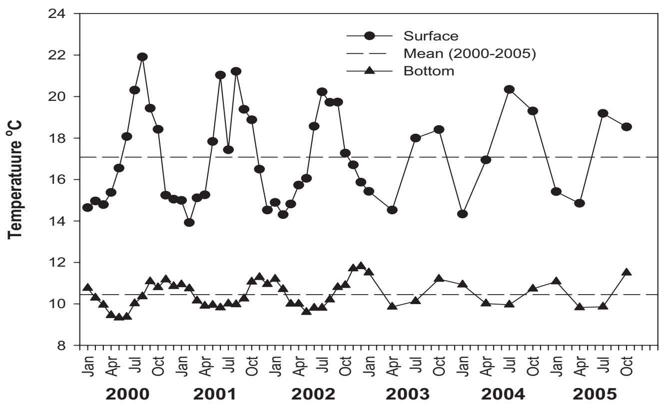

Figure 2.2
Average monthly surface and bottom temperatures (°C) for 2000–2005 compared to overall mean temperatures for 2000–2005.

late spring, minimal mixing conditions tend to remain throughout the summer and early fall months, with occasional interruptions by upwelling events. In October or November, cooler temperatures, reduced solar input, and increased stormy weather cause the return of the well-mixed, homogeneous waters that are characteristic of winter months. Despite a sampling schedule that is spread out over several days during each month, analyses of oceanographic data collected off Point Loma over the past 27 years support this pattern.

Observed Seasonal Patterns of Physical and Chemical Parameters

The record rainfall of October and December 2004 continued into early 2005, with above average rains occurring during January and February (**Figure 2.3A**, NOAA/NWS 2005). Normal conditions returned in March, continued through October, and were followed by drought conditions in November and December. Unseasonably warm air temperatures approaching the upper confidence limit for the historical averages occurred from January to March, and in May, and November (Figure 2.3B). Local weather conditions may have contributed to increased surface water temperatures during spring and summer, and decreased in salinity and transmissivity during the first part of the year, especially at the nearshore kelp bed stations (**Table 2.1**). Despite these circumstances, thermal stratification of the water column followed normal

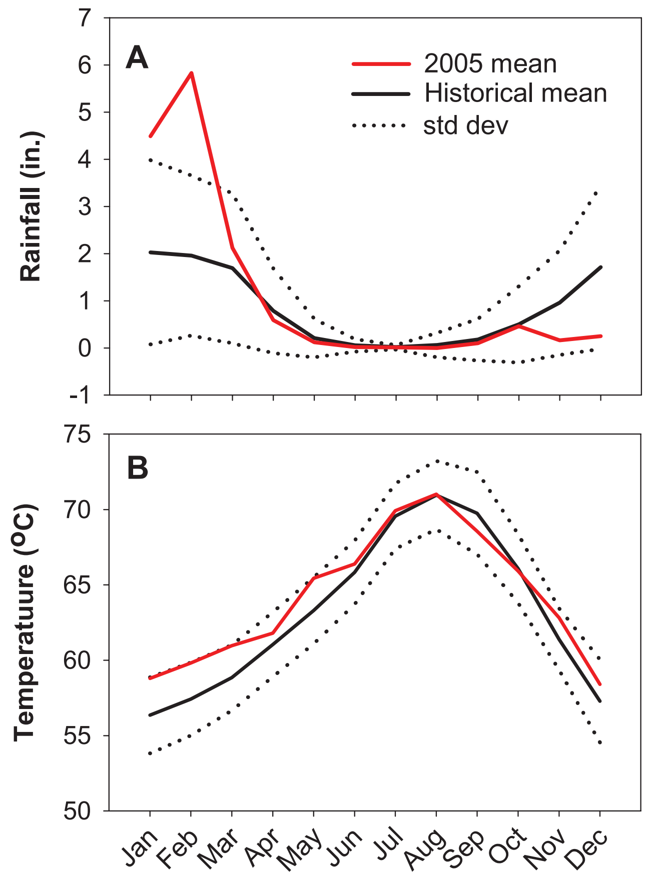

Figure 2.3
Total rainfall (A) and mean air temperatures (B) at Lindbergh Field (San Diego, CA) for each month in 2005 compared to monthly averages (+/-1 standard deviation) for the historical period 1914–2004.

seasonal patterns at both nearshore and offshore sampling areas off Point Loma.

