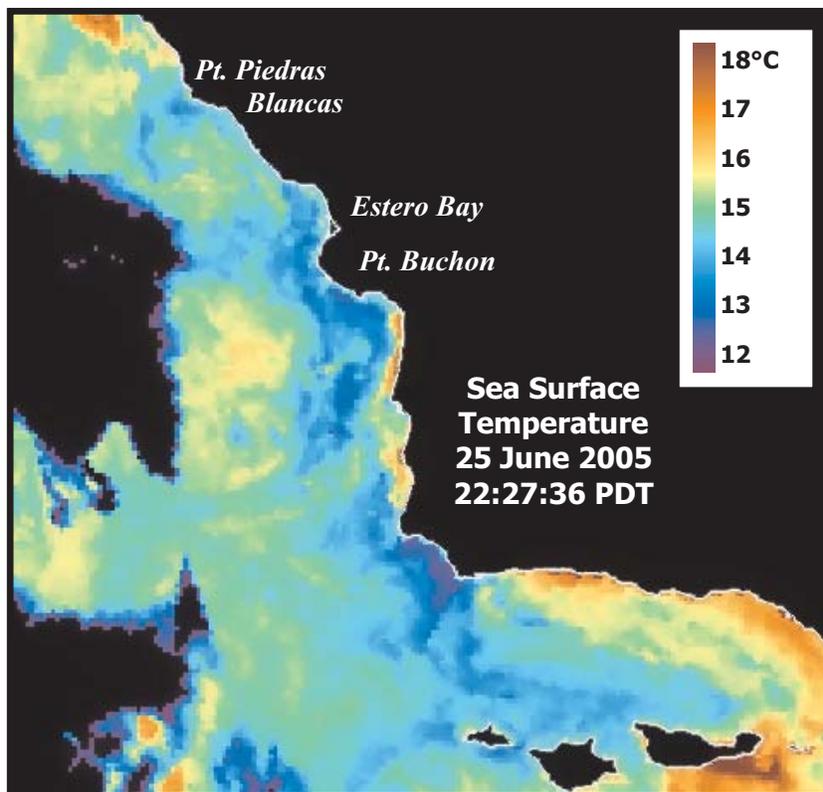**City of Morro Bay and**
Cayucos Sanitary District

OFFSHORE MONITORING AND REPORTING PROGRAM

QUARTERLY REPORT

WATER-COLUMN SAMPLING JULY 2005 SURVEY

Marine Research Specialists

3140 Telegraph Rd., Suite A
Ventura, California 93003

Report to

**City of Morro Bay and
Cayucos Sanitary District**

**955 Shasta Avenue
Morro Bay, California 93442
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OFFSHORE MONITORING
AND
REPORTING PROGRAM

QUARTERLY REPORT

WATER-COLUMN SAMPLING
JULY 2005

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August 2005

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Mr. Bruce Keogh   27 August 2005
Wastewater Division Manager
City of Morro Bay
955 Shasta Avenue
Morro Bay, CA 93442

Reference: Quarterly Receiving-Water Report – July 2005

Dear Mr. Keogh:

Enclosed is the Quarterly Report for the Water-Quality Survey conducted on 1 July 2005. This third-quarter survey assessed the effectiveness of effluent dispersion during summer oceanographic conditions. Based on quantitative analyses of continuous instrumental measurements and qualitative visual observations, the wastewater discharge was found to be in compliance with the receiving-water limitations specified in the NPDES discharge permit, and with the objectives of the California Ocean Plan.

Very slight lateral perturbations in five seawater properties marginally delineated the effluent signature below the thermocline near the southwest boundary of the zone of initial dilution. Dilution levels determined from salinity anomalies within the discharge plume exceeded those anticipated by modeling and outfall design criteria. The discharge-related anomalies in other water properties except transmissivity were generated by the upward displacement of ambient seawater, rather than the presence of wastewater constituents. A highly localized decrease in water clarity immediately above the seafloor at one of the stations was ascribed to the presence of diffuse wastewater particulates. All of the measurements were indicative of low contaminant concentrations within the discharged wastewater, and of an outfall operating as designed.

Please contact the undersigned if you have any questions regarding this report.

Sincerely,

Douglas A. Coats, Ph.D.
Program Manager

Enclosure (Seven Copies)

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Mr. Bruce Ambo
City of Morro Bay

Date _____

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INTRODUCTION

The City of Morro Bay and the Cayucos Sanitary District (MBCSD) jointly own the wastewater treatment plant operated by the City of Morro Bay. A National Pollutant Discharge Elimination System (NPDES) permit, modifying secondary treatment requirements, was issued to the City of Morro Bay and the Cayucos Sanitary District in December 1998 (Permit No. CA0047881). The permit was issued by Region 9 of the Environmental Protection Agency (EPA) and the Central-Coast California Regional Water Quality Control Board (RWQCB-EPA, 1998a). The previous permit expired in early 1998. An administrative extension was granted through 11 December 1998 to allow time for review and issuance of a new discharge permit (RWQCB, 1998).

As part of the new permit provisions, the previous monitoring program was modified to better evaluate short- and long-term effects of the discharge on receiving waters, benthic sediments, and infaunal communities (RWQCB-EPA, 1998b). The program continued to include a requirement for receiving-water-quality monitoring performed on a seasonal basis. Four quarterly surveys were intended to record ambient water properties that approximate winter, spring, summer, and fall conditions. In keeping with seasonal synopses, this quarterly report summarizes the results of water-quality sampling conducted on 1 July 2005. Specifically, this third-quarter survey was conducted in July to capture ambient oceanographic conditions along the central California coast during the summer season.

The water-quality surveys also provide timely assessments of the performance of the diffuser structure in dispersing wastewater within highly stratified receiving waters. Any significant, recent damage to the diffuser structure would be revealed by a decline in the level of wastewater dispersion measured in this survey compared to that of prior surveys, and compared to design specifications. As described in this report, no such decline was observed.

Both monitoring objectives were achieved through an evaluation of the water-column profiles and vertical sections of water-property distributions that are presented in Appendix A. Appendix B tabulates instrumental measurements and standard field observations. These data were used to assess compliance with the objectives of the California Ocean Plan (COP) as specified in the NPDES discharge permit.

The July-2005 field survey was the twenty-seventh receiving-water survey to be conducted under the monitoring provisions of the current permit. Compared to the previous permit, the number of stations increased from 11 to 16, and the stations were relocated closer (≤100 m) to the diffuser structure. Sampling at these more closely spaced stations could only be achieved because of the availability of increased navigational accuracy that resulted from implementation of the differential global positioning satellite (DGPS) system. This system was commissioned during the March 1998 survey (MRS, 1998a) and was subsequently employed in the precise determination of the open section of the diffuser structure during a diver survey on 29 September 1998 (MRS, 1998bc).

The current sampling design also allowed surveying to be conducted more rapidly than before by eliminating the requirement for the time-consuming collection of discrete water samples using Niskin bottles. Continuous deployment of the CTD[1] instrument package between stations now provides a more synoptic snapshot of the water properties immediately surrounding the diffuser structure. Consequently,

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[1] Conductivity, Temperature, and Depth (CTD) were the original measurements collected by this standard oceanographic instrument package but the moniker now connotes an electronic instrument package with a broader suite of probes and sensors capable of *in situ* measurement of dissolved oxygen, transmissivity, and pH.

the extent of the effluent plume and the amplitude of its associated water-property anomalies can be more precisely determined. The highly sensitive sensors in the CTD instrument package are capable of detecting minute changes in water properties. These sensors are described in the Methods section below.

Surveys conducted prior to 1999 rarely detected the effluent plume because sampling stations were too widely separated to resolve the dilute wastewater signature that is highly localized around the outfall diffuser. With the implementation of the current sampling design in 1999, the presence of well-mixed effluent near the diffuser structure was found in all 26 of the subsequent water-quality surveys (MRS, 2000, 2001, 2002, 2003, 2004, 2005), including the one described in this report. Moreover, improved navigation in concert with the denser sampling pattern more precisely delineated the location of the discharge-related perturbations in seawater properties.

Precision navigation is important for assessing compliance because most receiving-water limitations apply only beyond the narrow zone of initial dilution that surrounds the outfall. Additionally, the amplitudes of the effluent-related perturbations are better determined by the denser sampling pattern. The amplitudes of discharge-related salinity anomalies reveal the dilution experienced by the effluent plume. Dilution factors lend insight into the operational performance of the outfall and diffuser structure. As described in this report, the presence of dilute effluent undergoing turbulent mixing close to the diffuser structure was clearly delineated by the data collected during the July-2005 survey.

STATION LOCATIONS

The water-sampling stations surround the area where effluent is discharged within Estero Bay (Figure 1). The 1,450-m long outfall pipe, which carries the effluent from the onshore treatment plant, terminates at the diffuser structure, which lies on the seafloor approximately 827 m from the shoreline[2]. The diffuser structure itself extends an additional 52 m toward the northwest from the outfall terminus.

Twenty-eight of the 34 available ports discharge effluent along a 42-m section of the diffuser structure. The remaining six diffuser ports remain closed to improve dispersion by increasing the ejection velocity from the remaining ports. For a given flow rate, the diffuser ports were hydraulically designed to create an ejection jet, which serves to rapidly mix effluent with receiving seawater immediately upon discharge. Additional turbulent mixing occurs as the buoyant plume of dilute effluent rises through the water column. Most of this buoyancy-induced mixing occurs within a zone of initial dilution (ZID), whose lateral extent is approximately 15 m from the centerline of the diffuser structure.

Beyond the ZID, the energetic waves, tides, and coastal currents within Estero Bay further disperse the discharge plume within the open-ocean receiving waters. Areas of special concern, such as sanctuaries and estuaries, are too distant to be affected by the effluent discharge. For example, the southern boundary of the Monterey Bay National Marine Sanctuary is located 38 km to the north, near Cambria Rock. Similarly, although the entrance to the Morro Bay National Estuary lies only 2.8 km to the south of the discharge, direct seawater exchange between the discharge point and the Bay is restricted by the southerly orientation of the mouth of the Bay, and by the presence of Morro Rock. Morro Rock is the largest

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[2] This distance was determined from a navigational survey conducted on 6 July 2005 to benchmark the locations of the current surfzone sampling stations along the shoreline adjacent to the diffuser structure. The beginning of the section of the diffuser structure containing open diffuser ports lies directly offshore surfzone Station C (Figure 1). This closest-approach shoreline position was determined at the water's edge when the tidal level was +2.7 ft, referenced to mean lower low water (MLLW).

Figure 1. Regional Setting of Receiving-Water Sampling Stations within Estero Bay

physiographic feature of the adjacent coastline and extends into Estero Bay approximately 2 km south of the point of discharge (Figure 1). Its presence blocks the direct incursion of unmixed wastewater into the Bay.

Near the diffuser, prevailing currents generally follow bathymetric contours, which parallel the north-south trend of the adjacent coastline. Because of rapid initial mixing achieved within 15 m of the diffuser structure, impingement of unmixed effluent onto the adjacent coastline 827 m away is highly unlikely. Nevertheless, water samples are regularly collected along the shoreline at the surfzone sampling stations shown in Figure 1.

These surfzone samples are analyzed for total and fecal coliform levels. Results of these analyses are reported in monthly operational summaries and in annual reports. The occasional instances of elevated beach coliform levels result from onshore non-point sources rather than the discharge of disinfected wastewater from the MBCSD outfall (MRS, 2000, 2001, 2002, 2003, 2004, 2005).

As shown in Figure 2, the water-sampling design consists of 16 fixed offshore stations located within 100 m of the outfall diffuser structure. The target locations of the 16 offshore sampling stations are indicated by the red ⊙ symbols in the Figure. Stations are situated at three distances relative to the center of the diffuser structure to capture any discharge-related trends in water properties. Six of the stations lie along a north-south axis at the same water depth (15.2 m) as the diffuser centroid. Stations 3 and 4 are positioned at the upcoast and downcoast boundaries of the ZID, at a distance of 15 m from the closest diffuser ports (Table 1). Stations 2 and 5 are located at nearfield distances (60 m) from the diffuser centroid. Stations 1 and 6 represent reference stations and are situated 100 meters upcoast and downcoast of the centroid. Depending on the direction of the local oceanic currents at the time of sampling, one or more of these near and midfield stations could conceivably be influenced by the discharge. Under those circumstances, the midfield station on the opposite side of the diffuser can act as a reference station. Comparisons of water properties at these antipodal stations quantify departures from ambient seawater properties so that compliance with the NPDES discharge permit can be evaluated.

Six other stations (7 through 12) were aligned along a cross-shore transect in a pattern matching that of the along-shore transect. The four additional nearfield stations (13 through 16) measure the nearfield influence of effluent transported by ocean currents flowing at oblique angles to the bathymetry.

Although the discharge is considered a '*point source*,' it does not occur at a point of infinitesimal size. Instead, the discharge is distributed along a 42-m section of the seafloor. This finite size is an important consideration when assessing wastewater dispersion close to the discharge. Because of the finite length of

Table 1. Description of Receiving-Water Monitoring Stations

Station	Description	Latitude	Longitude	Closest Approach Distance[1] (m)	Center Distance[2] (m)
1	Upcoast Midfield	35° 23.253' N	120° 52.504' W	88.4	100
2	Upcoast Nearfield	35° 23.231' N	120° 52.504' W	49.4	60
3	Upcoast ZID	35° 23.210' N	120° 52.504' W	15.0	20
4	Downcoast ZID	35° 23.188' N	120° 52.504' W	15.0	20
5	Downcoast Nearfield	35° 23.167' N	120° 52.504' W	49.4	60
6	Downcoast Midfield	35° 23.145' N	120° 52.504' W	88.4	100
7	Offshore Midfield	35° 23.199' N	120° 52.570' W	85.8	100
8	Offshore Nearfield	35° 23.199' N	120° 52.544' W	46.7	60
9	Offshore ZID	35° 23.199' N	120° 52.519' W	15.0	23
10	Onshore ZID	35° 23.199' N	120° 52.489' W	15.0	23
11	Onshore Nearfield	35° 23.199' N	120° 52.464' W	46.7	60
12	Onshore Midfield	35° 23.199' N	120° 52.438' W	85.8	100
13	Southwest Nearfield	35° 23.176' N	120° 52.532' W	59.8	60
14	Northwest Nearfield	35° 23.222' N	120° 52.532' W	40.2	60
15	Northeast Nearfield	35° 23.222' N	120° 52.476' W	59.8	60
16	Southeast Nearfield	35° 23.176' N	120° 52.476' W	40.2	60

[1] Distance to the closest open diffuser port.
[2] Distance to the center of open diffuser section.

the discharge, the amount of wastewater dispersion at a given point in the water column is dictated by its

Figure 2. Offshore Water Sampling Locations on 1 July 2005
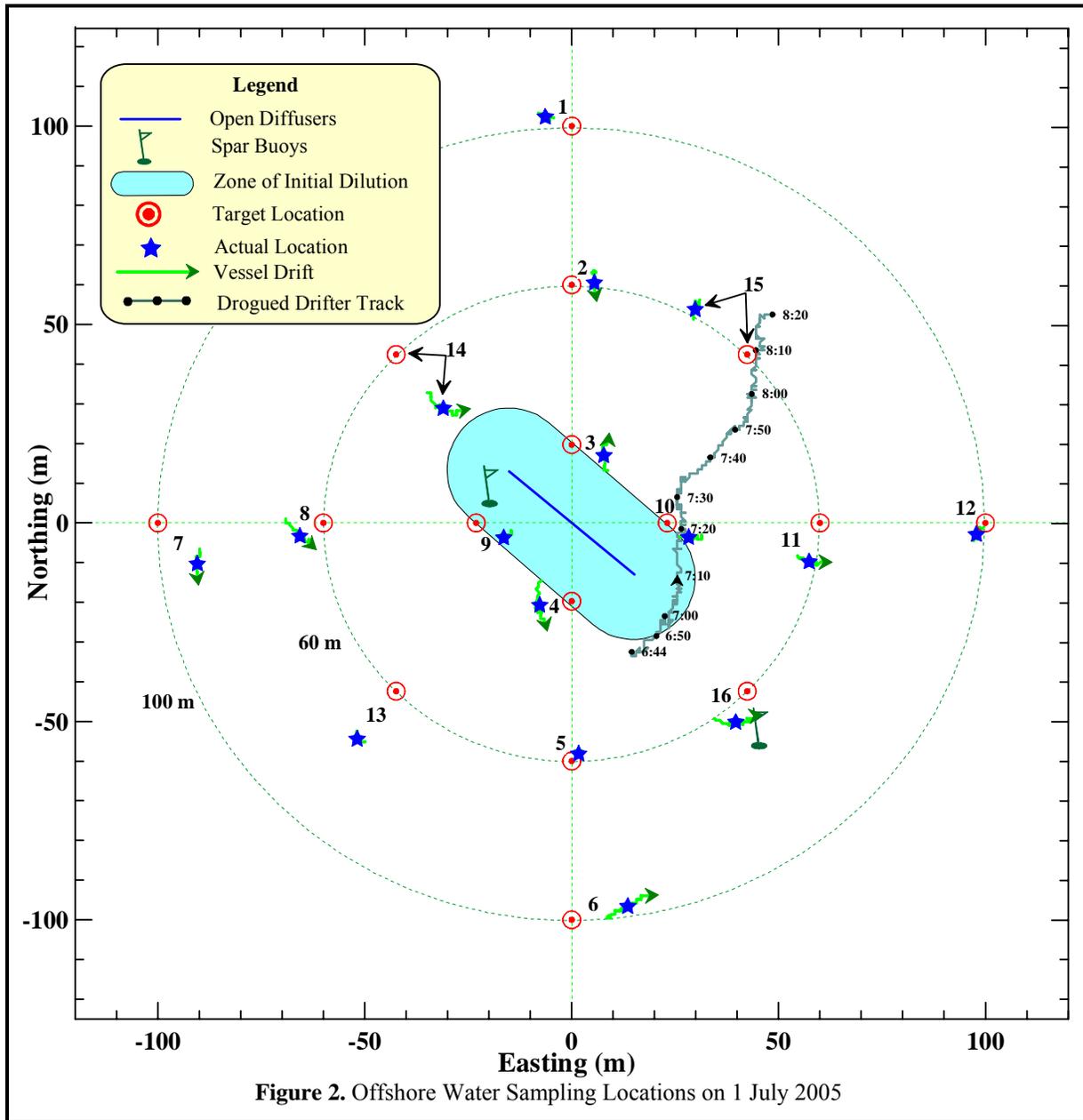
distance to the closest diffuser port, rather than its distance to the center of the diffuser structure. Because of the finite size of the source, this '*closest approach*' distance is considerably less than the centerline distance normally cited in modeling studies (Table 1).

