UPPER NEWPORT BAY ECOSYSTEM RESTORATION PROJECT
POST-RESTORATION MONITORING PROGRAM

ANNUAL REPORT
YEAR 2 – 2012

UPPER NEWPORT BAY ECOLOGICAL RESERVE
ORANGE COUNTY, CALIFORNIA

January 2014

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TABLE OF CONTENTS

1.0 INTRODUCTION 1

1.1. RESTORATION NEED AND DESIGN 1
1.2. UNB ECOSYSTEM RESTORATION PROJECT IMPLEMENTATION 3
1.3. POST-RESTORATION MONITORING 3
1.4. HORIZONTAL AND VERTICAL REFERENCE DATA 5

2.0 PHYSICAL MONITORING 7

2.1. BATHYMETRIC MONITORING 7
2.2. TIDAL MONITORING 12
2.3. WATER QUALITY MONITORING 18
2.4. LEAST TERN ISLAND ELEVATIONS 33

3.0 BIOLOGICAL MONITORING 35

3.1. AVIAN MONITORING 35
3.2. FISHERIES MONITORING 46
3.3. BENTHIC INVERTEBRATE MONITORING 60
3.4. VEGETATION MONITORING 70

4.0 SUMMARY 86

5.0 RECOMMENDATIONS 86

6.0 REFERENCES 88

LIST OF TABLES

Table 1. Post-restoration monitoring program schedule. 4
Table 2. Tidal minimum, maximum, and range in 2012 at the Newport Bay Entrance and each Upper Newport Bay station. 14
Table 3. Results of 2012 tidal lag and muting analyses performed to compare the Upper Newport Bay tidal monitoring stations to the Newport Bay entrance channel (January 1 to December 31, 2012).15
Table 4. Comparison of tidal parameters in 2011 and 2012 in Upper Newport Bay. Lag and muting are for higher high tide events. 16
Table 5. Water quality data collected January 11, 2012 at Upper Newport Bay. 19
Table 6. Water quality data collected April 19, 2012 at Upper Newport Bay. 22
Table 7. Water quality data collected July 25, 2012 at Upper Newport Bay. 24
Table 8. Water quality data collected October 10, 2012 at Upper Newport Bay. 26
Table 9. Elevation (feet MLLW, 83-01 epoch) of three control points at New Least Tern Island. 34
Table 10. Abundance of birds in UNB by area and sample date in Year 2 (2012). 40
Table 11. Total fish abundance (# of individuals) in UNB for all gear types in Year 2 (2012). 49
Table 12. Total mass (g) of fish in UNB for all gear types in Year 2 (2012). 49
Table 12. Total mass (g) of fish in UNB for all gear types in Year 2 (2012). 50
Table 13. Abundance and percent of total by species from most to least. 52
Table 14. Mass (g) and percent of total by species from largest to smallest. 52
Table 15. Maximum and minimum standard length (mm) of all fish species captured by quarter at all stations in 2012. 56

Table 16. Mean density (individuals/m2) (top table) and biomass (g/m2) (bottom table) of UNB infauna in January 2012. 63
Table 17. Mean density (individuals/m2) (top table) and biomass (g/m2) (bottom table) of UNB infauna in July 2012. 64
Table 18. Counts of epibenthic invertebrates captured in fishing gear (beach seine, otter trawl, and purse seine) in UNB. 67
Table 19. Mean density (individuals/m2) of infauna at three coastal wetlands in comparison to UNB. 69
Table 20. Area of habitats within the UNB study area (April 2012). 76
Table 21. Average percent cover of plant species in each marsh community at UNB in September 2012. 80
Table 22. Percentage frequencies of plant species in each marsh community at UNB in September 2012. 81

LIST OF FIGURES

Figure 1. Project Vicinity Map 2
Figure 2. Tide and Water Quality Monitoring Stations 8
Figure 3. 2011 and 2012 Bathymetry and Change Analysis 9
Figure 4. Depth Profile of Salinity (ppt) by Station at Upper Newport Bay (2012). 28
Figure 5. Depth Profile of Dissolved Oxygen (mg/L) by Station at Upper Newport Bay (2012). 29
Figure 6. Avian Survey Areas 36
Figure 7. Avian Abundance and Diversity by Survey in 2012 at UNB. 39
Figure 8. Light-footed Clapper Rail counts at Upper Newport Bay from 1980 to present. 44
Figure 9. Fisheries and Benthic Sampling Locations 47
Figure 10. Mean fish density (individuals/m^2) (+ 1 SE) by station for beach seine, otter trawl, and purse seine in each quarter of Year 2. 53
Figure 11. Mean fish biomass (g/m^2) (+ 1 SE) by station for beach seine, otter trawl, and purse seine in each quarter of Year 2. 54
Figure 12. Fish density (individuals/m^2) pre-restoration (MEC, Sept. 1997) and post-restoration (M&A, Oct. 2012).. 59
Figure 13. Mean UNB infauna density (individuals/m^2) and biomass (g/m^2) (+1 SD) in January and July 2012 by station and tidal elevation. 66
Figure 14. Vegetation Monitoring Transects. 74
Figure 15. Upper Newport Bay Habitat Map (April 2012). 77
Figure 16. Comparison of Habitat Distributions Between Year 1 (2011) and Year 2 (2012). 84

LIST OF APPENDICES

Appendix A. Upper Newport Bay Ecosystem Restoration Project Features and Summary
Appendix B. Sample Station Coordinates
Appendix C. Bathymetric Plots Enlarged from Figure 3
Appendix D. Physical Monitoring Photos
Appendix E. Monthly Plots of Tidal Data
Appendix F. Fish Data
Appendix G. Epibenthic Invertebrate Raw Data
Appendix H. Benthic Sample Plots
Appendix I. Vegetation Transect Data
Appendix J. Vegetation Transect Photos
Appendix K. CRAM Report September 2012

UPPER NEWPORT BAY ECOSYSTEM RESTORATION PROJECT POST-RESTORATION MONITORING PROGRAM

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YEAR 2 – 2012

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1.0 INTRODUCTION

Newport Bay is located on the southern California coast, approximately 40 miles south of Los Angeles (Figure 1). From the harbor entrance at the rocky headland at Corona del Mar, Newport Bay extends about 3.5 miles north northeastward. Newport Bay is a combination of two distinct units, termed "Lower Bay" and "Upper Newport Bay" (UNB), divided by the narrows at Pacific Coast Highway (PCH) Bridge (Figure 1). The 752-acre Lower Bay, where the majority of commerce and recreational boating exists, is heavily developed (predominantly as residential properties) and is a deep basin coastal lagoon. The 1,000-acre UNB is a drowned river valley, geologically much older than the Lower Bay, and is largely undeveloped. This portion of the bay is more formally considered to be an estuary. Much of UNB is included in the Upper Newport Bay Ecological Reserve, managed by the California Department of Fish and Wildlife (CDFW) (formerly the California Department of Fish and Game).

Upper Newport Bay is one of the largest coastal wetlands remaining in southern California. Natural habitats within UNB include open marine waters, intertidal mudflats, cordgrass-dominated low salt marsh, pickleweed-dominated mid salt marsh, high salt marsh, salt panne, riparian, freshwater marsh and upland. Because of its diversity of habitats and its location on the Pacific Flyway, UNB supports an impressive number and diversity of birds, particularly during fall and winter when shorebirds and waterfowl arrive from their northern breeding grounds. Upper Newport Bay also supports several endangered bird species and an endangered plant. The subtidal and intertidal waters of UNB provide important habitat for marine and estuarine fishes.

1.1. Restoration Need and Design

By the end of the 20th century, the ecological diversity and functionality of UNB was increasingly threatened by sedimentation from the surrounding urbanized watershed. The primary source of freshwater and sediment loads to UNB is San Diego Creek, which drains approximately 85 percent of the 98,500-acre San Diego Creek watershed. Sediment from the San Diego Creek watershed had increasingly filled open water areas within UNB. This sedimentation decreased the extent of tidal inundation, diminished water quality, degraded habitat for endangered species, migratory water birds, and marine and estuarine fishes. It also resulted in navigation problems in UNB marinas and navigation channels. If sediment deposition within UNB had been allowed to continue, the remaining open water areas would have eventually evolved into mudflats, and later, marsh or upland habitat, resulting in a loss of ecological diversity.

Site Locator and Vicinity Map

Upper Newport Bay Ecosystem Restoration Project
Post-restoration Monitoring Program

Figure 1

It became clear that a program was needed to develop a long-term management plan to control sediment deposition in UNB and to preserve the health of its habitats. Through a partnership among the U.S. Army Corps of Engineers (ACOE), the County of Orange, CDFW, and the California Coastal Conservancy, the UNB Ecosystem Restoration Project was developed.

The restoration project was designed to allow for the effective management of sediments deposited into the bay, reduce the frequency of maintenance dredging, improve or restore estuarine habitats, sustain a mix of open water, mudflat, and marsh habitat, increase tidal circulation for water quality, reduce predator access to sensitive habitats, improve public use and recreational access, and improve educational opportunities. Sediment will continue to be deposited into UNB to varying degrees depending on what control measures are implemented in the watershed. Therefore, one of the most important components of the project was to develop a plan to control sediments by designing two in-bay basins into which the bulk of the sediment would be captured and from which effective maintenance dredging removals could be undertaken.

1.2. UNB Ecosystem Restoration Project Implementation

After an extensive process of planning and environmental review, the restoration project was initiated in 2006. The first phase was conducted from April 2006 to July 2009. The second phase was conducted from November 2009 to October 2010. The total cost of restoration was approximately $37.4 million. Key project features included expansion and deepening of two sediment control basins (Basin I/III and Basin II), deepening of channels around five restoration islands, creation of three large mudflats, relocation of a least tern nesting island, installation of maintenance access at the two nesting islands, and installation of interpretive signs and buoys. Approximately 2.35 million cubic yards of sediment was dredged as part of the project. A detailed project summary and map labeled with key restoration features is provided in Appendix A.

1.3. Post-restoration Monitoring

In order to detect and document the long-term development processes following the restoration, the ACOE prepared the Post-restoration Monitoring Program for the Upper Newport Bay Ecosystem Restoration Project (ACOE 2010). The program outlines ten years of biological and physical monitoring, as detailed in the following sections. The schedule for the various monitoring events is provided in Table 1.

The ACOE has contracted with Merkel & Associates, Inc. (M&A) to implement portions of the first three years of the Post-Restoration Monitoring Program, after which time the ACOE commitment to post-restoration reporting will be completed and the County of Orange and CDFW will share the responsibility for the monitoring and reporting in Years 4 through 10 (note that Year 4 has no monitoring requirements).

Table 1. Post-restoration monitoring program schedule.

TASK	Post-Restoration Annual Cycle												Post-Restoration Program					
	J	F	M	A	M	J	J	A	S	O	N	D	Year 1 2011	Year 2 2012	Year 3 2013	Year 5 2015	Year 8 2018	Year 10 2020
Physical Monitoring Program																		
Bathymetric Mapping						▬							X-ACOE Jan	X-ACOE Jan	X-ACOE Jan	X	X	
Tidal Monitoring	▬			▬			▬			▬			X	X		X		X
Water Quality	▬			▬			▬			▬			X	X		X		X
Least Tern Island Elevations	▬	▬	▬										X	X	X	X	X	X
Biological Monitoring Program																		
General Avian Surveys	▬			▬			▬			▬				X		X		X
Species of Special Concern				▬	▬	▬	▬	▬	▬					X-CDFW		X-CDFW		X-CDFW
Fisheries	▬			▬			▬			▬				X		X		X
Epibenthic	▬			▬			▬			▬				X		X		X
Benthic Infauna	▬						▬							X		X		X
Vegetation																		
Aerial Photogrammetry and Georeferencing						▬							X-ACOE Jan	X-ACOE Jan	X-ACOE Jan	X	X	
Vegetation Mapping and Groundtruthing								▬					X-Aug	X-Aug	X-Aug	X	X	
Veg Transects									▬					X		X	X	
Cordgrass Monitoring					▬	▬	▬							X		X	X	
CRAM Survey					▬	▬	▬							X				
Data Management and Analysis																		
Quality Assurance Program	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	X	X	X	X	X	X
Reporting Program																		
Quarterly Summary Reports		✦			✦			✦			✦			X		X		X
Annual and Final Reports												✦	X	X	X	X	X	X

RESTORATION CONSTRUCTION COMPLETED OCTOBER 2010

▬ Data Collection ✦ Project Milestone / Report Deliverable

The goals and questions to be assessed by the program, as excerpted from the Monitoring Program document, include:

1. Are the sediment basins performing according to the design goals?
    a. Do the basins have enough capacity such that maintenance dredging will not be required for 20+ years (given the rate of sediment accumulation within the basins)?
    b. Are the basins trapping the majority of the sediment that enters the upper bay, and thus minimizing sediment accumulation in the tidal channels and the lower portions of the bay?

2. Has the restoration project reduced turbidity in the bay (by trapping incoming sediment deep in the basins)?

3. Are the deepened basins receiving adequate dissolved oxygen? There are concerns about increased density stratification and reduced oxygen supply to the deepest layers.

4. Has the project resulted in increased eelgrass survival in the upper bay?

5. Has the project resulted in increased (water) volume within the bay such that the water residence time in the bay is significantly increased [sic]?

6. Has the project resulted in improved diversity and abundance of benthic infauna and epifauna?

7. Has the project resulted in a significant increase in the number of targeted birds using UNB? Targeted species include listed species.

8. Has the project led to significant increases in fisheries habitat? Tracking habitat utilization and relative abundance across multiple species [sic].

9. Has the project resulted in the gain or loss of any habitat type greater then 10%?

The restoration project was completed in October 2010. The first monitoring year extended from January to December 2011, and the second year extended from January to December 2012. This document serves as the second annual report, covering monitoring performed in 2012.

1.4. Horizontal and Vertical Reference Data

Measurement units of numerical data from the monitoring program are presented as a combination of metric and English Standard System units in this report. Typically, collected scientific data would be reported using metric units such as hectares and meters. However, UNB has a long regulatory, engineering, and biological monitoring history that has made use of a blend of metric and English units. As a result, presentation of data has sought to continue using the units of measure that are most applicable to the various monitoring elements. Additionally, for some parameters such as tidal elevation and habitat area measurements, metric unit presentations are less familiar to most readers than English units. Therefore, where an area measurement has been

made through GIS-based mapping efforts, the results are presented in hectares, with conversions to acres provided due to the greater ease with which many readers can envision areas in this unit of measurement. Tidal data are presented in feet, rather than meters, due to the greater familiarity of most readers with tidal ranges in feet and the historic usage of English units for this element of the project. Additionally, discussion of sediment accumulation and dredging volumes will be in cubic yards due to the prevalence of this unit in the commercial dredging field. All other data, primarily biological measurements taken in the field, are reported in metric units.

The vertical datum used throughout this document is Mean Lower Low Water (83-01 epoch). Horizontally geo-referenced data are on the California State Plane Zone 6, North American Datum of 1983 (NAD 83).

2.0 PHYSICAL MONITORING

During the second year post-restoration, physical monitoring included collection of bathymetric data, monitoring tidal conditions, documenting water quality, and checking the elevation of the New Least Tern Island (Table 1). Monitoring stations were established using direction provided in the Post-Construction Monitoring Program for the Upper Newport Bay Ecosystem Restoration Project (Monitoring Program), as well as observations made in the field at the time of station determination in Year 1 of the monitoring program (Figure 2). Appendix B provides geographic coordinates of the physical monitoring locations.

2.1. Bathymetric Monitoring

The ACOE completed the annual bathymetric surveys of the restoration project area and provided the collected data to M&A for analysis. ACOE Los Angeles District survey personnel collected bathymetric data in 2012 between January 9 and 26. The information collected was a merged dataset from single beam and multi-beam sonar on a 3-foot grid. The vertical datum was feet MLLW and the horizontal datum was State Plane, Zone 6, NAD 83, feet. This dataset served as the Year 2 (2012) post-restoration bathymetric condition.

The bathymetric data were provided to M&A as point data. The point data were imported into the GIS software ESRI ArcView and converted to a grid with no interpolation. These data are presented in Figure 3 alongside the Year 1 baseline data collected by ACOE in January, February, and March 2011, which were also provided to M&A as point data. The ESRI extension 3D Analyst was used to perform a cut/fill volume analysis between the Year 2 and Year 1 grids to calculate the total volume change.

A subtraction between the grids was performed and a resulting grid prepared to illustrate areas of accretion and erosion between years. Areas of positive change (accretion) were plotted in shades of red and areas of negative change (erosion) were plotted in shades of blue. This comparison plot is presented on the far right of Figure 3. Regions within the study area that were not captured by both bathymetric surveys have been left blank and excluded from calculations of change.

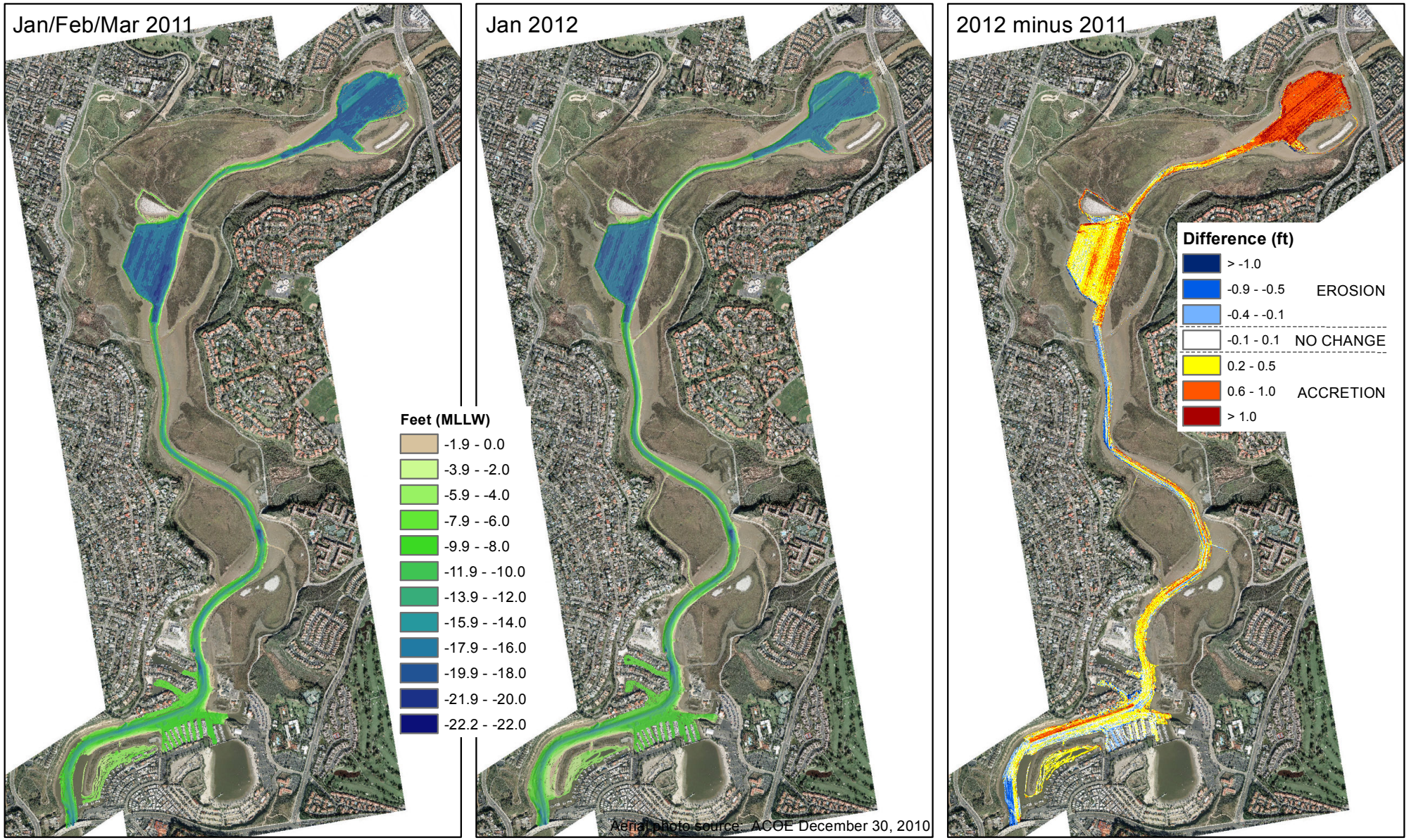
Larger, higher resolution versions of each of the three images in Figure 3 are provided in Appendix C to allow the reader more detailed examination. M&A has not been tasked with evaluating the quality of the data or adjusting the data to remove survey related noise. There appear to be some linear artifacts in the survey record (visible in Appendix C) that are related to the survey boat route rather than true bathymetric features, though the effects on the overall change analysis is believed to be minor.

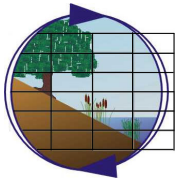
The areas of greatest sedimentation were the two basins, as anticipated by the project design, and in the channel between them (see Figure 1 for basin and landmark names). Accretion in Unit I/III Basin was generally in the 0.6 to 1.5-foot range, while accretion in Unit II Basin was primarily in the 0.2 to 1.0-foot range. The average depth was approximately –17.8 feet (-5.4 m) MLLW in Unit I/III Basin and –18 feet (-5.4 m) MLLW in Unit II Basin. Both were excavated by the restoration project to –19.0 feet (-5.8 m) MLLW. Erosional areas were more limited, occurring primarily on the west

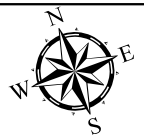
Tide and Water Quality Monitoring Stations

Upper Newport Bay Ecosystem Restoration Project
Post-restoration Monitoring Program

Figure 2







2011 and 2012 Bathymetry and Change Analysis
Upper Newport Bay Ecosystem Restoration Project
Post-restoration Monitoring Program - Year 2

Figure 3

shoreline of the Unit II Basin, in the narrowest part of the main channel between Unit II Basin and Middle Island, and in the main channel just north of Pacific Coast Highway (Figure 3). Based on the scale and characteristics of the exhibited erosional features, some of the quantified erosion is likely related to alignment noise at the edges of the multibeam sonar datasets rather than true areas of erosion. Between the January/February/March 2011 (Year 1 baseline) survey and the January 2012 (Year 2) survey, total accretion throughout the surveyed area was approximately 113,102 cubic yards (86,472 cubic meters). Total erosion was 22,080 cubic yards (16,881 cubic meters), for a net change of 91,022 cubic yards (69,591 cubic meters) of accretion.

The monitoring work was intended to answer Question 1 posed in Section 1.3 above: *Are the sediment basins performing according to the design goals?* More specifically, do the basins have enough capacity such that maintenance dredging will not be required for 20+ years (given the rate of sediment accumulation within the basins) and are the basins trapping the majority of the sediment that enters the upper bay, and thus minimizing sediment accumulation in the tidal channels and the lower portions of the bay?

The January 2011 Design Documentation Report (ACOE 2011) describes the design goals as follows. The two existing Unit II and Unit I/III sediment basins were configured to trap sediment coming from San Diego Creek. The project design called for expanding and deepening these basins to –17.3 feet (5.26 m) MLLW, with the final constructed basin depths being generally –19.0 feet (-5.8 m) MLLW with maximum depths of –19.7 feet (-6.0 m) MLLW. The previously maintained depth was -10.6 feet (–3.43 m) MLLW. The basins were sized to accommodate average annual sediment loading for a period of 21 years before requiring maintenance. The 21-year maintenance cycle was based upon historic annual sediment inflows into UNB from San Diego Creek ranging from 6,000 cubic yards (4,600 cubic meters) to nearly 700,000 cubic yards (535,000 cubic meters) during the 1972 to 1996 period. Modeling for the project design used an annual average of 164,000 cubic yards (125,000 cubic meters), though the Design Documentation Report notes there is updated sediment loading information available in the Newport Bay Watershed Sediment TMDL Annual Reports prepared by the County of Orange.

The total accretion of 113,102 cubic yards (86,472 cubic meters) between Year 1 and Year 2 is very consistent with the above design projections and would suggest that the 21-year maintenance cycle is reasonable. Further, it is important to note that the analysis of accreted volume is based on an unconsolidated surface-to-surface comparison between 2011 and 2012. With time and accumulation of greater sediment depths, the lower strata of the trapped sediment will consolidate, resulting in reduced sediment volume and increased density, thus returning some of the basin capacity through reduced sediment water content. Notwithstanding the early monitoring results, it is important to note that the 2011-2012 rainy season was more benign than average and it is not appropriate to draw long-term conclusions based on sub-average rainfall conditions. The greatest sediment delivery from upstream watersheds will result from high flow events. The winter of 2011-2012 was notably drier than most and also lacked significant high rainfall periods. To truly understand the likely frequency of maintenance required, it will be necessary to collect data over periods of average and above average storm conditions. This bathymetric analysis will performed again in monitoring years 3, 5, and 8.

The analysis of 2011 and 2012 bathymetric surveys confirms that sediment is being trapped in the basins. When the distribution of sediment trapping is explored across the UNB, it is clear that a disproportionately high amount of sediment was trapped in the upper portions of the UNB study area than further down the bay. Approximately 87,500 cubic yards (66,900 cubic meters) or 77 % of the accumulated sediment within the UNB study area has been accreted up-bay from the south end of the Unit II Basin (including the Unit II Basin, the Unit I/III basin and the channel between them). As would be expected, the degree of sediment capture decreased from the upper to lower portions of the UNB study area. The small tidal channels also continue to show sediment deposition, particularly in the northerly portions of UNB. Sediment trapping within the basins undoubtedly serves to reduce the availability of source sediment for deposition in smaller tidal channels, however, transportable fine sediments continue to be available and thus tidal channel infill is expected to continue. Where channels or moats were over-excavated by the restoration project to isolate islands, the velocities of tidal flow will typically be inadequate to keep sediment in suspension or re-suspend sediment once it is deposited in the channel. As a result, these channels will accrete sediment at a more rapid rate than channels that are naturally sized by the flows they convey. The rate of deposition within the excavated channels will diminish as the sectional area is reduced to a point at which flow velocities are adequate to prevent deposition and stimulate export of deposited sediments.

An estimate of the sediment input into UNB from the surrounding watershed is generated annually by the County of Orange in the Newport Bay Watershed Sediment TMDL annual reports. Using suspended sediment samples and hydrographic data, the monitoring estimated that freshwater tributaries input approximately 116,000 cubic yards into UNB during the 2010/2011 wet weather season and 4,000 cubic yards in the 2011/2012 season (County of Orange 2012 and 2013). The majority of the 2010/2011 sediment input is believed to have occurred during a major storm event from December 20 to 22, 2010, during which nearly nine inches of rain fell in the watershed. This storm occurred prior to the collection of the Year 1 bathymetric data in January through March 2011.

Comparison of the County calculated sediment input (derived from suspended sediment and flow data) to the ACOE bathymetric surveys of unconsolidated sediments in UNB is problematic. As discussed above the bathymetric surveys simply report the vertical position of the seafloor and the analysis of accreted volume is based on an unconsolidated surface-to-surface comparison between 2011 and 2012. It does not truly measure the volume of sediment added to UNB because the sediment below that surface has a large pore water component and over time will consolidate under self-weight. Therefore, for example, a drought year without input of large volumes of sediment could register as a net loss of sediment from the system based on the bathymetric data, while, in fact, there was simply a change in the density of the sediment as pore water was forced out and the seafloor surface moved deeper.

Keeping in mind the key purpose of the bathymetric monitoring, which is to determine the condition of the sediment basins and their capacity to capture future sediment inputs, it is less important to track the volumes calculated by the annual surface to surface comparisons and more important to track the available basin volume below the adjacent channel elevations. As the bottom of the two basins approach the channel elevations, the basins will become less effective at trapping and sequestering sediment and debris. This calculation of available basin space remaining

could be used in conjunction with the County estimates of sediment input to predict the remaining lifespan of the basins and to serve as the trigger for future maintenance dredging of the basins

Question 2 posed in Section 1.3 above asks: *Has the restoration project reduced turbidity in the bay by trapping incoming sediment deep in the basins?* Measured turbidity results are provided below in Section 2.3 along with the evaluation of this question.

2.2. Tidal Monitoring

The tidal monitoring element was designed to evaluate the degree of post-restoration tidal lag and muting in UNB, in comparison to the ocean tides. The Monitoring Plan calls for tidal monitoring in Years 1, 2, 5, and 10.

Methods

Logging pressure gauges (loggers) were deployed at three locations in UNB on January 25, 2011 (Figure 2). One month after deployment (on February 14, 2011) Station 1 had to be moved from its position at the Back Bay Science Center boat dock due to replacement of the dock. The station was re-established roughly 305 m (1000 ft) to the north on the edge of the Shellmaker Island mudflat (Figure 2). Station 1 and Station 2 (on the piling east of New Least Tern Island, referred to as the main dike in prior years) were positioned similarly to those used in a 1992 tide study conducted by Coastal Frontiers, Inc. and referenced in the Upper Newport Bay Feasibility Study Final Report Engineering Appendix (ACOE 2000). A third station was established to the northeast in Basin I/III, near the northern end of Tern Island.

Downloading a tide logger to a field tablet.

The tidal data were collected with RBR Instruments TGR2050 pressure gauges. The TGR2050 has a depth accuracy of ± 0.2 inches and a resolution of ± 0.004 inches. A fourth TGR2050 pressure gauge was deployed on shore at the Back Bay Science Center and used to correct the submerged pressure gauge for atmospheric pressure. Tidal sampling occurred every six minutes coincident with monitoring intervals used by NOAA for regional tidal monitoring stations.

The elevation data collected and reported in this study are subject to ±0.016 ft of error associated with the tide loggers and ±0.0018° station elevation error that varies with distance of the tide station from the established local benchmarks. Given the benchmark distances to the tide stations and instrument error, there are expected measurement error ranges of ±0.047, ±0.038, and ±0.041 feet for the tidal elevations reported from Stations 1, 2, and 3, respectively.

The Year 2 tidal monitoring was continuous from January 1 through December 31, 2012, continuing the data collection begun in Year 1. The water level loggers were downloaded quarterly, concurrent with other monitoring activities. The pressure data obtained from the submerged and atmospheric pressure gauges were used to calculate water depth at the sensor with the following formula:

$$\text{Depth} = (P_w - P_{atm}) / (\lambda * 0.980665);$$

where depth is the water depth in meters at the pressure gauge, P_w is the pressure in deciBars read at the in-water pressure gauge, P_{atm} is the local atmospheric pressure in deciBars, λ is the density of seawater at the site (1.027 g/cm^3), and 0.980665 is a gravitational constant (UNESCO 1983).

For analyses of tidal lag and tidal muting, the Los Angeles Outer Harbor (LAOH) (NOAA Station 9410660) historic data collected by NOAA were corrected to estimate conditions at the Newport Bay entrance channel. The NOAA gauge is located immediately adjacent to the open ocean, and the recorded tides represent the ocean tidal conditions. The data were obtained from the NOAA Tides and Currents website (http://tidesandcurrents.noaa.gov). NOAA no longer collects tide data at the Newport Bay entrance channel. However, for predictive purposes, NOAA uses temporal and elevation corrections to determine the timing and elevation of high and low tidal events at the Newport Bay entrance channel. Those temporal corrections consist of a deduction of 3 minutes at high tides and 4 minutes at low tides. The elevation correction is LAOH*0.98 to determine the Newport Bay entrance channel elevation throughout the tide range.

Tidal ranges were determined for all three UNB monitoring stations and the Newport Bay entrance channel. The tidal ranges were determined for the UNB monitoring stations by inspecting the data for the highest and lowest tidal events. The differences between the highest and lowest events at each of the three UNB monitoring stations were used to determine the tidal range over the period inspected. The range for the entrance channel was corrected by inspecting the LAOH tide data and then multiplying the highest and lowest observed values by 0.98.

An analysis of tidal lag and muting was performed by determining the timing and elevation of the higher high, lower high (referred to below as simply high), higher low (referred to below as simply low) and lower low tides for all three UNB monitoring stations. For comparison, the timing and elevation of the LAOH tides were determined from the NOAA data. The LAOH data were then corrected to the Newport Bay entrance channel using the corrections noted above. The time of tidal events at the Newport Bay entrance channel was subtracted from the UNB monitoring stations to determine the extent of tidal muting. The elevation of tidal events at the UNB monitoring stations was subtracted from the Newport Bay entrance channel values to determine the extent of muting at the monitoring stations.

Tidal monitoring will not be conducted in Years 3 and 4, but the monitoring stations (PVC pipes with known top elevations) have been left in the water to facilitate the resumption of monitoring in Years 5 and 10. Photos of the three monitoring stations are provided in Appendix D (photos 1, 2, and 3). The elevation of the stations will need to be re-established at the time of instrument deployment to account for settlement or disturbance of the station and allow for input of an accurate offset in the tide loggers. The local benchmarks used were *USACE Shellmaker 2* at the Back Bay Science Center for Station 1, *USACE Loren* on Back Bay Drive for Station 2, and *USACE UNB 10* on Jamboree Road for Station 3. The pipes will also need to be cleared of accreted biofouling with a narrower rod prior to logger deployment. As a scheduling and accessibility note, the Station 3 pipe goes underwater at approximately a +4-ft MLLW tide.

Results

All three tide monitoring stations recorded a full tide range in Year 2 (2012), with no dampening of the upper or lower end of the typical oceanic range (Table 2).

Table 2. Tidal minimum, maximum, and range in 2012 at the Newport Bay Entrance and each Upper Newport Bay station.

	Tidal Range (ft)						
Station	Date	Time	Minimum	Date	Time	Maximum	Range
Entrance	6/5/2012	4:39:00	-1.695	1/21/2012	8:20:00	7.575	9.27
Station 1	6/5/2012	5:00:00	-1.740	12/13/2012	8:24:00	7.813	9.55
Station 2	6/5/2012	5:06:00	-1.880	12/13/2012	8:36:00	7.844	9.72
Station 3	11/14/2012	15:42:00	-1.823	12/13/2012	8:42:00	8.005	9.83

The highest tides were recorded on December 13, 2012 during a period of low atmospheric pressure. These highs were higher than those typically seen throughout the year and are reflective of a single event in mid-December when atmospheric and tidal conditions coincided to create higher than normal tides. Similarly high water levels were measured at LAOH, indicating it was a regional occurrence, not specific to UNB. More typically throughout 2012 the maximum high tide at the three stations was approximately +7.0, +7.1, and +7.3 at Stations 1, 2, and 3 respectively. The lowest tides were recorded on June 5 and November 14, 2012. The oceanic range at the Newport Bay entrance channel was slightly smaller than the UNB stations.

Table 3 presents the findings of the tidal lag and muting analysis. In the table, positive tidal lag values represent observations where UNB stations were lagging relative to the entrance channel. Negative tidal lag values represent observations where the UNB tidal events occurred first (opposite of expectation assuming lag occurs) relative to the entrance channel. In the table, positive tidal muting values represent observations where the UNB stations were lower than the entrance channel at high tides. For example, at low tide negative muting values represent observations that UNB did not drain to the same elevation as the entrance channel. The mean values represent the averages of all tidal events (maximum or minimum) within each combination of the tide and monitoring station factors for all valid data obtained during 2012.

Table 3. Results of 2012 tidal lag and muting analyses performed to compare the Upper Newport Bay tidal monitoring stations to the Newport Bay entrance channel (January 1 to December 31, 2012).

Higher High Water

Monitoring Station	Tidal Lag (minutes)				Tidal Muting (feet)			
	Mean	SD	Maximum	Minimum	Mean	SD	Maximum	Minimum
Station 1	14.1	17.1	94.0	-56.0	0.06	0.10	0.35	-0.30
Station 2	20.3	19.7	76.0	-56.0	0.09	0.10	0.38	-0.27
Station 3	22.0	20.8	76.0	-56.0	0.23	0.10	0.49	-0.10

Lower High Water

	Tidal Lag (minutes)				Tidal Muting (feet)			
	Mean	SD	Maximum	Minimum	Mean	SD	Maximum	Minimum
Station 1	5.5	22.1	76.0	-92.0	0.02	0.09	0.25	-0.25
Station 2	8.5	25.3	70.0	-104.0	0.04	0.11	0.34	-0.25
Station 3	9.5	25.9	64.0	-80.0	0.17	0.11	0.44	-0.19

Higher Low Water

	Tidal Lag (minutes)				Tidal Muting (feet)			
	Mean	SD	Maximum	Minimum	Mean	SD	Maximum	Minimum
Station 1	7.4	22.2	87.0	-75.0	-0.04	0.11	0.20	-0.38
Station 2	10.2	26.7	75.0	-81.0	-0.09	0.11	0.22	-0.55
Station 3	11.7	27.2	87.0	-81.0	-0.02	0.11	0.24	-0.46

Lower Low Water

	Tidal Lag (minutes)				Tidal Muting (feet)			
	Mean	SD	Maximum	Minimum	Mean	SD	Maximum	Minimum
Station 1	6.7	18.5	57.0	-51.0	-0.01	0.09	0.21	-0.44
Station 2	9.5	22.3	63.0	-63.0	-0.08	0.12	0.22	-0.42
Station 3	9.7	22.8	63.0	-69.0	-0.02	0.12	0.29	-0.41

Statistics represent the difference across all logged high and low tide events from January 1, 2012 through December 31, 2012. Tidal lag equals Station minus Entrance and muting equals Entrance minus Station.

Tidal lag was variable across the three monitoring stations relative to the entrance channel. The shortest mean lag duration was 5.5 minutes during high tides at Station 1. The greatest mean lag was 22.0 minutes at Station 3 during higher high tides. Overall, tidal lag was shortest at Station 1, intermediate at Station 2, and greatest at Station 3. Across tidal events, the shortest mean lag occurred during high tides, followed by lower low tides, then low tides, with the longest lag at higher high tides.

Tidal muting was minimal for all UNB monitoring stations. The greatest mean muting was 0.23 ft at Station 3 during higher high tides. The maximum observed muting was 0.49 ft, at a higher high tide at Station 3. The lowest mean muting was –0.01 ft, observed during a lower low tide at Station 1.

During high and higher high tides, mean muting ranged from 0.02 to 0.23 ft across all monitoring stations, meaning all stations, on average, experienced slightly lower elevations than the entrance channel at high tides. During these tides the muting was greatest at Station 3. During low and lower low tides, mean muting ranged from -0.01 to -0.09 ft at all stations. The negative mean muting values mean that, on average, all stations experienced slightly higher elevations than the entrance channel during low and lower low tides.

Discussion

Newport Bay is defined by large basins (Lower Newport Bay [LNB] and Upper Newport Bay) connected by a constriction at Pacific Coast Highway. Newport Bay is in turn connected to the Pacific Ocean through the entrance channel constriction. This geometry creates a tidal muting and lag environment that has minor but detectable effects on both the top and bottom portions of the tidal curve. At the top of the tidal curve, water moving from LNB to UNB through the Pacific Coast Highway constriction is prevented from rising to the full ocean tidal height, while at low tide; slow drainage prevents the water from reaching the full drain-out condition. Storm surge, high and low pressure conditions, and river flows can have variable influences on the water levels across basins and between the ocean and the bay, but these are typically of short duration and not consequential to the overall average conditions. The overall system geometry is important in that it establishes a base muting condition that is inherent in Newport Bay and which would exist irrespective of the condition of channels and basins located within UNB. While the precise muting condition that would exist in a fully unconstrained UNB environment is not known, it is expected that some degree of muting would occur under any circumstance. As a result, the observation of tidal muting and tidal lag is not nearly as important to understanding system performance as the observed changes in in these conditions through time.

Overall, tidal lag and muting observed in 2011 (Year 1) and 2012 (Year 2) were minor relative to the entrance channel (Table 4). The values observed indicate that tidal movements through LNB and UNB are relatively unrestricted. The lack of significant tidal muting means that the upper bay flora and fauna are subjected to tidal patterns similar to those found closer to the open coast. Thus, the zonation of flora and fauna in the back bay should be similar to that observed at other coastal salt marsh habitats with unimpeded connections to the ocean.

Table 4. Comparison of tidal parameters in 2011 and 2012 in Upper Newport Bay. Lag and muting are for higher high tide events.

	Mean Lag (minutes)		Mean Muting (ft)		Range (ft)	
Station	2011	2012	2011	2012	2011	2012
Entrance					9.0	9.3
Station 1	12.6	14.1	0.05	0.06	9.2	9.6
Station 2	18.9	20.3	0.05	0.09	9.4	9.7
Station 3	18.4	22.0	0.13	0.23	9.2	9.8

Question 5 in Section 1.3 asks *Has the project resulted in increased (water) volume within the bay such that the water residence time in the bay is significantly increased [sic]?* From this question, it is not explicitly clear what the overall objective with respect to residence time was intended to be. Longer residence time for waters in the deepened sediment basins is positive with respect to the

basin capacity to capture and retain sediment entering the system. In this regard, portions of the increased water volume developed through non-outletting basins have increased bottom water residence time. Conversely the expansion of intertidal and shallow subtidal waters within UNB without substantial alteration of the tidal range results in an expected increased flow velocity and greater turnover of waters that are subject to tidal forces. Reduction of duration of depressed salinity in the upper bay reaches following storm events is an indication that residence time of these surface and shallow waters has been decreased. As a result, when considering the question regarding residence time of water masses within UNB, it is important to also consider the stratification of water masses that exists wherein some residence time (surface layers) is expected to have been decreased, while residence time of other waters (sediment basin bottom water) is expected to have been increased.

The plots of tide data for Stations 1, 2, and 3 and LAOH are provided for each month in 2012 as Appendix E. In the charts, the LAOH data are not corrected to the Newport Bay entrance channel. This is because the corrections applied in the lag and muting analyses only apply to the high and low water events. Given the small amount of observed lag and muting, any such corrections would be imperceptible in the data plots. The plots support the lag and muting analysis; the UNB monitoring stations closely follow the NOAA measured tides at LAOH.

The lag and muting values found within the 2011 and 2012 monitoring are similar to observations within UNB prior to the restoration project. The Upper Newport Bay Feasibility Study (2000) referenced tidal lag and muting values resulting from a tide and current data collection program performed in 1992. The 1992 study utilized the entrance channel NOAA tide monitoring station (no longer functioning) and loggers placed at Dover Shores and the main dike (at the present day New Least Tern Island). The Dover Shores and main dike monitoring stations were positioned similarly to Station 1 and Station 2 of this study, respectively. The 1992 tide study was summarized in the Feasibility Study as having found a temporal lag from the entrance channel of 12 and 25 minutes during high tides at Dover Shores and the main dike, respectively. It is not clear from this statement whether all high tides (higher high and lower high) were grouped or whether the values represent lag during higher high water only. However, the values reported are similar to the 14.1 minutes and 20.3 minutes of lag observed during higher high tides at the corresponding stations in this study. However, the 1992 study was performed for only one month and the specific month, which is critical to any comparison, was not referenced in the Feasibility Study and the original tide study report was not available for review.

The 1992 tidal study (ACOE 2000) found that at higher high tides, the main dike station was 0.1 foot higher than the entrance channel for the one-month period. The present study found that on average in 2012 the main dike station (Station 2) was 0.09 feet lower than the entrance during higher high tides. In 2011, it was 0.05 feet lower on average. No significant value can be ascribed to the differences between the 1992 and present studies given the unknown timing of the 1992 study and the unreported level of error surrounding the elevation measurements.

The lack of significant differences in muting of UNB between the 1992 study and the 2011 and 2012 monitoring is not surprising given the presence of a maintained deep harbor condition between the ocean and the UNB stations. Differing from coastal wetland complexes with direct coastal inlet connections that are susceptible to littoral bar formation and closure risks, the UNB complex is

protected from inlet muting by substantial harbor depth and navigational needs through the inlet channel. Under this condition, sediment loading to the system is predominantly one directional with some minor tidal redistribution. This depositional environment generates a gradient towards the inlet that generally gets broader and deeper as it approaches the maintained LNB. Under this condition, inlet constraints are never expected to result in muting and the system is not expected to substantially suffer from tidal muting, even when the sediment basins are filled.

For these reasons, consideration could be given to scaling back or eliminating the tidal monitoring program scheduled for Years 5 and 10. Intensive monitoring of this sort was useful to document the post-restoration conditions, but continued collection of the data would be more appropriate in a system that faced some risk of inlet closure or biological impairment as a result of tidal muting. As described above, such conditions would be detected by navigational constraints in the lower bay long before tidal monitoring in UNB would indicate a problem. The present monitoring is costly, requires elaborate data management and analysis, does not address any critical management question and therefore may not be warranted in Years 5 and 10.

2.3. Water Quality Monitoring

The Monitoring Plan calls for collection of quarterly spot water quality data in monitoring years 1, 2, 5, and 10. During Years 2, 5, and 10 the monitoring will be conducted concurrently with fisheries sampling. The intent of the monitoring is not to track water quality trends in UNB, but rather to document the conditions present at the time of fish sampling.

Methods

Spot readings were taken at each of six fisheries/water quality monitoring stations (Figure 2) with a Hydrolab Quanta® multi-probe, calibrated in accordance with manufacturer specifications. At each station, readings were taken near the shoreline where the shore-based fish sampling was done and also in the channel where the boat-based fish sampling was done. Parameters recorded were temperature, dissolved oxygen (DO), pH, salinity, and turbidity. Data were collected from the bottom to the surface to create a vertical profile of the water column. Water quality monitoring was performed concurrently with the otter trawling at each station on January 11, April 19, July 25, and October 10, 2012.

Collecting water quality data at a channel station.

Results

The collected water quality data are presented by quarter in Tables 5, 6, 7, and 8. Figures 4 and 5 summarize the salinity (density) and DO data as depth profiles, by station and sampling interval.

On January 11, 2012, sampling was conducted from 0812 to 1405 hours, capturing an incoming tide until it reached high at approximately 0946, then was falling for the rest of the sampling period. Table 5 presents the January water quality conditions at the time of the fish sampling. Salinity decreased from south to north, but was near oceanic levels at all stations, reflective of the recent

Table 5. Water quality data collected January 11, 2012 at Upper Newport Bay.

1/11/12 Station 1	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	14.5	7.3	8.0	34.3	4.4
	0.7	14.5	7.3	8.0	34.4	2.6
Time: 13:56	1.4	14.5	7.3	8.0	34.4	2.2
	2.1	14.5	7.3	8.0	34.4	2.5
	2.8	14.5	7.3	8.0	34.4	2.5
	3.5	14.5	7.3	8.0	34.5	2.7
	4.2	14.5	7.3	8.0	34.4	2.7
Shore	0.1	14.5	7.7	8.0	34.5	2.4
Time:14:05	0.3	14.6	7.6	8.0	34.5	1.4
	0.6	14.6	7.5	8.0	34.5	1.8

1/11/12 Station 2	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	14.4	8.1	7.9	35.0	3.4
	0.7	14.4	7.8	7.9	35.0	1.9
Time: 08:12	1.4	14.4	7.7	7.9	35.0	1.5
	2.1	14.4	7.6	7.9	35.0	1.3
	2.8	14.4	7.6	7.9	35.0	1.2
	3.5	14.4	7.6	7.9	35.0	1.4
	4.2	14.4	7.6	7.9	35.0	1.4
	4.9	14.4	7.5	7.9	35.0	1.2
Shore	0.1	14.3	7.6	7.9	34.9	0.5
Time: 08:18	0.3	14.4	7.4	7.9	34.9	1.2
	0.6	14.3	7.4	7.9	34.9	1.0
	0.9	14.3	7.3	7.9	34.9	0.7

1/11/12 Station 3	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	14.4	7.9	8.0	34.9	1.1
	0.7	14.4	7.2	8.0	34.9	1.3
Time: 09:14	1.4	14.4	7.1	8.0	34.9	1.2
	2.1	14.4	7.1	8.0	34.9	0.8
	2.8	14.4	7.1	8.0	34.9	0.8
	3.5	14.4	7.2	8.0	34.9	1.1
	4.2	14.4	7.1	8.0	34.9	0.8
	4.9	14.4	7.2	8.0	34.9	1.1
Shore	0.1	14.3	7.4	8.0	34.9	1.3
Time:	0.3	14.3	7.2	8.0	34.9	1.0
	0.6	14.3	7.1	8.0	34.9	0.9
9:20	0.9	14.3	7.0	8.0	34.9	1.4
	1.2	14.3	7.1	8.0	34.9	1.0

Table 5 (cont'd). Water quality data collected January 11, 2012 at Upper Newport Bay.

1/11/12 Station 4	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	14.0	6.8	7.9	34.0	3.3
	0.7	14.0	6.8	7.9	34.0	3.3
Time: 09:49	1.4	14.2	6.8	7.9	34.2	5.3
	2.1	14.3	6.8	7.9	34.4	3.6
	2.8	14.3	6.8	7.9	34.4	2.8
	3.5	14.3	6.8	7.9	34.4	3.5
	4.2	14.3	6.8	7.9	34.4	3.2
	4.9	14.3	6.9	7.9	34.5	2.6
	5.6	14.3	7.0	8.0	34.7	9.3
	6.3	14.3	7.1	8.0	34.7	14.3
	7.0	14.3	7.2	8.0	34.8	13.1
Shore	0.1	14.3	7.8	7.9	34.0	3.7
Time: 10:12	0.3	14.4	7.1	7.9	34.1	3.2
	0.6	14.4	6.9	7.9	34.1	3.2
	0.9	14.4	6.8	7.9	34.2	3.4

1/11/12 Station 5	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	14.0	7.4	7.9	33.2	2.4
	0.7	13.8	7.0	7.9	33.2	2.1
Time: 10.48	1.4	14.0	7.0	7.9	33.7	2.8
	2.1	14.1	6.8	7.9	33.9	3.2
	2.8	14.0	6.7	7.9	33.9	3.6
	3.5	14.1	6.7	7.9	34.0	3.3
	4.2	14.1	6.6	7.9	34.1	2.8
	4.9	14.1	6.6	7.9	34.2	2.6
	5.6	14.1	6.6	7.9	34.2	1.8
	6.3	14.1	6.7	7.9	34.4	3.4
Shore	0.1	13.5	7.5	7.9	33.0	2.9
Time: 10:57	0.3	13.6	7.0	7.9	32.9	4.0
	0.6	13.5	6.9	7.9	33.3	4.0
	0.9	13.9	6.9	7.9	33.5	6.4
	1.2	14.3	6.9	7.9	33.7	7.7
	1.5	14.2	6.8	7.9	33.6	6.8

Table 5 (cont'd). Water quality data collected January 11, 2012 at Upper Newport Bay.

1/11/12 Station 6	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	14.6	6.8	7.9	33.5	2.5
	0.7	14.6	6.6	7.9	33.7	2.8
Time: 11:18	1.4	14.5	6.6	7.9	33.9	3.3
	2.1	14.5	6.5	7.9	34.0	3.5
	2.8	14.4	6.5	7.9	33.9	4.6
	3.5	14.3	6.4	7.9	34.0	4.9
	4.2	14.3	6.3	7.9	34.0	5.1
	4.9	14.3	6.3	7.9	34.1	7.0
	5.6	14.3	6.2	7.9	34.1	6.7
	6.3	14.3	6.3	7.9	34.2	7.1
Shore	0.1	14.5	7.3	7.9	33.5	1.6
Time: 11:29	0.3	14.5	7.1	7.9	33.5	1.3
	0.6	14.5	6.8	7.9	33.5	3.1
	0.9	14.5	6.8	7.9	33.7	2.7
	1.2	14.5	6.7	7.9	33.7	8.2

Table 6. Water quality data collected April 19, 2012 at Upper Newport Bay.

4/19/12 Station 1	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	19.4	6.4	7.7	29.1	1.0
	0.7	18.4	6.3	7.7	31.3	2.1
Time: 14:43	1.4	17.4	6.2	7.7	32.0	3.1
	2.1	16.6	6.1	7.7	32.6	4.7
	2.8	16.5	6.1	7.7	32.6	5.2
	3.5	16.4	6.0	7.7	32.7	5.6
	4.0	16.4	5.9	7.7	32.8	12.4
Shore	0.1	19.6	7.1	7.9	31.7	4.0
Time:14:50	0.3	19.0	7.0	7.9	31.8	2.2

4/19/12 Station 2	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	19.7	7.3	7.8	27.0	2.2
	0.7	18.6	6.2	7.7	28.7	3.4
Time: 13:15	1.4	17.3	5.7	7.7	31.2	3.5
	2.1	16.8	5.4	7.6	31.8	2.1
	2.8	16.6	5.4	7.6	32.1	2.6
	3.5	16.6	5.3	7.6	32.2	2.8
Shore	0.1	19.6	6.8	7.7	26.9	42.0
Time: 13:21	0.3	19.6	6.6	7.7	27.2	43.0
	0.6	19.7	6.5	7.7	28.1	43.1

4/19/12 Station 3	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	19.9	6.5	7.8	23.2	2.8
	0.7	19.7	6.1	7.7	23.9	3.6
Time: 12:02	1.4	18.6	5.4	7.7	28.0	3.9
	2.1	17.0	4.9	7.6	31.0	3.7
	2.8	17.0	4.9	7.6	31.7	5.3
	3.5	17.0	5.0	7.6	31.9	3.7
	4.2	16.9	5.1	7.6	31.7	5.3
	4.9	16.7	5.4	7.7	32.1	7.1
Shore	0.1	19.7	6.5	7.8	23.4	1.6
Time: 12:10	0.3	18.7	6.7	7.7	26.5	2.6
	0.6	18.5	6.5	7.7	27.6	4.4

Table 6 (cont'd). Water quality data collected April 19, 2012 at Upper Newport Bay.

4/19/12 Station 4	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	18.4	5.9	7.9	20.1	2.8
	0.7	18.1	4.8	7.6	29.0	4.3
Time: 10:30	1.4	17.5	4.6	7.5	30.9	3.1
	2.1	17.3	4.7	7.6	31.2	3.0
	2.8	17.1	4.8	7.6	31.3	3.9
	3.5	16.9	4.9	7.6	31.7	4.6
	4.2	16.8	5.0	7.6	31.8	7.0
	4.9	16.7	5.1	7.6	31.9	7.4
	5.6	16.6	5.7	7.6	32.1	6.2
	6.3	16.4	5.2	7.6	32.3	14.0
Shore	0.1	18.5	7.1	8.0	18.7	2.1
Time: 10:12	0.3	18.4	6.9	7.9	19.3	2.2
	0.6	18.2	6.3	7.7	28.2	2.4
	0.9	17.6	5.4	7.6	30.5	9.6

4/19/12 Station 5	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	18.7	8.1	8.0	17.1	3.8
	0.7	18.1	4.9	7.6	28.1	5.5
Time: 09:35	1.4	17.3	4.9	7.6	30.9	2.7
	2.1	17.2	4.7	7.6	31.4	3.3
	2.8	17.1	4.7	7.6	31.4	4.8
	3.5	17.1	4.7	7.5	31.6	6.9
	4.2	17.1	4.5	7.5	31.8	7.2
	4.9	17.1	1.8	7.3	33.0	12.4
Shore	0.1	18.7	6.9	7.9	17.1	3.2
Time: 09:42	0.3	18.7	6.8	7.9	21.5	3.3
	0.6	18.8	6.2	7.7	24.9	4.3

4/19/12 Station 6	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	18.9	8.6	8.0	16.8	7.0
	0.7	19.1	6.1	7.7	28.5	5.9
Time: 09:10	1.4	17.8	4.9	7.5	30.4	4.9
	2.1	17.6	4.6	7.5	30.8	3.8
	2.8	17.5	4.4	7.5	31.0	3.1
	3.5	17.1	3.8	7.4	31.4	2.6
	4.2	17.0	3.6	7.4	31.7	5.5
	4.9	16.9	3.5	7.4	31.8	2.4
	5.6	17.0	3.0	7.4	32.7	2.3
	6.3	17.2	0.7	7.1	33.5	15.8
Shore	0.1	19.2	6.8	7.8	18.8	4.0
Time: 8:55	0.3	20.2	5.6	7.7	23.0	4.4
	0.6	20.4	6.2	7.7	25.5	4.7
	0.9	19.2	4.9	7.6	28.3	5.1
	1.2	18.4	4.8	7.5	29.9	5.3
	1.5	17.9	4.6	7.5	30.4	4.7
	1.8	17.8	4.4	7.5	30.7	4.3
	2.1	17.5	4.5	7.5	30.9	11.0

Table 7. Water quality data collected July 25, 2012 at Upper Newport Bay.

07/25/12 Station 1	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	22.7	5.9	7.7	32.9	7.5
	0.7	22.7	5.8	7.8	33.0	11.8
Time: 07:55	1.4	22.6	5.7	7.9	33.3	10.7
	2.1	22.5	5.6	7.9	33.3	8.3
	2.8	22.4	5.6	7.9	33.5	5.7
	3.5	22.3	5.7	7.9	33.5	3.9
	4.2	22.3	5.4	7.9	33.5	2.0
Shore	0.1	22.5	6.4	7.9	33.0	4.0
	0.3	22.6	5.8	7.9	33.0	4.5
Time: 08:10	0.6	22.6	5.6	7.9	33.1	5.8

07/25/12 Station 2	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	23	6.0	7.9	32.4	5.6
	0.7	22.5	5.9	7.9	33.2	5.4
	1.4	22.5	5.9	7.9	33.3	4.2
	2.1	22.4	5.8	7.9	33.5	4.2
Time: 09:55	2.8	22.4	5.8	7.9	33.5	3.9
	3.5	22.4	5.8	7.9	33.5	3.0
	4.2	22.4	5.8	7.9	33.4	2.8
	4.9	22.4	5.8	7.9	33.5	2.0
Shore	0.1	23.1	5.9	7.9	32.6	3.4
	0.3	23.1	5.8	7.9	32.6	2.0
Time: 10:05	0.6	23.1	5.8	7.9	32.7	10.0

07/25/12 Station 3	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	23.8	6.2	7.9	31.6	1.8
	0.7	23.8	5.8	7.9	31.5	2.3
Time: 10:35	1.4	23.6	5.7	7.9	32.5	1.8
	2.1	23.5	5.5	7.9	32.8	1.2
	2.8	23.3	5.3	7.9	32.9	1.1
	3.5	23.3	5.2	7.9	32.9	1.1
	4.2	23.3	5.2	7.8	32.9	1.8
	4.9	23.3	5.2	7.8	32.9	2.0
Shore	0.1	23.8	6.0	7.9	31.3	2.4
	0.3	23.9	6.0	7.9	31.3	2.4
Time: 10:42	0.6	23.8	6.1	7.9	31.5	0.9

Table 7 (cont'd). Water quality data collected July 25, 2012 at Upper Newport Bay.