Quarterly surface water temperatures at the offshore stations averaged from 14.8 to 19.2 °C, with the highest temperatures occurring in July and October (**Table 2.2**). Surface temperatures in January were approximately 1 °C warmer than the previous year while temperatures for April were about 2 °C cooler (**Table 2.3**). Temperatures for July and October were approximately 1 °C cooler than those of 2004. Bottom waters ranged from 9.8 to 11.5 °C and were similar to those of the previous year except during October when temperatures were nearly 1 °C warmer.

Monthly water temperatures at the kelp stations followed a similar pattern (Table 2.1). Mean surface temperatures in the kelp beds from

Table 2.1

Mean values of temperature (Temp, °C), salinity (ppt), density (δ/θ), dissolved oxygen (DO, mg/L), pH, transmissivity (XMS, %), and chlorophyll *a* (Chl *a,* µg/L) for top (≤2 m) and bottom (9 and 18 m) waters at all PLOO kelp station stations during 2005.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp	*Surface*	15.2	15.5	16.0	15.0	17.7	18.4	19.4	19.3	17.3	17.6	16.5	15.0
	Bottom	15.0	14.4	12.4	11.6	11.5	11.9	12.1	11.9	11.9	13.5	14.2	13.3
Salinity	*Surface*	32.77	32.89	32.74	33.38	33.43	33.54	33.52	33.42	33.41	33.37	33.37	33.41
	Bottom	33.16	33.19	33.42	33.65	33.65	33.64	33.55	33.49	33.50	33.43	33.38	33.42
Density	*Surface*	24.21	24.25	24.01	24.71	24.12	24.05	23.77	23.72	24.21	24.12	24.37	24.75
	Bottom	24.56	24.70	25.29	25.61	25.62	25.54	25.43	25.42	25.45	25.07	24.89	25.12
DO	*Surface*	7.9	8.2	8.4	9.4	8.5	8.7	9.4	10.2	8.9	7.8	7.3	7.8
	Bottom	7.0	6.9	5.1	4.6	4.7	3.9	5.3	5.0	4.6	5.5	5.8	6.2
pH	*Surface*	8.1	8.1	8.2	8.3	8.2	8.3	8.4	8.3	8.3	8.2	8.3	8.1
	Bottom	8.0	8.0	7.9	7.9	7.9	7.8	7.9	7.8	7.9	8.0	8.1	8.0
XMS	*Surface*	61	71	62	72	78	69	71	73	76	75	79	82
	Bottom	56	77	70	84	84	84	86	85	84	83	83	76
Chl *a*	*Surface*	2.17	2.19	3.61	6.46	2.80	9.90	10.91	9.41	3.48	3.14	2.58	2.75
	Bottom	1.93	1.67	1.92	3.72	2.85	1.49	2.31	2.02	2.77	1.95	1.94	1.95

January through March of 2005 ranged from 15.2 to 16.0 °C, which was slightly warmer than the previous year. Coincident with a subsequent decline in air temperature and possible upwelling (see below), April surface temperatures dropped slightly to 15.0 °C. The seasonal warming of the nearshore waters began in May, and mean surface waters ranged between 17.7 and 19.4 °C from May through August. Surface temperatures declined in September and October to about 17.0 °C, and then continued to decline through December (15.0 °C). Bottom waters at the kelp stations ranged from 11.5 to 15.0 °C during the year. Relative to 2004, bottom water temperatures in 2005 were over 1 °C warmer in January and February, but 0.9–3.2 °C cooler the rest of the year.

Thermal stratification in 2005 generally followed the typical annual pattern (**Figure 2.4**). Seasonal stratification of the upper water column at quarterly stations was absent in January with surface and mid-level waters differing by only 0.1 °C (**Table 2.4**). By April, mid-depth waters declined 3.6 °C, from 15.3 °C (January) to 11.7 °C (April), and a stratified upper water column had developed. Surface waters were highly stratified in July. Mean temperatures were above 19 °C at this time and differed from mid-level and bottom waters by 6.4 and 9.3 °C, respectively. Stratification continued into October, with a 4.1 °C difference between surface and mid-depth waters. The shallower kelp stations showed a similar pattern, with stratification beginning in March and breaking down in November (see Figure 2.5, Table 2.1). Bottom waters were generally much cooler than surface or mid-level waters over the 4 quarterly surveys, with temperatures at least 4.3 °C colder than surface waters, and 1.9 °C cooler than mid-level waters (Table 2.4). Since temperature is the main contributor to water column stratification in southern California (Dailey et. al. 1993), these differences were important to limiting the surfacing potential of the waste field to depths below 60 m (see Chapter 3). Although a region-wide phytoplankton bloom (see below) likely prevented Ocean Imaging's DMSC camera from penetrating much below 10 m depth, aerial imagery acquired

Table 2.2

Quarterly average values of temperature (Temp, °C), salinity (ppt), density (δ/θ), dissolved oxygen (DO, mg/L), pH, transmissivity (XMS, %), and chlorophyll *a* (Chl *a,* μg/L), for top (≤2 m), mid-depth (10–20 m), and bottom (≥88 m) waters at all quarterly PLOO stations during 2005 (stations F01–F36).

