UPPER NEWPORT BAY ECOSYSTEM RESTORATION PROJECT
POST-RESTORATION MONITORING PROGRAM

VEGETATION MONITORING

ANNUAL REPORT
YEAR 5 – 2015

UPPER NEWPORT BAY ECOLOGICAL RESERVE
ORANGE COUNTY, CALIFORNIA

March 2016

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VEGETATION MONITORING YEAR 5– 2015

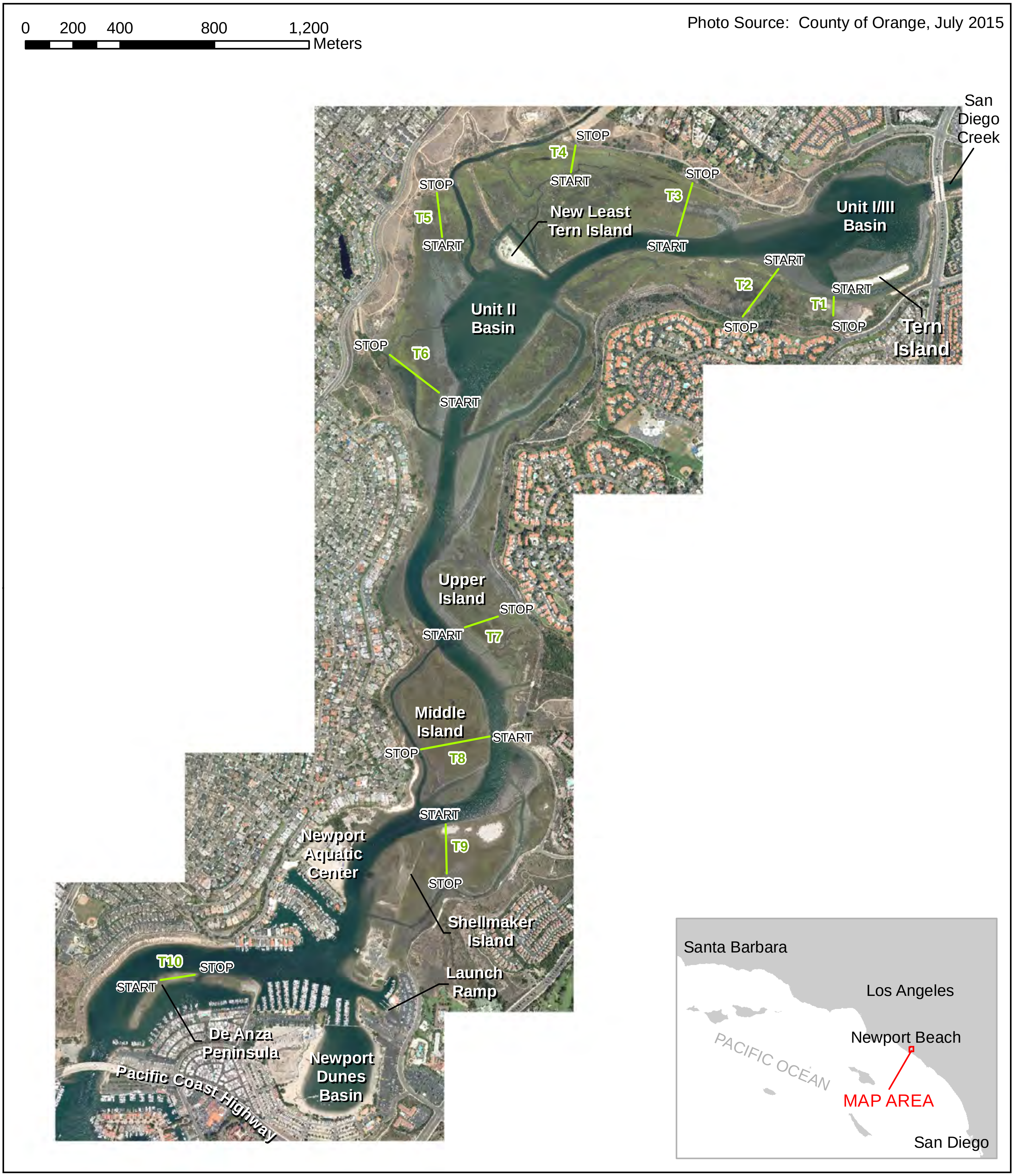
Merkel & Associates, Inc.
March 2016

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 one endangered plant species. The subtidal and intertidal waters of UNB provide important habitat for marine and estuarine fishes.

By the end of the 20th century, the ecological diversity and functionality of UNB was increasingly threatened by sedimentation from the surrounding urbanized watershed. 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 UNB Ecosystem 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. The restoration project was initiated in 2006 and completed in October 2010.



Vegetation Monitoring Transects

Upper Newport Bay Ecosystem Restoration Project

Post-restoration Monitoring Program - Year 5

Figure 1

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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 prior annual monitoring reports (Merkel & Associates, Inc. 2014a, 2014b, 2013). The first monitoring year extended from January to December 2011 and continued annually. The ACOE performed the first three years of the Post-Restoration Monitoring Program, with the County of Orange and CDFW sharing responsibility for the monitoring and reporting in Years 4 through 10. The County of Orange has contracted Merkel & Associates, Inc. (M&A) to perform the Vegetation Monitoring portion of the Year 5 (2015) Post-Restoration Monitoring Program.

2.0 METHODS

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 Program calls for the use of aerial photographs in Years 1, 2, 3, 5, and 8 and quantitative surveys of transects in Years 2, 5, and 8. Therefore Year 5 monitoring included both habitat mapping from aerial photography and quantitative transect surveys.

Measurement units of numerical data 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. For 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 elevations are described 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 project. The vertical datum used in this document is Mean Lower Low Water (MLLW) (83-01 epoch). Horizontally geo-referenced data are on the California State Plane Zone 6, North American Datum of 1983 (NAD 83).

2.1. Habitat Mapping

To map vegetated and non-vegetated habitats during Year 5 (2015), the County of Orange contracted GPSi Corp. to collect the aerial imagery of the UNB study area. The study area was flown by GPSi Corp. on July 10, 2015. Four-band (RGB and near infrared) imagery was collected to generate an orthomosaic of the study area at a pixel resolution 3-inch Ground Sampling Distance. The imagery was collected between 10:15am and 11:52am at roughly a +1.6-foot MLLW tidal elevation. To collect imagery at the 0 MLLW elevation called for in the Monitoring Program, and captured in the prior monitoring years, the flight would have needed to be scheduled during the spring, when low tides coincide with suitable sun angles for image collection. A delay in the initiation of Year 5 monitoring pushed the imagery collection to July when only higher tides occurred during appropriate flight times. No other complications were encountered with the image collection.

To establish a consistent study area, a boundary was established during Year 1 at the extreme high water line, which is 7.8 feet MLLW for UNB, and generally corresponds to the upper boundary of salt marsh habitat. All areas extending from that outer boundary toward the main channel were included, including raised areas above 7.8 feet, such as the least tern islands. The geographic position of the 7.8 feet contour line was determined using topographic data collected by ACOE in 2011. It was not possible to also evaluate only 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. Each polygon was assigned a habitat description, based on the plant assemblages present or the origin and nature of other non-vegetated areas. Eelgrass (*Zostera marina*) visible in the aerial image was delineated, however the higher tide at the time of image collection likely limited the amount of eelgrass that could mapped visually from aerial images and complicated comparisons to prior mapping efforts made using imagery collected a the 0 MLLW tidal elevation.

The only habitats that were not mapped strictly from the aerial were intertidal mudflat and open water. During the project planning process, the lower edge of the mudflat was defined as the -1.54 feet MLLW contour. Therefore all post-restoration habitat monitoring has used the same definition and relied on bathymetric data provided by the ACOE to position that mudflat boundary. This approach was problematic in Years 2 and 3 (2012 and 2013), because in many cases the bathymetric data 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 the contour line broke off, by examining the aerial photo, or through comparison with the previous contours. In Year 5 the bathymetric dataset extended high enough to capture the -1.54-ft MLLW contour for most of the study area. Where gaps occurred, the same method of estimation was used to delineate the mudflat boundary.

Bathymetric data were not collected in most of the shallow side channels of UNB. In these areas, the open water/mudflat boundary was mapped from the aerial image. For example, the Santa Ana Delhi Channel was not included in the bathymetric survey, therefore the open water and emerging mudflat was mapped exclusively from the aerial photographs. This was done by examining the visual characteristics of the boundary in adjacent areas where bathymetric data were available, and using those same indicators to estimate the lower mudflat edge where data were not available. The 2011 (Year 1) dataset was also examined as a guide; bathymetric data was collected for the entire site that year. To maintain consistency in this technique, the same GIS Specialist has performed the habitat delineation at M&A during each monitoring year.

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 between the habitats mapped in Year 1 post-restoration (2011) and Year 5 (2015). Comparisons were not made to the interim monitoring Years 2 and 3, because the aerial imagery was manually georeferenced during those monitoring efforts, resulting in habitat mapping that was affected on a small scale by factors such as camera tilt, terrain relief, lens distortion, and image stretching. As was recommended in the Year 3 report (M&A 2014a), collection of an orthophoto in Year 5 allowed for comparison with the Year 1 habitat map, which was also generated from an orthophoto, allowing better detection of small-scale changes in habitat distribution.

Cordgrass Transplant Monitoring

Separate from the Post-restoration Monitoring Program habitat mapping, an assessment was also made of the cordgrass (*Spartina foliosa*) that was transplanted in November 2009 on the windward (south) and west shores of New Least Tern Island. The purpose of the transplant effort was to mitigate the estimated 500 square meters (0.1 acre) of cordgrass loss that resulted from the excavation of the channel around New Least Tern Island as part of the Restoration Project. The mitigation obligation for the project included the creation of 1,500 square meters (0.4 acre) of new cordgrass beds. The condition of the transplanted cordgrass was evaluated on foot on November 12, 2015.

2.2. Vegetation Transect Monitoring

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 first transect monitoring performed in Year 2 (2012) was designed simply to repeat transect investigations conducted prior to the restoration for comparison to post-restoration conditions. The Year 5 monitoring implemented the same methodology.

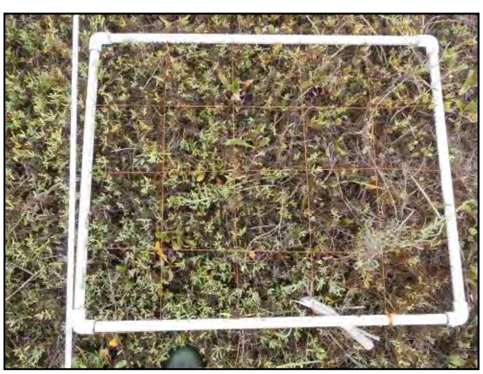
The two pre-restoration studies that were reviewed were the *Newport Bay Sediment and Vegetation Monitoring Sediment Total Maximum Daily Load, Vegetation Monitoring 2004* performed by Wetlands Research Associates in October 2004 (WRA 2004) and *Biological Resources of Upper Newport Bay, California* (MEC 1997), which included transect monitoring performed in October 1997. The 2004 WRA 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 Year 2 (2012) field work, both the 2004 and 1997 transects were plotted on an aerial image using GIS. With two exceptions, the 2004 transects were best positioned to capture the 2012 post-restoration 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. There was also a typo in one of the coordinates for the 2004 Transect 10, so it was adjusted until it matched the alignment shown in a figure presented in the report.