Station positioning within the compact sampling pattern became feasible only after the advent of DGPS. The accuracy of traditional navigation systems such as LORAN or standard GPS is typically ±15 m, a span approaching the width of the ZID itself. Prior to 2 May 2000, standard commercial GPS receivers were not allowed to be perfectly accurate by law; and a built-in-error system called Selective Availability (SA) was encoded into GPS transmissions. SA could introduce a misreading of up to 100 meters, although it altered most measurements by less than 30 meters. After May 2000, SA was turned off and the

accuracy of standard GPS receivers improved substantially, with horizontal position errors of typically less than 10 m.

Nevertheless, extreme atmospheric conditions and physiographic obstructions can cause signals to bounce around, leading to errors in position beyond those that were previously introduced by SA. These other errors are greatly reduced with the Differential GPS (DGPS) system that was first implemented by the U.S. Coast Guard. DGPS incorporates a second signal from a nearby land-based beacon. Because the beacon is fixed at a known location, the position error in the reading from the GPS satellites can be precisely calculated at any given time. This correction is continuously transmitted to the DGPS receiver onboard the survey vessel and results in extremely stable and accurate offshore navigation, typically with position errors of less than 4 m.

At the beginning of 1998, the survey vessel F/V *Bonnie Marietta* was fitted with a Furuno™ GPS 30 and FBX2 differential beacon receiver. This navigational system was used on 29 July 1998 to precisely locate the position of the open section of the diffuser structure (MRS, 1998b) and establish the new target locations for the receiving-water monitoring stations shown in Figure 2 and listed in Table 1.

In addition, DGPS allows precise determination of sampling locations during individual water-quality surveys. Knowledge of the precise location of the actual sampling sites relative to the diffuser position is crucial for accurate interpretation of the water-property fields. During any given survey, the actual sampling locations do not coincide with the exact target coordinates listed in Table 1. Winds, waves, and currents induce offsets during sampling. Using DGPS, these offsets can be resolved and the vessel location can be precisely tracked during sampling at each station. This is an important consideration because vertical profiling conducted at an individual station can cover a large horizontal distance relative to the ZID. The magnitude of this horizontal drift is apparent in Figure 2 from the length of the green tracklines. These tracklines trace the horizontal location of the CTD instrument package as it was lowered to the seafloor at each station. The horizontal drift of the CTD instrument package was unusually small during July-2005 sampling due to the relatively quiescent wind and current conditions that prevailed at the time.

The CTD tracklines shown in Figure 2 show perceptible drift at only about half of the stations. Nevertheless, the horizontal drift in the position of the CTD as it was lowered to the seafloor at stations close to the diffuser structure complicated the assessment of compliance with discharge limitations. In particular, downcasts at Stations 3, 4, and 10 traversed the boundary of the ZID, and all of the measurements at Station 9 were collected within the ZID. Receiving-water limitations specified in the COP only apply to measurements collected beyond the ZID boundary because within the ZID, rapid initial turbulent mixing associated with the effluent discharge is expected to occur.

Compliance assessments notwithstanding, measurements collected close to the diffuser structure within the ZID lend valuable insight into the outfall's effectiveness at dispersing wastewater during this particular survey. Damaged or broken diffuser ports would be reflected by low dilution rates and measurements of concentrated effluent throughout ZID. Without measurements collected within the ZID, the discharge plume would probably go undetected. This was the case in nearly every water-quality survey conducted prior to 1999, before the denser sampling pattern now in use was instituted.

Surveys prior to 1999 also predated the advent of DGPS. Consequently, the 6.4-m average drift experienced during sampling at each station would not have been resolved with the navigation available at the time. In fact, before 1999, sampling was presumed to occur at a single, imprecisely determined, horizontal location near each station. For consistency with past surveys, a single reportable sampling

location was also determined for each station during the July-2005 survey. These were based on the average location as shown by the blue stars in Figure 2. Average positions are also listed in Table 2, along with their distance from the diffuser structure. However, based on the foregoing discussion, the distance between the average station position and the ZID does not determine whether all the measurements at that station are subject to the receiving-water objectives in the COP. For example, 20.6-m closest-approach distance specified for Station 10 would suggest that all of the data at Station 10 was collected well outside of the ZID. In reality, as shown by the green tracklines in Figure 2, the near-surface measurements were collected within the ZID where water-quality limitations do not apply.

The vessel drift indicted by the green tracklines in Figure 2 was largely dictated by the complex interaction of wind forces and residual vessel momentum remaining after station approach. As summarized in Table B-8, light variable winds prevailed throughout the survey, and made vessel positioning somewhat easier than is the case in most surveys. Oceanic currents typically play a smaller role in determining vessel positioning, particularly when current speeds are low, as was the case during the July-2005 survey.

In contrast to the variable wind direction, current flow in the upper water column was consistently toward the northeast as shown by the drifter track in Figure 2. The grey line with black dots shown in Figure 2 traces the path of the satellite-tracked drifter. It is designed to drift with the subsurface current, with little influence from the wind. Each dot along the drifter trackline represents a time span of five minutes. The drogued drifter was deployed near the diffuser structure at 06:44. The drifter was recovered at 08:20 PDT at a location 91.5 m north-northeast of its deployment location. In a time span of one hour and 36 minutes, it traveled at an average speed of 1.6 cm/s or 0.03 knots along a direction of 21.8°T.

Table 2. Average Coordinates of Vertical Profiles in July 2005

| Station | Time (PDT) | | Latitude | Longitude | Closest Approach | |
	Downcast	Upcast			Range[1](m)	Bearing[2](ºT)
1	6:55:26	6:56:37	35° 23.254' N	120° 52.508' W	90.0	6
2	6:59:42	7:00:52	35° 23.232' N	120° 52.500' W	52.0	23
3	7:05:23	7:06:42	35° 23.208' N	120° 52.499' W	**18.1 [3]**	41
4	7:09:05	7:10:18	35° 23.188' N	120° 52.509' W	**20.6 [3]**	221
5	7:12:53	7:14:21	35° 23.168' N	120° 52.503' W	47.0	197
6	7:16:46	7:18:09	35° 23.147' N	120° 52.495' W	83.4	181
7	7:44:16	7:45:28	35° 23.194' N	120° 52.564' W	78.8	253
8	7:39:45	7:41:06	35° 23.197' N	120° 52.547' W	53.0	252
9	7:35:31	7:36:55	35° 23.197' N	120° 52.515' W	**13.3 [4]**	221
10	7:31:43	7:32:56	35° 23.197' N	120° 52.485' W	**16.2 [3]**	54
11	7:27:53	7:29:06	35° 23.194' N	120° 52.466' W	42.4	85
12	7:22:31	7:23:45	35° 23.198' N	120° 52.439' W	83.3	83
13	8:28:13	8:29:23	35° 23.170' N	120° 52.538' W	74.9	221
14	8:12:55	8:14:07	35° 23.215' N	120° 52.524' W	22.6	315
15	8:17:40	8:18:42	35° 23.228' N	120° 52.484' W	60.4	41
16	8:22:54	8:24:02	35° 23.172' N	120° 52.478' W	44.4	147

[1] Distance from the closest open diffuser port. Observations collected within the ZID shown in bold
[2] Direction measured clockwise in degrees from true north from the closest diffuser port to the actual sampling location.
[3] Portions of the CTD cast were within the ZID boundary.
[4] All of the CTD (Conductivity-Temperature-Depth) cast was within the ZID boundary.

Figure 3. Estero Bay Tidal Level during the Field Survey of 1 July 2005
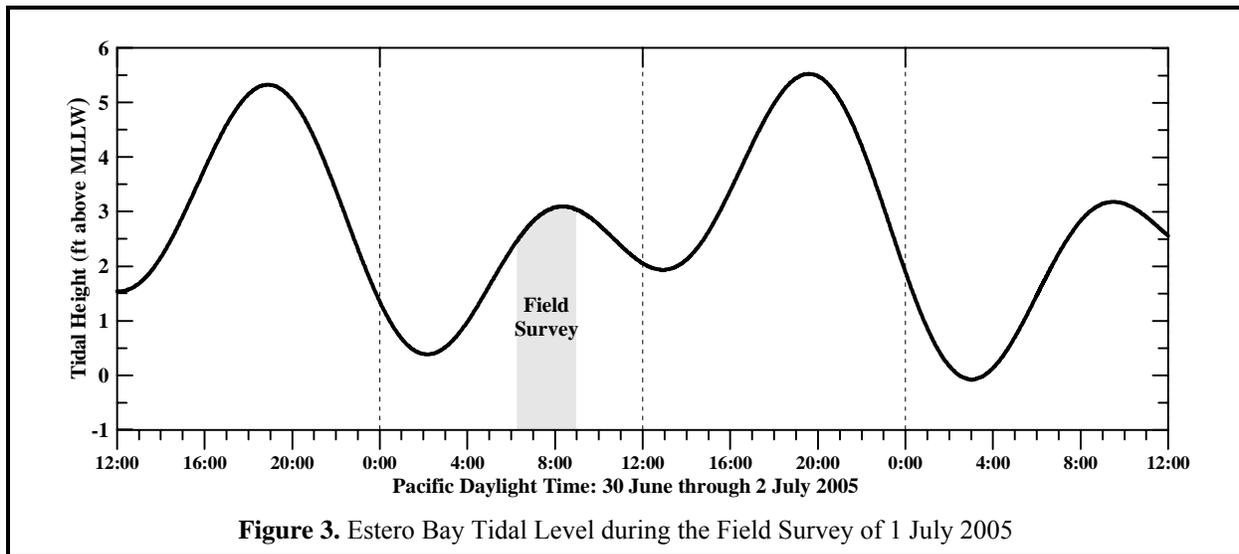
The weak northeastward (shoreward) flow that was measured by the drogued drifter was consistent with the incoming (flood) tide that prevailed during the survey (Figure 3). In the absence of external influences, a flood tide normally induces a weak northeastward flow in the survey region. However, the flow is often also influenced by external processes, such as wind-generated upwelling. Strong upwelling conditions prevailed prior to the survey as is apparent in the satellite image on the cover of this report. The image was recorded on five days prior to the survey when skies were clear enough for sea-surface temperatures to be measured by infrared sensors on NOAA's polar orbiting satellite.

The intense upwelling that occurred around the time of the survey was largely responsible for the strong water-column stratification that was evident around the outfall in vertical profiles collected with the CTD (Figures A-1 through A-3 in Appendix A). Upwelling season normally begins sometime during late March and or early April when there is a "spring transition" to more persistent southward-directed winds along the Central California Coast. The spring transition is marked by the stabilization of a high atmospheric pressure field over the northeastern Pacific Ocean. Clockwise winds around this pressure field drive the prevailing northwesterly winds along the Central Coast. The prevailing winds move surface waters southward and offshore. To replace these coastal surface waters, deep, cool, nutrient-rich waters upwell near the coast as delineated in the cover image with blue (13°C) water along the shoreline. For example, the satellite image shows that sea-surface temperatures were near or below 13°C within Estero Bay. This is consistent with the near-surface temperatures measured by the CTD during the survey, which were at or below 12.77°C as shown in Table B-1 in Appendix B.

The nutrient-rich seawater that is brought to the sea surface by upwelling enables phytoplanktonic blooms that are the foundation of the productive marine fishery found along the California coast. The cross-shore flow associated with persistent upwelling conditions also leads to vertical stratification of the water column. The resulting shallow (<10 m) thermocline is commonly maintained throughout the summer and into the fall. In contrast, winter oceanographic conditions are generally characterized by a vertically uniform water column that has been well mixed by intense winds generated by passing local storm fronts and large waves produced in distant Pacific storms.

METHODS

The 38-ft F/V *Bonnie Marietta*, owned and operated by Captain Mark Tognazzini of Morro Bay, served as the survey vessel on 1 July 2005. Dr. Douglas Coats and Mr. Carlos Penaloza of Marine Research Specialists (MRS) provided scientific support. Captain Mark Tognazzini supervised vessel operations, while Mr. Marc Tognazzini acted as marine technician. Secchi depth measurements and standard observations for weather, seas, water clarity/coloration, and the presence of any odors, floating debris, and oil and grease were recorded during the survey. Wind speeds and air temperatures were measured with a Kestrel® 2000 Thermo-Anemometer. These ancillary observations were collected during the rapid water-column profiling that was conducted at each station using a CTD instrument package.

Ancillary Measurements

At all stations, a Secchi disk was lowered through the water column to determine its depth of disappearance (Table B-8). Secchi depths provide a visual measure of near-surface turbidity or water clarity. The depth of disappearance is inversely proportional to the average amount of organic and inorganic suspended material along a line of sight in the upper water column. As such, the Secchi depth measures natural light penetration, which can be limited by increased suspended particulate loads from plankton blooms, onshore runoff, seafloor resuspension, and wastewater discharge. It is also of biological significance because the depth of the euphotic zone, where most oceanic photosynthesis occurs, extends to approximately twice the Secchi depth. The comparatively shallow euphotic zone observed during the July-2005 survey, which only reached to a depth of approximately 8 m, is fairly typical of upwelling conditions when increased primary productivity results in decrease light transmissivity in the upper water column.

Secchi depths are less precise than measurements collected by the transmissometer mounted on the CTD instrument package. For example, the visibility of the disk, and hence its depth of disappearance, depends on the amount of natural light available at the time of the measurement. Thus, the Secchi depth reading can artificially change by as much as 0.5 m depending on whether the sample is taken on the sunny or shady side of the boat. Moreover, a temporal drift in the measurements can be introduced as the sun rises in the sky while the survey progresses. Nevertheless, Secchi depth measurements reflect general turbidity levels within the upper portion of the water column, including waters within a meter of the sea surface where, because of the physical size of the CTD package, the transmissometer cannot record turbidity.

During the July-2005 survey, a satellite-tracked drifter was deployed near the center of the open section of the diffuser structure. The drifter was drogued at mid-depth (7 m) using the curtain-shade design of Davis *et al* (1982). In this configuration, the drifter's trajectory was largely dictated by the oceanic flow field rather than by surface winds. The time and precise position of the drifter deployment and recovery were recorded. The July-2005 survey was the fourth MBCSD survey to continuously record the drifter position throughout its deployment. In the past, the average ambient flow velocity during each survey was estimated solely from the deployment and recovery positions. However, during the July-2005 survey, the added satellite-tracking capability of the drifter revealed some curvature in the path of the drifter as shown in Figure 2. Drifter data collected in most prior surveys lacked information on this and other short-term flow fluctuations that can occur within the duration of a survey.

Instrumental Measurements

Vertical water-column profiling was conducted using an electronic instrument package equipped with a number of probes and sensors. A Sea Bird Electronics SBE-19 Seacat CTD package was used to collect profiles of conductivity, salinity, temperature, light transmittance, dissolved oxygen (DO), pH, density, and pressure at each station. A submersible pump on the CTD continuously flushed water through the conductivity cell and oxygen plenum at a constant rate, independent of the CTD's motion through the water column. After the October-2001 survey, the CTD was returned to the factory for full testing, repair, and calibration. Temporal drifts in the oxygen and alkalinity readings during the October-2001 survey indicated that the sensitivity of these probes had degraded because of an accumulation of marine growth. During the factory repair, the pH probe was replaced and the electrolyte in the oxygen sensor was refurbished. The entire CTD system was then recalibrated at the factory. Upon return of the instrument, the transmissivity, dissolved oxygen, and pH sensors were recalibrated at the MRS laboratory. Calibration coefficients determined at the factory and by MRS were nearly identical, and confirmed the accuracy and stability of the refurbished sensors.