07/25/12 Station 4	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	24.4	7.6	8.1	27.6	4.0
	0.7	24.6	7.1	8	29.5	5.0
Time:	1.4	24.8	6.3	7.9	31.4	5.1
11:30	2.1	23.9	5.8	7.9	32.5	4.0
	2.8	23.9	5.6	7.9	32.6	0.8
	3.5	23.8	5.5	7.8	32.7	0.8
	4.2	23.7	5.5	7.8	32.9	0.0
	4.9	23.2	5.4	7.8	33.0	0.0
	5.6	23.0	5.3	7.8	33.1	2.4
Shore	0.1	24.9	7.4	8.1	27.3	1.2
	0.3	24.6	7.3	8.1	27.4	1.5
Time: 11:40	0.6	24.4	7.3	8.1	27.6	1.3

07/25/12 Station 5	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	24.8	6.6	8.1	27.6	3.0
	0.7	24.8	5.9	7.9	31.4	2.5
Time:	1.4	24.2	5.6	7.9	32.4	1.8
12:00	2.1	23.8	5.3	7.8	32.7	3.9
	2.8	23.6	5.3	7.8	32.8	0.9
	3.5	23.5	5.3	7.8	32.9	0.4
	4.2	23.3	5.0	7.8	32.9	0.5
Shore	0.1	25.8	8.3	8.2	25.4	2.8
	0.3	25.0	6.8	8	27.4	2.6
Time: 12:05	0.6	25.0	7.1	8	30.9	2.2

07/25/12 Station 6	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	26.2	7.4	8.1	26.1	5.6
	0.7	25.8	7.0	8	28.1	3.9
Time: 13:10	1.4	25.1	5.4	7.8	32.2	1.6
	2.1	24.4	5.2	7.8	32.6	5.2
	2.8	23.8	4.0	7.7	32.6	7.8
	3.5	23.7	3.5	7.6	32.7	1.8
	4.2	23.4	2.6	7.6	32.7	1.7
	4.9	23.3	2.1	7.5	32.8	1.9
	5.6	23.2	1.5	7.5	32.8	4.2
	6.0	23.1	1.0	7.4	32.9	3.0
	6.3	22.8	0.3	7.4	32.8	3.6
Shore	0.1	26.9	7.8	8.1	25.5	4.7
	0.3	26.4	7.7	8.1	26.0	2.5
Time: 13:27	0.6	26.4	7.6	8.1	26.1	4.1

Table 8. Water quality data collected October 10, 2012 at Upper Newport Bay.

10/10/12 Station 1	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	22.4	5.7	8.0	34.0	3.5
	0.7	22.4	6.0	8.0	34.2	4.6
Time: 08:30	1.4	22.4	5.9	8.0	34.3	5.5
	2.1	22.4	6.0	8.0	34.4	6.8
	2.8	22.4	6.0	8.0	34.4	7.5
	3.5	22.2	6.1	8.0	34.4	9.1
	4.2	22.0	6.2	8.0	34.5	9.9
	4.9	22.0	6.4	8.0	34.6	10.5
Shore	0.1	22.4	5.8	8.0	34.1	7.3
	0.3	22.4	6.0	8.0	34.1	5.3
	0.6	22.5	6.0	8.0	34.0	6.7
Time: 08:50	0.9	22.4	6.2	8.0	34.0	7.1

10/10/12 Station 2	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	22.8	5.5	8.0	33.1	3.5
	0.7	22.7	5.5	8.0	33.6	3.5
	1.4	22.6	5.5	8.0	33.7	4.1
	2.1	22.6	5.3	8.0	33.9	3.8
Time: 10:10	2.8	22.6	5.3	8.0	34.0	3.2
	3.5	22.5	5.5	8.0	34.0	3.1
	4.2	22.5	5.6	8.0	34.0	3.0
	4.9	22.5	6.2	8.0	34.1	3.8
Shore	0.1	23.2	5.7	8.0	32.9	5.3
	0.3	23.2	5.6	8.0	33.1	5.1
Time: 10:20	0.6	23.1	6.1	8.0	33.1	5.5

10/10/12 Station 3	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.0	23.9	6.2	8.1	31.5	3.4
	0.7	23.7	5.6	8.0	32.1	4.3
Time: 11:40	1.4	23.7	5.1	8.0	32.7	4.1
	2.1	23.6	4.3	7.9	33.3	4.5
	2.8	23.4	4.3	7.9	33.5	10.6
	3.5	23.4	4.5	7.9	33.5	8.8
	4.2	23.2	4.5	7.9	33.6	9.7
	4.9	23.2	4.6	7.9	33.6	13.9
Shore	0.0	23.9	6.1	8.1	31.7	4.3
	0.3	23.8	6.3	8.1	31.6	3.4
Time: 11:52	0.6	23.9	6.7	8.1	31.7	11.5

Table 8 (cont'd). Water quality data collected October 10, 2012 at Upper Newport Bay.

10/10/12 Station 4	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	24.0	6.3	8.1	31.2	2.6
	0.7	24.1	5.9	8.0	31.3	3.6
Time: 13:30	1.4	23.9	5.2	8.0	32.3	5.4
	2.1	23.9	5.0	7.9	33.3	7.4
	2.8	23.7	4.6	7.9	33.0	7.0
	3.5	23.3	4.6	7.9	33.5	5.3
	4.2	23.3	4.7	7.9	33.4	5.8
	4.9	23.1	4.7	7.9	33.5	6.0
	5.6	23.1	4.3	7.8	33.6	35.0
	6.2	23.3	2.4	7.7	33.7	40.0
Shore	Not Collected					

10/10/12 Station 5	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	24.7	6.9	8.1	31.2	4.5
	0.7	24.7	6.7	8.1	31.2	3.7
Time:	1.4	24.7	5.9	8.0	32.1	3.9
12:00	2.1	24.7	6.8	7.9	33.4	2.7
	2.8	24.0	2.6	7.6	33.3	18.0
	3.5	23.8	2.1	7.6	33.5	20.0
Shore	0.1	25.2	8.8	8.3	30.7	4.4
	0.3	25.3	9.9	8.3	30.7	6.0
Time: 12:10	0.6	25.2	9.3	8.3	30.8	5.0

10/10/12 Station 6	Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)
Channel	0.1	25.3	8.7	8.3	30.8	3.7
	0.7	25.3	8.6	8.3	30.9	3.6
Time: 13:05	1.4	25.0	7.9	8.2	31.0	3.4
	2.1	24.1	4.6	7.8	33.1	2.5
	2.8	24.1	3.5	7.7	33.5	2.2
	3.5	23.9	3.3	7.7	33.5	2.1
	4.2	24.0	2.0	7.7	33.5	1.8
	4.9	23.5	1.6	7.5	33.6	1.3
	5.6	23.5	0.3	7.5	33.6	1.2
	5.9	23.4	0.3	7.5	33.5	14.6
Shore	0.1	25.6	8.6	8.2	30.6	12.5
	0.3	25.5	8.5	8.3	30.6	14.1
Time: 13:00	0.6	25.4	8.4	8.3	30.7	18.6

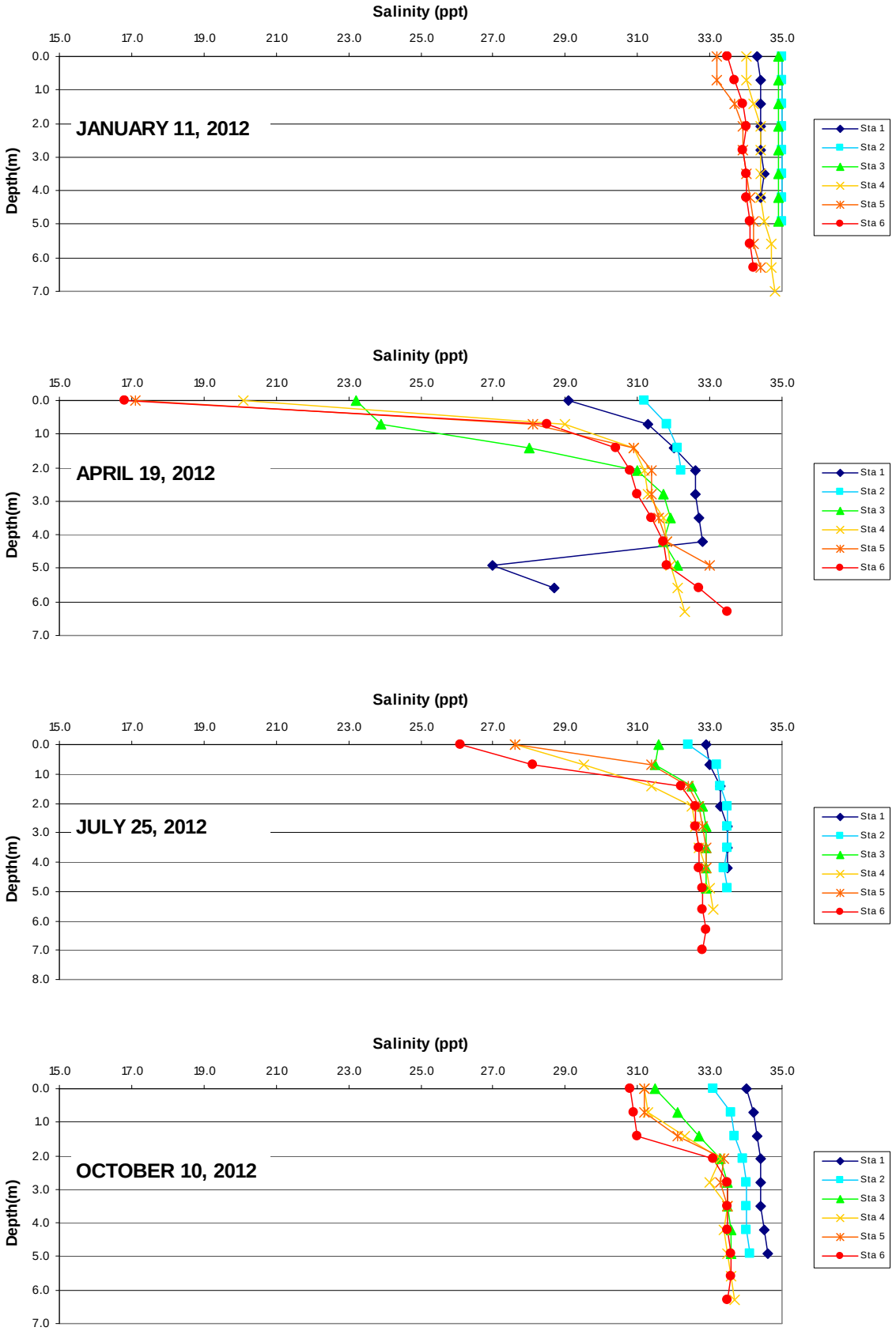


Figure 4. Depth Profile of Salinity (ppt) by Station at Upper Newport Bay (2012).

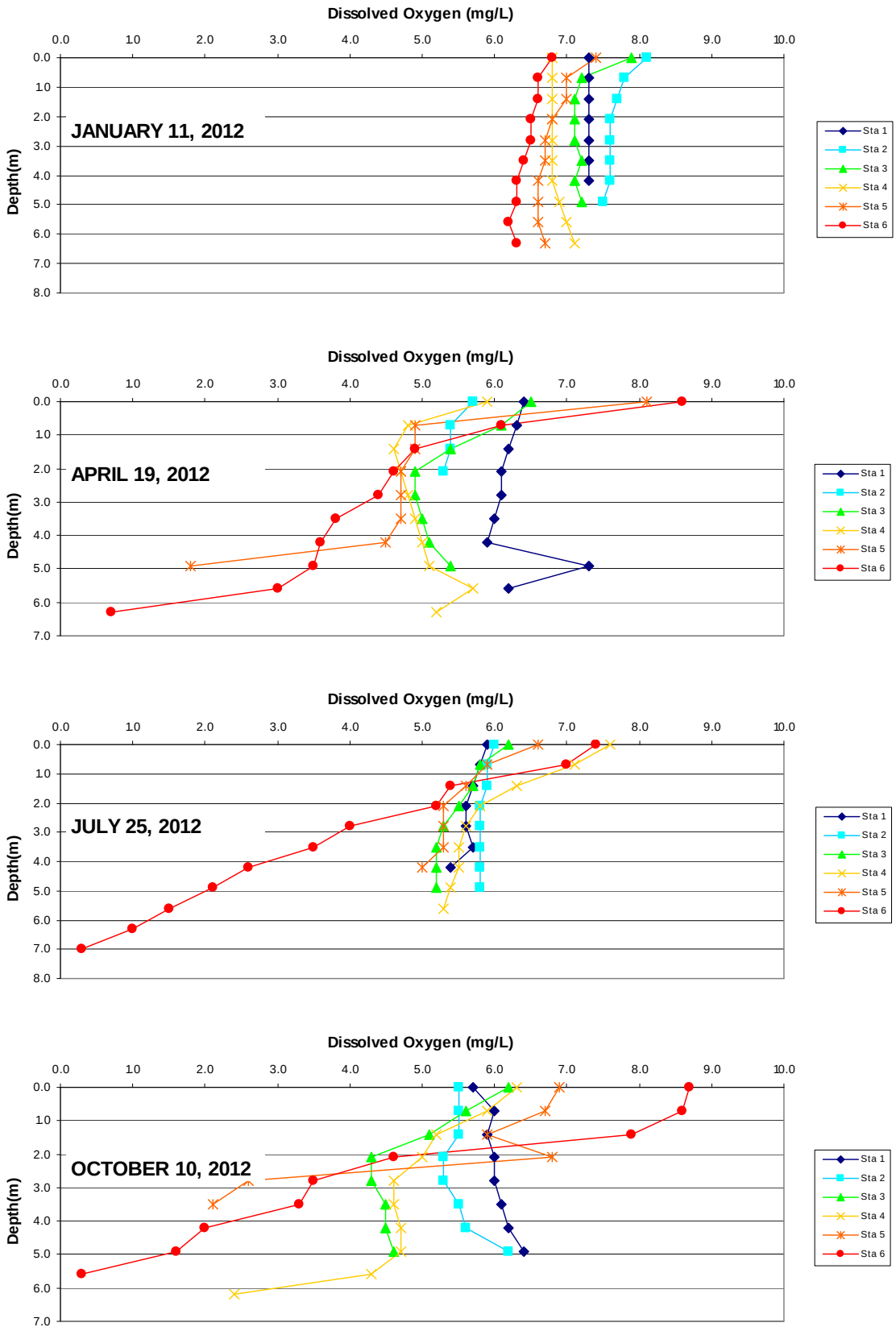


Figure 5. Depth Profile of Dissolved Oxygen (mg/L) by Station at Upper Newport Bay (2012).

high tide and lack of recent precipitation (Figure 4). Dissolved oxygen was high at all stations and depths, ranging from 6.2 to 8.1 mg/L (Figure 5). Turbidity was low at all stations and depths, though it was slightly elevated at the bottoms of Stations 4 and 6, as would be expected near the bottom of the two basins where loosely consolidated sediments and organic debris are easily disturbed. Temperature and pH all fell within the ranges anticipated.

Data collected on April 19, 2012 are presented in Table 6. Sampling was performed between 0855 and 1450 hours, capturing an incoming tidal that reached the low high at 0912, then fell to the high low as the monitoring period ended. A reddish tint was visible in the waters of Stations 4, 5, and 6, suggesting an algal bloom resulting from eutrophication from the watershed. The only prior precipitation in April had occurred one week earlier, on April 11, when approximately one third of an inch of rain was reported from the area (Santa Ana Airport). However March rainfall totaled approximately 1.4 inches (Santa Ana Airport). The freshwater inputs were evidenced by the depressed salinities in the surface waters of Stations 4, 5, and 6 (Figure 4). Dissolved oxygen generally declined from south to north and from the surface to the bottom, with DO particularly low at the bottom of Stations 5 and 6 (Figure 5). Turbidity was slightly higher than in January, with the exception of the shoreline at Station 2, where at all depths turbidity was quite high (42-43 NTU). Turbidity in the channel nearby was low, suggesting the elevated turbidity was localized to the shoreline.

The July 25, 2012 sampling was conducted from 0755 to 1327 hours, capturing an incoming tide rising from 1.4 feet MLLW. The sampling date fell on the quarter moon, neap tide series. Table 7 presents the collected water quality data. Temperatures increased from south to north, with temperatures at Station 6 more than four degrees C warmer than Station 1. Dissolved oxygen ranged from 5.0 to 8.3 mg/L across Stations 1-5. Hypoxic conditions were detected at depth in the basin at Station 6, with DO dropping from 4.0 mg/L at a depth of 2.8 meters down to 0.3 mg/L at the bottom (6.3 meters deep) (Figure 5). The surface waters at Station 5 and 6 had a reddish green tint suggestive of a mild algal bloom. Salinity measurements reflected the incoming tide and lack of recent precipitation. Turbidity and pH all fell within the ranges anticipated.

Table 8 presents the water quality data collected on October 10, 2011 between 0830 and 1330 hours, capturing a moderate falling tide. The sampling date fell near the quarter moon, on a neap tide series. Dissolved oxygen was lower than that recorded in prior quarters and ranged from 4.3 to 6.7 mg/L across Station 1-3. Hypoxic conditions were detected at depth at Station 5 and in the basins at Stations 4 and 6. At Station 6, DO dropping from 4.6 mg/L at a depth of 2.1 meters down to 0.3 mg/L at the bottom (5.9 meters deep) (Figure 5). Salinity measurements showed a gradient of slightly reduced surface salinity moving from the lower to upper stations, as would be expected. Temperature increased from Station 1 to 6. Turbidity and pH all fell within the ranges anticipated.

Discussion

These data do not document the full range of water quality conditions present within the UNB restoration area as data were collected at four discrete points in time, rather than continuously. There are many factors that will considerably affect the conditions at a given sampling time including tidal condition (whether oceanic water is coming in with the tide or whether creek-influenced water is flowing out with the tide), recent precipitation, recent wind conditions, and time of day. Primary production and thus dissolved oxygen levels would be expected to be lower

early in the morning than later in the day after photosynthetic processes had been underway for a longer period of time. Additionally, the monitoring is done concurrent with the boat-based fisheries sampling, which is scheduled for optimal conditions for fishing (generally on either side of a moderate high tide). Therefore, water quality data were not always collected at consistent tide stages. The July data were collected on an incoming tide, while most of the other data were collected during moderate falling tides. However, the data do provide some indication of water quality during the specific tidal, time, and weather conditions noted above. Overall they reflect a well-flushed system consistent with the findings of the tide monitoring work, with the exception of the deepest portions of the basins (Stations 4 and 6) and upper channel (Station 5), which don't appear to be as well flushed based on the regularly low DO readings taken at lower elevations within the water column.

Question 2 posed in Section 1.3 above asks: *Has the restoration project reduced turbidity in the bay by trapping incoming sediment deep in the basins?* In general, turbidity is a function of multiple interacting factors including the delivery of suspendable particulates to UNB, the sequestering of suspendable materials, resuspension of settled particulates, and generation of suspended materials within the water column. Deep sediment basins are beneficial for trapping and retaining suspendable particulates. In many shallow water systems, recurrent resuspension of particulates by wind waves and vessel wakes is a primary source of elevated turbidity, with turbidity diminishing as suspended material is translocated to deeper waters or marshes where it becomes unavailable for resuspension, or is exported with the tides. Elevated turbidity levels return following fresh sediment loads from the watershed.

As was observed in 2011, turbidity levels in surface waters were fairly low all stations, generally below 10 NTU. This renders it impractical to draw definitive conclusions regarding the role of the sediment basins in mediating turbidity in UNB. However, surface turbidity levels were typically lower over deeper water basins than along the shoreline where wind wave resuspension occurs. It has been demonstrated that the sediment basins serve to trap a disproportionately high amount of sediment entering the system and it is expected that the large sediment basins would serve not only to initially trap sediment entering from the creeks, but also to trap sediments that are suspended from the shallower flats by wind wave energy.

Interestingly, in some cases, turbidity trends were reversed. Based on a review of the data, including coincident salinity and DO data, this occurred both following a storm event when resuspension of sediment was less likely to drive turbidity patterns than initial stream yield and also where seasonally elevated phytoplankton levels may have contributed to turbidity detected within the most northerly back-bay stations.

While the basins do play a role in turbidity reduction within UNB, the capture of this sediment and organic detritus in the deep basins has the consequence of resulting in periods of low DO near the bottom. The following discussion was initially presented in the Year 1 monitoring report and remains relevant to the data collected during Year 2 (2012).

Dissolved oxygen is a parameter of particular interest in relation to the restoration project. One of the primary questions posed in the Monitoring Plan is Question 3 from Section 1.3 above. *Are the deepened basins receiving adequate dissolved oxygen?* There were some concerns raised during

the development of the restoration plans that there would be increased density stratification and reduced oxygen levels (hypoxia) in the deepest basins and channels. Hypoxic conditions can develop as a result of several contributory factors. After an algal bloom or influx of organic debris, the resulting accumulation of organic material and the consumption of DO due to respiration and decomposition can result in the formation of hypoxic bottom waters and an interruption of the exchange of oxygen between surface and bottom waters, due to stratification or windless conditions.

The EPA and Regional Water Quality Control Board have prepared a Basin Plan for the watershed and UNB with a water quality objective that DO shall not be depressed to levels that adversely affect beneficial uses. Although no numerical criterion has been specified, concentrations above 5 mg/L typically are considered adequate to support biological organisms. The conventionally accepted DO threshold at which lethal and sublethal impacts occur is 2 mg/L, although newer research has found the number to be highly variable among benthic organisms, with higher thresholds for many sensitive fish and invertebrates (Vaquer-Sunyer and Duarte 2008). Kamer and Stein (2003) considered values below 3 mg/L as hypoxic following a literature review of criteria developed for other embayments. A recent review of available literature on DO tolerances of estuarine species developed protective criteria of 2.9 mg/L for acute exposure and 5.8 mg/L for chronic exposure (SCCWRP 2012). Other factors influencing the lethality of hypoxia include the duration of the condition and the thickness of the hypoxic layer. Many species are well adapted to survive brief periods of extremely low or even no DO by either physiologic or behavioral responses. If necessary, motile organisms can move to other areas, while some sessile invertebrates are able to stretch from their burrows or extend body parts up into better oxygenated waters, increase water flow over respiration organs, or even shut down most metabolic functions until conditions improve.

Figures 4 and 5 summarize the salinity (density) and DO data as depth profiles, by station and sampling interval. Recognizing that these data represent only four points in time over any entire year, stratification appears limited at Stations 1, 2, and 3 (the southernmost stations) except after storm events such as the heavy rains of March 2012. Stations 4, 5, and 6 at the northern reach of UNB were stratified during April, July, and October sampling events, with a lens of fresher water evident in the top one to two meters. Very little stratification was seen in January 2012, a dry month.

Incidences of low DO also occurred in all sampling events except January, particularly at the depths of Stations 4, 5, and 6 (Figure 5). Similar conditions were observed at these stations in 2011. There are likely heavy accumulations of detritus on the bottom of Stations 4, 5, and 6, which consume the available oxygen as a part of the decomposition process. In conjunction with periods of warmer water temperatures, which reduces the ability of water to hold DO in solution, an anoxic or hypoxic bottom layer likely forms in some portions of the UNB basins (Stations 4 and 6) and upper channel (Station 5). As such, the answer to whether the deeper basins support adequate DO appears to vary seasonally. During most periods of the year, DO is depressed at depth to levels that are considered to be biologically detrimental. When viewing the results in the context of the Basin Plan objective and a goal of achieving DO above 5 mg/L, lower values were often seen at the deeper parts of Stations 3, 4, 5 and 6, particularly in April and October.

Continual water quality monitoring performed with deployed instruments over a six-month period in 2005 found hypoxic events to be most closely tied to increased freshwater discharge, low solar radiation, and reduced bottom water circulation during neap tide series (Nezlin et al. 2006). Without similar monitoring during the current program, it is not possible to determine for how long and over what area hypoxic conditions continue to occur post-restoration, however the dredging project should have resulted in improved water circulation and reduced residence time in the upper portions of UNB. Deployment of such instrumentation in the basins of UNB would be difficult however, due to the depth and the intensive maintenance that would be needed to keep the DO probe functioning properly at the basin bottom. The Nezlin et al. study required intensive quality control procedures and replacement of missing data as a result of biofouling, instrument failure, and vandalism. While a robust dataset resulted from the effort, the intensity is outside the scope of the current biological monitoring program and comparisons of the 2005 findings to the current data are not appropriate.

2.4. Least Tern Island Elevations

The Monitoring plan calls for an annual assessment of New Least Tern Island, the nesting site created by the restoration project near the old salt dike (Figure 1). Since its construction in 2007 and 2008, least terns and western snowy plovers have not been observed nesting there, though killdeer were observed by CDFW staff exhibiting defensive behavior in 2011. After confirming with CDFW that no nesting had been initiated at New Least Tern Island in 2012, an assessment of the island was made on April 26, 2012. Notes were taken on the condition of the surface, photos were collected, and elevation data were collected with a rod and total station. In addition to checking the elevation of three permanent control points, four to five elevations were recorded along six representative transects crossing the island from edge to edge to document the range of elevations present.

New Least Tern Island was well prepared for nesting season, with the white sand cap intact, black skimmer decoys in place, and weeds cleared (see photo 4 in Appendix D). CDFW had removed weeds from the site in April 2012 using a California Conservation Corps crew (C. Navarro, pers. comm.). The island appeared to be in good physical condition, with limited erosion and a generally flat surface. The main surface of the nesting area slopes downward from north to south, with the higher northern edge around +10.2 feet (+3.1 meters) MLLW and the lower southern edge around +8.5 feet (+2.6 meters) MLLW. The design elevation of the island was +3.0 $\pm$ 0.2 meters. Elevations were lower at the eastern end of the island as it slopes down to the access ramp on the east point. There are three existing elevated control points on the nesting site (NLTI 1, NLTI 2, NLTI 3), installed and initially surveyed by ACOE in May 2009, roughly one year after the island was completed in March 2008. Table 9 presents the original 2009 measurements, the measurement at NLTI 2 that was taken in 2011, and the current 2012 data. Note that although the 2011 and 2012 measurements were taken during the Year 1 and Year 2 post-restoration monitoring program, they actually represent the condition three and four years since the completion of the island in March 2008, midway through the overall restoration process. Also note that the control point monuments are elevated above the surface of the island and should therefore not be compared to the stated design elevations.

Table 9. Elevation (feet MLLW, 83-01 epoch) of three control points at New Least Tern Island.

Control Point ID	May 2009* ACOE	January 25, 2011 M&A	April 26, 2012 M&A
NLTI 1	9.96		9.52
NLTI 2	10.77	10.38	10.35
NLTI 3	9.95		9.36

* 14 months after island was completed

These data suggest the ground near the control points may have settled by between 0.42 and 0.59 feet (0.12 and 0.17 meters) since the first measurement in 2009. No evidence of land bridges to the main marsh were detected and the channel around the island was still fully subtidal. The south-facing (windward) shoreline was heavily lined with plastic trash and plant debris that is continually pushed up against the island scarp by the wind and tides (see photo 5 in Appendix D).

An assessment was also made of the cordgrass that was previously transplanted in November 2009 on the shoreline of New Least Tern Island. The largest persisting patch was at the eastern end of the island, on the sand shoreline between 2.8 and 3.5 feet MLLW. The patch was roughly 17 meter long and 2 meters wide. A few small patches were observed at the same elevations at the middle and west ends of the island as well. The cordgrass was roughly 15 cm tall and not flowering (see photo 6). The cordgrass was planted into sandy substrate that is considerably different from the mud substrate supporting the extensive cordgrass stands throughout the rest of UNB. It is unlikely that cordgrass on this shoreline will ever expand to a form dense stand around the island; more likely, it will persist or spread to particular areas along the island shoreline where substrate and wave exposure are most opportune.

Cordgrass planted on the west slope of the island was taller, more dense, and thriving (see photo 7). In this area some of the sand shoreline had eroded to expose a mud base that is more suitable for cordgrass growth.

3.0 BIOLOGICAL MONITORING

3.1. Avian Monitoring

The Monitoring Plan calls for general avian monitoring quarterly in Years 2, 5, and 10 and nesting season surveys for four sensitive avian species in Year 2. These species include Belding's Savannah sparrow (*Passerculus sandwichensis beldingi*), light-footed clapper rail (*Rallus longirostris levipes*), western snowy plover (*Charadrius nivosus nivosus*), and California least tern (*Sternula antillarum browni*). The abundance, distribution, behavior, and habitat usage of the avian community at UNB was monitored during Year 2 by quarterly saturation surveys.

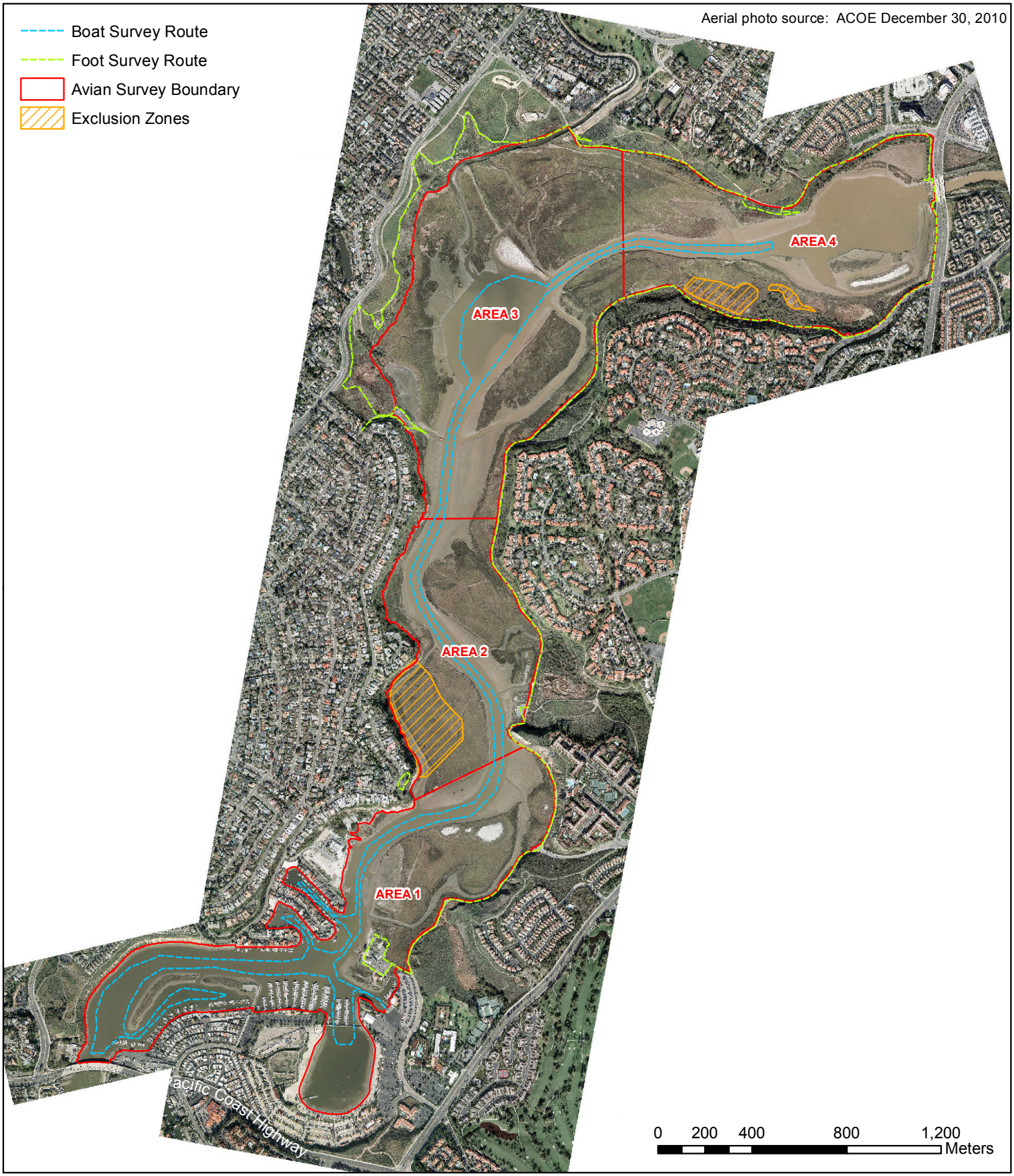
Methods

To establish a consistent project study area for the present monitoring, a boundary was established at the extreme high water line, which is 7.8 feet (2.4 meters) MLLW for UNB, and corresponds to the upper boundary of salt marsh habitat. All habitats extending from that outer boundary toward the channel were included, including raised areas above 7.8 feet (2.4 meters), such as the least tern nest sites.

The project study area was then divided into smaller, survey areas. Reports from prior bird surveys at UNB do not clearly define the boundaries of the areas surveyed, but the most recent complete survey did describe a division of UNB into four survey areas (MEC 1997). These same survey areas were used for the present study (Figure 6). These survey areas include Area 1 at the south end of the study area at Pacific Coast Highway and extend north through Area 4 to Jamboree Road at the northeastern end of the study area. The four survey areas were surveyed from shore and by boat. Walking routes were established on either side of the bay, and a third route was conducted by boat along the main channel of the bay. This allowed nearly complete viewing of the project study area. There were three sections of habitat, termed exclusion zones, indicated in Figure 6 that were not clearly visible from any authorized vantage point. It is believed that uncounted avian usage of these zones represents only a small fraction of the total bird usage at UNB.

Avian monitoring was conducted on January 16, April 26, July 24, and November 13, 2012. Four teams of biologists, containing one or two observers and one recorder, surveyed the site simultaneously during low tide. During the four surveys, the tide ranged from 2.3 ft. to 1.1 feet in January, 0.03 ft. to 1.4 ft. in April, 0.9 ft. to 2.9 ft. in July, and 2.4 ft. to -0.3 ft. in November. Surveys were started at 0700 and continued until complete (3.2 to 5.6 hours) depending on the density of the birds. Though the Monitoring Plan called for quarterly morning surveys, there were no morning low tides in October or November. Therefore the planned October survey was moved to the soonest day with suitable tides of adequate duration, on November 13. The survey was conducted from 1130 to 1610.

The ideal tide range for this survey is between +0.5 and +1.5 feet MLLW and future surveys should be conducted on days that offer the most time within this range. As tides get higher than +1.5 feet, the mudflat becomes narrow and birds move to higher, vegetated ground to loaf. At lower tides it is more difficult for the boat team to view marsh plain birds due to the lower elevation of the boat



Avian Survey Areas

Upper Newport Bay Ecosystem Restoration Project
Post-restoration Monitoring Program

Figure 6

and it is more difficult for the shore teams to view some mudflat birds that are using the exposed lower slopes of the mudflat.

In order to complete each survey, three teams were on foot, walking Back Bay Drive on the east side of UNB or following the elevated trail on the west side. A fourth team surveyed the remaining portions of the marsh from a small survey vessel. The survey was conducted on foot by a team of field biologists using binoculars and spotting scopes and all four survey areas were surveyed simultaneously. Each team followed a specific route, moving in the same direction each time. Along each survey route, viewpoints were indicated that provided the best view of specific areas, mudflats, and channels, though observations were also made continually as the route was walked. Repeated use of the same viewpoints provided consistency between surveys. Each of the four survey areas was surveyed by one or all of the same biologists each quarter to further maintain consistency of route.

The teams were arbitrarily numbered one to four (the numbers do not correspond to survey areas, as multiple teams surveyed each area). Team 3 began on Back Bay Drive at the Back Bay Science Center then followed Back Bay Drive north until it met Team 2. Team 3 surveyed the side channels and marsh plain out to its visible edge. Team 2 began on Brown Trail just 0.25 miles west of Bayview Way and Shearwater Place parking area, then followed the paved and dirt paths along the northeastern corner of UNB, passed over the Jamboree Road bridge, and followed the sidewalk to Eastbluff Drive and down onto Back Bay Drive. They continued south on Back Bay Drive until they met Team 3. Team 4 began at the same point as Team 2, and headed west and south along dirt paths and paved trails, ending at the northern end of Galaxy Drive. Team 1 launched a small vessel at the Newport Dunes launch ramp and followed a specified route down toward Pacific Coast Highway, then back up the main channel of UNB. Team 1 generally surveyed the open water of the channel, some mudflats, and the channel-facing edges of the marsh that weren't visible to the shore teams. All teams took great care to survey only areas assigned to them, regardless of their view from their route. This was essential to minimize double-counts along boundaries between teams.

All birds observed in the study area were recorded. Data collected included identification of species, individual counts by species, activities of the birds (foraging, flying, and resting), and habitats in which the birds occurred (open water, mudflat, salt marsh, freshwater and brackish marsh, southern willow scrub, mulefat scrub, coastal sage and baccharis scrub, salt panne, non-native vegetation, disturbed [natural, but disturbed by humans such as trails], and urban/developed. These habitats correspond to those tracked in the vegetation portion of the monitoring program described in a later section of this report.

These data, along with date, time, and survey area, were recorded on datasheets using standardized lettered codes. For quality assurance purposes, each team carried identical copies of maps indicating the regions of each survey area to be covered by each team. Additional data collected included any factor affecting the behavior of birds, such as an injury or the presence of a predator, breeding activities, as well as notes that may help determine whether double-counts of a single bird were made by multiple teams. Each team was equipped with a phone in order to communicate about potential double counts and survey progress. In order to avoid double-counts of birds, birds that crossed from one team's survey area to another were recorded by only one

team. This was determined by communicating directly with the other team by phone or by noting details on the data sheets including time of sighting or flight direction. Weather conditions, including air temperature, wind speed, wind direction, cloud cover, and precipitation, were recorded at the beginning and end of the survey and when any changes occurred through the course of the surveys.

Due to the large size of the project study area and the limited accessibility, identifications were often made over great distances. When it was not possible to identify a bird to the species level due to distance, overhead flight, unfavorable lighting, or a limited view of the bird, a less specific identification was made such as "unidentified gull" or "unidentified sandpiper". In cases where these conditions prevented the distinction between two species that are very similar and require close inspection to identify, the less specific name was used if necessary, i.e. greater and lesser scaup or long-billed and short-billed dowitcher were identified as "unidentified scaup" and "unidentified dowitcher", respectively.

After each survey, the survey teams rejoined to review the data sheets for completeness, ensure consistency of data recording methods, and, if necessary, correct suspected double-counts of individual birds. In some cases it was not possible to definitively assess whether a double-count had occurred, particularly with large flocks of highly transitory shorebirds and with raptors, which ranged over all survey areas. In cases where an over-count was suspected, a note was included in the reported table of birds observed.

All survey data were later transferred to digital database files and checked for accuracy. The database was then queried to extract summary information used to prepare tables and figures. Data were analyzed to identify spatial and temporal trends in total avian abundance, numbers of species, and patterns of habitat usage, activity, and seasonal variation.

The survey results under-represent bird usage of the marsh plains due to the more secretive nature of marsh birds and the difficulty of viewing them over such a great distance from a low elevation. Bird usage of open water and mudflat habitat was more accurately documented.

The Monitoring Plan also called for breeding season surveys for Belding's Savannah sparrow, light-footed clapper rail, western snowy plover, and California least tern. Merkel & Associates was originally tasked with performing these surveys in Year 2 (2012), however at the post-restoration monitoring program kickoff meeting on September 16, 2009, CDFW staff indicated that they would be performing the Year 2 surveys and providing M&A with the survey data for incorporation into the annual report. Based on communications with CDFW, Belding's Savannah sparrow surveys were not performed in Year 2. Light-footed clapper rail surveys were performed in Year 2 by Mr. Dick Zembal in coordination with CDFW and the reported results have been referenced below. Western snowy plover surveys were not performed due to their absence from Upper Newport Bay. The status of California least tern monitoring and reporting for Year 2 is unknown.

The following results section includes all data collected from avian monitoring conducted on January 16, April 26, July 24, and November 13, 2012, capturing all four quarters of monitoring Year 2. Data are then compared to avian work done in September 1997 at UNB as reported in the Biological Resources of Upper Newport Bay Report (MEC 1997).

Results

A summary of the 2012 avian survey results is presented by species, survey event, and survey area in Table 10. Over the course of 2012 surveys, the ten most abundant species observed were California gull (*Larus californicus*) (18% of total) and western sandpiper (*Calidris mauri*) (18%), followed by green-winged teal (*Anas crecca*) (7%), unidentified sandpiper (Calidris sp.) (6%), dowitcher (Limnodromus spp.) (6%), American coot (*Fulica americana*) (5%), willet (*Tringa semipalmata*) (5%), marbled godwit (*Limosa fedoa*) (4%), least sandpiper (*Calidris minutilla*) (4%), and black-bellied plover (*Pluvialis squatarola*) (4%).

Although the California gull was the most abundant species observed overall, nearly all individuals of this species (99.5%) were observed during the January survey, primarily loafing on the mudflats in Area 1 and Area 3.

Temporal Avian Trends

Total avian abundance was much greater during January and November than during April and July (Figure 7). This was due to the absence or low counts of many shorebirds, wintering ducks, and gulls in the spring and summer. Higher numbers in late fall and winter were due to the arrival of wintering shorebirds and ducks, including green-winged teal, American coot, American wigeon (*Anas americana*), black-bellied plover, bufflehead (*Bucephala albeola*), and northern pintail (*Anas acuta*).

Similarly, species diversity was highest in the fall and winter surveys. Diversity ranged from 54 species in July to 71 species during the November surveys. A total of 102 species was observed throughout the year in 2012.

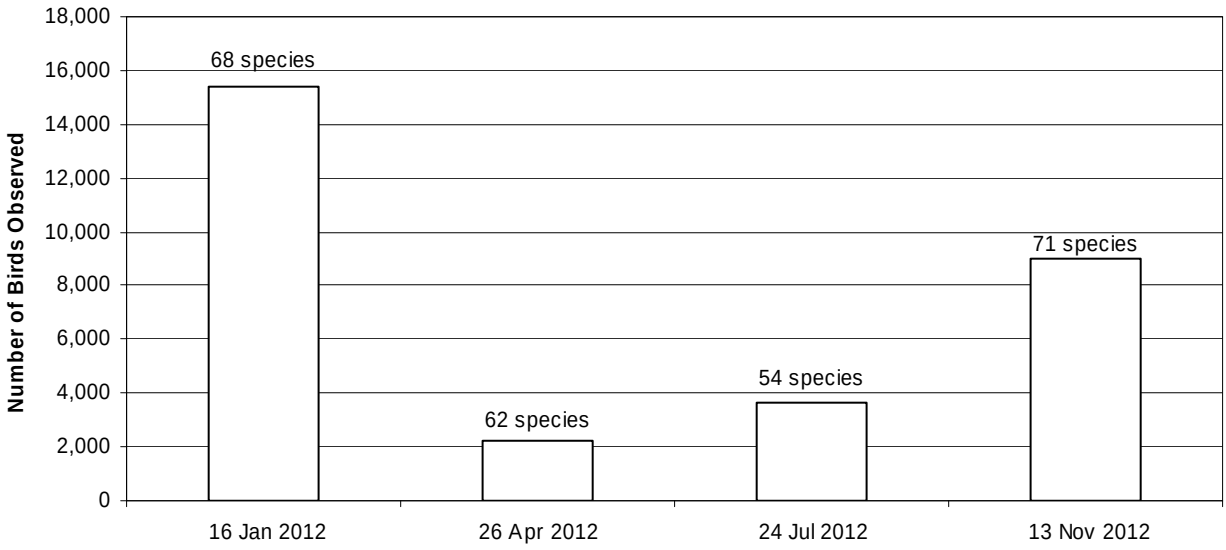


Figure 7. Avian Abundance and Diversity by Survey in 2012 at UNB.

Table 10. Abundance of birds in UNB by area and sample date in Year 2 (2012).

	2012	January 16, 2012					April 26, 2012					July 24, 2012					November 13, 2012				
Species	**Total**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Total**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Total**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Total**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Total**
Pacific Loon	2						2				2										
Common Loon	2	1		1		2															
Horned Grebe	1	1				1															
Eared Grebe	33	9	2	8	2	21	3	1	2	1	7						2	1	1	1	5
Pied-billed Grebe	70	2	1	7	2	12	1		1	1	3			1	20	21		1	29	4	34
Clark's Grebe	2								1	1	2										
Western Grebe	170	15	2	56	7	80	1	2	10	21	34	1			4	5	15		8	28	51
American White Pelican	4																		4		4
Brown Pelican	35	7	3	6	3	19	2		1	2	5		1		1	2	4	2	2	1	9
Double-crested Cormorant	78	1		1		2	3		1		4	6		2	5	13	7		15	37	59
Unidentified Cormorant	1			1		1															
Black-crowned Night Heron	3								1		1	2				2					
Green Heron	4													2	2	4					
Snowy Egret	105	5	2	2	2	11	9	6	3	3	21	11	3	6	23	43	9	4	11	6	30
Great Egret	66	1	3	6	2	12		2	1	5	8	4	2	3	12	21	4	3	14	4	25
Great Blue Heron	31	1		1	1	3	5	1	1	2	9	2		4		6	7		4	2	13
Canada Goose	26																26				26
Brant	2								2		2										
Mallard	130	2		12	7	21	2	3	7	10	22	28	28		21	77	1		9		10
Gadwall	63	2	7	45	5	59	1		2		3				1	1					
American Wigeon	960	22	119	127	30	298			8		8						83	112	273	186	654
Northern Pintail	210	68	19	81	12	180											7	6	4	13	30
Northern Shoveler	161	4		54	35	93			26	5	31								10	27	37
Blue-winged Teal	213		3	27	22	52	2		61	53	116								36	9	45
Green-winged Teal	2,206	251	311	678	311	1,551	15	20	64	80	179						19	22	387	48	476
Unidentified Teal	1																			1	1
Cinnamon Teal	138	6	7	47	20	80	1	12	19	4	36		2			2			20		20
Redhead	40				23	23			2	1	3									14	14
Ruddy Duck	177	15		15	44	74			20	31	51	2				2	2		12	36	50
Greater Scaup	2				2	2															
Lesser Scaup	34				34	34															
Unidentified Scaup	47	40				40													2	5	7
Surf Scoter	1				1	1															
Bufflehead	184	69	30	16	19	134											22	12	13	3	50
Common Goldeneye	1	1				1															
Hooded Merganser	4				4	4															
Unidentified Duck	85				2	2						2		6		8			62	13	75

Table 10. Abundance of birds in UNB by area and sample date in Year 2 (2012) (cont'd).

	2012	January 16, 2012					April 26, 2012					July 24, 2012					November 13, 2012				
Species	**Total**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Total**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Total**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Total**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Total**
Turkey Vulture	26			13	1	14		1	1	3	5		1		1	2	1		1	3	5
Osprey*	22	4		2		6	5		2	2	9			1		1	1		2	3	6
White-tailed Kite	8			1		1			1	3	4				1	1		1	1		2
Northern Harrier*	21	1		6	6	13			1	3	4								2	2	4
Cooper's Hawk	1													1		1					
Red-tailed Hawk*	10		1	4	2	7												1	1	1	3
American Kestrel*	6			1	1	2											1		3		4
Peregrine Falcon	1			1		1															
Virginia Rail	1			1		1															
Light-footed Clapper Rail	15	4				4			1	2	3		1	1	4	6			1	1	2
Sora	5			1	2	3									1	1			1		1
American Coot	1,658	118	46	295	295	754	24	33	97	112	266			5		5	68	47	330	188	633
Common Moorhen	2							2			2										
Black-bellied Plover	1,122	23	4	375	139	541				14	14	20	4	24	126	174	31	8	251	103	393
Semipalmated Plover	134	13		1		14						3			27	30	8	14	20	48	90
Killdeer	170	35		1	3	39			1	4	5	3			10	13	41	32	19	21	113
American Avocet	374	12	95	64	87	258		2	25	62	89						1		11	15	27
Black-necked Stilt	2									2	2										
Willet	1,616	50	264	84	76	474	37	1	18	43	99	111	135	142	102	490	76	123	184	170	553
Greater Yellowlegs	8			2	1	3								1	4	5					
Unidentified Yellowlegs	28			1		1											1	1	6	19	27
Spotted Sandpiper	2								1		1								1		1
Whimbrel	43	3		8	5	16	1			1	2	6		2	1	9	1	3	3	9	16
Long-billed Curlew	42	6	1	2	12	21				2	2	1	2	4	4	11	2	2	2	2	8
Marbled Godwit	1,341	235	94	196	191	716	7	1	30	36	74	22	25	38	46	131	132	48	83	157	420
Red Knot	12													1	2	3	6	1	2		9
Dowitcher spp.	1,732	79	44	388	241	752	12		85	20	117	6	6	160	164	336	134	94	214	85	527
Dunlin	211		42	123		165				7	7						9	9	12	9	39
Western Sandpiper	5,287	328		57	80	465	18		106	5	129	48		163	1,183	1,394	573	1,198	1,198	330	3,299
Least Sandpiper	1,144	350	3	299	56	708				4	4	39		49	217	305	59	15	3	50	127
Unidentified Sandpiper	1,770	95	603	392	240	1,330				2	2		42	42		84	53		44	257	354
Unidentified Shorebird	210																		130	80	210
Ring-billed Gull	132	49	16	3	40	108											4	12	8		24
California Gull	5,369	3,390	24	1,930		5,344			1		1						8		11	5	24
Western Gull	268	124	3	6	3	136	13	10	1	1	25	10	1	1	5	17	63		24	3	90
Unidentified Gull	505	424				424									1	1			50	30	80
Elegant Tern	208						196		3	2	201	5	1	1		7					
Caspian Tern	46						20				20	17	1		6	24				2	2
Forster's Tern	198	3	5	14	9	31	23	1	78	25	127			5	3	8	14	1	6	11	32
Least Tern	18												2	1	15	18					
Black Skimmer	533	138				138	169		43	36	248	2		7	119	128	19				19

Table 10. Abundance of birds in UNB by area and sample date in Year 2 (2012) (cont'd).

	2012	January 16, 2012					April 26, 2012					July 24, 2012					November 13, 2012				
Species	**Total**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Total**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Total**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Total**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Total**
Mourning Dove	12								1		1	4			4	8	2		1		3
Anna's Hummingbird	5							1			1								2	2	4
Allen's Hummingbird	14			3	1	4	4	1	1	1	7	1	1	1		3					
Belted Kingfisher	3			2		2													1		1
Northern Flicker	1																			1	1
Black Phoebe	21	1			2	3							1	2	4	7	2	3	4	2	11
Say's Phoebe	9	3		2	1	6											1	1	1		3
Cassin's Kingbird	6																4		2		6
Loggerhead Shrike	1			1		1															
American Crow	32	2			3	5		1	15	7	23	2			1	3			1		1
Common Raven	7						4	2			6		1			1					
Cliff Swallow	46											10	22	14		46					
No. Rough-winged Swallow	5						2			1	3			2		2					
Barn Swallow	14													3	11	14					
Bushtit	28							2			2				10	10	6		10		16
House Wren	1													1		1					
Bewick's Wren	1			1		1															
Marsh Wren	74	3		9	5	17	1	9	13	15	38			1	12	13	5		1		6
Ruby-crowned Kinglet	1																			1	1
California Gnatcatcher	2																		2		2
Northern Mockingbird	7									3	3	1				1			3		3
Yellow-rumped Warbler	1																		1		1
Wilson's Warbler	3									3	3										
Common Yellowthroat	96	10	2	3	8	23	4	7	9	19	39	8	3	5	6	22	8		3	1	12
California Towhee	4			1	1	2												1	1		2
Belding's Savannah Sparrow	97						11	12	11	10	44	1		24	17	42	7		2	2	11
Song Sparrow	75	6		3	11	20	6	4	11	11	32	4		4	3	11		5	7		12
White-crowned Sparrow	7	1			5	6													1		1
Unidentified Sparrow	2																		1	1	2
Red-winged Blackbird	4																		4		4
Brewer's Blackbird	2									2	2										
House Finch	32			4	2	6		2	3		5				16	16			5		5
Total	**34,230**	**6,033**	**1,756**	**5,491**	**2,119**	**15,399**	**604**	**139**	**792**	**683**	**2,218**	**382**	**285**	**730**	**2,215**	**3,612**	**1,549**	**1,783**	**3,593**	**2,052**	**8,977**

Avian Usage of the Survey Areas

The greatest number of birds, over one third of the yearly total (35%), was observed in Area 3, while the least number of birds was observed in Area 2 (13%). Area 3 has the largest expanses of open water and mudflats of the four survey areas. Area 2 is the smallest in overall size and has more modest mudflats and a narrow open water channel. This distribution is generally consistent with that found by MEC in September 1997, except in Area 1. M&A had consistently higher counts (39%, 27%, 11%, and 17% of all birds recorded during the January, April, July and November survey, respectively) in Area 1 than MEC (7% of all birds recorded during their September survey).

Avian Usage by Habitat

Mudflats were the most utilized habitat type, with 77% of total birds observed foraging or resting on this habitat type. Small shorebirds (western and least sandpipers) were the most abundant avian group utilizing the mudflats, and made up 34% of birds using that habitat type. Large and medium shorebirds, primarily dowitchers, willet, black-bellied plover, and marbled godwit, were the second most abundant avian group and made up 28% of birds using mudflats. Resting California gulls also had high utilization of the mudflats (21% of total birds), followed by wintering ducks (13% of total birds), which included green-winged teal, American wigeon, American coot, and blue-winged teal (*Anas discors*), in decreasing order of abundance. The September 1997 survey by MEC recorded 90% of all observed birds utilizing the mudflats.

Open water was also highly utilized at UNB (19% of all birds observed). Along the shoreline, in the shallows, both shorebirds and dabbling ducks were observed foraging or resting. Commonly observed species included American coot (17% of birds using open water), green-winged teal (15%), and California gull (10%), as well as marbled godwit, willet, and dowitchers, in decreasing order of abundance. The deeper water of the bay was used by fewer birds, primarily by diving ducks and grebes. These species included bufflehead, ruddy duck (*Oxyura jamaicensis*), western grebe (*Aechmophorus occidentalis*), and pied-billed grebe (*Podilymbus podicep*).

Salt marsh had the third highest usage, though it was used by only 2% of all birds recorded. The primary species using this habitat was the Belding's Savannah sparrow (which accounted for 14% of all birds recorded in salt marsh) and common yellowthroat (*Geothlypis trichas*)(14%). As mentioned above, the avian usage of this habitat is believed to be considerably underestimated by the methodology used for this survey work and due to the more secretive nature of birds inhabiting the salt marsh.

Sensitive Species

The four sensitive bird species identified as target species by the restoration project were light-footed clapper rail, Belding's Savannah sparrow, western snowy plover, and California least tern.

Light-footed Clapper Rail

Upper Newport Bay has the largest subpopulation of light-footed clapper rail, a state- and federally-listed endangered species, that is resident in coastal wetlands in southern California and northern Baja, California, Mexico. In 2012, Zembal and Hoffman (2012) reported 165 pairs at Upper Newport Bay, continuing a general increase that has been observed since a recent low of 86 pairs in 2008 (Figure 8).

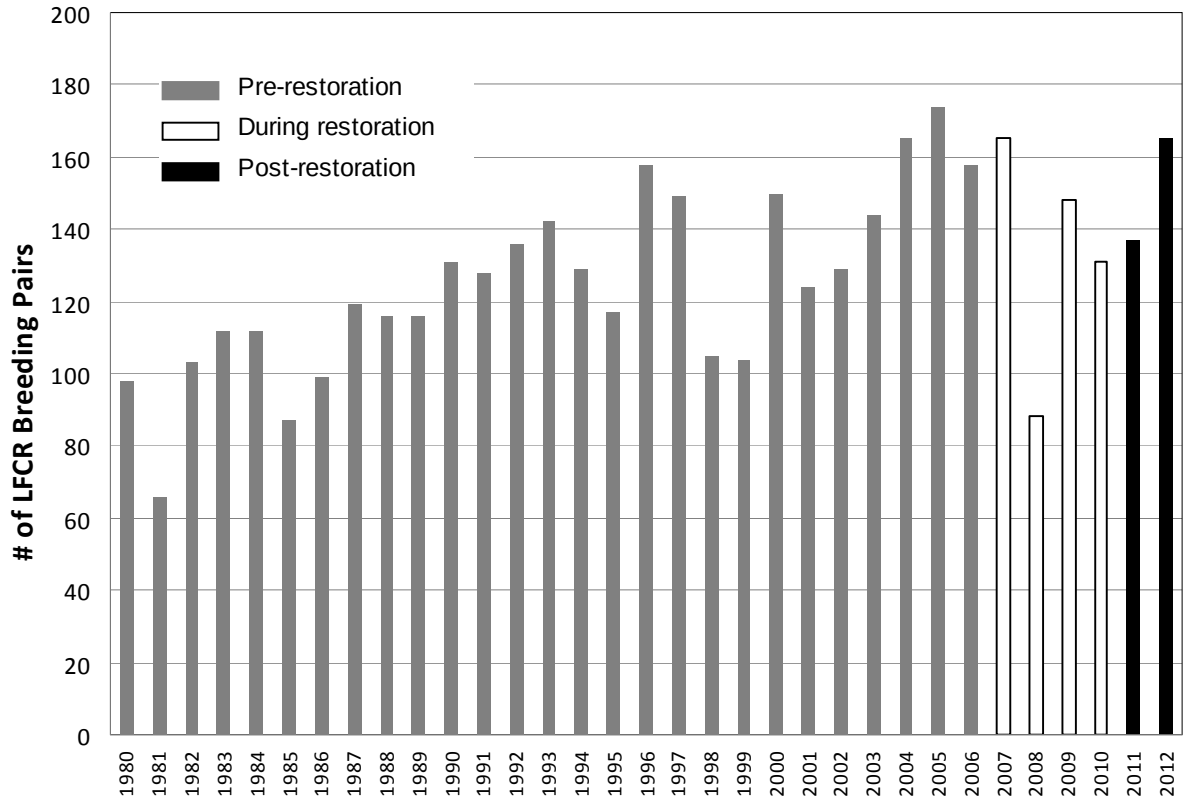


Figure 8. Light-footed Clapper Rail counts at Upper Newport Bay from 1980 to present (data from Zembal and Hoffman 2012).

