Ballona Wetlands Ecological Reserve
Comprehensive 5-Year Monitoring Report

December 2015

The Bay Foundation

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Prepared by: The Bay Foundation

Prepared for: California State Coastal Conservancy

California Department of Fish and Wildlife

Photo: Area B, tide channels confluence (top); Area A, ruderal marsh (bottom) (R. Abbott, 2014).

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Photo: Area B East adjacent to the Ballona Freshwater Marsh (upper-right) taken from Bluff Trail Road south of the Reserve (R. Abbott, 2014).

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Executive Summary

Level 1: Landscape and Historical Change

In the Los Angeles region, over 96% and 98% of the vegetated and unvegetated coastal estuarine wetlands, respectively, have been lost over the past century and a half; this loss is mainly attributed to conversion of wetland habitat to uplands through fill deposition or development (Stein et al. 2014). The Ballona Wetlands Ecological Reserve (Reserve) is an example of this phenomenon, having suffered from over a century of abuse and land degradation (Shreiber et al. 1981). Historically a bar-built estuary of over 2,100 acres (Grossinger 2010, Dark et al. 2011), the original Ballona Wetlands ecosystem included a variety of habitats, dominated by vegetated wetland and salt pan habitat types (Grossinger et al. 2010). Currently, the Reserve has been reduced in size to less than 600 acres of open space and only approximately one quarter of the site, 153 acres, is considered delineated wetland. Only a small portion of the remaining wetland habitats are still exposed to tidal influence, including approximately 15 acres at the western edge of the Reserve and the Fiji Ditch in Area A. The Reserve is the largest opportunity for significant coastal wetland restoration in the Los Angeles region and the goal of these surveys, this report, and related technical reports and memoranda was to provide accurate scientific data to aid in restoration planning efforts. The California Department of Fish and Wildlife (CDFW) manages the Reserve for the state.

Level 2: Rapid Assessments

California Rapid Assessment Method (CRAM)

California Rapid Assessment Method (CRAM) can be used as a measure of general aquatic resource health and produces condition scores that are comparable and repeatable for all wetlands and regions in California, yet accommodates special characteristics of different regions and types of wetlands. CRAM was used to assess the condition of wetlands within the Reserve in 2012, 2014 and 2015, with a primary objective of assessing the condition of the delineated wetland habitats on site. Five distinct wetland sub-areas within the Reserve were identified based on differences in dominant hydrology, elevation, and historic general impacts such as hydrological modifications or fill sediment placement. Multiple Assessment Areas (AAs) were established within each of three sub-areas, with a single AA established in each of the two remaining hydrologically distinct wetland sub-areas. The scoring range was from a minimum of 25 to a maximum of 100.

CRAM condition scores varied by attribute and year (2012 to 2014). For the three repeated sub-areas with multiple AAs, there was a significant difference in average final score by sub-area ($F_{2, 15} = 28.111$, $p < 0.001$), with Area A displaying the significantly lowest final score, followed by seasonal Area B; the highest scores occurred in the tidally influenced portion of Area B. The AA north of Culver Boulevard (i.e. “Area B – north”) had the lowest final score of any AA on site at 40.9, as well as the lowest buffer and landscape score and the lowest possible physical structure score (i.e. 25). "Area B – ruderal" received a score of 43.4. The average for Area A was 43.7 ± 0.7; the average for "Area B – seasonal" was 53.5 ± 1.4; the average for "Area B – tidally influenced" was 64.2 ± 3.0. Additionally, CRAM final scores declined slightly between 2012 and 2014, which can be attributed to several specific sub-metrics, including a decrease in biotic structure characteristics and an influx of annual, non-native plants.

Photo Point Surveys

The primary purpose of the Photo Point sampling was to qualitatively and visually capture broad changes in the landscape and vegetation communities over seasons and years. Georeferenced photographs collected through the survey will be used for site management (e.g. invasive species tracking) and long-term data collection. Thirty-seven permanent, Photo Point locations were established to visually document vegetation change and large-scale landscape changes over time. For all survey locations, small seasonal variations in the vegetation were apparent.

Level 3: Site-Intensive Assessments

Water and Sediment Quality

Urban wetlands can be contaminated by a wide variety of constituents and sources (Comeleo et al. 1996, Bay et al. 2010). Water quality measurements may be used as indicators of both human health risks and the overall chemical and physical conditions of a site. Water quality surveys across the five monitoring years included general parameters such as dissolved oxygen and salinity, fecal indicator bacteria (FIB), nutrients, other constituents of concern such as heavy metals, and water isotope analyses. Soil and sediment surveys focused on salinity, constituents of concern such as heavy metals, and amphipod toxicity.

Data Sonde

To assess general water quality parameters within tidal Area B, a Yellow Springs Instruments 6600 XLM multi-parameter data logger was deployed continuously in the main inflow channel adjacent to the tide gates to monitor water depth, dissolved oxygen (DO), temperature, salinity, conductivity, and pH at 15-minute intervals. All parameters followed expected and predictable trends such as average temperature increases in summer months and decreases in winter months, relatively consistent pH levels, and depth range changes synchronous with tidal oscillations. Depth was relatively proportional to DO and salinity but inversely proportional to turbidity and temperature. Resuspension of sediments on outgoing tides in the tidal channels caused spikes in turbidity. Dissolved oxygen concentrations varied across a wide temporal scale; however, an overarching trend was that extremely low dissolved oxygen levels (i.e. < 1mg/L) occurred less than two percent of the time across all years. Long-term data across the five monitoring years suggest that general water quality parameters followed expected trends of muted tidal conditions in the tidal channels, e.g. restricted depth, consistent pH, consistently high levels of DO.