A total of ten transects were established, with new transect endpoints recorded with a differential Global Positioning System (dGPS) unit in Year 2 and recovered in Year 5 (Figure 1). Endpoint coordinates are provided in Appendix A. It is important to note that there is a mix of measurement units involved with the transects. The coordinates of the transects are provided in meters (State Plane), the standard unit of measurement established for the Restoration Project. However, to be consistent with the pre-restoration vegetation transect survey work, the positions of survey plots along each transect were recorded in feet. The transect start point coordinates provided in Appendix B mark the absolute 0 start point, of which all plots are measured. However, the transect end point coordinates provided in Appendix B are only the approximate end point. The points establish the alignment 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 Year 5 transect monitoring was performed on November 11 and 12, 2015 by M&A biologists Rachel Woodfield, Thomas Valencia, and Cameron Newell. The start of each transect was recovered by dGPS and generally was positioned at the upper edge of the mudflat. 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 1). A photo was taken of each transect from the start point. A photo was also taken from the end point on transects where the alignment made it difficult to view it in its entirety from the start point only. 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-foot tape measures was extended end to end along the transect. A series of plots were analyzed along each transect, characterizing each marsh community. The low marsh, middle marsh, and high marsh communities were identified in Year 2 using indicator species coverage identified in the 1997 and 2004 studies. Low marsh was identified as areas dominated (60-70% cover) by cordgrass. Middle marsh was at least 50% pickleweed (*Sarcocornia pacifica*), with other species such as saltwort (*Batis maritima*) and jaumea (*Jaumea carnosa*). High marsh was defined as dominated by salt grass (*Distichlis spicata*), with areas of shore grass (*Distichlis littoralis*) and pickleweed. One transect (Transect 1) had an expanse of freshwater marsh at its upper end that was also included in the assessment.

The 2004 study recommended that the Sediment Total Maximum Daily Load Vegetation 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. Therefore a fixed set of plot locations was established in Year 2 (2012), measured by their distance in feet from the transect start point. A plot was always analyzed at the zero end of the transect in the low marsh, and then additional plots analyzed at regular intervals based on the width of each community and the length of the transect. The location of each transect and each plot along that transect was recovered for the 2015 survey and will be again in Year 8 (2018) surveys. The position of the plots along each transect is presented in Appendix C. A total of 160 plots were analyzed, with 10 to 22 plots per transect. In Year 2 each plot was assigned a marsh type (low, middle, high, freshwater) based on the plant communities present in 2012. This designation was later used to group the marsh types for analysis. The designation assigned to each plot did not change in 2015, since the elevation of the plots did not change. For example, if a middle marsh plot were invaded in 2015 by a non-native upland species, the plot would still be analyzed as middle marsh.



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-foot 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 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 of the twenty squares, 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 same M&A biologist, Rachel Woodfield, surveyed the plots in 2012 and 2015.

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 post-restoration study the quadrat was a rectangle with an area of 0.5-meters, roughly 80 centimeters by 60 centimeters. The exact dimensions allowed for the positioning of the 20 squares (roughly 16 by 16 centimeters) 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-meter band along the transect (0.5 meter 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 in the calculations as 1% cover to ensure their presence in the plot was accounted for. Average percent cover was the average of each species' cover in each plot, and therefore included plots where the species was not present. Frequency was calculated as the percentage of plots where the plant occurred, to quantify the distribution of each species throughout the UNB marsh community. These Year 5 data were compared to those collected in Year 2. General comparisons were made to findings reported in the 2004 study, which included 2004, 2001, and 1997 data.

3.0 RESULTS

3.1. Habitat Mapping

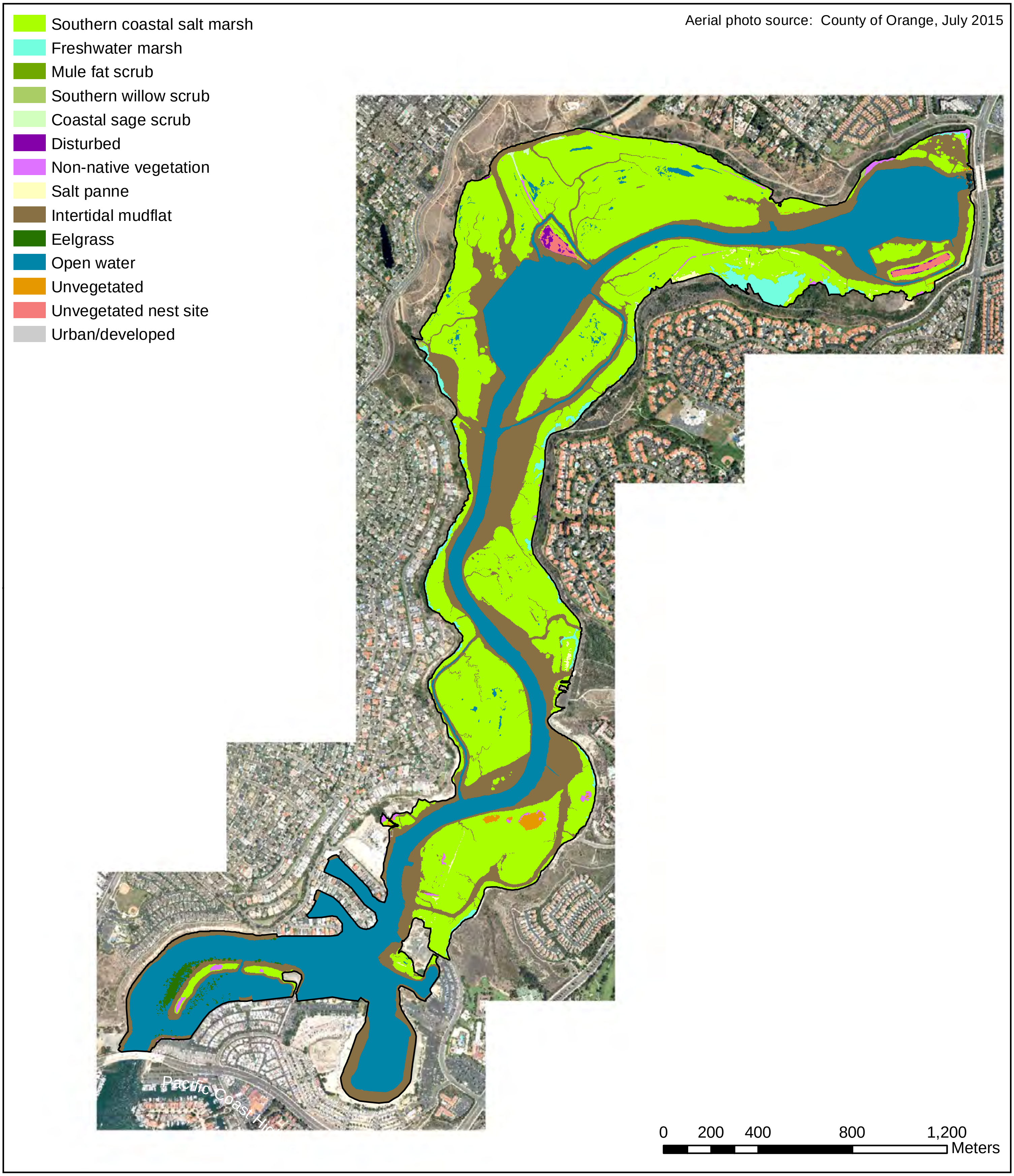
Based on the July 2015 imagery, seven vegetated and seven non-vegetated habitats were mapped within the study area in Year 5. Figure 2 presents the distribution of habitats on-site and Table 1 summarizes the extent of each.

Table 1. Area of habitats within the UNB study area (July 2015).

Habitat	Hectares	Acres
Southern coastal salt marsh	146.5	362.1
Freshwater marsh	5.8	14.4
Mule fat scrub	0.2	0.4
Southern willow scrub	0.4	1.0
Coastal sage scrub	1.1	2.8
Disturbed	0.6	1.5
Non-native vegetation	1.8	4.5
Salt panne	0.7	1.7
Intertidal mudflat	70.9	175.2
Eelgrass	1.2	2.9
Open water	97.0	239.7
Unvegetated	1.0	2.5
Unvegetated nest site	1.3	3.2
Urban/developed	0.3	0.8

Southern coastal salt marsh was the most abundant habitat in UNB, with 146.5 hectares (362.1 acres) mapped in 2015. The low marsh was dominated by cordgrass and occurred at the lower edge of the marsh plain and in areas where broad expanses of the marsh plain lay at a low elevation. The cordgrass fringing the middle marsh was generally sparser than in prior monitoring years, and absent altogether in some areas. Where large beds of cordgrass were intermixed with pickleweed, the cordgrass was sparse and often laid over. However the overall marsh boundary mapped did not retreat much, and localized losses were offset by continued expansions onto mudflat created by the Restoration Project. The middle marsh was dominated by jaumea and pickleweed. The high marsh was predominantly jaumea, salt grass, and shore grass.

Cordgrass northeast of New Least Tern Island.



Habitat Map - July 2015

Upper Newport Bay Ecosystem Restoration Project
Post-restoration Monitoring Program - Year 5

Figure 2

Merkel & Associates, Inc.

Non-native Limonium ramosissimum in the marsh.

Expanding colonies of the invasive non-native Algerian sea lavender (*Limonium ramosissimum*) were noted in several locations in the salt marsh on the eastern side of the main channel, generally on elevated and disturbed areas in the middle and high marsh. No quantitative assessment was made of its extent, but it appeared to have expanded since the last observations made by the monitoring biologist in 2012. 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. A colony of several hundred plants has become established on the upper edge of the salt marsh that has developed on the Shellmaker Island Mudflat created by the restoration. CDFW made a few pesticide applications to treat Algerian sea lavender in 2015 and plans to do additional treatment in 2016. The extent of this plant at UNB is still limited enough that an eradication effort could be implemented at UNB. It would require a comprehensive mapping of infested areas, repeated treatment, and long term monitoring.

The 70.9 hectares (175.2 acres) mapped as intertidal 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 MLLW for this project by prior habitat mapping efforts. Therefore, the 97 hectares (239.7 acres) mapped as open water includes all waters below -1.54 feet 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 and mapped as freshwater marsh. This habitat is mostly 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 (*Peritoma arborea*), telegraph weed (*Heterotheca grandiflora*), coast cholla (*Cylindropuntia prolifera*), coastal prickly pear (*Opuntia littoralis*), coast quailbush (*Atriplex lentiformis*), 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.

Habitats mapped as non-native vegetation were dominated by exotic species including castor-bean (*Ricinus communis*), tree tobacco (*Nicotiana glauca*), sea fig (iceplant) (*Carpobrotus chilensis*), white sweetclover (*Melilotus albus*), large Brazilian pepper trees (*Schinus terebinthifolius*), pampas grass

(*Cortaderia selloana*), giant reed (*Arundo donax*), and Canary Island date palms (*Phoenix canariensis*). It appeared there had been efforts to control non-natives on the sandy areas of Shellmaker Island, particularly pampas grass and iceplant. 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.

Approximately 1.2 hectares (2.9 acres) of eelgrass were mapped in the vicinity of the De Anza Peninsula, the arm of land that parallels the main channel just north of Pacific Coast Highway. This is an underestimate due to the limitations of mapping submerged habitats at deeper depths from aerial imagery. Eelgrass occurred in this area prior to the restoration project, primarily on the western shoreline of the peninsula. Improvements in water clarity envisioned by the restoration project were projected to improve the vigor and extent of this bed. After completion of the UNB restoration, the Orange County Coast Keeper conducted an eelgrass restoration project in June 2012, near this original eelgrass bed. A total of 200 square meters (0.05 acre) of eelgrass was transplanted to expand the bed. The following year, during the Year 3 (2013) vegetation monitoring, approximately 0.2 hectares (0.6 acre) were mapped using the aerial imagery. The 2015 imagery shows considerable expansion of the eelgrass to the east side of the peninsula, and to the shorelines of the main channel. A survey conducted using sidescan sonar would be needed to more accurately quantify and map the subtidal eelgrass.