Prior to the restoration of UNB, which began in 2006, the number of clapper rail pairs located during Zembal's surveys averaged 124 pairs per year from 1980 to 2005, with a low of 87 pairs in 1985 and a high of 174 pairs in 2005. During the restoration period the pair numbers remained fairly stable; however, there was a small decline in 2008, when only 86 clapper rail pairs were located. This decline in 2008 was observed at many southern California sites and was presumed to be weather related (Zembal et al. 2011). There was a noticeable increase in cordgrass at UNB in 2009 and the detected clapper rail population increased to 148 pairs in 2009 (Zembal et al. 2010).

Belding's Savannah Sparrow

Breeding surveys for Belding's Savannah sparrow were not performed by CDFW in Year 2 (2012). Region-wide surveys are performed every five years by Mr. Dick Zembal, including UNB. The most recent survey was done in 2010, during construction. At that time 268 pair of Belding's Savannah sparrow were observed, which was 155% higher than the previous count in 2006 (Zembal and Hoffmann 2010). Zembal does not speculate on the cause for the increase, but notes that year-to-year fluctuations at UNB can be related to levels of human and pet trespassing, as well as competition from upland and freshwater marsh species in areas receiving heavy freshwater influence. The next Belding's Savannah sparrow survey is anticipated to be done by Zembal in 2015.

Western Snowy Plover

Western snowy plover are not known to currently nest in UNB and, therefore, focused nesting surveys were not conducted by CDFW. No western snowy plovers were observed at the site during the four avian surveys reported on above.

California Least Tern

Monitoring of nesting California least terns was performed in 2012 by CDFW. The results of the monitoring were summarized in the statewide annual report for California least terns (CDFW 2013). In 2013 an estimated 16 to 21 breeding pairs nested at Tern Island, the established tern colony located at the north end of UNB. Twenty nests produced four fledglings. Predation by coyote was evident on the island, despite the subtidal channel that surrounds the island. No terns were observed nesting on New Least Tern Island, the nest site created in 2008 as part of the restoration project. The site has been well prepared each year by CDFW to attract terns and exhibits no clear characteristics that would discourage nesting. The reasons for its lack of use are unknown, but not unexpected given that it can take many years for least terns to attempt nesting at a newly created site. Continued annual maintenance will be important for attracting terns and other desirable species in the future.

Discussion

Question 7 posed in Section 1.3 above asks: *Has the project resulted in a significant increase in the number of targeted birds using UNB? Targeted species include listed species*. The listed species at UNB that would constitute the 'targeted birds' referred to in the question are: light-footed clapper rail, California least tern, western snowy plover, and Belding's Savannah sparrow. To answer this question, these species were to be monitored in Year 2 by CDFW, however only data on light-footed clapper rail are available for review. The current Zembal clapper rail report (2012) describes the population as stable, but does not comment on the effects of the restoration on the observed usage of the site by rails. However, the usage observed in Years 1 and 2 post-restoration are well within the ranges seen in the years leading up to the restoration initiation. The 165 pairs documented in Year 2 (2012) represent the second highest number reported by Zembal at the site since 1980 and made up 31.7% of the state population in 2012 (Zembal 2012).

A primary objective of the restoration project was to increase the ability of UNB to trap incoming sediment in a manner that would slow the conversion of open water to mudflat and subsequently salt marsh. Meeting this goal should have resulted in increased usage of UNB by open water species and there is some evidence that this has occurred within the bay. When roughly comparing the September 1997 data from MEC and the 2012 data from M&A some trends emerge. There were some increases in the abundance of diving birds that commonly utilize deeper open water. These species included ruddy duck, western grebe (*Aechmophorus occidentalis*), double-crested cormorant (*Phalacrocorax auritus*), and brown pelican (*Pelecanus occidentalis*). There were also a number of deep water avian species observed during the M&A surveys that were not observed during the MEC survey conducted prior to the restoration. These species include Pacific loon (*Gavia pacifica*), common loon (*Gavia immer*), scaup (*Aythya* spp.), bufflehead, and hooded merganser (*Lophodytes cucullatus*). However, many of these species could have occurred in winters prior to the restoration but were not captured by the September survey by MEC. There was also an increase in total abundance of some dabbling ducks and large shorebird species between 1997 and 2012 surveys. These species include green-winged teal, blue-winged teal, northern shoveler,

American coot, whimbrel (*Numenius phaeopus*), and marbled godwit. Again some of these differences can be attributed to the seasonal differences in which the surveys were conducted, but some are more likely to be attributed to the change in habitat structure (more open water).

3.2. Fisheries Monitoring

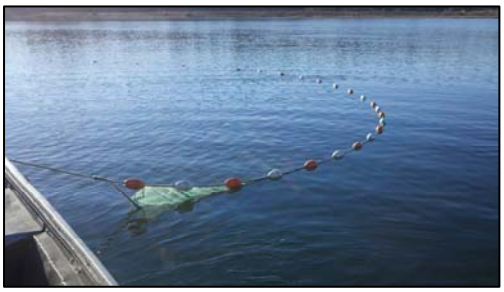
The Monitoring Plan calls for fisheries monitoring to be conducted quarterly in Years 2, 5, and 10 following completion of the restoration. The Year 2 monitoring was conducted in January, April, July, and October 2012.

Methods

Fisheries sampling was conducted over a three-day period each quarter to obtain the appropriate tidal elevations for each gear type. In 2012, surveys were conducted during daylight hours on January 10, 11, and 16, April 19, 20, and 25, July 9, 25, and 29, and October 9, 10, and 25. Each quarter, sampling was performed at six stations (Figure 9). Stations 2, 3, and 5 were identified in the Monitoring Plan as "channel" stations and Stations 1, 4, and 6 were designated as "basin" stations. The coordinates of the sampling stations are provided in Appendix B.

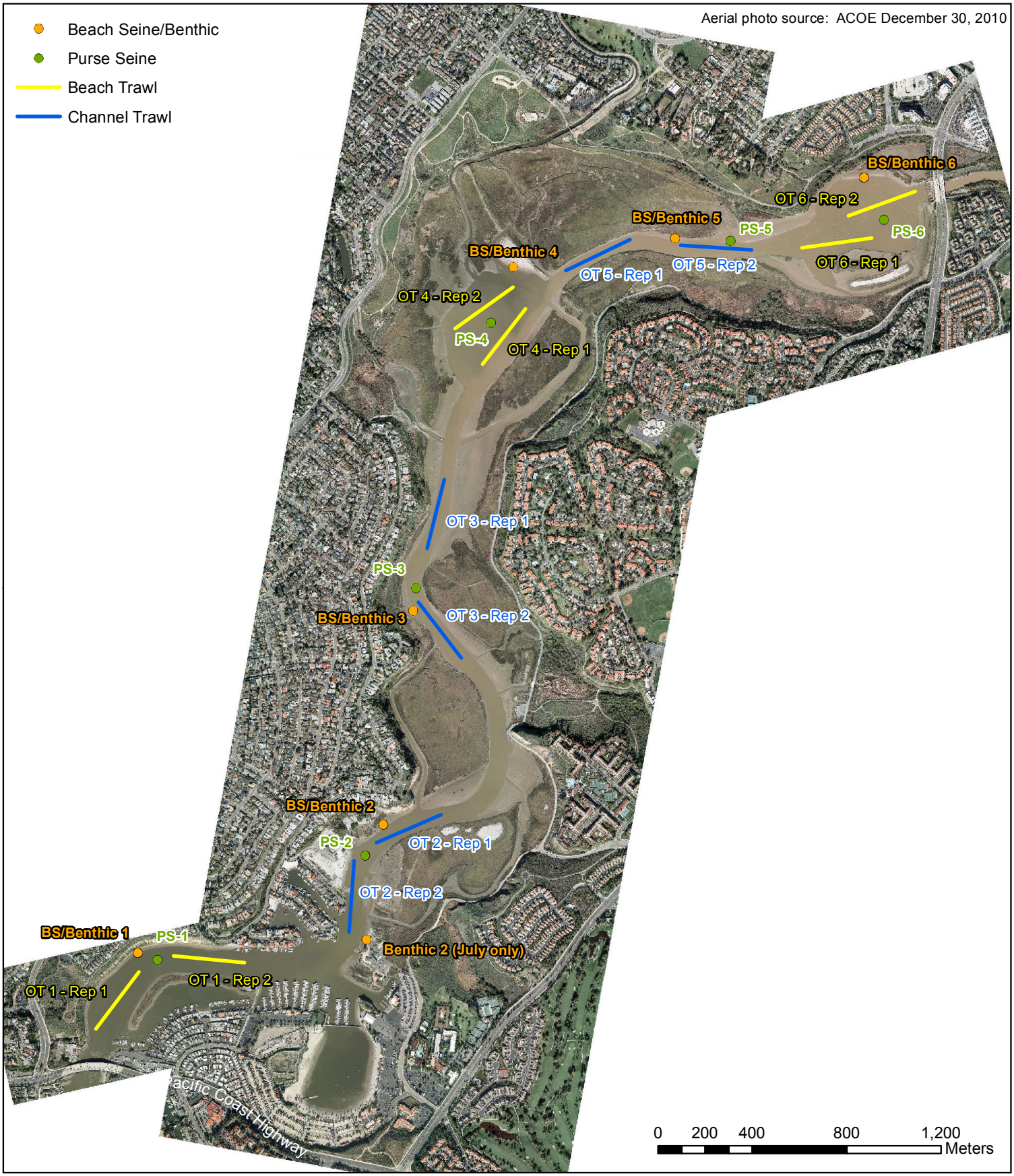
Sampling equipment utilized at each station included an otter trawl, purse seine, and beach seine. Two replicates hauls were made using each gear type at each station. The following text describes the usage of each gear type.

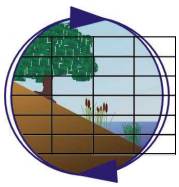
The otter trawl consists of a 4.6-m (15-foot [ft]) trawl with 2-cm (0.8-inch [in]) mesh in the body and 0.3-cm (0.1-in) mesh in the cod end. The lead line is weighted with both lead weights and chain to maintain contact with the bottom and target demersal fish. The otter trawl was deployed on 23.8-m (78-ft) tow lines behind a small vessel traveling between 1.5 and 2 knots along 305-m (1000-ft) transects in the channels and basins. The two replicate trawl transects at each station were navigated using a differential Global Positioning System (dGPS). Each trawl sampled an area of approximately 976 square meters.



Purse seine being deployed from survey vessel

The purse seine consists of a 66-m (216-ft) x 6-m (19.7-ft) seine with 1.2-cm (0.5-in) mesh and a bag with 0.6-cm (0.2-in) mesh. The purse seine was deployed in the channels and basins using a small vessel. This gear was used to sample adult and juvenile fish in the water column. The two replicate hauls were collected on either side of, and within 100 m (33.3 ft) of, the station marker indicated in Figure 9. Each haul sampled an area of approximately 347 square meters. At Station 2, a large piece of debris was discovered on the bottom while purse seining that snagged the net and interrupted its proper deployment at the station marker shown in Figure 9. The net was retrieved, inspected for damage, and redeployed in a nearby alternate position. This debris was avoided in subsequent efforts.





Fisheries and Benthic Sampling Locations
Upper Newport Bay Ecosystem Restoration Project
Post-restoration Monitoring Program

Figure 9

The beach seine consists of a 15-m (49.2–ft) x 1.8-m (5.9-ft) net with a 1.8-m (5.9-ft) x 1.8-m (5.9-ft) x 1.8-m (5.9-ft) bag in the center. The seine has 1.2-cm (0.5-in) mesh in the wings and 0.6-cm (0.2-in) mesh in the bag. It was utilized to sample shoreline waters between the bottom and surface at depths of 0 to 1 m (0 to 3.3 ft). The seine was positioned parallel to shore between 8 and 22 m from the water's edge, depending on bottom contours. Both replicate hauls within a station were deployed the same distance from shore, on either side of the station marker shown in Figure 9. The seine was held in place for 3 minutes and then walked slowly to shore, and pulled from the water while maintaining the lead line in contact with the bottom. Each haul sampled an area ranging from approximately 124 to 341 square meters. The area sampled is presented with the results to allow meaningful interpretation of the findings.

All fish captured in the nets were transferred to buckets or tubs filled with seawater, worked up, and released. Data collected for fish caught in each haul included species identification, individual counts, standard length (in millimeters [mm]), and wet weight (in grams [g]). Sharks and rays were measured to total length. Ectoparasites, lesions, or tumors, if any, were also noted. Species that were not identified in the field were transported to the laboratory and identified utilizing field identification references and/or a dissecting microscope. All fish identifications were made using widely accepted field identification guides such as Miller and Lea (1972) and Eschmeyer et al. (1983). Fish nomenclature was standardized in conformance with Nelson et al. (2004).

If more than 30 individuals of a species were caught in a replicate of any gear type, a batch sampling procedure was utilized. First, the standard length and weight was measured for 30 randomly selected individuals within the species. Second, the batch weight was measured for 100 additional randomly selected individuals. Finally, the total weight was measured for all of the remaining, uncounted individuals caught in the replicate. The number of uncounted individuals was then estimated using the batch weight of the 100 randomly selected individuals. All survey data were initially recorded in the field on hard copy data sheets and later transferred to a digital database and checked for accuracy.

Due to the difficulty of rapidly and conclusively distinguishing between small arrow goby (*Clevelandia ios*) and shadow goby (*Quietula y-cauda*) in the field, gobies that may have belonged to either species were identified as "arrow/shadow goby complex". These functionally similar species commonly co-occur and occupy similar niches in the demersal fish community.

All macroinvertebrates captured in the fish sampling nets were collected, identified to the lowest taxonomic level possible, counted, and released. Due to the tremendous spatial variability of these species and the non-targeted methodology employed here to sample them, collected data were intended to generate a list of species that occur in the project area, rather than to provide definitive density and biomass data on their populations.

Results

Table 11 presents the abundance (# individuals) of fish captured in UNB in both replicates of all gear types during the four Year 2 (2012) sampling events. A total of 37 species of fish was captured, with a total count of 27,024 individuals. Abundances were highest in July, with 15,851 fish captured across all stations and gear types. Roughly half the abundance was measured in October (7,519 fish), and lowest abundances were measured in April (2,543 fish) and January (1,111 fish). The total

Table 11. Total fish abundance (# of individuals) in UNB for all gear types in Year 2 (2012).

	January 2012						April 2012						July 2012						October 2012					
Species	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**
Gray smoothhound												1												
Shovelnose guitarfish																	1							
Bat ray																							2	
Round stingray		1	1				38	5	1	22	37	6		65	3		9	1	38	14	34	2	15	2
California butterfly ray											1												1	
Northern anchovy	2		4	13						196	23													
Slough anchovy	1		2	27	24	14	1					3	330	173	8	51	8,239	2,760	674	742	398	24	403	568
California lizardfish			1																					
Specklefin midshipman										1						1	1					3		
California halfbeak																2	2	3				8	4	4
California needlefish				2									1					1	5				1	
California killifish		298			2					53		1		68	49	4	9	11		443	326	62	13	204
California grunion													15		9									
Topsmelt	38	146	5	205	247		237	606	653	215	160	89	335	306	775	507	1,245	372	369	577	1,349	219	606	237
Atherinid, unid. juvenile	16	24	12	7	5	1																		
Bay pipefish	1															2	17	1					1	1
Barred pipefish											3					1								
Staghorn sculpin				2	2			4			8	5		1	1									
Kelp bass																			26	13	5			1
Spotted sand bass													2	4										
Barred sand bass									2								1		2	1				
Salema																					1			
Sargo														1										
Queenfish						1					4					1					16			3
Yellowfin croaker							1												1		2	1		
Spotfin croaker							2						1											
Shiner surfperch							3	20	1	2	8	34	1			1								
Striped mullet														1								18		3
California barracuda											1	1							1					
Bay blenny																			1					
Longjaw mudsucker														2	143	114	32	8						
Yellowfin goby*										1	19	9		2	1				1			2		
Cheekspot goby	1	1			1	1								4	5	12	7			4				
Arrow/Shadow goby complex								2			2			1	72	3	4	1		1	1			
Goby, unid. juvenile																	1	2						
California halibut					1		3	2	1	3	6			13		3	6		9	6	3	8	13	1
Hornyhead turbot							5						1						1					
Diamond turbot			2				22	4	3	3	8	2	2	16			4		2	5	14		4	
Total Abundance	59	470	27	256	282	17	312	643	661	496	280	151	688	657	1,066	702	9,578	3,160	1,130	1,806	2,149	347	1,063	1,024
Area Sampled (m^2)	3,113	3,036	3,067	3,253	3,206	2,974	3,020	3,020	3,113	3,051	2,958	2,927	3,020	3,050	3,020	3,020	2,958	2,896	3,114	2,958	3,114	2,958	2,958	2,896

* non-native species

mass of fish captured was 160.9 kg and is presented by species, station, and quarter in Table 12. Mass was highest in April (75.7 kg), followed by October (48.3 kg), July (33.5 kg), and January (4.4 kg).

Table 13 presents the total fish abundance by species ranked in descending order from most to least abundant during Year 2. The most abundant species were slough anchovy (*Anchoa delicatissima*) (53% of the total catch) and topsmelt (*Atherinops affinis*) (35% of the total catch). Table 14 presents total mass by species, ranked in descending order from greatest to least total mass. Round stingray (*Urobatis halleri*) made up the majority of the total mass (44%), followed by topsmelt (18%) and diamond turbot (*Pleuronichthys guttulatus*) (12%). It should be noted that striped mullet (*Mugil cephalus*) were present year round but were not targeted by the fishing gear used for this study and are, therefore, under-represented in the catch data. Some small juveniles were captured in the beach seine and purse seine. The monitoring team regularly observed adult striped mullet leaping from the water (a typical behavior) throughout UNB during various monitoring events.

Species captured in 2012 that were not noted in reviewed prior reports from UNB (MEC 1997, CDFG 1989, Horn and Allen 1981,) were California lizardfish (*Synodus lucioceps*) (one juvenile was captured), California halfbeak (*Hyporhamphus rosae*), and California needlefish (*Strongylura exilis*). These species are not uncommon in southern California bays and estuaries. No freshwater fish species were captured during the post-restoration monitoring.

It is important to note when reviewing Tables 11 and 12 that survey intensity varied slightly between stations due to variations in beach seine haul sizes, so direct comparisons of total abundance and mass between stations and quarters should be made carefully (the area sampled is presented at the bottom of each table). In addition, the sampling biases between gear types preclude a lumping of abundance and mass data from all gear types together for comparisons. To standardize for the area sampled and to allow direct comparisons of density and biomass between stations and sampling quarters, Figure 10 presents the mean density (individuals/m^2) by gear by quarter for each station. Figure 11 presents mean biomass (g/m^2) by gear by quarter for each station. Each data point shows the mean of the two replicates, plus or minus one standard error (SE).

Temporal Variability

Figure 10 illustrates a general seasonal trend in fish density, with the greatest densities of fish occurring during the July and October samplings and the lowest densities occurring during the January sampling. These trends primarily reflect summer reproductive and recruitment events for slough anchovy and topsmelt. Figure 11 shows trends in biomass, which was highest overall in April due to the capture of a large number of rays.

Thirteen species were captured in January, with topsmelt and killifish most abundant. The majority of fish (76%) were captured along the shoreline in the beach seine, with few fish captured in the channels and basins by the other gears. In April, 22 species were captured and abundance roughly doubled compared to January. Topsmelt made up 77% of the total catch, with northern anchovy (*Engraulis mordax*) the second most abundant at 9% of the total. Again, the majority of fish (76%) were captured along the shoreline in the beach seine. Of interest was the capture of two adult

Table 12. Total mass (g) of fish in UNB for all gear types in Year 2 (2012).

	January 2012						April 2012						July 2012						October 2012					
Species	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**
Gray smoothhound												1,300												
Shovelnose guitarfish																	907							
Bat ray																							740	
Round stingray		290	515				6,520	1,263	250	7,070	12,505	3,032		12,241	1,352		2,773	125	8,068	2,444	8,779	451	3,084	348
California butterfly ray											10,200												275	
Northern anchovy	2		2	8						319	4													
Slough anchovy	< 0.5		<0.5	19	32	9	3					3	702	528	1	24	2,039	146	1,159	1,116	569	4	113	67
California lizardfish			2																					
Specklefin midshipman										200						<0.5	1					1		
California halfbeak																<0.5	<0.5	<0.5				6	1	6
California needlefish				368									1					152	341				200	
California killifish		830			<0.5					299		1		41	7	13	7	8		1,162	1,160	158	18	179
California grunion													6		2									
Topsmelt	26	401	3	1,147	225		1,771	7,323	2,228	3,064	2,309	926	334	286	342	158	713	65	1,183	987	2,404	1,158	1,227	594
Atherinid, unid. juvenile	3	2	2	1	2	<0.5																		
Bay pipefish	<0.5															1	5	<0.5					<0.5	<0.5
Barred pipefish											2					1								
Staghorn sculpin				1	1			17			7	30		7	6									
Kelp bass																			149	88	40			1
Spotted sand bass													650	1,356										
Barred sand bass									12								54		153	45				
Salema																					70			
Sargo														91										
Queenfish						53					345					2					20			2
Yellowfin croaker							240												59		389	241		
Spotfin croaker							1,050						474											
Shiner surfperch							53	25	29	65	55	205	6			20								
Striped mullet														800								4		3
California barracuda											530	680							1					
Bay blenny																			2					
Longjaw mudsucker														1	45	47	16	2						
Yellowfin goby*										<0.5	3	2		2	1				11			33		
Cheekspot goby	<0.5	<0.5			<0.5	<0.5								1	1	2	1			1				
Arrow/Shadow goby complex								1			<0.5			1	21	2	1	<0.5		<0.5	1			
Goby, unid. juvenile																	<0.5	<0.5						
California halibut					24		662	2,440	95	1,185	369			889		59	373		212	742	165	190	1,605	123
Hornyhead turbot							282						50						18					
Diamond turbot			430				4,210	980	540	30	2	2	360	3,910			1,234		565	1,132	3,251		975	
Total Mass	31	1,523	954	1,544	284	62	14,791	12,049	3,154	12,232	26,330	6,179	2,583	20,154	1,777	329	8,124	499	11,920	7,717	16,847	2,246	8,238	1,323
Area Sampled (m^2)	3,113	3,036	3,067	3,253	3,206	2,974	3,020	3,020	3,113	3,051	2,958	2,927	3,020	3,050	3,020	3,020	2,958	2,896	3,114	2,958	3,114	2,958	2,958	2,896

* non-native species

Table 13. Abundance and percent of total by species from most to least.

Species	Total Abund. Year 2 (2012)	% of Total Abundance
Slough anchovy	14,442	53.44%
Topsmelt	9,498	35.15%
California killifish	1,543	5.71%
Longjaw mudsucker	299	1.11%
Round stingray	294	1.09%
Northern anchovy	238	0.88%
Diamond turbot	91	0.34%
Arrow/Shadow goby	87	0.32%
California halibut	78	0.29%
Shiner surfperch	70	0.26%
Atherinid, unid. juvenile	65	0.24%
Kelp bass	45	0.17%
Cheekspot goby	36	0.13%
Yellowfin goby*	35	0.13%
Queenfish	25	0.09%
California grunion	24	0.09%
California halfbeak	23	0.09%
Bay pipefish	23	0.09%
Staghorn sculpin	23	0.09%
Striped mullet	22	0.08%
California needlefish	10	0.04%
Hornyhead turbot	7	0.03%
Specklefin midshipman	6	0.02%
Spotted sand bass	6	0.02%
Barred sand bass	6	0.02%
Yellowfin croaker	5	0.02%
Barred pipefish	4	0.01%
Spotfin croaker	3	0.01%
Goby, unid. juvenile	3	0.01%
Bat ray	2	0.01%
California butterfly ray	2	0.01%
California barracuda	3	0.01%
Gray smoothhound	1	0.00%
Shovelnose guitarfish	1	0.00%
California lizardfish	1	0.00%
Salema	1	0.00%
Sargo	1	0.00%
Bay blenny	1	0.00%
Total Abundance	27,024	100.00%

* non-native species

Table 14. Mass (g) and percent of total by species from largest to smallest.

Species	Total Mass (g) Year 2 (2012)	% of Total Mass
Round stingray	71,110	43.93%
Topsmelt	28,871	17.83%
Diamond turbot	17,620	10.95%
California butterfly ray	10,475	6.47%
California halibut	9,132	5.64%
Slough anchovy	6,531	4.03%
California killifish	3,882	2.40%
Spotted sand bass	2,006	1.24%
Spotfin croaker	1,524	0.94%
Gray smoothhound	1,300	0.80%
California barracuda	1,211	0.75%
California needlefish	1,062	0.66%
Yellowfin croaker	929	0.57%
Shovelnose guitarfish	907	0.56%
Striped mullet	807	0.50%
Bat ray	740	0.46%
Shiner surfperch	458	0.28%
Queenfish	422	0.26%
Hornyhead turbot	350	0.22%
Northern anchovy	335	0.21%
Kelp bass	278	0.17%
Barred sand bass	264	0.16%
Specklefin midshipman	202	0.12%
Longjaw mudsucker	110	0.07%
Sargo	91	0.06%
Salema	70	0.04%
Staghorn sculpin	69	0.04%
Yellowfin goby*	51	0.03%
Arrow/Shadow goby	26	0.02%
California halfbeak	15	0.01%
Atherinid, unid. juvenile	11	0.01%
California grunion	8	0.01%
Bay pipefish	6	0.00%
Cheekspot goby	6	0.00%
Barred pipefish	3	0.00%
California lizardfish	2	0.00%
Bay blenny	2	0.00%
Goby, unid. juvenile	0	0.00%
Total Mass (g)	161,885	99.45%

* non-native species

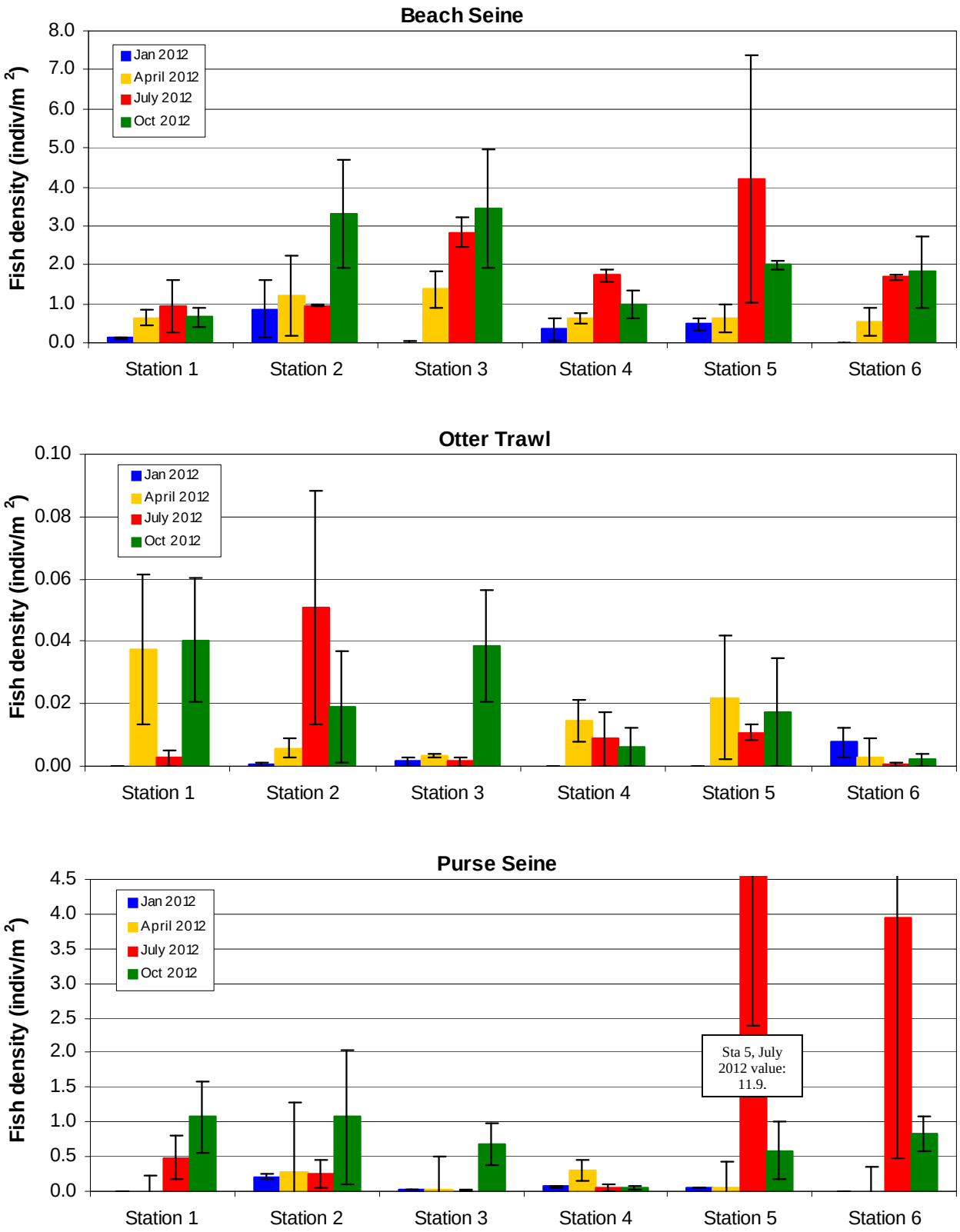


Figure 10. Mean fish density (individuals/m^2) (± 1 SE) by station for beach seine, otter trawl, and purse seine in each quarter of Year 2 (note variable y-axis scales).

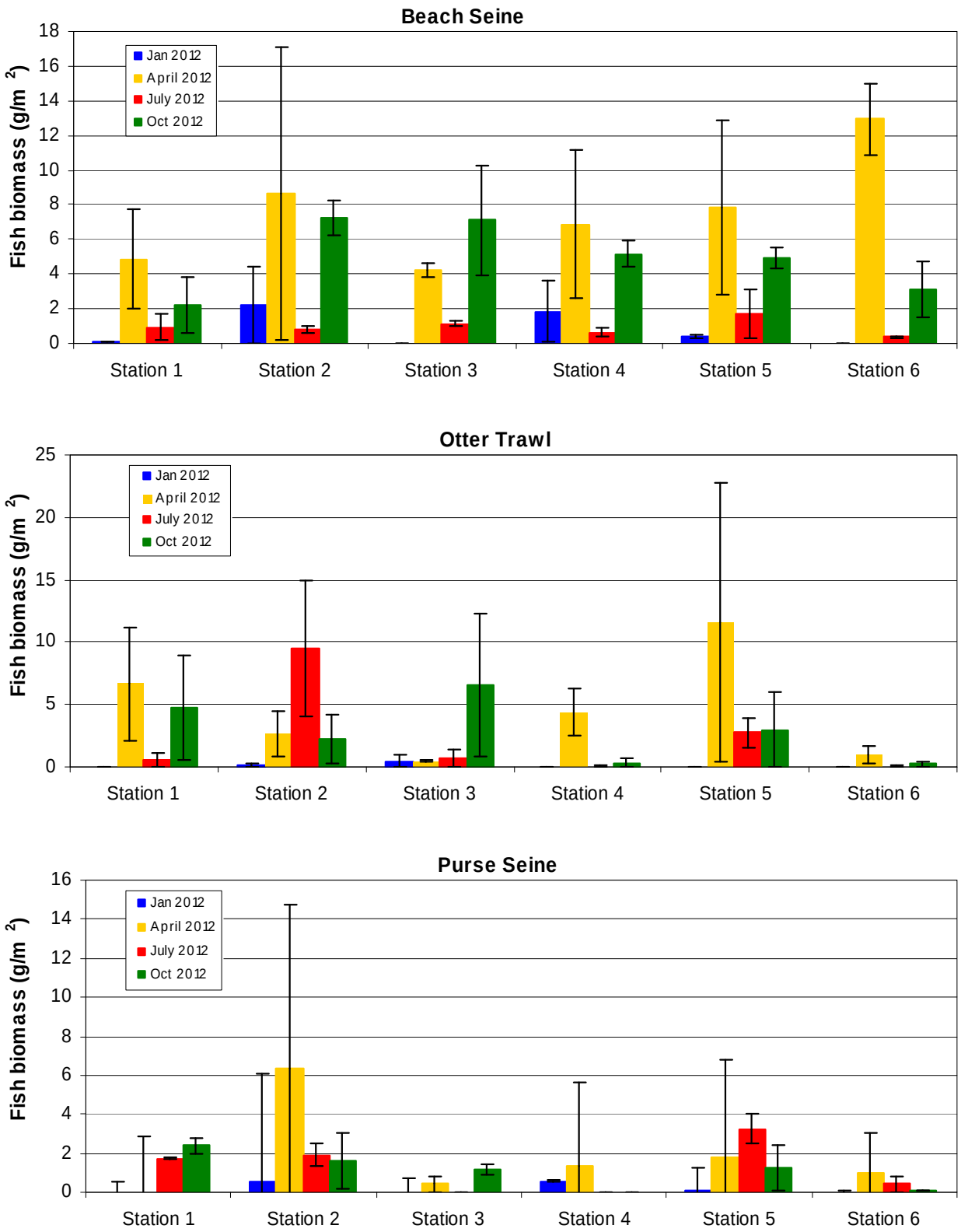


Figure 11. Mean fish biomass (g/m^2) (± 1 SE) by station for beach seine, otter trawl, and purse seine in each quarter of Year 2 (note variable y-axis scales).

California barracuda (*Sphyraena argentea*) at Stations 5 and 6 and a large 10.2-kg California butterfly ray (*Gymnura marmorata*) at Station 5, which dominated the total biomass for the quarter. The greatest number of fish, represented by 27 species, was captured in July. The high numbers were driven by the capture of thousands of juvenile slough anchovy in the purse seine at Stations 5 and 6. The majority of the biomass in July (49%) was accounted for by high densities of round stingray at Station 2. Of interest were seven juvenile California halfbeak captured at Stations 4, 5, and 6. In October, 23 species were captured. The dominant species were topsmelt (45%) captured along the shoreline in the beach seine, and slough anchovy (37%) captured in the purse seine. Round stingray again made up the majority of the biomass (48%). Of interest was a juvenile California barracuda captured at Station 1.

Spatial Variability

Figures 10 and 11 also allow spatial comparisons of density and biomass by both gear type and station. Tables presenting the catch data by gear type and station are provided in Appendix F. Generally, the greatest number of fish was captured in shallow water along the channel and basin shorelines, as sampled by the beach seine. These shoreline samples were dominated by topsmelt (80% of the total beach seine count for the year), California killifish (14%), and gobies (4%), primarily juvenile longjaw mudsuckers (*Gillichthys mirabilis*). These species captured along the shorelines were most abundant at Stations 2, 3, and 5. The basins at Stations 4 and 6 had roughly half as many fish, and Station 1 had the least fish in the samples.

The demersal fish in the channels and basins, as sampled by the otter trawl, were found in the lowest densities, as would be expected for this community of largely solitary fish. Demersal fish counts were dominated by round stingray (50% of the total otter trawl count for the year), diamond turbot (14%), California halibut (*Paralichthys californicus*) (12%), and kelp bass (*Paralabrax clathratus*)(9%). Abundance was highest at Station 1 and 2, moderate in the channels at Stations 3 and 5, and low in the basins of Stations 4 and 6.

Round stingray, Ca. halibut, and bivalves in the otter trawl.

The pelagic community sampled by the purse seine was dominated by slough anchovy (94% of the total purse seine count for the year), with topsmelt (4%) and northern anchovy (2%) the only other species making up more than 1% of the total count. No deepbody anchovy (*Anchoa compressa*) were captured during the four sampling events, though this species is common in bays and has been present historically in UNB. Spatial trends evident in Figures 10 and 11 are therefore nearly completely driven by the distribution and abundance of slough anchovy. Overall abundance for the year was highest at Station 5, where one of the two July purse seine hauls had 7,425 slough anchovy. In other quarters, hauls at Station 5 were generally smaller than most other stations. Pelagic community abundance was lowest in the basin at Station 4.

Fish Length

The minimum and maximum standard length of each fish species captured in 2012 is presented in Table 15. Of all 37 fish species captured, all but three were represented to some degree by juveniles, based on ages of maturity in Emmett et al. (1991). Species captured only as mature individuals were shovelnose guitarfish (*Rhinobatos productus*), spotfin croaker (*Roncador sternsii*),

Table 15. Maximum and minimum standard length (mm) of all fish species captured by quarter at all stations in 2012.

	January 2012		April 2012		July 2012		October 2012	
Species	Min SL (mm)	Max SL (mm)	Min SL (mm)	Max SL (mm)	Min SL (mm)	Max SL (mm)	Min SL (mm)	Max SL (mm)
Arrow/shadow goby			30	35	20	36	31	36
Barred pipefish			104	114	110	110		
Barred sand bass			63	68	125	125	130	158
Bat ray (wing length)							160	210
Bay blenny							31	31
Bay pipefish	68	68			52	125	72	82
California barracuda			500	536			50	50
California butterfly ray			635	635			201	201
California grunion					22	50		
California halfbeak					20	56	35	120
California halibut	110	110	65	510	62	230	36	265
California killifish	16	57	30	68	13	80	19	69
California lizardfish	67	67						
California needlefish	520	570			98	475	84	533
Cheekspot goby	22	26			15	32	26	36
Diamond turbot	180	255	24	250	117	266	155	245
Goby, unidentified juvenile					13	16		
Gray smoothhound			72	72				
Hornyhead turbot			125	130	124	124	90	90
Kelp bass							26	94
Longjaw mudsucker					15	41		
Northern anchovy	37	58	26	75				
Queenfish	155	155	155	192	20	20	22	55
Round stingray (disk length)	285	350	210	425	175	390	152	405
Salema							142	142
Sargo					135	135		
Shiner surfperch			21	111	58	87		
Shovelnose guitarfish					660	660		
Slough anchovy	23	68	33	70	17	72	14	68
Specklefin midshipman			270	270	20	43	24	30
Spotfin croaker			320	320	235	235		
Spotted sand bass					205	265		
Staghorn sculpin	25	34	22	86	65	69		
Striped mullet					350	350	21	39
Topsmelt	30	110	16	170	12	142	30	132
Yellowfin croaker			229	229			142	230
Yellowfin goby			18	40	40	50	94	105

and spotted sand bass (*Paralabrax maculatofasciatus*). In a few cases, species were captured only as juveniles, such as California grunion (*Leuresthes tenuis*), kelp bass, gray smoothhound (*Mustelus californicus*), bay blenny (*Hypsoblennius gentilis*), and bay pipefish (*Syngnathus leptorhynchus*). The majority of California halibut captured were juveniles.

Discussion

Question 7 posed in Section 1.3 above asks if the restoration project has led to significant increases in fisheries habitat. Clearly the creation of roughly 30 acres of additional open water by the project represents an increase in fisheries habitat available. To evaluate if the increased habitat availability resulted in increased usage, comparisons should be made between the current Year 2 findings and data collected prior to the restoration. The most recent fish investigation conducted prior to the 2006 start of construction was done nine years earlier in 1997 by MEC. The present (M&A) monitoring was conducted 15 years after the MEC study using similar equipment and station positioning. MEC collected two replicate hauls at each station using a beach seine and beam trawl, and one replicate with a purse seine. M&A collected two replicate hauls with all gear and sampled several comparable stations. Both beach seines were the same size, though M&A sample areas were variable based on the distance from shore (resulting in a sample area between 124 to 341 square meters), while the MEC net was always placed 15 meters from shore, resulting in a sample area of 228 square meters. The purse seines were the same dimensions and sampled the same area in both studies; however only one replicate purse seine was performed by MEC (two by M&A). The MEC beam trawl and the M&A otter trawl both sampled demersal fish, but the sampled areas were quite different due to the longer M&A haul length and larger net opening. MEC sampled 100 square meters per haul and M&A sampled 978 square meters per haul. These variations in sample effort were standardized in both studies to catch per unit effort (count or mass per square meter). However, such dramatically different sample areas for the beam trawl and otter trawl may make comparisons difficult. Demersal fish targeted by these nets are generally solitary and scattered, with low numbers captured in any length haul. The small number of fish standardized by the much larger M&A haul size may depress density values in comparison to MEC values on a scale not truly reflective of true density disparities.

The MEC study was a single sampling event in September 1997 and, therefore, did not characterize the fish community throughout the year. To make comparisons of pre- and post-restoration conditions, the October 2012 M&A data are the most appropriate to compare to the September 1997 data. Figure 12 presents the density (abundance/m^2) of fish in the two studies by pairing stations that are most comparable. At Station 3 there was no comparable MEC station for comparison of beach seine and beam trawl and at Station 5 there was no comparable MEC purse seine station (as noted in the figure by an asterisk).

In 1997, MEC found 15 fish species in UNB, with abundance dominated by deepbody anchovy, topsmelt, and California killifish. In October 2012 the M&A monitoring found 23 species, including 12 of the 15 MEC species. Two species, spotted sand bass and longjaw mudsucker, present in October 1997 but not in October 2012, were captured in other quarters in 2012. Deepbody anchovy were notably absent from all of the 2012 samples, after being numerically dominant in nearly all prior studies back to 1978 (MEC 1997). Slough anchovy were instead dominant in 2012. Fish sampling performed in recent years in other bays have also found deepbody anchovy to be absent or present in very low numbers. At Bolsa Chica, fourteen fish sampling events conducted

between 2007 and 2011 using the same sampling gear as at UNB found only 245 deepbody anchovy, with most of them captured during a single survey (M&A 2010a, M&A unpublished data). A quarterly fish study currently in progress in Anaheim Bay by M&A, using the same sampling gear, has only captured one deepbody anchovy during all sampling in 2013 (H. Henderson, M&A, pers. com.). Seven fish monitoring events conducted by M&A in the Huntington Beach Wetlands between 2007 and 2009 using beach seines and an otter trawl captured only 55 deepbody anchovy (out of a total of 9,776 fish) (M&A 2011). These recent and local low counts of deepbody anchovy suggest that their absence in UNB post-restoration is more likely a result of a regional shift in anchovy distribution and not a result of the restoration work.

Looking at the shallow water, shoreline fish communities sampled by the beach seine, densities were three to twenty times greater post-restoration (Figure 12). This increase was due to the much greater numbers of topsmelt captured in 2012. Species composition was similar between the two studies, though the deepbody anchovy that dominated the MEC catches was absent in 2012.

Demersal fish were captured by the beam trawl and otter trawl in the basins and channels in much higher densities pre-restoration. An examination of the composition of the catches, however, shows a more diverse assemblage post-restoration. Pre-restoration demersal samples were composed nearly entirely of gobies, and dominated by the non-native yellowfin goby (*Acanthogobius flavimanus*). The post-restoration fish community, particularly the more southern stations below the basins, was made up of larger fish at higher trophic levels such as kelp bass, round stingray, queenfish (*Seriphus politus*), California halibut, hornyhead turbot (*Pleuronichthys verticalis*), and diamond turbot. MEC does not present biomass (g/m^2) figures, but it is much higher in the 2012 trawls due to the much larger size of fish captured.

Pelagic fish targeted by the purse seine were captured in higher densities overall in the pre-restoration survey than post-restoration, though results were variable by station. At the most northern Station 6 (what is now Basin I/III), topsmelt and anchovy were the dominant species in both surveys, though in much lower numbers in 1997. There was no appropriate MEC comparison station for Station 5 in the channel between the two basins. Densities were higher at Stations 3, 4, and 5 during the pre-restoration survey and higher at Station 1 in the post-restoration survey. The density of the catch in a purse seine haul is largely dependent on whether a school of small fish is captured or missed. With the replication in the M&A study (2 hauls per station) replicates with a low count reduced the final density value even if the second replicate produced a high fish count comparable to the MEC count in the single haul. Overall, the purse seine in both studies documented schools of either deepbody or slough anchovy at most stations.

Quantitative comparisons of fish density and biomass pre- and post-restoration using the 1997 one-time MEC study and one quarter of the present four-quarter study is not possible, due the small dataset, limited replication, lack of sampling in other seasons, and the absence of biomass data in the MEC report for comparison. Multi-year fish studies performed earlier in the history of UNB by Horn and Allen found very high variability in abundance year to year, which they attributed to variability in bay salinity, temperature, and sedimentation and its effect on reproductive and recruitment success (Allen 1988, Allen 1983, Horn and Allen 1981). A review by MEC of these prior fish studies in UNB also found very high variability in the number of species caught during each survey, ranging from 14 to 31 species. It is not possible to separate this variability from the effect of

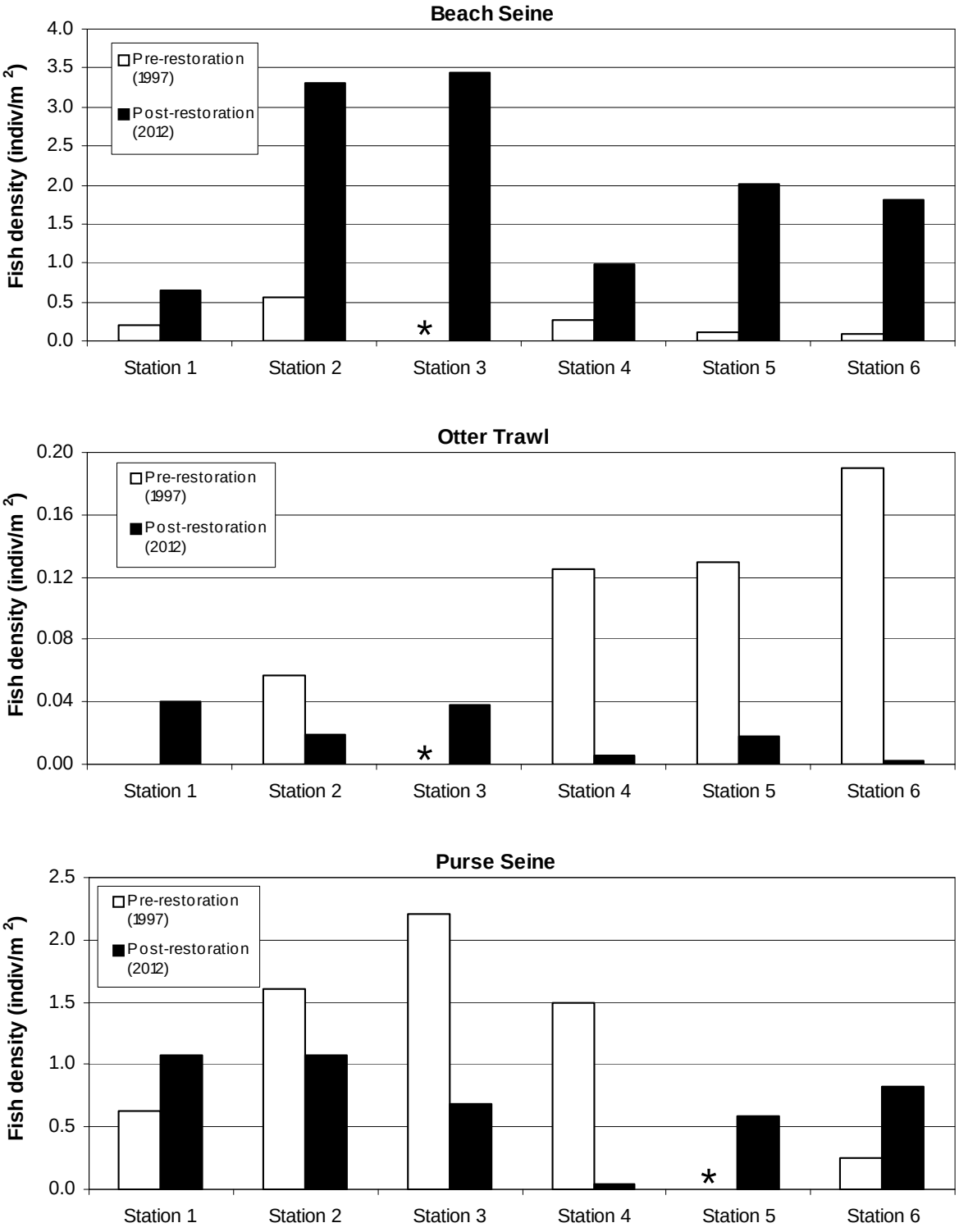


Figure 12. Fish density (individuals/m^2) pre-restoration (MEC, Sept. 1997) and post-restoration (M&A, Oct. 2012). * No comparable data available. (M&A Sta 1=MEC Sta F1, P5; M&A Sta 2=MEC Sta F2, F3, P1; M&A Sta 3=MEC Sta P2; M&A Sta 4=MEC Sta P3, F8; M&A Sta 5=MEC Sta F9; M&A Sta 6=MEC Sta F10, P4).

the restoration with any certainty using these data. However, the review discussed above generally suggests that diversity in the basins is improved post-restoration, shoreline fish are abundant, and there are no clear signs that key guilds or trophic levels are missing from the bay post-restoration.

The absence of freshwater fish at even the northernmost stations reflects the full tidal influence assured by the restoration project. The presence of multiple size classes throughout the year in many of the species indicates favorable conditions for reproduction and recruitment of species in both low and higher trophic levels.

While the restoration project does suggest an overall expansion of fish habitat and utilization, as well as an increase in species richness, a concern over fish utilization of the deeper sediment basins in association with low DO does exist. The strictly demersal sampling within these basins using an otter trawl suggests that very little fish utilization occurs on or near the bottom of the deep basins with the northerly Basin I/III exhibiting the least fish use. While purse seine sampling did yield schooling fish in the basins, the numbers were not as high as initially anticipated given observed trends in other restored systems such as Batiquitos Lagoon where the abundance of juvenile schooling fish typically increased with distance from the ocean. Notwithstanding the low capture of upper water column fish, the density of fish within the water column in the northerly basin was higher in the 2012 post-restoration sampling than observed in the 1997 pre-restoration sampling. Conversely, open water schooling fish captures were higher in 1997 than in 2012 for more southerly stations. This fish distribution pattern is likely attributable to many factors, including differences in physical site characteristics and DO levels between the sampling years, but also a high expected variability driven by low sampling intensity.

While utilization of the basins may be reduced as a result of DO conditions, they do provide usable habitat as evidenced by their usage reported above. In addition, by trapping introduced sediment as designed, the basins contribute to more favorable conditions throughout the remainder of UNB.

3.3. Benthic Invertebrate Monitoring

Benthic invertebrate monitoring can characterize the marine invertebrate food resources available to higher trophic levels, as well as document any changes in distribution and abundance over time, following the restoration. Monitoring at UNB focused on infauna, though some epifaunal invertebrate inventories were also performed. The Monitoring Plan calls for benthic invertebrate monitoring to be conducted in January and July of Years 2, 5, and 10 post-restoration.

Methods

Infauna

Sampling was conducted at extreme low tides on January 19 and July 5, 2012. Six shoreline benthic sampling stations were positioned roughly at the center of each shoreline fisheries (beach seine) monitoring station (Figure 9). In July, the Station 2 samples were inadvertently collected from a different location, indicated on Figure 9. Though close to the true Station 2, the July Station 2 substrate had a much greater sand component than the original sample location.

At each station, three replicate sediment cores were collected from the + 0.3-m (+1-foot) MLLW elevation and from the -0.6-m (–2-foot) MLLW elevation. These elevations will be referred to in feet only throughout this section. The sediment cores were collected using a 15-cm diameter corer inserted to a sediment depth of 15 cm, and rinsed through a 1.0-mm sieve. The sediment area sampled by each core was 0.018 square meter. Core collection unavoidably captured the biota occurring on the surface of the sampled core, as well as in the water column for the submerged –2-foot samples. Therefore, the collected samples could infrequently include epibenthic and open water organisms along with the infauna. Although captured fish were removed from the samples, all invertebrate organisms were retained and worked up along with the infauna. Organisms from each sample were placed in containers, preserved in a buffered 10% formalin:seawater solution, and transported to the laboratory for subsequent analysis.

Rinsing a sediment core through the 1-mm sieve.

After approximately one week, organisms collected from the benthic cores were transferred in the laboratory into 70% isopropyl alcohol. All individuals in each replicate sample were identified to the lowest practical taxonomic level, counted, and the wet weight measured. Wet weight was determined by transferring the sample, including alcohol, onto a paper towel and blotting quickly to remove excess liquid from the animals. Organisms were then transferred to a tared weighing dish and weighed to the nearest 0.0001 gram using an analytical balance. All samples were returned to the alcohol solution and archived for future reference.

Because the benthic monitoring program was intended to broadly characterize the communities of infaunal organisms within UNB, species level classification was not performed. The density (individuals/m^2) and biomass (g/m^2 wet weight) of higher-order taxonomic groups were assembled into summary tables and charts.

<u>Epifauna</u>

The epibenthic invertebrate sampling program made use of both a focused quadrat investigation and a more expansive effort undertaken as a part of the fish community surveys. For the quadrat survey, a 1-square meter quadrat was tossed randomly three times at each of the sampling stations, at each of the two tidal elevations (+1 foot and -2 feet MLLW). All epifaunal organisms present on the surface of the substrate within the quadrat were identified and counted. Macroalgae present in the quadrats were also recorded. The –2-foot quadrats (which were in shallow water) were examined first visually, then swept with a net to collect any missed organisms from the surface of the benthos.

Xantu's swimming crabs captured in the beach seine.

Additionally, during the completion of fish studies described above, the incidental by-catch of epibenthic invertebrates was collected, identified, and counted to further enhance the detection of epibenthic organisms and characterize their distribution, composition, and rough abundance within UNB. Because of the incidental nature of these collections, density information was not generated from the count data.

After identification, the organisms were released. Only representatives of those organisms that could not be positively identified in the field were collected for subsequent laboratory taxonomy. These individuals were preserved in a 10% formalin:seawater mixture and transported to the laboratory for identification. After approximately one week, organisms were transferred into 70% isopropyl alcohol and identified.

Results

Observations made at the time of sampling noted the considerable variation in sediment type and surface conditions between stations. Station 1 is generally firm with a large sand component, and is littered with small rocks and gravel. Station 2 is soft clay mud, though the Station 2 sampling site from July is predominantly sand. Station 3 is soft clay mud, and littered with shell debris. Station 4 is sand at the +1-foot elevation and firm sandy mud at the –2-foot elevation. Station 5 is soft clay mud frequently covered by macroalgae in warmer months. Station 6 is also soft clay mud and quite flat, with pooled tide water at the +1-foot elevation. The –2-foot sampling point falls on a steep slope dropping down into the Unit I/III Basin.

Infauna

In January 2012, seven phyla were collected in the infauna cores from each station and elevation combined. Table 16 presents the mean density of infauna for the three replicates at each station and elevation in January. Polychaetes were the dominant taxa at both elevations, accounting for roughly half of the total abundance of captured invertebrates. Amphipods and bivalves were the second and third most abundant (26% and 11% of the total, respectively). Total density at the –2-foot elevation was just over double the density at the +1-foot elevation, driven primarily by greater numbers of polychaetes, bivalves, and phoronids at the lower elevation. Table 16 also presents the mean biomass (g/m^2) of infauna for the three replicates at each station and elevation in January. Infaunal biomass was overwhelmingly dominated by bivalves, as would be expected due to their relatively high mass shells.

In July 2012, an additional phylum, Echinodermata, was observed, represented by holothurians. Table 17 presents the mean density of infauna for the three replicates at each station and elevation in July. At the –2-foot elevation, polychaetes were the dominant taxa (accounting for 51% of the total abundance), with individual replicates yielding densities as high as 29,887 per square meter at Station 2. Bivalves were the second most abundant, at 32% of total invertebrates captured. Amphipods and polychaetes were the most abundant at the +1-foot elevation (45% and 34% of the total abundance, respectively). Infaunal density was higher in July than in January, driven primarily by a large increase in bivalves at the –2-foot elevation and by amphipods at the +1-foot elevation. Table 17 also presents the mean biomass (g/m^2) of infauna for the three replicates at each station and elevation in July. Again, the majority of the biomass was accounted for by the bivalves, which drove variations in biomass between January and July.

Table 16. Mean density (individuals/m^2) (top table) and biomass (g/m^2) (bottom table) of UNB infauna in January 2012.