		Jan	Apr	Jul	Oct
Temp	*Surface*	15.4	14.8	19.2	18.5
	Mid	15.3	11.7	12.8	14.5
	Bottom	11.1	9.8	9.9	11.5
Salinity	*Surface*	32.62	33.31	33.48	33.40
	Mid	33.10	33.53	33.50	33.41
	Bottom	33.55	34.09	33.88	33.75
Density	*Surface*	24.1	24.7	23.8	23.9
	Mid	24.4	25.5	25.3	24.9
	Bottom	25.6	26.3	26.1	25.7
DO	*Surface*	8.6	9.9	8.7	8.8
	Mid	8.0	6.9	8.3	8.0
	Bottom	4.8	3.0	3.9	3.2
pH	*Surface*	8.1	8.3	8.3	8.3
	Mid	8.1	8.0	8.1	8.1
	Bottom	7.8	7.8	7.8	7.7
XMS	*Surface*	80	76	79	84
	Mid	84	82	83	84
	Bottom	90	91	90	90
Chl *a*	*Surface*	4.0	6.2	5.0	4.3
	Mid	3.2	7.6	7.2	6.1
	Bottom	0.6	0.5	0.4	0.6

for the Point Loma area confirmed that the plume remained below surface waters throughout the year (see Ocean Imaging 2005a, b, c, 2006).

Surface water salinity was strongly influenced by above normal rainfall that occurred early in the year. Surface salinity at the offshore stations averaged from 32.62 to 33.48 ppt in 2005, with storm related runoff reducing mean surface salinity to <33.0 ppt in January (Table 2.2). The effects of storm runoff were stronger at the shallow kelp stations where mean surface salinity was <33.0 ppt from January through March (Table 2.1). Seawater density, a function of temperature, salinity, and

Table 2.3

Differences between the surface (≤2 m) and bottom (≥88 m) waters for mean values of temperature (°C) at all PLOO stations during 2000–2005. The greatest differences (Δ) between surface and bottom values are in bold type.

		2000	2001	2002	2003	2004	2005
January	*Surface*	14.6	15.0	14.9	15.4	14.3	15.4
	Bottom	10.8	10.9	11.2	11.5	10.9	11.1
	Δ	3.8	4.1	3.7	3.9	3.4	**4.3**
April	*Surface*	15.4	15.3	15.7	14.5	16.9	14.8
	Bottom	9.5	9.9	10.0	9.8	10.0	9.8
	Δ	5.9	5.4	5.7	4.7	**6.9**	5.0
July	*Surface*	20.3	17.4	20.2	18.0	20.3	19.2
	Bottom	10.0	10.0	9.8	10.0	10.0	9.9
	Δ	10.3	7.4	**10.4**	8.0	10.3	9.3
October	*Surface*	18.4	18.9	17.3	18.4	19.3	18.5
	Bottom	10.8	11.1	10.9	11.2	10.7	11.5
	Δ	7.6	7.8	6.4	7.2	**8.6**	7.0

pressure, reflected the changes brought about by the increased storm activity at the beginning of 2005. Water density was slightly lower during January at the quarterly stations and during January–March at the nearshore kelp stations where the influence of storm runoff was stronger. Generally, offshore water density throughout the water column from April through October was similar to densities in 2004.

Density increased in April as the result of a decline in surface and mid-level water temperatures (Table 2.2). This change was more apparent at the kelp stations where relatively dramatic changes in salinity and density were also apparent (Figure 2.5). These cooling events are similar to those of previous years and may be the result of localized upwelling or inshore movement of water originating from the California current.

Data for the various other measured parameters (i.e., pH, transmissivity, chlorophyll *a*, dissolved oxygen) mostly varied in response to sporadic natural events, such as storm activity and the increased primary productivity associated with a persistent local red tide event. Increased turbidity following rainfall

Table 2.4

Average temperature differences (°C) between surface waters (≤2 m), mid-depth waters (10–20 m) and bottom waters (≥88 m) surrounding the PLOO during 2005.