Disturbed habitat was mapped in areas that had a growth of opportunistic weedy species as a result of human action, primarily on two least tern islands. The dominant vegetation in these areas was telegraph weed and black mustard (*Brassica nigra*), 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.

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 rainwater or seawater at extreme high tides and remain ponded due to the micro-topography of the area. Evaporation of the ponded water leads to hypersaline conditions and depressed oxidation-reduction potential that are inhospitable to most vascular plants. The expansion of salt marsh vegetation into salt panne areas is variable year to year; therefore, variations in the extent of salt panne present each year is to be expected. 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 dotted with goldenbush and patches of non-native species that showed evidence of the regular manual and herbicide control efforts made by CDFW.

Cordgrass transplant monitoring

Cordgrass six years post- transplant on the west shore of New Tern Island.

The 2015 assessment of the cordgrass transplanted in November 2009 on the shoreline of New Least Tern Island found little change from conditions in Year 3 (2013). The only persisting planted patches were on the west slope of the island, where the sandy shoreline has eroded to expose a mud base more suitable for cordgrass growth than the other shorelines of the island. Field measurements of the cordgrass patch dimensions estimated a total area of approximately 36 square meters, growing at elevations between +2.5 and 3.5 feet MLLW. Similar to much of the cordgrass in UNB, the transplanted cordgrass was sparse. As noted in 2013, none of the transplanted cordgrass on the south shore remained. It is unlikely that cordgrass will ever establish on this windward shoreline due to the intense wind wave exposure, and the sandy nature of the substrate. The limited areas of sandy substrate elsewhere in UNB also do not support cordgrass. It should continue to persist on the west side of the island, where substrate and wave exposure are most suitable, though there is limited additional area for expansion in this area.

Although the goal of 1,500 square meters of cordgrass restoration will not be met on New Least Tern Island, well over this amount of cordgrass habitat has developed further east on the Bullnose Wetland Restoration Area excavated to create mudflat during the Restoration Project. Because this area transitions from mudflat elevations into elevations suited to support vascular vegetation, the upper edge of this restoration area has transitioned cordgrass supporting salt marsh.

3.2. Vegetation Transect Monitoring

The compiled transect data provided 160 plots: 40 low salt marsh, 88 middle salt marsh, 19 high salt marsh, 4 freshwater marsh, and 9 plots that were classified as other habitats (e.g., upland, 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 24 species were recorded in the 151 vegetated plots, with no additional species found within the 1-m band along the transects, but not within the plots. The transect data are included in Appendix B and photos of each transect, including a photo from 2012 (Year 2) for comparison, are provided in Appendix C.

Table 2 presents the average percent cover and Table 3 presents plant frequency for each species within each of the four marsh community types in Year 5. 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. The Year 2 (2012) percent cover and frequency data are provided in Appendix D for comparison.

Table 2. Average percent cover of plant species (with overlap) in each marsh community at UNB in November 2015.

	Average Percent Cover (%)			
Plant Species	**Low Marsh**	**Middle Marsh**	**High Marsh**	**Freshwater Marsh**
*Apium graveolens**		<0.05		0.3
Atriplex prostrata		0.1		
Batis maritima	8.8	15.1	19.2	
Bolboschoenus maritimus				7.5
*Carpobrotus chilensis**			0.3	
Cressa truxillensis		0.6	4.5	
Cuscuta salina		1.3	0.3	
Distichlis littoralis		3.5	22.4	
Distichlis spicata		6.4	17.7	12.5
Frankenia salina	2.9	6.9	5.3	
Heterotheca grandiflora			0.1	
Jaumea carnosa	13.8	50.9	25.9	25.0
Juncus acutus		0.2		
Limonium californicum	0.1	3.9	0.8	
*Limonium ramosissimum**			3.4	
Pluchea odorata				1.3
*Pulicaria paludosa**				25.0
Sarcocornia pacifica	12.2	30.1	21.6	
Spartina foliosa	47.4	9.7		
Suaeda esteroa	0.1	2.7	0.8	
Suaeda taxifolia		0.1		
*Symphyotrichum subulatum**		0.3		
Triglochin maritima		0.1		
Typha domingensis				50.0
Total Plant Cover (with overlap)	**85.3**	**131.9**	**122.3**	**121.6**
Dead Plant Matter	2.6	0.2	10.3	
Bare Ground/Open Water	21.8	0.6		

* non-native species

Table 3. Percentage frequencies of plant species in each marsh community at UNB in November 2015.

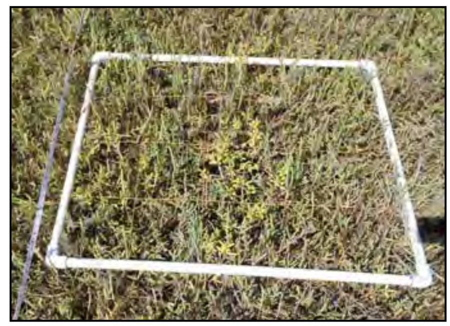
	Frequency (%)			
Plant Species	**Low Marsh**	**Middle Marsh**	**High Marsh**	**Freshwater Marsh**
*Apium graveolens**		1.1		25.0
Atriplex prostrata		1.1		
Batis maritima	40.0	58.0	26.3	
Bolboschoenus maritimus				25.0
*Carpobrotus chilensis**			5.3	
Cressa truxillensis		4.5	15.8	
Cuscuta salina		11.5	5.3	
Distichlis littoralis		9.1	42.1	
Distichlis spicata		23.9	36.8	25.0
Frankenia salina	10.0	31.8	26.3	
Heterotheca grandiflora			5.3	
Jaumea carnosa	27.5	69.3	52.6	25.0
Juncus acutus		1.1		
Limonium californicum	2.5	30.7	5.3	
*Limonium ramosissimum**			5.3	
Pluchea odorata				25.0
*Pulicaria paludosa**				25.0
Sarcocornia pacifica	45.0	86.4	68.4	
Spartina foliosa	77.5	21.6		
Suaeda esteroa	2.5	14.8	15.8	
Suaeda taxifolia		2.3		
*Symphyotrichum subulatum**		4.5		
Triglochin maritima		3.4		
Typha domingensis				50.0
Dead Plant Matter	7.5	1.1	26.3	
Bare Ground/Open Water	30.0	2.3		
Total Number of Plots	40	88	19	4

* non-native species

The low marsh was dominated by cordgrass and pickleweed (*Sarcocornia pacifica*), with average percent covers of 47% and 12%, respectively (Table 2). Jaumea (*Jaumea carnosa*) and saltwort (*Batis maritima*) were present in lower percentages. A total of seven native species was recorded in the low marsh. Table 3 shows that cordgrass occurred in 78% of the low marsh plots, with pickleweed and saltwort present in 45% and 40%of low marsh plots, respectively. The other four native species were present in lower frequencies in the low marsh plots. The total percent vegetative cover in the low marsh, including overlap of multiple species, was 85.3%.

Dead and thinned cordgrass NE of New Least Tern Island.

Seventeen species were recorded in the middle marsh plots, two of which were non-native (Table 2). Although middle marsh had been defined previously as having at least 50% pickleweed, in 2015 the middle marsh was dominated by jaumea, with an average of 51% cover. Pickleweed and saltwort had less cover: 30% and 15%, respectively. These species were also present in the highest frequencies within middle marsh plots (Table 3). Other species seen frequently in 2015 were salt grass (*Distichlis spicata*), alkali heath (*Frankenia salina*), and western marsh rosemary (*Limonium californicum*). The non-native species were present in small amounts in a small percentage of the plots. Overall the middle marsh appeared notably dry, with the plants sparse and desiccated in many areas. The total percent vegetative cover in the middle marsh, including overlap of multiple species, was 131.9%.


Middle marsh on T8, showing low stature.

As was noted in 2012 (Year 2), much of the middle marsh in UNB was notably short in stature and sparse, due to both the dominance of low growing species such as jaumea and saltwort, and to the highly reduced growth habit of the pickleweed. In many places the pickleweed ranged in height from 20 to 40 centimeters and individual plants had simple structure, with very little branching. 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 along the transects was short and sparse. In particular, large expanses of middle marsh on Middle Island and Upper Island 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, or poor drainage that increases the inundation duration. This low growing mix of salt marsh plants provides little canopy for nesting by state endangered Belding's Savannah sparrows (*Passerculus sandwichensis beldingi*), which relies on salt marsh habitat for nesting. The most recent Belding's Savannah sparrow breeding survey reported the majority of nesting activity occurring instead in the more limited high marsh of Upper Newport Bay, between New Least Tern Island and Jamboree Road (Zembal et al. 2015).

A total of 13 species were identified in the high marsh plots, two of which were non-native (Table 2). The dominant species in high marsh plots were shore grass and jaumea, though they only occurred in roughly half of the plots each. Pickleweed occurred with the greatest frequency in the high marsh plots, though it made up only 22% cover. Other species frequently observed in high marsh plots were salt grass, alkali heath, and saltwort (Table 3). The invasive non-native Algerian sea lavender was present in one plot on Transect 2. The total percent vegetative cover in the high marsh, including overlap of multiple species, was 122.3%. The high marsh also appeared stressed by dry conditions.

Seven species were observed in the four freshwater marsh plots, which were all at the upper end of Transect 1. The community was dominated by southern cattail (*Typha domingensis*), with jaumea and the non-native Spanish false fleabane (*Pulicaria paludosa*) growing over the base of the cattails. The fleabane was not present on this transect in Year 2.

4.0 DISCUSSION

The Post-restoration Monitoring Program document provides a list of goals and questions to be assessed by the program. The two questions from that list pertaining to vegetation are:

- Has the project resulted in the gain or loss of any habitat type greater than 10%?
- Has the project resulted in increased eelgrass survival in the upper bay?

The first of the two questions relating to vegetation in the Post-Restoration Monitoring Program 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 (M&A 2013) and cannot be addressed further by the present monitoring. Aside from the question specifically about eelgrass, discussed further below, there were no other habitat goals identified by the Monitoring Program.