Bacteria and Nutrients

A diverse set of water quality surveys were performed to assess fecal indicator bacteria (FIB) and nutrients in and around the Reserve. Stratification studies were conducted to investigate the tidally-influenced movement of bacteria in the wetlands and their relationship to turbidity and sediment resuspension. Overall, the Reserve experienced highly variable concentrations of FIB ranging up to three orders of magnitude. Baseline data from years 1, 2, and other publications (Dorsey 2006, Dorsey et al. 2010, Johnston et al. 2011, 2012, 2015a) suggest that the wetlands are acting as a sink for FIB. This indicates that the tidal wetlands at the Reserve provide a significant ecosystem service in the form of water purification, even in a degraded state. Additionally, significant stratification of both FIB concentrations and loading occurred in the water column during all but the most highly-mixed portions of the tidal cycle. Loading was found to be greatest during flood flows from the contaminated estuary waters and diminished during low tide periods.

Constituent Sampling

Dissolved metals were sampled as part of the baseline monitoring program during both dry and wet weather surveys. Several metals including copper, cadmium, zinc, lead, and selenium consistently exceeded recommended levels for toxicity (USEPA 2009) and TMDL numeric targets (for the full list, see Results section in the first and second year baseline reports; Johnston et al. 2011, 2012). While exceedances of different thresholds are common in urban environments, especially during wet weather sampling events, wetland vegetation species often provide significant water quality services, including reductions of heavy metals.

Isotopic Analysis

Stable isotopes of oxygen and deuterium (^2H or D) were used to identify water sources contributing to the estuary based on the unique isotopic signature of each water body. Water isotope and dissolved major ion concentration data indicate that upper (eastern) Ballona Creek and Dockweiler Beach (ocean) were both found to contribute to the Ballona Estuary (tidal portion of Ballona Creek) and the western channels of the Reserve, with oceanic water as the primary contributor. Upper Ballona Creek contributions to the Ballona Estuary were found to increase after a precipitation event.

Phytoplankton Surveys

In 2014, a phytoplankton community assessment was conducted at two stations in the tidal channels of the Reserve and one station in Ballona Creek to determine baseline phytoplankton taxa present across a 24-hour survey period during a spring tide event. Similar communities and proportions of dominant species were found in all three sites, though specific phytoplankton abundances were highly variable in all locations across the 24-hour period. Fifty-two different genera of phytoplankton were identified (54 total taxa), with the majority of the taxa identified as diatoms within the Bacillariophyceae class.

Amphipod Toxicity

Sediment samples were collected during baseline year two using sterile scoops to a depth of approximately 10 cm at each station. Amphipod toxicity was conducted using *Eohaustorius estuarius* 10-day survival sediment bioassay under guidelines prescribed in Methods for Assessing the Toxicity of Sediment-associated Contaminants with Estuarine and Marine Amphipods. Out of the seven stations tested, two showed low-toxicity as indicated by a lower survival rate, but the other five stations had greater than 92% average amphipod survival.

Soil Salinity

The objective of the soil salinity surveys was to determine concentrations of salts within terrestrial soil samples using existing collected material from the first baseline year. Salt pan transects demonstrated the highest average soil salinity concentrations with a grand mean of 92.27 ± 5.19 ppt. Tidal wetland habitat areas displayed the second highest average soil salinity values followed by non-tidal salt marsh with concentrations of 41.91 ± 4.31 and 34.98 ± 4.77 ppt, respectively. The lowest soil salinity concentrations were found within dune areas and regions which support high vegetative cover of non-native species: dune, non-native dune, non-native "tall" herbaceous, and iceplant stand. Each of these habitat types displayed soil salinities of less than 10 ppt on average.

Soil Grain Size and Organic Content

The objective of the soil particle analysis procedure was to conduct a protocol evaluation of a combination of traditional and advanced technology to analyze soil type and total organic content on previously collected first baseline year soils. Sand was separated from fine-grained sediments for each sample using a 62 micron sieve. Fine sediments were mixed and tested in the LISST Particle Analyzer three or four times and averaged. After several rounds of testing, replication results revealed too much variability within a single sample to provide useful data to the monitoring program.

To analyze organic content, soil aggregates were thoroughly ground with mortar and pestle, and the sample was weighed. The prepared sample was placed in a furnace for 15 minutes at a temperature of 500 °C to burn off organic matter and subsequently reweighed. The percent of total organic matter in five individual soil samples from three habitat types ranged from a minimum of 8.70 % in the salt pan to a maximum of 31.05 % in the tidal wetland habitat type.

Biological Communities – Vegetation

Long-term monitoring of vegetation cover is one of the most common methods to evaluate the health and functioning of a wetland system (Zedler 2001); changes in the relative presences of native and non-native plant species may affect the distributions of associated wildlife species.