Density

		-2-feet MLLW						+1-foot MLLW					
Phylum	**Taxa**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**
Annelida	Class Polychaeta	5,819	3,691	7,100	2,316	4,576	2,561	2,241	1,450	2,090	3,446	810	508
Arthropoda	Order Amphipoda	2,373	1,262	4,218	1,488	1,168	2,015	565	169	3,785	2,486	56	94
	Order Diptera										38		38
Cnidaria	Class Anthozoa		151	207									
Mollusca	Class Bivalvia	207	2,260	2,109	56	847	471	339	527	414	132	188	433
	Class Gastropoda	358	490	19	264	75	188	301	490	19	75	904	264
Nemertea	Phylum Nemertea			38	19		75		19		19		
Phoronida	Phylum Phoronida	2,919	621		94	678	452	264	301			414	19
Platyhelminthes	Class Turbellaria						38						
Total Mean Density all Taxa (individuals/m^2)		11,751	8,512	13,729	4,275	7,345	5,800	3,710	2,957	6,347	6,196	2,373	1,356

Biomass

		-2-feet MLLW						+1-foot MLLW					
Phylum	**Taxa**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**
Annelida	Class Polychaeta	14.18	78.21	32.22	1.16	17.20	40.80	24.59	13.69	44.94	6.21	1.31	0.50
Arthropoda	Order Amphipoda	1.68	16.58	3.67	0.86	1.15	2.22	0.39	0.09	2.68	1.23	0.10	0.17
	Order Diptera										0.28		7.62
Cnidaria	Class Anthozoa		0.42	0.44									
Mollusca	Class Bivalvia	23.27	4,448.46	3,569.84	98.18	228.82	98.04	1,339.32	625.65	904.53	229.35	157.40	231.00
	Class Gastropoda	19.06	79.37	8.24	1.19	0.24	2.48	0.78	2.83	0.09	0.11	1.17	2.21
Nemertea	Phylum Nemertea			0.40	0.15		0.18		0.04		0.04		
Phoronida	Phylum Phoronida	3.41	0.68		0.23	0.70	0.29	0.33	0.26			1.60	0.03
Platyhelminthes	Class Turbellaria						0.64						
Total Mean Biomass all Taxa (g/m^2)		61.68	4,623.72	3,614.80	101.76	248.12	144.65	1,365.42	642.56	952.24	237.22	161.58	241.53

Table 17. Mean density (individuals/m^2) (top table) and biomass (g/m^2) (bottom table) of UNB infauna in July 2012.

Density

		-2-feet MLLW						+1-foot MLLW					
Phylum	**Taxa**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**
Annelida	Class Polychaeta	7,269	19,058	6,648	1,921	2,674	1,959	5,650	4,934	2,034	2,109	998	1,638
Arthropoda	Order Amphipoda	339	772	3,145	1,412	772	1,488	1,827	2,298	3,691	7,815	1,940	5,028
	Order Diptera										56	19	19
Cnidaria	Class Anthozoa	19	19	320	151								19
Echinodermata	Class Holothuroidea		19										19
Mollusca	Class Bivalvia	56	94	2,392	264	20,640	1,036	640	207	659	94	1,130	2,166
	Class Gastropoda	169	75		169	75	113	19	603	56	1,733	282	1,582
Nemertea	Phylum Nemertea	56	19		19			75		38			
Phoronida	Phylum Phoronida	1,111	1,469		603	56	584		490	19		282	
Platyhelminthes	Class Turbellaria		19			19				19	113		56
Total Mean Density all Taxa (individuals/m^2)		9,021	21,544	12,505	4,539	24,237	5,179	8,362	8,531	6,516	11,921	4,652	10,527

Biomass

		-2-feet MLLW						+1-foot MLLW					
Phylum	**Taxa**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**
Annelida	Class Polychaeta	16.66	14.92	81.39	3.89	40.71	4.79	13.06	25.51	69.61	1.85	17.36	8.37
Arthropoda	Order Amphipoda	11.27	0.44	2.54	1.05	0.64	1.42	1.62	1.49	3.97	6.52	2.20	3.72
	Order Diptera										0.14	0.00	0.01
Cnidaria	Class Anthozoa	0.01	0.02	0.38	0.24								0.04
Echinodermata	Class Holothuroidea		0.09										0.01
Mollusca	Class Bivalvia	162.82	21.66	2,040.87	18.06	416.79	144.64	2,861.10	194.67	1,565.67	23.04	302.80	174.53
	Class Gastropoda	1.00	0.42		0.42	0.14	0.27	0.03	1.58	0.19	4.95	0.66	3.99
Nemertea	Phylum Nemertea	0.06	0.04		0.02			0.63		0.07			
Phoronida	Phylum Phoronida	2.63	6.73		3.64	0.02	1.76		1.27	0.04		0.95	
Platyhelminthes	Class Turbellaria		0.03			0.04				0.01	0.16		0.20
Total Mean Biomass all Taxa (g/m^2)		194.45	44.35	2,125.18	27.31	458.34	152.88	2,876.44	224.52	1,639.55	36.66	323.98	190.86

Ribbed horsemussels on the edge of the cordgrass near Station 5.

Although invertebrates from infaunal cores were not classified to species, it was observed that the majority of the captured bivalves were the invasive non-native Japanese mussel *Musculista senhousia*, occurring as small individuals in densities as high as 41,000 per square meter in July (extrapolated from the count in a 0.0177 square meter core). This species was most abundant at Station 5 at the –2-foot elevation. Other common, though less abundant, non-native invasive bivalves included the Japanese littleneck (*Venerupis philippinarum*) and the ribbed horsemussel (*Geukensia demissa*). The ribbed horsemussel has densely colonized UNB, occupying the vertical banks of the low salt marsh cordgrass beds in very high densities.

Figure 13 presents a summary comparison between the January and July density and biomass of all taxa combined, by station and tidal elevation. There were no clear trends across stations, with high variability within and between season, station, and elevation.

Epifauna

The 1-m quadrat assessment of epifauna documented few organisms. In January 2012 the only animals observed were ribbed horsemussels at the –2-foot elevations of Stations 2 and 3, and a small moon jelly (*Aurelia* sp.) trapped in a wet depression in the mudflat at the +1-foot elevation of Station 6. A small amount of green algae (*Ulva* and *Enteromorpha* spp.) was noted at Stations 2 and 4. A table presenting these findings is included in Appendix G.

In July 2012, the only epifauna observed in the quadrat survey were horsemussels at Stations 3 and 6, single shore crabs (*Hemigrapsus oregonensis*) at Stations 1 and 2, and an unidentified green sponge at Station 2. There was considerable cover by green algae (*Ulva* and *Enteromorpha* spp.) and red algae (*Ceramium* sp.) at Stations 4, 5, and 6 (see Appendix G for % cover).

The epifaunal invertebrates captured in the fishing nets in 2012 are presented in Table 18 by station and sampling quarter (both replicates combined). Considerably more diversity was recorded than was seen in the quadrat assessment due the greater area and depth range sampled. The majority of the invertebrates were captured in the otter trawl, which is held to the bottom by a weighted lead line and chain. In many cases, when each otter trawl haul was pulled up onto the boat the net contained a large ball of mud composed entirely of balls of *M. senhousia* nests. Communities of this mussel enclose themselves in nests of byssal threads and mud, often excluding other invertebrate and plant species.

***Musculista senhousia* in mud balls from otter trawl.**

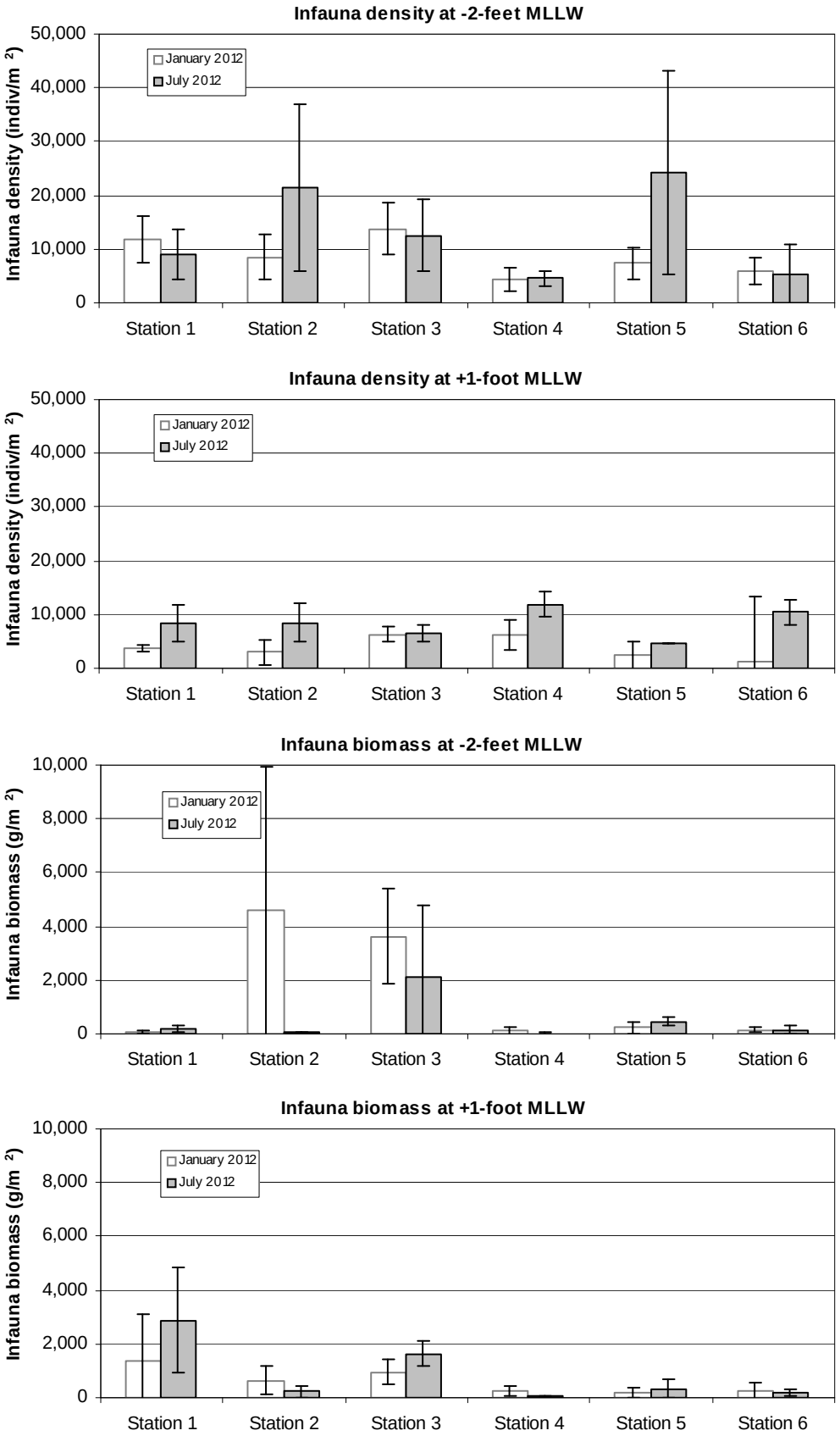


Figure 13. Mean UNB infauna density (individuals/m^2) and biomass (g/m^2) (±1 SD) in January and July 2012 by station and tidal elevation.

Table 18. Counts of epibenthic invertebrates captured in fishing gear (beach seine, otter trawl, and purse seine) in UNB.

			January 2012						April 2012						July 2012						Ocotber 2012					
Phylum	**Taxa**	**Common name**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**	**Sta 1**	**Sta 2**	**Sta 3**	**Sta 4**	**Sta 5**	**Sta 6**
Arthropoda	*Balanus* sp.	Barnacle					1							1						10	1					
	Hemigrapsus oregonensis	Shore crab														15	1		13		6	1		2	4	2
	Pyromaia tuberculata	Tuberculate pear crab							2																	
	*Palaemon macrodactylus**	Oriental shrimp																	6							
	Crangon nigricauda	Blacktail shrimp							1																	
	Portunis xantusii	Xantu's swimming crab																			19	1				
	Penaeus californicus	Brown shrimp																								6
Bryozoa	*Thalamoporella californica*	Bryozoan													0						0					
	*Zoobotryon verticillatum**	Zoobotryon																			0					
Chordata	*Botrylloides* spp.*	Colonial tunicate													0	0						0				
	Order Ascidiacea	Tunicate	3	7					9	1		1			12			20				29	6			
	*Styela plicata**	Leathery tunicate		2					31	4					21	5						5	2			
	*Styela clava**	Rough sea squirt							1	3					11	1					10	27	3			
Cnidaria	*Aurelia* sp.	Moon jelly	236	10	21	51	2	242						1												
Echinodermata	Class Ophiuroidea	Brittle star																			10					
	Lytechinus anamesus	White sea urchin							3																	
Mollusca	*Bulla gouldiana*	Bubble snail							1							14		50	3		2	1				
	Cerithidea californica	California horn snail													7	53	2	2								
	Serpulorbis squamigerus	Scaled worm shell						6																		
	Pterpurpura festiva	Festive murex													7	4										
	Family Buccinidae	Whelk		4					1	3		1									2					
	Navanax inermis	Navanax							1												3			1		
	Argopecten ventricosus	Speckled scallop	1	4	1				6	19	6				1	2					1	10	5	2		
	Limaria hemphilli	Hemphill's file shell							1																	
	Chione californiensis	California venus		1					2																	
	Tagelus californianus	California jacknife clam	1																							
	Venerupis philippinarum	Japanese littleneck		5	8		2		2	31	29					3		1	1				11			
	Mytilus edulis	Bay mussel		42	1	1	14		7	38					1	2				1	9					
	*Musculista senhousia**	Japanese mussel		8	45		219	6	500	205	54	520	225	10		6		70	367	112	5	16	217	1300	240	50
	*Geukensia demissa**	Ribbed horsemussel									1		1		1	5		200	5	54		25	104		5	60
	Ostrea lurida	Olympia oyster		2	1					9					1	3	1	2			8	18	9			
	Crepidula fornicata	Slipper snail	12	15						30		1			30						160	250	40			
	Crucibulum spinosum	Cup-and-saucer limpet	38	40	20				500	20					20	30					420	500	50			
	Octopus bimaculoides	Two-spot octopus													1											
Porifera	Phylum Porifera	Sponge	0	0	0		0		1	1					0	0	0		0		0	0	0			
Total			291	140			238	254	1069	364			226	12	113	143			395	177	656	883			249	118

* non-native species

In most cases the number of mussels present was estimated by counting the number of nest balls; an exact count was not made due to the excessive time involved in digging into each ball to pull out the enclosed mussel. Invertebrates in Table 18 that are not typically found on soft bottom had colonized trash (jars, tires, plastic debris), shell hash, tree branches, leaf litter, and small rocks that make up a large component of the channel bottoms where the otter trawl sampled.

The most abundant invertebrates were *M. senhousia* (51% of the 8,191 individuals captured), the limpets *Crucibulum spinosum* (20% of the total) and *Crepidula fornicata* (7% of the total) (both attached to the debris described above), and the non-native ribbed horsemussel (*G. demissa*) (6% of the total). In January 2012 large numbers of moon jellies (*Aurelia* sp.) were captured in the purse seine and had been collected from the water column rather than on the bottom, though they are included in the table for informational purposes. Seven non-native invertebrate species were identified (as indicated in Table 18 by an asterisk) during the monitoring year.

Discussion

Considerable variability in the infaunal invertebrate community was recorded by the sampling. Patchiness is an established characteristic of benthic invertebrate communities, with community composition being driven by sediment characteristics and the frequency and spatial scale of disturbances (Thrush et al. 1996, Levin and Talley 2002). The variability seen in invertebrate abundance and biomass between seasons and across stations in 2012 can be attributed to the gradient of water quality conditions from the upper to the lower end of UNB, uneven distribution of food or other resources, substrate differences, or localized environmental impacts within the system. During the sediment core collection, considerable variability in sediment type was noted between stations as described above, with some stations having very soft muds, others a firmer clay component, and others being primarily sand. Some stations had dense shell hash or rocks on the surface and at depth. The limited level of replication employed by the monitoring program may make it difficult to detect directional trends in coming years, amidst the high variability within and between station elevations.

The UNB monitoring program does not identify infauna below major taxonomic groups (though the presence of the invasive bivalves above was noted incidentally). Therefore, the identity or ecological function of the other dominant organisms (polychaetes and amphipods) cannot be examined in relation to their trophic interactions in UNB. The lack of lower level taxonomic data also makes it impossible to evaluate the UNB benthic communities with some common indices (e.g., Index of Biotic Integrity, Benthic Response Index) year to year or in comparison to other reference sites.

Rough comparisons can be made to other tidal wetlands in southern California to make relative comparisons of infaunal density. Batiquitos Lagoon is located in Carlsbad, California and was monitored for 10 years following a large restoration project that reintroduced tidal influence to the wetland. Benthic monitoring was conducted in the tenth year post-restoration (2006) using the same methodology as the present survey (in January and October). Similar monitoring was conducted at Bolsa Chica in Huntington Beach during the second year after introduction of tidal influence (2008), and also in the Huntington Beach Wetlands, specifically in Talbert Marsh (July 2008 and January 2009), which serves as a mature reference station for adjacent marsh restoration work in Huntington Beach Wetlands. Table 19 presents the mean density of all invertebrate infauna at these locations in comparison to the 2012 UNB findings.

Table 19. Mean density (individuals/m^2) of infauna at three coastal wetlands in comparison to UNB.

Sample Month	Elevation	Upper Newport Bay 2012*	Talbert Marsh HB Wetlands 2008/9[1]	Bolsa Chica 2008[2]	Batiquitos Lagoon 2006[3]
January	+1 ft MLLW	3,823	2,167	2,172	4,908
	-2 ft MLLW	8,569	4,944	6,365	8,784
July	+1 ft MLLW	8,418	8,148	8,562	1,808 (October)
	-2 ft MLLW	12,873	3,925	3,540	2,284 (October)

* n=18 replicates per mean
[1] M&A 2011 (n=3 replicates per mean)
[2] M&A 2009a (n=9 replicates per mean)
[3] M&A 2009b (n=18 replicates per mean)

Comparisons between the sites show similarities in order of magnitude at the different elevations and sample months; however, they do not reflect the dramatically different composition of the infaunal community. A major component of UNB infauna is invasive non-native bivalves (*M. senhousia*, *G. demissa,* and *V. philippinarum*), creating a different ecological community in the intertidal and subtidal seafloor than exists at the other wetlands noted above. Infestations of *M. senhousia*, in particular, can alter water circulation, nutrient and sediment trapping rates, availability of space for native bivalves, and colonization rates by other invertebrates, all as a result of the dense mat of byssal threads formed by this nest building bivalve. In the intertidal zone, *G. demissa* has been reported to negatively affect light-footed clapper rails in the low salt marshes of UNB and San Francisco Bay by closing on the toes or bills of rails, resulting in starvation through entrapment or the loss of the birds' toes (De Groot 1927, Zembal and Fancher 1988). This species also forms dense aggregations that compete for resources with native suspension feeding invertebrates. *Geukensia demissa* and *V. philippinarum* were not observed at the three wetlands in Table 19, and *M. senhousia* was only found in very low numbers, if at all (M&A 2011, 2009a, 2009b).

When reviewing the epibenthic sampling results, it is clear that the quadrat sampling effort to characterize epibenthic communities did not provide a good representation of the invertebrates present. Many epibenthic organisms are highly mobile and had vacated the mudflat shoreline during the low tides targeted for the survey work. The tracking of invertebrates in the fishing gear more comprehensively and frequently documented the epibenthic community, though examination of community parameters, such as density, diversity, and evenness, cannot be done due to the incidental nature of the sample collection.

Epibenthic invertebrates present in UNB were all marine species associated with estuarine or bay environments. It is expected that the species list will continue to expand over time as additional sampling is conducted. These macroinvertebrates provide an important prey base for fish and birds in the basin. It is recommended that future monitoring in Years 5 and 10 continue to include tabulation of macroinvertebrates captured in the three fisheries sampling gears.

Question 6 posed by the Monitoring Plan asks: *Has the project has resulted in improved diversity and abundance of benthic infauna and epifauna*? Such an evaluation of these metrics of the

intertidal benthic community cannot be made because a comparable pre-restoration study was not performed prior to the 2006 start of construction. Although there has been extensive benthic monitoring in UNB in recent years, sampling was conducted mostly in the deeper subtidal portions of the bay, at different locations, and is therefore, not an appropriate baseline to compare to the present data in the context of evaluating the effect of the restoration project. A map showing the location of National Pollutant Discharge Elimination System (NPDES) sampling performed annually by the County of Orange, Orange County Watersheds Program in relation to the sampling points of the present monitoring program is provided in Appendix H. Information provided to ACOE by the County of Orange indicates that all samples in UNB are collected subtidally, within 50 feet of a set of 4 coordinates (Thoms(a) 2010). When plotted on a 2010 bathymetric chart, the coordinates correspond to depths of –1, -4, -9, and –12 feet MLLW. However, the County notes that the elevations have changed on a seasonal/yearly basis and cannot be definitively stated (Thoms(b) 2010). Sampling subtidally within even 20 feet of these points could result in depths ranging down to –22 feet MLLW. The present monitoring program was conducted at intertidal and very shallow subtidal depths of +1 and –2-foot MLLW elevations.

It is not appropriate to draw conclusions on changes in benthic invertebrate diversity and abundance related to the restoration through comparison with the NPDES data. The difference in elevation at which the two sample sets were collected will reflect habitat variations in inundation period, accessibility by predators, water circulation and temperature, and light penetration, preventing those data from serving as a pre-restoration baseline against which to compare the data collected by the Monitoring Plan methodology. Additionally, the current methodology selected by ACOE allows for examination of abundance, but not diversity (as sought by Question 6), due to the limited taxonomy performed. Tracking diversity within the infaunal community will require intensive taxonomic work and considerably increase the expense of this monitoring task.

It is likely that Question 6 could best be addressed by an examination of just the pre-and post-restoration NPDES data, which includes abundance data to the species level. Such an evaluation is outside of the scope of the present monitoring program, but the data are available in an electronic database format from the County of Orange for year 2005 to 2011.

The present monitoring is scheduled to be repeated in Years 5 and 10, and will allow for detection of changes in major taxonomic groups should they occur. However, consideration could be given to either expanding the level of taxonomy down to a more meaningful level, or adopting the NPDES program in its place, given its longer history and greater level of analysis.

3.4. Vegetation Monitoring

The distribution, composition, and evolution of vegetation communities and unvegetated habitats were monitored through the use of aerial photography and quantitative transect methods. The Monitoring Plan calls for collection of aerial photographs in Years 1, 2, 3, 5, and 8 and surveys of transects in Years 2, 5, and 8. Therefore Year 2 monitoring included both habitat mapping and transect monitoring. The cordgrass monitoring was discussed in Section 2.4.

Methods

Habitat Mapping

To map vegetated and non-vegetated habitats during Year 2 (2012), the UNB study area was contract flown on April 3, 2012 to photograph the site from true vertical position on full-color film. The site was broken into a series of ten tiles, collected at a scale of 1 inch =666 feet. A single higher elevation spot shot of the entire UNB area was collected at a scale of 1 inch =2000 feet. The photos were taken between 1350 and 1400 at roughly a 0 foot MLLW tidal elevation. This allowed photography of as much exposed intertidal habitat as possible while lighting and weather conditions were suitable for the photography. Collection of aerial imagery in subsequent years will be conducted at the same tidal elevation.

Because of the scale of the study area, full registration of the image tiles was not directly possible due to lens distortion. To rectify this issue, the tiles were broken into multiple smaller tiles and then rectified by aligning physical features within each of the smaller tiles with the same features present in orthorectified imagery originally flown for the site in 2010. The smaller tiles were rubber sheeted to the rectified image such that error generated by image distortion could be substantially reduced. By clipping the spot image multiple times with differing tile centers and repeating the process, the rectification was substantially improved. Digitization from the rectified tiles rather than a single mosaic was then performed. When a static feature used for alignment (sign, utility pole, road shoulder, small tidal channel, or single shrub) began to diverge in alignment between the known rectified image and the rubber sheeted tiles, differing tiles would be used in the mapping to maintain tighter horizontal control.

To establish a consistent study area, a boundary was established during Year 1 at the extreme high water line, which is 7.8 feet (2.4 meters) MLLW for UNB, and corresponds to the upper boundary of salt marsh habitat. All areas extending from that outer boundary toward the channel were included, including raised areas above 7.8 feet (2.4 meters), such as the least tern islands. The geographic position of the 7.8 feet line was determined using topographic data collected by ACOE in 2011. It was not possible to also evaluate just the habitat occurring within the UNB Ecological Reserve because a GIS-based reserve boundary was not available at the time of analysis. In addition, some portions of the reserve extend outside the boundary of the restoration and monitoring program.

Heads-up digitization of vegetation boundaries visible in the imagery was performed using ArcGIS 10, generally following the Holland (1986) and Oberbauer (2008) classification system where appropriate, with other habitat types assigned as needed. Because it is not feasible to distinguish between low, middle, and high salt marsh vegetation using the true color aerial imagery, all zones of coastal salt marsh were mapped as a single habitat. Eelgrass (*Zostera marina*) visible in the aerial image was delineated, though it is likely that the lower edges of the eelgrass extend to depths below what can be mapped from aerial images.

The only habitats that were not mapped strictly from the aerial were intertidal mudflat and open water. The upper edge of the mudflat was determined based on inspection of the aerial image, where the mudflat met the salt marsh, regardless of elevation. However, during the project planning process, the existing acreage of mudflat was calculated in 2004 based on both bathymetry

and aerial photos. To capture comparable mudflat expanses during the Year 1 (2011) mapping effort, the lower edge of the mudflat was extended from the 0 MLLW line (visible in the aerial image) down to the -1.54 feet (-0.47 meter) MLLW contour, based on the bathymetric data provided by the ACOE. This approach became problematic in Year 2 (2012), however, because in many cases the bathymetric data for 2012 did not extend up as shallow as the –1.54-ft MLLW contour, so it could not be used to delineate the lower boundary of the mudflat (and upper edge of open water). In these cases, attempts were made to estimate the position of the –1.54-ft MLLW contour by joining the ends where line broke off, by examining the aerial photo, or through comparison with the Year 1 contours. Bathymetric data were not collected in the Newport Dunes basin and a few others areas within the southern portion of the habitat mapping boundary (data gaps visible in Figure 3). In these areas, the lower edge of the mudflat was also approximated.

The approximation of boundaries where bathymetric data were not available, and the inherent error associated with attempts to perfectly overlay consecutive annual images, reduced the level of accuracy and precision of the mapping process. Small changes in habitat coverage year to year will, therefore, be difficult to distinguish from imprecision arising from these mapping issues. This can be seen particularly in comparisons of habitats that are linear or near the edge of the survey area, such as the road along the east shoreline of UNB. A very slight shift of the photo position from year to year, while the survey boundary remains geographically fixed, can, for example, result in a small sliver of the road falling within the survey boundary, when it had previously been excluded. These mapping errors are most distinct along the urban transition as it is the periphery of the project and exhibited the greatest amount of photographic distortion in the mapping process. We assume that changes in habitat coverage of less than 1% of the mapped habitat types from survey to survey could be due to the mapping technique used and cannot be viewed with certainty as a true change on the ground.

The draft digitized habitat maps were printed and taken into the field for ground-truthing from various vantage points along the shoreline and from the water. The habitat maps were updated and map products and summary statistics of habitat acreage and distribution were generated. Comparisons were made to the Year 1 habitat data.

<u>Vegetation Transect Monitoring</u>

Although the vegetation monitoring program includes a transect element, there are no specific goals or questions identified by the Monitoring Program in relation to plant community composition that can be answered by transect work. Therefore, the transect monitoring was designed simply to repeat transect investigations conducted prior to the restoration for comparison to post-restoration conditions. The two studies reviewed were the *Newport Bay Sediment and Vegetation Monitoring Sediment Total Maximum Daily Load, Vegetation Monitoring 2004* performed by Wetlands Research Associates in October 2004 (WRA 2004) and *Biological Resources of Upper Newport Bay, California* (MEC 1997), which included transect monitoring performed in October 1997.

The 2004 study included survey transects in roughly the same location as those established by MEC in 1997. At that time, WRA adjusted some of the transect endpoints and included their coordinates in the report. Prior to the current field work, both the 2004 and 1997 transects were plotted on an aerial using GIS. With two exceptions, the 2004 transects were best positioned to capture the 2012

configuration of the marsh at UNB. The 2004 report included a typo in the coordinate table that made the recovery of Transect 1 impossible; in that case the 1997 transect was adopted. A guessed correction to another typo in the 2004 Transect 10 positioned it in a plausible location. A total of ten transects were surveyed, with new transect endpoints recorded with dGPS and included in Appendix B (Figure 14). It is important to note that there is a mix of measurement units involved with the transects. The coordinates of the transects are, as with all station points included in Appendix B, provided in meters (State Plane). However, to be consistent and more easily comparable to the prior transect survey work, the positions of survey plots along each transect are recorded in feet (Appendix I). Also, the transect start point coordinates provided in Appendix B mark the absolute 0 start point off of which all plots are measured. However, the transect end point coordinates provided in Appendix B are only the approximate end point. The point establishes the path of the transect, but in some cases, based on the judgment of the field surveyor, data collection along the transect may have stopped short of or gone past the end point.

The start of each transect was established and mapped by GPS at the upper edge of the mudflat, along the recovered historical transect alignment. This was done in past studies to track any shifts in the mudflat/low marsh boundary. The transect then generally extended up through low, middle, and high marsh communities, terminating at the lower edge of the fringing upland habitat. In some cases, the positioning of the transect and topography of the site was such that this progression of communities was different. For example, Transects 8 and 9 both start and end at the mudflat/low marsh interface after crossing over an island (Figure 14). A photo was taken of each transect from each end of the transect. In several cases the ends of the transects were in the water, therefore photos were taken from the closest accessible point near the transect end.

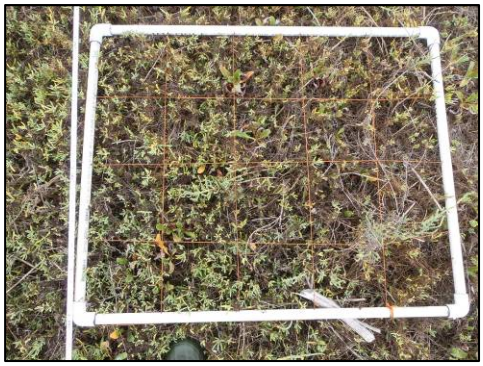
A series of two to three 330-ft tape measures was extended end to end along the transect and the transect length recorded (feet were used for transect measurements for ease of comparison with prior reports). A series of plots were analyzed along each transect, characterizing each marsh community. The low marsh, middle marsh, and high marsh communities were identified using indicator species identified in the 1997 and 2004 studies. Low marsh was identified as areas dominated (60-70% cover) by cordgrass (*Spartina foliosa*). Middle marsh was at least 50% pickleweed (*Sarcocornia pacifica*), with other species such as saltwort (*Batis maritima*) and jaumea (*Jaumea carnosa*). High marsh was dominated by salt grass (*Distichlis spicata*), with areas of shore grass (*Monanthochloe littoralis*) and *Sarcocornia pacifica*. One transect (Transect 1) had a large area of freshwater marsh at its upper end that was also included in the assessment.

A plot was always analyzed at the zero end of the transect in the low marsh, and then additional plots analyzed at intervals determined by the surveyor (R. Woodfield, Merkel & Associates) based on the width of each community and the length of the transect. This was done following the recommendations in the 2004 study that the monitoring program be modified to analyze plots at regular intervals rather than at random sample points along the transect and that the interval be shorter in the low marsh zone due to its narrow width. The fixed interval was recommended to allow repeatability year to year. WRA felt that comparisons could not be made between annual studies performed on plots randomly placed along the transect, and on transects whose position was not precisely recovered year to year. The precise location of each transect and each plot along that transect for the 2012 survey can be recovered for the 2015 (Year 5) and 2018 (Year 8) surveys

Vegetation Monitoring Transects
Upper Newport Bay Ecosystem Restoration Project
Post-restoration Monitoring Program

Figure 14

using the information provided in Appendix B. A total of 160 plots were analyzed, with 10 to 22 plots per transect.



Gridded quadrat for determining percent cover.

Each plot was analyzed using a rectangular quadrat 0.5 square meters in area. The quadrat was gridded with twine to form 20 squares. At each selected plot point, the lower left corner of the quadrat was placed at the measuring tape marker (e.g., the 100-ft mark), to the right of the tape. The percent cover of each species present within the quadrat (plot) was estimated in the following way. Each of the 20 squares was examined. If a plant species covered more than half of a given square, it was considered to be 'present' in the square and to represent 5% cover within the quadrat. If it covered less than half of the square, it was considered to be 'absent' and not counted. Each of the 20 squares was inspected for presence/absence of the species, and the resulting coverages totaled in 5% increments for a maximum of 100%. If a species was present in only one square, and in less than half of it, it was marked down as 'trace', meaning less than 5% cover. This was repeated for each species present. Overlapping or intermixed species were counted each time they occurred (i.e., they did not preclude each other in the coverage estimation). The determination of a plant's coverage in a square is quite subjective, particularly for plants like cordgrass, which extend up from a single stem, with leaves extending out higher up, above the quadrat. Therefore, using a single observer is best for consistency, or at a minimum a team that has analyzed multiple plots together beforehand to agree on a consistent method.

The 2004 and 1997 study reports do not specify the method used to estimate percent cover in the plot, only that estimates were made to the closest 5% cover. Both studies used what they referred to as a "0.5-meter square quadrat". It is not clear if that refers to a quadrat that is 0.5 meter on a side (as suggested by the wording and resulting in a total area of 0.25 square meters) or one that has a total area of 0.5 square meter. For this study the quadrat was a rectangle with an area of 0.5-meters, roughly 80 cm by 60 cm. The exact dimensions allowed for the positioning of the 20 squares (roughly 16 by 16 cm) within the quadrat.

To document other species present along the transect that were sparsely distributed and did not fall within the plots, a list of all species present in a 1-m band along the transect (0.5m to either side) were noted.

Vegetation percent cover averages and frequencies were calculated for the ten transects collectively, for each of the four marsh communities. Species recorded as 'trace' were entered as 1% cover to ensure their presence in the plot was accounted for. Frequency was calculated as the percentage of plots where the plant occurred, to quantify the distribution of each species throughout the UNB marsh community.

<u>California Rapid Assessment Method</u>

M&A also performed a California Rapid Assessment Method (CRAM) evaluation within the monitoring area on September 11, 2012 and provided the write-up to ACOE. The findings were then uploaded to the CRAM website (www.cramwetlands.org) on January 28, 2013, per the project

Monitoring Plan; however several glitches in the website resulted in a slightly inaccurate record being made. The website tool that allows users to insert a circle representing the Assessment Area was not functional so the area had to be drawn in with the freehand tool. It therefore may not be positioned exactly on the geographic coordinate where the assessment was truly done (though it is a close approximation). Also, the CRAM website would not allow entry of data into Table 21: Wetland Disturbances and Conversions, which resulted in a total CRAM score of 85 being calculated by the website, while the true value calculated by the full assessment on paper was 87. A copy of the written report is provided in Appendix K and accurately presents the Assessment Area and final score.

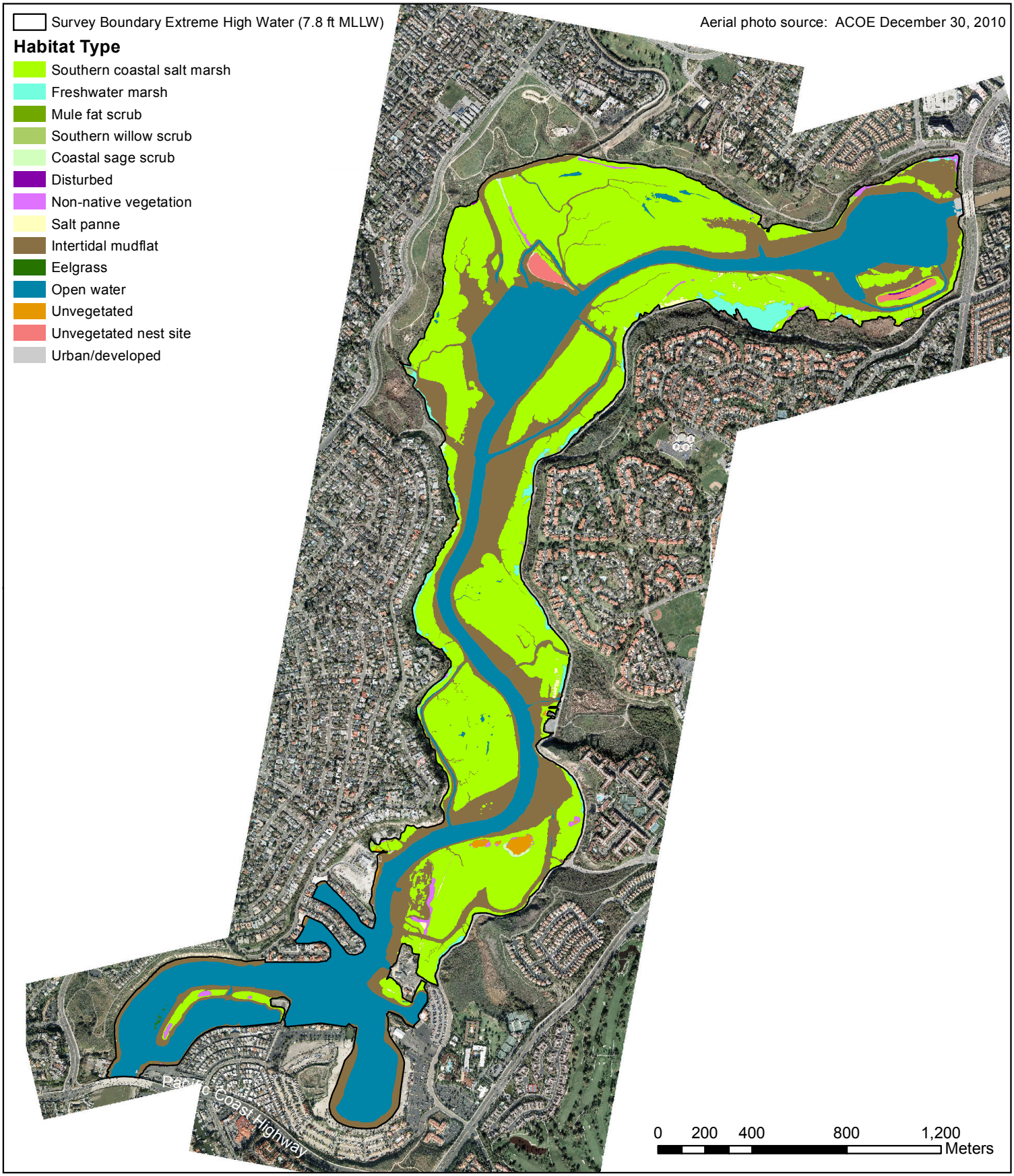
Results

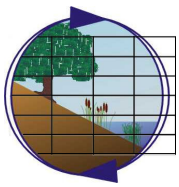
Habitat Mapping

Based on the April 2012 imagery, seven vegetated and six non-vegetated habitats were mapped within the study area. Figure 15 presents the distribution of habitats on-site and Table 20 summarizes the extent of each.

Table 20. Area of habitats within the UNB study area (April 2012).

Habitat	Hectares	Acres
Southern coastal salt marsh	144.4	356.7
Freshwater marsh	5.2	12.8
Mule fat scrub	0.1	0.2
Southern willow scrub	0.4	1.0
Coastal sage scrub	1.6	3.8
Disturbed	0.2	0.4
Non-native vegetation	2.0	5.0
Salt panne	0.8	1.9
Intertidal mudflat	72.0	177.8
Eelgrass	0.1	0.1
Open water	98.8	244.2
Unvegetated	1.2	3.0
Unvegetated nest site	1.7	4.3
Urban/developed	0.4	1.0





Habitat Map - April 2012

Upper Newport Bay Ecosystem Restoration Project
Post-restoration Monitoring Program

Figure 15

Merkel & Associates, Inc.

As it was prior to the restoration project, southern coastal salt marsh continues to be the dominant habitat occurring in UNB post-restoration, with 144.5 hectares (357.2 acres) mapped in 2012. As mentioned above, without infrared photography it was not possible to distinguish from the imagery the delineations between low, middle, and high marsh. The species that made up each of these marsh communities are presented in the following section on vegetation transects.

The 72.0 hectares (177.8 acres) mapped as mudflat reflect the amount of mudflat that occurs between the lower edge of the salt marsh and the open water, which was set at -1.54 feet (-0.47 meter) MLLW for this project by prior habitat mapping efforts. Therefore, the 98.8 hectares (244.2 acres) mapped as open water includes all waters below -1.54 feet (-0.47 meter) MLLW, including the main channel, inundated side channels, and the dendritic network of smaller channels flooded at that tide level. Pools of ponded water fed by these channels on the salt marsh plain were also mapped as open water.

Areas identified in the field as brackish marsh and coastal and valley freshwater marsh were grouped together as freshwater marsh, and tended to be dominated by cattails (*Typha latifolia, T. domingensis,* and *T. angustifolia*) and bulrush (*Bolboschoenus maritimus*). Other emergent wetland habitats occurring between the salt marsh and the upper edge of the survey boundary included southern willow scrub and mule fat scrub. These generally constituted small groupings of arroyo willow (*Salix lasiolepis*) and mule fat (*Baccharis salicifolia*) growing along Back Bay Drive at the upper edge of the marsh, and in the northwestern corner of the bay.

Small areas of coastal sage scrub dominated by goldenbush (*Isocoma menziesii*) occurred on elevated areas in the salt marsh and at the upper edge of the marsh. Other species within this habitat included California sagebrush (*Artemisia californica*), California buckwheat (*Eriogonum fasciculatum*), coyote brush (*Baccharis pilularis*), bladder pod (*Isomeris arborea*), and four-wing saltbush (*Atriplex canescens*). The steep slopes on either side of UNB, which support extensive expanses of coastal sage scrub, were generally outside of the survey area for this monitoring program. In a few cases, coastal sage scrub that lies outside of the intended study boundary was actually included in the acreage calculations due to the minor geographic shifts of the aerial image in relation to the fixed geographic boundary established by the topographic data in 2011. This resulted in an increase in coverage values between years that is not reflective of true gains in coastal sage scrub in the system.

Habitats mapped as non-native vegetation were well-established stands of exotic species including castorbean (*Ricinus communis*), tree tobacco (*Nicotiana glauca*), hottentot fig, white sweetclover (*Melilotus albus*), large Brazilian peppertrees (*Schinus terebinthifolius*), pampas grass (*Cortaderia selloana*), giant reed (*Arundo donax*), and Canary Island date palms (*Phoenix canariensis*). Only a small portion of the non-native vegetation on the margins of UNB fell within the survey boundary (extreme high tide line: +7.8 feet MLLW), with additional ornamental exotic species occurring higher in the adjacent upland between the marsh and Back Bay Drive or northern trail system.

Disturbed habitat was mapped in areas that had a growth of opportunistic weedy species as a result of human action. The dominant vegetation in these small areas was telegraph weed (*Heterotheca grandiflora*), with some wild radish (*Raphanus sativus*).

Areas mapped as urban/developed had been constructed upon or otherwise physically altered to an extent that native vegetation was no longer supported. Within the survey area at UNB this included riprap and concrete, particularly where San Diego Creek enters the Unit I/III basin and on the south shore of the Newport Aquatic Center across from Shellmaker Island. Again small shifts in the position of the aerial photo captured portions of Back Bay Drive that were not intended to be within the survey area but fell within the geographically fixed project boundary.

Several other habitats devoid of vegetation were distinguished due to the variable origins of their unvegetated condition. The bare sand portions of the created tern islands were called out as "unvegetated nest site" in order to track the extent of habitat available for nesting over time. This excluded the small portions of the tern islands that were vegetated to a degree that nesting by tern species or plovers would be unlikely. Areas mapped as salt panne collect seawater at higher tides and remain ponded as the tide falls due to the microtopography of the area. Evaporation of the ponded seawater leads to hypersaline conditions and depressed oxidation-reduction potential that are inhospitable to most vascular plants. The expansion of pickleweed into salt panne areas is variable year to year; therefore, variations in the extent of salt panne present each year is anticipated. Finally, areas with no vegetation, but apparently unaltered by human action, were mapped as simply "unvegetated". These were generally raised areas on Shellmaker Island made up of unstable sands that may preclude the establishment of most plant species. These raised areas were generally ringed by hottentot fig and goldenbush. Once established these species can expand into shifting sands and some reduction in the extent of unvegetated habitat may occur in future years.

Approximately 544 square meters (0.13 acre) of eelgrass was mapped on the western shoreline of the DeAnza Peninsula, the arm of land that parallels the main channel just north of Pacific Coast Highway. This is believed to be an underestimate due to mapping methodologies as discussed above. A survey conducted using sonar would be needed to map the complete distribution of eelgrass within UNB. The extent of this particular eelgrass bed is known to vary annually, and improvements in water clarity envisioned by the restoration project were projected to improve the vigor and extent of this bed. Following the present habitat mapping effort in April, an eelgrass restoration project was undertaken in June 2012 by the Orange County Coast Keeper near the eelgrass bed described above. A total of 200 square meters (0.05 acre) of eelgrass was transplanted using three methods: bare root bundles, units of eelgrass tied to wire frames, and bags of eelgrass seeds anchored to the bay floor. This supplemental planting complicates efforts to link the size of the eelgrass bed to improvements in water quality associated with the restoration.

Vegetation Transect Monitoring

The compiled transect data provided 160 plots: 40 low marsh, 88 middle marsh, 19 high marsh, 4 freshwater marsh, and 9 plots that were classified as other habitats (e.g., mudflat, salt panne, open water). The 151 marsh plots were analyzed for average percent cover and frequency by plant species. The nine non-vegetated plots classified as other habitats were not analyzed further.

A total of 21 species were recorded in the 151 vegetated plots, plus an additional three species found within the 1-m band along the transect, but not in the plots. The transect data are included in Appendix I and photos of each transect are provided in Appendix J.

Table 21 presents the average percent cover and Table 22 presents plant frequency for each species within each of the four marsh community types. Percent cover averages add up to more than 100% due to plant overlap within the marsh canopy. Non-native species are denoted with an asterisk.

Table 21. Average percent cover of plant species in each marsh community at UNB in September 2012.

	Average Percent Cover (%)			
Plant Species	**Low Marsh**	**Middle Marsh**	**High Marsh**	**Freshwater Marsh**
*Apium graveolens**				4.0
Arthrocnemum subterminale		0.7	0.8	
Batis maritima	14.1	28.3	2.4	
Bolboschoenus maritimus		0.2	1.1	25.0
*Carpobrotus chilensis**			4.2	
Cressa truxillensis		0.6	0.9	
Cuscuta salina		4.4	9.7	17.5
Distichlis spicata	1.5	16.0	34.2	7.5
Frankenia salina	1.4	6.3	19.2	
Jaumea carnosa	9.7	37.4	32.4	47.5
Juncus acutus		1.4		
Limonium californicum		1.9	1.8	
*Limonium ramosissimum**		0.7	5.5	
Monanthochloe littoralis		1.3	22.1	
Polypogon monspeliensis			0.3	
Salicornia bigelovii	0.1			
Sarcocornia pacifica	24.9	51.7	12.2	0.3
Spartina foliosa	74.5	5.8		
Suaeda esteroa		2.7	0.3	
Typha domingensis				50.0
Atriplex prostrata		0.2	0.3	
Open Open	0.4			
Bare Ground	6.3	0.9		
Total Plant Cover (with overlap)	**126.1**	**159.4**	**147.1**	**151.3**

* non-native species

Table 22. Percentage frequencies of plant species in each marsh community at UNB in September 2012.

	Frequency (%)			
Plant Species	**Low Marsh**	**Middle Marsh**	**High Marsh**	**Freshwater Marsh**
*Apium graveolens**				50.0
Arthrocnemum subterminale		1.1	5.3	
Batis maritima	30.0	64.8	10.5	
Bolboschoenus maritimus		1.1	5.3	50.0
*Carpobrotus chilensis**			10.5	
Cressa truxillensis		2.3	21.1	
Cuscuta salina		22.7	21.1	25.0
Distichlis spicata	2.5	48.9	52.6	25.0
Frankenia salina	2.5	29.5	36.8	
Jaumea carnosa	27.5	65.9	52.6	50.0
Juncus acutus		2.3		
Limonium californicum		17.0	21.1	
*Limonium ramosissimum**		2.3	10.5	
Monanthochloe littoralis		6.8	36.8	
Polypogon monspeliensis			5.3	
Salicornia bigelovii	2.5			
Sarcocornia pacifica	47.5	88.6	57.9	25.0
Spartina foliosa	97.5	27.3		
Suaeda esteroa		12.5	5.3	
Typha domingensis				50.0
Atriplex prostrata		1.1	5.3	
Open Open	2.5			
Bare Ground	17.5	1.1		
Total Number of Plots	40	88	19	4

* non-native species

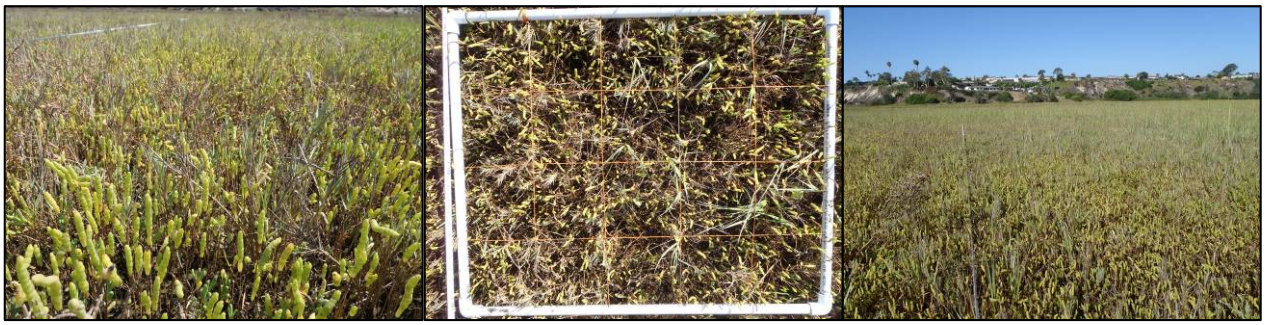
The low marsh was dominated by cordgrass and pickleweed (*S. pacifica*), with average percent covers of 75% and 25%, respectively (Table 21). Saltwort (*Batis maritima*) and jaumea (*Jaumea carnosa*) were present in lower percentages. A total of seven species were recorded in the low marsh. Table 22 shows that cordgrass occurred in 98% of the low marsh plots, with pickleweed present in 48% of low marsh plots. The other five species were present within 30% or less of the low marsh plots.

Sixteen species were recorded in the middle marsh plots (Table 21), and arrowgrass (*Triglochin maritima*) was also observed within the 1-m band along the transect but was not recorded in the plots. The middle marsh was dominated by pickleweed (with an average of 52% cover), jaumea (37% cover), and saltwort (28% cover). These species were also present in the highest frequencies within middle marsh plots (Table 22). Other species seen frequently were salt grass (*Distichlis spicata*), alkali heath

Non-native Limonium ramosissimum in the marsh.

(*Frankenia salina*), saltmarsh dodder (*Cuscuta salina*), and western marsh rosemary (*Limonium californicum*). Cordgrass was present in small amounts in 27% of the plots. The invasive non-native Algerian sealavender (*Limonium ramosissimum*) had an average percent cover of 0.7% in the middle marsh plots, but was located only in plots along Transect 1. In San Francisco Bay and Carpinteria Marsh this species has been shown to rapidly displace native marsh species (Archbald 2011). Archbald reports that this species prefers disturbed areas of high marsh habitat, including areas disturbed to facilitate restoration, though its presence at UNB does not appear to be related to the recent restoration project.

Much of the middle marsh in UNB is notably short in stature and sparse, due to both the abundance of low growing species such as jaumea and to the highly reduced growth habit of the pickleweed (*S. pacifica*). Although taller, more dense areas of pickleweed are present in UNB, similar to that found in other salt marshes regionally, the most common growth morphology of pickleweed was short and sparse. In many places the *S. pacifica* ranged in height from 20 to 50 cm and individual plants had simple structure, with very little branching (see photos in Appendix J). It was so sparse and so heavily intermixed with lower-growing marsh plants that no canopy of substance was formed and it would not be suitable for nesting by Belding's Savannah sparrows in those areas. Large expanses of middle marsh on Middle Island and Upper Island (Figure 1) have this appearance. This condition is not a result of the restoration project, but more likely related to localized soil conditions that dictate species composition and plant growth. Although current maps on Belding's Savannah sparrow breeding distributions are not available for review, it's likely that the number of breeding birds per area of salt marsh is much lower than other estuarine systems that support more robust middle marsh.



Short, sparse pickleweed and other marsh species on T7 and T8 as an example of the unsuitability for nesting by Belding's Savannah sparrow.

A total of 16 species were identified in the high marsh plots (Table 21). Woolly seablite (*Suaeda esteroa*), a California Native Plant Society rare plant species, was also identified but was not located within survey plots. The dominant species in high marsh plots were salt grass and jaumea, though they only occurred in roughly half of the plots each. Other species frequently observed in high marsh plots were shore grass, alkali heath, alkali weed (*Cressa truxillensis*), and saltmarsh dodder (Table 22). Algerian sealavender was present in one plot in each of Transects 1 and 2.

The freshwater marsh community along Transect 1 was dominated by narrowleaf cattail (*Typha domingensis*) (with an average cover of 50%) with jaumea growing over the base of the cattails (an average of 48% cover). Also present were alkali bulrush (*Bolboschoenus maritimus*) and saltmarsh dodder (Table 21). Seven species were observed in the freshwater marsh plots.

Discussion

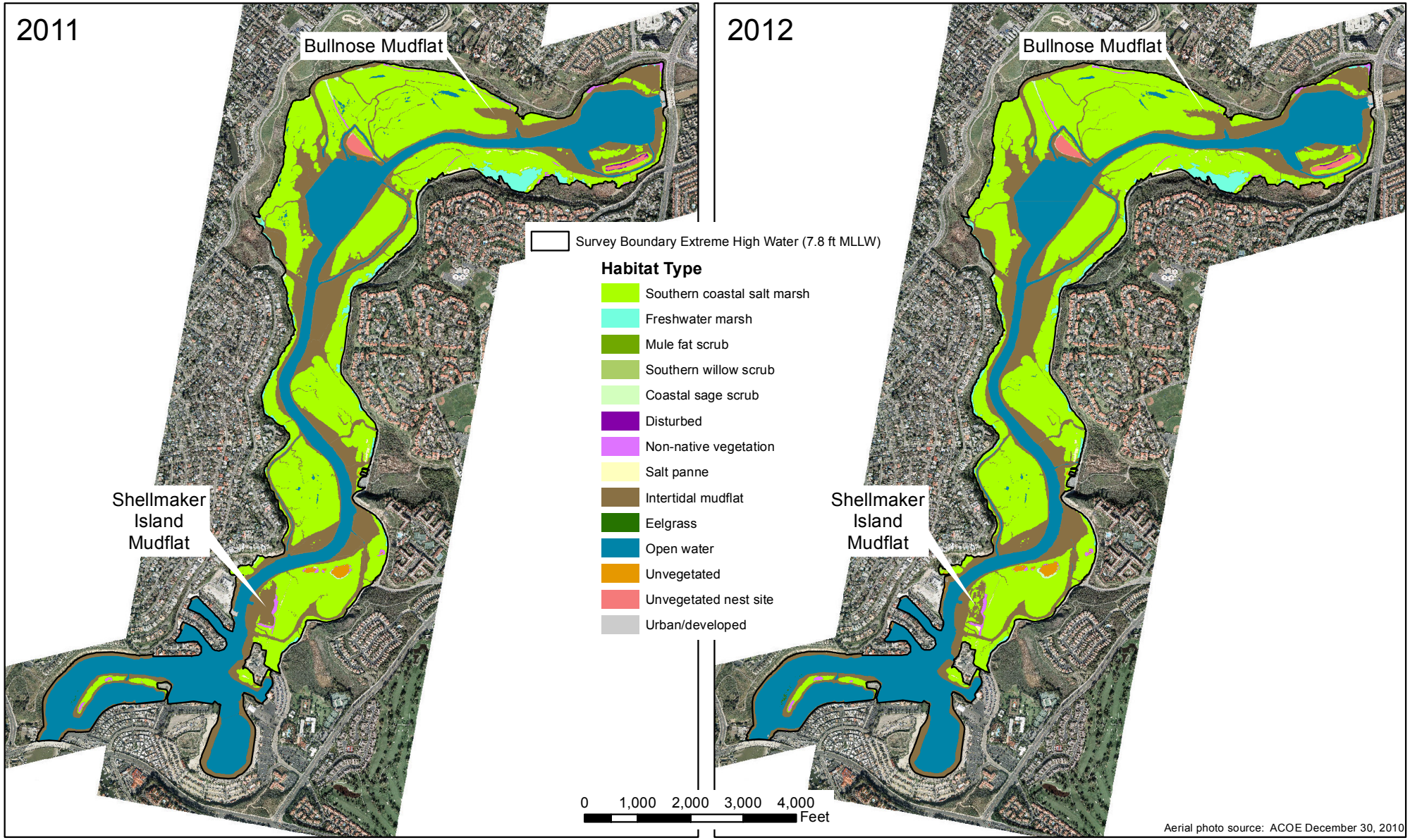
Question 9 posed in Section 1.3 above asks if the restoration project has resulted in a 10 percent gain or loss of any habitat. This question, and the difficulty of answering it without appropriate pre-restoration habitat mapping, was discussed at length in the Year 1 report. Aside from a question specifically about eelgrass, there were no other habitat goals identified by the Monitoring Plan. The habitats of primary interest in relation to the effect of the restoration work, however, were salt marsh, mudflat, and open water. Changes in their distribution before and after the restoration were discussed in the Year 1 report. The following discussion, therefore, will look at changes between post-restoration Years 1 (2011) and 2 (2012). Figure 16 compares habitat distributions between 2011 and 2012.