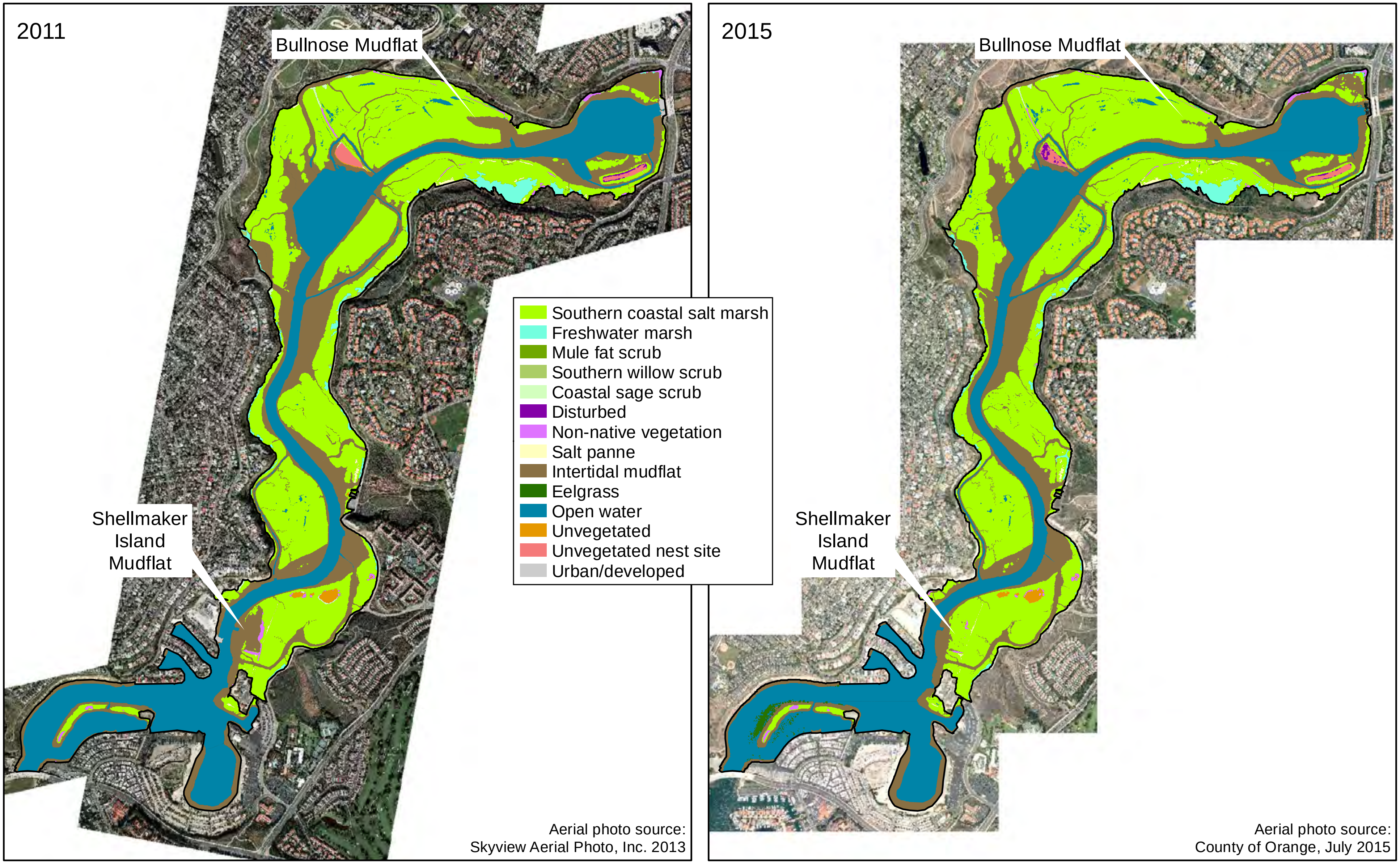
The habitats of primary interest in relation to the effect of the restoration work were salt marsh, mudflat, and open water. Changes in the distribution of these habitats before and after the restoration were discussed in the Year 1 report. The following discussion examines changes in these three habitats since the first year post-restoration (2011). Table 4 and Figure 3 compare the coverage and distribution between years.

Table 4. Comparison of key habitats (hectares) within the UNB study area during Years 1 and 5.

Habitat	Year 1 (2011)	Year 5 (2015)
Southern coastal salt marsh	141.6 ha.	146.5 ha.
Intertidal mudflat	74.3 ha.	70.9 ha.
Open water	99.2 ha.	97.0 ha.

By Year 5, southern coastal salt marsh had expanded by 4.9 hectares (12.1 acres) since Year 1. The majority of this increase was due to the expansion of salt marsh down onto the mudflat in two areas. The Bullnose Wetland Restoration Area was excavated during the Restoration Project to create intertidal mudflat. The majority of the mudflat, however, was excavated to elevations too high to preclude the growth of low marsh vegetation, and each year since its creation cordgrass and pickleweed have expanded onto the mudflat (Figure 3). It is anticipated that the majority of the Bullnose mudflat will continue to convert to low salt marsh as the established patches of cordgrass expand, with the lower area where it joins the main channel remaining mudflat. The second area of major salt marsh expansion was the Shellmaker Island mudflat. This mudflat was also created during the Restoration Project. It was also excavated to elevations that are too high to maintain an open mudflat and was very rapidly colonized by both low and mid marsh species, nearly filling in completely with marsh between 2011 and 2015 (Figure 3).

Smaller increases in salt marsh cover occurred through the minor expansion of salt marsh along its lower edge, primarily on the eastern side of the main channel. The Year 5 bathymetric surveys for the Monitoring Program (MTS 2015) found mudflat accretion on the eastern shore of the main channel in the 0 to 0.3 meter range between 2013 and 2015, which would allow expansion of salt



Comparison of Habitat Distributions Between Year 1 (2011) and Year 5 (2015)

Upper Newport Bay Ecosystem Restoration Project
Post-restoration Monitoring Program - Year 5

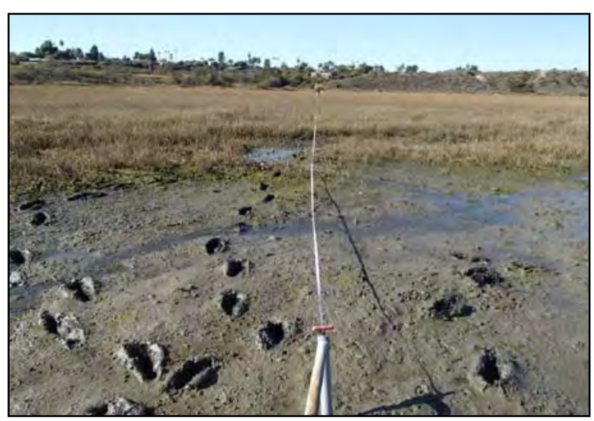
Figure 3

marsh. There was also continued expansion of isolated cordgrass tussocks by radial clonal growth across the mudflat. This can be seen clearly in Figure 3 in the northeast corner of UNB, where circular patches of expanded cordgrass are evident. Finally, salt marsh cover has increased in some areas due to the removal of non-native vegetation that had been displacing it, while in other areas there were losses of salt marsh due to continued expansion of non-native vegetation, on De Anza Peninsula for example.

The reduction in mudflat by 3.4 hectares (8.3 acres) since Year 1 is accounted for primarily by the expansion of salt marsh discussed above. The losses are offset by sediment accretion that converted open water to mudflat at its lower boundary (-1.54 feet MLLW). Other small reductions in mapped mudflat corresponded with areas of shoreline erosion reported in the bathymetric survey report (MTS 2015), where mudflat was eroded to an elevation below -1.54 feet MLLW and therefore mapped as open water in 2015.

Small losses of open water habitat resulted from the modest mudflat expansion primarily on the east shore of the main channel, and were offset by the mudflat retreat on the west shore of the channel. Minor reductions in mapped open water also resulted from the removal of hard structures from the water at Newport Aquatic Center and the expansion of eelgrass, that converted habitat previously mapped as open water to eelgrass, though in reality all eelgrass habitat should be counted as part of the open water coverage.

In Year 5 (2015) UNB experienced several stressors: California was in its fifth year of severe drought, California's 2015 and 2014 Water Years were the warmest years on record, and in 2015 California experienced the beginning of a strong El Nino-Southern Oscillation (ENSO) event. The transect monitoring revealed a considerable shift in the salt marsh makeup between Year 2 and 5, that likely reflects these environmental conditions. It is important to note, however, that the timing of the Year 5 survey was conducted in November compared to September for Year 2. Conducting the survey two months later in the growing season for Year 5 would capture a later period of the cycling of cordgrass leaves, when more foliage would be dying back and knocked flat by wind and tide water. This offset in the timing is only believed to account for a portion of the differences seen in the marsh conditions between Years 2 and 5. These changes can be seen visually in the transect photo comparisons presented in Appendix C and provided as an example below.



A comparison of low marsh habitat at the start of Transect 6 in September 2012 (left) and in November 2015 (right).

From Year 2 to Year 5, the low marsh dropped in total vegetative cover from 126% to 85%, with overlap of species. In Year 2, cordgrass occurred in 98% of the plots, with an average cover of 75%. In Year 5, cordgrass occurred in only 78% of the plots, with an average cover of 47%. Photos 11 and 12 in Appendix C exemplify changes seen in the low marsh. Photo 12 shows robust cordgrass and pickleweed in 2012, while Photo 11 shows the same marsh dominated by jaumea, with sparse cordgrass and pickleweed remaining.

The loss or thinning of cordgrass is likely related to extended periods of inundation resulting from elevated sea level during the strong El Nino conditions in 2015. Data collected by NOAA tide gauges and NASA satellites have shown that average water levels on the west coast of California for October 2015 were 0.15 – 0.23 meter (6 to 9 inches) above normal (Ocean Protection Council 2015). The cordgrass may be experiencing continued excess inundation as large winter storms have hit the region during the 2015-2016 winter, which were expected to add an additional 0.3 to 0.6 meter of sea level excess. This loss of cordgrass within the salt marsh habitat was not as evident in the habitat mapping effort because the cordgrass is still largely present and visible in the July 2015 aerial imagery. Closer inspection during the transect monitoring revealed its less functional condition, with large areas of dead plant material laid down and the remaining growing plants sparsely distributed and short in stature. It should be noted though that there were areas where the cordgrass was robust even on the lower edges of the mudflat.

The WRA (2004) vegetation report summarizes the historically monitored low marsh cover of cordgrass at 42% in 2004, 55% in 2001, and 60-70% in 1997. This suggests there is considerable inter-annual variability and the 2015 cordgrass average coverage (i.e., 47%) is within the recent historical range. When inundation and climatic conditions improve, cordgrass should regrow through expansion of remaining rhizomes and re-establishment by seed.

The notably dry and sparse middle marsh was dominated by jaumea in 2015, rather than pickleweed, which had an average cover of 30%. In 2012, pickleweed had an average cover of 52%. The total percent vegetative cover in the middle marsh was reduced from 159% in 2012 to 132% in 2015. The 2004 WRA vegetation report summarizes the middle marsh history with pickleweed covers of 36% in 2004, 40-50% in 2001, and 45-50% in 1997. This historic loss of pickleweed cover recorded in 2015 is likely the result of the ongoing drought and persistent record high temperatures. Although the salt marsh receives moisture from tidal inundation, it also benefits from freshwater input from runoff and rainfall. This is a primary source of nutrient inputs to the system. The loss of pickleweed is of concern because the remaining salt marsh species are low growing and do not provide suitable habitat for Belding's Savannah sparrow.

The high marsh also appeared stressed by dry conditions and had dropped from a total percent vegetative cover of 147% in 2012 to 122% in 2015. There were no major changes in species composition.

Question #4 posed in Section 1.3 was as follows: *Has the project resulted in increased eelgrass survival in the upper bay?* The only persistent eelgrass bed known in UNB, described above and located off of DeAnza Peninsula, has expanded considerably from 2010 to 2015. A sidescan sonar survey conducted in September 2010 mapped approximately 160 square meters (0.04 acre) (M&A 2010). The 2015 estimate made from the aerial imagery was 1.2 hectares (2.9 acres), including the original eelgrass bed and the eelgrass that colonized and expanded after the 2012 transplant by Coast Keeper at the same site. The supplemental planting complicates efforts to link the size of the eelgrass bed to improvements in water quality associated with the restoration, as envisioned in the Monitoring Program. However, the capacity for eelgrass to persist in Upper Newport Bay is generally considered an indication of improved tidal prism and associated flushing. There is potential for eelgrass to have expanded further north into UNB as hoped. To achieve accurate and efficient surveillance for eelgrass elsewhere in UNB, a more sophisticated survey technique would need to be employed. If such a program were implemented, Question #4 could be more precisely addressed, however on a qualitative basis, the answer to this question is that the project has increased the survival of eelgrass within Upper Newport Bay.

The Monitoring Program calls for a final vegetation monitoring event in Year 8 (2018), including collection of aerial photographs for habitat mapping and surveys of the vegetation monitoring transects.