Habitat and Vegetation Alliance/Association Mapping

Surveys were conducted at the Reserve from May through October 2013 in accordance with methods developed by CDFW's Vegetation and Classification Mapping Program, with supplemental information derived from previous monitoring surveys (2009–2013) conducted throughout the site (Johnston et al. 2011, 2012). Data were compared to surveys conducted in 2007 by CDFW. Habitat categories were highly variable from subtidal to high elevation upland and were classified on an individual basis based on georeferenced polygons categorizing dominant vegetation community and physical characteristics such as soil and hydrology.

A notable increase of non-native "tall" herbaceous habitat, defined by fast growing monocultures or co-dominant mixes of invasive herbs, accounts for the conversion, and subsequent loss, of a portion of annual/ruderal grassland habitat. Additionally, Area A showed some conversion of ruderal marsh and brackish scrub habitat types to non-native "tall" herbaceous habitat, indicating that fast-growing invasive species in that habitat type continue to propagate and expand within remaining native habitat areas, especially in Area A. The loss of non-tidal salt marsh habitat areas in portions of Area B display a conversion, in part, to ruderal marsh habitat. The 2013 tidal and non-tidal wetland habitat types corresponded primarily to a native-dominant alliance/association classification, while the upland habitat types tended to have mixed or non-native dominant vegetation classifications.

Additional species-level, site-wide comparative evaluations of several of the dominant non-native and native vegetation species were conducted. Areas with the largest historic fill impacts displayed the most drastic habitat transformations. One of the most significant invading vegetation species, *Brassica nigra* (black mustard), grew profusely between the survey years, and it produces allelopathic chemicals that prevents germination of native plants (Holloran et al. 2004). The non-native *Carpobrotus edulis* (iceplant) showed a 20% increase, with over 35 acres mapped in the 2013 survey. Some changes, such as the relatively small increase in acreage of non-native *Cortaderia selloana* (pampas grass), should still be evaluated carefully as that particular species is very difficult to extirpate. Areas in the tidal inundation zone show replacement of *Cressa truxillensis* (alkaliweed) with another native, *Salicornia pacifica* (pickleweed). There were minor changes in aerial extent of the native species *Distichlis spicata* (saltgrass)*, Jaumea carnosa* (fleshy jaumea), and *Frankinia salina* (alkali heath), but not in overall acreage.

Vegetation – Plant Cover Transect Monitoring

The objective of the vegetation surveys was to determine average percent cover of vegetation over time using habitat-level assessments. Vegetation cover surveys for absolute cover were conducted on a total of 356 randomly allocated transects throughout 11 habitat types across five monitoring years. Multiple survey methods (i.e. laser quadrats and percent cover quadrats) were used to assess percent cover and diversity in different habitat types because of the differing conditions across multiple habitats (e.g. plant height and density, species diversity, topography).

The average (grand mean) cover of native vegetation (± standard error) for all habitats combined across monitoring years 1 and 2 was 36.3 ± 2.3%; the average cover of non-native vegetation combined was 44.9 ± 2.2%, with bare ground or "other" making up the remaining 19.9 ± 1.4%. Frequently identified native species on the transects included: *S. pacifica*, *D. spicata*, *J. carnosa*, *C. truxillensis*, and *Arthrocnemum subterminale* (Parish's pickleweed). Frequently identified non-native species on the transects included: *B. nigra*, *Glebionis coronaria* (crown daisy), and *C. edulis*. Additionally, many berms and elevated areas also had a high prevalence of non-native annual grasses and herbaceous vegetation such as *Polypogon monspeliensis* (rabbitsfoot grass), *Bromus diandrus* (ripgut brome), and *Melilotus indicus* (yellow sweetclover).

In general, results evaluated at the habitat-level indicated predominately native vegetation within saline influenced areas (i.e. tidal wetland, non-tidal salt marsh, and brackish marsh), which consistently displayed the highest native percent cover across all years. However, areas impacted by historic fill placements displayed the highest non-native percent cover (e.g. non-native "tall" herbaceous, annual ruderal grassland) across all years.

Vegetation – Germinated Seed Bank

To survey the seed bank of the Reserve, soil cores were collected and grown in a greenhouse, and germinated seedlings were identified to species. Cores were analyzed by number of germinated seedlings per m^2 and averaged across each habitat type. The seed bank of the wetland habitat types surveyed at Ballona was dominated by native seedlings in the tidal habitats and non-native seedlings in the non-tidal and ruderal habitats. The salt pan, ruderal marsh, and intertidal habitats had the fewest average germinated seedlings per transect overall. Native seedlings were predominantly *S. pacifica* and *J. carnosa*. Non-native seedlings were primarily annual grasses such as *P. monspeliensis*, which was also the second most common species, overall. The pattern of seedling nativity reflects, to some extent, the nativity of the vegetative cover of the adult species along similar representative transects.