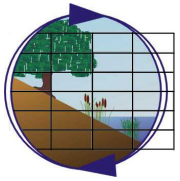
Cordgrass and pickleweed expanding onto the Bullnose Mudflat (September 2012).

Between 2011 and 2012, the amount of mudflat in UNB decreased by 3%, from 74.3 hectares (183.6 acres) to 72.0 hectares (177.8 acres). This is due primarily to the expansion of salt marsh onto the mudflat in two areas. The Bullnose Wetland Restoration Area was excavated during the restoration project to create intertidal mudflat. Portions of the mudflat, however, are at elevations too high to preclude the growth of low marsh vegetation; and by 2012, cordgrass and pickleweed had expanded onto the mudflat. It is anticipated that the higher areas of the Bullnose mudflat will continue to convert to low salt marsh as the established patches of cordgrass expand, with the lower areas remaining mudflat. The second area of mudflat loss was the Shellmaker Island Mudflat. This mudflat was also created during the restoration project. It was also excavated to too high an elevation to maintain an open mudflat and was very rapidly colonized by both low and mid marsh species (Figure 16). It is anticipated that this mudflat will convert nearly entirely to salt marsh in the coming years.

Salt marsh increased from 141.6 hectares (349.9 acres) in 2011 to 144.4 hectares (356.7 acres) in 2012. In addition to the two large expansion areas described above, there was a smaller cumulative expansion of the lower boundary of salt marsh throughout much of UNB. In addition, isolated patches of cordgrass mapped on the mudflat in 2011 continued to expand in several areas, with adjacent patches merging together to form more solid beds. These minor expansions can be seen upon close examination of Figure 16 and account for minor additional losses of mudflat.

The small reported loss of open water between 2011 (99.2 hectares [245.1 acres]) and 2012 (98.8 hectares [244.2 acres]) is most likely due to the limitations of the methodology used to the map the upper edge of the open water, as described in the methods section above. The upper boundary of the open water had to be approximated in some cases due to an absence of bathymetric data. For such a small change in area (less than 1%), it is not possible to distinguish between mapping error and true habitat changes. However, true losses of open water would happen largely as a result of expansion of mudflat from upstream sediment influxes, and there was no evidence of such mudflat expansion.





Comparison of Habitat Distributions Between Year 1 (2011) and Year 2 (2012)

Upper Newport Bay Ecosystem Restoration Project

Post-restoration Monitoring Program

Figure 16

Question #4 posed in Section 1.3 was Has the project resulted in increased eelgrass survival in the upper bay? The only persistent eelgrass bed in UNB, described above off of DeAnza Peninsula, appears to have expanded from 2010 to 2012. A sidescan sonar survey conducted in September 2010 mapped approximately 160 square meters (0.04 acre) (M&A 2010b), while the present 2012 survey, using an aerial mapping technique known to underestimate eelgrass bed size, found more than three times as much (544 square meters) eelgrass present. This expansion cannot be definitively attributed to the restoration, although enhanced tidal prism has been identified as a factor in expansion of eelgrass in many other areas and expansion of eelgrass at this location is consistent with expectations of project benefits. The transplant of eelgrass at the same location late in 2012 may complicate future evaluation of the natural spread of this bed. Typically, improved prism results in a spatial extension of eelgrass further into the restored system than existed prior to improvements. This has not been identified as; however, suitable mapping methodologies have not been undertaken to fully evaluate the potential that this may have occurred. To achieve accurate and efficient surveillance for eelgrass elsewhere in UNB, a more sophisticated survey technique, such as sidescan sonar, would need to be employed. If such a program were implemented, Question #4 could be more fully addressed; however, the existing data would suggest that the project has likely had some benefit to eelgrass in the upper bay.

The other peripheral habitats presented in Table 20 were largely unchanged between 2011 and 2012. As described above, very small changes in coverage are largely attributable to the slight shifts in the aerial image under the geographically fixed survey boundary.

4.0 SUMMARY

Overall observations made during the second year of monitoring suggest the restoration has maintained or improved the biological resources in UNB. Upper Newport Bay is fully tidal, has a greatly improved capacity to capture incoming sediment, and provides good water quality in most areas. Hypoxia at depth in the sediment basins is a largely unavoidable consequence driven by the depth of the basins that extend the functional life of the basins between required dredging events. These basins are functioning properly to trap incoming sediment and organic debris. As they fill, they will be less effective at sediment and debris capture, while at the same time DO levels and biological productivity would increase. Shoreline fish are abundant and diversity is high. The salt marsh is healthy and supports numerous migratory and sensitive bird species. The two least tern nesting islands remain better protected from mammalian predators due to the channels around them. The Year 2 monitoring effort will be repeated in Year 5 (2015) by the County of Orange and again to a lesser degree in Years 8 (2018) and 10 (2020), further tracking the condition of UNB post-restoration.

In summary, most of the original objectives of the restoration program have been achieved, although the magnitude of achievement varies. In some cases, concerns raised during the design and review process have been realized; specifically hypoxia within the deeper basins does occur and does appear to affect biological productivity of these basins. Conversely, the sediment basins are functioning as intended for trapping sediment to the benefit of conditions elsewhere in the system. Fish and bird communities appear to have benefitted from the restoration with specific groups such as diving ducks, dabbling ducks, and plunge diving species such as pelicans being favored by the restoration. There has been a notable expansion in the richness of fish species, while also transitioning to fully marine community make up following the restoration. It is not as clear from the data that benthic infaunal and epifaunal communities have benefited from the restoration, however, this has as much to do with high variability and lack of adequate baseline data as anything else and it cannot be said from the data available that benthic community metrics have been adversely affected by the restoration.

5.0 RECOMMENDATIONS

The following observations and recommendations have been made based on the monitoring work reported on above:

- The spot water quality data collected during Years 1 and 2 have suggested that the northern channels and basins experience some degree stratification and hypoxia. This condition was not an anticipated result of the construction of the two sediment capture basins. The design team felt that the large footprint of the two basins would preclude formation of anaerobic zones in the bottom of the basins. Monitoring has shown that this was likely an incorrect assumption. The monitoring plan was not designed to do more than spot check dissolved oxygen levels in the two basins. If there is concern about the frequency, persistence, and severity of the hypoxia, it is recommended that the water quality monitoring program be expanded to include the use of deployed instruments or more frequent sampling across a range of time and tide conditions.

- The present UNB Ecosystem Restoration monitoring plan includes a list of questions to be addressed by the program (presented verbatim in Section 1.3 above) that are in some cases ambiguous, or in other cases inappropriate because they are not answerable by the monitoring plan, or not answerable due to the lack of pre-restoration baseline data. These limitations were discussed in Sections 2.2, 2.3, 3.1, 3.2, 3.3, and 3.4. It is recommended that consideration be given to reviewing and revising the questions as appropriate, and possibly modifying the monitoring approach, to document meaningful change in a feasible manner given budgetary and pre-restoration data constraints.
- As discussed above, UNB is not expected to substantially suffer from tidal muting, even when the sediment basins are filled. It is therefore recommended that the tidal monitoring program scheduled for Years 5 and 10 be eliminated or considerably scaled back, perhaps to a small monitoring effort in Year 10 if any field observations suggest a concern about tidal conditions, though none are anticipated.
- As discussed above, the monitoring program cannot answer the posed question about benthic invertebrate diversity. It is recommended that to do so the benthic monitoring scheduled for Years 5 and 10 be expanded to take taxonomy down to a more meaningful level (a change that will come with great expense) or utilize the NPDES program data instead, given its longer history and greater level of analysis. Alternatively, the monitoring plan question could be revisited and revised as proposed above.
- The absence of baseline physical and biological data collected immediately prior to the restoration has made it difficult or, in some cases, impossible to meaningfully evaluate the effects of the restoration project. It is recommended that future similar large-scale restoration projects incorporate both pre- and post-restoration monitoring, using consistent methodologies, into the evaluation process. The pre- and post-restoration monitoring should be detailed in a single monitoring plan that includes clear statements of the monitoring goals, restoration goals, and detailed discussions of how the monitoring methodology will evaluate if those goals have been achieved.

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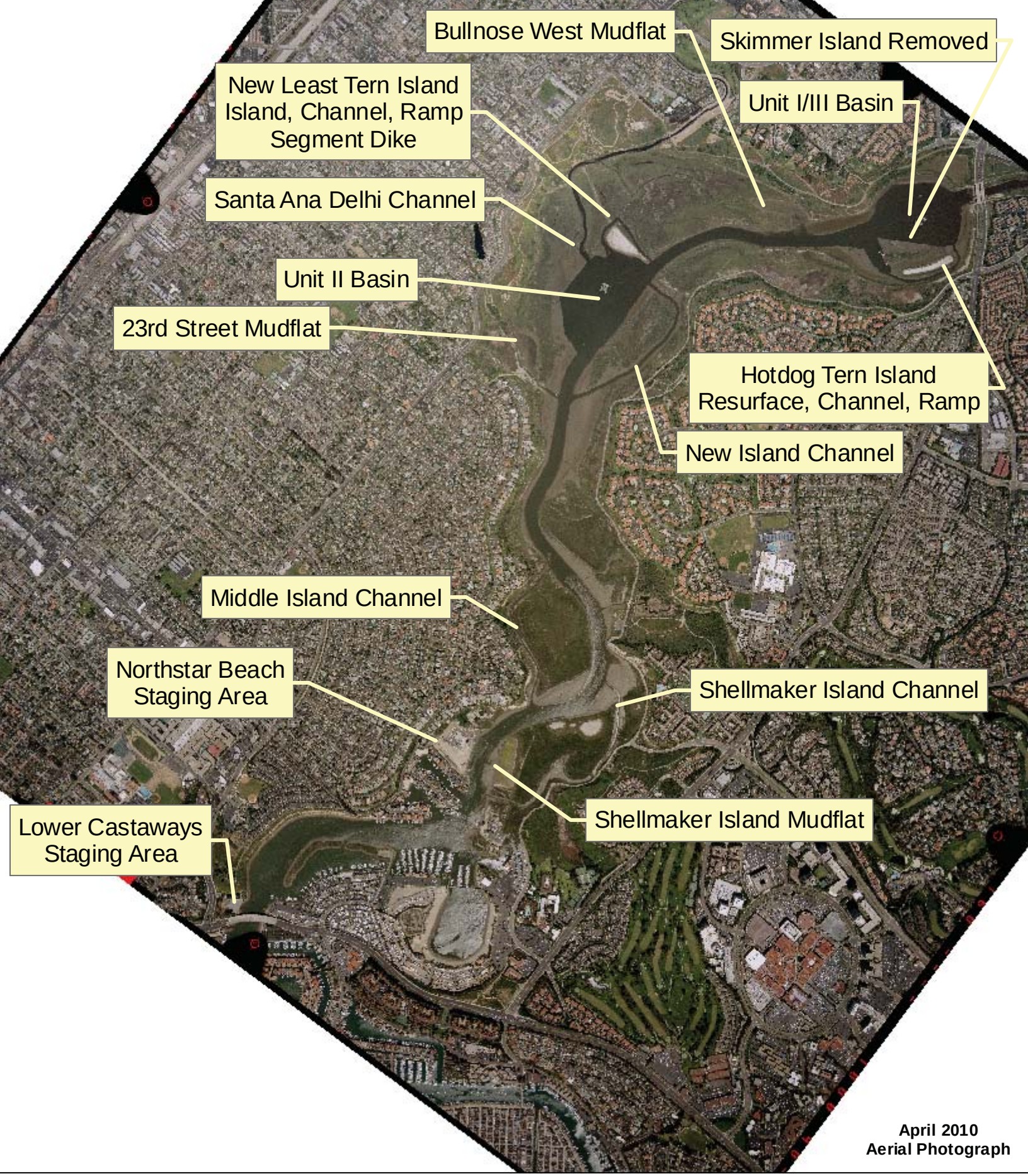
Appendix A

Upper Newport Bay Ecosystem Restoration Project Features and Summary

Retrieved from http://www.newportbeachca.gov/index.aspx?page=115

Document entitled Project Completion Summary Report 11/2010



Upper Newport Bay Ecosystem Restoration
Project Features

Upper Newport Bay Ecosystem Restoration

14 October 2010 Project Summary

- Period of Contractual Construction: November 2005 to October 2010
- Period of Dredging Construction: April 2006 to September 2010
- 2.35 million cubic yards (mcy) dredged, 2.2 mcy removed from the bay and 0.15 placed in-bay
- Constructed the following:
    - Widened and deepened 2 Sediment Control Basins (Unit II and Unit I/III)
    - Deepened 5 shallow island restoration channels (Shellmaker Island, Middle Island, New Island, Hotdog Tern Island, and New Least Tern Island)
    - Created 3 mudflats (Shellmaker, 23rd Street, Bullnose West)
    - Relocated 1 tern nesting island
    - Provided maintenance access to 2 nesting islands (New Least Tern and Hotdog)
    - Provided interpretive signs and buoys
- Phase 1 Contractor was DD-M Crane and Rigging dredged 1.737 mcy from April 2006 to July 2009
- Phase 2 Contractor was RDA, Contracting Inc. dredged 613 kcy from January 2010 to September 2010
- 1.05 mcy removed from Unit II Basin (DD-M Phase 1 removed 865 kcy; RDA Phase 2 removed 186 kcy)
- 905 kcy removed from Unit I/III Basin (DD-M Phase 1 removed 494 kcy; RDA Phase 2 removed 411 kcy)
- 92% disposed offshore at LA3 and 1% nearshore at Newport Beach
- 7% disposed in-bay for construction of nesting islands
- Approximately 5,000 tug and scow trips passed underneath PCH without incident (from 1,685 DD-M tug and scow trips to LA3, 680 RDA tug and scow trips to LA3 and numerous tug and scow maneuvers)
- 2 to 4 scows were in use at any one time for construction, 7 different scows ranging from 1000 cy capacity to 3000 cy capacity
- 2 tugs
- Staging areas were Lower Castaways and Northstar Beach
- 1,558,000 cy were disposed at LA3 under Phase 1, 565 days of actual dredging for an average production of 2,750 cy per dredge day, over a period of 1,183 days. Primary dredge was a 5 cy clamshell bucket mounted on the CB-3 Crane Barge, with some of the dredging performed by 10-inch hydraulic dredge “Pelican”.
- 613,000 cy were disposed at LA3 under Phase 2, 175 days of actual dredging for an average production of 3,500 cy per dredge day, over a period of 240 days. Primary dredge was a Cat 385 excavator mounted on the CB-3 Crane Barge, with a minor amount of dredging performed by 10-inch hydraulic dredge “Pelican”.
- An amphibious excavator was used to: complete the shallow dredging at Middle Island and Shellmaker Island Restoration Channels; construct the maintenance access ramps at New Least Tern Island and Hotdog Tern Island; and excavate the Skimmer Island to mudflat elevation. In December 2009 there was an incident where the excavator, while being parked on the mudflat for the day, turned over into the bay. No injuries and no environmental damage occurred. It took a few days to bring the excavator upright.

UPPER NEWPORT BAY ECOSYSTEM RESTORATION PROJECT
April 2006 to September 2010
TOTAL

FEATURE	START	FINISH	Volume Removed CM	Placed LA-3 CM	Placed Nearshore CM	Placed NLTI/Pit CM	Hotdog Tern Island	Scow Volume CM	e-trac report
Access Channel Between PCH and Unit II Basin	Apr-06	Sep-10	5,800	5,800				15,467	
Northstar Beach Wetland Restoration	Feature not built per County request		na						
Shellmaker Island Wetland Restoration	Feb-07	May-08	39,400	0		33,700	5,700		
Shellmaker Island Restoration Channel	May-06	Jun-06	9,700	9,700				8,318	
Middle Island Restoration Channel	May-06	May-06	9,600	9,600				11,148	
Access Channel to 23rd Street Wetland Restoration	Apr-07	Apr-07	4,600	4,600				4,752	
23rd Street Wetland Restoration	Aug-07	Mar-08	98,200	20,000		62,200		38,305	
Rev A Nearshore	Mar-08	Apr-08			15,000			20,479	
Rev B Nearshore	May-08	May-08			1,000			1,270	
New Island Restoration Channel	Jun-06	Jul-06	16,800	16,800				9,230	
Unit II Basin	Jun-06	Sep-10	803,860	803,860				796,778	
Access Channel to New Least Tern Island Pit	Jun-06	Jun-06	3,000	3,000					
New Least Tern Island Pit	Jun-06	Feb-07	74,600	74,600				69,113	
New Least Tern Island	Feb-07	Mar-08	na						
Segment Main Dike	Jun-07	Oct-07	900			900			
Cordgrass Transplant	Nov-09	Nov-09	na						
New Least Tern Island Channel	Jan-10	Jan-10	11,000	11,000					
New Least Tern Island Ramp	Jan-10	Jan-10	na						
Access Channel Between Unit II and Unit I/III	Feb-07	Apr-07	1,060	1,060				part of Unit I/III S	
Bullnose Access	Apr-07	Apr-07	1,800	1,800				2,485	
Bullnose West Wetland Restoration	Feb-07	Nov-07	18,100			18,100			
Hotdog Tern Island Restoration Channel	Feb-07	Apr-07	6,400	6,400				7,552	
Hotdog Tern Island Sand/Shell Layer	Mar-07	Apr-07	na						
Hotdog Tern Island Maintenance Access Ramp	Mar-10	Mar-10	na						
Unit I/III Basin	Feb-07	Sep-10	691,680	691,680				661,698	
Cubic Meters			1,796,500	1,659,900	16,000	120,600	<-------	1,624,846	1,946,239
		check	1,796,500					1,632,098	
Cubic Yards	0.764555		2,349,733	2,171,067	20,927	157,739		2,125,218	2,545,584
			Volume Removed	LA-3	Nearshore	In-Bay		Scow	e-Trac
Cubic Yards, Rounded			2,349,700	2,171,100	20,900	157,700		2,125,200	2,545,600
Disposal Percentage of Total Removed				92%	1%	7%			8%

Note: September 2000 Feasibility Study estimated the total volume of material to be dredged from the Upper Bay would be approximately 2.1 million cubic yards, and initial construction would take 2 years. The project was dredged in two phases, taking close to five years, and 2.35 million cubic yards were dredged and placed at LA3, Nearshore and In-Bay.
2,190,000 cubic yards were removed from the bay
158,000 cubic yards were placed in the bay

UPPER NEWPORT BAY ECOSYSTEM RESTORATION PROJECT
April 2006 to July 2009
PHASE 1

FEATURE	START	FINISH	Bid Volume CM	Volume Removed CM	Placed LA-3 CM	Placed Nearshore CM	Placed NLTI/Pit CM	Hotdog Tern Island	Scow Volume CM	e-Trac START	e-Trac FINISH	e-Trac Approx. Volume
Access Channel Between PCH and Unit II Basin	Apr-06	May-06	Lump Sum	5,800	5,800				15,467	Apr-06	Jul-06	89,720
Northstar Beach Wetland Restoration	Feature not built per County request		NA	NA	NA					Sep-06	Jun-07	515,050
Shellmaker Island Wetland Restoration	Feb-07	May-08	Lump Sum	39,400	0		33,700	5,700		Jun-07	Apr-08	500,400
Shellmaker Island Restoration Channel	May-06	Jun-06	Lump Sum	9,700	9,700				8,318	May-08	Aug-08	127,000
Middle Island Restoration Channel	May-06	May-06	Lump Sum	9,600	9,600				11,148	Mar-09	Jul-09	149,850
Access Channel to 23rd Street Wetland Restoration	Apr-07	Apr-07	Lump Sum	4,600	4,600				4,752			
23rd Street Wetland Restoration	Aug-07	Mar-08	124,906	98,200	20,000		62,200		38,305			
Rev A Nearshore	Mar-08	Apr-08				15,000			20,479			
Rev B Nearshore	May-08	May-08				1,000			1,270			
New Island Restoration Channel	Jun-06	Jul-06	Lump Sum	16,800	16,800				9,230			
Unit II Basin Base + Option + Santa Ana Delhi Channel	Jun-06	Jan-08	678,811	661,800	661,800				656,832			
Base			144,543	114,500					122,587			
Option 1			172,299	181,800					534,245			
Option 2			361,969	363,900								
Santa Ana Delhi Channel			part of Options	1,600								
Access Channel to New Least Tern Island Pit	Jun-06	Jun-06	Lump Sum	3,000	3,000							
New Least Tern Island Pit	Jun-06	Feb-07	74,626	74,600	74,600				69,113			
New Least Tern Island	Feb-07	Mar-08	NA	NA								
Segment Main Dike	Jun-07	Oct-07	part of Bullnose	900			900					
Access Channel Between Unit II and Unit I/III	Feb-07	Apr-07	Lump Sum	0	0							
Bullnose Access	Apr-07	Apr-07	part of Bullnose	1,800	1,800				2,485			
Bullnose West Wetland Restoration	Feb-07	Nov-07	19,994	18,100			18,100					
Hotdog Tern Island Restoration Channel	Feb-07	Apr-07	Lump Sum	6,400	6,400				7,552			
Hotdog Tern Island Sand/Shell Layer	Mar-07	Apr-07	part of Bullnose		0		NA					
Unit I/III Basin + Modifications	Feb-07	Jul-09	379,149	377,300	377,300				354,438			
Base			111,149	140,500								
Mod Phase 1			150,000	153,600								
Mod Phase 2			40,000	40,000								
Mod CLIN 42 & 43			78,000	43,200								
Cubic Meters			1,277,486	1,328,000	1,191,400	16,000	120,600	<-------	1,177,640			1,382,020
		check		1,328,000					1,177,639			
Cubic Yards	0.764555		1,670,888	1,736,958	1,558,292	20,927	157,739		1,540,295			1,807,614
			Bid Volume	Volume Removed	LA-3	Nearshore	In-Bay		Scow			e-Trac
Cubic Yards, Rounded			1,670,900	1,737,000	1,558,300	20,900	157,700		1,540,300			1,807,600
Disposal Percentage of Total Removed				100%	90%	1%	9%					4%

UPPER NEWPORT BAY ECOSYSTEM RESTORATION PROJECT 10/13/2010
September 2009 thru September 2010
PHASE 2

FEATURE	START	FINISH	Bid Volume CM	Approximate Volume Removed CM	Placed LA-3 CM	Scow Volume		
Access Channel Between PCH and Unit II Basin	na	na	na	na	na	na		
Cordgrass Transplant	Nov-10	Nov-10	na	na	na	na		
New Least Tern Island Channel	Jan-10	Jan-10	Lump Sum	11,000	11,000	7,252		
New Least Tern Island Ramp	Jan-10	Jan-10	na	na	na	na		
Top of Skimmer Island	Dec-10	Mar-10	10,600	10,600	10,600	part of Unit I/III S		
Southern Unit I/III Basin	Jan-10	Jun-10	225,000	235,836	235,836	256,788		
Additional Southern Unit I/III Basin, Closeout Phase 1	Jan-10	Feb-10	Phase 1	17,944	17,944	part of Unit I/III S		
Northern Unit I/III Basin	Jun-10	Jul-10	50,000	50,000	50,000	50,472		
Access Channel Between Unit II and Unit I/III	Mar-10	Mar-10	Lump Sum	1,060	1,060	part of Unit I/III S		
Unit II Basin	Jul-10	Aug-10	140,000	142,060	142,060	139,946		
Hotdog Tern Island Ramp	Mar-10	Mar-10	na	na	na	na		
Cubic Meters			425,600	468,500	468,500	454,458	564,219	
		check		468,500				
Cubic Yards	0.764555		556,664	612,775	612,775	594,409	737,970	
			Bid Volume	Volume Removed	LA-3	Scow	e-Trac	
Cubic Yards, Rounded				613,000	613,000	594,000	738,000	
Disposal Percentage of Total Removed					100%		20%	higher than actual

* Volume included in Phase 1

Appendix B
Sample Station Coordinates

Sampling Station Coordinates

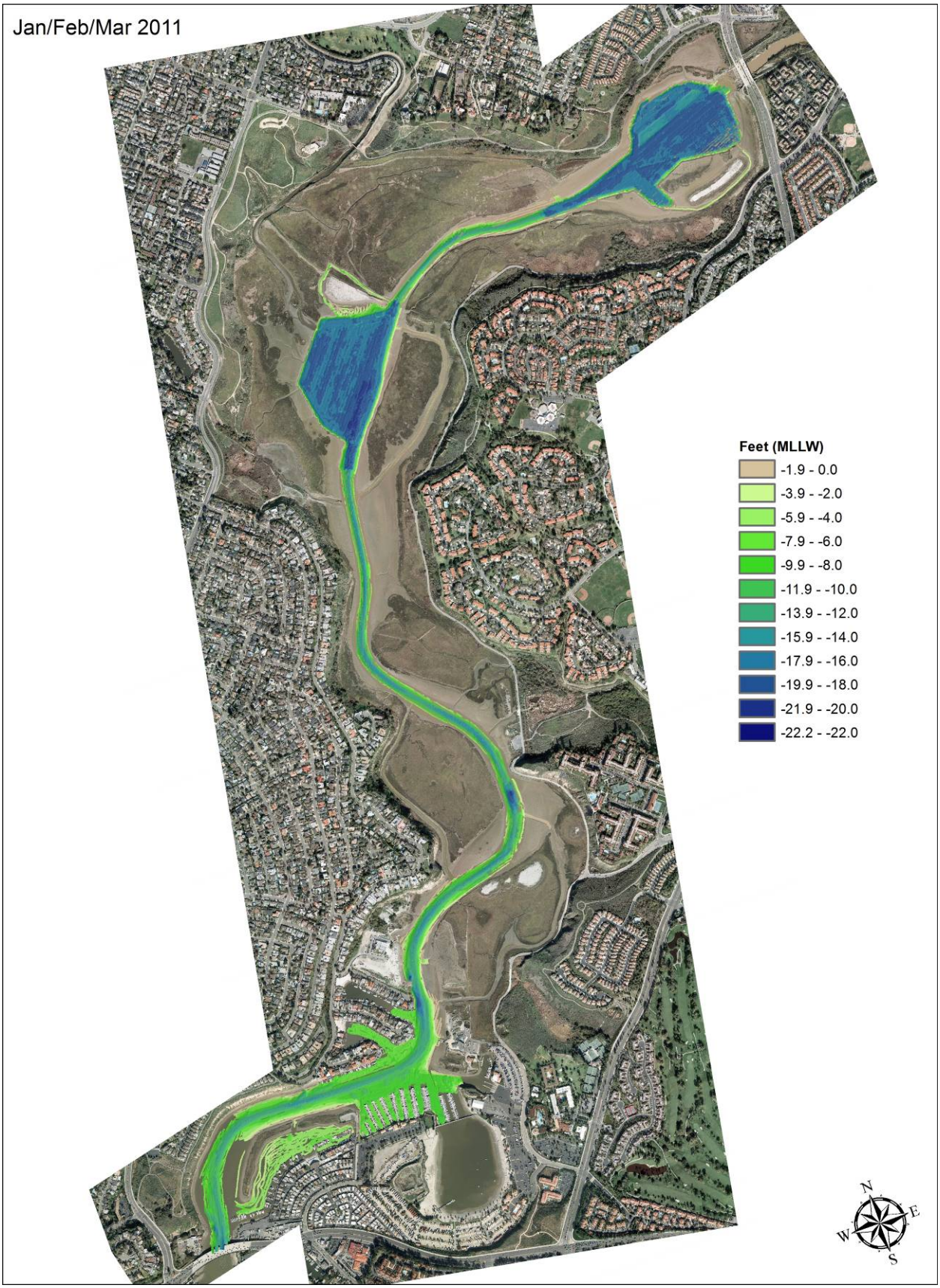
California State Plane, Zone 6, NAD 83, Feet

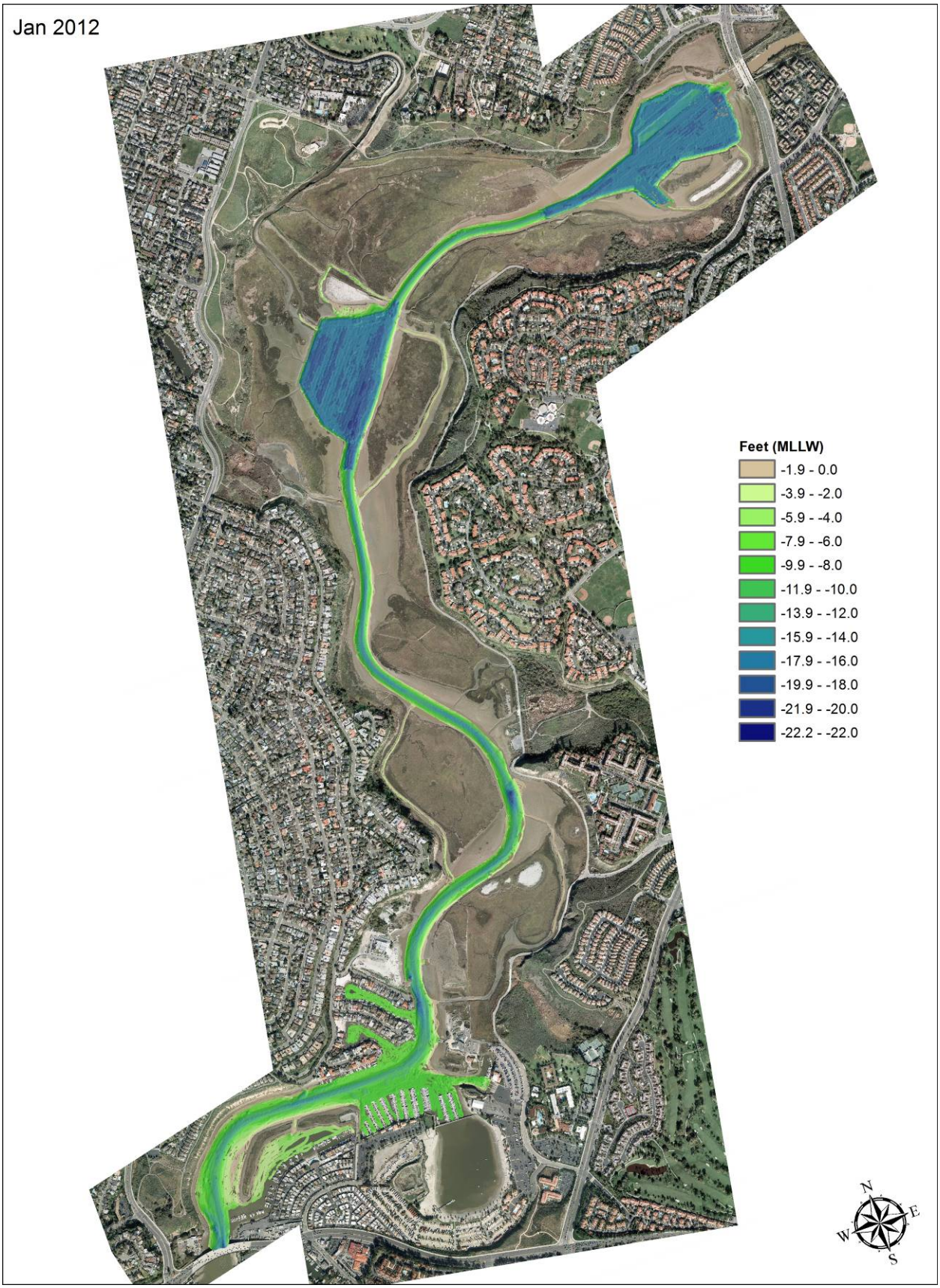
EQUIPMENT	STATION ID	X	Y
Tide Logging Stations	Station 1	6,061,778	2,174,691
	Station 2	6,064,424	2,182,935
	Station 3	6,069,256	2,183,398
	Barometric Logger	6,061,699	2,173,500
Water Quality/Beach Seine/Benthic	Station 1 - shore	6,058,537	2,173,623
	Station 2 - shore	6,061,954	2,175,409
	Station 3 - shore	6,062,363	2,178,386
	Station 4 - shore	6,063,755	2,183,173
	Station 5 - shore	6,066,004	2,183,564
	Station 6 - shore	6,068,634	2,184,405
Water Quality/Purse Seine	Station 1 - channel	6,058,814	2,173,535
	Station 2 - channel	6,061,698	2,174,974
	Station 3 - channel	6,062,404	2,178,695
	Station 4 - channel	6,063,446	2,182,393
	Station 5 - channel	6,066,781	2,183,531
	Station 6 - channel	6,068,906	2,183,822
Otter Trawl Transect Endpoints	Station 1, Rep 1 start	6,057,957	2,172,571
	Station 1, Rep 1 end	6,058,556	2,173,356
	Station 1, Rep 2 start	6,059,036	2,173,581
	Station 1, Rep 2 end	6,060,022	2,173,486
	Station 2, Rep 1 start	6,061,858	2,175,155
	Station 2, Rep 1 end	6,062,759	2,175,543
	Station 2, Rep 2 start	6,061,480	2,173,910
	Station 2, Rep 2 end	6,061,550	2,174,904
	Station 3, Rep 1 start	6,062,561	2,179,251
	Station 3, Rep 1 end	6,062,798	2,180,208

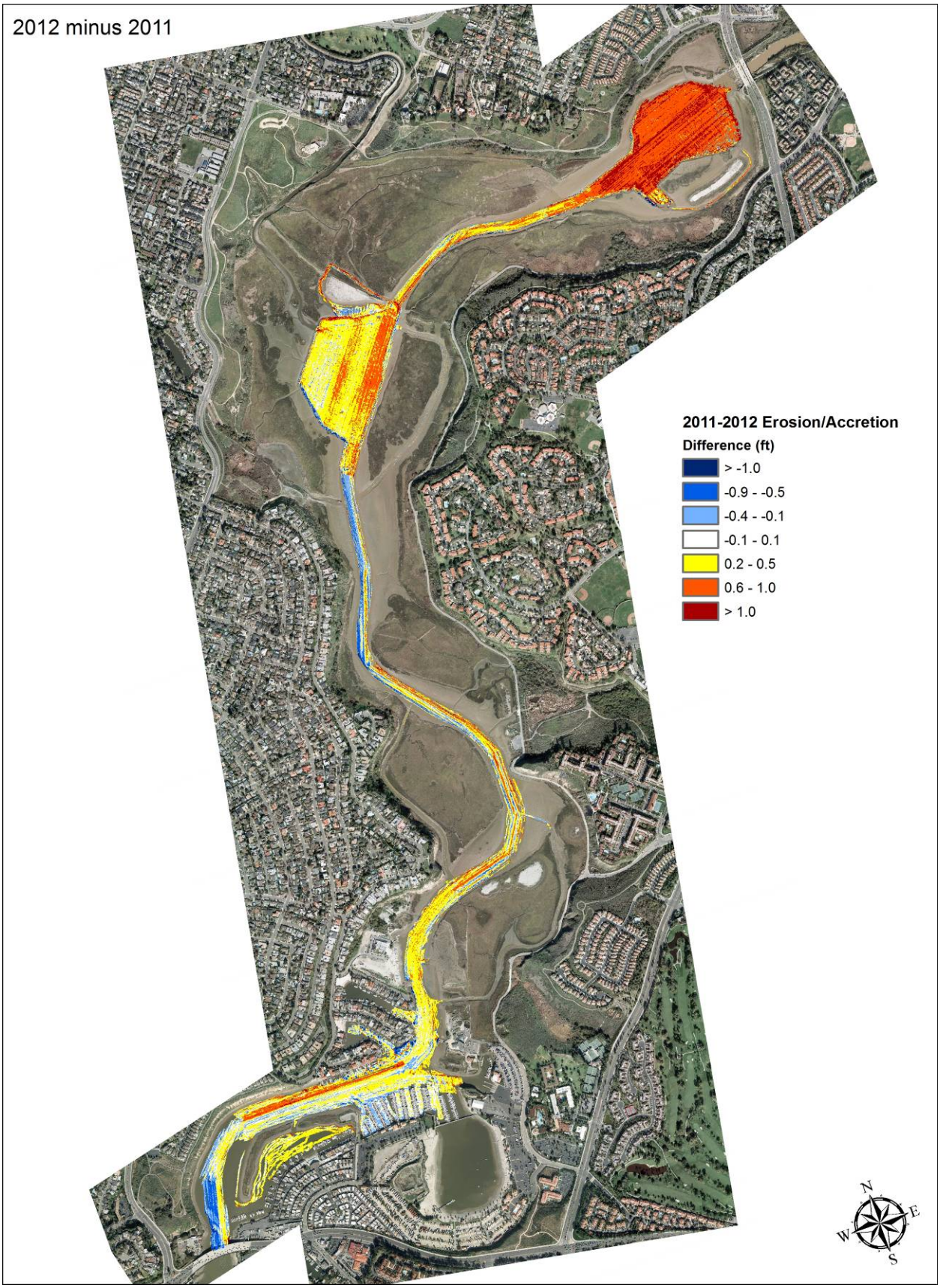
Otter Trawl Transect Endpoints (cont'd.)	Station 3, Rep 2 start	6,063,038	2,177,724
	Station 3, Rep 2 end	6,062,439	2,178,500
	Station 4, Rep 1 start	6,063,330	2,181,809
	Station 4, Rep 1 end	6,063,933	2,182,582
	Station 4, Rep 2 start	6,062,952	2,182,304
	Station 4, Rep 2 end	6,063,755	2,182,885
	Station 5, Rep 1 start	6,064,490	2,183,113
	Station 5, Rep 1 end	6,065,379	2,183,545
	Station 5, Rep 2 start	6,066,087	2,183,461
	Station 5, Rep 2 end	6,067,073	2,183,400
	Station 6, Rep 1 start	6,067,769	2,183,432
	Station 6, Rep 1 end	6,068,741	2,183,565
	Station 6, Rep 2 start	6,068,421	2,183,876
	Station 6, Rep 2 end	6,069,347	2,184,214

	Station ID	X	Y
Vegetation Transect Endpoints	T1 start	6,068,215	2,182,745
	T1 end	6,068,207	2,182,488
	T2 start	6,067,445	2,183,135
	T2 end	6,066,951	2,182,475
	T3 start	6,066,039	2,183,597
	T3 end	6,066,253	2,184,328
	T4 start	6,064,564	2,184,482
	T4 end	6,064,631	2,184,850
	T5 start	6,062,771	2,183,582
	T5 end	6,062,697	2,184,191
	T6 start	6,062,731	2,181,413
	T6 end	6,062,044	2,181,943
	T7 start	6,063,091	2,178,146
	T7 end	6,063,546	2,178,299
	T8 start	6,063,433	2,176,631
	T8 end	6,062,480	2,176,455
	T9 start	6,062,820	2,175,412
	T9 end	6,062,835	2,174,727
	T10 start	6,058,858	2,173,245
	T10 end	6,059,331	2,173,319

Appendix C
Bathymetric Plots Enlarged from Figure 3


Jan/Feb/Mar 2011
Feet (MLLW)
-1.9 - 0.0
-3.9 - -2.0
-5.9 - -4.0
-7.9 - -6.0
-9.9 - -8.0
-11.9 - -10.0
-13.9 - -12.0
-15.9 - -14.0
-17.9 - -16.0
-19.9 - -18.0
-21.9 - -20.0
-22.2 - -22.0
N
E
S
W


Jan 2012
Feet (MLLW)
-1.9 - 0.0
-3.9 - -2.0
-5.9 - -4.0
-7.9 - -6.0
-9.9 - -8.0
-11.9 - -10.0
-13.9 - -12.0
-15.9 - -14.0
-17.9 - -16.0
-19.9 - -18.0
-21.9 - -20.0
-22.2 - -22.0
N
E
S
W


2012 minus 2011
2011-2012 Erosion/Accretion
Difference (ft)
> -1.0
-0.9 - -0.5
-0.4 - -0.1
-0.1 - 0.1
0.2 - 0.5
0.6 - 1.0
> 1.0
N
E
S
W

Appendix D
Physical Monitoring Photos

Photo 1. Looking south at tide Station 1, on the Shellmaker Island mudflat.

Photo 2. Looking south at tide Station 2, on the pile east of New Least Tern Island.

Photo 3. Looking east at tide Station 3, near the north end of Tern Island.

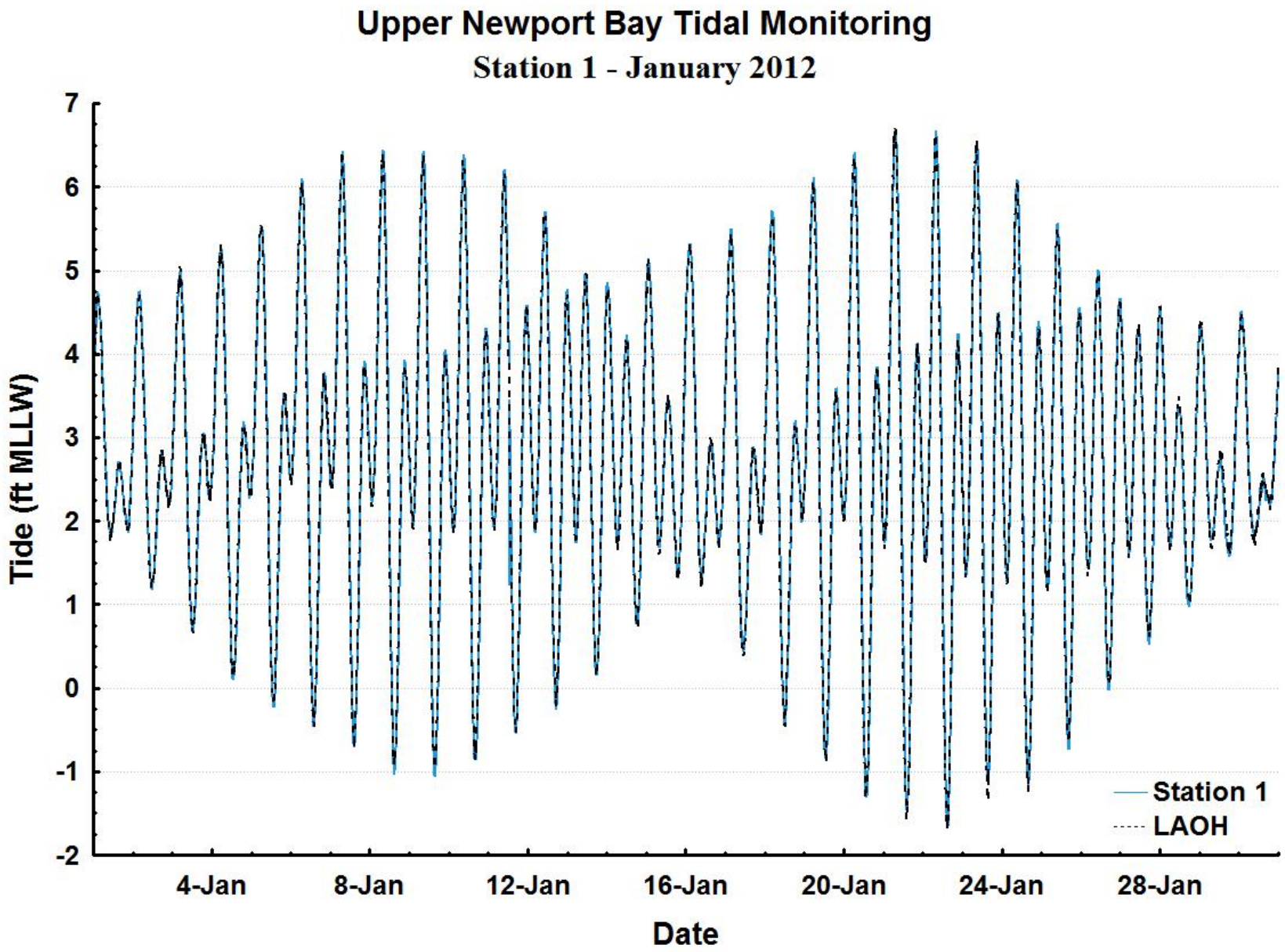
Photo 4. New Least Tern Island with black skimmer decoys (4/26/12).

Photo 5. New Least Tern Island shoreline plant and garbage debris (4/26/12).

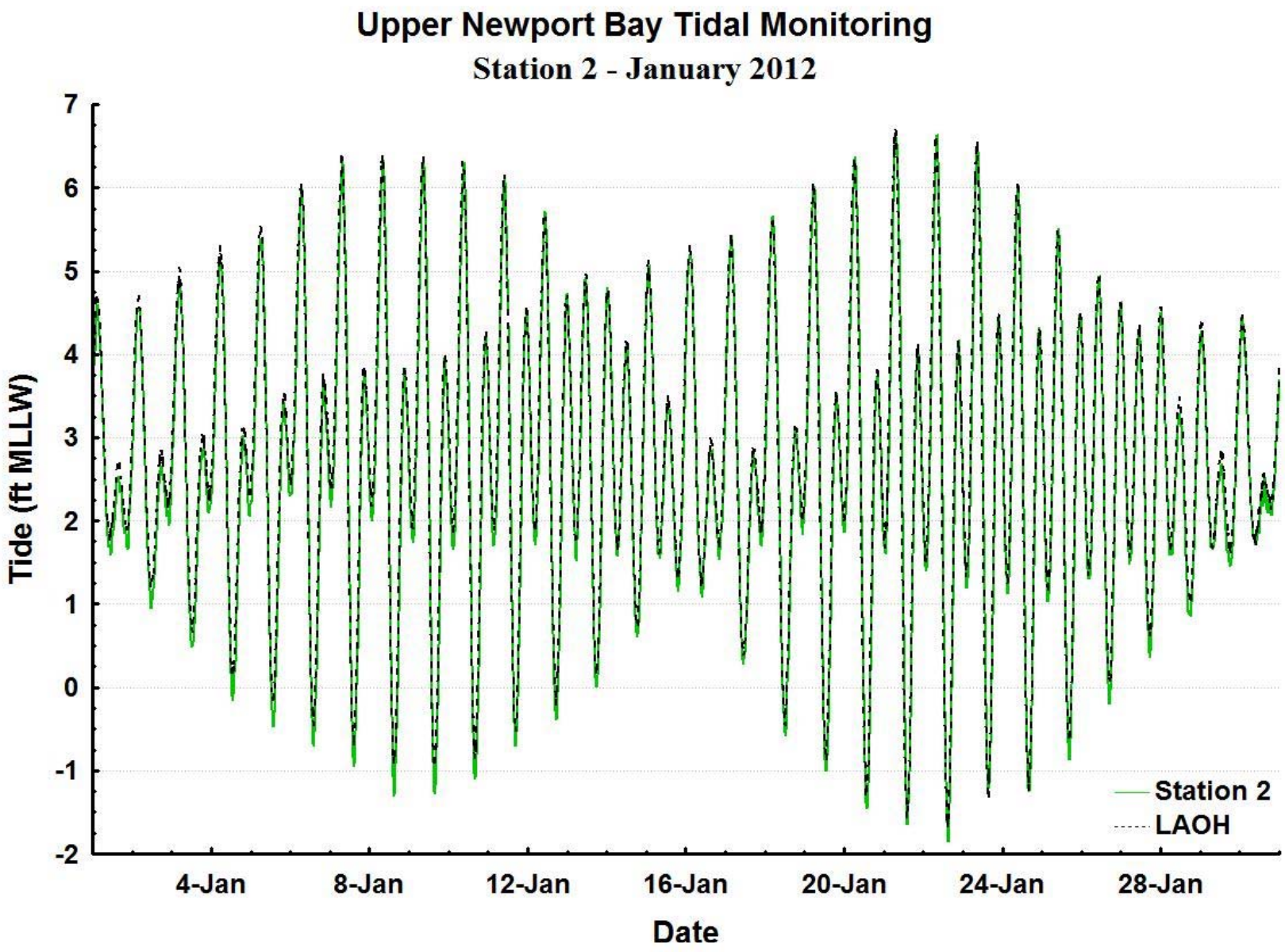
Photo 6. New Least Tern Island cordgrass on the south shoreline (4/26/12).

Photo 7. New Least Tern Island cordgrass on the west shoreline (7/26/12)..

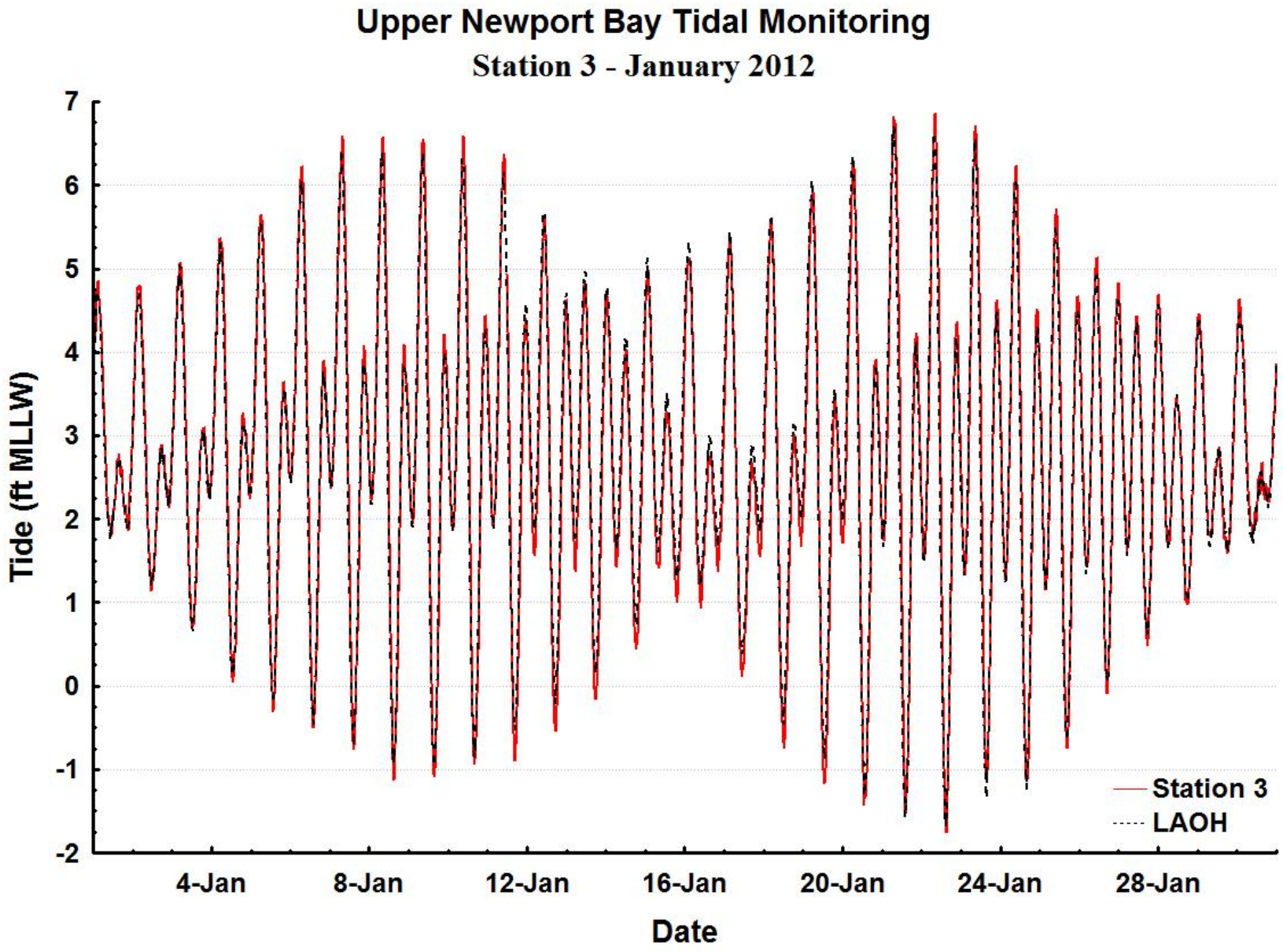
Appendix E
Monthly Plots of Tidal Data



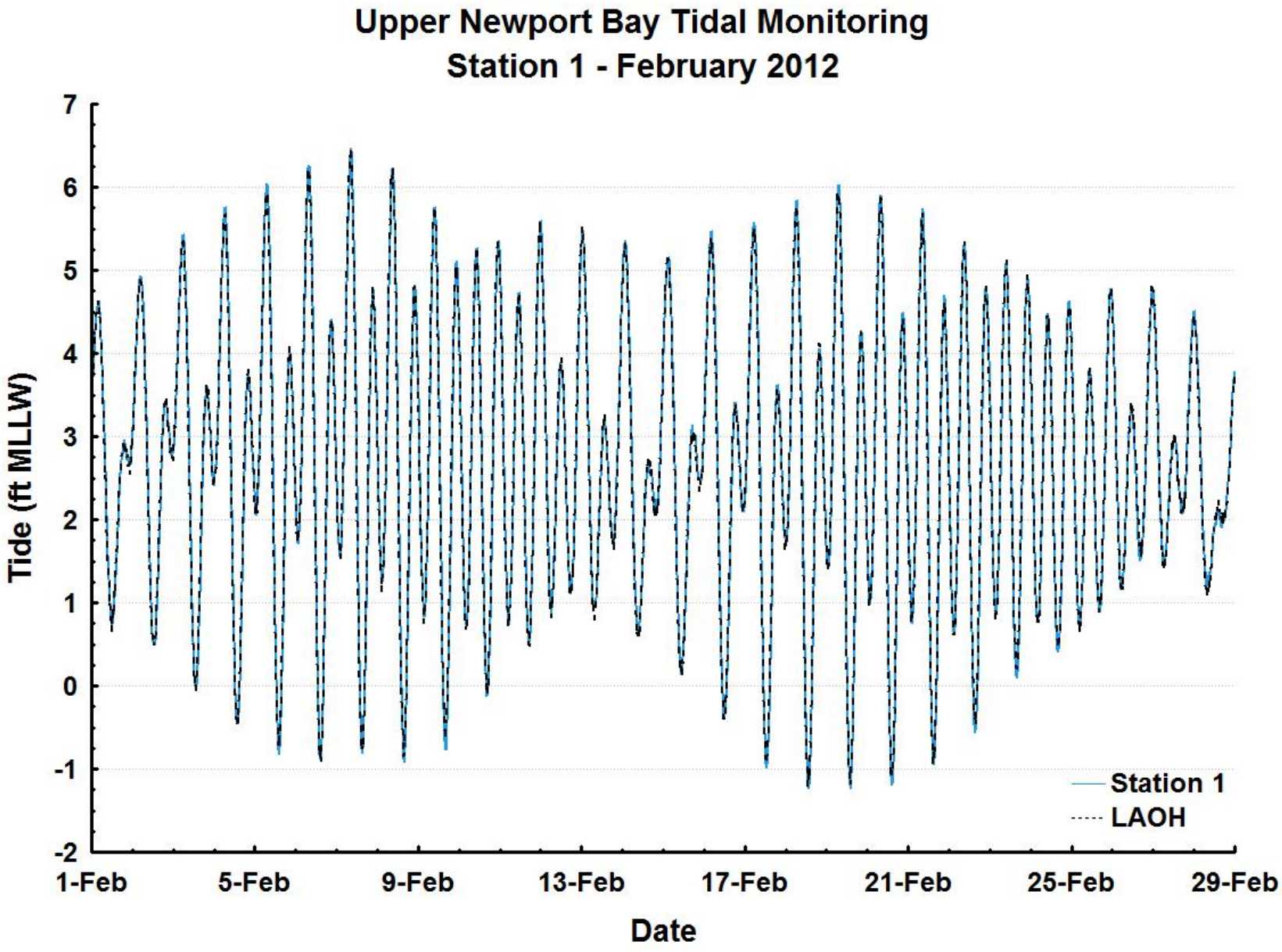
Tide data at UNB Station 1 and Los Angeles Outer Harbor, January 2012 (feet, MLLW).