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Appendix A
Vegetation Transect Coordinates

Vegetation Transect Coordinates

California State Plane, Zone 6, NAD 83, Feet

Vegetation Transect Endpoints	Transect	X	Y
	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 B
Vegetation Transect Data

Vegetation transect data for Transect 1 in November 2015 (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			
Atriplex prostrata															
Batis maritima			80	10	65	80	20								
Bolboschoenus maritimus												30			
Carpobrotus chilensis															
Cressa truxillensis						trace	45	10	15						
Cuscuta salina															
Distichlis spicata											80	50			
Frankenia salina					10										
Heterotheca grandiflora															
Jaumea carnosa								trace	25		100	100			
Juncus acutus															
Limonium californicum															
Limonium ramosissimum															
Monanthochloe littoralis															
Pluchea odorata													5		
Pulicaria paludosa													100		
Sarcocornia pacifica			5	100	95		35	5	15	60	25				
Spartina foliosa	trace	40	15												
Suaeda esteroa															
Suaeda taxifolia															
Symphyotrichum subulatum															
Triglochin maritima															
Typha domingensis														100	100
Dead Plant Matter								85	45	40					
Bare Ground/Open Water	100	60													
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 November 2015 (values are percent cover in 0.5m² quadrat).

Transect #	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
pt # (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																						trace
Atriplex prostrata																						5
Batis maritima		20	45	90	90	95	95	15	5					20								
Bolboschoenus maritimus																						
Carpobrotus chilensis																						
Cressa truxillensis																					5	5
Cuscuta salina			30							30			5							15		
Distichlis spicata													trace	35	trace					90	45	100
Frankenia salina			45						60	10	15		5									
Heterotheca grandiflora																						
Jaumea carnosa						10			5	100		10		15						trace	10	
Juncus acutus																						
Limonium californicum									15				15									
Limonium ramosissimum					65																	
Monanthochloe littoralis			15	100	15																	
Pluchea odorata																						
Pulicaria paludosa																						
Sarcocornia pacifica		30	30	20	35	35	15	10	65	100	20	100	90	35	100	100	100	100	95	35	35	
Spartina foliosa	75	95																				
Suaeda esteroa										15	60		10	50			10			trace		
Suaeda taxifolia																						
Symphyotrichum subulatum																					10	
Triglochin maritima																						
Typha domingensis																						
Dead Plant Matter																						
Bare Ground/Open Water																			5			
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 November 2015 (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																			
Atriplex prostrata																			
Batis maritima		5	5	30	35	75	45	100					40	15	95	100	70	80	80
Bolboschoenus maritimus																			
Carpobrotus chilensis																			
Cressa truxillensis																			
Cuscuta salina					trace	5							10						
Distichlis spicata			15			15											60		
Frankenia salina		25	35	30	trace	20							5					70	
Heterotheca grandiflora																			
Jaumea carnosa			55	15	trace	trace							5						
Juncus acutus																			
Limonium californicum				40	10	10							10	10					
Limonium ramosissimum																			
Monanthochloe littoralis													70						
Pluchea odorata																			
Pulicaria paludosa																			
Sarcocornia pacifica		80		10	50	20	75	10					25	95	100	70	30	40	
Spartina foliosa	5								100	45	30	100							
Suaeda esteroa					trace	35		trace					45						
Suaeda taxifolia																			
Symphyotrichum subulatum																			
Triglochin maritima																			
Typha domingensis																			
Dead Plant Matter																			
Bare Ground/Open Water	95									55	70								
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 November 2015 (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										
Atriplex prostrata										
Batis maritima					10	5	5	20	40	
Bolboschoenus maritimus										
Carpobrotus chilensis										
Cressa truxillensis										
Cuscuta salina										
Distichlis spicata										
Frankenia salina										
Heterotheca grandiflora										
Jaumea carnosa	5	100	100	100	100	100	100	15		
Juncus acutus										
Limonium californicum										
Limonium ramosissimum										
Monanthochloe littoralis										100
Pluchea odorata										
Pulicaria paludosa										
Sarcocornia pacifica	50	25	35	30		trace	5	85	100	
Spartina foliosa	90	30	30		50	45	65			
Suaeda esteroa										
Suaeda taxifolia										
Symphyotrichum subulatum										
Triglochin maritima										
Typha domingensis										
Dead Plant Matter										
Bare Ground/Open Water										
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 November 2015 (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													
Atriplex prostrata													
Batis maritima		15		5					trace	65	trace	5	
Bolboschoenus maritimus													
Carpobrotus chilensis													
Cressa truxillensis													
Cuscuta salina												5	
Distichlis spicata												30	20
Frankenia salina													20
Heterotheca grandiflora													
Jaumea carnosa				100	60	100				5	100	100	20
Juncus acutus													
Limonium californicum													
Limonium ramosissimum													
Monanthochloe littoralis													
Pluchea odorata													
Pulicaria paludosa													
Sarcocornia pacifica			35	20	5	15	40			5	5	10	55
Spartina foliosa		10		20	75	15	10	100	100	100	50		
Suaeda esteroa													
Suaeda taxifolia													
Symphyotrichum subulatum													
Triglochin maritima													
Typha domingensis													
Dead Plant Matter	45												5
Bare Ground/Open Water	55	75	65				50						
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 November 2015 (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																			
Atriplex prostrata																			
Batis maritima			5	5	5	45	85									25	5	10	
Bolboschoenus maritimus																			
Carpobrotus chilensis																			
Cressa truxillensis																			
Cuscuta salina																15			
Distichlis spicata								25							trace	15			trace
Frankenia salina									trace					75		85	5	5	15
Heterotheca grandiflora																			
Jaumea carnosa								100	100					100	80	100	90	85	100
Juncus acutus																	15		
Limonium californicum																		30	
Limonium ramosissimum																			
Monanthochloe littoralis									45									40	trace
Pluchea odorata																			
Pulicaria paludosa																			
Sarcocornia pacifica					10		25		10					10	50	trace	20	35	5
Spartina foliosa		85	100	95	100	100	60												
Suaeda esteroa																			trace
Suaeda taxifolia																			
Symphyotrichum subulatum																			
Triglochin maritima																			
Typha domingensis																			
Dead Plant Matter																			
Bare Ground/Open Water	100	15								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 November 2015 (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													
Atriplex prostrata													
Batis maritima			5	trace	trace	20		10	20		trace	5	
Bolboschoenus maritimus													
Carpobrotus chilensis													
Cressa truxillensis													
Cuscuta salina													
Distichlis spicata					80	5							
Frankenia salina							40	25	35				
Heterotheca grandiflora													
Jaumea carnosa			70	60	90	50	45	10	25	95	80	100	
Juncus acutus													
Limonium californicum							trace	5			20	5	
Limonium ramosissimum													
Monanthochloe littoralis													
Pluchea odorata													
Pulicaria paludosa													
Sarcocornia pacifica			70	5		5	25	10	45	30	10		
Spartina foliosa	trace	90		45		50		95	35	30	75	5	100
Suaeda esteroa													
Suaeda taxifolia													
Symphyotrichum subulatum													
Triglochin maritima								5					
Typha domingensis													
Dead Plant Matter		10											
Bare Ground/Open Water													
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 November 2015 (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
# (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																						
Atriplex prostrata																						
Batis maritima			trace				trace	trace	trace		5	trace	trace	trace	5	trace		trace				
Bolboschoenus maritimus																						
Carpobrotus chilensis																						
Cressa truxillensis																						
Cuscuta salina																						
Distichlis spicata							5	50	5													
Frankenia salina									10								20					
Heterotheca grandiflora																						
Jaumea carnosa			100	100	85	100	100	100	25	75	95	100	100	100	90	100	80	100		85		
Juncus acutus																						
Limonium californicum			10	trace	10				50	5			5			trace	10					
Limonium ramosissimum																						
Monanthochloe littoralis									60													
Pluchea odorata																						
Pulicaria paludosa																						
Sarcocornia pacifica		50	15	trace	trace	10	trace	trace	55	20	5	trace	trace	15	90	5	trace	10	65			
Spartina foliosa												10			10					5	100	
Suaeda esteroa			trace																			
Suaeda taxifolia																						
Symphyotrichum subulatum																						
Triglochin maritima							trace		trace													
Typha domingensis																						
Dead Plant Matter		50																				
Bare Ground/Open Water	100																		35	15		100
Habitat Type FW,H, M, L, SP,	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 November 2015 (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															
Atriplex prostrata															
Batis maritima						90		10	trace	trace		trace	trace		
Bolboschoenus maritimus															
Carpobrotus chilensis															
Cressa truxillensis	60														
Cuscuta salina												trace			
Distichlis spicata	trace	100		100						10					
Frankenia salina					5		10		80		5	trace	trace		
Heterotheca grandiflora		trace	5												
Jaumea carnosa	trace				35		75	trace	85	85	60	95	100		
Juncus acutus															
Limonium californicum							30		5		10	10			
Limonium ramosissimum															
Monanthochloe littoralis	55				5										
Pluchea odorata															
Pulicaria paludosa															
Sarcocornia pacifica	5				100	5	20	trace	10	trace	60	15	5	15	
Spartina foliosa								100					10	65	100
Suaeda esteroa	5				10										
Suaeda taxifolia															
Symphyotrichum subulatum															
Triglochin maritima															
Typha domingensis															
Dead Plant Matter														20	
Bare Ground/Open Water			95												
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 November 2015 (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												
Atriplex prostrata												
Batis maritima												
Bolboschoenus maritimus												
Carpobrotus chilensis					5	30	20					
Cressa truxillensis												
Cuscuta salina										5		
Distichlis spicata				5	5				trace			
Frankenia salina	5	5	5	trace					35			5
Heterotheca grandiflora												
Jaumea carnosa	5	20	100	100					85	100	100	100
Juncus acutus												
Limonium californicum			15	5					20	trace		5
Limonium ramosissimum												
Monanthochloe littoralis			25	15	80			100	5			
Pluchea odorata												
Pulicaria paludosa												
Sarcocornia pacifica		30							10	5	25	5
Spartina foliosa	15	5										
Suaeda esteroa		5	trace	5								
Suaeda taxifolia									trace			5
Symphyotrichum subulatum										10	trace	trace
Triglochin maritima												
Typha domingensis												
Dead Plant Matter					20		80					
Bare Ground/Open Water						70						
Habitat Type FW,H, M, L, SP, U	L	L	H	M	H	upland	upland	H	M	M	M	M

Appendix C
Vegetation Transect Photos
November 2015 and September 2012

Photo 1. Transect 1, viewed from north to south near the start of the transect (**2015**).

Photo 2. Transect 1, viewed from north to south near the start of the transect (**2012**).