	Surface vs Mid	Surface vs Bot	Mid vs Bot
January	0.1	4.3	4.3
April	3.1	5.0	1.9
July	6.4	9.3	3.0
October	4.1	7.0	3.0

events was readily visible in satellite and aerial imagery (see Ocean Imaging 2005a, b, 2006), and data from transmissivity measurements generally supported these aerial observations. For example, aerial images from January through March revealed increased discharge of turbid waters from San Diego Bay, Mission Bay, the San Diego River, and more northern sources following storm activity (Ocean Imaging 2005a). During this period, the PLOO region was also affected periodically by northward-reaching runoff from the Tijuana River due to the combined effects of excessive runoff volume and relatively frequent northward current episodes (i.e., from April through December) (**Figure 2.5A**). When southerly currents prevailed, the PLOO region was subject to heavy sediment loads originating at the mouth of the San Diego River, and southward-advected effluent originating from North County lagoons (Figure 2.6B).

In April, a regional phytoplankton bloom developed that was apparent in aerial imagery and which strongly affected nearshore and offshore water clarity. This bloom developed into a red tide and persisted throughout the remainder of the year (**Figure 2.6**). The presence of the phytoplankton bloom was also apparent in CTD profile data. For example, mean chlorophyll *a* values at quarterly offshore stations in April reached 7.6 µg/L in mid-depth waters, with a maximum value of 91 µg/L occurring in July. Similarly, the nearshore kelp stations had mean chlorophyll *a* values >9 µg/L from June through August, with values as high as 70 µg/L in June and August (see City of San Diego 2005a, b, c, d). CTD profile data also included high dissolved oxygen levels (>10 mg/L) and decreased transmissivity values (<80% light transmission) that corresponded to

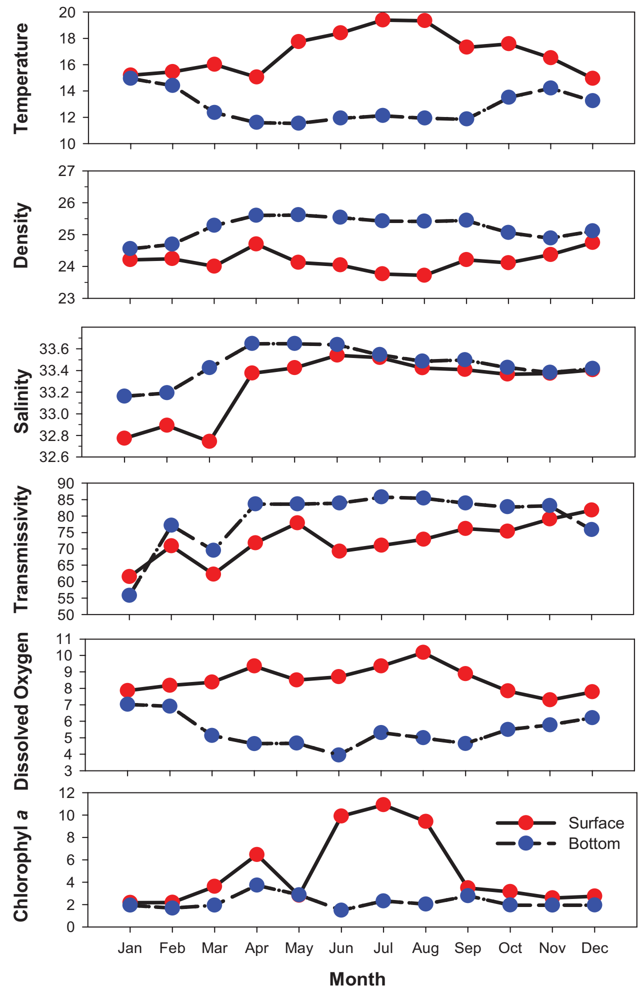

Figure 2.4

Average temperature (°C), density (δ/θ), salinity (ppt), transmissivity (%), dissolved oxygen (mg/L), and chlorophyll *a* (µg/L) for surface (<2 m) and bottom waters for the Point Loma nearshore kelp bed stations sampled during 2005.

increased chlorophyll *a* concentrations.