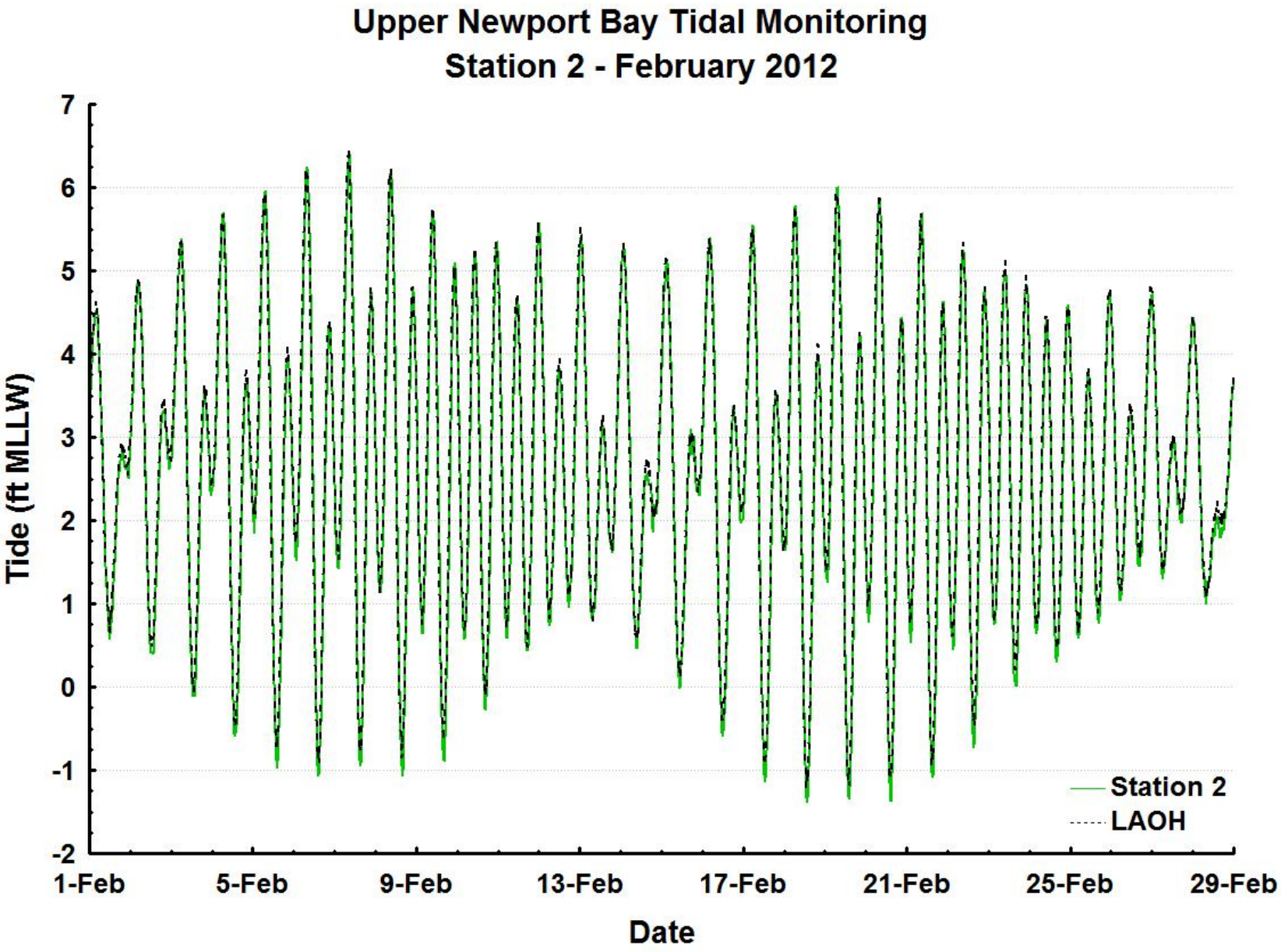
Tide data at UNB Station 2 and Los Angeles Outer Harbor, January 2012 (feet, MLLW).



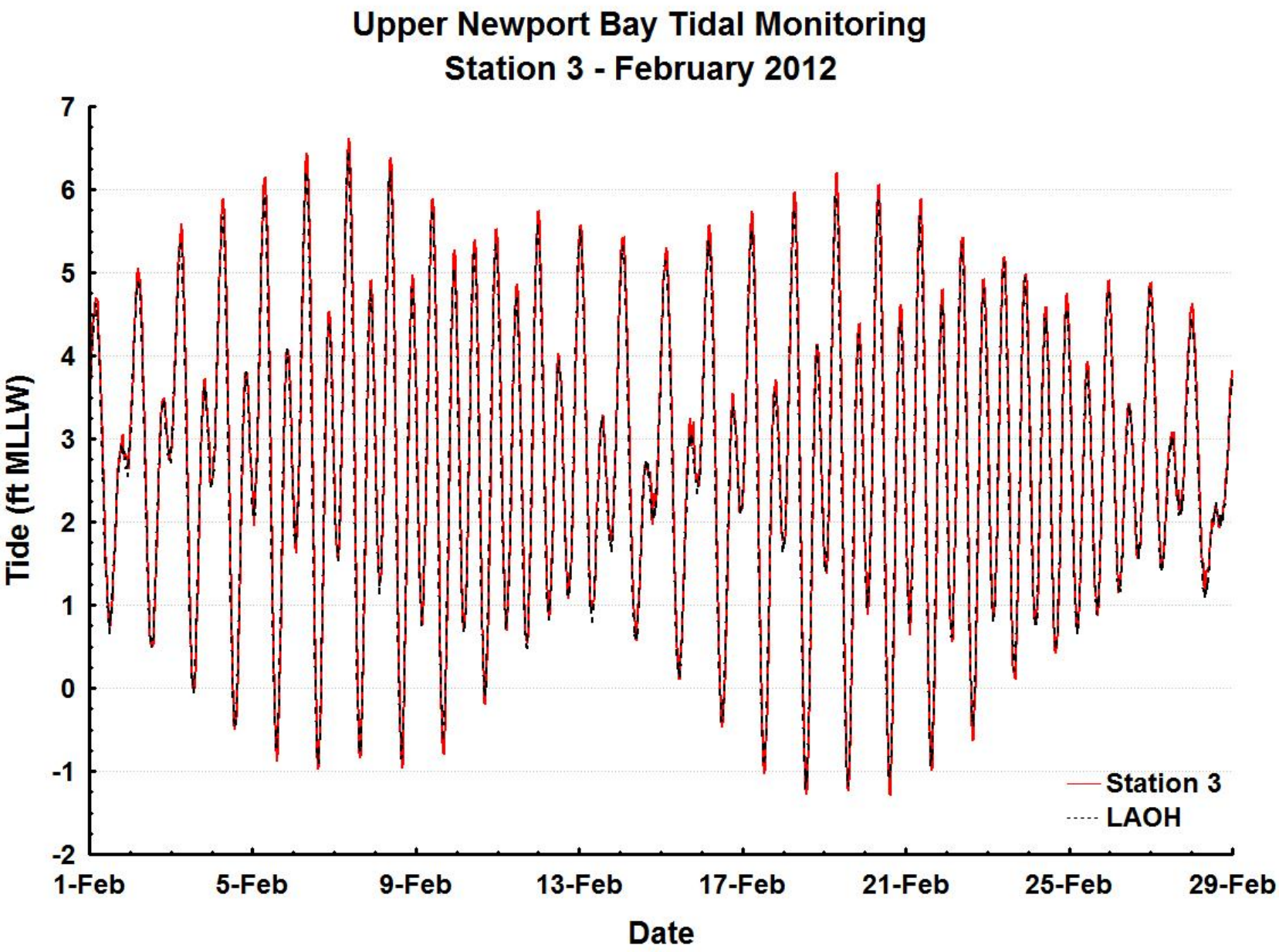
Tide data at UNB Station 3 and Los Angeles Outer Harbor, January 2012 (feet, MLLW).



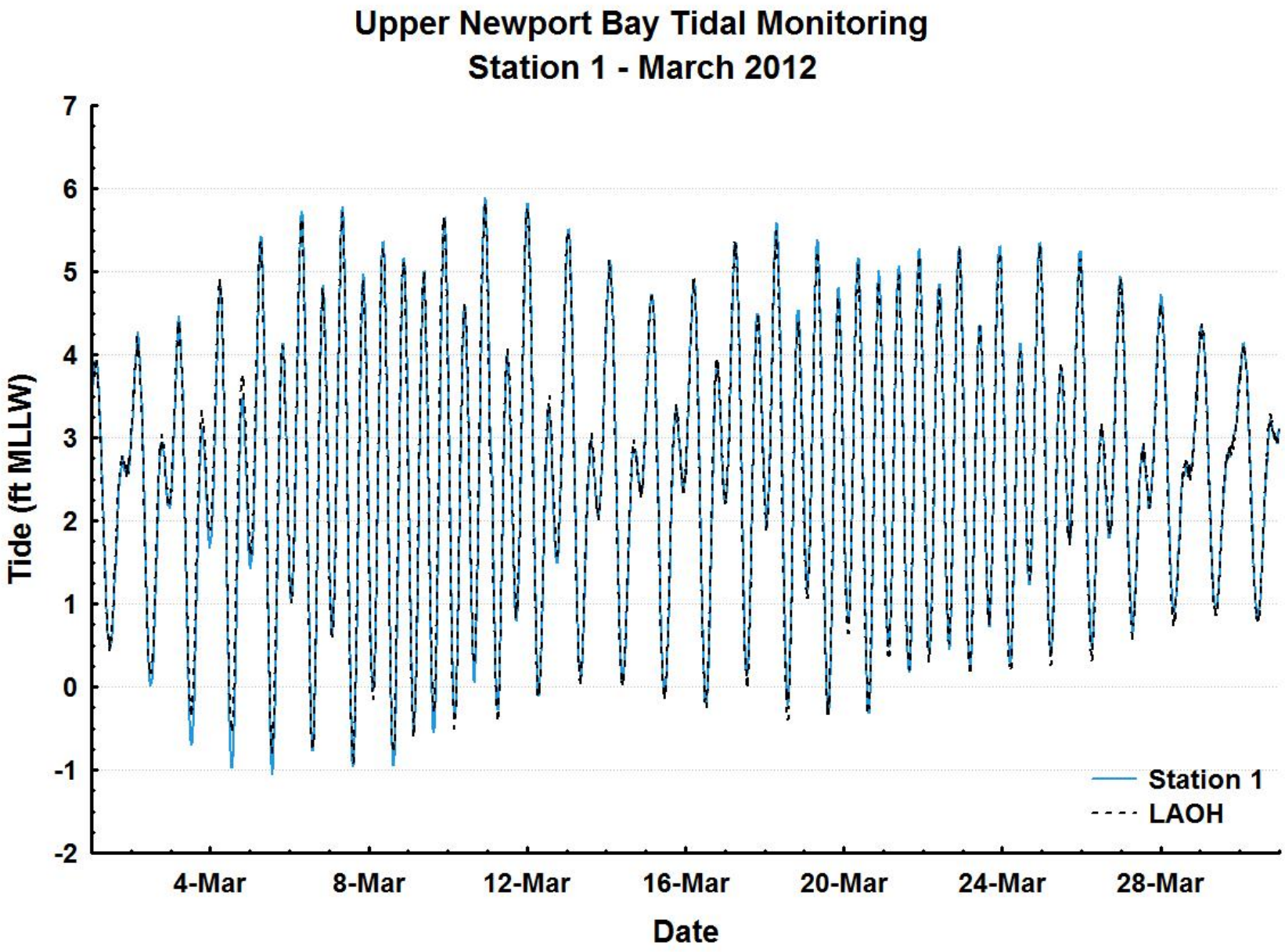
Tide data at UNB Station 1 and Los Angeles Outer Harbor, February 2012 (feet, MLLW).



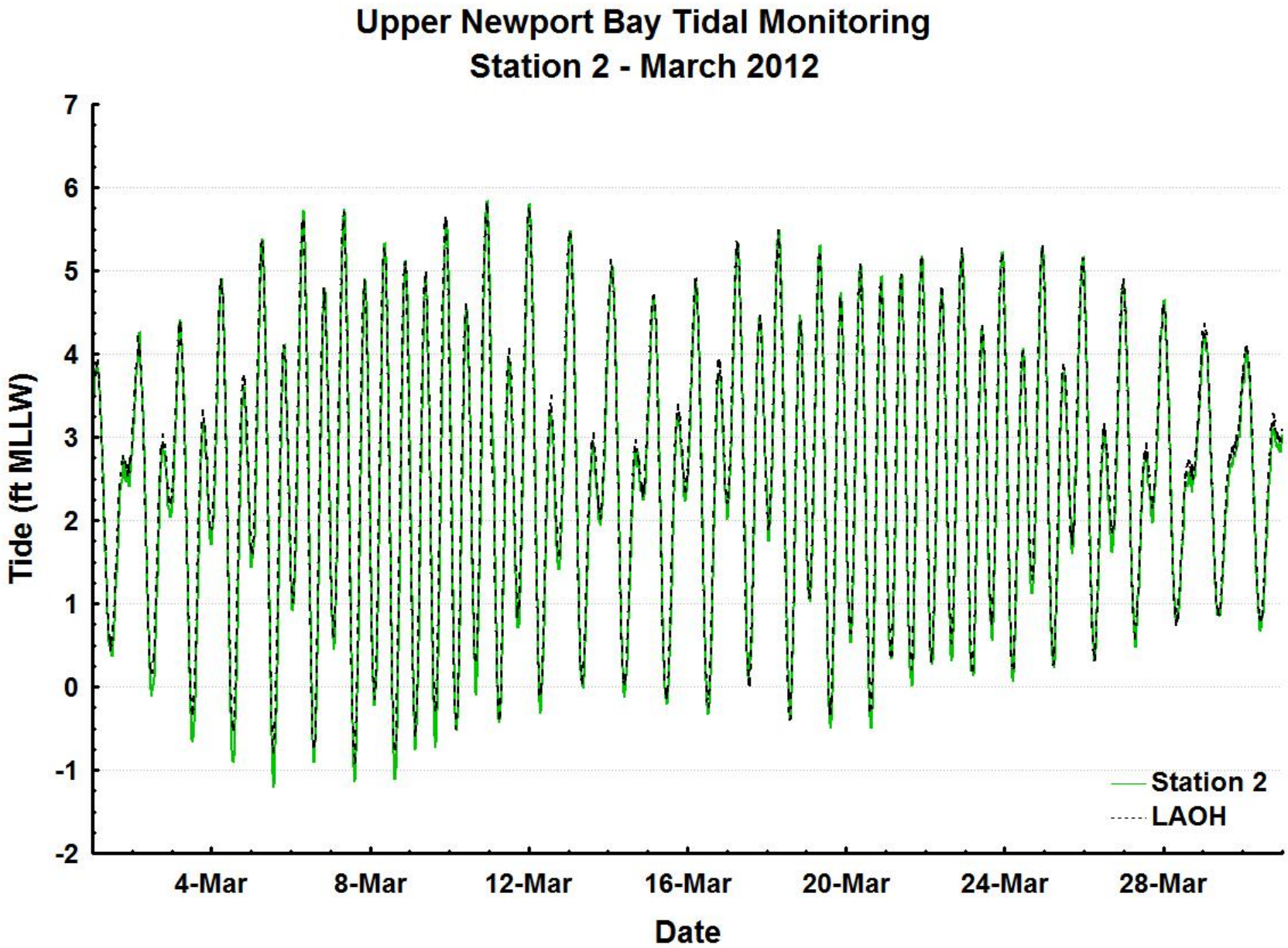
Tide data at UNB Station 2 and Los Angeles Outer Harbor, February 2012 (feet, MLLW).



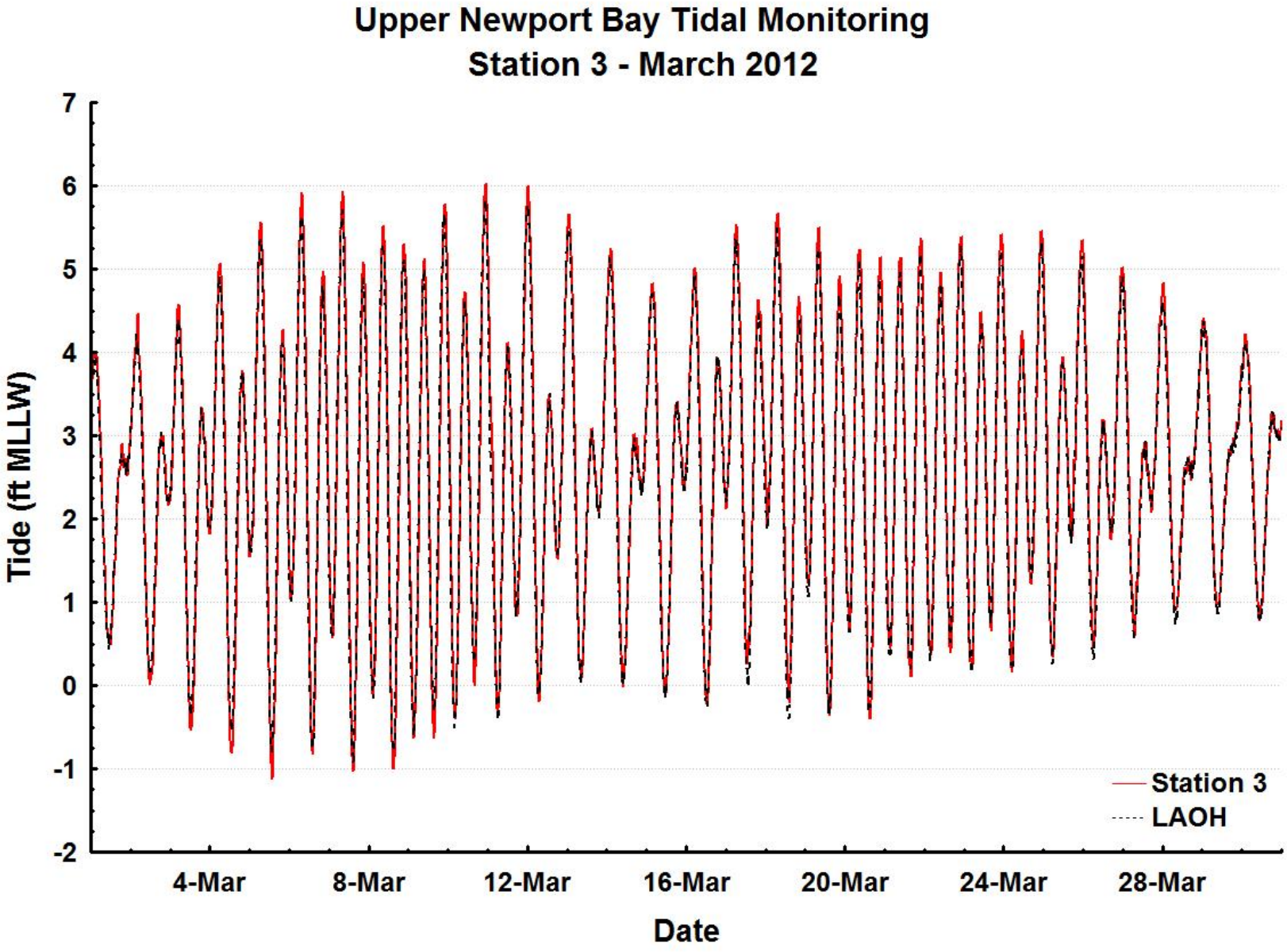
Tide data at UNB Station 3 and Los Angeles Outer Harbor, February 2012 (feet, MLLW).



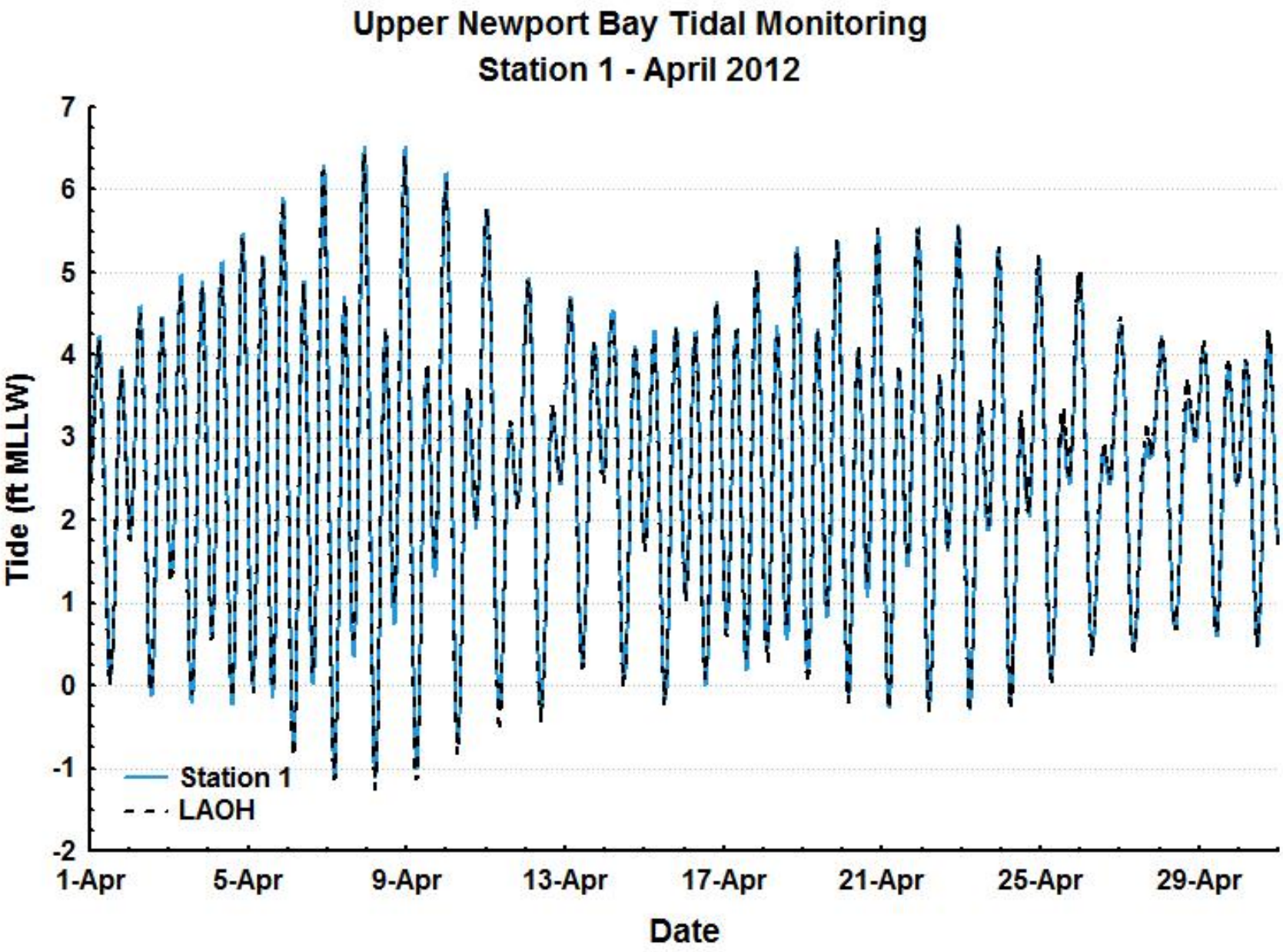
Tide data at UNB Station 1 and Los Angeles Outer Harbor, March 2012 (feet, MLLW).



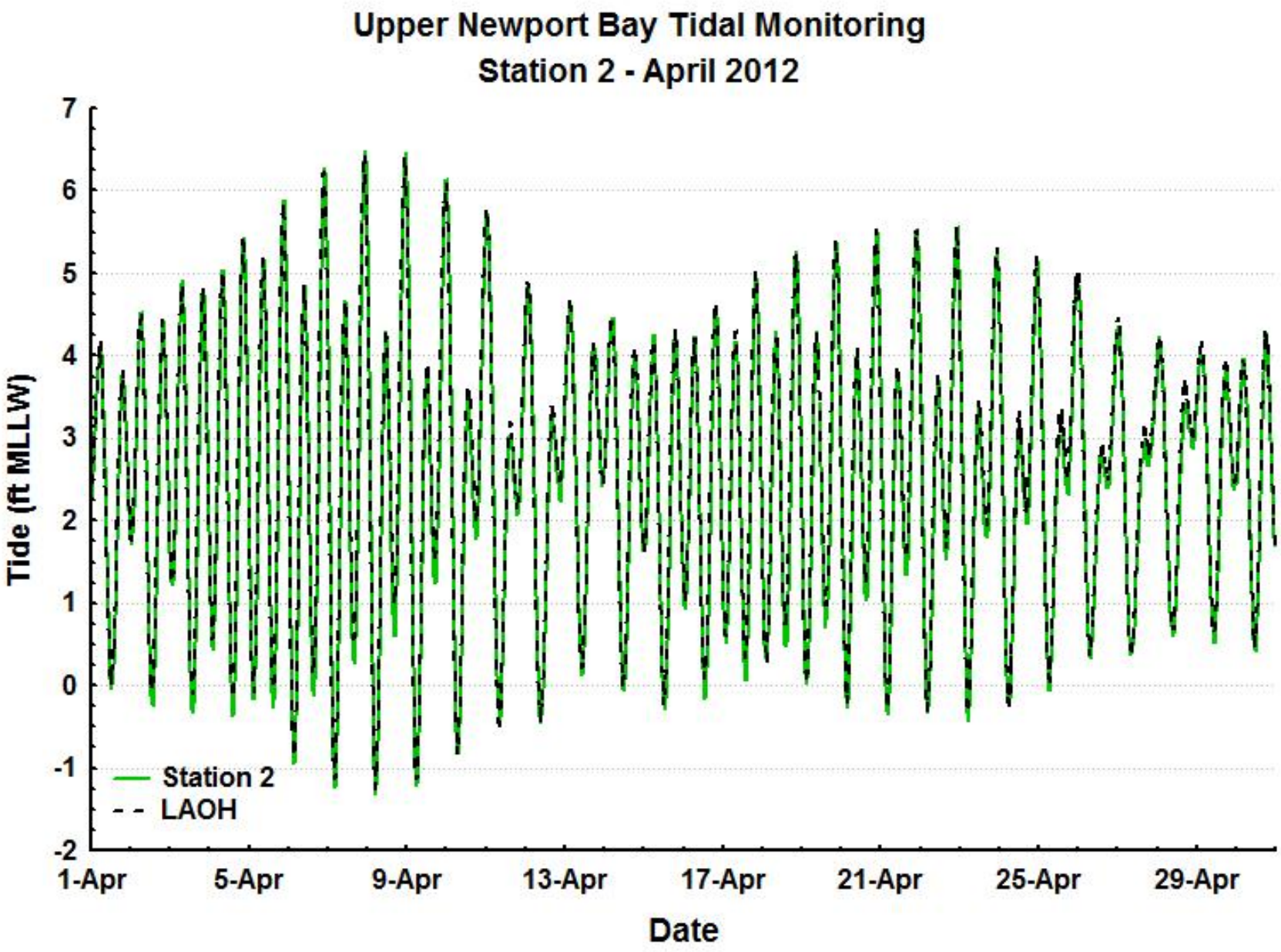
Tide data at UNB Station 2 and Los Angeles Outer Harbor, March 2012 (feet, MLLW).



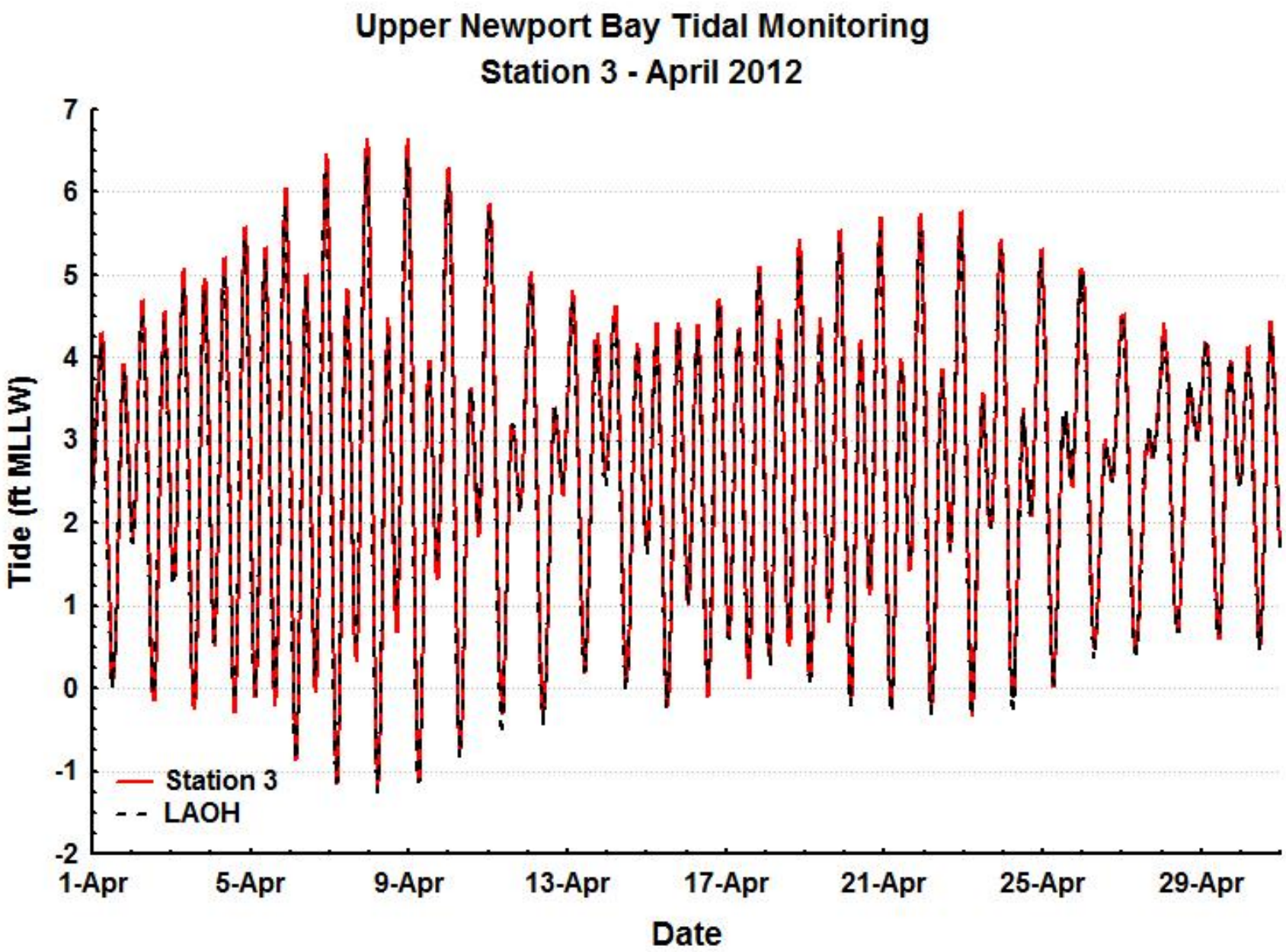
Tide data at UNB Station 3 and Los Angeles Outer Harbor, March 2012 (feet, MLLW).



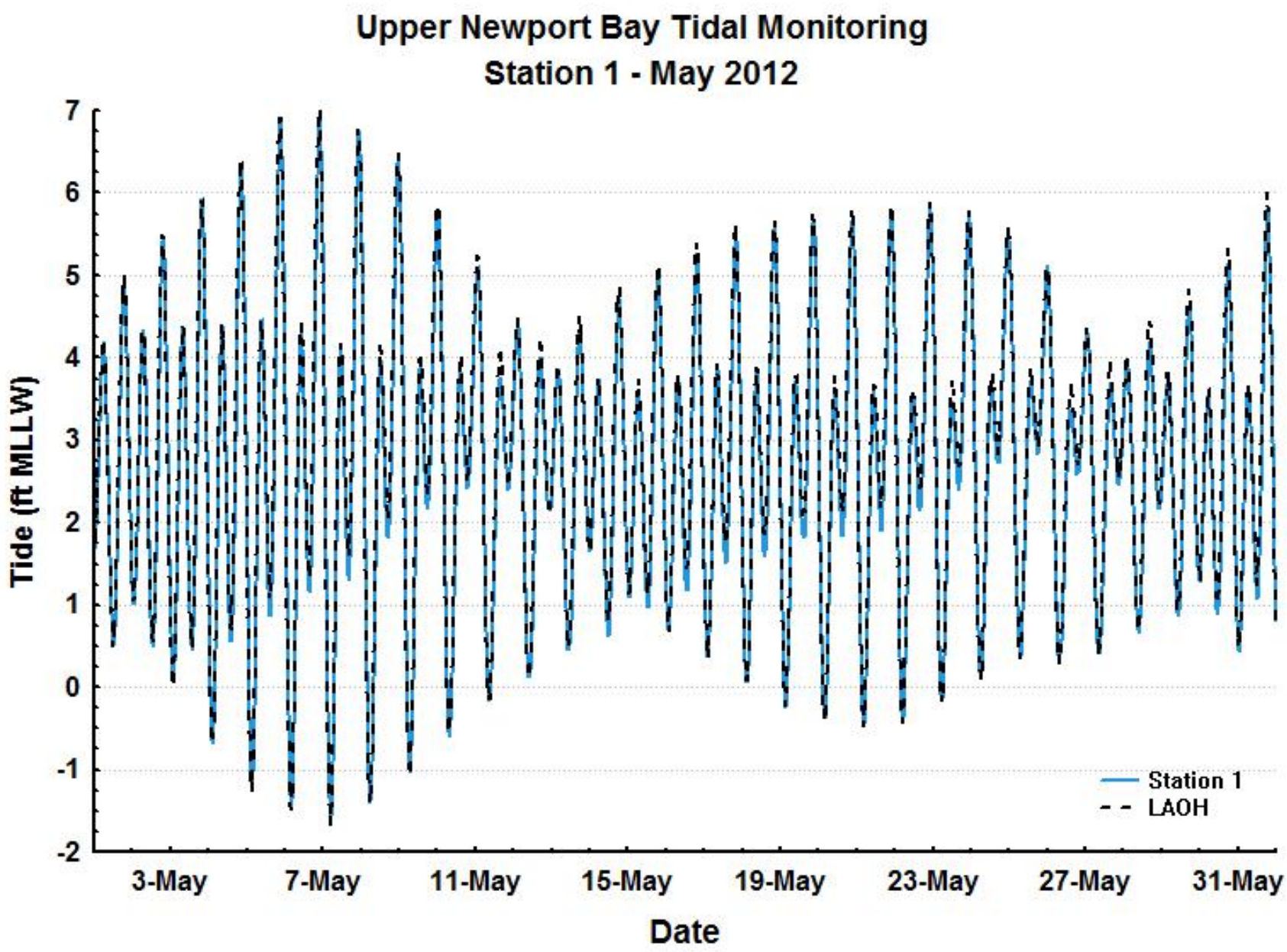
Tide data at UNB Station 1 and Los Angeles Outer Harbor, April 2012 (feet, MLLW).



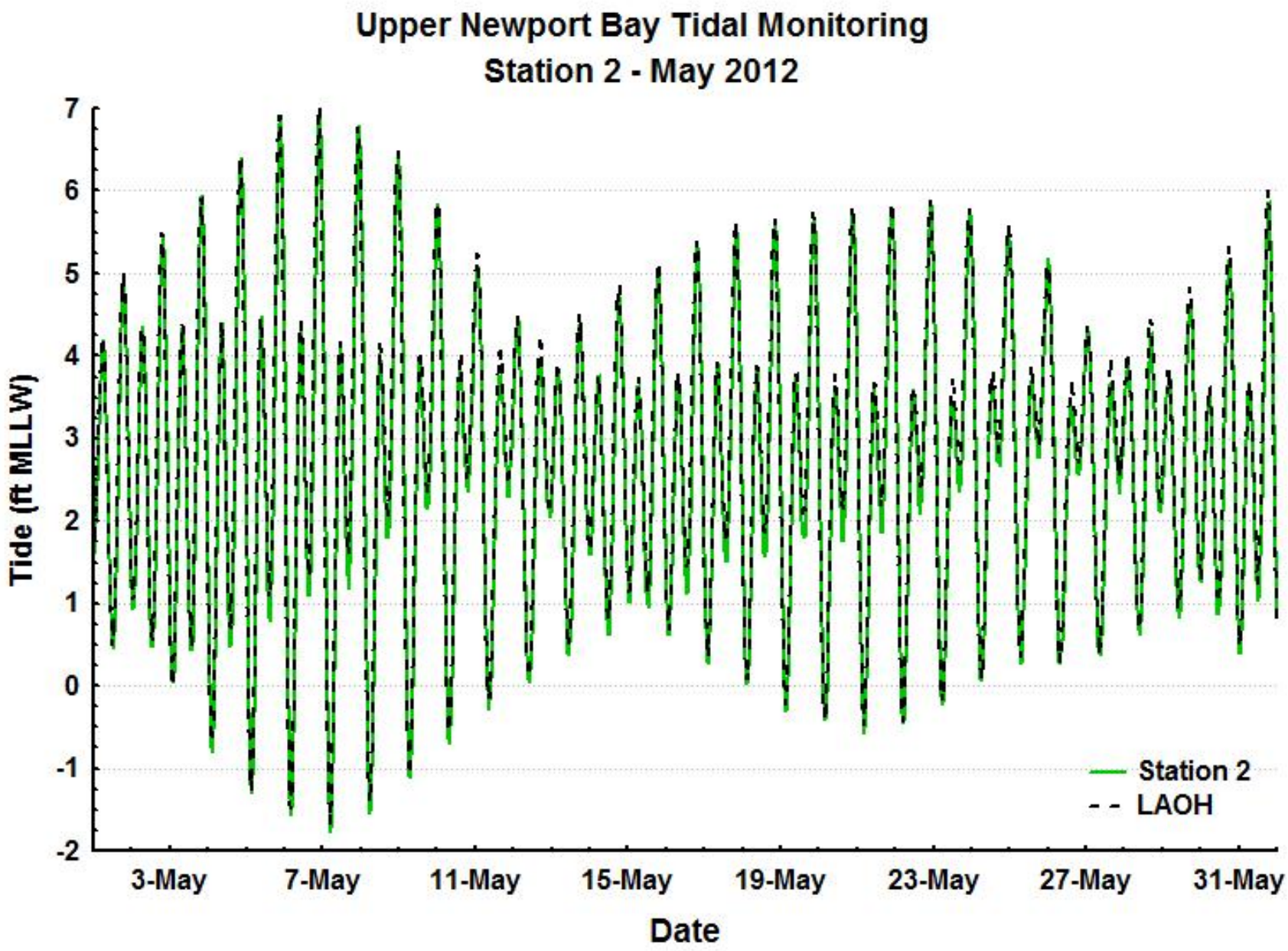
Tide data at UNB Station 2 and Los Angeles Outer Harbor, April 2012 (feet, MLLW).



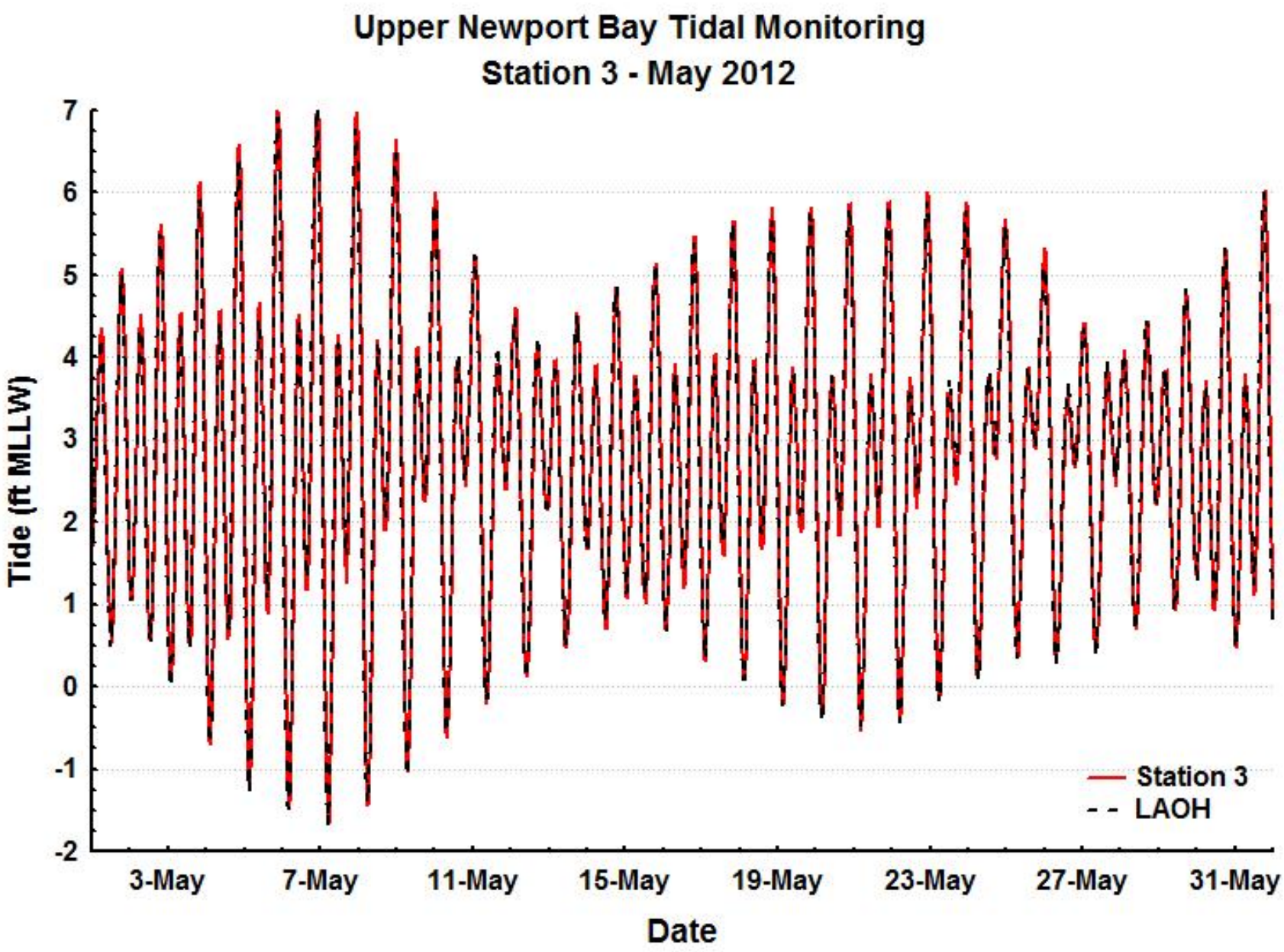
Tide data at UNB Station 3 and Los Angeles Outer Harbor, April 2012 (feet, MLLW).



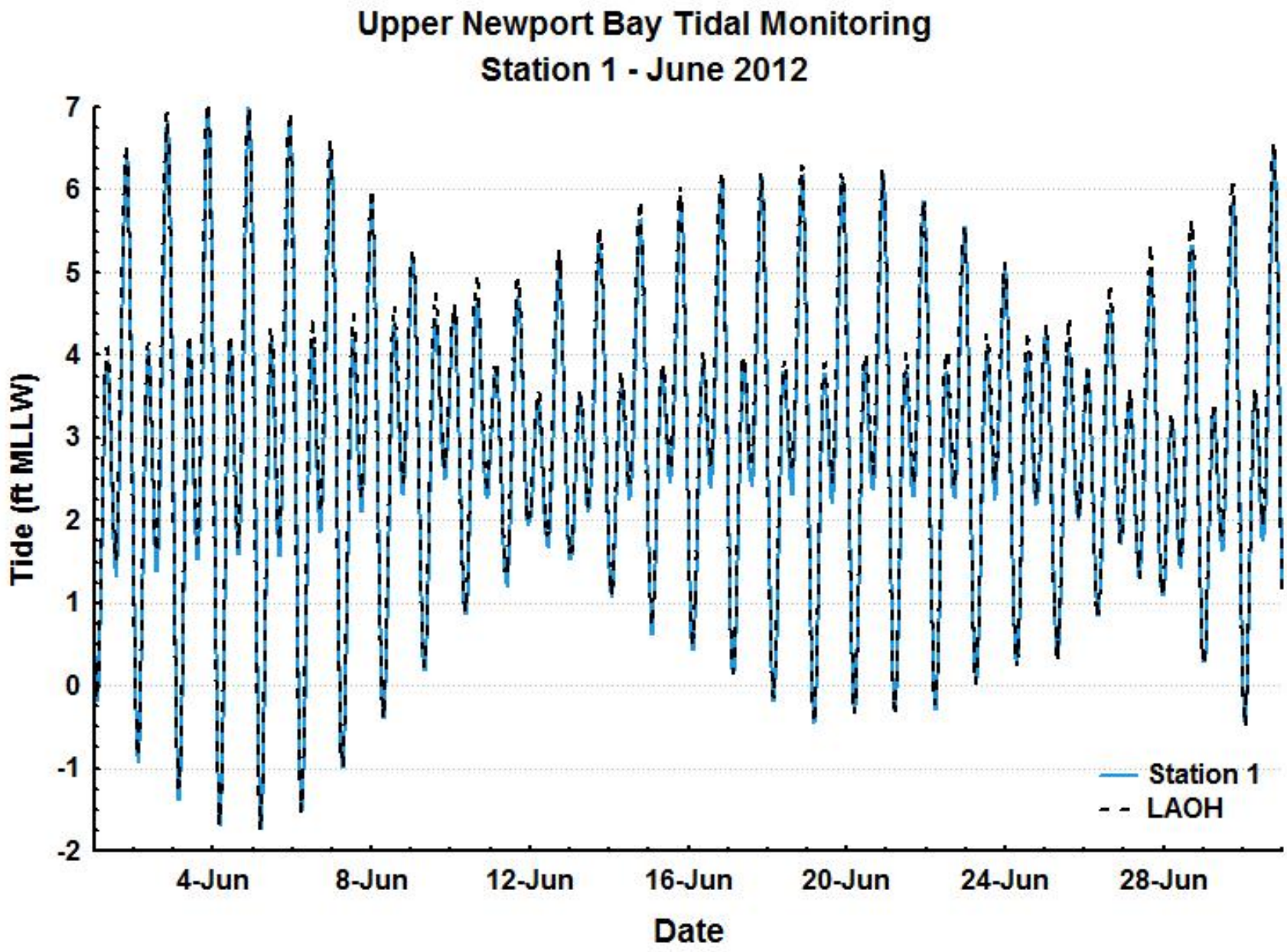
Tide data at UNB Station 1 and Los Angeles Outer Harbor, May 2012 (feet, MLLW).



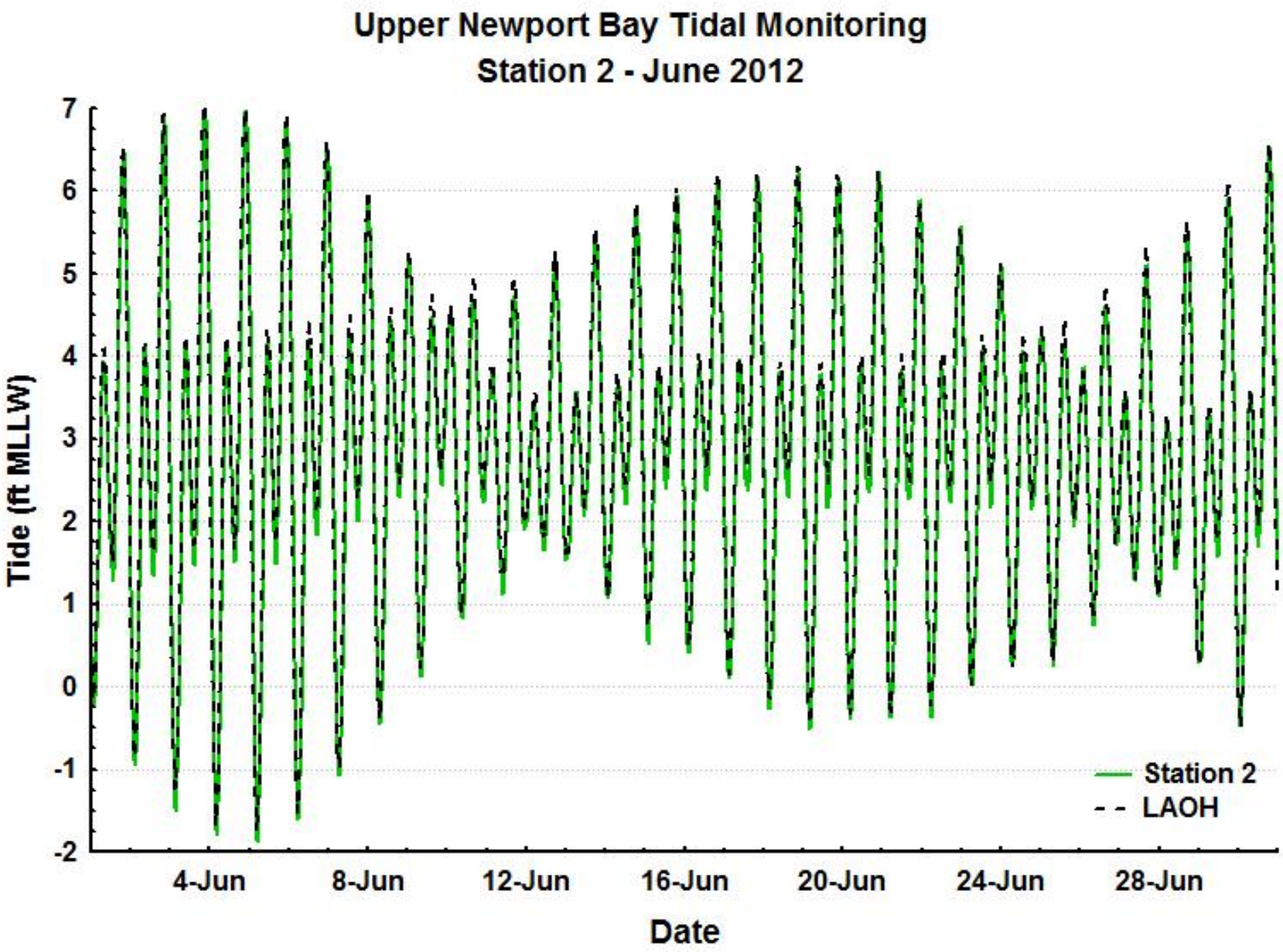
Tide data at UNB Station 2 and Los Angeles Outer Harbor, May 2012 (feet, MLLW).



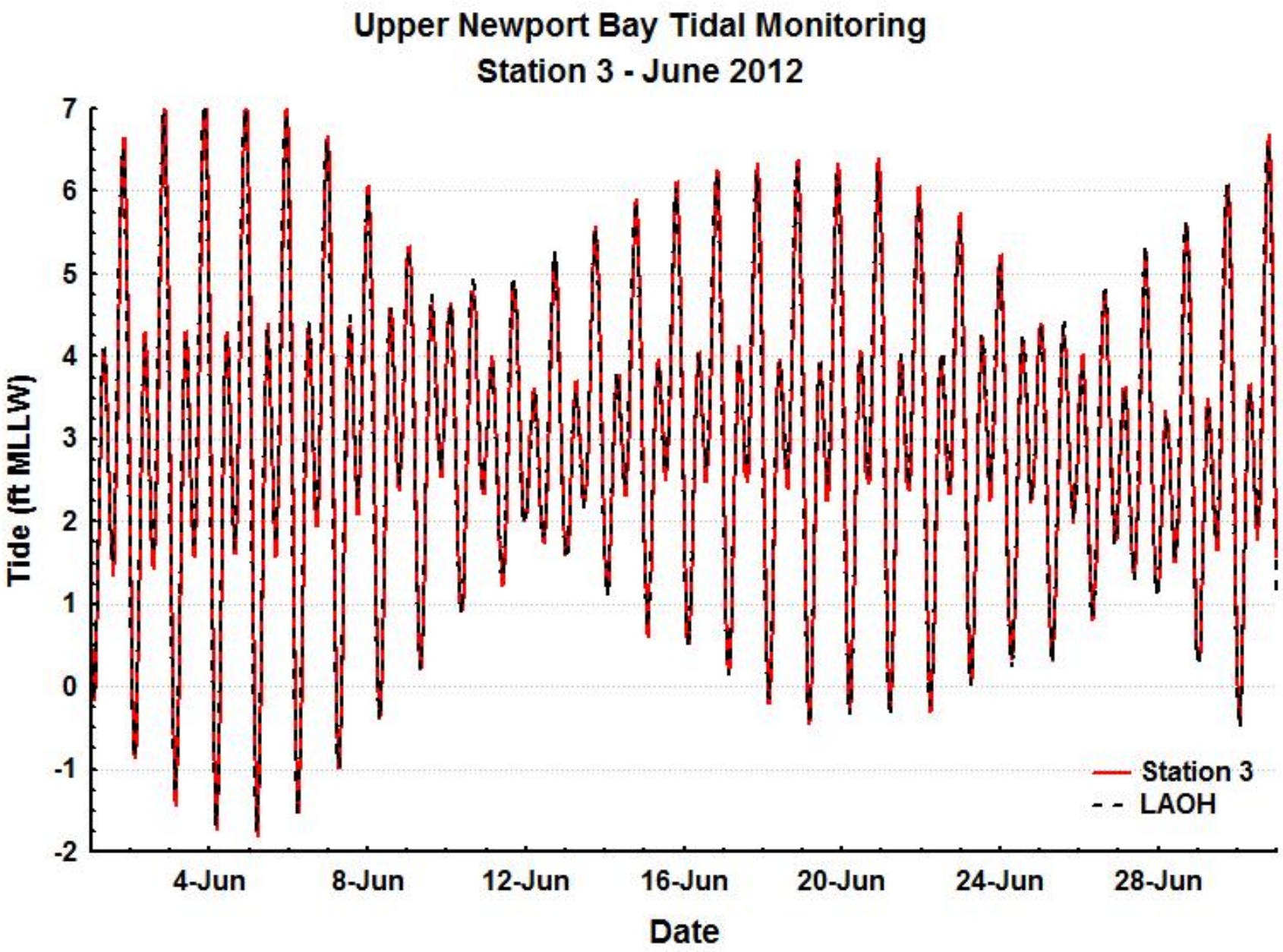
Tide data at UNB Station 3 and Los Angeles Outer Harbor, May 2012 (feet, MLLW).



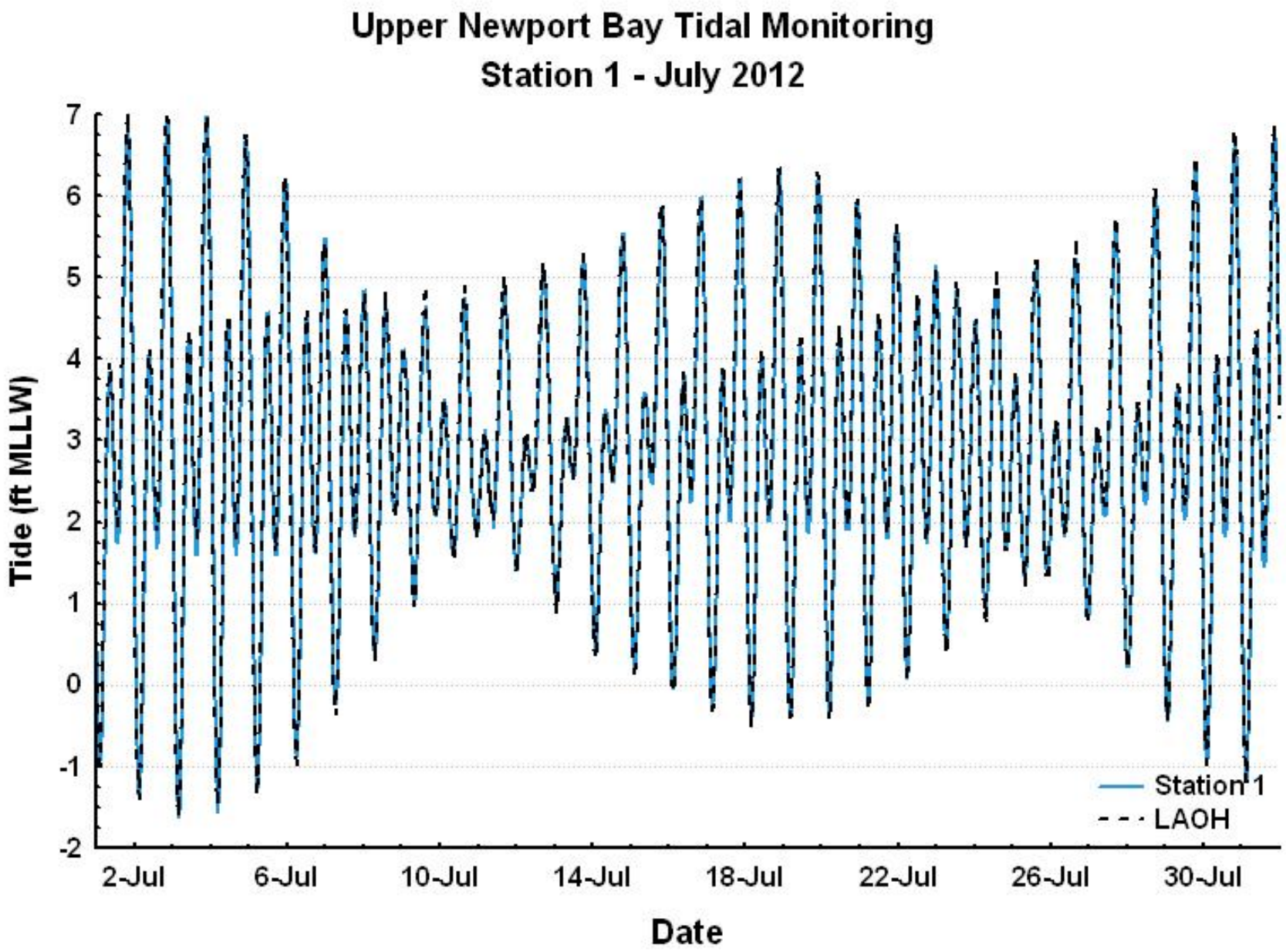
Tide data at UNB Station 1 and Los Angeles Outer Harbor, June 2012 (feet, MLLW).