The DO and pH sensors were again returned to the factory in May 2003 for testing and recalibration. Because of increasing temporal drift associated with the aging DO probe, it was replaced with a new DO probe. As is the case before all surveys, the CTD system was recalibrated at the MRS laboratory prior to the July-2005 survey. Calibration at upper-bound DO concentrations was established by immersing the CTD in an aerated, temperature-controlled calibration tank. In addition to oxygen readings at full saturation, a zero-oxygen calibration point was determined by filling the oxygen-sensor plenum with an 8% solution of sodium sulfite (Na_2SO_3). Oxygen calibration coefficients were determined by regression analysis of sensor-membrane current and temperature, as recommended by the manufacturer (SBE, 1993). As with prior factory calibrations, pre-cruise calibration coefficients determined by MRS closely corresponded to those determined by the factory.

A prolonged equilibration time of the pH sensor has been an ongoing challenge that has required removal of temporal trends in the pH data collected in most surveys, even those following the pH-sensor replacement. Laboratory tests conducted in conjunction with pre-cruise calibrations have demonstrated that the equilibration time is reduced if the sensor is immersed in water prior to deployment. This was accomplished during the July-2005 survey by attaching a water-filled hose to the sensor during transit to the survey area. Immediately prior to deployment, the hose was removed. Although this procedure did not entirely eliminate the temporal offsets, it markedly reduced their amplitude. The required pH adjustments were small, and less than 0.05 pH units.

During the pre-cruise calibration, coefficients for the pH (alkalinity) sensor were determined from a linear regression of output voltage after immersion in three separate buffered solutions of known pH. Buffering solutions with a pH of 4±0.01, 7±0.01, and 10±0.02 were used to bracket the range of *in situ* measurements. The SeaTech transmissometer was air calibrated by fitting the voltages recorded with and without blocking of the light transmission path in air, as recommended by the manufacturer (SBE, 1989). Revised calibration coefficients determined prior to the survey were used in the algorithms that convert sensor voltage to engineering units when the field data were processed. Comparison with the factory calibration of the entire CTD package that was conducted in December 2001 confirmed the continued accuracy and stability of the temperature, pressure, and conductivity sensors, as well as the operational integrity of the oxygen and pH probes.

Six seawater properties were used to assess receiving-water quality in this report. They were derived from the continuously recorded output from the probes and sensors on the CTD. Depth limitations on the

Table 3. Instrumental Specifications for CTD Profiler

Component	Depth[1]	Units	Range	Accuracy	Resolution
Housing	600	—	—	—	—
Pump	3400	—	—	—	—
Pressure	680	Psia	0 to 1000	± 5.0	± 0.5
Depth	—	Meters	0 to 690	± 3.0	± 0.3
Conductivity	600	Siemens/m	0 to 6.5	± 0.001	± 0.0001
Salinity	600	‰	0 to 38	± 0.006	± 0.0006
Temperature	600	ºC	−5 to 35	± 0.01	± 0.001
Transmissivity	2000	%	0 to 100	± 0.1	± 0.025
Dissolved Oxygen	200	mg/L	0 to 21.5	± 0.14	± 0.014
Acidity/Alkalinity	200	pH	0 to 14	± 0.1	± 0.006

[1] Maximum depth limit in meters

combination oxygen/pH sensor confine the CTD to depths less than 200 m (Table 3), which is well beyond the maximum depth of the deepest station in the outfall survey. The precision and accuracy of the various probes, as reported in manufacturer's specifications, are also listed in the Table. Salinity (‰) was calculated from conductivity (Siemens/m) measurements. Density was derived from contemporaneous temperature (°C) and salinity data. It was expressed as 1000 times the specific gravity minus one, which is a unit of sigma-T (σ_t).

All three of these physical parameters (salinity, temperature, and density) were used to determine the lateral extent of the effluent plume. Additionally, they define the layering (vertical stratification) of the receiving waters, which determines the behavior and dynamics of the wastewater as it mixes with seawater within the ZID. Data on three remaining seawater properties, consisting of light transmittance (water clarity), hydrogen-ion concentration (acidity/alkalinity – pH), and dissolved oxygen (DO), further characterize receiving waters, and were used to assess compliance with water-quality criteria. Light transmittance was measured as a percentage of the transmitted beam of light detected at the opposite end of a 0.25-m path. Increased transmittance indicates increased water clarity and decreased turbidity.

Before deployment at the initial station, the CTD was held below the sea surface for a six-minute equilibration period. Subsequently, the CTD was raised to within 1.0 m of the sea surface and profiling commenced. The CTD was lowered at a continuous rate of speed to the seafloor. Measurements at multiple stations were collected during each deployment by towing the CTD package below the water surface while transiting between adjacent stations. Upon retrieval of the CTD, the profile data were downloaded to a portable computer.

Temporal Trends in the pH Sensor

The pH sensor exhibited a slight temporal drift during the beginning of the July-2005 survey. Perceptible drift in pH measurements has been consistently observed in prior water-quality surveys as a result of ongoing sensor equilibration during profiling. Prolonged exposure to the atmosphere between surveys results in the largest offsets and can also affect the dynamic range of the measurements. Smaller equilibration offsets have been observed when the CTD is redeployed after being brought onboard to download data. Previous attempts to mitigate sensor drift have included prolonging the soak time of the CTD after deployment below the sea surface prior to profiling. Soak times in excess of 6 minutes at the beginning of a survey were found to reduce but not entirely eliminate sensor drift. During the July-2005

survey, a tube filled with seawater was placed around the pH sensor to limit atmospheric exposure before the CTD was first deployed. This technique was successful at further ameliorating sensor drift.

Temporal drift in the pH sensor was responsible for slight, but perceptibly lower pH measurements at those stations occupied during the beginning of each CTD deployment. The pH measurements at these stations were averaged 0.013 pH units lower than the measurements collected later in the deployments. Comparison with Table 3 shows that this artificial reduction in measured pH is smaller than the instrumental accuracy (± 0.1 pH). However, it is larger than the instrumental resolution (±0.006 pH). As a result, slight artificial differences are embedded in the measurements reported at Stations 1 through 6 in Table B-7. Station 1 was the first station occupied during the survey and required the largest adjustment for sensor drift (0.042 pH). Temporal detrending removed these instrumental anomalies, and the results are tabulated in Table B-6.

RESULTS

The water-quality survey for the third quarter of 2005 began on Friday, 1 July 2005, at 06:44 PDT with the initial deployment of the drogued drifter. Subsequently, all water-column measurements were collected as required by the NPDES monitoring program (Table 2 and B-8). Sunrise was at 05:52 PDT and skies were clear throughout the survey, which ended at 08:58 PDT. Wind direction varied throughout the survey and speeds ranged between 0.2 kt and 3.3 kt on average, with maximum speeds approaching 4.1 kts. A 2-ft swell moved through the survey area from the west. Atmospheric visibility was greater than 2 nM along the ocean surface owing to the absence of fog and haze at that time. As such, Morro Rock and the shoreline remained visible throughout the survey, although skies were overcast with a low ceiling. At an average near at 15.5°C, air temperature was warm and relatively constant throughout the survey. Surface seawater temperature (13°C) in the survey area was notably cooler than the average air temperature, and was consistent with coastal sea-surface temperatures within Estero Bay recorded by the satellite image shown on the cover of this report. The discharge plume was not visibly apparent at the sea surface at any time during the survey. Throughout the survey, there was no visual evidence of floating particulates, oil and grease, or seawater discoloration associated with the discharge.

Beneficial Use

During the July-2005 survey, observations of beneficial use demonstrated that the coastal waters in the outfall vicinity continued to be utilized by wildlife and for recreation. In addition to a number of unidentified seabirds observed flying through the survey area, western gulls (*Larus occidentalis*) were prevalent throughout the area. A juvenile western gull was observed resting on the sea surface within the survey area during much of the sampling. Six California brown pelicans (*Pelecanus occidentalis californicus*) were observed transiting through the survey area. Sea otters (*Enhydra lutris*) were observed during transit to the survey area from Morro Bay and one was observed 20 m north of the diffuser structure toward the end of the survey. Two private recreational fishing vessels were observed approximately 400 m seaward of the diffuser structure. They appeared to be trolling for Chinook Salmon (*Oncorhynchus tshawytscha*). No other evidence of beneficial use of receiving waters was noted during the survey.

Ambient Seawater Properties

Data collected during the July-2005 survey reflect the classical, stratified conditions that are indicative of upwelling. Upwelling results in an influx of dense, cold, saline water at depth and often leads to a sharp

thermocline, halocline, and pycnocline where temperature, salinity, and density change rapidly over short vertical distances. Under stratified conditions, isotherms crowd together to form a thermocline that restricts the vertical transport of the effluent plume and reduces its dispersion.

Sharp upwelling-induced vertical gradients are plainly evident close to the sea surface in the vertical profiles of Figures A-1 through A-3. A thermocline, where temperature sharply decreases with increasing depth is evident between 2 m and 6 m in all sixteen of the vertical profiles shown in Figures A-1 through A-3 (red lines). In addition, most other seawater properties exhibit vertical stratification nearly identical to that of the thermal structure. For example, the temperature profile at any given station is closely reflected in the profiles of dissolved oxygen (dark blue lines) and pH (gold lines). Similarly, the abrupt decrease in temperature, DO, and pH with depth is mirrored by a pycnocline where density (black lines) sharply increases with depth. Thus, upwelling-induced stratification dictates the vertical structure of all ambient seawater properties except salinity (green lines) and transmissivity (light-blue lines).

Large-scale features of the upwelling process within Estero Bay were described by MRS (2004 and Morro Group, Inc., 2000). Near the seafloor, upwelling transports cold, dense seawater onshore to replace nearshore surface waters that are driven offshore by prevailing winds. The low dissolved oxygen found at depth is a clear indicator of its deep offshore origin. Deep offshore waters are undersaturated in oxygen because they have not had direct contact with the atmosphere for long periods, and biotic respiration and decomposition have slowly depleted dissolved-oxygen levels. Similarly, slightly elevated salinity is often indicative of waters that originate in the Southern California Bight and are carried northward by the Davidson undercurrent. They differ from the relatively fresh surface water associated with the southward-flowing California Current.

The near-surface seawater properties also reflect the increased primary productivity associated with upwelling conditions. Nutrient-rich seawater brought to the sea surface by upwelling enables phytoplanktonic blooms that are the foundation of the productive marine fishery found along the California Coast. Markedly reduced water clarity (light-blue lines) within the shallow euphotic zone results from an increase in planktonic biomass. The enhanced primary productivity near the sea surface also produces oxygen and consumes carbon dioxide (CO_2). The removal of carbonic acid (dissolved CO_2) accounts for the pH maximum found at the sea surface (gold line). As the ratio of respiration to photosynthesis increases with depth, there is an increase in dissolved CO_2 (carbonic acid) and a decline in pH (more acidic). Accordingly, respiration consumes oxygen and produces acid, which accounts for the decline in DO and pH with increasing depth seen in Figures A-1 through A-3.

In contrast with other water properties, the vertical profiles of salinity (green lines) do not exhibit a distinct halocline. Normally, a halocline would be expected in conjunction with the upwelling-induced thermocline. Although not immediately apparent in the vertical profiles, salinity was slightly higher near the seafloor than near the sea surface. The slight increase in salinity at depth reflects the onshore transport of a deep water-mass that originated in the saline waters to the south. However, subtle vertical trends in salinity are difficult to discern because of the presence of large salinity spikes. These salinity spikes are artifacts of the instrumental measurements collected under certain conditions. The spikes are evident as an erroneous zigzag pattern that is present in most of the salinity profiles, at shallow depths coincident with the sharp thermocline. As described later in this report, salinity spikes are instrumental artifacts arising from the mismatch between conductivity and temperature measurements collected near strong thermal gradients. In many vertical profiles, these spikes often mask the presence of the weak halocline.

Lateral Variability

The influence of the effluent discharge can be best identified from localized anomalies in seawater properties, particularly salinity. These discharge-related anomalies are evident below the thermocline at Stations 4 and 9 in the vertical sections shown in Figures A-4 through A-7. Discharge-related anomalies are especially apparent when seawater properties from the same depth level are compared at adjacent stations. The vertical sections show that the shallow temperature and DO anomalies have the same characteristics as ambient waters at depth. They are only apparent because these deep water properties have been displaced upward into the water column where the surrounding seawater characteristics differ. Because of this, the analysis of lateral variability in seawater properties forms the basis for assessments of water-quality impacts.

In particular, the significance of each potential discharge-related anomaly can be evaluated statistically by comparing its amplitude to the natural background variability. To that end, each observation at a particular station was compared with the observations from other stations at the same depth level. Measurements collected within 10 m of the sea surface were compared with other measurements at the same depth level below the sea surface. However, deeper measurements were compared with other measurements collected at the same height above the sloping seafloor. This is done because deep seawater properties tend to parallel the sloping seafloor rather than the horizontal sea surface.

The statistical significance of departures from ambient seawater properties was computed from the raw CTD data listed in Tables B-1 through B-7. First, anomalies from mean conditions were computed by subtracting a particular measurement from the average of all other measurements at the same depth level, be it measured relative to the sea surface or seafloor. Natural variability was estimated from the standard deviation of all measurements (excluding the one in question) for a given seawater parameter (*e.g.*, salinity). Statistically significant anomalies were those that departed from mean conditions by more than the 95% confidence interval determined from the standard deviation and number of observations used to compute the average. Statistically significant departures from ambient conditions are highlighted in Tables B-1 through B-7, with bolded values enclosed in boxes.

Salinity (Table B-2) and transmissivity (Table B-5) were the only seawater properties that exhibited statistically significant anomalies in the July-2005 data. This contrasts with other surveys where significant anomalies in other water properties were occasionally found (MRS, 2004). The lack of statistical significance in other seawater anomalies during the July-2005 survey was not because the amplitudes of the anomalies were smaller than in other seasons. In fact, fairly clear discharge-related thermal and DO anomalies are visually apparent at Stations 4 and 9 in the middle frames of Figure A-4 through Figure A-7. However, the amplitudes of these anomalies were not large relative to the variability in ambient DO temperatures and consequently, they were not found to be statistically significant. Because the spatial variability in most seawater properties was large during the July-2005 survey, particularly in the vertical direction, the amplitude of the anomalies would need to be proportionally larger in order to be reliably resolved on a statistical basis. Thus, statistical significance is a function of overall variability during a given survey. It is more difficult to reliably discern small differences in a noisy field of measurements than in a uniform field.

Instrumental artifacts complicate the analysis of lateral variability in the salinity field. Specifically, the statistical significance of all the salinity anomalies that are highlighted in Table B-2 is an artifact of salinity spiking that occurs when the CTD sensors cross a strong thermocline. Salinity is computed from the conductivity and temperature probes that do not measure the same water parcel because the sensors are physically separated on the CTD instrument package. In addition, the sensors do not have the same

response times. Consequently, in regions of strong vertical temperature gradients, the mismatch between the conductivity and temperature measurements causes erroneous spikes in salinity. Salinity spiking is a common, unavoidable problem with CTD measurements collected within strong thermal gradients in the upper ocean. They are routinely observed in MBCSD surveys conducted when the water column is well stratified, as was the case during the July-2005 survey (MRS, 2001, 2002, 2003, 2004, 2005).

The presence of erroneous salinity spikes is evident from visual inspection of the high-resolution vertical profiles of temperature and salinity that were used to compute the depth-averaged data collated in the appendices. Salinity spikes are characterized by marked isolated changes in salinity that occur within strong thermoclines. They are generally less than 0.5 m thick in the high-vertical resolution profiles and appear as zigzag features in the lower-resolution salinity profiles shown as green lines in Figures A-1 through A-3. It is unlikely that the observed salinity reductions were caused by the presence of wastewater constituents, because the discharge plume is typically trapped beneath strong thermoclines, particularly one as shallow as that observed during the July-2005 survey.

Even without instrumental discrepancies, the presence of statistically significant anomalies that are unrelated to the discharge is expected. From the definition of a 95% confidence level, one '*significant*' departure out of every 20 measurements should occur by chance alone. With 500 measurements examined for each of the six parameters, it would not be surprising if a few departed from the mean by an amount more than the 95% confidence interval. Moreover, when multiple hypotheses are being tested (*i.e.*, one for each observation), the error rate for each individual test should be adjusted to achieve the overall experimentwise error rate of 5% (95% confidence). By definition, this error rate is the probability that one or more of the hypothesis tests would incorrectly find a significant difference when none exists. Thus, without correcting for repeated hypothesis testing, the individual tests are conservative and "significant" departures will be found more often than if a single test were being performed at the 95% confidence level.