Vegetation – SAV/Algal Percent Cover

Algae and submerged aquatic vegetation (SAV) cover surveys were conducted along four 30-m transects deployed parallel to the channel bank with the same elevation contour as the muted tidal channel. The algae/SAV community in the tide channels of the Reserve was primarily unattached or floating algal mats, with the occasional presence of attached submerged aquatic vegetation (i.e. *Ruppia* sp., or ditch grass). Most of the algae present was found to be *Ulva intestinalis* (green alga), with *U. lactuca* (sea lettuce) also present throughout the survey years. Overall, the Reserve does not experience excessive eutrophication, which would lead to significant algal blooms and have the potential to affect dissolved oxygen levels as well as the benthic invertebrate community.

Biological Communities – Vertebrates

The Ballona Wetlands region and the Reserve have suffered a decline in native vertebrate populations, a reduction in species ranges, and an increase in the types and population sizes of introduced species throughout the last century (Friesen et al. 1981). Comprehensive vertebrate surveys are imperative to the establishment of current ranges and species present within the Reserve. Vertebrate populations surveyed included ichthyofauna, herpetofauna, mammals, and avifauna.

Ichthyofauna

Ichthyofauna (or fish) sampling using beach seines occurred six times across the first and second year of baseline assessment for both day and night surveys, and sampling occurred four times using shrimp trawls deployed from a boat in Ballona Creek. Fifteen species of fish were caught in the Reserve or in Ballona Creek across all survey years. The most common fish caught was topsmelt (*Atherinops affinis*); California killifish (*Fundulus parvipinnis*) and gobies (*Clevelandia ios* or *Ilypnus gilberti*) were the next most abundant species. Within the tide channels and Fiji Ditch, the beach seine surveys identified a total of seven native species and one non-native species, the western mosquitofish (*Gambusia affinis*). The round stingray (*Urobatis halleri*) was found exclusively within the Fiji Ditch. All fish species found during the monitoring program are representative of southern California estuarine marsh systems (Miller and Lea 1972, Moyle et al*.* 1995, Allen et al*.* 2006). Overall, the muted nature of the tides allows several typical salt marsh fish species of southern California to access the tide channels of Area B, but prevents them from accessing and foraging the marsh plain habitats (e.g. high marsh).

Herpetofauna

A diverse set of field methods were implemented across the five monitoring years and were intentionally varied to assess a wider potential diversity of herpetofauna species and to address potential data gaps. Driftnet and pitfall arrays were implemented during the first monitoring year, and cover board arrays were used in combination with site searches from November 2010 to May 2014. Additionally, targeted surveys for the California legless lizard (*Anniella pulchra*), a California Species of Special Concern, were conducted in the dune habitats in the first monitoring year. Surveys were not repeated at the request of CDFW to avoid disturbance in subsequent years.

For all surveys combined, a total of ten herpetofauna species were captured or observed on site, including two species previously unidentified at the Reserve prior to baseline surveys: garden slender salamander (*Batrachoseps major*) and San Bernardino Ring-necked snake (*Diadophis punctatus modestus*). Five reptile species were ubiquitous throughout the Reserve, especially in the non-tidal habitats, and were found on almost every survey across all five survey years. These five species were Great Basin fence lizard (*Sceloporus occidentalis longipes*), Western side-blotched lizard (*Uta stansburiana elegans*), San Diego alligator lizard (*Elgaria multicarinata webbii*), San Diego gopher snake (*Pituophis catenifer annectens*), and California kingsnake (*Lampropeltis getula californiae*). Several rare herpetofauna species were also found to present at the Reserve, including garden slender salamander, San Bernardino ring-necked snake, and California legless lizard.

Mammals

Mammal community surveys were conducted at the Reserve using four different types of survey methods, including Sherman live traps, motion camera stations, acoustic Chiroptera (bat) surveys, and road mortality surveys. Small mammals were surveyed throughout non-tidal Reserve habitat types in the first two monitoring years using baited Sherman live traps deployed as both arrays and transects. Medium and large mammal sampling was conducted using Scout Guard camera stations ("Critter Cams") and visual and auditory site searches during the first four survey years. Three locations were surveyed in November 2014 for resident and migratory Chiroptera (bat) species utilizing non-invasive acoustic monitoring that detected and recorded bat echolocation calls in flight. Three major roadway transects were surveyed semi-monthly for vertebrate mortality from October 2010 through September 2013.

Over the entire monitoring period, 64 small mammals were captured using the Sherman live traps, including primarily western harvest mice (*Reithrodontomys megalotis*) and South Coast marsh voles (*Microtus californicus stephensi*). Forty four camera trap stations recorded a total of 22 total species across all monitoring years. Ten species were mammals and ten species were birds; additionally, one reptile (unidentified lizard species) and one marsupial (Virginia opossum, *Didelphis virginiana*) were also identified. Based on the six nights of surveys, 98 total bat echolocation calls were detected and recorded on or adjacent to the Reserve.

Several mammalian species were fairly ubiquitous throughout the site, including western harvest mice, cottontail rabbits, coyotes, and humans. The highest overall species richness was consistently observed within Area B, with Area C exhibiting the lowest relative number of species observed each year. Frequent occurrences of non-native or invasive species such as Virginia opossum and domestic cats and dogs were observed. Lastly, results from vertebrate mortality surveys indicated that roadways bisecting the Reserve present a major obstacle to wildlife mobility, with specific segments of the roadways depicting higher kills rates than other segments. In three years of surveys, a total of 654 kills were recorded during 70 surveys of the three roadway transects. Warmer months corresponded with increasing vertebrate mortality. The species with the highest number of roadkill incidences overall, the cottontail rabbit, was also the species most frequently identified at the motion camera stations.