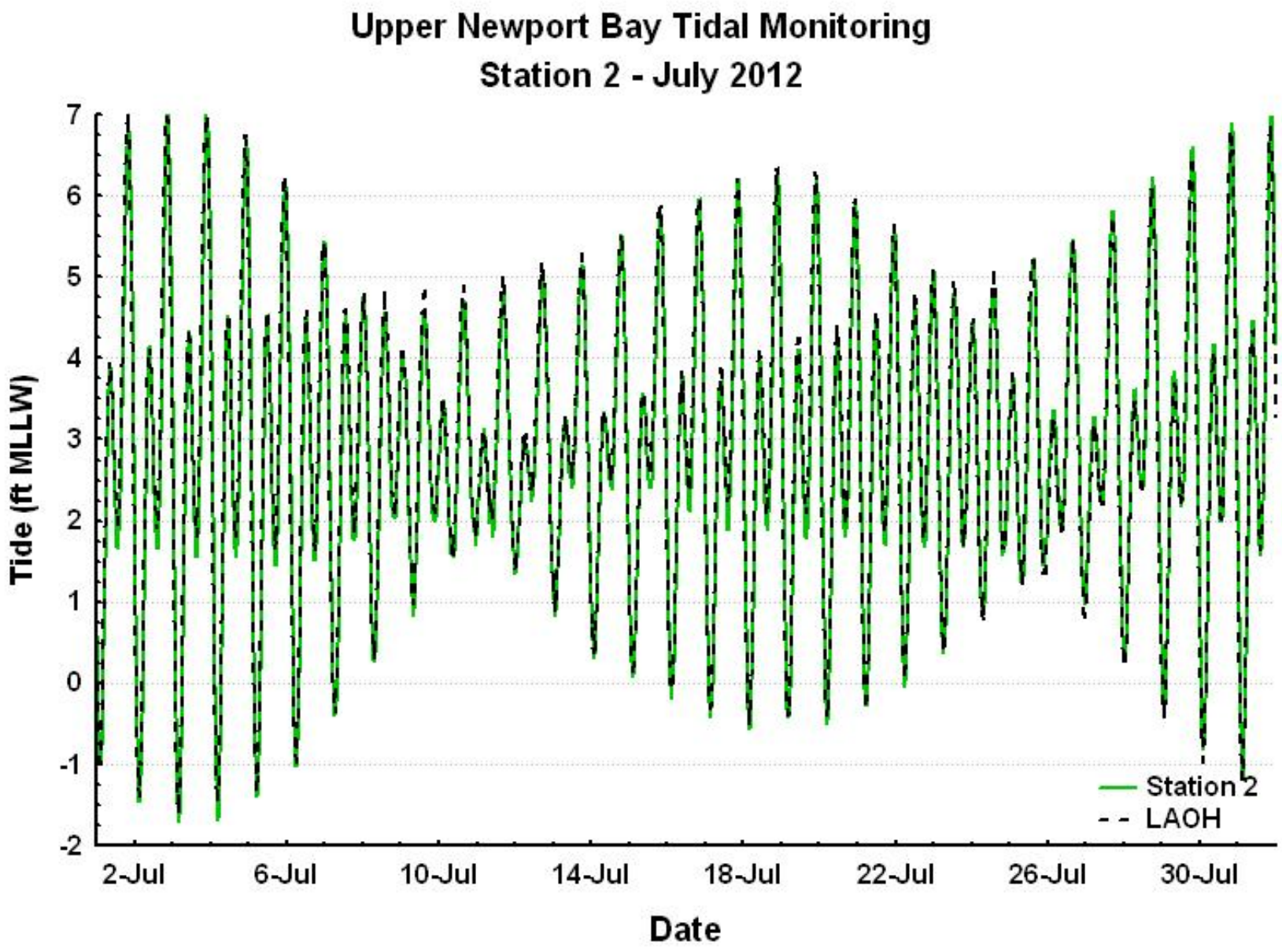
Tide data at UNB Station 2 and Los Angeles Outer Harbor, June 2012 (feet, MLLW).



Tide data at UNB Station 3 and Los Angeles Outer Harbor, June 2012 (feet, MLLW).



Tide data at UNB Station 1 and Los Angeles Outer Harbor, July 2012 (feet, MLLW).



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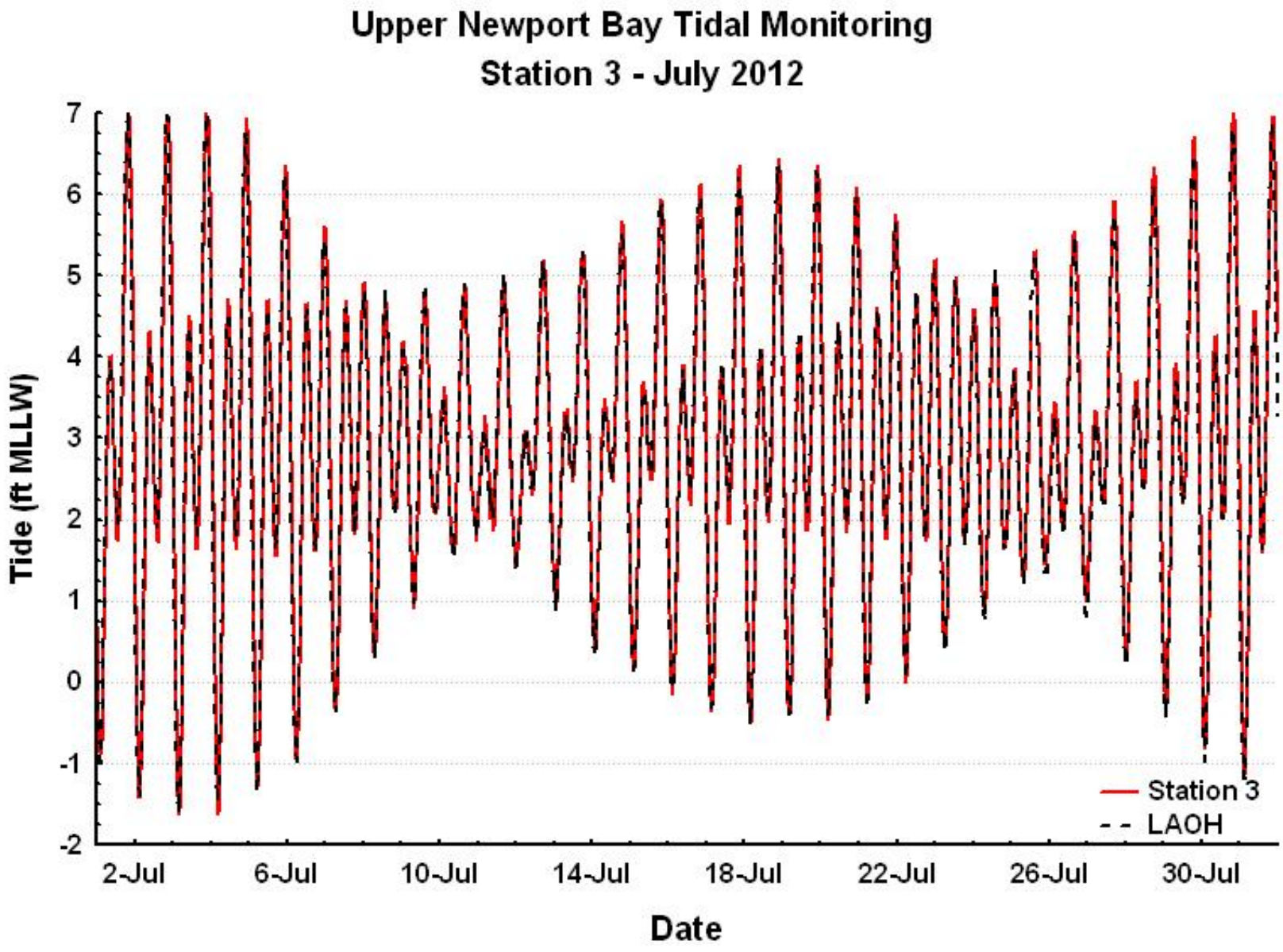

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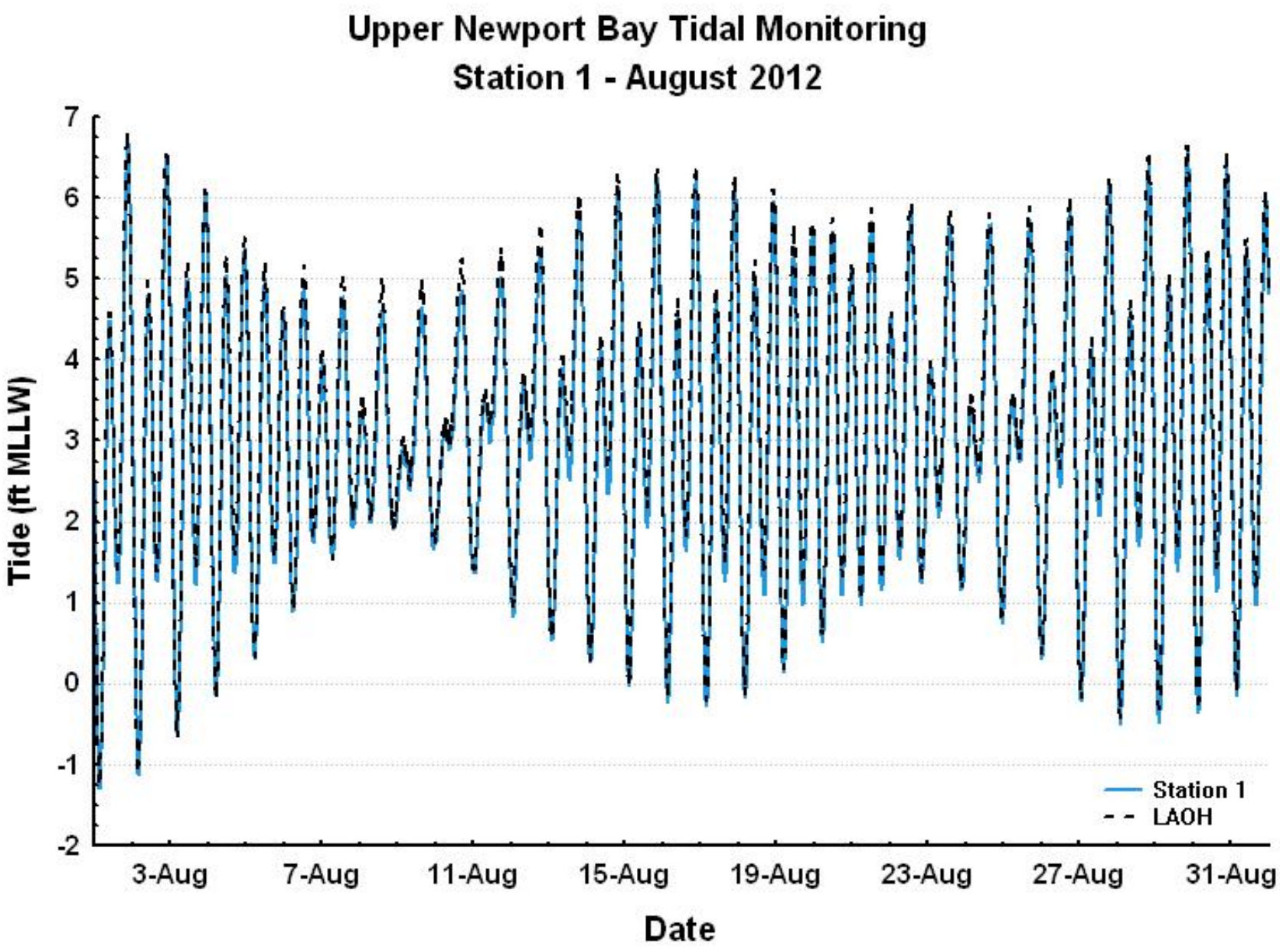
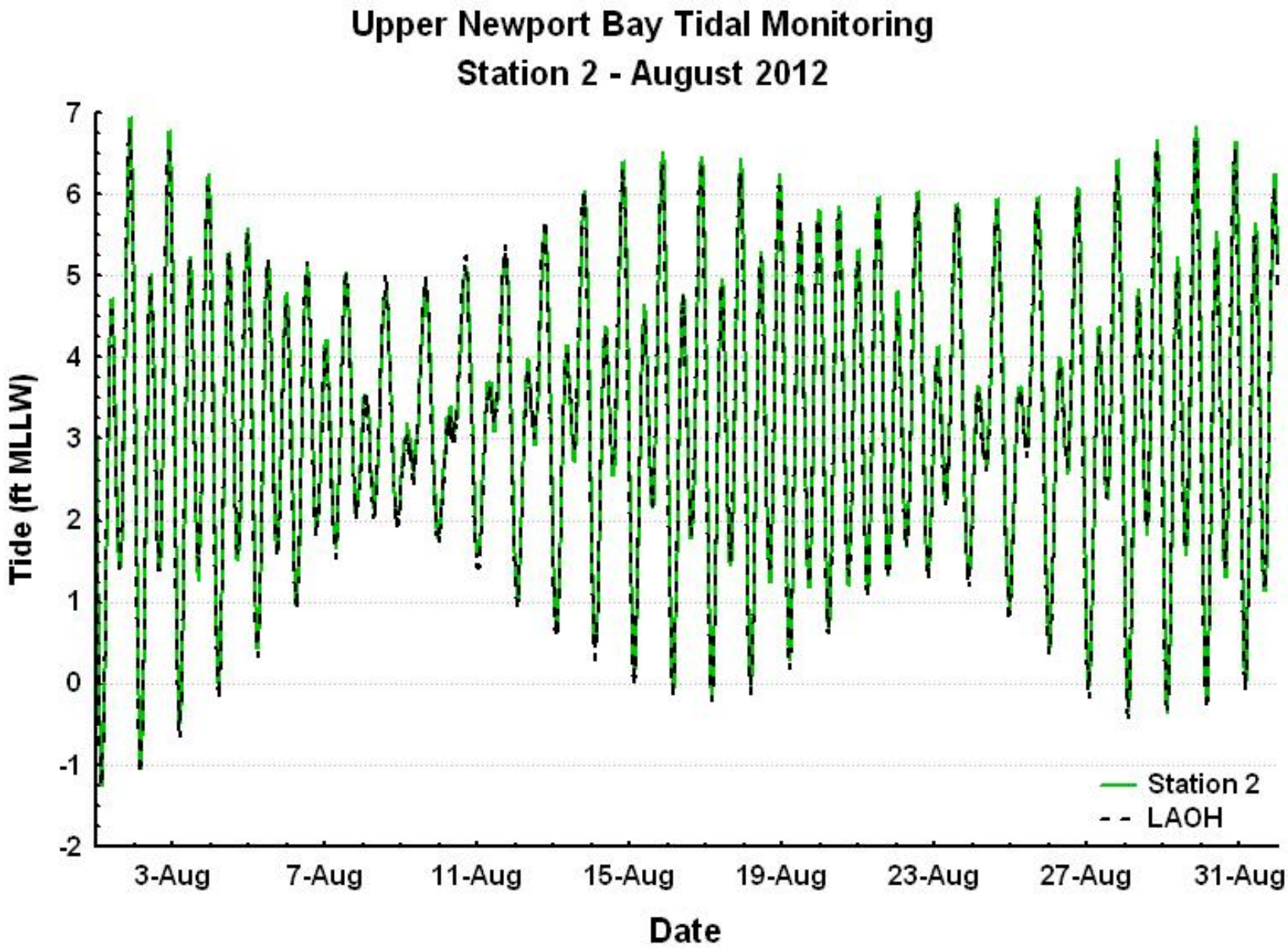
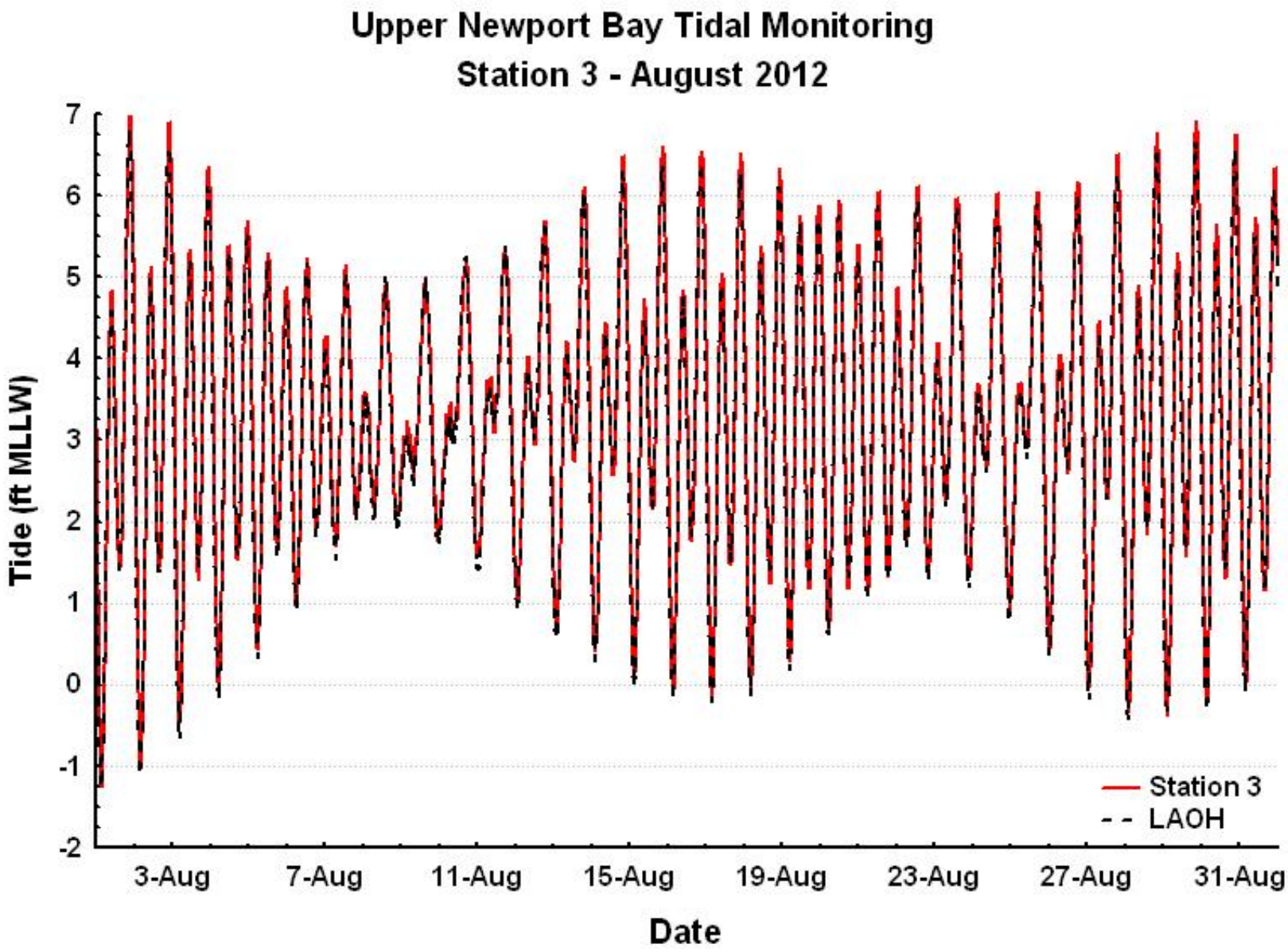


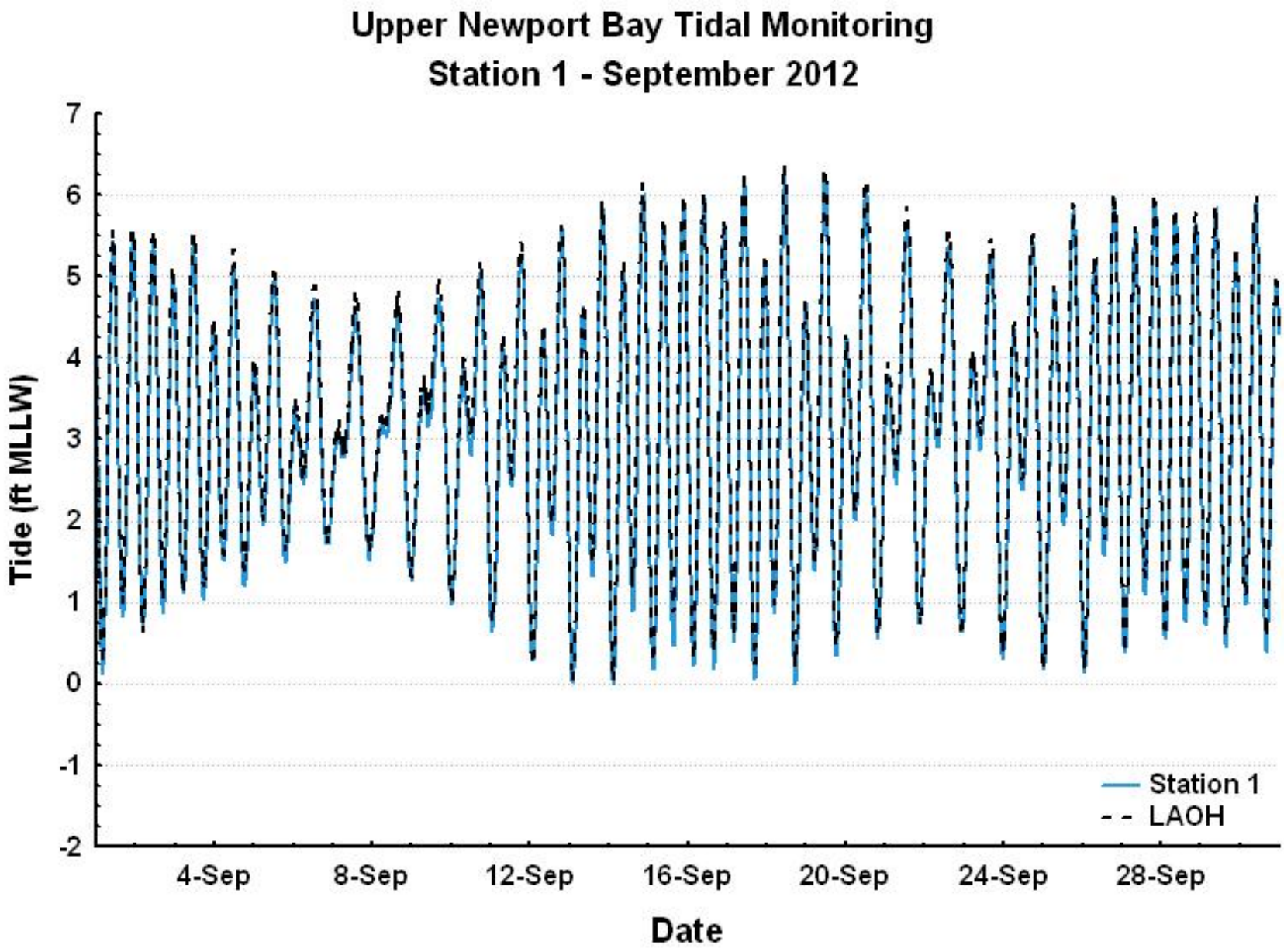
Tide data at UNB Station 1 and Los Angeles Outer Harbor, August 2012 (feet, MLLW).



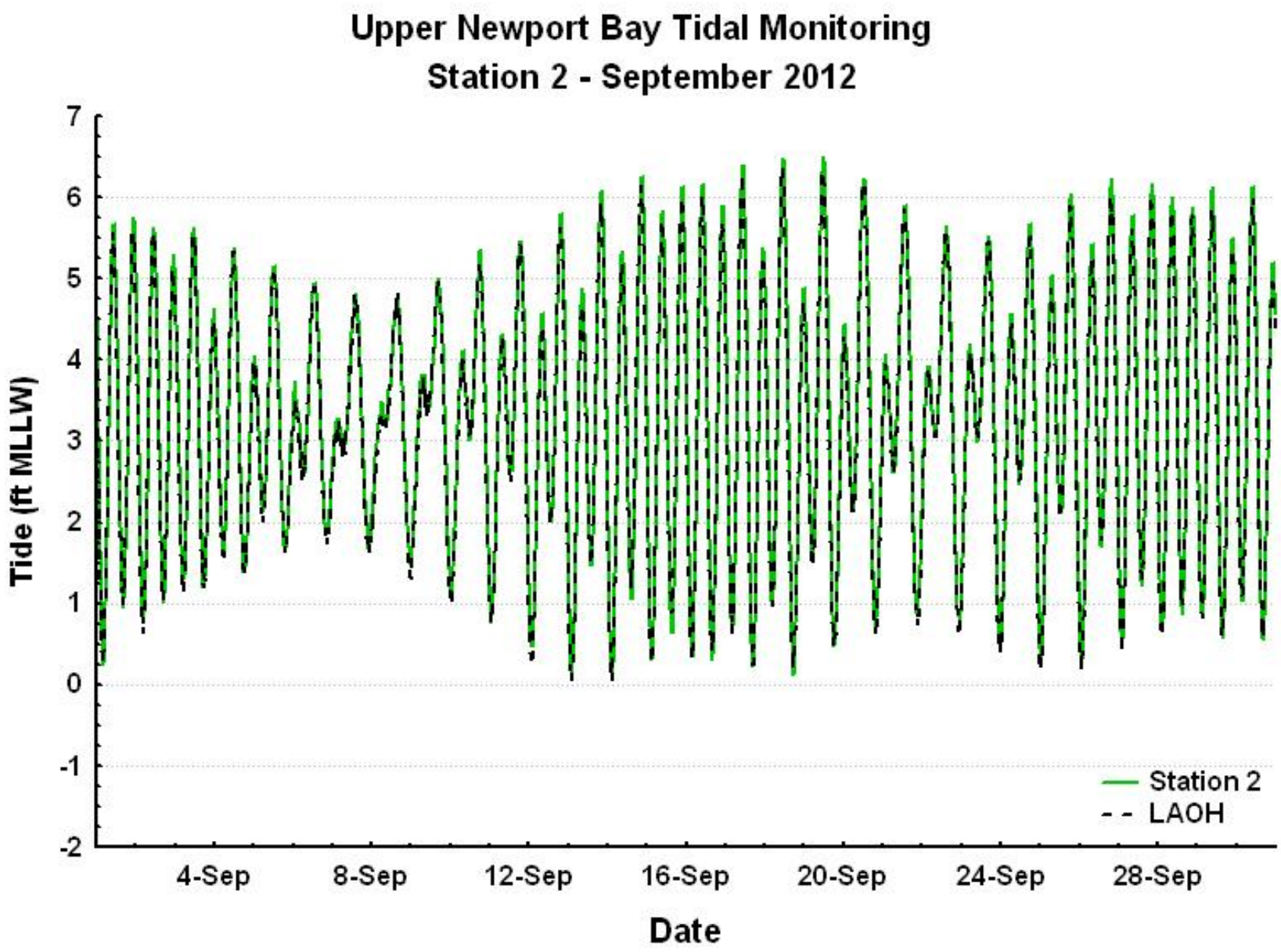
Tide data at UNB Station 2 and Los Angeles Outer Harbor, August 2012 (feet, MLLW).



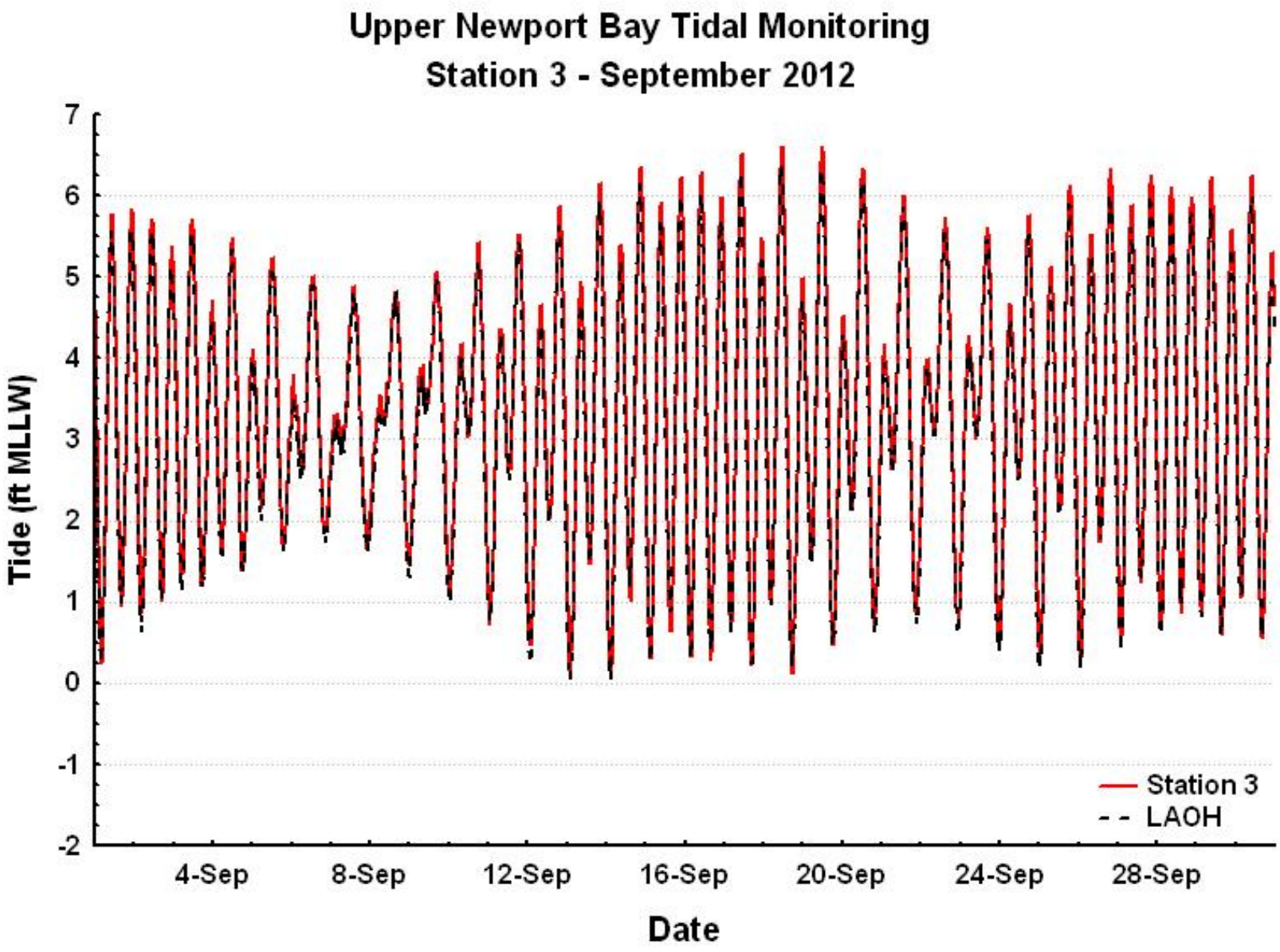
Tide data at UNB Station 2 and Los Angeles Outer Harbor, August 2012 (feet, MLLW).



Tide data at UNB Station 1 and Los Angeles Outer Harbor, September 2012 (feet, MLLW).



Tide data at UNB Station 2 and Los Angeles Outer Harbor, September 2012 (feet, MLLW).



Tide data at UNB Station 3 and Los Angeles Outer Harbor, September 2012 (feet, MLLW).).

Appendix F
Fish Data

Total fish counts in January 2012 by gear type and station (both replicates combined).

	Beach Seine						Otter Trawl						Purse Seine					
Station #	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Area Sampled (m^2)	465	388	419	605	558	326	1952	1952	1952	1952	1952	1952	694	694	694	694	694	694
Fish (# of indiv.)																		
Round stingray								1	1									
Northern anchovy													2		4	13		
Slough anchovy				2	5							14	1		1	25	19	
Anchovy-unid. juvenile															1			
California lizardfish															1			
California needlefish																2		
California killifish		298			2													
Topsmelt	38			203	228									146	5	2	19	
Atherinid juvenile	16	24	5	2	5	1									7	5		
Bay pipefish	1																	
Staghorn sculpin				2	2													
Queenfish												1						
Cheekspot goby	1	1			1	1												
California halibut					1													
Diamond turbot									2									
Total	**56**	**323**	**5**	**209**	**244**	**2**	**0**	**1**	**3**	**0**	**0**	**15**	**3**	**146**	**19**	**47**	**38**	**0**
Total fish density (indiv/m^2)	0.12	0.83	0.01	0.35	0.44	0.01	0	<0.01	<0.01	0	0	0.01	<0.01	0.21	0.03	0.07	0.05	0

Total fish counts in April 2012 by gear type and station (both replicates combined).

	Beach Seine						Otter Trawl						Purse Seine					
Station #	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Area Sampled (m^2)	372	372	465	403	310	279	1952	1952	1952	1952	1952	1952	694	694	694	694	694	694
Fish (# of indiv.)																		
Gray smoothhound												1						
Round stingray					2	5	38	4	1	22	35	1		1				
California butterfly ray											1							
Northern anchovy																196	23	
Slough anchovy						2	1					1						
Specklefin midshipman										1								
California killifish				53		1												
Topsmelt	237	422	637	199	148	89								184	16	16	12	
Barred pipefish					3													
Staghorn sculpin		4			8	5												
Barred sand bass									2									
Queenfish																	4	
Yellowfin croaker							1											
Spotfin croaker							2											
Shiner surfperch	2	20	1		6	31	1			2	2	3						
California barracuda																	1	1
Yellowfin goby				1	19	9												
Arrow/shadow goby		2			2													
California halibut					1		3	2	1	3	5							
Hornyhead turbot							5											
Diamond turbot				3	8	2	22	4	3									
Total	**239**	**448**	**638**	**256**	**197**	**144**	**73**	**10**	**7**	**28**	**43**	**6**	**0**	**185**	**16**	**212**	**40**	**1**
Total fish density (indiv/m^2)	0.64	1.20	1.37	0.64	0.64	0.52	0.04	0.01	<0.01	0.01	0.02	<0.01	0	0.27	0.02	0.31	0.06	<0.01

Total fish counts in July 2012 by gear type and station (both replicates combined).

	Beach Seine						Otter Trawl						Purse Seine					
Station #	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Area Sampled (m^2)	372	402	372	372	310	248	1952	1952	1952	1952	1952	1952	694	694	694	694	694	694
Fish (# of indiv.)																		
Shovelnose guitarfish											1							
Round stingray								65	3		9	1						
Slough anchovy						21				13			330	173	8	38	8239	2739
Specklefin midshipman				1	1													
California halfbeak				2	2													3
California needlefish													1					1
California killifish		68	49	4	9	11												
California grunion	15		9															
Topsmelt	328	306	775	507	1235	372							7				10	
Bay pipefish				2	17	1												
Barred pipefish				1														
Staghorn sculpin		1	1															
Spotted sand bass							2	4										
Barred sand bass											1							
Sargo								1										
Queenfish										1								
Spotfin croaker													1					
Shiner surfperch	1									1								
Striped mullet														1				
Longjaw mudsucker		2	143	114	32	8												
Yellowfin goby		2	1															
Cheekspot goby		4	5	12	7													
Arrow/shadow goby		1	72	3	4	1												
Goby, unidentified juvenile					1	2												
California halibut				1				13		2	6							
Hornyhead turbot							1											
Diamond turbot							2	16			4							
Total	**344**	**384**	**1055**	**647**	**1308**	**416**	**5**	**99**	**3**	**17**	**21**	**1**	**339**	**174**	**8**	**38**	**8249**	**2743**
Total fish density (indiv/m^2)	0.92	0.96	2.84	1.74	4.22	1.68	0.00	0.05	<0.01	0.01	0.01	<0.01	0.49	0.25	0.01	0.05	11.89	3.95

Total fish counts in October 2012 by gear type and station (both replicates combined).

	Beach Seine						Otter Trawl						Purse Seine					
Station #	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Area Sampled (m^2)	466	310	466	310	310	248	1952	1952	1952	1952	1952	1952	694	694	694	694	694	694
Fish (# of indiv.)																		
Bat ray											1						1	
Round stingray				1			38	14	34	1	15	2						
California butterfly ray					1													
Slough anchovy						1					1		674	742	398	24	402	567
Specklefin midshipman										3								
California halfbeak				1												7	4	4
California needlefish	1												4				1	
California killifish		443	326	62	13	204												
Topsmelt	300	577	1274	219	606	237							69		75			
Bay pipefish					1	1												
Kelp bass							26	13	5			1						
Barred sand bass							2	1										
Salema									1									
Queenfish						3			16									
Yellowfin croaker							1		2	1								
Striped mullet				18		3												
California barracuda													1					
Bay blenny							1											
Yellowfin goby	1									2								
Cheekspot goby		4																
Arrow/shadow goby		1	1															
California halibut	1	2		3			8	4	3	5	13	1						
Hornyhead turbot							1											
Diamond turbot							2	5	14		4							
Total	**303**	**1027**	**1601**	**304**	**621**	**449**	**79**	**37**	**75**	**12**	**34**	**4**	**748**	**742**	**473**	**31**	**408**	**571**
Total fish density (indiv/m^2)	0.65	3.31	3.44	0.98	2.00	1.81	0.04	0.02	0.04	0.01	0.02	<0.01	1.08	1.07	0.68	0.04	0.59	0.82

Fish mass (g) in January 2012 by gear type and station (both replicates combined).

	Beach Seine						Otter Trawl						Purse Seine					
Station #	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Area Sampled (m^2)	465	388	419	605	558	326	1952	1952	1952	1952	1952	1952	694	694	694	694	694	694
Fish mass (g)																		
Anchovy, unid. juvenile															0.1			
Atherinid juvenile	2.7	2.4	0.5	0.4	2.0	0.1									1.7	0.7		
Bay pipefish	0.1																	
California halibut					23.6													
California killifish		829.6			0.2													
California lizardfish															1.5			
California needlefish																368.0		
Cheekspot goby	0.2	0.2			0.1	0.2												
Diamond turbot									430.0									
Northern anchovy													2.4		1.9	8.0		
Queenfish												53.0						
Round stingray								290.0	515.0									
Slough anchovy				2.7	2.3							11.6	0.2		0.2	15.9	29.4	
Staghorn sculpin				1.1	1.3													
Topsmelt	25.8			1141.3	181.3									400.5	3.3	5.6	43.5	
Total (g)	**28.8**	**832.2**	**0.5**	**1145.5**	**210.8**	**0.3**	**0.0**	**290.0**	**945.0**	**0.0**	**0.0**	**64.6**	**2.6**	**400.5**	**8.7**	**398.2**	**72.9**	**0.0**
Total biomass (g/m^2)	0.06	2.14	<0.01	1.89	0.38	<0.01	0.00	0.15	0.48	0.00	0.00	0.03	<0.01	0.58	0.01	0.57	0.11	0.00

Fish mass (g) in April 2012 by gear type and station (both replicates combined).

	Beach Seine						Otter Trawl						Purse Seine					
Station #	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Area Sampled (m^2)	372	372	465	403	310	279	1952	1952	1952	1952	1952	1952	694	694	694	694	694	694
Fish mass (g)																		
Arrow/shadow goby complex		0.6			0.4													
Barred pipefish					1.7													
Barred sand bass									12.0									
California barracuda																	530.0	680.0
California butterfly ray											10200.0							
California halibut					3.8		662.0	2440.0	95.0	1185.0	365.0							
California killifish				299.2		0.7												
Diamond turbot				29.9	2.3	1.7	4210.0	980.0	540.0									
Gray smoothhound												1300.0						
Hornyhead turbot							282.0											
Northern anchovy																318.7	4.3	
Queenfish																	345.0	
Round stingray					425.0	2522.0	6520.0	1030.0	250.0	7070.0	12080.0	510.0		233.0				
Shiner surfperch	27.4	24.8	28.9		8.8	125.8	26.0			65.0	46.0	79.0						
Slough anchovy						0.8	2.5					2.0						
Specklefin midshipman										200.0								
Spotfin croaker							1050.0											
Staghorn sculpin		17.3			6.8	29.6												
Topsmelt	1770.8	3183.4	1947.0	2443.9	1977.7	926.3								4139.4	280.7	620.0	331.0	
Yellowfin croaker							240.0											
Yellowfin goby				0.1	2.5	1.5												
Total (g)	**1798.2**	**3226.1**	**1975.9**	**2773.1**	**2429.0**	**3608.4**	**12992.5**	**4450.0**	**897.0**	**8520.0**	**22691.0**	**1891.0**	**0.0**	**4372.4**	**280.7**	**938.7**	**1210.3**	**680.0**
Total biomass (g/m^2)	4.83	8.67	4.25	6.88	7.84	12.93	6.66	2.28	0.46	4.36	11.62	0.97	0.00	6.30	0.40	1.35	1.74	0.98

Fish mass (g) in July 2012 by gear type and station (both replicates combined).

	Beach Seine						Otter Trawl						Purse Seine					
Station #	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Area Sampled (m^2)	372	402	372	372	310	248	1952	1952	1952	1952	1952	1952	694	694	694	694	694	694
Fish mass (g)																		
Arrow/shadow goby complex		0.6	20.7	1.8	1.1	0.2												
Barred pipefish				0.9														
Barred sand bass											54.0							
Bay pipefish				0.6	5.3	0.1												
California grunion	6.4		2.0															
California halfbeak				0.2	0.4													0.3
California halibut				4.4				889.0		55.0	373.0							
California killifish		41.3	6.9	12.9	7.0	7.7												
California needlefish													0.5					152.0
Cheekspot goby		0.5	0.5	2.4	0.9													
Diamond turbot							360.0	3910.0			1234.0							
Goby, unid. juvenile					0.1	0.2												
Hornyhead turbot							50.0											
Longjaw mudsucker		1.3	44.5	46.8	15.5	2.1												
Queenfish										2.0								
Round stingray								12241.0	1352.0		2773.0	125.0						
Sargo								91.0										
Shiner surfperch	5.9									20.0								
Shovelnose guitarfish											907.0							
Slough anchovy						13.5				20.0			701.7	528.2	1.2	3.8	2038.7	132.4
Specklefin midshipman				0.2	1.1													
Spotfin croaker													474.0					
Spotted sand bass							650.0	1356.0										
Staghorn sculpin		7.1	5.9															
Striped mullet														800.0				
Topsmelt	327.5	285.6	341.8	157.9	497.9	65.0							6.8				215.1	
Yellowfin goby		2.0	1.2															
Total (g)	**339.8**	**338.4**	**423.5**	**228.1**	**529.3**	**88.8**	**1060.0**	**18487.0**	**1352.0**	**97.0**	**5341.0**	**125.0**	**1183.0**	**1328.2**	**1.2**	**3.8**	**2253.8**	**284.7**
Total biomass (g/m^2)	0.91	0.84	1.14	0.61	1.71	0.36	0.54	9.47	0.69	0.05	2.74	0.06	1.70	1.91	<0.01	0.01	3.25	0.41

Fish mass (g) in October 2012 by gear type and station (both replicates combined).

	Beach Seine						Otter Trawl						Purse Seine					
Station #	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Area Sampled (m^2)	466	310	466	310	310	248	1952	1952	1952	1952	1952	1952	694	694	694	694	694	694
Fish mass (g)																		
Arrow/shadow goby complex		0.3	0.5															
Barred sand bass							153.2	45.2										
Bat ray											190.0						550.0	
Bay blenny							1.5											
Bay pipefish					0.1	0.1												
California barracuda													1.1					
California butterfly ray					275.0													
California halfbeak				3.5												2.9	1.3	6.4
California halibut	5.5	96.3		50.5			206.6	645.4	165.0	139.0	1605.0	123.0						
California killifish		1162.2	1159.6	158.4	17.6	179.0												
California needlefish	0.3												340.8				200.0	
Cheekspot goby		1.1																
Diamond turbot							564.7	1131.8	3251.0		975.0							
Hornyhead turbot							18.0											
Kelp bass							149.0	88.2	40.0			0.6						
Queenfish						2.0			19.7									
Round stingray				228.0			8068.2	2444.0	8779.0	223.0	3084.0	348.0						
Salema									70.0									
Slough anchovy						0.9					0.3		1158.6	1116.0	569.3	3.6	112.6	65.8
Specklefin midshipman										1.0								
Striped mullet				4.1		2.5												
Topsmelt	1026.4	986.7	2153.4	1157.7	1226.6	594.2							156.5		250.5			
Yellowfin croaker							58.8		389.0	241.0								
Yellowfin goby	10.8									33.0								
Total (g)	**1043.0**	**2246.6**	**3313.5**	**1602.2**	**1519.3**	**778.7**	**9220.0**	**4354.6**	**12713.7**	**637.0**	**5854.3**	**471.6**	**1657.0**	**1116.0**	**819.8**	**6.5**	**863.9**	**72.2**
Total biomass (g/m^2)	2.24	7.25	7.11	5.17	4.90	3.14	4.72	2.23	6.51	0.33	3.00	0.24	2.39	1.61	1.18	0.01	1.24	0.10

Appendix G
Epibenthic Invertebrate Raw Data

Epibenthic organisms observed in 1 m^2 quadrat survey in January and July 2012 at UNB (# of individuals or % cover).

January 2012 - Stations 1-3

			Sta 1			Sta 1			Sta 2			Sta 2			Sta 3			Sta 3		
			+ 1-foot			-2-foot			+ 1-foot			-2-foot			+ 1-foot			-2-foot		
Phylum	**Taxa**	**Common name**	Rep 1	Rep2	Rep 3	Rep 1	Rep2	Rep 3	Rep 1	Rep2	Rep 3	Sta 1	Sta 2	Sta 3	Rep 1	Rep2	Rep 3	Rep 1	Rep2	Rep 3
Cnidaria	*Aurelia* sp.	Moon jelly																		
Mollusca	*Geukensia demissa**	Ribbed horsemussel										5	20	10				20	35	50
Plants/Algae	*Ulva* sp.									1%										
	Enteromorpha sp.								1%											

January 2012 - Stations 4-6

			Sta 4			Sta 4			Sta 5			Sta 5			Sta 6			Sta 6		
			+ 1-foot			-2-foot			+ 1-foot			-2-foot			+ 1-foot			-2-foot		
Phylum	**Taxa**	**Common name**	Rep 1	Rep2	Rep 3	Rep 1	Rep2	Rep 3	Rep 1	Rep2	Rep 3	Sta 1	Sta 2	Sta 3	Rep 1	Rep2	Rep 3	Rep 1	Rep2	Rep 3
Cnidaria	*Aurelia* sp.	Moon jelly													1					
Mollusca	*Geukensia demissa**	Ribbed horsemussel																		
Plants/Algae	*Ulva* sp.																			
	Enteromorpha sp.		5%	5%	5%															

* non-native species

July 2012 - Stations 1-3

			Sta 1			Sta 1			Sta 2			Sta 2			Sta 3			Sta 3		
			+ 1-foot			-2-foot			+ 1-foot			-2-foot			+ 1-foot			-2-foot		
Phylum	**Taxa**	**Common name**	Rep 1	Rep2	Rep 3	Rep 1	Rep2	Rep 3	Rep 1	Rep2	Rep 3	Sta 1	Sta 2	Sta 3	Rep 1	Rep2	Rep 3	Rep 1	Rep2	Rep 3
Arthropoda	*Hemigrapsus oregonens*	Yellow shore crab				1						1								
Porifera		Green sponge																1		
Mollusca	*Geukensia demissa**	Ribbed horsemussel																	15	
Plants/Algae	*Ulva* sp.	Green algae																		
	Enteromorpha sp.	Green algae													10%					
	Ceramium sp.	Red algae													50%	50%	40%	10%		

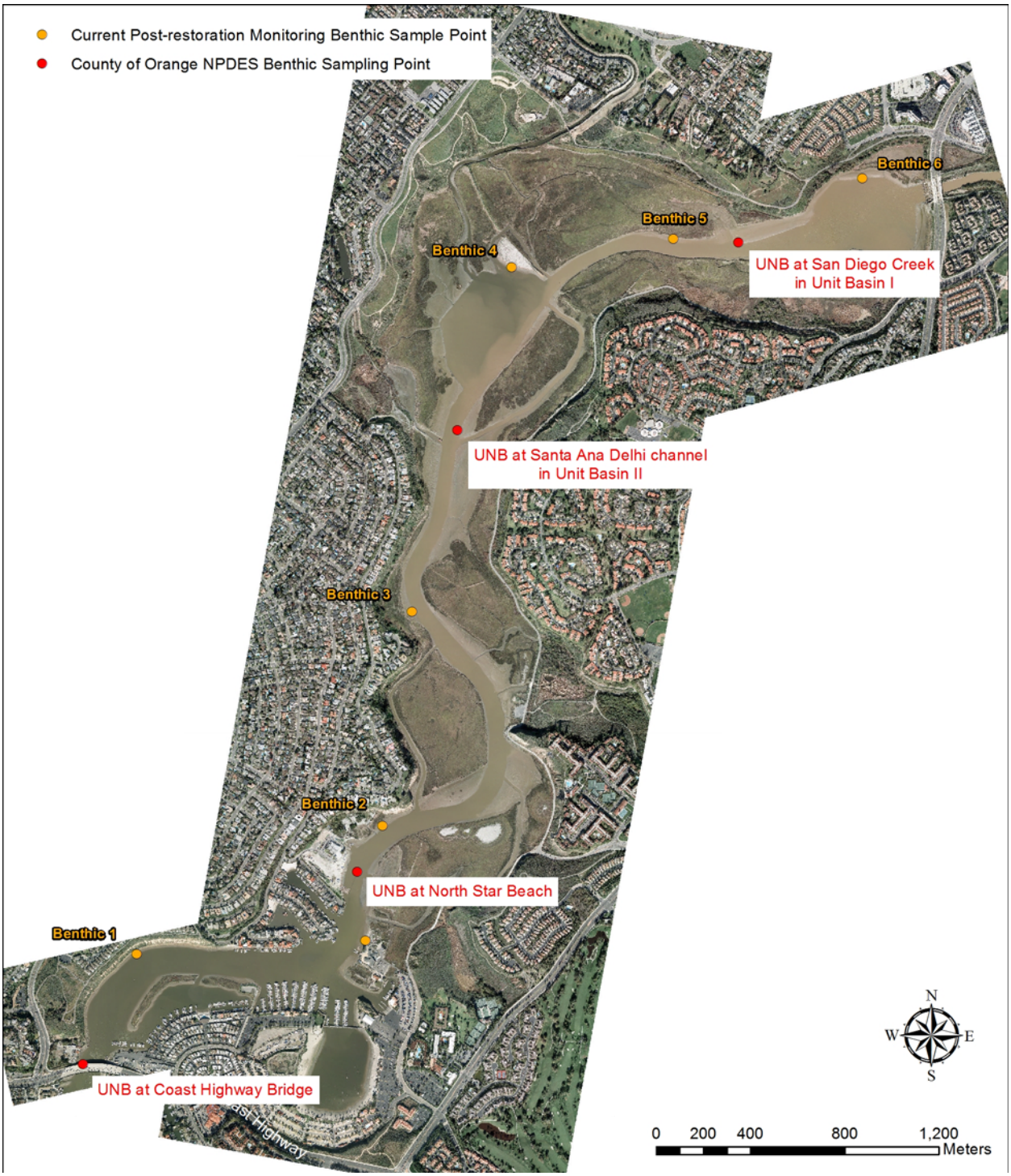
July 2012 - Stations 4-6

			Sta 4			Sta 4			Sta 5			Sta 5			Sta 6			Sta 6		
			+ 1-foot			-2-foot			+ 1-foot			-2-foot			+ 1-foot			-2-foot		
Phylum	**Taxa**	**Common name**	Rep 1	Rep2	Rep 3	Rep 1	Rep2	Rep 3	Rep 1	Rep2	Rep 3	Sta 1	Sta 2	Sta 3	Rep 1	Rep2	Rep 3	Rep 1	Rep2	Rep 3
Arthropoda	*Hemigrapsus oregonens*	Yellow shore crab																		
Porifera		Green sponge																		
Mollusca	*Geukensia demissa**	Ribbed horsemussel															1			
Plants/Algae	*Ulva* sp.	Green algae							10%	50%	20%	10%	20%	20%	10%	10%	20%	50%	50%	20%
	Enteromorpha sp.	Green algae	80%	40%	50%	100%	50%	20%	20%		80%	20%	50%		100%	90%	70%		20%	20%
	Ceramium sp.	Red algae						20%	50%	50%	10%	80%	40%	70%	10%	10%	10%	100%	80%	50%

* non-native species

Appendix H
Benthic Sample Points

Comparison of benthic sampling points with NPDES sampling points.



Appendix I
Vegetation Transect Data

Vegetation transect data for Transect 1 in September 2012 (values are percent cover in 0.5m^2 quadrat).

Transect #	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Plot # (feet from transect start)	0	15	30	46	58	66	75	90	120	155	200	240	270	300	350
Apium graveolens												trace	15		
Arthrocnemum subterminale				60											
Batis maritima					60	90	70								
Bolboschoenus maritimus										20		30	70		
Carpobrotus chilensis															
Cressa truxillensis							20	trace							
Cuscuta salina						5		5					70		
Distichlis spicata							trace	25	5	15	95	30			
Frankenia salina						40									
Heterotheca grandiflora															
Jaumea carnosa			trace	5				100	100	100	90	100	90		
Juncus acutus															
Limonium californicum															
Limonium ramosissimum						35	30	50							
Monanthochloe littoralis								50							
Polypogon monspeliensis											5				
Salicornia bigelovii															
Sarcocornia pacifica			35	60	100	55	10	trace	5	trace	25	trace			
Spartina foliosa	100	100	90	5											
Suaeda esteroa						5									
Suaeda taxifolia															
Triglochin maritima															
Typha domingensis														100	100
Atriplex prostrata															
Open Open															
Bare Ground															
Habitat Type FW,H, M, L, SP, U	L	L	L	M	M	M	M	H	H	H	H	FM	FM	FM	FM

Vegetation transect data for Transect 2 in September 2012 (values are percent cover in 0.5m^2 quadrat).

Transect #	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Plot # (feet from transect start)	0	8	25	60	80	100	120	150	200	250	300	350	400	450	500	550	600	650	700	750	800	822
Apium graveolens																						
Arthrocnemum subterminale																						
Batis maritima			50	100		40		10	25	5					100	100						
Bolboschoenus maritimus												15										
Carpobrotus chilensis																						
Cressa truxillensis							trace															35
Cuscuta salina				5	30						5	trace	40	80	50							
Distichlis spicata										35	35	15		100		25	25	100	trace	95	10	70
Frankenia salina							100			80	10											
Heterotheca grandiflora																						
Jaumea carnosa					50	5				100	80	100		15			100				100	
Juncus acutus													100									
Limonium californicum					trace																	
Limonium ramosissimum					55																	
Monanthochloe littoralis						85																
Polypogon monspeliensis																						
Salicornia bigelovii																						
Sarcocornia pacifica		35	100	15		35	10	100	100	10		15	50	25	50	50		95		25	5	25
Spartina foliosa	100	80	trace																			
Suaeda esteroa											25			5				trace				
Suaeda taxifolia																						
Triglochin maritima																						
Typha domingensis																						
Atriplex prostrata																						20
Open Open																						
Bare Ground																			100			
Habitat Type FW,H, M, L, SP, U	L	L	M	M	H	H	H	M	M	M	M	M	M	M	M	M	M	M	SP	M	M	M

Vegetation transect data for Transect 3 in September 2012 (values are percent cover in 0.5m^2 quadrat).

Transect #	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Plot # (feet from transect start)	0	10	20	70	120	170	220	270	320	370	420	470	520	570	620	670	720	734	760
Apium graveolens																			
Arthrocnemum subterminale																			
Batis maritima			15	5	65	55	100	80	80				100	70	25	100	90	5	85
Bolboschoenus maritimus																			
Carpobrotus chilensis																			
Cressa truxillensis																			
Cuscuta salina				5									trace	5					
Distichlis spicata					15	5												100	
Frankenia salina			80	100		95		50					5					5	5
Heterotheca grandiflora																			
Jaumea carnosa			40	5	10								trace	trace	10				
Juncus acutus																			
Limonium californicum				trace	10									5					
Limonium ramosissimum																			
Monanthochloe littoralis								5											
Polypogon monspeliensis																			
Salicornia bigelovii																			
Sarcocornia pacifica			100	80	45	15	30	90					20	60	100	15	95	5	80
Spartina foliosa	100	100								100		10							
Suaeda esteroa				10									trace						
Suaeda taxifolia																			
Triglochin maritima																			
Typha domingensis																			
Atriplex prostrata																			
Open Open																			
Bare Ground											100	90							
Habitat Type FW,H, M, L, SP, U	L	L	M	M	M	M	M	M	M	L	MF	L	M	M	M	M	M	H	M

Vegetation transect data for Transect 4 in September 2012 (values are percent cover in 0.5m^2 quadrat).

Transect #	4	4	4	4	4	4	4	4	4	4
Plot # (feet from transect start)	0	40	80	120	160	200	240	280	330	370
Apium graveolens										
Arthrocnemum subterminale										
Batis maritima			80			5	35		85	
Bolboschoenus maritimus										
Carpobrotus chilensis										
Cressa truxillensis										5
Cuscuta salina		25						85		
Distichlis spicata										
Frankenia salina									5	60
Heterotheca grandiflora										
Jaumea carnosa		100	5	100	100	100	100	100		
Juncus acutus										
Limonium californicum								30		
Limonium ramosissimum										
Monanthochloe littoralis										50
Polypogon monspeliensis										
Salicornia bigelovii										
Sarcocornia pacifica	80	15	40	20			15	10	60	
Spartina foliosa	55	20	25	30	30	50	45			
Suaeda esteroa										
Suaeda taxifolia										
Triglochin maritima										
Typha domingensis										
Atriplex prostrata										
Open Open										
Bare Ground										
Habitat Type FW,H, M, L, SP, U	L	M	M	M	M	M	M	M	M	H

Vegetation transect data for Transect 5 in September 2012 (values are percent cover in 0.5m^2 quadrat).

Transect #	5	5	5	5	5	5	5	5	5	5	5	5	5
Plot # (feet from transect start)	0	50	100	150	200	250	300	350	400	450	500	550	611
Apium graveolens													
Arthrocnemum subterminale													
Batis maritima					5				100	80	20		
Bolboschoenus maritimus													
Carpobrotus chilensis													
Cressa truxillensis													
Cuscuta salina												50	
Distichlis spicata												40	95
Frankenia salina												85	
Heterotheca grandiflora													
Jaumea carnosa					30	100					100	85	20
Juncus acutus													
Limonium californicum													
Limonium ramosissimum													
Monanthochloe littoralis													
Polypogon monspeliensis													
Salicornia bigelovii													
Sarcocornia pacifica		80	100	100	75	45	95			trace	5	35	10
Spartina foliosa	100	100	60	60	65	35	30	85	95	85	50		
Suaeda esteroa													
Suaeda taxifolia													
Triglochin maritima													
Typha domingensis													
Atriplex prostrata													
Open Open								15					
Bare Ground													
Habitat Type FW,H, M, L, SP, U	L	L	L	L	L	L	L	L	L	L	L	H	H

Vegetation transect data for Transect 6 in September 2012 (values are percent cover in 0.5m^2 quadrat).