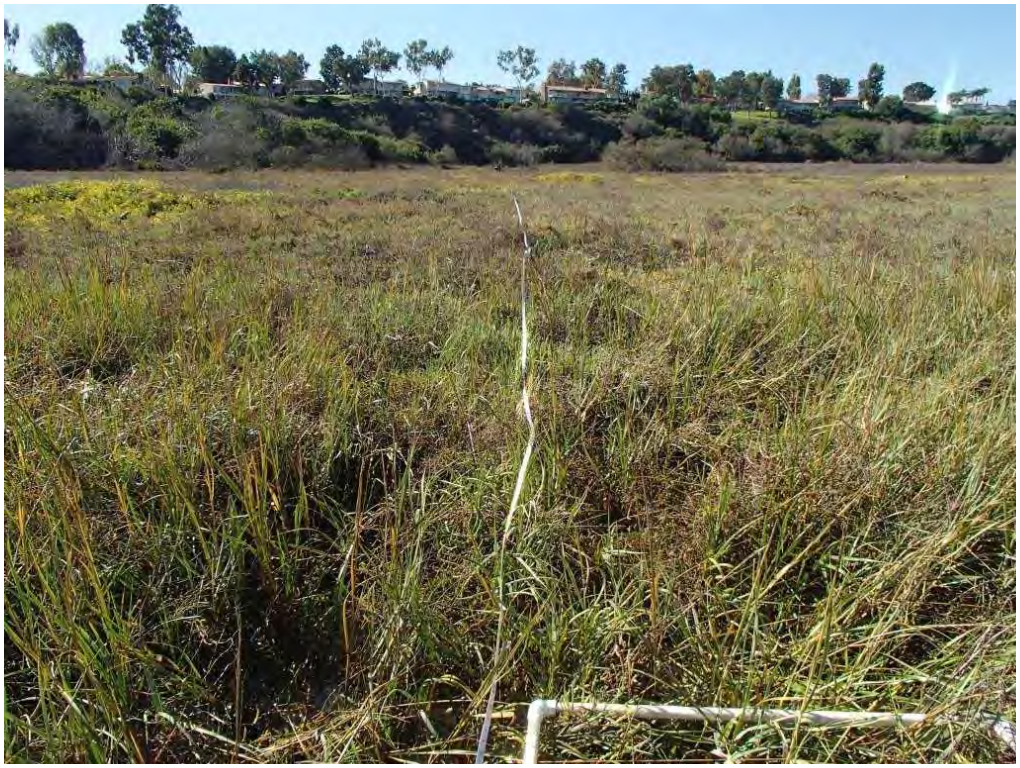

Photo 3. Transect 2, viewed from north to south near the start of the transect (**2015**).

Photo 4. Transect 2, viewed from north to south near the start of the transect (**2012**).

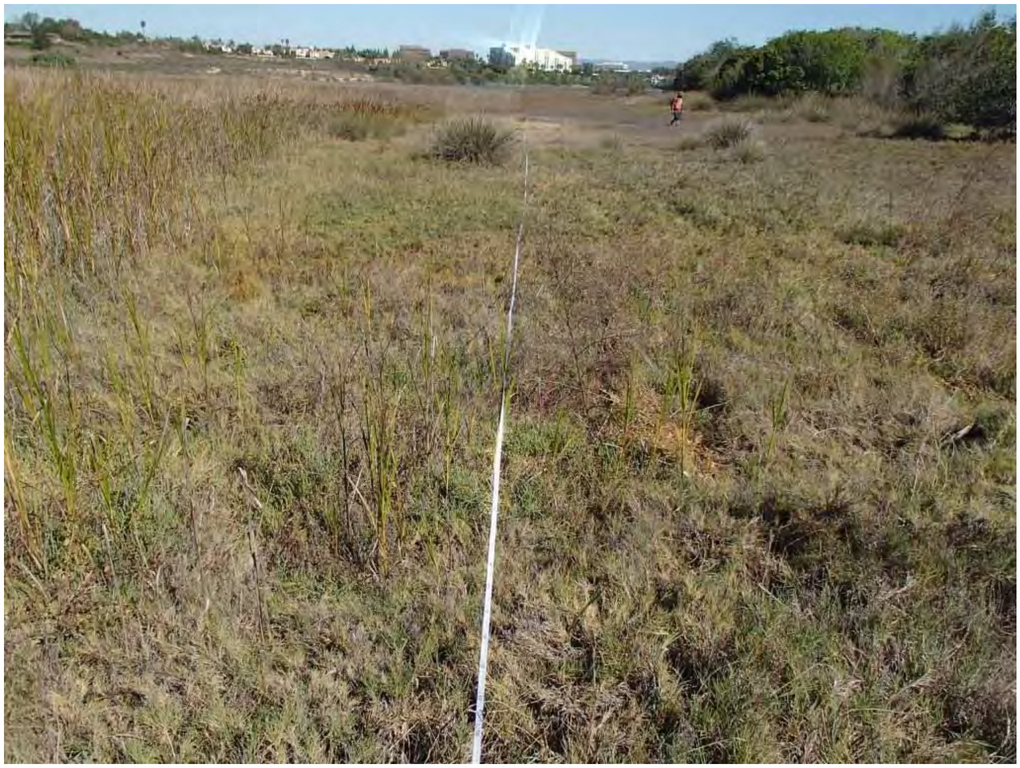

Photo 5. Transect 2, viewed from south to north at the end of the transect (**2015**).

Photo 6. Transect 2, viewed from south to north at the end of the transect (**2012**).

Photo 7. Transect 3, viewed from south to north near the start of the transect (**2015**).

Photo 8. Transect 3, viewed from south to north near the start of the transect (**2012**).

Photo 9. Transect 3, viewed from north to south at the end of the transect (**2015**).

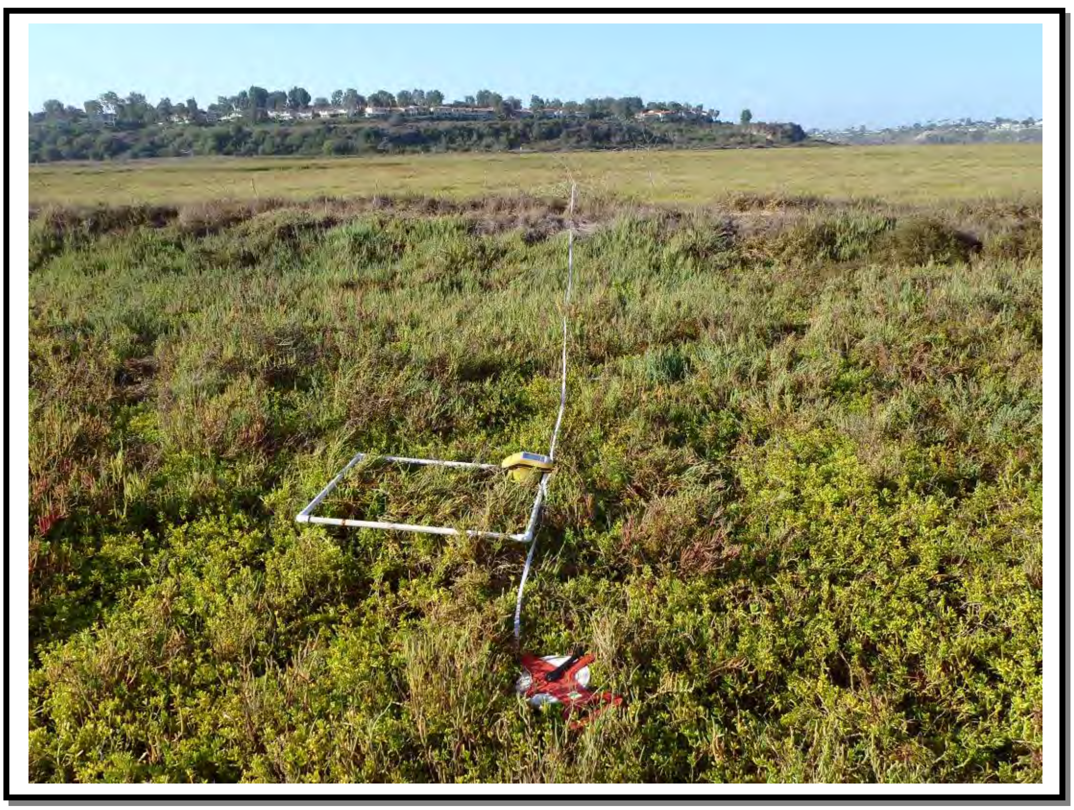

Photo 10. Transect 3, viewed from north to south at the end of the transect (**2012**).

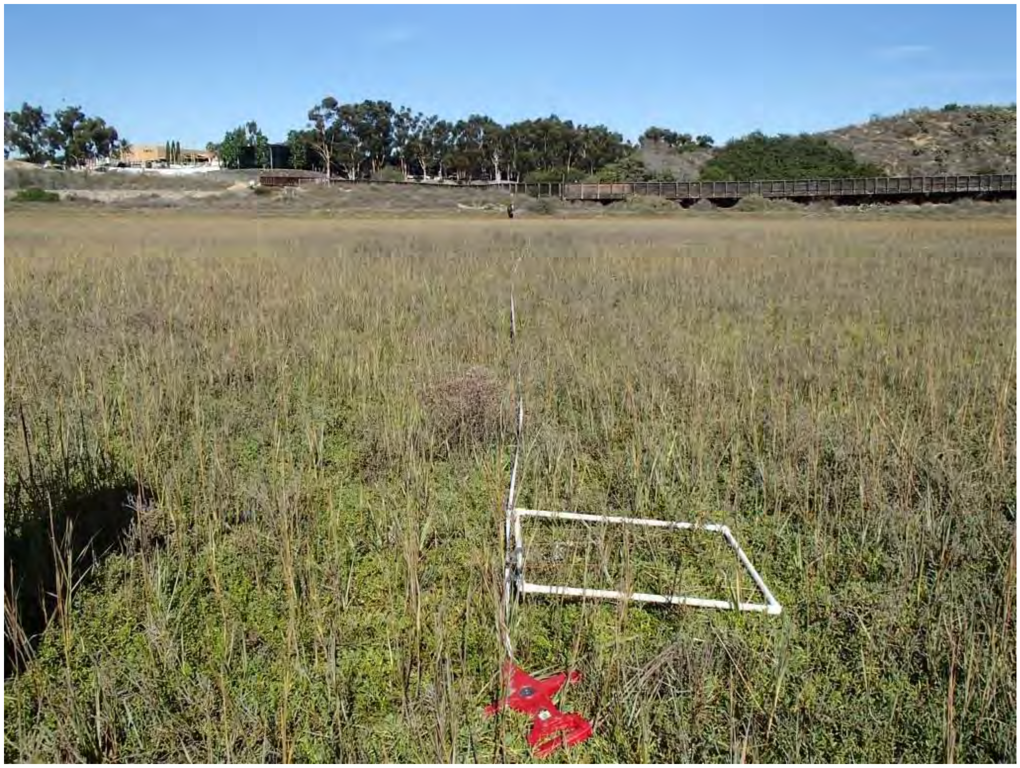

Photo 11. Transect 4, viewed from south to north near the start of the transect (**2015**).

Photo 12. Transect 4, viewed from south to north near the start of the transect (**2012**).

Photo 13. Transect 4, viewed from north to south at the end of the transect (**2015**).

Photo 14. Transect 4, viewed from north to south at the end of the transect (**2012**).

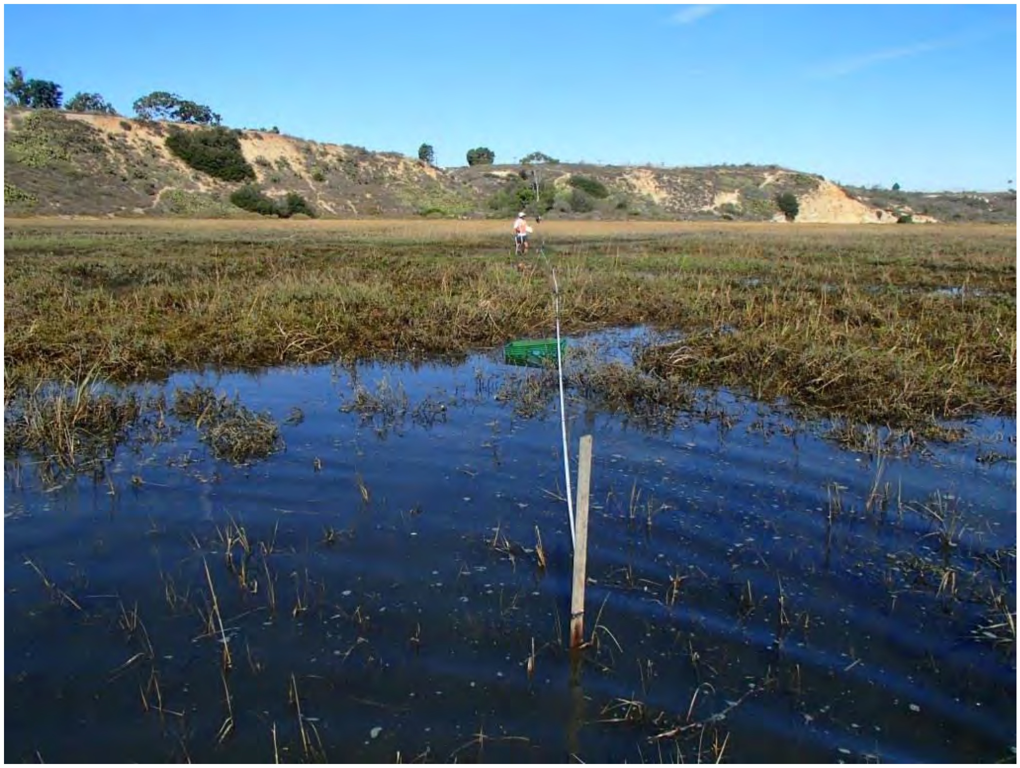

Photo 15. Transect 5, viewed from south to north near the start of the transect (**2015**).