A bloom of the dinoflagellate *Lingulodinium polyedra was the primary cause of the* red tides present in the region from April through October. This species has dominated the Southern California Bight since 1995. Gregorio and Pieper (2000) have found that this species persists at the Los Angeles River mouth from winter through summer and that river runoff during the rainy season provides significant amounts of nutrients that allow for rapid population increases. Runoff containing agricultural and effluent materials from the Tijuana River during the heavy rains of January through March most likely contributed to the widespread red tides observed in the South Bay (City of San

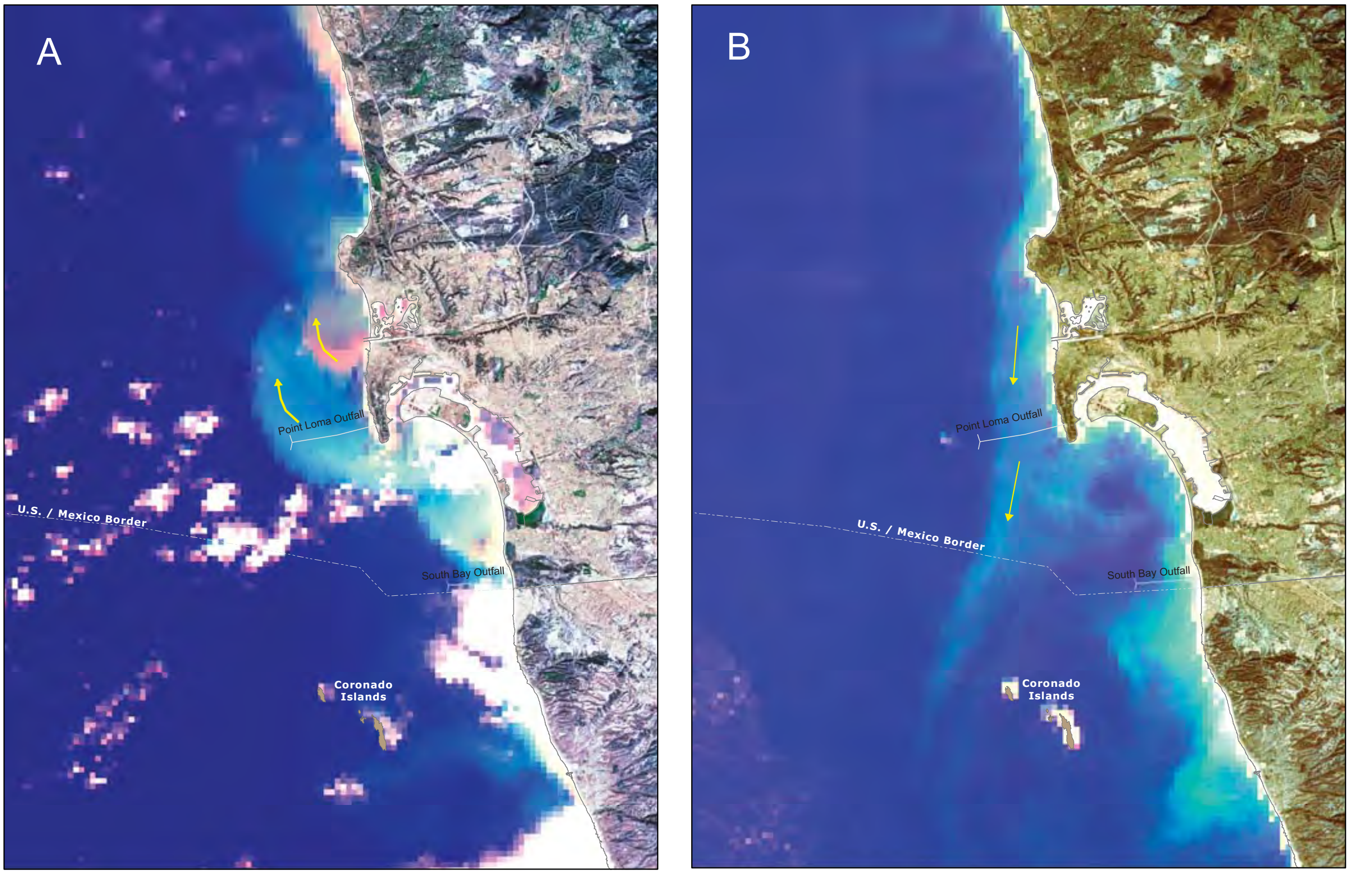

Figure 2.5
MODIS satellite images showing the San Diego water quality monitoring region with turbidity plumes indicating direction of surface current flow: (A) February 23, northward flow; (B) April 12, southward flow. White pixels in the MODIS image represent areas obscured by cloud cover offshore or "washout" or band saturation due to the histogram stretches used to enhance turbidity features in surface waters along the shoreline.