Transect #	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Plot # (feet from transect start)	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	868
Apium graveolens																			
Arthrocnemum subterminale																			
Batis maritima				80	40	85	70									35	50		
Bolboschoenus maritimus																			
Carpobrotus chilensis																			
Cressa truxillensis																			
Cuscuta salina								5						5	30		5		
Distichlis spicata								75	100					5		85		25	trace
Frankenia salina									85									10	
Heterotheca grandiflora																			
Jaumea carnosa		trace		5			20	100						80	95	80	55	80	
Juncus acutus																	20		
Limonium californicum																			
Limonium ramosissimum																			
Monanthochloe littoralis																		30	
Polypogon monspeliensis																			
Salicornia bigelovii																			
Sarcocornia pacifica	5				10		100	50						90	85		60		15
Spartina foliosa	60	100	70	100	100	25	50												
Suaeda esteroa																		15	100
Suaeda taxifolia																			
Triglochin maritima																			
Typha domingensis																			
Atriplex prostrata									5										
Open Open																			
Bare Ground	40		30			10				100	100	100	100						
Habitat Type FW,H, M, L, SP, U	L	L	L	L	L	L	L	M	H	water	water	water	water	M	M	M	M	M	M

Vegetation transect data for Transect 7 in September 2012 (values are percent cover in 0.5m^2 quadrat).

Transect #	7	7	7	7	7	7	7	7	7	7	7	7	7
Plot # (feet from transect start)	0	15	30	50	100	150	200	250	300	350	400	450	480
Apium graveolens													
Arthrocnemum subterminale													
Batis maritima				10	15	30	5		trace		5	10	75
Bolboschoenus maritimus													
Carpobrotus chilensis													
Cressa truxillensis													
Cuscuta salina					15								
Distichlis spicata				60	90	60	30	15	15		5		
Frankenia salina					5	trace	trace	5		10	15		
Heterotheca grandiflora													
Jaumea carnosa				5	trace	15			trace		15	15	35
Juncus acutus													
Limonium californicum				15	5						15		
Limonium ramosissimum													
Monanthochloe littoralis													
Polypogon monspeliensis													
Salicornia bigelovii													
Sarcocornia pacifica			10	85	85	60	100	95	100	100		95	20
Spartina foliosa	50	80	100	5		10	10	40	50	15		25	5
Suaeda esteroa													30
Suaeda taxifolia													
Triglochin maritima													
Typha domingensis													
Atriplex prostrata													
Open Open													
Bare Ground	50	20											
Habitat Type FW,H, M, L, SP, U	L	L	L	M	M	M	M	M	M	M	M	M	M

Vegetation transect data for Transect 8 in September 2012 (values are percent cover in 0.5m^2 quadrat).

Transect #	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Plot # (feet from transect start)	0	6	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	968
Apium graveolens																						
Arthrocnemum subterminale																						
Batis maritima		20		5	30	5		trace	15	10	15	15	55	50	55	40	70	15				
Bolboschoenus maritimus																						
Carpobrotus chilensis																						
Cressa truxillensis																						
Cuscuta salina			20																			
Distichlis spicata			25	30	20	25	50	45		20	5	15	5	25	35	trace						
Frankenia salina									trace													
Heterotheca grandiflora																						
Jaumea carnosa		5	95	95	80	100	85	100	25	20	100	15	10	5	50	40	5					
Juncus acutus																						
Limonium californicum			5						25						5							
Limonium ramosissimum																						
Monanthochloe littoralis									trace													
Polypogon monspeliensis																						
Salicornia bigelovii																						
Sarcocornia pacifica	30	85		15	80	50	95	100	100	100	10	100	100	100		80	35	100	25	5		
Spartina foliosa	70										5		5	5		5	20	5		100	100	100
Suaeda esteroa																						
Suaeda taxifolia																						
Triglochin maritima																						
Typha domingensis																						
Atriplex prostrata																						
Open Open																						
Bare Ground	10																		75			
Habitat Type FW,H, M, L, SP, U	L	L	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	L	L

Vegetation transect data for Transect 9 in September 2012 (values are percent cover in 0.5m^2 quadrat).

Transect #	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Plot # (feet from transect start)	0	20	50	150	200	250	300	350	400	450	500	550	600	650	700
Apium graveolens															
Arthrocnemum subterminale															
Batis maritima						100	70	10	40	10		5	trace		
Bolboschoenus maritimus															
Carpobrotus chilensis				50											
Cressa truxillensis	10														
Cuscuta salina		100										trace			
Distichlis spicata				95					60	50	10	trace	5	45	
Frankenia salina	5					trace	5					5	5		
Heterotheca grandiflora			15												
Jaumea carnosa					10		5	100	20	55	60		50	100	
Juncus acutus															
Limonium californicum	10				15		5					10	15		
Limonium ramosissimum															
Monanthochloe littoralis	60				5							20			
Polypogon monspeliensis															
Salicornia bigelovii															
Sarcocornia pacifica	5				100	50	60	5	100	95	80	90	85	95	
Spartina foliosa								100	50					trace	100
Suaeda esteroa							40								
Suaeda taxifolia															
Triglochin maritima															
Typha domingensis															
Atriplex prostrata															
Open Open															
Bare Ground															
Habitat Type FW,H, M, L, SP, U	H	H	upland	H	H	M	M	L	L	M	M	M	M	M	L

Vegetation transect data for Transect 10 in September 2012 (values are percent cover in 0.5m^2 quadrat).

Transect #	10	10	10	10	10	10	10	10	10	10	10	10
Plot # (feet from transect start)	0	6	50	100	150	200	250	300	350	400	450	492
Apium graveolens												
Arthrocnemum subterminale								15				
Batis maritima		15		5								
Bolboschoenus maritimus												
Carpobrotus chilensis					30	100	100					
Cressa truxillensis												
Cuscuta salina											trace	
Distichlis spicata					80							
Frankenia salina		55	25	5					5	5		5
Heterotheca grandiflora												
Jaumea carnosa		5	55	90					100	95	85	80
Juncus acutus												
Limonium californicum			10								5	10
Limonium ramosissimum												
Monanthochloe littoralis			70	60				100				trace
Polypogon monspeliensis												
Salicornia bigelovii		5										
Sarcocornia pacifica				20					10	20	25	5
Spartina foliosa	100	25										
Suaeda esteroa			5									5
Suaeda taxifolia												
Triglochin maritima												
Typha domingensis												
Atriplex prostrata												
Open Open												
Bare Ground												
Habitat Type FW,H, M, L, SP, U	L	L	H	M	H	upland	upland	H	M	M	M	M

Appendix J
Vegetation Transect Photos and Additional Field Photos from Transect Monitoring
September 2012

Photo 1. Transect 1, viewed from north to south near the start of the transect.

Photo 2. Transect 1, viewed from south to north at the end of the transect..

Photo 3. Transect 2, viewed from north to south near the start of the transect.

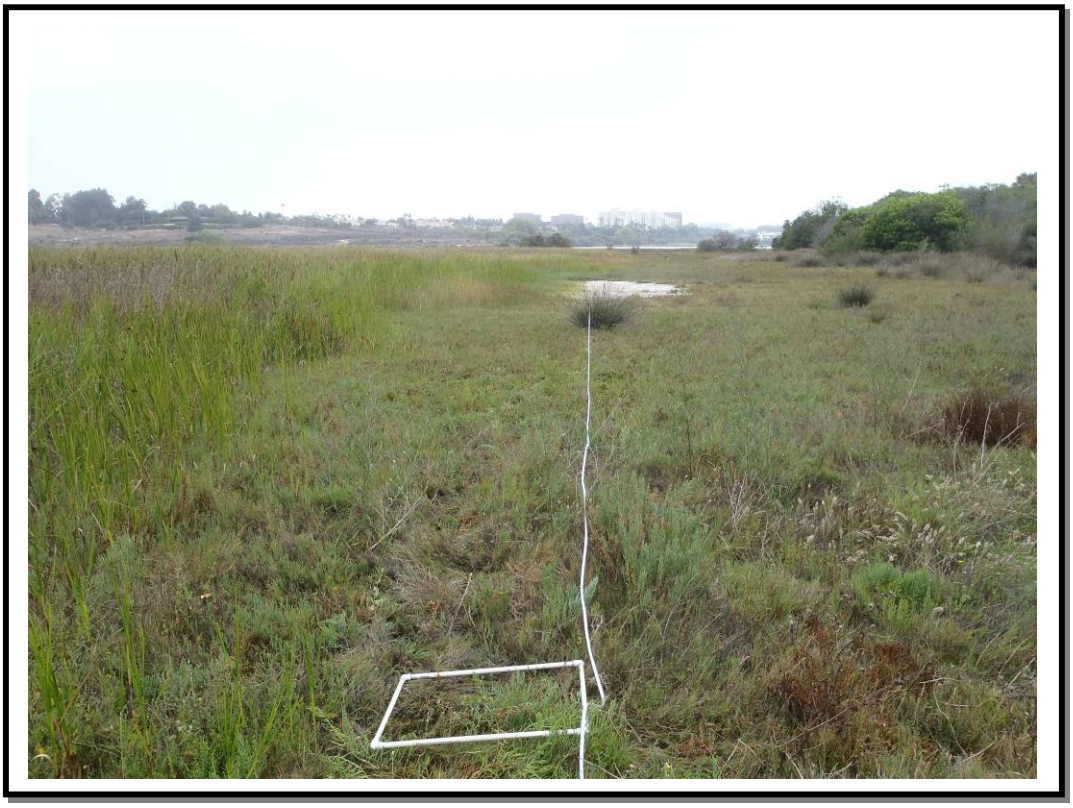


Photo 4. Transect 2, viewed from south to north at the end of the transect

Photo 5. Transect 3, viewed from south to north near the start of the transect.

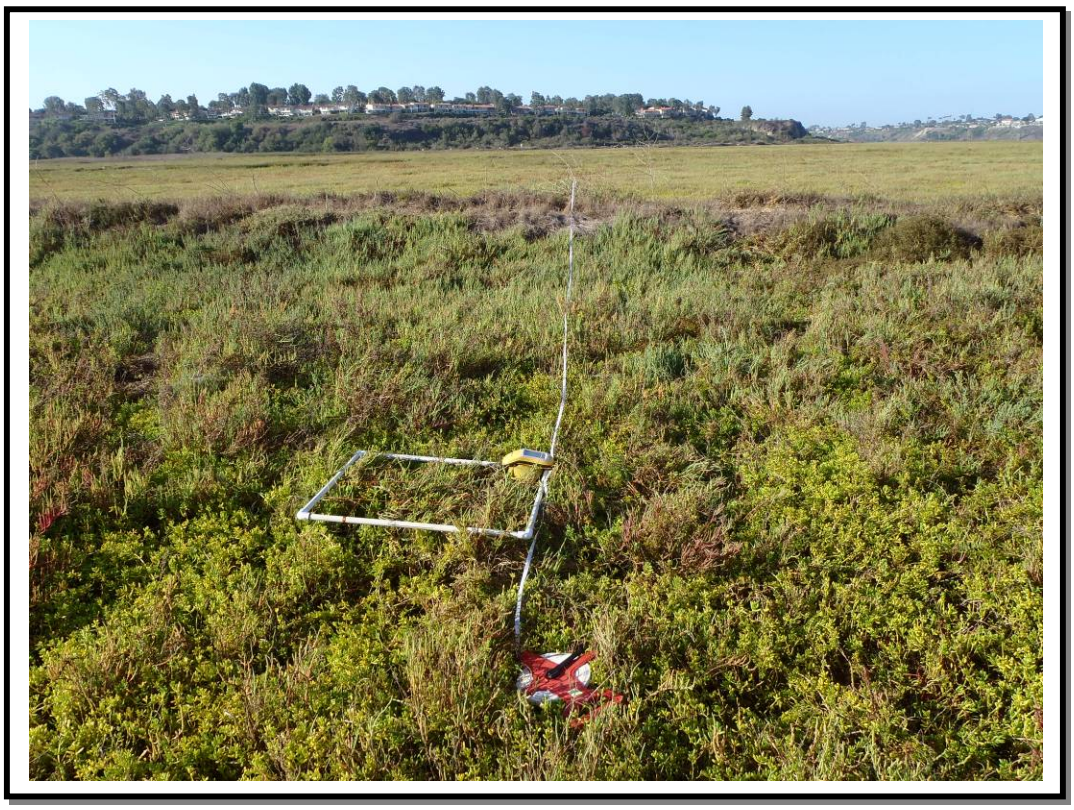


Photo 6. Transect 3, viewed from north to south at the end of the transect.

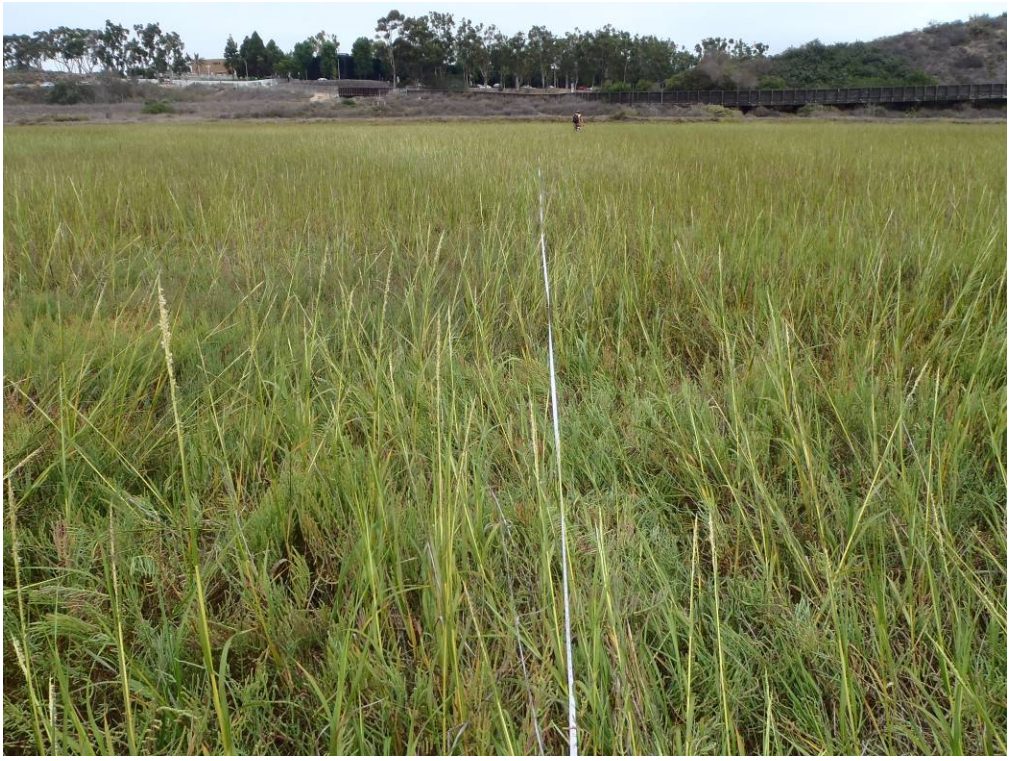


Photo 7. Transect 4, viewed from south to north near the start of the transect..

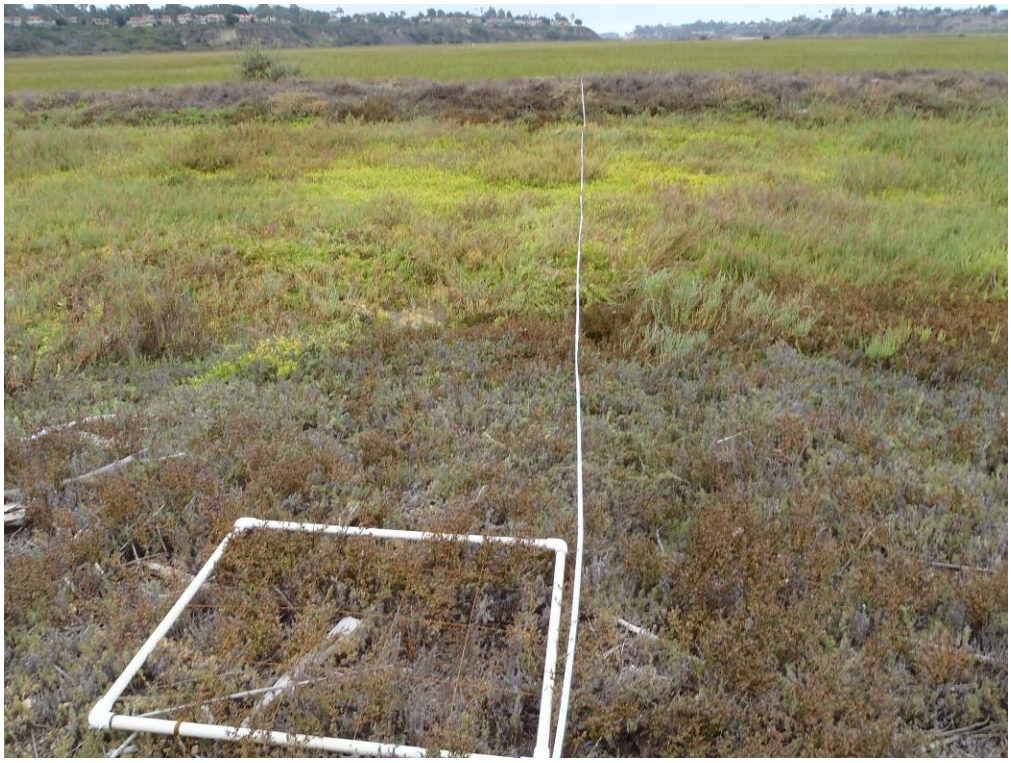


Photo 8. Transect 4, viewed from north to south at the end of the transect.

Photo 7. Transect 5, viewed from south to north near the start of the transect.

Photo 8. Transect 5, viewed from north to south at the end of the transect.

Photo 9. Transect 6, viewed from south to north at the start of the transect

Photo 10. Transect 6, viewed from north to south near the end of the transect

Photo 11. Transect 7, viewed from north to south near the start of the transect

Photo 12. Transect 7, viewed from south to north near the end of the transect

Photo 15. Transect 8, viewed from south to north near the start of the transect.

Photo 16. Transect 8, viewed from north to south near the end of the transect

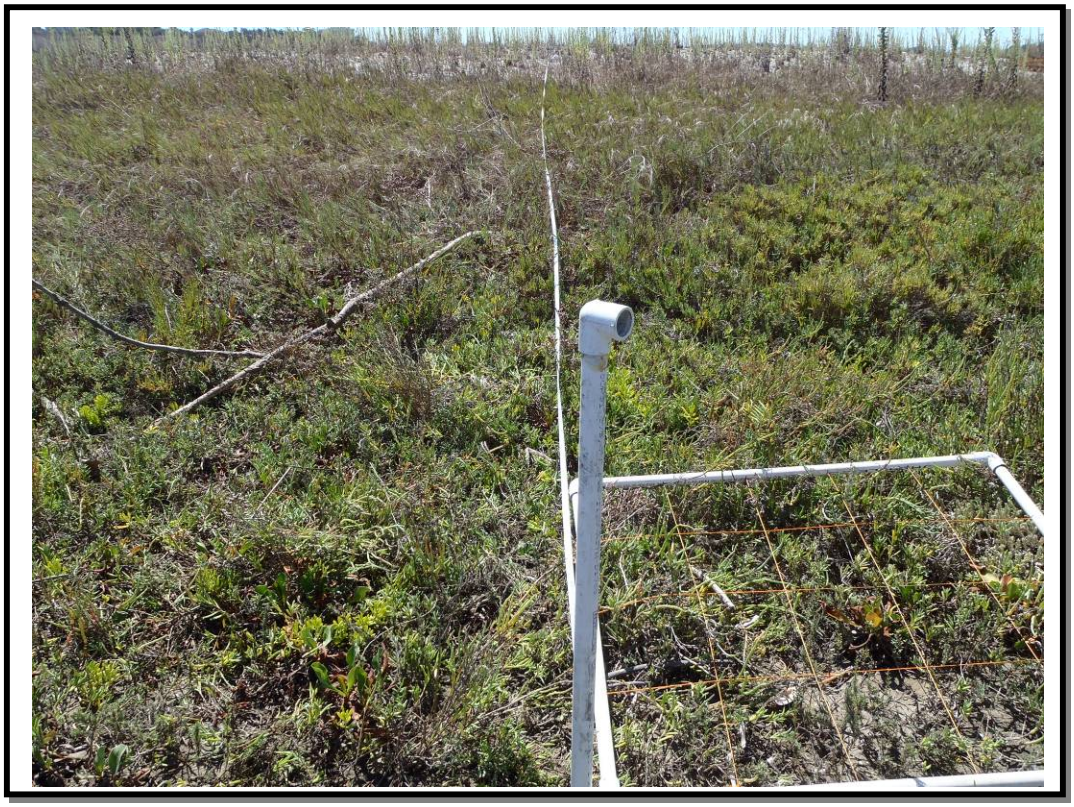


Photo 17. Transect 9, viewed from north to south at the start of the transect.

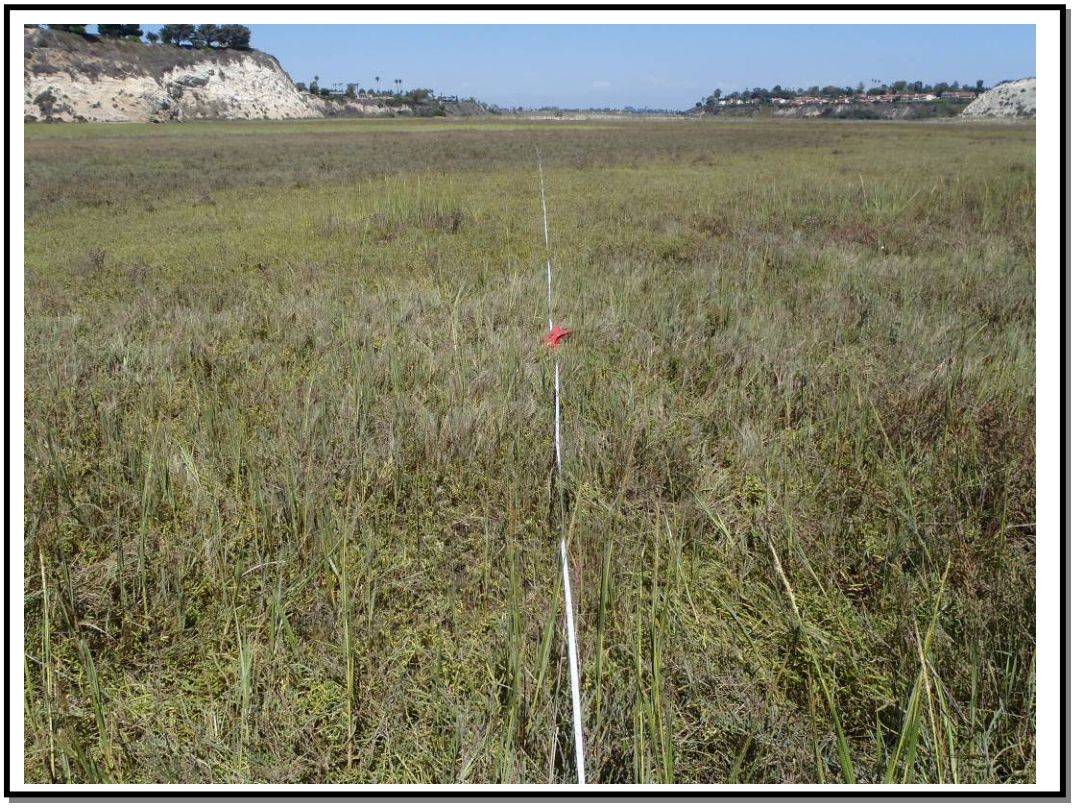


Photo 18. Transect 9, viewed from south to north near the end of the transect

Photo 19. Transect 10, viewed from west to east near the start of the transect.

Photo 20. Transect 10, viewed from east to west at the end of the transect

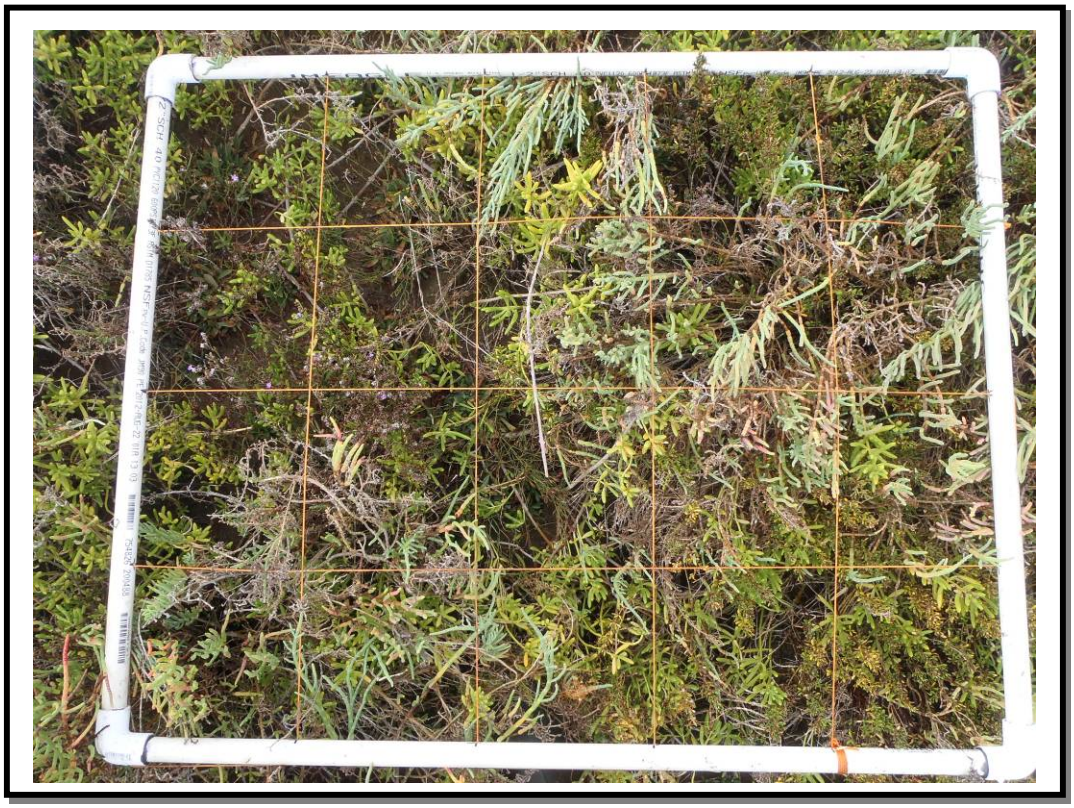


Photo 21. Typical UNB middle marsh plot (Transect 1). Note short stature.

Photo 22. Non-native invasive Algerian sealavender (*Limonium ramosissimum*) near Transect 2

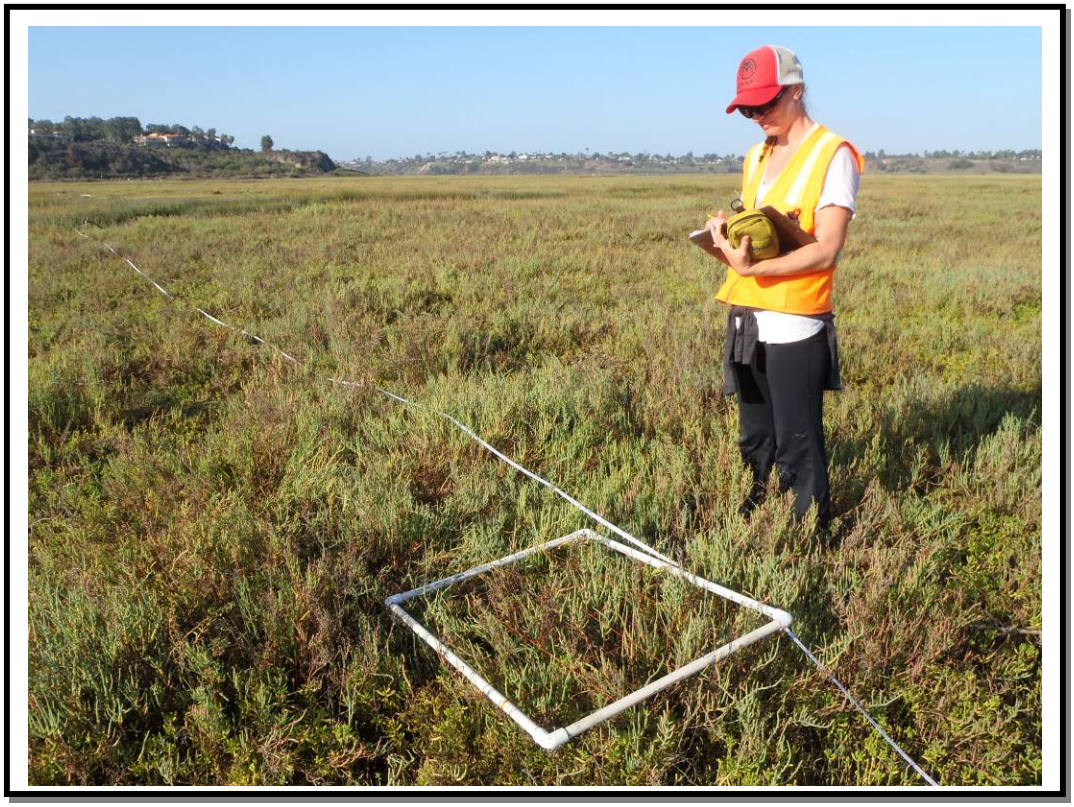


Photo 23. Higher canopy height middle marsh on Transect 3.

Photo 24. Middle marsh on Transect 4 dominated by jaumea and interspersed with sparse cordgrass.

Photo 25. Cordgrass in the low marsh on Transect 5.

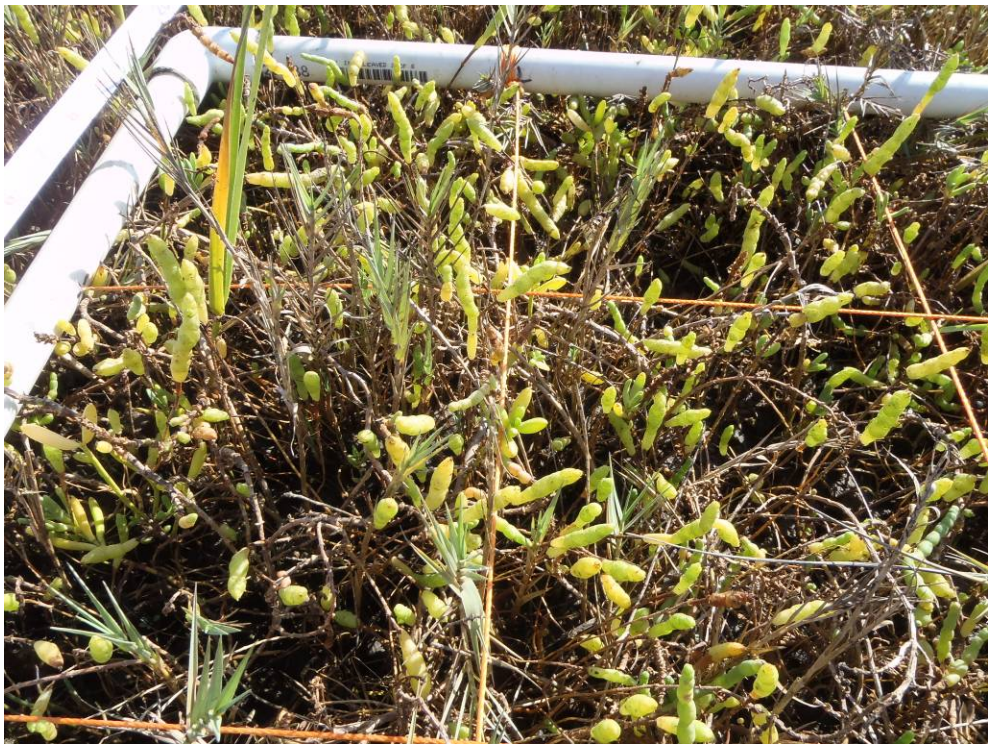


Photo 26. Close-up of middle salt marsh on Transect 7. Note short stature.

Photo 27. Middle salt marsh on Transect 8. Note sparse density and low stature.

Photo 28. Sand crossed by Transect 9 (no sample plots placed here- not marsh).

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Photo 29. Middle salt marsh on Transect 9. Note short stature.

Photo 30. High salt marsh on Transect 10, dominated by shore grass (*Monanthochloe littoralis*).

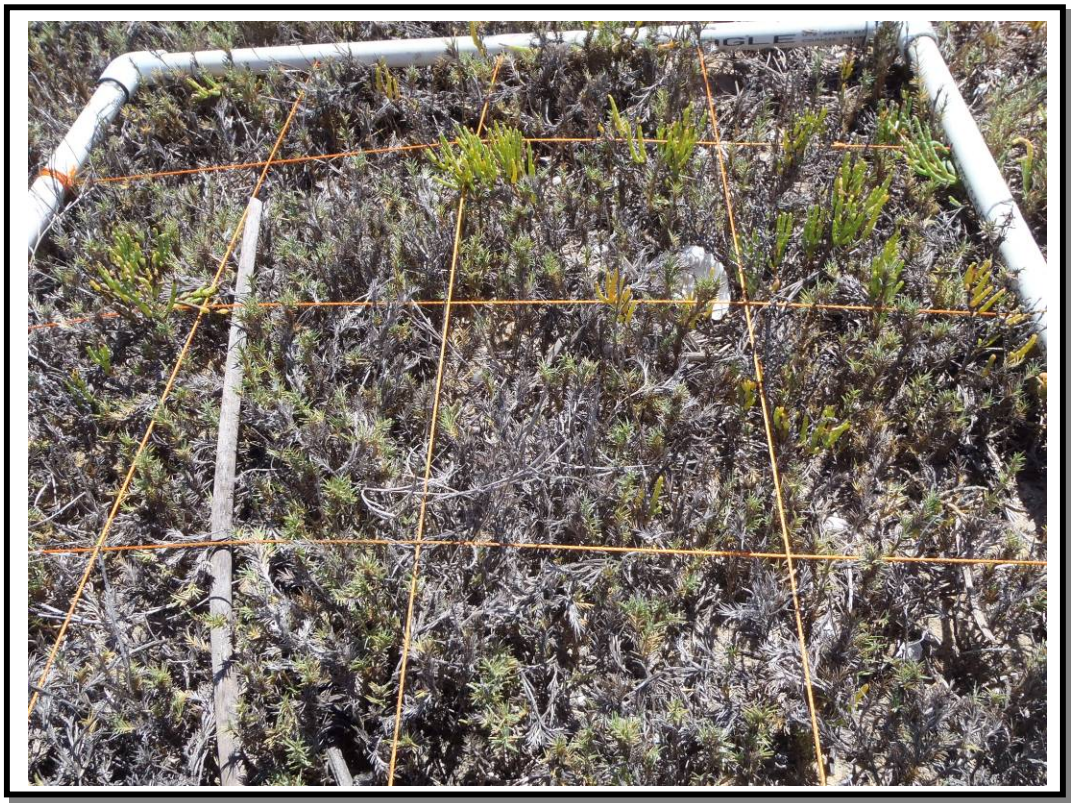


Photo 31. Close-up of high salt marsh on Transect 10.

Appendix K
California Rapid Assessment Method (CRAM) Report
September 2012

Basic Information Sheet: Perennial Estuarine Wetlands

CRAM Site ID:				
Project Site ID: Upper Newport Bay				
Assessment Area Name: AA1				
Project Name: UNB Ecosystem Restoration	**Date (m/d/y)**	09	11	2012

Assessment Team Members for This AA

Harold (Joe) Thompson - Merkel & Associates, Inc.

Rachel Woodfield - Merkel & Associates, Inc.

James Schacher - Merkel & Associates, Inc.

Center of AA:

Latitude: 33.65037 **Longitude:** -117.88268

Wetland Sub-type:

☒ Perennial Saline ☐ Perennial Non-saline

AA Category:

☒ Restoration ☐ Mitigation ☐ Impacted ☐ Ambient ☐ Reference ☐ Training

☐ Other:

What best describes the tidal stage over the course of the time spent in the field?
Note: It is recommended that the assessment be conducted during low tide.

☐ high tide ☒ low tide

Photo Identification Numbers and Description:

	Photo ID No.	Description	Latitude	Longitude	Datum
1	P1	North	33.65037	-117.88268	WGS84
2	P2	South	33.65037	-117.88268	WGS84
3	P3	East	33.65037	-117.88268	WGS84
4	P4	West	33.65037	-117.88268	WGS84
5	P5	Southeast	33.65046	-117.88223	WGS84
6	P6	North	33.65062	-117.88267	WGS84
7	P7	-	33.65030	-117.88305	WGS84
8	P8	Southwest	33.65002	-117.88228	WGS84
9	P9	East	33.65058	-117.88223	WGS84
10	P10	East	33.65051	-117.88172	WGS84

Site Location Description:

Newport Bay is located on the southern California coast, approximately 40 miles south of Los Angeles. The upper region of the bay is referred to as Upper Newport Bay (UNB). The 1,000-acre UNB is a drowned river valley, geologically much older than the lower region of the bay, and is largely undeveloped. This portion of the bay is more formally considered to be an estuary. Much of UNB is included in the Upper Newport Bay Ecological Reserve, managed by the California Department of Fish and Game. Natural habitats within UNB include open marine waters, intertidal mudflats, cordgrass-dominated low salt marsh, pickleweed-dominated mid salt marsh, high salt marsh, salt panne, riparian, freshwater marsh and upland. To facilitate long-term management of sediment deposition in UNB and to preserve the health of its habitats, a restoration project was initiated in 2006 and completed in 2010. Key project features included expansion and deepening of two sediment control basins, deepening of channels around five restoration islands, restoration of three large mudflats, relocation of a least tern nesting island, installation of maintenance access at the two nesting islands, and installation of interpretive signs and buoys. Approximately 2.35 million cubic yards of sediment was dredged as part of the project.

The AA is located on the north side of the deepened main channel in southern coastal salt marsh, at low marsh elevations. Due to the low elevation, plant diversity is limited, as would be expected. This region of UNB was not part of the restoration project and any effects from the restoration work would have been indirect, related to improved tidal circulation and reduced turbidity. Examination of aerial photographs from before and after the restoration, and vegetation transect work conducted nearby in 2004 and 2012, do not indicate noticeable habitat changes. Based on a tide study conducted as part of the Post-restoration Monitoring Program for the Upper Newport Bay Ecosystem Restoration Project (currently in its second year), the entire UNB is known to be fully tidal, with no muting and minimal lag. This region of the marsh is of high quality, is largely undisturbed, and occupied by light-footed clapper rails.

The CRAM results website indicates that an assessment was conducted nearby on July 27, 2007, at a similar tidal elevation and in salt marsh of similar structure and plant composition.

The boundary of the AA was selected based on the criteria presented in the California Rapid Assessment Method for Wetlands (CRAM) Estuarine Module and positioned in the same region of UNB as the prior CRAM assessment conducted in 2007, to allow comparisons between the two assessment results.

Scoring Sheet: Perennial Estuarine Wetlands

AA Name: UNB1				**(m/d/y)**	09	11	2012
Attribute 1: Buffer and Landscape Context				**Comments**			
(D) Aquatic Area Abundance Score		Alpha.	Numeric				
		A	12	Aquatic Area Abundance Metric is 83			
Buffer (based on sub-metrics A-C)							
(A submetric) Score for Buffer: Percent of AA with Buffer	Alpha.	Numeric		A: AA with buffer = 100%			
	A	12		B: Average AA buffer width = 233			
(B submetric) Score for Buffer: Average Buffer Width	A	12		C: Buffer for AA is dominated by native vegetation, has undisturbed soils, and is subject to little or no human visitation.			
(C submetric) Score for Buffer: Buffer Condition	A	12					
Raw Attribute Score = D+[C x (A x B)^{½}]^{½} (use numerical value to nearest whole integer)			24	**Final Attribute Score = (Raw Score/24) x 100**			100
Attribute 2: Hydrology Attribute							
Water Source		Alpha.	Numeric	Dry season freshwater primarily urban runoff.			
		C	6				
Hydroperiod		A	12	AA is subject to the full tidal prism			
Hydrologic Connectivity		B	9	Berm on wetland edge likely impedes freshwater entry into wetland			
Raw Attribute Score = sum of numeric scores			27	**Final Attribute Score = (Raw Score/36) x 100**			75
Attribute 3: Physical Structure Attribute							
Structural Patch Richness		Alpha.	Numeric	No. of observed patch types = 8			
		B	9				
Topographic Complexity		B	9	Less topographic variability than that of optimal conditions			
Raw Attribute Score = sum of numeric scores			18	**Final Attribute Score = (Raw Score/24) x 100**			75
Attribute 4: Biotic Structure Attribute							
Plant Community Composition (based on sub-metrics A-C)							
Plant Community submetric A: Number of plant layers	Alpha.	Numeric		No. of plant layers = 2			
	B	9					
Plant Community submetric B: Number of Co-dominant species	A	12		No. of co-dominant species = 5			
Plant Community submetric C: Percent Invasion	A	12		% invasives = 0			
Plant Community Composition (*average of submetrics A-C rounded to nearest whole integer*)			11				
Horizontal Interspersion		B	9	Moderate degree of plan-view interspersion			
Vertical Biotic Structure		A	12				
Raw Attribute Score = sum of numeric scores			32	**Final Attribute Score = (Raw Score/36) x 100**			89
Overall AA Score (average of four final Attribute Scores)				87			

Worksheet for Aquatic Area Abundance Metric for Estuarine Wetlands

Percentage of Transect Lines that Contains an Aquatic Feature of Any Kind	
Segment Direction	Percentage of Transect Length That is an Aquatic Feature
North 148 + 19 = 167	167/500 x 100 = 33
South 500	100
East 500	100
West 500	100
Average Percentage of Transect Length that is an Aquatic Feature	333/400 x 100 = 83

Percent of AA with Buffer Worksheet.

In the space provided below make a quick sketch of the AA, or perform the assessment directly on the aerial imagery; indicate where buffer is present, estimate the percentage of the AA perimeter providing buffer functions, and record the estimate amount in the space provided.

Please see attached aerial image.

Percent of AA with Buffer: 100 %

Worksheet for calculating average buffer width of AA

Line	Buffer Width (m)
A	151
B	215
C	250
D	250
E	250
F	250
G	250
H	250
Average Buffer Width	1866/8 = 233

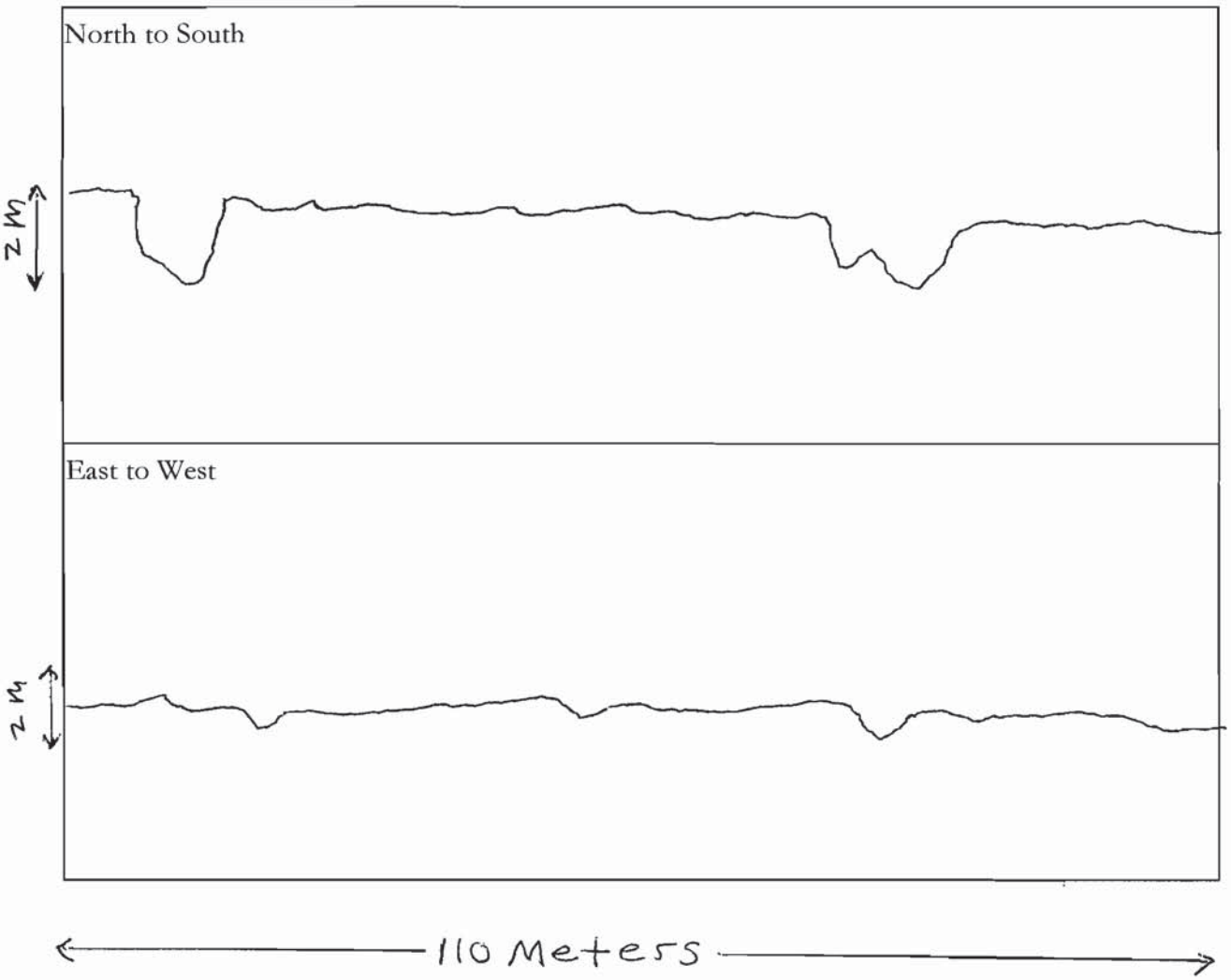
Structural Patch Type Worksheet for Estuarine Wetlands

Circle each type of patch that is observed in the AA and enter the total number of observed patches in the worksheet below.

STRUCTURAL PATCH TYPE (circle for presence)	**Estuarine**
Minimum Patch Size	**3 m^2**
Abundant wrackline or organic debris in channel, on floodplain, or across depressional wetland plain	①
Animal mounds and burrows	①
Bank slumps or undercut banks in channels or along shoreline	**1**
Debris jams	**1**
Filamentous macroalgae or algal mats	①
Non-vegetated flats or bare ground (sandflats, mudflats, gravel flats, etc.)	①
Pannes or pools on floodplain	①
Plant hummocks and/or sediment mounds	①
Point bars and in-channel bars	**1**
Pools or depressions in channels (wet or dry channels)	**1**
Secondary channels on floodplains or along shorelines	①
Shellfish beds (living)	①
Soil cracks	**1**
Standing snags (at least 3 m tall)	**1**
Submerged vegetation	**1**
Total Possible	**15**
No. Observed Patch Types (enter here and use in Table 14 below)	8

Worksheet for AA Topographic Complexity

At two locations in the AA, make a sketch of the profile from the AA boundary to AA boundary. Try to capture the major channels, slopes and intervening micro-topographic relief. Based on these sketches and the profiles in Figure 8, choose a description in Table 16 that best describes the overall topographic complexity of the AA.



Plant Community Metric Worksheet: Co-dominant species richness
(A dominant species represents ≥10% *relative* cover)

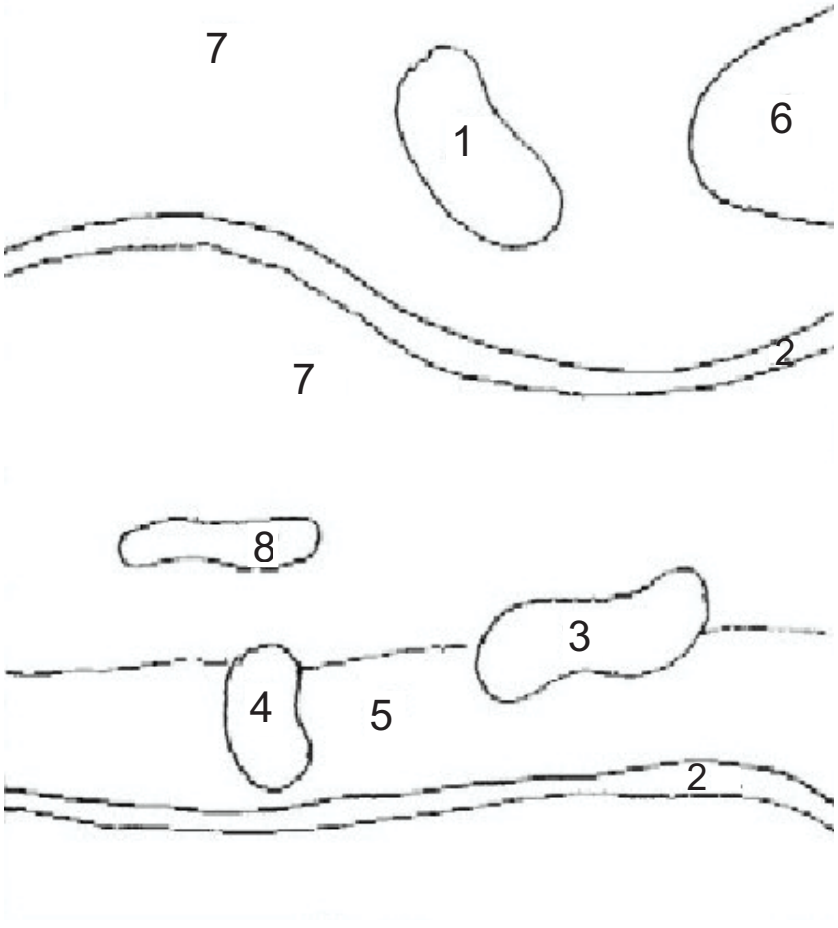
Special Note:

** Combine the counts of co-dominant species from all layers to identify the total species count. Each plant species is only counted once when calculating the Number of Co-dominant Species and Percent Invasion submetric scores, regardless of the numbers of layers in which it occurs.*

Floating or Canopy-forming	Invasive?	Short (<0.3 m)	Invasive?
None	n/a	*Suaeda esteroa*	No
		Batis maritima	No
		Jaumea carnosa	No
Medium (0.3 – 0.75 m)	**Invasive?**	**Tall (0.75 – 1.5 m)**	**Invasive?**
Spartina foliosa	No	*Spartina foliosa*	No
Sarcocornia pacifica	No		
Very Tall (>1.5 m)	**Invasive?**		
None	n/a	**Total number of co-dominant species for all layers combined (enter here and use in Table 18)**	5
		Percent Invasion (enter here and use in Table 18)	0

Horizontal Interspersion Complexity Worksheet.

Use the spaces below to make a quick sketch of the AA in plan view, outlining the major plant zones (this should take no longer than 10 minutes). Assign the zones names and record them on the right. Based on the sketch, choose a single profile from Figure 10 that best represents the AA overall.



Assigned zones:

1) *Spartina foliosa, Sarcocornia pacifica, Jaumea carnosa*
2) Tidal channel
3) Mud flat
4) *Sarcocornia pacifica*
5) *Spartina foliosa, Sarcocornia pacifica*
6) *Suaeda esteroa*
7) *Spartina foliosa, Jaumea carnosa, Sarcocornia pacifica*
8) Shallow water

Table 21: Wetland disturbances and conversions.

Has a major disturbance occurred at this wetland?	Yes	No		
If yes, was it a flood, fire, landslide, or other?	flood	fire	landslide	other
If yes, then how severe is the disturbance?	likely to affect site next 5 or more years	likely to affect site next 3-5 years	likely to affect site next 1-2 years	
Has this wetland been converted from another type? If yes, then what was the previous type?	depressional	vernal pool	vernal pool system	
	non-confined riverine	confined riverine	seasonal estuarine	
	perennial saline estuarine	perennial non-saline estuarine	wet meadow	
	lacustrine	seep or spring	playa	

Stressor Checklist Worksheet

HYDROLOGY ATTRIBUTE (WITHIN 50 M OF AA)	Present	Significant negative effect on AA
Point Source (PS) discharges (POTW, other non-stormwater discharge)		
Non-point Source (Non-PS) discharges (urban runoff, farm drainage)	X	
Flow diversions or unnatural inflows		
Dams (reservoirs, detention basins, recharge basins)		
Flow obstructions (culverts, paved stream crossings)		
Weir/drop structure, tide gates		
Dredged inlet/channel		
Engineered channel (riprap, armored channel bank, bed)		
Dike/levees		
Groundwater extraction		
Ditches (borrow, agricultural drainage, mosquito control, etc.)		
Actively managed hydrology		
Comments		
No hydrology attributes within 50 M of AA.		

PHYSICAL STRUCTURE ATTRIBUTE (WITHIN 50 M OF AA)	Present	Significant negative effect on AA
Filling or dumping of sediment or soils **(N/A for restoration areas)**		
Grading/ compaction **(N/A for restoration areas)**		
Plowing/Discing **(N/A for restoration areas)**		
Resource extraction (sediment, gravel, oil and/or gas)		
Vegetation management		
Excessive sediment or organic debris from watershed		
Excessive runoff from watershed		
Nutrient impaired (PS or Non-PS pollution)	X	X
Heavy metal impaired (PS or Non-PS pollution)	X	X
Pesticides or trace organics impaired (PS or Non-PS pollution)	X	X
Bacteria and pathogens impaired (PS or Non-PS pollution)		
Trash or refuse	X	
Comments: 503(d) listed for PCB's, sediment toxicity, pesticides, excess nutrients,		
sediment/siltation metals, DDT, copper, chlordane, bacteria (source unknown). Contaminants		
in channel sediments were tested and found to be less than "trace" amounts as defined by		
federal regulation (Marine Protection, Research, and Sanctuaries Act). The sediments were		
determined to be suitable for ocean disposal.		

BIOTIC STRUCTURE ATTRIBUTE (WITHIN 50 M OF AA)	Present	Significant negative effect on AA
Mowing, grazing, excessive herbivory (within AA)		
Excessive human visitation		
Predation and habitat destruction by non-native vertebrates (e.g., *Virginia opossum* and domestic predators, such as feral pets)		
Tree cutting/sapling removal		
Removal of woody debris		
Treatment of non-native and nuisance plant species		
Pesticide application or vector control		
Biological resource extraction or stocking (fisheries, aquaculture)		
Excessive organic debris in matrix (for vernal pools)		
Lack of vegetation management to conserve natural resources		
Lack of treatment of invasive plants adjacent to AA or buffer		
Comments		
Some non-native vegetation just outside of buffer; however, it is not intensive.		

BUFFER AND LANDSCAPE CONTEXT ATTRIBUTE (WITHIN 500 M OF AA)	Present	Significant negative effect on AA
Urban residential	X	X
Industrial/commercial		
Military training/Air traffic	X	X
Dams (or other major flow regulation or disruption)		
Dryland farming		
Intensive row-crop agriculture		
Orchards/nurseries	X	X
Commercial feedlots		
Dairies		
Ranching (enclosed livestock grazing or horse paddock or feedlot)		
Transportation corridor		
Rangeland (livestock rangeland also managed for native vegetation)		
Sports fields and urban parklands (golf courses, soccer fields, etc.)		
Passive recreation (bird-watching, hiking, etc.)	X	
Active recreation (off-road vehicles, mountain biking, hunting, fishing)		
Physical resource extraction (rock, sediment, oil/gas)		
Biological resource extraction (aquaculture, commercial fisheries)		
Comments		
Urban-residential habitat results in non-point source upstream discharges of pollutants. Tree nurseries are present up stream and may be a significant source of sediment deposition into the AA.		

1 Hectare CRAM Assessment Area
500 Meter Transect
250 Meter Transect
2007 CRAM Centroid
N
W
E
S
0
100
200
300
400
500 Meters

Photo Point 1. Center of Assessment Area facing north. Date of photo: 9/11/12.

Photo Point 2. Center of Assessment Area facing south. Date of photo: 9/11/12.

Photo Point 3. Center of Assessment Area facing east. Date of photo: 9/11/12.

Photo Point 4. Center of Assessment Area facing west. Date of photo: 9/11/12.

Photo Point 5. Shallow pool in Assessment Area facing southeast. Date of photo: 9/11/12.

Photo Point 6. Close-up of vegetation, consisting of *Spartina foliosa* and *Sarcocornia pacifica*, facing north. Date of photo: 9/11/12.

Photo Point 7. Close-up of shellfish in Assessment Area. Species include non-native Japanese horse mussels (*Geukensia demissa*) and California horned snails (*Cerithidea californica*). Date of photo: 9/11/12.

Photo Point 8. Wrack lines, facing southwest. Date of photo: 9/11/12.

Photo Point 9. Low marsh vegetation, consisting of cordgrass (*Spartina foliosa*) and seablite (*Suaeda esteroa*). Date of photo: 9/11/12.

Photo Point 10. Bank-slump in foreground and mudflat in background. Feature is approximately 100 meters east of Assessment Area. Date of photo: 9/11/12.