Photo 16. Transect 5, viewed from south to north near the start of the transect (**2012**).

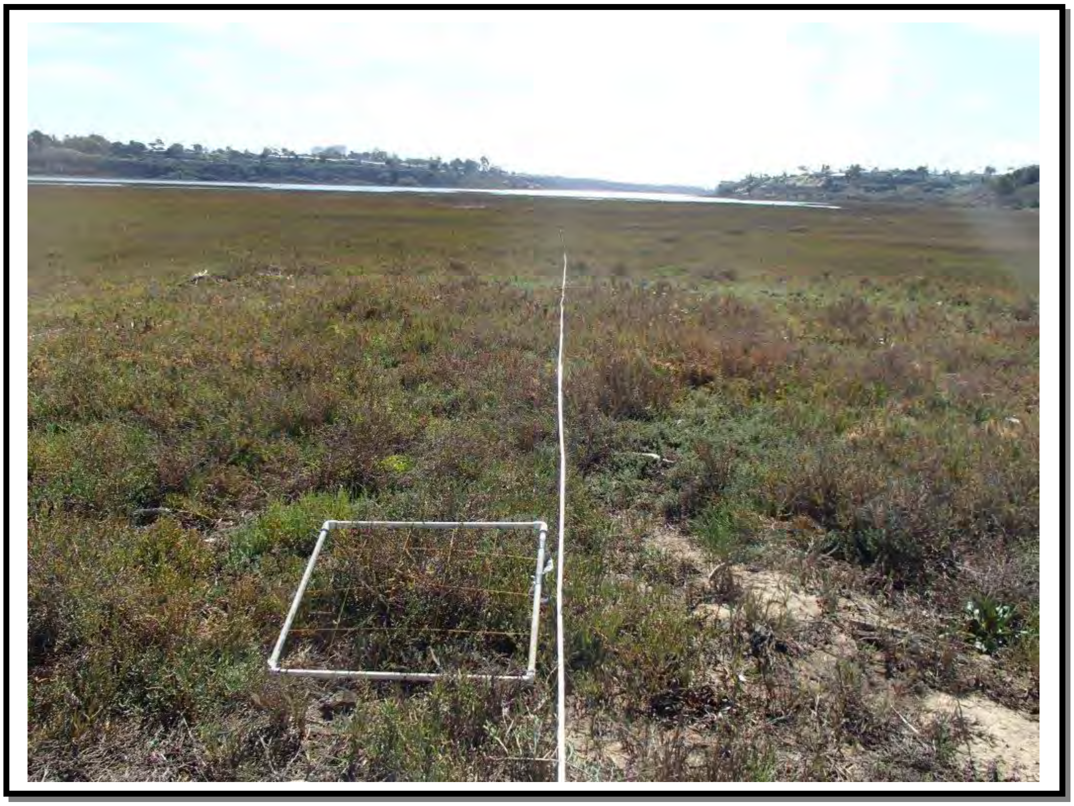

Photo 17. Transect 5, viewed from north to south at the end of the transect (**2015**).

Photo 18. Transect 5, viewed from north to south at the end of the transect (**2012**).

Photo 19. Transect 6, viewed from south to north at the start of the transect (**2015**).

Photo 20. Transect 6, viewed from south to north at the start of the transect (**2012**).

Photo 21. Transect 6, viewed from north to south near the end of the transect (**2015**).

Photo 22. Transect 6, viewed from north to south near the end of the transect (**2012**).

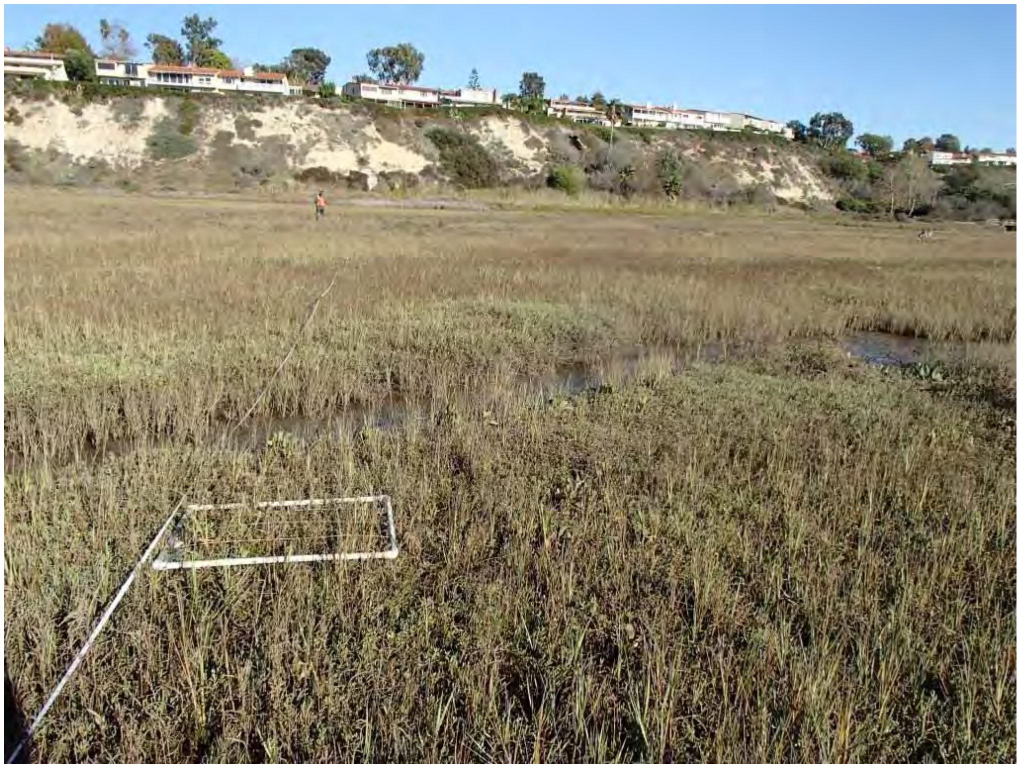

Photo 23. Transect 7, viewed from north to south near the start of the transect (**2015**).

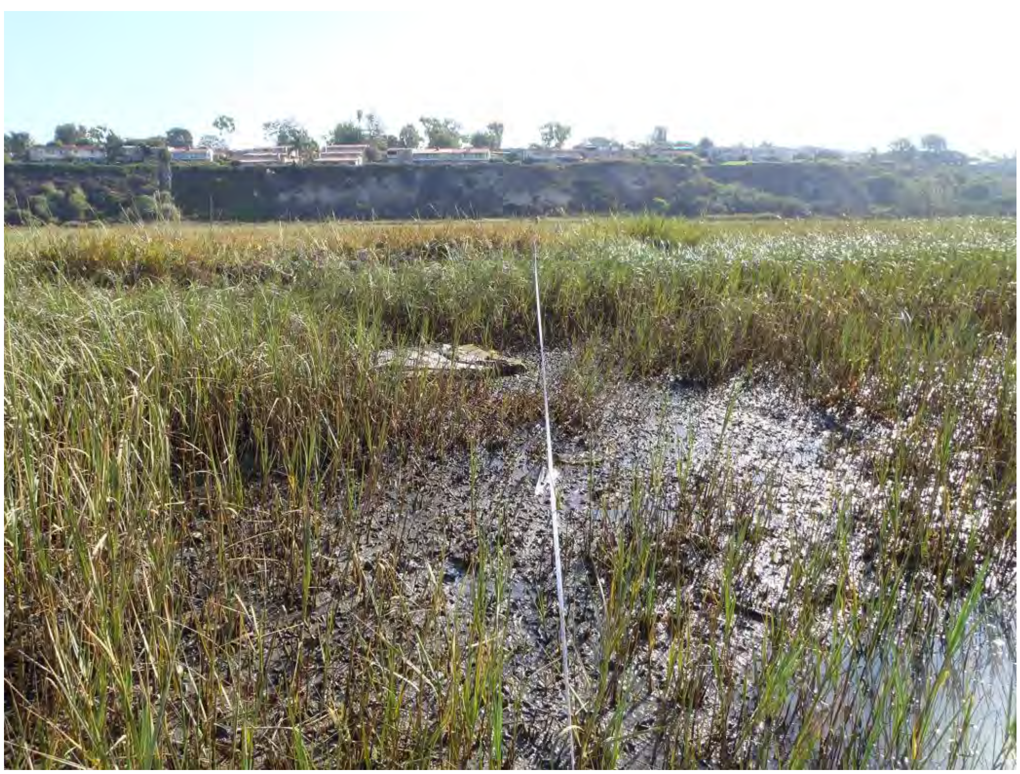

Photo 24. Transect 7, viewed from north to south near the start of the transect (**2012**).

Photo 25. Transect 8, viewed from south to north near the start of the transect (**2015**).

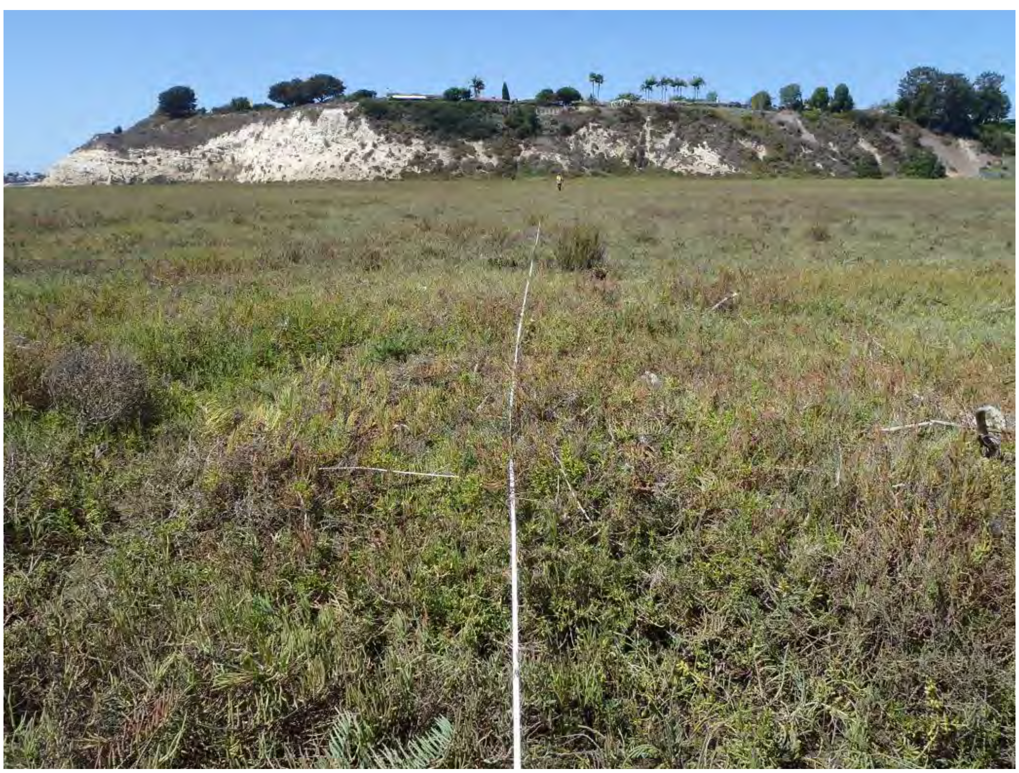

Photo 26. Transect 8, viewed from south to north near the start of the transect (**2012**).