Diego 2006) (see **Figure 2.7**). High chlorophyll *a* values near the mouth of the San Diego River and Mission Bay during July suggest that these areas are also sources of nutrients that may have contributed to the development of the phytoplankton bloom.

SUMMARY AND CONCLUSIONS

The record rainfall of October and December 2004 that continued into early 2005 resulted in heavy runoff and turbid waters both inshore and offshore in the Point Loma region. In addition, air temperatures were unseasonably warm during January–March, May, and November. Despite these circumstances, oceanographic conditions during 2005 generally followed normal seasonal patterns. Surface water temperatures at the offshore stations were cool in January and April and warmest in July and October. In contrast, bottom temperatures were warmer in January and October and cooler during April and July. These conditions contributed to the typical cycle of water column thermal stratification, with seasonal stratification developing in spring. Although the greatest difference between surface and botom water temperatures occurred in July and declined thereafter, evidence of stratification remained apparent in nearshore waters through November.

Surface water salinity was lower during a period of above average rainfall during January–March, particularly in nearshore waters. Surface salinity early in the year was less than 33.0 ppt as a result of freshwater input from heavy rains and the resulting river and bay discharge. Salinity increased to more normal levels of >33.3 ppt from March to April. Seawater density values corresponded to lower

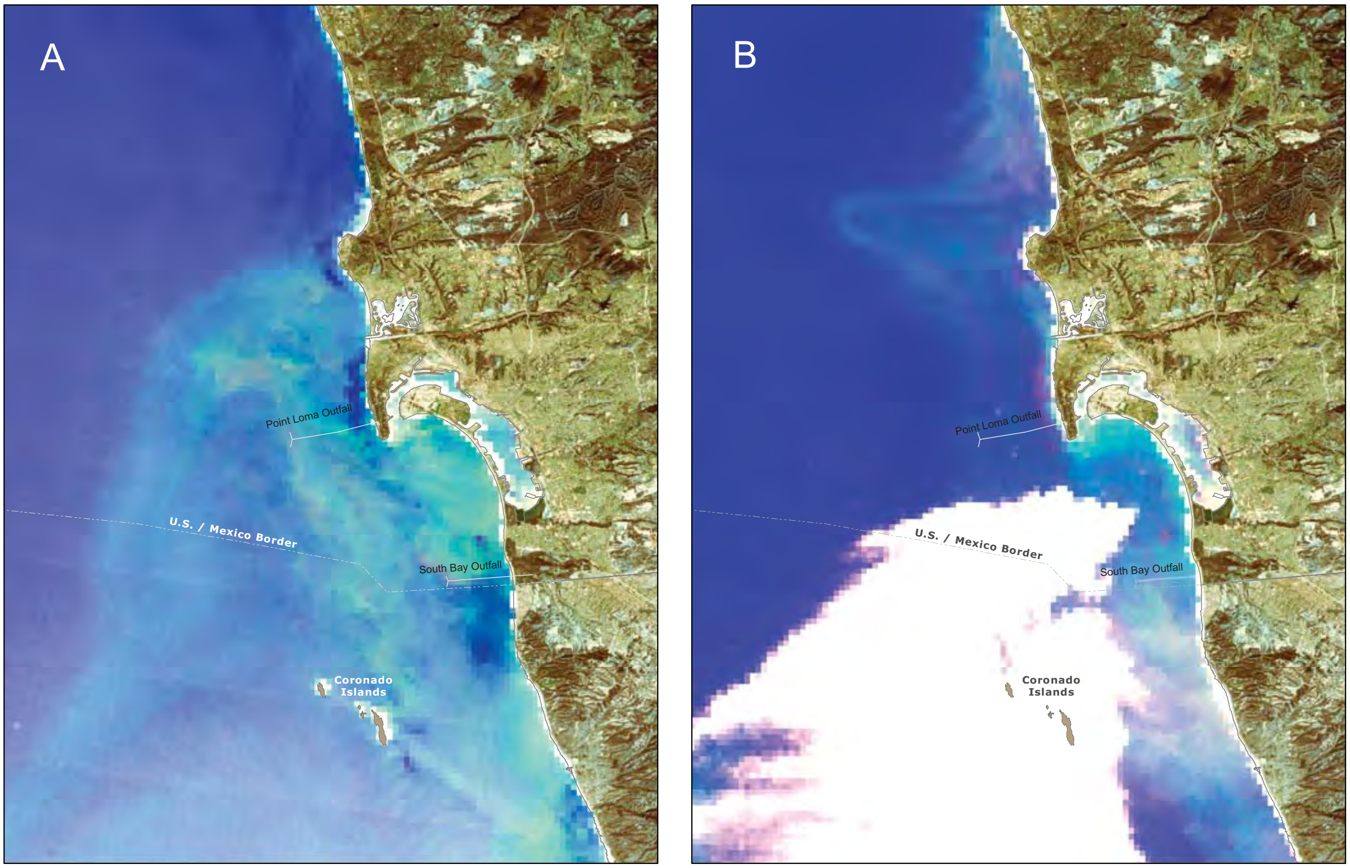

Figure 2.6
Satellite imagery of the Point Loma region acquired on (A) August 28, 2005 and (B) September 29, 2005. Both images show a red tide bloom extending over the outfall area.

salinity values during January through March, but returned to normal conditions from April through December.

Aerial and satellite imagery indicated that water clarity during 2005 was affected by sediment resuspension and embayment flushing following the heavy rainfall from January through March, and by a long lasting red tide that developed in April and persisted throughout the year. These events caused a decrease in surface water transmissivity, and increases in chlorophyll *a* and dissolved oxygen concentrations. Patterns in surface water turbidity resulting from these events indicated northward surface current patterns were relatively common during January through February, but southward surface flow with occasional northward reversals was dominant from April through December. When southerly currents prevailed, particularly in the latter part of the year, the PLOO region was affected by sediment-bearing surface plumes originating from the San Diego River and North County lagoons. Despite the limited visibility afforded by the reduced water clarity, aerial imagery collected throughout the year confirmed that the PLOO plume was not detected in surface waters during 2005, and was most likely restricted to lower depths by thermal stratification from March through November. Analysis of the physical water column properties in conjunction with aerial and satellite imagery acquired of the area surrounding Point Loma indicate that wastewater discharged via the PLOO did not reach either inshore sites or surface waters. Even during the winter months when water column stratification was weakest, there was no indication that the wastewater plume reached depths shallower than 60 m. These conditions are important to the analysis of spatial patterns of bacterial concentrations discussed in the following chapter.