For example, four of the ten statistically significant salinity anomalies represent increases in salinity. These positive salinity spikes could not have been generated by the discharge of effluent that is essentially devoid of salinity. Instead, as described above, they were instrumental artifacts related to salinity spiking or were random artifacts of the statistical test that was repeatedly applied to a large number of measurements. Similarly, the statistically significant transmissivity anomaly located at depth at Station 13 (Table B-5), is a positive anomaly where water clarity is higher than the surrounding waters at depth. Consequently, it could not have been generated by the presence of wastewater particulates. Instead, it was probably an artifact of natural variation in the distribution of suspended ambient particulates within the water column.

Discharge-Related Perturbations

During the July-2005 survey, two perturbations in seawater properties were unequivocally related to the discharge (Perturbations P1 and P2 in Table 4). A discharge-related perturbation is a group of anomalies in one or more seawater properties that are contiguous in depth at a particular station. In addition to their spatial co-occurrence, the sign, or direction of the anomalies, lends insight into their origins. For example, the negative salinity anomalies at 10.5 m at Station 4, and 8 m at Station 9 indicate the presence of dilute wastewater constituents. These anomalies are apparent as downward excursion of the low salinity found near the sea surface that is delineated by green shading in the top frames of Figures A-4 and A-6. Salinity at depth is measurably higher, so upward displacement of ambient seawater that was entrained in a rising effluent plume could not have generated the salinity anomalies.

Table 4. Discharge-Related Water-Property Anomalies[a]

Perturbation[b]	Station	Depth Range	Depth of Extremum	Property	Magnitude	Process
P1 Dilution>784:1	4	6.0 to 11.0 m	10.5 m	Salinity	–0.043 ‰	Effluent
		6.5 to 9.0 m	7.0 m	Temperature	–0.16 ºC	Entrainment
		10.0 to 12.0 m	10.5 m	Density	–0.038 σ_t	Effluent
		6.5 to 16.5 m	**15.5 m**	**Transmissivity**	**–5.3 %**	**Effluent**
		6.5 to 8.5 m	8.0 m	Dissolved Oxygen	–0.39 mg/L	Entrainment
P2 Dilution>636:1	9	7.0 to 8.5 m	8.0 m	Salinity	–0.053 ‰	Effluent
		7.0 to 8.5 m	8.0 m	Temperature	–0.09 ºC	Entrainment
		7.0 to 8.5 m	8.5 m	Density	–0.026 σ_t	Effluent
		7.0 to 8.5 m	7.5 m	Dissolved Oxygen	–0.34 mg/L	Entrainment

[a] Anomalies shown in bold type were statistically significant
[b] Perturbations consist of a group of spatially consistent anomalies in different seawater properties

As with the salinity anomalies, the significantly decreased transmissivity observed close to the sea floor at Station 4 (top frame of Figure A-5) was probably generated by the presence of effluent particulates. At all the other stations, transmissivity less than 69% only occurs in the near-surface waters where phytoplankton blooms increase turbidity. Station 4, where the significant decrease in seafloor transmissivity was observed, was close to the diffuser structure (Figure 2). Although it was located southwest of the diffuser structure, in a direction opposite of the measured current, the flow close to the seafloor could have easily been in a different direction than the drifter track shown in Figure 2, which was determined from a drogue at mid-depth where flow was very weak.

In contrast to anomalies in the other water properties, the negative anomalies in temperature and DO that co-occur with the salinity anomies are consistent with the upward displacement of ambient seawater at depth. This is apparent from the upward displacement in the 11ºC isotherm at Station 4 shown in the middle frame of Figure A-4. The perturbation's direct connection to deep water properties is even more apparent in the 5.8-mg/L DO contour shown in the middle frame of Figure A-5. At Station 9, upward displacement of ambient seawater that is naturally low in DO and temperature forms an inversion as shown in the middle frames of Figures A-6 and A-7.

The presence of wastewater constituents alone did not induce the DO and thermal anomalies. Wastewater is generally warmer and tends to have a higher DO concentration than seawater at depth. If wastewater properties were materially contributing to the perturbations, then positive thermal and DO anomalies would be generated by the presence of effluent particulates. Instead, the opposite was the case indicating that the perturbations were cooler and less oxygenated than surrounding shallow seawater. These are characteristics of deep ambient seawater, not wastewater. Although reductions in DO can be caused by oxygen-demanding material in wastewater, this has not been the case with the MBCSD discharge. Most of the oxygen-demanding material is removed in the treatment process, and the resulting effluent has historically had low biochemical oxygen demand (MRS, 2005). Instead, because of its recent contact with the atmosphere, wastewater generally has higher DO than ambient seawater at depth, which has depleted oxygen levels due to respiration and decay over a long period since its equilibration with the atmosphere.

Entrainment-generated anomalies only become apparent when ambient seawater properties at depth are distinctly different from shallow water properties. Without this naturally occurring stratification, entrainment of deep ambient seawater within the rising effluent plume would not produce obvious differences between the entrained water and shallow water properties. Thus, the entrained deep seawater

acts as a tracer of the effluent plume after discharge. These same entrainment-generated anomalies could just as easily have been produced by the discharge of warm seawater, containing no suspended solids or other contaminants whatsoever. Conversely, they would not be apparent in unstratified receiving waters. This indicates why many of the receiving-water limitations specified in the COP explicitly state that limitations only apply to impacts caused by the presence of wastewater constituents, and, by implication, not to changes generated by the entrainment of ambient seawater. Entrainment-generated impacts are largely dictated by existing ambient seawater stratification rather than the quality of discharged wastewater. Naturally occurring vertical differences in seawater properties are eventually mixed throughout the water column by natural nearshore processes; plume entrainment simply serves to accelerate this process over a localized area.

Initial Dilution Computations

The amplitude of negative salinity anomalies at Stations 4 and 9 lends insight into effectiveness of the outfall at dispersing effluent and, ultimately, compliance with the receiving-water objectives of the COP and NPDES discharge permit. The critical initial dilution applicable to the MBCSD outfall was conservatively estimated to be 133:1 (Tetra Tech, 1992). This estimate was based on worst-case modeling results using highly stratified conditions. These dispersion models found that 133 parts of ambient water would have mixed with each part of wastewater after initial mixing was complete. This dilution ratio was predicted to occur after the plume rose 9 m from the seafloor, whereupon it became trapped below a thermocline and spread laterally with no further substantive dilution. A 9-m rise translates into a trapping depth 6.4 m below the sea surface. This trapping depth lies 1.6 m above the shallowest salinity anomaly observed in the July-2005 survey (Perturbation P2 in Table 4), so slightly lower dilution levels than those predicted by modeling would be expected to occur at that location. However, as described below, the amplitude of that salinity anomaly implies that the effluent was diluted 636 times, which is much larger than the dilution ratio predicted by modeling. This demonstrates that the diffuser structure was operating more efficiently than predicted by the modeling.

The conservative nature of the dilution ratio determined from modeling is an important consideration because it was used to specify permit limitations on chemical concentrations in wastewater discharged from the treatment plant. These end-of-pipe effluent limitations were back-calculated from the receiving-water objectives listed in the COP (SWRCB, 1997) using the 133:1 dilution ratio determined from modeling. Use of a higher critical dilution ratio would relax the stringent end-of-pipe effluent limitations that were thought to be necessary in order to meet Ocean-Plan standards.

End-of-pipe effluent limitations are based on the definition of dilution (Fischer *et al*., 1979), where the concentration of a particular contaminant in effluent is given by:

$$C_e \equiv C_o + D\left(C_o - C_s\right) \qquad \textbf{Equation 1}$$

where: C_e = the concentration of a constituent in the effluent,
  C_o = the concentration of the constituent in the ocean after dilution by *D*,
  D = the dilution ratio of the volume of seawater mixed with effluent, and
  C_s = the background concentration of the constituent in ambient seawater.

The actual dilution achieved by the outfall can also be computed from Equation 1 using measured seawater anomalies. This measured dilution can then be compared with the critical dilution factor determined from modeling. Salinity is an especially useful tracer because it directly reflects the magnitude of ongoing dilution. Specifically, the salinity concentration in effluent is negligible so C_e is

eliminated in Equation 1 and the dilution ratio (D) can be computed from the salinity anomaly (A = C_o – C_s) as:

$$D = \frac{-C_o}{(C_o - C_s)} \equiv \frac{-C_o}{A}$$ **Equation 2**

where: D = the dilution ratio of the volume of seawater mixed with effluent,
C_o = the salinity of the effluent-seawater mixture after dilution by D,
C_s = the background seawater salinity (approximately 33.7‰), and
$A = C_o – C_s$ = the salinity anomaly.

Computed dilutions during the stratified conditions of the July-2005 survey demonstrate that the modeled dilution factors are more conservative than those actually achieved by the diffuser structure. Specifically, the largest salinity anomaly (–0.053‰) yields a dilution ratio of 636:1 in Equation 2. It indicates a dilution ratio that is more than four-times higher than the 133:1 critical dilution used to establish limitations on contaminant concentrations in wastewater. The dilution computation demonstrates that, during the July-2005 survey, the outfall was performing better than designed, and was rapidly diluting effluent more than 600-fold. Consequently, COP receiving-water objectives were easily met by the chemical concentration limits promulgated by the NPDES discharge permit issued to the MBCSD.

DISCUSSION

Sampling during the July-2005 survey indicated that the wastewater discharge was in compliance with the receiving-water limitations specified in the NPDES permit, and with the water-quality objectives of the COP (SWRCB, 1997) and the Central Coast Basin Plan (RWQCB, 1994). Specifically, there were no particulates of sewage origin seen floating on the ocean surface at any of the stations sampled during the July-2005 water-quality survey. Although statistically significant reductions in salinity and transmissivity were generated by the discharge plume, they were small compared to the receiving-water limits specified in the NPDES discharge permit.

Although not statistically significant, discharge-related reductions in DO and temperature were also apparent below the thermocline southwest of the diffuser structure near the margin of the ZID. However, these resulted from entrainment of deep ambient seawater and not the presence of wastewater itself. Wastewater constituents were too dilute to measurably contribute to these anomalies. The DO measured within the mid-depth anomalies at Stations 4 and 9 was comparable to the DO of ambient seawater at depth, so the mid-depth DO anomaly could not be ascribed to the presence of oxygen-demanding material within the effluent.

Similarly, the upward movement of ambient seawater, which is naturally lower in temperature at depth, produced the anomalous reduction in temperature measured at mid-depth. Wastewater, which is warmer than ambient seawater could not have been responsible for the observed decrease in temperature. Finally, all of the anomalies were small compared to natural oceanic variability, and the water properties within the survey area remained close to natural levels at all stations within and beyond the ZID. This includes the discharge-related anomalies identified at Stations 4 and 9. The ranges in measured temperatures (2.2ºC) and salinities (0.22‰) across all data collected in July 2005 were too small to be considered harmful to marine biota or deleterious to beneficial uses.

Outfall Performance

Small anomalies in salinity indicated the presence of dilute wastewater below the thermocline at Stations 4 and 9, near the southwest boundary of the ZID. These high-precision observations demonstrated that the diffuser structure was operating better than predicted by modeling, and that the discharged wastewater experienced high levels of dilution within and beyond the ZID. A dilution of 636:1 was determined from the salinity anomaly located at Station 9. This is nearly five times the minimum critical dilution of 133:1 specified in the NPDES permit. With the higher dilution ratio that was determined from actual measurements during the July-2005 survey, contaminant concentrations within the wastewater could have been more than four-times the limits specified in the NPDES discharge permit, and the receiving-water objectives of the California Ocean Plan (COP) would still have been achieved.

NPDES Permit Limits

The seawater properties measured during the July-2005 survey were statistically evaluated for compliance with the pertinent receiving-water limitations promulgated by the NPDES discharge permit and the COP. Specifically, the permit and COP state that the discharge shall not cause:

1. *Natural light to be significantly reduced at any point outside the initial dilution zone as the result of the discharge of waste.*

2. *The dissolved oxygen concentration outside the zone of initial dilution to fall below 5.0 mg/L or to be depressed more than 10 percent from that which occurs naturally.*

3. *The pH outside the zone of initial dilution to be depressed below 7.0, raised above 8.3, or changed more than 0.2 units from that which occurs naturally.*

4. *Temperature of the receiving water to adversely affect beneficial uses.*

The COP (SWRCB, 1997) further defines a '*significant*' difference as '*…a statistically significant difference in the means of two distributions of sampling results at the 95 percent confidence level.*' For each observation in Tables B-1 through B-6, the statistical significance of departures from mean conditions at a given depth level were determined with an analysis of variance that compares a single observation with the mean of a larger set of samples (see Page 228 in Sokal and Rohlf, 1997; Ury, 1976). Although 15 independent hypothesis tests were performed at each depth level, no Bonferroni adjustment to the error rate was included, so the tests are conservative. Specifically, Bonferroni adjustment indicates that the actual confidence level for the overall null hypothesis test for differences in properties is higher, around 99.7%, rather than the 95% level that applies to a single test. The standard deviation that was applied in the tests was determined from the entire data set to reflect the full range in ambient properties, including vertical variations.

Light Transmittance

Based on the statistical analysis, only one significant reduction in instrumentally recorded light transmittance was found beyond the ZID (Station 4 in Table B-5). Another significant anomaly in the transmissivity field was observed near the seafloor at Station 13 but it was associated with an increase in water clarity. The significant, discharge-related reduction in transmissivity at Station 4 is visually perceptible in the vertical section shown in the top frame of Figures A-5. The significant reduction, which represents a drop in transmissivity of as much as 5.3%, extends 1.5 m above the seafloor. Because the significant reduction in water clarity was restricted to the seafloor, it does not constitute an exception to the Ocean-Plan objectives. Because it was located just above the seafloor, it could not have caused

"*Natural light to be significantly reduced....*" Based on the deepest measured Secchi depths of 4 m (Table B-8), the bottom of the euphotic zone was approximately 8.0 m, indicating that very little natural light was reaching the seafloor where the statistically significant anomalies in transmissivity were observed.

Dissolved Oxygen

Although it is not stated in the NPDES discharge permit, the COP specifies that the DO limitation only applies to reductions that occur "*…as a result of the discharge of oxygen demanding waste materials.*" Clearly, then, the DO limitation does not apply to reductions in DO caused by the movement of ambient waters, regardless of whether or not they were induced by the physics of the discharge. Thus, the slightly reduced DO concentrations observed below the thermocline at Stations 4 and 9, which were generated by entrainment of ambient seawater, are not subject to the limitations. Even so, the amplitudes of the DO anomalies were so small (-0.39 mg/L) that they did not constitute statistically significant deviations from the norm. Moreover, they complied with the numerical limits specified in the permit. Specifically, none of the anomalous DO concentrations fell below the 5-mg/L minimum specified in the Basin Plan and the NPDES discharge permit. In fact, none of the 500 measurements collected during the July-2005 survey fell below 5 mg/L. In addition, the amplitude of the discharge-related anomalies at Stations 4 and 9, were too small to be considered "*...to be depressed more than 10 percent from that which occurs naturally.*"

pH

No statistically significant lateral anomalies in pH were measured during the July 2005 survey (Table B-6). In addition, there were no visually perceptible pH anomalies apparent in the vertical sections shown in the bottom frames of Figures A-5 and A-7. In fact, the range in pH among all of the measurements was only less than 0.2 pH units, so none of the measurements can be considered changed by '*…more than 0.2 pH units from that which occurs naturally.*' The range across the entire pH field remained between 7.241 and 7.437, and thus, all of the measurements also complied with the lower (7.0 pH) and upper (8.3 pH) bounds on discharge-induced pH changes.

Temperature and Salinity

The total range in temperature of 2.2ºC across all observations was largely due to naturally occurring vertical stratification. Even if changes this large were generated by the discharge, they would be considered too small '*…to adversely affect beneficial uses….*' This is because the temperature range was less than the large-scale spatial variability in sea-surface temperature shown in the satellite image on the cover of this report. The small, discharge-induced decreases in temperature (≤-0.16ºC) that were visually apparent in the vertical sections at Station 4 and 9 clearly resulted from the upward displacement of naturally occurring, cooler bottom water rather than as a result of warmer wastewater constituents.

Although salinity anomalies provide the best tracer of discharged effluent, their actual amplitude (≤0.053‰) was small compared to ambient salinity variability observed during the July-2005 survey. The total range in measured salinities was 0.22‰. This salinity range is less than the 0.25‰ average seasonal difference in mean surface salinity, and is well within the spatial differences in salinity that occur along the south-central California coast. Moreover, much of the variability in the salinity field was generated by salinity spiking that was artificially introduced by the CTD instrument. In any regard, the observed range in both the measured temperature (2.2ºC) and salinity (0.22‰) across all data collected during the July-2005 survey was too small to be considered harmful to marine biota or deleterious to beneficial uses.

Conclusions

The measurements collected at all stations during the July-2005 survey complied with receiving-water limitations specified in the NPDES discharge permit. The discharge-related anomalies found below the thermocline near the southwest boundary of the ZID, were largely caused by the upward displacement of ambient seawater, and not the presence of wastewater constituents. Computations of effluent mixing demonstrated that discharged wastewater was undergoing rapid dilution close to the diffuser structure, and that the outfall was operating as designed.