Avifauna

Multiple methods were implemented over several days for different monitoring years including Reserve-wide surveys, waterbird surveys, and box count method surveys. Across all monitoring years, 167 bird species and distinct subspecies were recorded, including all survey types. Reserve-wide surveys not including Ballona Creek conducted during monitoring year three recorded 83 bird species. Eighteen bird species were recorded as present during all five monitoring years, regardless of survey type. Species included a variety of waterbirds, shorebirds, raptors, and landbirds including, but not limited to: American Kestrel (*Falco sparverius*), Anna's Hummingbird (*Falco sparverius)*, Belding's Savannah Sparrow (*Passerculus sandwichensis beldingi*), Common Yellowthroat (*Passerculus sandwichensis beldingi*), Great Blue Heron (*Ardea herodias*), Great Egret (*Ardea alba*), Least Sandpiper (*Calidris minutilla*), Western Sandpiper (*Calidris mauri*), and Snowy Egret (*Egretta thula*).

Monitoring data combined across all five years suggest that the assorted range of habitats within the Reserve support a diverse bird community – from water-associated birds to urban-adapted species. Bird species identified ranged from vagrant species stopping over during migration events (e.g. wintering, roosting) to established year round populations for which the Reserve appeared to provide needed resources (e.g. food) to the regional avian assemblages.

Biological Communities – Invertebrates

Benthic invertebrate taxa are useful ecological indicators; the presence or absence of certain infauna or epifauna within tidal channels can serve as indicators of water quality, anthropogenic stressors to the estuary, and the potential to support other trophic levels (WRP 2006). Similarly, terrestrial invertebrates are a vital link in wetland food webs and may be considered system health indicators (Zedler 2001).

Benthic Invertebrates

Deep dwelling infauna (e.g. bivalves and shrimp) were collected using a handheld, 10 cm diameter corer pushed into the sediment to a depth of 30 cm in the tidal channels of Area B. Smaller invertebrate infauna (e.g. polychaetes and amphipods) were collected using a 6 cm diameter corer pushed into the sediment to a depth of 5 cm. The most common taxa by total density (number of individuals / m^2) for all stations for the small cores in the second monitoring year in descending order included two amphipods (i.e. *Monocorophium insidiosum* and *Grandidierella japonica*), a relatively pollution-tolerant group of polychaetes (i.e. *Capitella capitata Cmplx*), one gastropod (*Acteocina inculta*), unidentifiable oligochaetes, and another polychaete (*Streblospio benedicti*). Similar results were identified in the small cores in year three. The most common taxa by total density in descending order included unidentifiable oligochaetes, *C. capitata Cmplx*, *M. insidiosum*, *A. inculta*, *Exogone sp*., *Fabricinuda limnicola*, and *G. japonica*. The four most common taxa by density identified in the large cores for the second year, but present in much smaller densities than the small cores, included the following: *A. inculta*, *Cirriformia sp.*, *M. insidiosum*, and *Solen rostriformis*. Similar results were found in the third monitoring year for the large cores: *F. limnicola*, *Pygospio elegans*, *A. inculta*, and *Cirriformia sp*.

Similar taxa were represented across monitoring years; however, differences in densities as well as species lists were detected between the two survey areas (i.e. Fiji Ditch and west Area B tidal channels). For example, 17 and 20 taxa were found in the Fiji Ditch in years two and three, respectively, while 36 and 39 taxa were found in the west Area B muted tide channels for both years, approximately twice as many. The differences in the benthic invertebrate communities were likely due to hydrological and water/sediment quality differences between the two areas.

Terrestrial Inverts

Three traps for each of two survey methods (i.e. three sticky traps and three pitfall traps) were deployed equidistant along 30 m transects. All individual invertebrates on the sticky traps were counted and classed by operationally-defined size classes: <0.5 mm, 0.5-2 mm, 2-5 mm, 5-10 mm, or >10 mm. Invertebrates found in the pitfall traps were preserved in ethanol, identified to the lowest possible taxonomic level, counted, and measured.

Both the aerial arthropod and pitfall invertebrate sampling methods produced highly variable results across spatial and temporal scales. For aerial arthropod surveys, the highest biomass was identified in the brackish marsh habitat type [10.73 ± 2.35 grams per transect (g/t)] with second highest identified in the annual ruderal grassland habitat type (9.53 ± 4.20 g/t). The lowest biomass was identified in the non-native dune and salt pan habitat types at 1.51 ± 0.59 and 2.12 ± 0.84 g/t, respectively. For pitfall surveys, over 9,000 individual epigeal (or surface) invertebrates encompassing twenty-six orders (or the equivalent taxonomic level) were identified in the pitfall traps across ten habitat types in the Reserve across all survey years. The relative abundances of specimens from one order or taxon in respect to others were found to vary considerably by habitat type. Although different taxa were found to be more prevalent in specific habitats consistent with their life histories, some groups – such as the Argentine ants (*Linepithema humile*), an aggressive invader – were found ubiquitously throughout the Reserve within all habitat types surveyed.