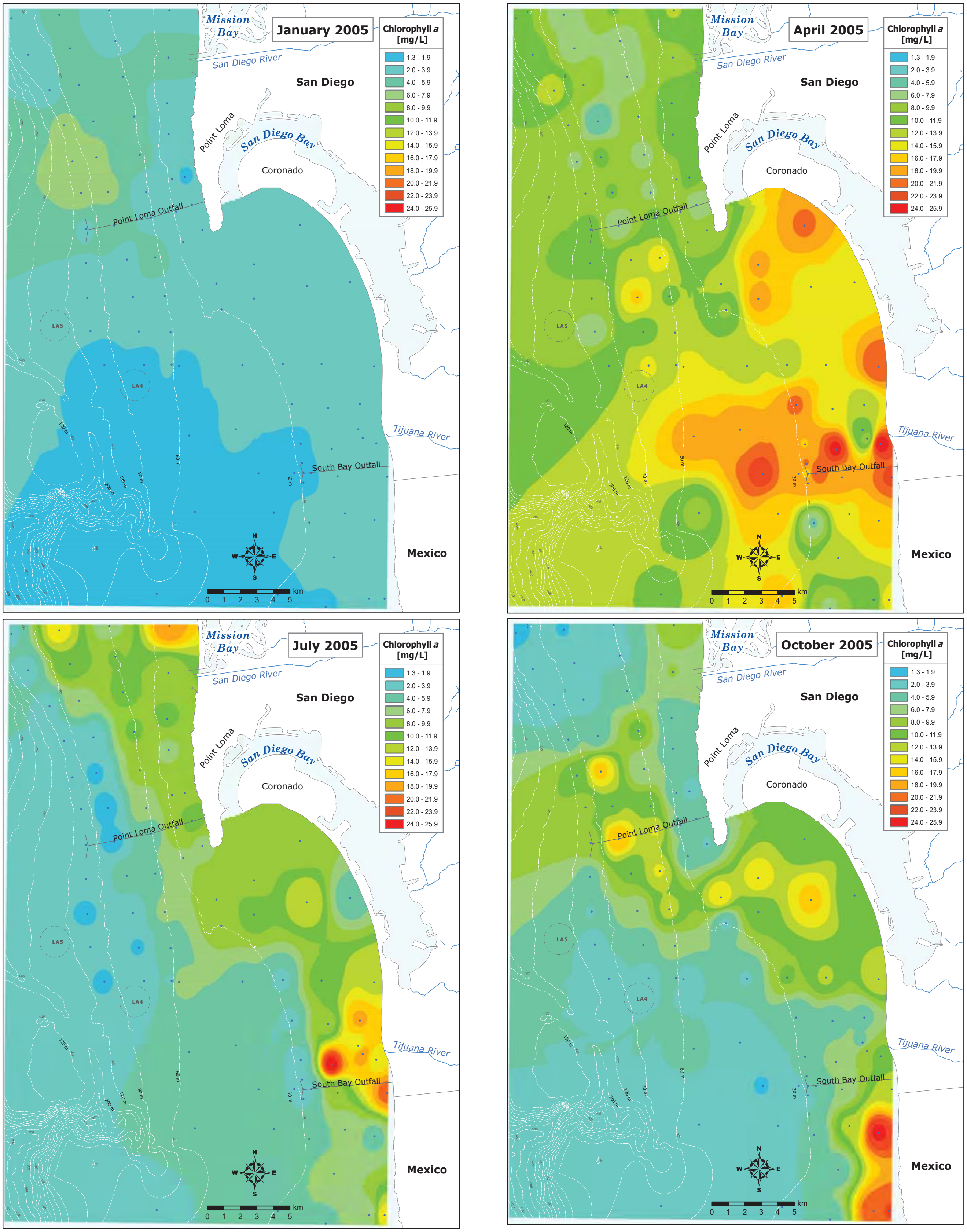

Figure 2.7

GIS plots of mean surface (0–15 m depth) chlorophyll *a* concentrations (µg/L) for the San Diego coast for January, April, July, and October of 2005.

LITERATURE CITED

Bowden, K.F., 1975. Oceanic and Estuarine Mixing Processes. In: Chemical Oceanography, 2nd Ed., J.P. Riley and G. Skirrow, eds. Academic Press, San Francisco. Pp 1–43.

City of San Diego. (2005a). Monthly Receiving Waters Monitoring Report for the Point Loma Ocean Outfall, April 2005. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

City of San Diego. (2005b). Monthly Receiving Waters Monitoring Report for the Point Loma Ocean Outfall, June 2005. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

City of San Diego. (2005c). Monthly Receiving Waters Monitoring Report for the Point Loma Ocean Outfall, July 2005. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

City of San Diego. (2005d). Monthly Receiving Waters Monitoring Report for the Point Loma Ocean Outfall, August 2005. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

City of San Diego. (2006). Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (South Bay Water Reclamation Plant), 2005. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

City of San Diego. (in prep). EMTS Division Laboratory Quality Assurance Project Plan. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

Dailey, M.D., Reish, D.J. and Anderson, J.W. (eds.) (1993). Ecology of the Southern California Bight: A Synthesis and Interpretation. University of California Press, Berkeley, CA. 926 pp.