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APPENDIX A

Water Quality Profiles and Vertical Sections
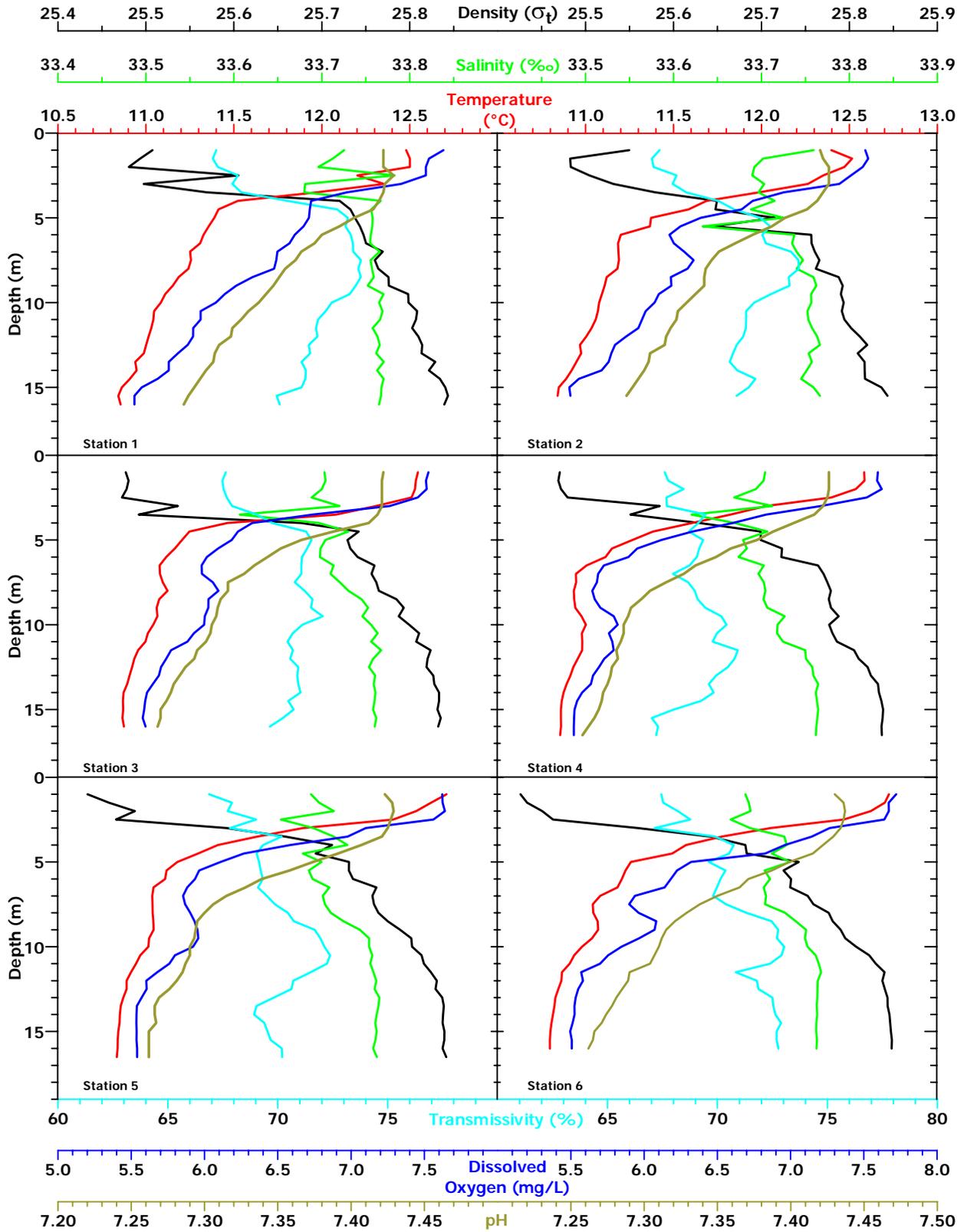
Figure A-1. Vertical Profiles of Water-Quality Parameters for Stations 1 through 6 measured on 1 July 2005
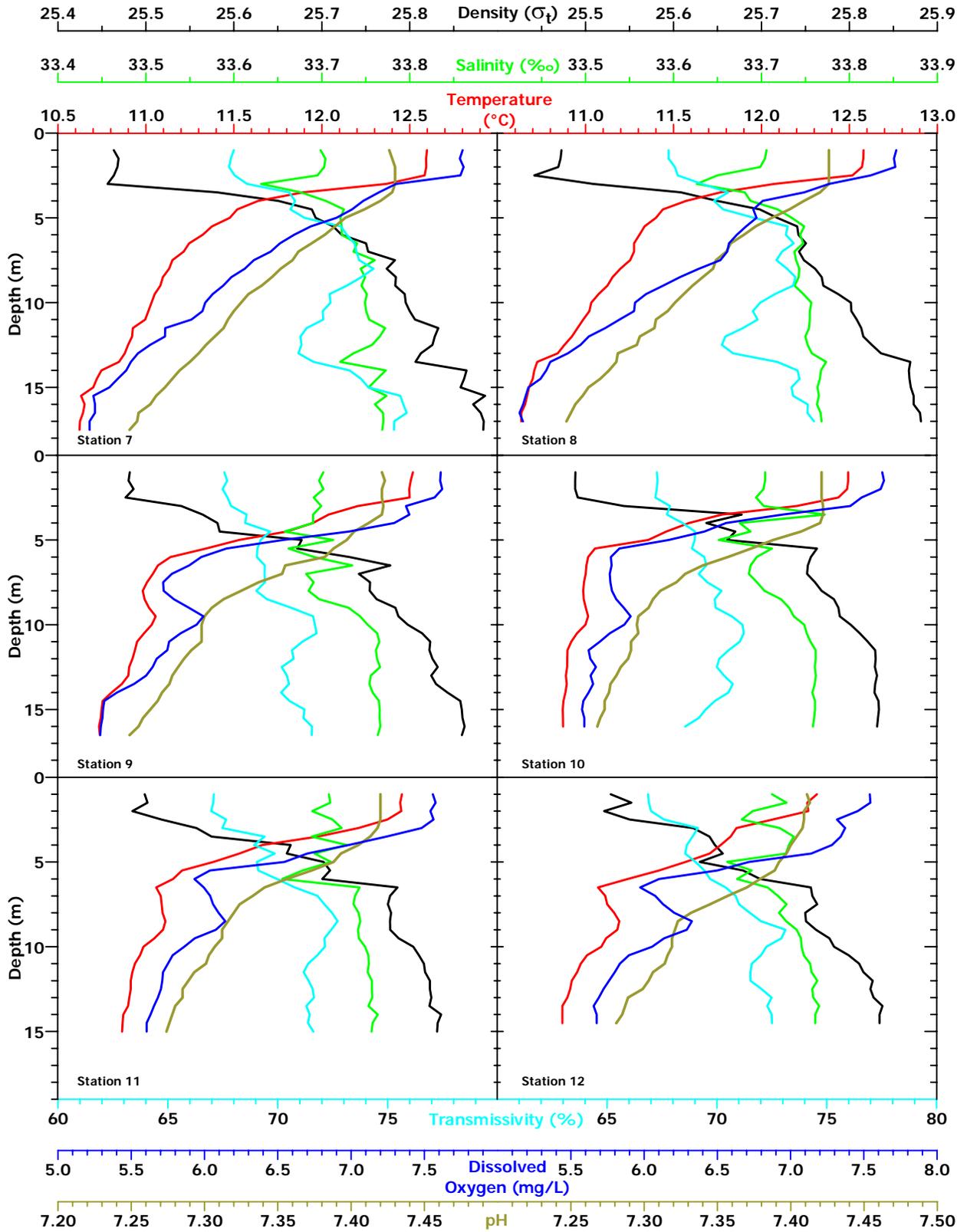
Figure A-2. Vertical Profiles of Water-Quality Parameters for Stations 7 through 12 measured on 1 July 2005
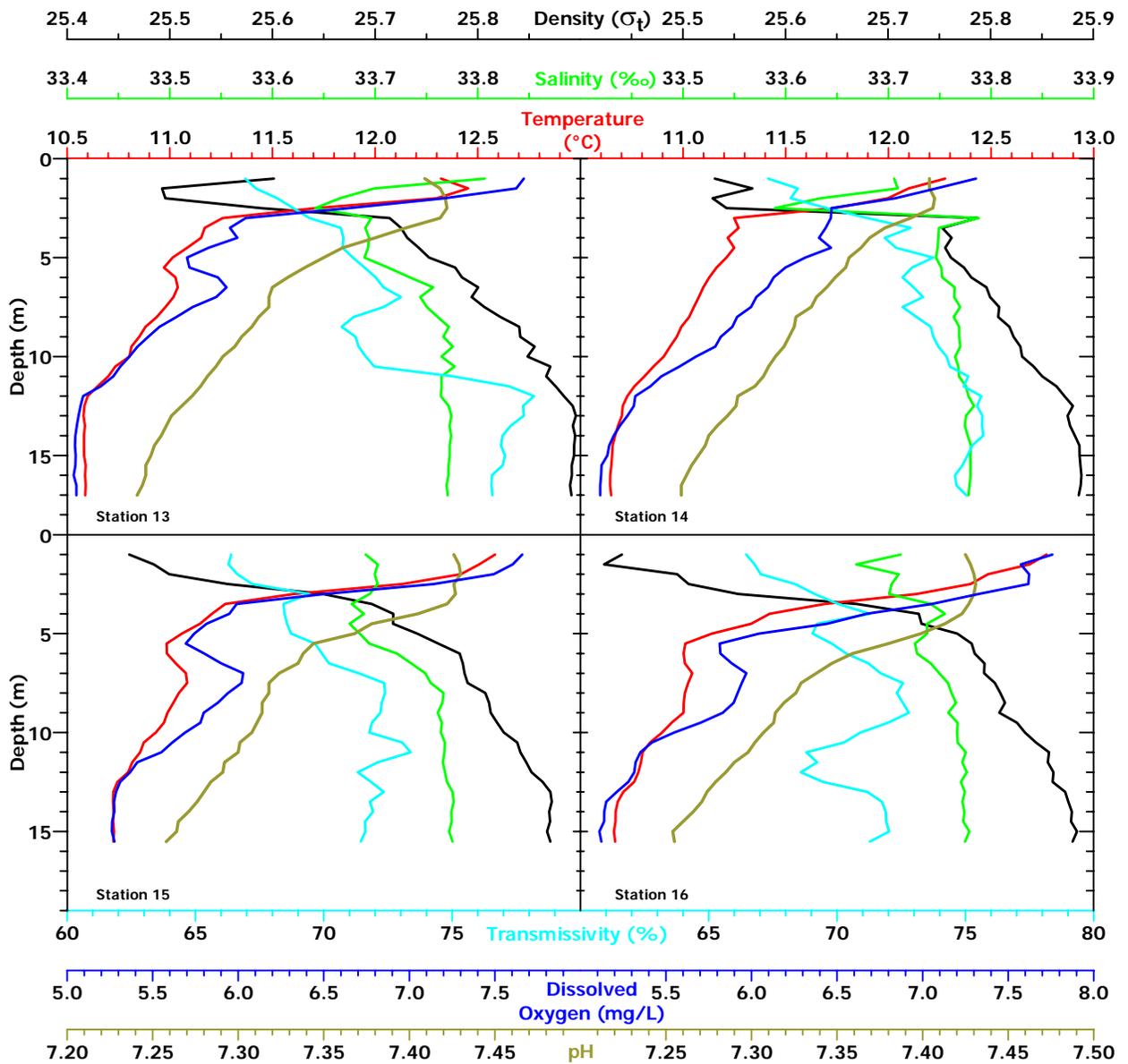
Figure A-3. Vertical Profiles of Water-Quality Parameters for Stations 13 through 16 measured on 1 July 2005
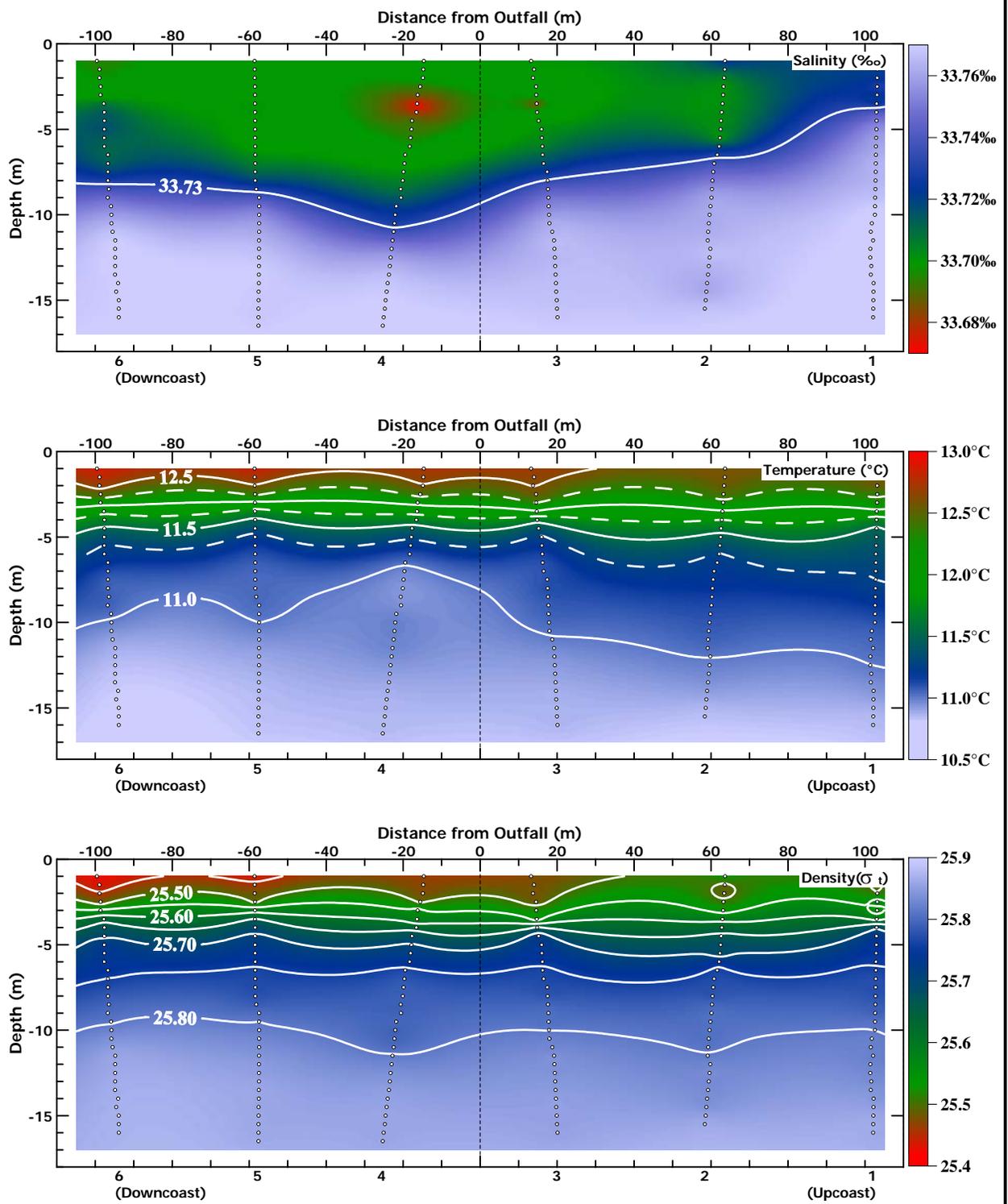
Figure A-4. Along-Shore Transects of Salinity, Temperature, and Density on 1 July 2005
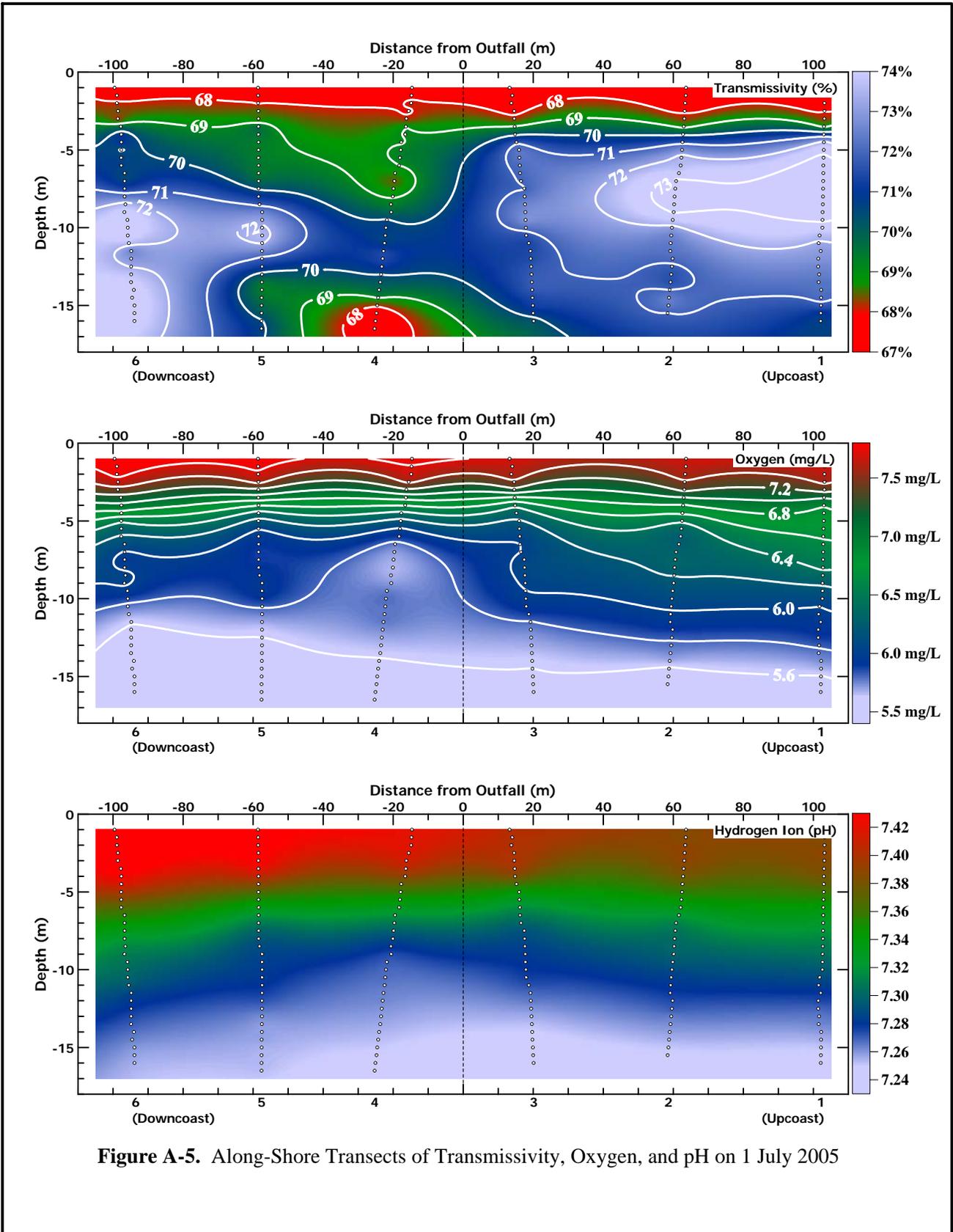
Figure A-5. Along-Shore Transects of Transmissivity, Oxygen, and pH on 1 July 2005
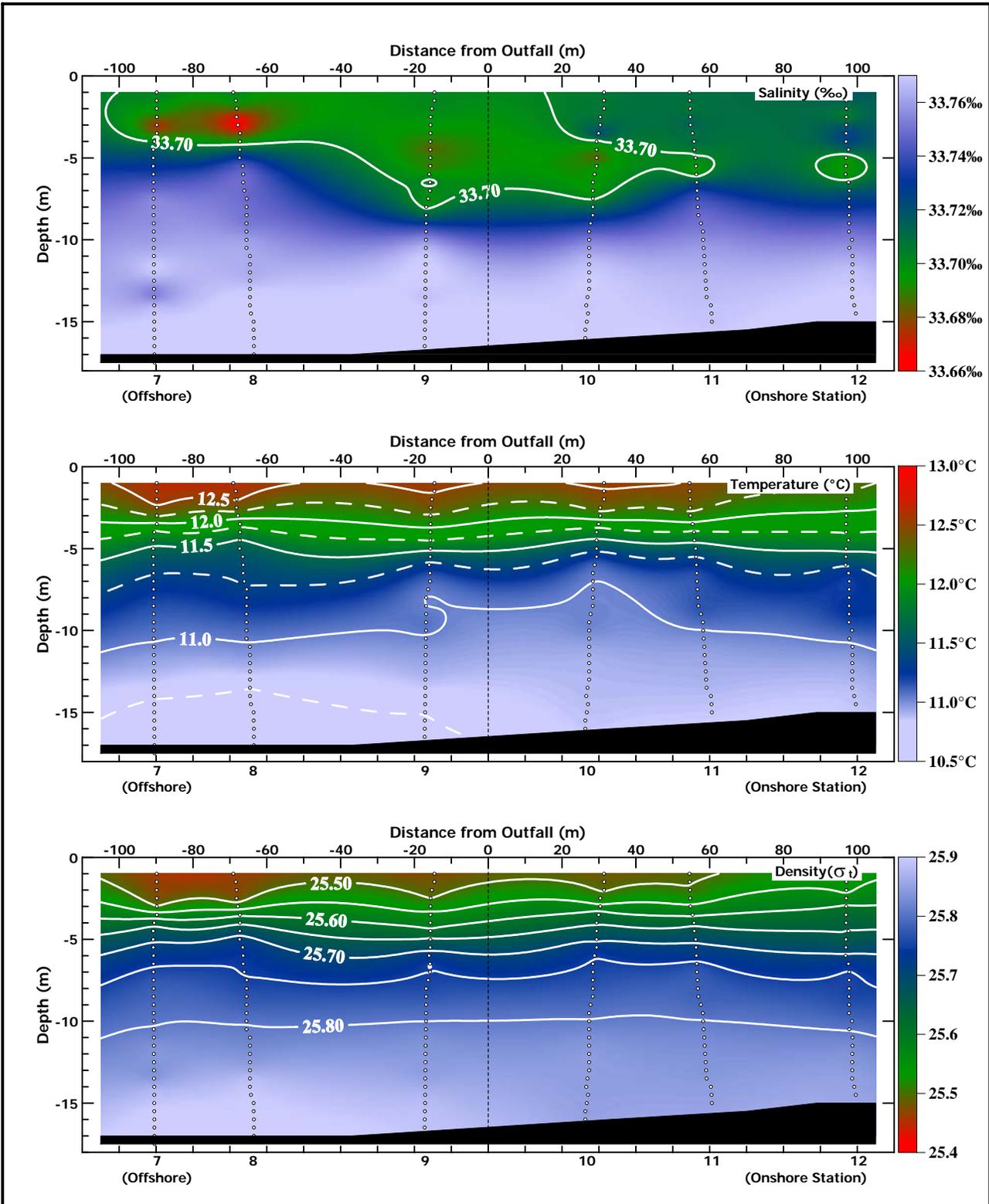
Figure A-6. Cross-Shore Transects of Salinity, Temperature, and Density on 1 July 2005
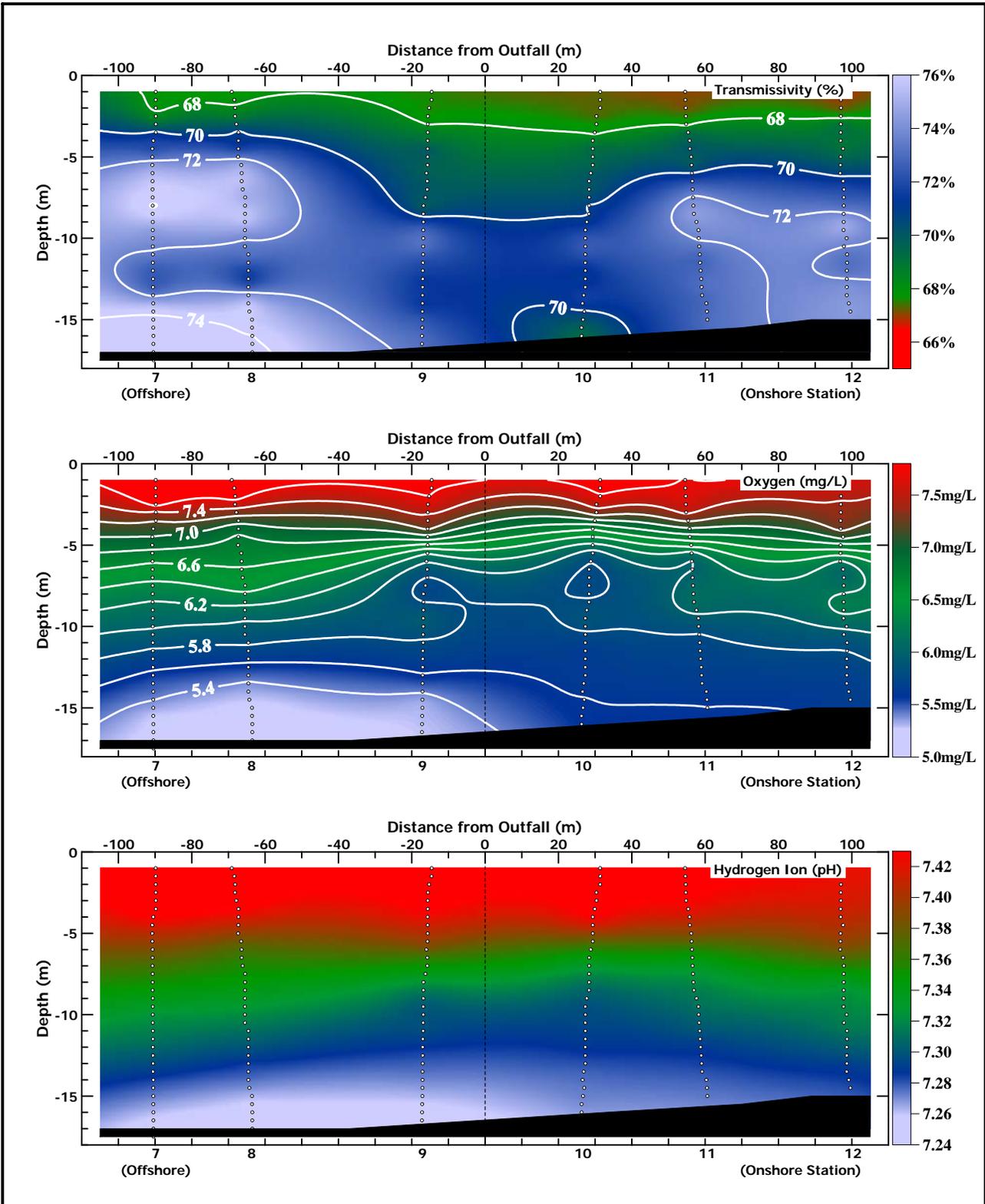
Figure A-7. Cross-Shore Transects of Transmissivity, Oxygen, and pH on 1 July 2005