Physical Characteristics

Physical surveys of hydrology, topography, and tidal inundation regimes (Zedler 2001, PWA 2006) can be used to assess temporal changes to a site, including erosion and sedimentation over time. Many of the biological and chemical processes that occur in wetlands are driven by the physical and hydrologic characteristics of the site (Nordby and Zedler 1991, Williams and Zedler 1999, Zedler 2001).

Elevation

The 2006 U.S. Geological Survey (USGS) 10-foot Digital Elevation Model (DEM) was analyzed in ArcMap 10.3 Geographic Information Systems (GIS) software to characterize general landscape level elevation and derive site-wide cross-sectional profiles. Additionally, on-the-ground elevation surveys were completed on the same subset of vegetation transects used for soil, terrestrial invertebrates, and seed bank surveys. Habitat-level assessments indicate that the contrast between upland and marsh habitat elevations follows predictable elevation patterns. Evaluations of the site-wide cross-sections and DEM analyses produced similar results, showing areas of historic fill placement and a wide variety of impacts to the original wetland soils.

Channel Cross-Sections

Channel cross-sections were surveyed within the tidal channels of Area B and the Fiji Ditch during the summer of 2011 and compared to surveys from 2006. Using a level transit and stadia rod, measurements were taken every 50 cm and at every break in slope. In general, channel cross-sections within the Reserve remained relatively stable across years with the exception of a slight widening within higher tidal energy environments (e.g. adjacent to the main tide gate) as the result of bank undercutting and sloughs. The cross-section surveys showed steep channel banks often surrounded by an upland berm. Individual cross-sections varied based on their location within the tidal channel system, but all exhibited a similar overall pattern. The steep banks and channel bank berms restrict floodplain inundation by confining tidal waters to the channels and eliminating the vertical zonation of vegetation from most of the adjacent areas.

Inundation

The inundation extent of a 7.0 and 6.9 ft king (high spring) tide was tracked with a sub-meter Trimble GeoXH handheld unit within Area B on 3 and 4 December 2013, respectively, to determine maximum inundation area. King tides inundated 15.07 acres of intertidal channel, tidal wetland, and salt pan habitats. The surveys captured the maximum extent of tidal inundation; however, inundation from a neap tide would cover a much smaller area. The large areas within the salt pan and south of Culver Boulevard do not normally receive extensive tidal inundation except for occasional king tides.

Final Conclusions

Several clear conclusions emerge based on more than five years of data collection at the Reserve, literature reviews of previous site evaluations, and input from scientists throughout California. As no significant management actions (e.g. full-scale restoration, tide gate modifications) occurred within the sampling period, these results are likely indicative of long-term trends until significant restoration commences. Ultimately, these data serve as a pre-restoration baseline assessment of the condition of the site; they could be compared to post-restoration data in the future to evaluate changes in site conditions resulting from management actions.

Both the Level 2 and Level 3 data corroborate that the Reserve is experiencing slowly deteriorating conditions across most of the areas hydrologically disconnected from tidal influence. This disconnection due to the presence of the Ballona Creek levees, in combination with the substantial amount of fill placement, are generally agreed upon as the most significant negative impacts to the wetlands. The impacts are evident through the continued influx of non-native and invasive vegetation and a lack of hydrological connection to estuarine water sources. The Reserve is the largest opportunity for significant coastal wetland restoration in the Los Angeles region, and these data and results were provided to the Draft Environmental Impact Report/Statement planning team to inform the Ballona Wetlands Restoration Project.

Introduction

In 2009, The Bay Foundation (TBF, also known as the Santa Monica Bay Restoration Foundation) partnered with the California Department of Fish and Wildlife (CDFW), California State Coastal Conservancy (SCC), and Loyola Marymount University (LMU) to assess the ecological condition of the Ballona Wetlands Ecological Reserve (BWER or Reserve). The monitoring program was developed to comprehensively survey the biological, chemical, and physical characteristics needed to inform the State's restoration planning process at the Reserve, as well as to develop baseline information and data to assist long-term and regional monitoring programs.

This final, five-year monitoring report is a complementary document to the previous comprehensive baseline reports (Johnston et al. 2011, 2012) as well as supplemental technical memoranda, publications, and documents generated in the interim years. It presents data collected during all five years of the monitoring program and compares results across years when possible. To consolidate the information and immense data sets, detailed methods and specific data results were not repeated from the first two baseline reports unless new information was obtained in the subsequent monitoring years.