Gregorio, D.E. and R.E. Pieper. (2000). Investigations of Red Tides Along the Southern California Coast. Southern California Academy of Sciences. Vol. 99, No. 3. pp147–160.

NOAA/NWS. (2005). The National Oceanic and Atmospheric Association and the National Weather Service Archive of Local Climate Data for San Diego, CA. http://www.wrh.noaa.gov/sandiego/climate/lcdsan-archive.htm

Ocean Imaging. (2005a). Satellite and Aerial Coastal Water Quality Monitoring in The San Diego / Tijuana Region: Monthly Report for January, February and March 2005. Solana Beach, CA.

Ocean Imaging. (2005b). Satellite and Aerial Coastal Water Quality Monitoring in The San Diego / Tijuana Region: Monthly Report for April & May 2005. Solana Beach, CA.

Ocean Imaging. (2005c). Satellite and Aerial Coastal Water Quality Monitoring in The San Diego / Tijuana Region: Monthly Report for June, July, August & September 2005. Solana Beach, CA.

Ocean Imaging. (2006). Satellite and Aerial Coastal Water Quality Monitoring in The San Diego / Tijuana Region: Monthly Report for October, November and December 2005. Solana Beach, CA.

[SWRCB] California State Water Resources Control Board. (2001). California Ocean Plan, Water Quality Control Plan, Ocean Waters of California. California Environmental Protection Agency. Sacramento, CA.

Pickard, D.L, and W. J. Emery. 1990. Descriptive Physical Oceanorgraphy. 5Th Ed. Pergamon Press, Oxford. 320 pp.

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