APPENDIX B

Tables of Profile Data and Standard Observations

Table B-1. Seawater Temperature on 1 July 2005

Depth (m)	Temperature (°C)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.0	12.48	12.40	12.55	12.58	12.71	12.73	12.60	12.58	12.52	12.49	12.46	12.32	12.32	12.28	12.58	12.77
1.5	12.50	12.52	12.54	12.59	12.62	12.70	12.59	12.58	12.51	12.49	12.45	12.26	12.45	12.10	12.51	12.69
2.0	12.50	12.47	12.53	12.54	12.54	12.62	12.59	12.57	12.50	12.49	12.45	12.27	12.30	12.00	12.42	12.49
2.5	12.20	12.35	12.51	12.40	12.41	12.47	12.59	12.52	12.50	12.44	12.37	12.06	11.71	11.74	12.13	12.40
3.0	12.35	12.26	12.31	12.03	11.89	12.05	12.37	12.07	12.20	12.20	12.21	11.86	11.26	11.25	11.60	12.14
3.5	11.97	11.99	12.08	11.82	11.63	11.77	11.89	11.77	12.04	11.78	11.98	11.82	11.17	11.27	11.27	11.69
4.0	11.52	11.69	11.46	11.61	11.41	11.57	11.64	11.57	11.95	11.59	11.66	11.77	11.15	11.22	11.21	11.42
4.5	11.41	11.59	11.25	11.38	11.30	11.49	11.52	11.44	11.80	11.46	11.53	11.71	11.09	11.25	11.15	11.33
5.0	11.39	11.37	11.21	11.27	11.18	11.26	11.48	11.40	11.53	11.36	11.38	11.57	11.01	11.21	11.06	11.14
5.5	11.36	11.37	11.17	11.15	11.12	11.23	11.38	11.34	11.34	11.05	11.21	11.42	10.97	11.16	10.99	11.01
6.0	11.33	11.20	11.12	11.11	11.11	11.21	11.32	11.31	11.14	11.01	11.15	11.24	11.03	11.13	10.99	11.00
6.5	11.31	11.18	11.08	11.01	11.04	11.18	11.25	11.28	11.07	11.01	11.06	11.07	11.04	11.10	11.03	11.01
7.0	11.25	11.19	11.08	10.94	11.04	11.08	11.21	11.28	11.04	11.00	11.08	11.11	11.02	11.08	11.08	11.04
7.5	11.26	11.19	11.10	10.95	11.04	11.04	11.15	11.25	11.01	10.99	11.09	11.12	10.98	11.05	11.09	11.02
8.0	11.24	11.18	11.12	10.93	11.04	11.04	11.13	11.20	10.98	10.99	11.09	11.16	10.94	11.03	11.04	11.01
8.5	11.19	11.12	11.08	10.94	11.04	11.07	11.10	11.15	10.99	10.99	11.11	11.19	10.88	10.99	11.02	11.00
9.0	11.15	11.11	11.06	10.94	11.04	11.07	11.08	11.12	11.02	11.00	11.10	11.18	10.85	10.97	10.99	11.00
9.5	11.11	11.09	11.07	10.98	11.02	11.04	11.05	11.07	11.06	11.02	11.05	11.12	10.81	10.94	10.97	10.94
10.0	11.09	11.08	11.04	11.00	11.01	10.98	11.03	11.03	11.03	11.00	10.99	11.09	10.80	10.91	10.93	10.90
10.5	11.05	11.07	11.01	10.98	10.97	10.94	11.01	11.02	10.99	10.95	10.97	11.01	10.73	10.86	10.87	10.84
11.0	11.04	11.06	11.00	10.98	10.94	10.91	11.00	10.99	10.95	10.92	10.94	10.97	10.70	10.81	10.86	10.80
11.5	11.03	11.03	10.96	10.98	10.92	10.87	10.93	10.95	10.94	10.90	10.92	10.95	10.65	10.76	10.82	10.80
12.0	11.02	11.00	10.93	10.96	10.89	10.86	10.92	10.92	10.92	10.90	10.91	10.92	10.60	10.73	10.80	10.78
12.5	11.00	10.97	10.92	10.93	10.89	10.85	10.90	10.88	10.90	10.90	10.91	10.91	10.58	10.71	10.74	10.76
13.0	10.99	10.97	10.91	10.91	10.87	10.83	10.88	10.84	10.90	10.89	10.91	10.90	10.58	10.70	10.73	10.71
13.5	10.94	10.95	10.89	10.89	10.86	10.82	10.85	10.72	10.86	10.89	10.90	10.87	10.59	10.68	10.72	10.68
14.0	10.95	10.92	10.87	10.87	10.85	10.81	10.75	10.71	10.80	10.89	10.87	10.87	10.58	10.67	10.73	10.67
14.5	10.91	10.89	10.87	10.86	10.85	10.81	10.72	10.70	10.75	10.87	10.87	10.87	10.58	10.66	10.72	10.67
15.0	10.86	10.85	10.87	10.86	10.84	10.80	10.70	10.68	10.75	10.87	10.87		10.58	10.65	10.73	10.66
15.5	10.84	10.84	10.87	10.86	10.84	10.80	10.63	10.67	10.74	10.87			10.59	10.65	10.73	10.67
16.0	10.86		10.88	10.86	10.84	10.80	10.65	10.66	10.73	10.87			10.59	10.64		
16.5				10.86	10.83		10.64	10.63	10.74				10.59	10.64		
17.0							10.63	10.63					10.59	10.65		
17.5							10.62									