This document was assembled using various studies and work products that were developed over the course of the program. For additional details within individual subsections, refer to the referenced technical documents contributing to this report. Many documents are available online on TBF's website (www.santamonicabay.org) or the Ballona Wetlands Restoration Project website (www.ballonarestoration.org). Summary details of the monitoring protocols and prior results are compiled from the following, as well as documents listed in the literature cited:

- "The Ballona Wetlands Ecological Reserve Baseline Assessment Program: Year One Report" (Johnston et al. 2011).
- "The Ballona Wetlands Ecological Reserve Baseline Assessment Program: Second Year Report" (Johnston et al. 2012).
- "Regional Monitoring Report for Southern California Coastal Wetlands: Application of the USEPA Three-Tiered Monitoring Strategy" (Johnston et al. 2015c).
- "California Estuarine Wetlands Monitoring Manual (Level 3)" (Johnston et al. 2015d).
- "Ballona Wetlands Ecological Reserve – Fall 2014 Bat Survey Results" (ESA 2014).
- "Stratification and loading of fecal indicator bacteria (FIB) in a tidally muted urban salt marsh" (Johnston et al. 2015a).
- "Technical Memorandum: Condition Assessment of the Wetland Habitats in the Ballona Wetlands Ecological Reserve" (Johnston et al. 2015b).
- "Technical Memorandum: Patterns of Vehicle-Based Vertebrate Mortality in the Ballona Wetlands Ecological Reserve" (Johnston et al. 2014).
- "Technical Memorandum: Ballona Wetlands Ecological Reserve Vegetation Alliance and Habitat Crosswalk" (Medel et al. 2014).

About this Project

Comprehensive Monitoring Report Goals

This comprehensive monitoring report briefly outlines the methods implemented for each data set, but focuses efforts on providing overarching trends in data accumulated since the inception of the baseline monitoring program in August 2009. The specific goals of this document are as follows:

(1) Collect comprehensive pre-restoration baseline information for the Reserve;
(2) Fill data gaps at the Reserve, including data on rare species, and develop protocols for addressing data gaps at other wetland projects;
(3) Inform adaptive management and long-term restoration plans;
(4) Increase comprehensive knowledge of the health and functioning of the site in an urban environment;
(5) Identify stressors;
(6) Identify temporal data trends, when possible;
(7) Inform both a site-specific and regional long-term monitoring program; and
(8) Contribute ecological data from the BWER to local, regional, and national databases.

Monitoring activities were conducted for a period of five years, although several protocols were extended at the request of the restoration planning team or as part of complementary regional survey programs. Table 1 summarizes the types of surveys completed and the corresponding monitoring years in which data were collected. Generally, monitoring years comprised the following schedule; any exceptions to this schedule are described in individual methods subsections.

- Year 1: August 2009 – September 2010
- Year 2: October 2010 – September 2011
- Year 3: October 2011 – September 2012
- Year 4: October 2012 – September 2013
- Year 5: October 2013 – September 2014

Table 1. Monitoring activities and timeline. Asterisk indicates additional monitoring completed.

Survey Type	Survey Activities				
	Year 1	Year 2	Year 3	Year 4	Year 5
Level 2: Rapid Assessments					
California Rapid Assessment Method (CRAM)			X	X	X
Photo Point Monitoring and Geotagged Photos				X	X
Level 3: Site-Intensive Assessments					
Water Quality					
Automated Data Sonde	X	X	X	X	X *
Bacteria and Nutrients	X	X			
Metals and Constituents of Concern	X	X	X		
Isotope Analysis				X	
Phytoplankton Community Survey					X
Sediment Quality					
Amphipod Toxicity		X			
Constituent Sampling	X	X			
Soil Quality					
Constituent Sampling	X	X			
Salinity			X	X	X
Grain Size and Organic Content	X	X			X
Vegetation					
Habitat + Vegetation Alliance/Association Mapping				X	
Plant Cover Transect	X	X	X	X	X
Germinated Seed Bank	X	X	X	X	X
SAV/Algal Percent Cover	X	X	X	X	X
Vertebrates					
Ichthyofauna	X	X			
Herpetofauna - Cover Boards	X	X	X	X	X
Mammal - Sherman Live Traps	X	X			
Mammal - Motion Cameras			X	X	X
Mammal - Acoustic Surveys					X
Mammal - Road Mortality Surveys		X	X	X	
Avian	X	X	X	X	X
Invertebrates					
Benthic	X	X	X		
Terrestrial	X	X	X	X	X
Physical					
Elevation	X	X	X		
Channel Cross-Sections	X	X			
Inundation		X	X	X	X

USEPA Three-Level Monitoring Structure

In 2002, a consortium of scientists and managers from around the state began developing a monitoring and assessment program modeled after the United States Environmental Protection Agency's (USEPA) Level 1-2-3 framework for monitoring and assessment of wetland resources. Assessments in this project span all three levels of the three-level framework for surface water monitoring and assessment issued to the state by USEPA (2006). The original intent behind this tri-level framework was to explicitly encourage the collection of data at all three levels such that agencies and managers could more easily compile and more robustly interpret individual site performance as well as local and regional trends (Figure 1). This project represents one such effort at the Reserve.

Level 1: Mapping and Landscape Level Assessments

Level 1 assessments use broad landscape-level characterizations or wetland and riparian inventories (e.g. National Wetland Inventory) to answer questions about wetland extent and distribution. Assessment results can also provide a coarse gauge of the geology and hydrology of a watershed, broad impacts, and wetland type.

Level 2: Rapid Assessments

Level 2 evaluations are rapid assessment methods which use cost-effective field-based diagnostic tools to assess the condition of wetland and riparian areas. Level 2 assessments answer questions about general habitat health along a gradient through qualitative assessments and "stressor checklists".