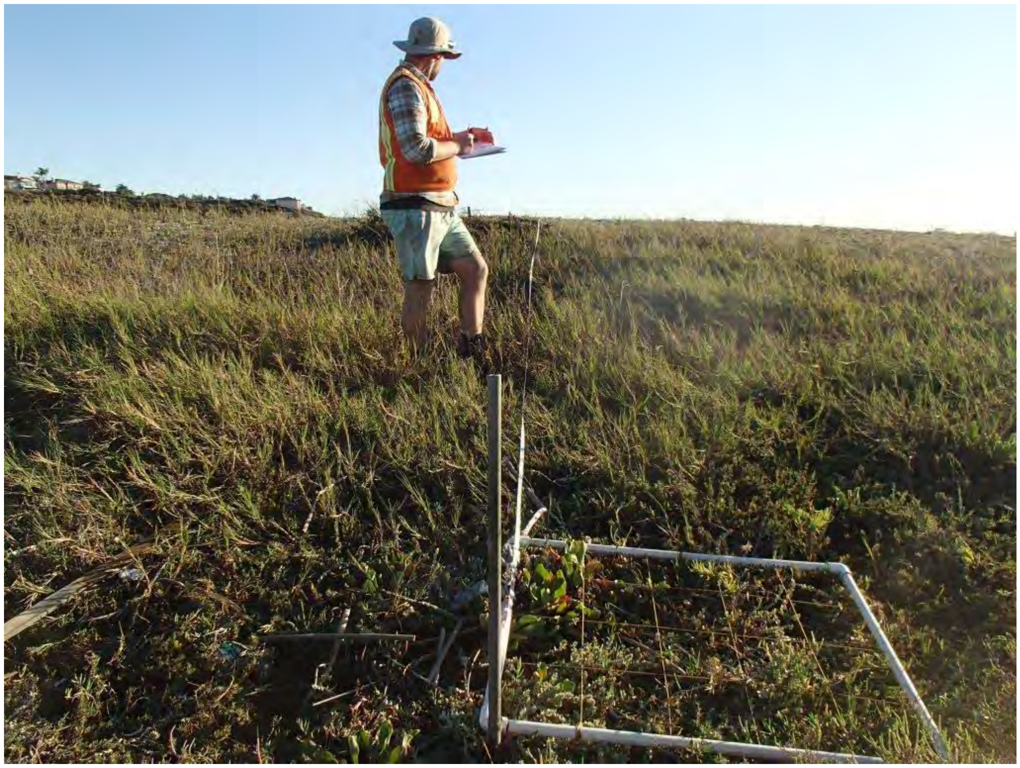

Photo 27. Transect 9, viewed from north to south at the start of the transect (**2015**).

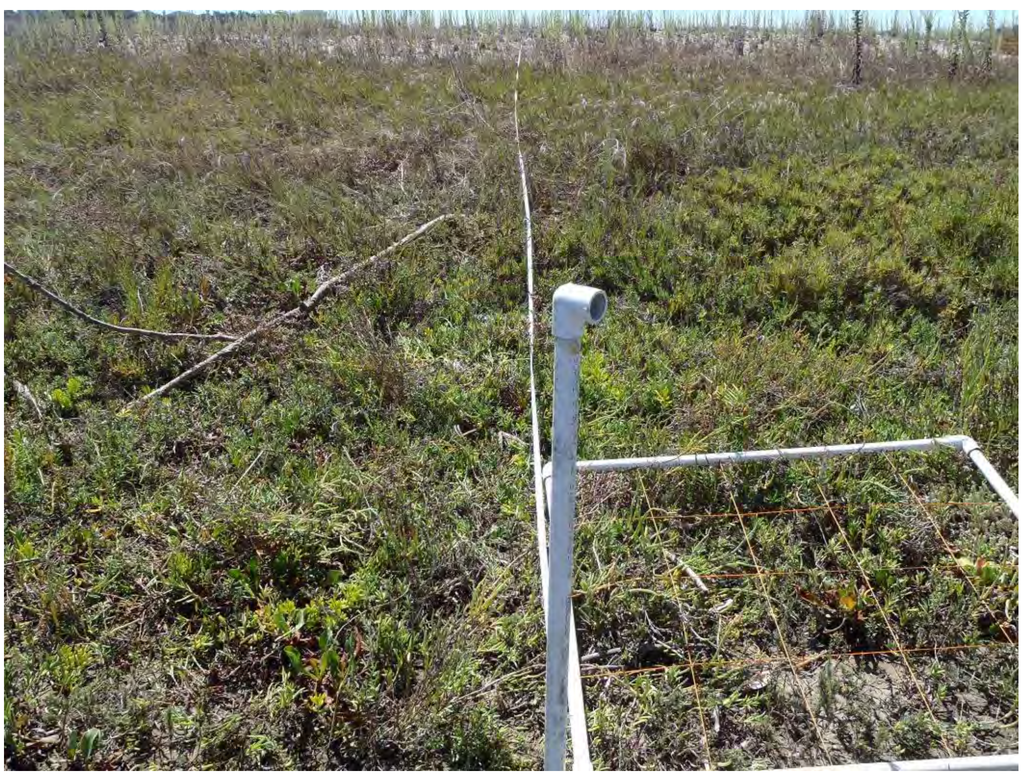

Photo 28. Transect 9, viewed from north to south at the start of the transect (**2012**).

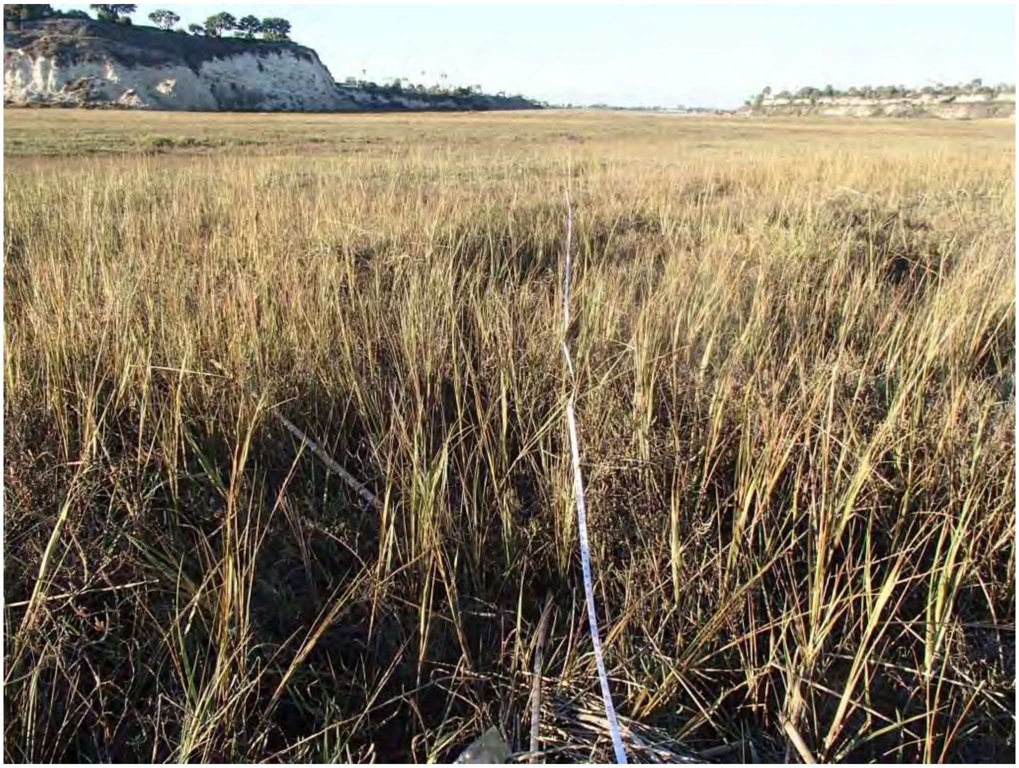

Photo 29. Transect 9, viewed from south to north at the end of the transect (**2015**).

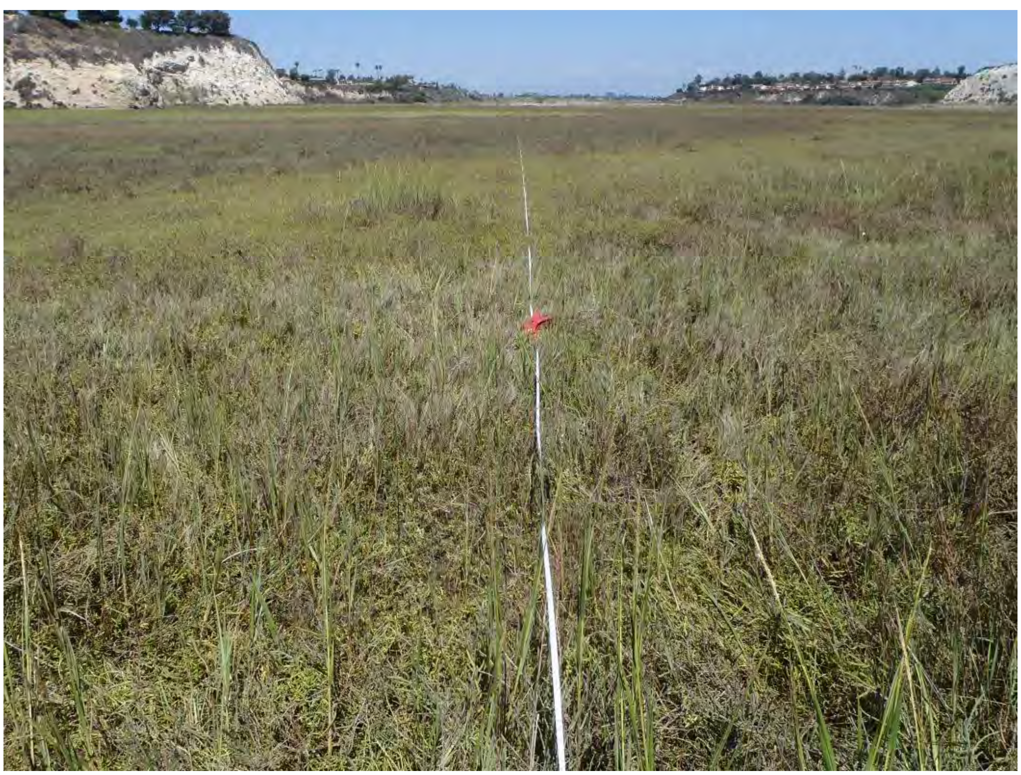

Photo 30. Transect 9, viewed from south to north at the end of the transect (**2012**).

Photo 31. Transect 10, viewed from west to east near the start of the transect (**2015**).

Photo 32. Transect 10, viewed from west to east near the start of the transect (**2012**).

Photo 33. Transect 10, viewed from east to west at the end of the transect (**2015**).

Photo 34. Transect 10, viewed from east to west at the end of the transect (**2012**).

Appendix D
Year 2 (September 2012) Transect Survey Results

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

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