Table B-2. Salinity[1] on 1 July 2005

Depth (m)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.0	33.726	33.759	33.703	33.704	33.688	33.682	33.699	33.706	33.702	33.704	33.708	33.712	**33.807**	33.706	33.691	33.712
1.5	33.713	33.702	33.704	33.702	33.697	33.686	33.704	33.704	33.697	33.704	33.710	33.729	33.699	33.709	33.703	33.669
2.0	33.696	33.692	33.700	33.694	33.714	33.688	33.703	33.699	33.702	33.702	33.689	33.690	33.666	33.634	33.700	33.710
2.5	**33.783**	33.690	33.688	33.669	33.654	33.665	33.695	33.650	33.691	33.694	33.712	33.678	33.642	**33.589**	33.702	33.703
3.0	33.681	33.703	33.720	33.712	33.690	33.687	**33.631**	**33.627**	33.699	33.703	33.723	33.721	33.696	**33.788**	33.695	33.701
3.5	33.680	33.697	**33.607**	**33.621**	33.714	33.726	33.676	33.681	33.690	**33.772**	33.689	33.737	33.690	33.749	33.677	33.741
4.0	33.767	33.715	33.697	33.670	33.729	33.729	33.705	33.688	33.690	33.675	33.728	33.731	33.694	33.749	33.689	33.755
4.5	33.756	33.688	33.730	33.707	33.678	33.712	33.725	33.719	33.658	33.688	33.692	33.728	33.693	33.748	33.675	33.738
5.0	33.758	33.725	33.704	33.679	33.700	33.733	33.721	33.735	33.713	33.651	33.711	33.661	33.690	33.746	33.685	33.738
5.5	33.757	**33.633**	33.699	33.683	33.685	33.704	33.723	33.749	33.662	33.712	33.678	33.689	33.713	33.752	33.694	33.726
6.0	33.756	33.738	33.698	33.674	33.690	33.710	33.723	33.744	33.691	33.695	33.655	33.672	33.734	33.752	33.721	33.728
6.5	33.755	33.735	33.714	33.703	33.709	33.703	33.740	33.747	33.735	33.688	33.743	33.707	33.757	33.765	33.735	33.741
7.0	33.766	33.740	33.710	33.697	33.701	33.705	33.736	33.737	33.682	33.686	33.738	33.719	33.744	33.764	33.749	33.749
7.5	33.756	33.747	33.721	33.703	33.704	33.704	33.760	33.739	33.691	33.695	33.736	33.729	33.750	33.770	33.754	33.758
8.0	33.757	33.740	33.730	33.705	33.710	33.727	33.744	33.743	33.685	33.703	33.742	33.720	33.761	33.764	33.767	33.761
8.5	33.759	33.759	33.745	33.702	33.725	33.739	33.749	33.742	33.697	33.722	33.744	33.728	33.772	33.769	33.766	33.766
9.0	33.752	33.762	33.753	33.707	33.743	33.751	33.745	33.738	33.731	33.731	33.741	33.740	33.766	33.769	33.761	33.758
9.5	33.770	33.756	33.746	33.726	33.754	33.750	33.751	33.748	33.744	33.737	33.742	33.745	33.776	33.770	33.765	33.767
10.0	33.765	33.757	33.756	33.718	33.754	33.752	33.749	33.757	33.752	33.749	33.749	33.746	33.765	33.765	33.764	33.767
10.5	33.769	33.752	33.764	33.718	33.757	33.762	33.751	33.755	33.763	33.751	33.753	33.748	33.777	33.768	33.768	33.767
11.0	33.766	33.753	33.756	33.725	33.755	33.765	33.754	33.755	33.766	33.756	33.754	33.755	33.765	33.769	33.768	33.775
11.5	33.758	33.758	33.768	33.750	33.759	33.768	33.772	33.754	33.762	33.762	33.752	33.757	33.765	33.776	33.766	33.772
12.0	33.763	33.763	33.758	33.751	33.762	33.764	33.766	33.750	33.763	33.762	33.757	33.764	33.764	33.778	33.768	33.776
12.5	33.766	33.766	33.754	33.758	33.760	33.764	33.757	33.753	33.766	33.761	33.757	33.758	33.772	33.783	33.770	33.771
13.0	33.762	33.754	33.761	33.759	33.766	33.764	33.736	33.757	33.756	33.762	33.757	33.759	33.774	33.776	33.775	33.774
13.5	33.771	33.757	33.759	33.765	33.765	33.763	33.721	33.774	33.754	33.761	33.753	33.766	33.773	33.774	33.777	33.772
14.0	33.763	33.751	33.761	33.762	33.762	33.763	33.773	33.768	33.758	33.758	33.764	33.761	33.774	33.777	33.774	33.774
14.5	33.770	33.745	33.760	33.763	33.761	33.762	33.763	33.766	33.765	33.761	33.758	33.761	33.773	33.780	33.775	33.773
15.0	33.768	33.759	33.758	33.765	33.762	33.762	33.753	33.764	33.766	33.761	33.757		33.773	33.780	33.772	33.779
15.5	33.767	33.766	33.762	33.764	33.761	33.763	33.774	33.765	33.766	33.760			33.772	33.780	33.775	33.775
16.0	33.765		33.760	33.762	33.758	33.763	33.761	33.763	33.767	33.759			33.771	33.780		
16.5				33.762	33.763		33.770	33.767	33.764				33.770	33.779		
17.0							33.770	33.768					33.771	33.778		
17.5							33.769									

[1] Values enclosed in boxes were significantly different from the mean of other salinity measurements at the same depth.

Table B-3. Seawater Density on 1 July 2005

Depth (m)	Density (sigma-t)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.0	25.508	25.550	25.477	25.471	25.434	25.426	25.464	25.473	25.482	25.489	25.499	25.529	25.601	25.531	25.461	25.441
1.5	25.493	25.482	25.480	25.469	25.458	25.434	25.469	25.472	25.480	25.488	25.502	25.552	25.492	25.568	25.485	25.423
2.0	25.481	25.483	25.478	25.472	25.487	25.451	25.468	25.469	25.486	25.488	25.485	25.521	25.496	25.529	25.500	25.495
2.5	25.605	25.504	25.473	25.480	25.466	25.463	25.464	25.442	25.477	25.491	25.518	25.550	25.588	25.543	25.556	25.506
3.0	25.497	25.532	25.537	25.584	25.592	25.560	25.456	25.509	25.540	25.544	25.558	25.622	25.714	25.787	25.649	25.554
3.5	25.570	25.579	25.492	25.551	25.658	25.642	25.581	25.608	25.565	25.678	25.575	25.641	25.725	25.753	25.697	25.670
4.0	25.720	25.650	25.677	25.630	25.712	25.682	25.651	25.650	25.581	25.637	25.665	25.647	25.731	25.762	25.718	25.730
4.5	25.733	25.648	25.742	25.699	25.693	25.683	25.689	25.698	25.584	25.670	25.660	25.656	25.743	25.756	25.717	25.733
5.0	25.738	25.715	25.729	25.699	25.731	25.742	25.693	25.718	25.677	25.661	25.702	25.630	25.753	25.761	25.741	25.767
5.5	25.743	25.645	25.732	25.723	25.731	25.725	25.713	25.741	25.672	25.763	25.709	25.679	25.778	25.774	25.762	25.782
6.0	25.747	25.757	25.741	25.723	25.736	25.734	25.723	25.742	25.732	25.756	25.701	25.699	25.785	25.781	25.782	25.785
6.5	25.750	25.757	25.760	25.764	25.762	25.733	25.750	25.751	25.778	25.753	25.786	25.756	25.800	25.796	25.785	25.794
7.0	25.769	25.761	25.757	25.771	25.758	25.753	25.753	25.743	25.742	25.752	25.778	25.758	25.794	25.799	25.787	25.794
7.5	25.760	25.766	25.762	25.775	25.759	25.759	25.783	25.748	25.755	25.761	25.775	25.763	25.806	25.808	25.790	25.804
8.0	25.764	25.762	25.765	25.779	25.764	25.776	25.774	25.761	25.755	25.768	25.779	25.750	25.822	25.807	25.807	25.809
8.5	25.776	25.788	25.785	25.777	25.775	25.781	25.784	25.769	25.762	25.782	25.778	25.751	25.840	25.818	25.811	25.814
9.0	25.776	25.792	25.793	25.779	25.789	25.790	25.784	25.770	25.784	25.788	25.778	25.762	25.841	25.822	25.813	25.808
9.5	25.798	25.790	25.788	25.788	25.802	25.795	25.794	25.787	25.787	25.789	25.787	25.777	25.855	25.829	25.819	25.826
10.0	25.799	25.794	25.799	25.777	25.803	25.808	25.796	25.802	25.798	25.801	25.804	25.783	25.849	25.831	25.825	25.834
10.5	25.809	25.791	25.811	25.781	25.814	25.823	25.800	25.802	25.814	25.812	25.811	25.799	25.871	25.842	25.839	25.844
11.0	25.807	25.794	25.807	25.786	25.816	25.830	25.806	25.808	25.823	25.821	25.816	25.811	25.867	25.850	25.842	25.857
11.5	25.803	25.802	25.824	25.805	25.824	25.840	25.833	25.814	25.822	25.829	25.82	25.816	25.876	25.864	25.847	25.856
12.0	25.810	25.812	25.820	25.811	25.831	25.838	25.829	25.816	25.826	25.830	25.823	25.827	25.884	25.872	25.852	25.861
12.5	25.814	25.820	25.819	25.821	25.829	25.840	25.826	25.826	25.832	25.829	25.823	25.824	25.893	25.880	25.863	25.861
13.0	25.814	25.810	25.827	25.825	25.837	25.843	25.813	25.836	25.825	25.831	25.825	25.828	25.896	25.875	25.871	25.873
13.5	25.829	25.817	25.828	25.833	25.839	25.844	25.807	25.869	25.830	25.829	25.822	25.838	25.893	25.877	25.872	25.876
14.0	25.822	25.817	25.833	25.834	25.838	25.846	25.865	25.868	25.843	25.829	25.836	25.834	25.895	25.882	25.870	25.879
14.5	25.834	25.818	25.833	25.836	25.837	25.846	25.862	25.868	25.858	25.833	25.832	25.834	25.894	25.887	25.870	25.878
15.0	25.841	25.836	25.832	25.838	25.840	25.847	25.858	25.870	25.859	25.834	25.831		25.894	25.887	25.868	25.884
15.5	25.844	25.843	25.835	25.838	25.839	25.848	25.886	25.873	25.860	25.833			25.892	25.888	25.871	25.880
16.0	25.839		25.832	25.837	25.837	25.848	25.872	25.873	25.862	25.832			25.892	25.889		
16.5				25.837	25.842		25.881	25.880	25.859				25.890	25.888		
17.0							25.884	25.881					25.891	25.886		
17.5							25.884									

Table B-4. Dissolved Oxygen on 1 July 2005

Depth (m)	Dissolved Oxygen (mg/L)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.0	7.63	7.51	7.53	7.60	7.62	7.72	7.76	7.72	7.61	7.63	7.56	7.54	7.67	7.31	7.66	7.76
1.5	7.53	7.53	7.51	7.59	7.62	7.67	7.74	7.71	7.61	7.64	7.58	7.55	7.63	7.08	7.60	7.57
2.0	7.51	7.49	7.52	7.62	7.64	7.67	7.77	7.71	7.62	7.62	7.54	7.46	7.20	6.84	7.49	7.62
2.5	7.51	7.41	7.45	7.52	7.56	7.64	7.75	7.55	7.57	7.49	7.56	7.32	6.65	6.47	7.14	7.62
3.0	7.34	7.33	7.26	7.21	7.10	7.27	7.31	7.26	7.37	7.41	7.48	7.37	6.04	6.46	6.50	7.33
3.5	6.97	6.95	6.74	6.83	6.98	7.14	7.19	7.09	7.40	6.94	7.24	7.34	5.95	6.43	5.99	7.05
4.0	6.73	6.74	6.33	6.61	6.59	6.96	7.08	6.81	7.29	6.56	6.98	7.28	5.99	6.39	5.95	6.67
4.5	6.72	6.67	6.23	6.33	6.27	6.83	7.01	6.75	6.98	6.41	6.70	7.14	5.83	6.46	5.81	6.44
5.0	6.71	6.39	6.19	6.12	6.11	6.32	6.90	6.77	6.54	6.17	6.55	6.72	5.70	6.31	5.74	6.04
5.5	6.68	6.25	6.09	5.95	5.96	6.22	6.73	6.70	6.15	5.83	6.04	6.50	5.71	6.20	5.69	5.81
6.0	6.62	6.17	6.02	5.89	5.93	6.18	6.61	6.63	5.98	5.77	5.93	6.10	5.88	6.13	5.80	5.82
6.5	6.58	6.20	5.98	5.72	5.88	6.14	6.51	6.58	5.89	5.78	5.99	5.97	5.93	6.10	5.90	5.88
7.0	6.50	6.27	5.98	5.69	5.85	5.94	6.45	6.57	5.78	5.77	6.04	6.08	5.87	6.03	6.03	5.97
7.5	6.49	6.34	6.06	5.68	5.87	5.90	6.34	6.52	5.72	5.77	6.06	6.13	5.73	6.00	6.02	5.94
8.0	6.47	6.30	6.09	5.65	5.90	5.96	6.27	6.37	5.72	5.78	6.10	6.21	5.64	5.92	5.94	5.92
8.5	6.33	6.18	6.03	5.66	5.93	6.08	6.18	6.24	5.79	5.81	6.14	6.33	5.54	5.89	5.88	5.90
9.0	6.22	6.19	6.03	5.70	5.95	6.07	6.13	6.13	5.89	5.86	6.08	6.29	5.47	5.82	5.80	5.83
9.5	6.14	6.10	6.00	5.79	5.96	5.97	6.06	6.01	5.99	5.91	5.93	6.14	5.41	5.79	5.78	5.70
10.0	6.08	6.07	6.00	5.82	5.92	5.84	6.01	5.94	5.95	5.86	5.86	6.05	5.36	5.68	5.69	5.55
10.5	5.97	6.01	5.93	5.76	5.80	5.75	5.99	5.93	5.84	5.77	5.78	5.90	5.31	5.58	5.61	5.42
11.0	5.97	5.99	5.88	5.78	5.76	5.70	5.91	5.83	5.76	5.70	5.75	5.83	5.27	5.47	5.55	5.35
11.5	5.92	5.96	5.77	5.79	5.68	5.57	5.73	5.73	5.75	5.62	5.72	5.80	5.20	5.41	5.41	5.32
12.0	5.92	5.88	5.74	5.73	5.60	5.58	5.73	5.62	5.67	5.63	5.71	5.76	5.09	5.32	5.37	5.31
12.5	5.88	5.80	5.70	5.69	5.61	5.55	5.63	5.57	5.65	5.67	5.70	5.72	5.08	5.31	5.31	5.28
13.0	5.82	5.78	5.69	5.65	5.57	5.53	5.55	5.48	5.60	5.63	5.68	5.69	5.07	5.27	5.29	5.21
13.5	5.76	5.76	5.65	5.64	5.54	5.52	5.50	5.36	5.52	5.65	5.65	5.66	5.06	5.23	5.27	5.15
14.0	5.76	5.71	5.61	5.58	5.54	5.53	5.47	5.33	5.40	5.62	5.63	5.68	5.05	5.19	5.28	5.14
14.5	5.68	5.55	5.60	5.54	5.53	5.51	5.41	5.29	5.32	5.59	5.61	5.68	5.05	5.17	5.26	5.14
15.0	5.57	5.49	5.59	5.52	5.54	5.49	5.35	5.21	5.31	5.58	5.60		5.05	5.16	5.26	5.11
15.5	5.52	5.50	5.58	5.52	5.54	5.51	5.24	5.19	5.30	5.59			5.05	5.12	5.28	5.12
16.0	5.52		5.60	5.52	5.54	5.51	5.25	5.17	5.29	5.59			5.04	5.12		
16.5				5.52	5.54		5.25	5.15	5.29				5.05	5.12		
17.0							5.22	5.17					5.05	5.12		
17.5							5.22									

Table B-5. Light Transmittance[1] across a 0.25-m path on 1 July 2005

Depth (m)	Light Transmittance (%)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.0	67.19	67.36	67.63	67.60	66.87	67.45	67.99	67.80	67.57	67.27	67.09	66.87	66.94	67.31	66.39	66.46
1.5	67.05	67.02	67.49	67.76	67.91	67.53	67.86	67.80	67.70	67.29	67.07	66.90	67.35	68.47	66.28	66.79
2.0	67.27	67.09	67.53	68.46	67.73	68.19	67.78	68.08	67.49	67.26	66.96	67.00	68.18	68.19	66.63	67.02
2.5	68.19	68.14	67.68	67.69	69.01	68.77	68.04	68.22	67.71	67.19	67.65	67.59	68.81	69.61	67.21	68.36
3.0	67.93	67.96	67.92	67.69	67.82	67.15	68.60	69.32	67.87	67.87	67.48	69.14	69.44	71.18	69.43	69.13
3.5	68.34	68.58	69.05	69.46	70.17	69.89	70.52	70.51	68.58	67.72	69.40	68.89	70.66	72.87	68.43	70.04
4.0	70.45	70.03	69.75	69.12	69.33	70.74	70.79	69.86	68.51	68.43	68.93	68.63	70.76	71.85	68.47	71.28
4.5	72.70	70.75	71.29	68.71	69.04	70.53	70.58	70.29	69.65	69.01	69.86	68.55	70.74	72.29	68.57	69.22
5.0	73.19	71.95	71.53	69.35	69.15	69.60	71.22	71.69	69.22	68.99	69.05	69.03	71.14	73.74	68.72	69.04
5.5	73.07	72.39	71.33	69.17	69.22	70.37	72.86	73.22	69.07	68.86	69.12	69.43	71.59	72.92	69.66	69.79
6.0	73.32	72.04	71.10	69.06	69.33	70.14	73.14	73.14	69.05	69.43	69.96	69.69	72.02	72.55	69.93	70.36
6.5	73.41	72.20	71.07	68.72	69.09	69.98	73.49	73.50	69.41	69.52	70.77	70.40	72.33	72.98	70.21	71.22
7.0	73.43	73.34	71.07	67.97	69.50	69.80	73.58	72.97	69.40	69.18	71.80	70.85	73.01	73.35	71.36	71.69
7.5	73.78	73.68	70.77	68.67	69.87	70.39	73.70	72.71	69.42	69.56	72.12	71.01	72.33	72.55	72.35	72.57
8.0	73.66	73.70	71.23	68.97	70.45	71.32	74.35	73.19	69.02	70.21	72.46	71.50	71.17	73.10	72.38	72.33
8.5	73.78	73.24	71.58	69.10	70.73	72.46	73.80	73.58	69.50	69.91	72.72	72.01	70.70	73.65	72.26	72.56
9.0	73.54	73.28	71.51	69.45	71.68	72.76	73.13	73.47	70.61	69.94	72.43	73.12	71.24	73.75	72.21	72.79
9.5	73.27	72.44	72.05	70.18	71.94	72.70	72.36	72.64	71.60	70.68	72.12	72.94	71.35	73.94	71.88	71.98
10.0	72.46	71.67	71.12	70.41	72.13	73.03	72.40	71.98	71.69	71.16	72.14	72.25	71.64	74.27	71.77	70.91
10.5	72.17	71.30	70.68	69.98	72.38	72.92	72.04	71.64	71.77	71.22	71.80	72.01	71.97	74.39	73.06	70.27
11.0	71.83	71.30	70.44	69.79	72.24	72.39	72.07	71.85	71.12	71.05	71.38	71.59	75.04	75.11	73.38	68.80
11.5	71.73	71.29	70.69	70.92	71.50	70.83	71.31	71.19	70.65	70.53	71.18	71.53	**77.22**	74.93	72.10	69.22
12.0	71.80	71.17	70.56	70.78	70.70	71.79	71.03	70.38	70.72	70.11	71.40	71.53	**78.19**	75.61	71.32	68.58
12.5	71.41	70.87	70.93	70.48	70.62	71.86	71.08	70.23	70.18	69.99	71.59	72.03	**77.77**	75.45	71.84	69.46
13.0	71.47	70.71	70.89	69.94	69.82	72.50	70.94	70.73	70.42	70.32	71.64	72.49	**77.79**	75.66	72.33	71.17
13.5	71.08	70.56	70.93	69.61	69.03	72.55	71.62	72.74	70.51	70.72	71.30	72.29	**77.28**	75.65	71.79	71.75
14.0	71.28	70.90	71.03	69.82	68.93	72.64	73.27	73.67	70.15	70.53	71.45	72.49	**76.97**	75.69	71.92	71.89
14.5	71.25	71.72	70.48	69.25	69.39	72.89	73.79	73.76	70.53	69.91	71.37	72.51	**76.91**	75.26	71.61	71.91
15.0	71.08	71.42	70.72	68.01	69.53	72.69	74.12	73.39	71.21	69.49	71.62		**77.06**	75.08	71.61	72.03
15.5	69.95	70.88	70.23	**67.01**	69.68	72.69	75.57	73.47	71.16	69.18			**76.98**	74.88	71.44	71.29
16.0	70.09		69.64	**67.29**	70.18	72.77	75.71	74.13	71.55	68.55			**76.55**	74.59		
16.5				**67.22**	70.20		75.86	74.12	71.54				**76.53**	74.65		
17.0							75.29	74.41					**76.58**	75.02		
17.5							75.29									

[1] Values enclosed in boxes were significantly different from the mean of other transmissivity measurements at the same distance above the seafloor.

Table B-6. Detrended[1] pH on 1 July 2005

Depth (m)	Alkalinity (pH)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.0	7.422	7.420	7.422	7.426	7.423	7.430	7.426	7.426	7.421	7.421	7.420	7.411	7.409	7.404	7.426	7.425
1.5	7.422	7.422	7.421	7.426	7.428	7.436	7.428	7.426	7.423	7.421	7.420	7.413	7.418	7.404	7.429	7.428
2.0	7.422	7.426	7.421	7.426	7.429	7.437	7.430	7.426	7.421	7.421	7.420	7.409	7.421	7.407	7.430	7.430
2.5	7.429	7.426	7.421	7.425	7.427	7.436	7.430	7.426	7.421	7.421	7.420	7.409	7.422	7.406	7.426	7.431
3.0	7.423	7.426	7.421	7.422	7.425	7.434	7.430	7.426	7.422	7.422	7.418	7.408	7.418	7.393	7.427	7.430
3.5	7.422	7.422	7.418	7.416	7.421	7.429	7.428	7.420	7.421	7.422	7.413	7.404	7.398	7.378	7.422	7.427
4.0	7.419	7.418	7.412	7.402	7.407	7.422	7.420	7.409	7.412	7.420	7.405	7.400	7.380	7.369	7.405	7.423
4.5	7.415	7.411	7.388	7.388	7.391	7.415	7.409	7.399	7.402	7.407	7.393	7.397	7.361	7.364	7.378	7.413
5.0	7.402	7.396	7.366	7.377	7.374	7.399	7.396	7.387	7.397	7.388	7.388	7.392	7.350	7.357	7.368	7.399
5.5	7.392	7.387	7.352	7.359	7.358	7.387	7.389	7.376	7.388	7.373	7.373	7.389	7.339	7.355	7.344	7.380
6.0	7.380	7.374	7.343	7.349	7.339	7.371	7.382	7.368	7.382	7.357	7.356	7.379	7.329	7.349	7.338	7.359
6.5	7.375	7.362	7.334	7.335	7.328	7.365	7.373	7.359	7.355	7.340	7.341	7.370	7.320	7.344	7.335	7.347
7.0	7.366	7.351	7.327	7.327	7.315	7.350	7.364	7.356	7.353	7.328	7.333	7.357	7.318	7.338	7.324	7.338
7.5	7.362	7.346	7.316	7.315	7.306	7.338	7.360	7.349	7.337	7.322	7.324	7.345	7.318	7.335	7.318	7.329
8.0	7.355	7.342	7.316	7.304	7.300	7.329	7.352	7.347	7.325	7.311	7.320	7.332	7.312	7.326	7.318	7.326
8.5	7.351	7.341	7.311	7.298	7.295	7.321	7.346	7.340	7.313	7.306	7.316	7.323	7.308	7.325	7.314	7.319
9.0	7.347	7.341	7.309	7.291	7.294	7.315	7.339	7.333	7.305	7.303	7.312	7.321	7.302	7.322	7.314	7.314
9.5	7.342	7.335	7.308	7.289	7.29	7.312	7.330	7.327	7.300	7.296	7.312	7.319	7.298	7.319	7.311	7.313
10.0	7.337	7.329	7.305	7.286	7.290	7.310	7.325	7.321	7.298	7.295	7.307	7.319	7.291	7.314	7.308	7.307
10.5	7.330	7.323	7.304	7.286	7.290	7.307	7.320	7.316	7.298	7.296	7.303	7.316	7.287	7.310	7.301	7.302
11.0	7.325	7.322	7.301	7.284	7.287	7.304	7.316	7.308	7.298	7.291	7.301	7.314	7.282	7.307	7.300	7.298
11.5	7.319	7.318	7.295	7.281	7.285	7.290	7.313	7.307	7.291	7.291	7.293	7.306	7.278	7.302	7.292	7.290
12.0	7.318	7.315	7.293	7.282	7.281	7.289	7.307	7.297	7.286	7.289	7.289	7.303	7.273	7.292	7.291	7.285
12.5	7.310	7.314	7.287	7.278	7.276	7.285	7.301	7.295	7.282	7.284	7.285	7.299	7.267	7.291	7.284	7.279
13.0	7.307	7.304	7.283	7.277	7.269	7.281	7.296	7.282	7.278	7.281	7.285	7.289	7.261	7.286	7.280	7.274
13.5	7.306	7.303	7.279	7.275	7.266	7.278	7.290	7.281	7.276	7.277	7.280	7.287	7.258	7.280	7.276	7.271
14.0	7.301	7.300	7.277	7.272	7.266	7.274	7.283	7.276	7.271	7.276	7.278	7.285	7.255	7.275	7.271	7.266
14.5	7.297	7.296	7.274	7.271	7.267	7.271	7.278	7.270	7.268	7.273	7.276	7.281	7.251	7.273	7.265	7.260
15.0	7.293	7.292	7.270	7.269	7.262	7.266	7.273	7.262	7.263	7.273	7.274		7.249	7.269	7.264	7.254
15.5	7.289	7.288	7.270	7.266	7.262	7.265	7.267	7.258	7.258	7.270			7.246	7.265	7.258	7.255
16.0	7.286		7.268	7.262	7.262	7.262	7.263	7.253	7.255	7.268			7.246	7.262		
16.5				7.258	7.262		7.255	7.250	7.249				7.244	7.259		
17.0							7.254	7.247					7.241	7.259		
17.5							7.249									

[1] Measured pH levels were corrected for temporal drift to account for ongoing equilibration of the pH sensor.

Table B-7. Uncorrected pH on 1 July 2005

Depth (m)	Alkalinity (pH)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.0	7.380	7.379	7.395	7.408	7.415	7.423	7.426	7.426	7.421	7.421	7.417	7.406	7.409	7.390	7.426	7.425
1.5	7.380	7.381	7.394	7.408	7.420	7.429	7.428	7.426	7.423	7.421	7.417	7.408	7.418	7.390	7.429	7.428
2.0	7.380	7.385	7.394	7.408	7.421	7.430	7.430	7.426	7.421	7.421	7.417	7.404	7.421	7.393	7.430	7.430
2.5	7.387	7.385	7.394	7.407	7.419	7.429	7.430	7.426	7.421	7.421	7.417	7.404	7.422	7.392	7.426	7.431
3.0	7.381	7.385	7.394	7.404	7.417	7.427	7.430	7.426	7.422	7.422	7.415	7.403	7.418	7.379	7.427	7.430
3.5	7.380	7.381	7.391	7.398	7.413	7.422	7.428	7.420	7.421	7.422	7.410	7.399	7.398	7.364	7.422	7.427
4.0	7.377	7.377	7.385	7.384	7.399	7.415	7.420	7.409	7.412	7.420	7.402	7.395	7.380	7.355	7.405	7.423
4.5	7.373	7.370	7.361	7.370	7.383	7.408	7.409	7.399	7.402	7.407	7.390	7.392	7.361	7.350	7.378	7.413
5.0	7.360	7.355	7.339	7.359	7.366	7.392	7.396	7.387	7.397	7.388	7.385	7.387	7.350	7.343	7.368	7.399
5.5	7.350	7.346	7.325	7.341	7.350	7.380	7.389	7.376	7.388	7.373	7.370	7.384	7.339	7.341	7.344	7.380
6.0	7.338	7.333	7.316	7.331	7.331	7.364	7.382	7.368	7.382	7.357	7.353	7.374	7.329	7.335	7.338	7.359
6.5	7.333	7.321	7.307	7.317	7.320	7.358	7.373	7.359	7.355	7.340	7.338	7.365	7.320	7.330	7.335	7.347
7.0	7.324	7.310	7.300	7.309	7.307	7.343	7.364	7.356	7.353	7.328	7.330	7.352	7.318	7.324	7.324	7.338
7.5	7.320	7.305	7.289	7.297	7.298	7.331	7.360	7.349	7.337	7.322	7.321	7.340	7.318	7.321	7.318	7.329
8.0	7.313	7.301	7.289	7.286	7.292	7.322	7.352	7.347	7.325	7.311	7.317	7.327	7.312	7.312	7.318	7.326
8.5	7.309	7.300	7.284	7.280	7.287	7.314	7.346	7.340	7.313	7.306	7.313	7.318	7.308	7.311	7.314	7.319
9.0	7.305	7.300	7.282	7.273	7.286	7.308	7.339	7.333	7.305	7.303	7.309	7.316	7.302	7.308	7.314	7.314
9.5	7.300	7.294	7.281	7.271	7.285	7.305	7.330	7.327	7.300	7.296	7.309	7.314	7.298	7.305	7.311	7.313
10.0	7.295	7.288	7.278	7.268	7.282	7.303	7.325	7.321	7.298	7.295	7.304	7.314	7.291	7.300	7.308	7.307
10.5	7.288	7.282	7.277	7.268	7.282	7.300	7.320	7.316	7.298	7.296	7.300	7.311	7.287	7.296	7.301	7.302
11.0	7.283	7.281	7.274	7.266	7.279	7.297	7.316	7.308	7.298	7.291	7.298	7.309	7.282	7.293	7.300	7.298
11.5	7.277	7.277	7.268	7.263	7.277	7.283	7.313	7.307	7.291	7.291	7.290	7.301	7.278	7.288	7.292	7.290
12.0	7.276	7.274	7.266	7.264	7.273	7.282	7.307	7.297	7.286	7.289	7.286	7.298	7.273	7.278	7.291	7.285
12.5	7.268	7.273	7.260	7.260	7.268	7.278	7.301	7.295	7.282	7.284	7.282	7.294	7.267	7.277	7.284	7.279
13.0	7.265	7.263	7.256	7.259	7.261	7.274	7.296	7.282	7.278	7.281	7.282	7.284	7.261	7.272	7.280	7.274
13.5	7.264	7.262	7.252	7.257	7.258	7.271	7.290	7.281	7.276	7.277	7.277	7.282	7.258	7.266	7.276	7.271
14.0	7.259	7.259	7.250	7.254	7.258	7.267	7.283	7.276	7.271	7.276	7.275	7.280	7.255	7.261	7.271	7.266
14.5	7.255	7.255	7.247	7.253	7.259	7.264	7.278	7.270	7.268	7.273	7.273	7.276	7.251	7.259	7.265	7.260
15.0	7.251	7.251	7.243	7.251	7.254	7.259	7.273	7.262	7.263	7.273	7.271		7.249	7.255	7.264	7.254
15.5	7.247	7.247	7.243	7.248	7.254	7.258	7.267	7.258	7.258	7.270			7.246	7.251	7.258	7.255
16.0	7.244		7.241	7.244	7.254	7.255	7.263	7.253	7.255	7.268			7.246	7.248		
16.5				7.240	7.254		7.255	7.250	7.249				7.244	7.245		
17.0							7.254	7.247					7.241	7.245		
17.5							7.249									

Table B-8. Ancillary Observations on 1 July 2005 during the Receiving-Water Survey

	Location		Diffuser Distance	Time	Air Temperature	Cloud Cover	Wind Avg	Wind Max	Wind Dir (from)	Swell Ht/Dir	Secchi Depth
Station	Latitude	Longitude	(m)	(PDT)	(°C)	(%)	(kt)	(kt)	(°T)	(ft/°T)	(m)
1	35°23.2533' N	120°52.5025' W	100.5	06:56:01	15.0	100	1.5	1.8	193	<2 W	3.0
2	35°23.2306' N	120°52.5044' W	58.5	07:00:43	15.1	100	1.6	1.8	183	<2 W	3.0
3	35°23.2100' N	120°52.5029' W	20.6	07:06:40	15.1	100	0.8	0.9	183	<2 W	3.5
4	35°23.1862' N	120°52.5023' W	23.8	07:11:08	14.2	100	1.4	1.7	183	<2 W	4.0
5	35°23.1646' N	120°52.5041' W	63.5	07:14:39	16.4	100	0.2	0.4	188	<2 W	4.0
6	35°23.1461' N	120°52.4947' W	98.9	07:18:32	15.1	100	0.9	2.1	283	<2 W	3.5
7	35°23.1955' N	120°52.5667' W	94.9	07:45:46	15.3	100	1.2	2.7	73	<2 W	4.0
8	35°23.1977' N	120°52.5409' W	55.6	07:41:25	17.2	100	0.5	0.8	83	<2 W	4.0
9	35°23.1990' N	120°52.5198' W	23.5	07:36:55	16.5	100	0.8	1.3	223	<2 W	4.0
10	35°23.1979' N	120°52.4914' W	19.6	07:32:53	15.2	100	1.3	2.8	223	<2 W	3.5
11	35°23.1958' N	120°52.4630' W	62.7	07:28:55	16.1	100	0.3	1.7	73	<2 W	4.0
12	35°23.1980' N	120°52.4339' W	106.5	07:23:41	16.1	100	1.0	1.9	263	<2 W	4.0
13	35°23.1744' N	120°52.5382' W	68.6	08:29:14	18.2	100	0.8	1.8	283	<2 W	4.0
14	35°23.2164' N	120°52.5252' W	45.3	08:14:26	14.1	100	2.6	2.9	293	<2 W	4.0
15	35°23.2280' N	120°52.4761' W	67.9	08:19:21	14.9	100	3.3	4.1	293	<2 W	4.0
16	35°23.1755' N	120°52.4748' W	62.3	08:23:59	13.9	100	2.8	3.4	293	<2 W	4.0

There was no visual expression of the effluent plume at the sea surface. Neither odors nor debris of sewage origin were observed at any time during the survey.

Tidal Conditions (Pacific Daylight Time)
Low Tide: 02:10   0.38 ft
High Tide: 08:21   3.09 ft
Low Tide: 12:55   1.93 ft
High Tide: 19:35   5.53 ft