Level 3: Site-Intensive Assessments

Intensive site assessments provide data to validate rapid methods, provide more thorough or rigorous datasets, characterize reference conditions, and diagnose causes of wetland condition observed in Levels 1 and 2. Level 3 assessments can also be used to test hypotheses and provide insight into detailed functions and processes.

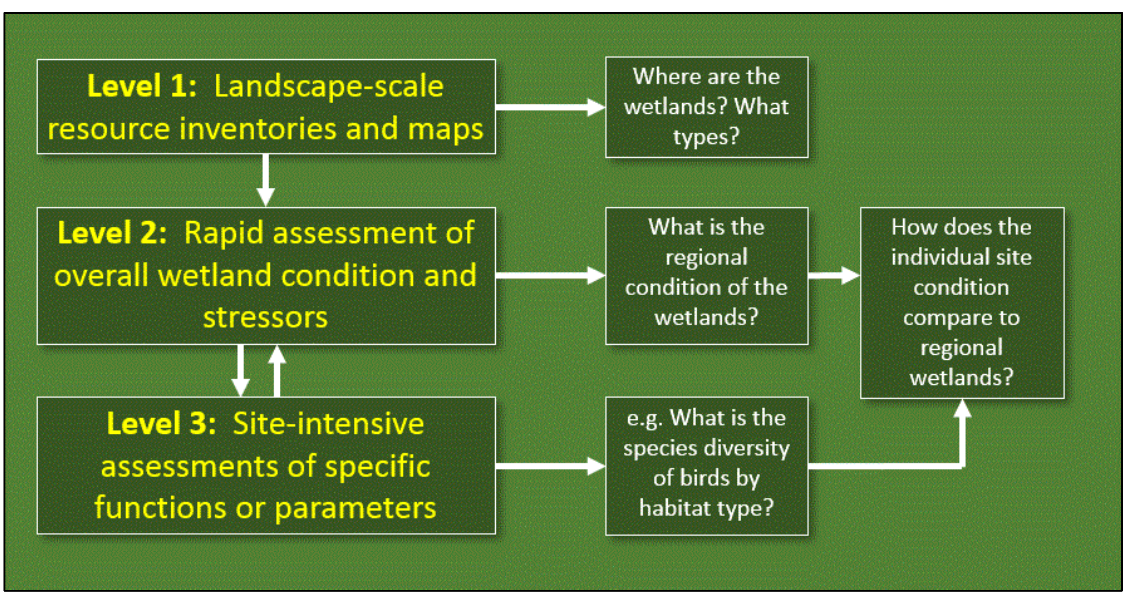


Figure 1. Graphic illustrating the three Levels of the EPA tiered monitoring program and connections.

Organization of this Report

This report is organized into several sections focused on the three tiers of the USEPA monitoring program, with emphasis placed on the rigorous, Level 3 site-intensive data evaluations. Within the Level 1 or landscape-scale, section, descriptions are given of the Ballona Creek Watershed and the Reserve through both a historical and current lens. Within the Level 2, or rapid assessment section, there are two primary subsections: California Rapid Assessment Method (CRAM) surveys and Photo Point surveys. Within the Level 3, or site-intensive monitoring section, there are three broad subsections, including: water and soil quality, biological communities, and physical characteristics.

Detailed parameters were assessed for each subsection. In the water and soil quality subsection, water quality data are provided that include: general water quality parameters, bacteria, nutrients, isotopes, amphipod toxicity, phytoplankton communities, and data for constituents such as heavy metals. Additionally, soil and sediment quality data include: soil salinity, grain size, organic content, and data for constituents such as heavy metals. In the biological communities subsection, data results are provided for surveys of habitat types, vegetation mapping of species alliances and associations, vegetation cover, germinated seed bank, submerged aquatic vegetation and algae, ichthyofauna, herpetofauna, mammals, avifauna, and invertebrates. In the physical characteristics subsection, data results are provided for surveys of elevation, channel cross-sections, and inundation.

Each section includes the goals of the monitoring program for that component of the project, summary methods, results and analyses for each subsection, and five-year conclusions. Brief summary methods and sampling dates/times are included in each subsection of the report. For detailed methods, refer to the referenced monitoring literature for each section.

Taxonomic nomenclature for vegetation species changes constantly and is occasionally in dispute. For consistency and accuracy, species are identified using the Jepson Online Interchange California Floristics (Jepson Flora Project; accessed: November 2015). Vegetation nomenclature occurs in the report in the format of "*Genus species* (common name)" and as "*G. species*" when mentioned subsequently. Bird species are identified initially as "Common Name (*Genus species*)" and as "Common Name" when mentioned subsequently, following nomenclature from the American Ornithologists' Union's check-list of North American birds (7th Edition, 1998). Similarly, herpetofauna are identified initially as "common name (*Genus species*)" and as "common name" when mentioned subsequently, following nomenclature from SSAR 2008. Many other taxa, e.g. invertebrates, do not have universally-recognized common names and are therefore reported as their scientific name only ("*Genus species*").

This report will be available for free download on the TBF website (www.santamonicabay.org) and the Ballona Wetlands Restoration Project website (www.ballonarestoration.org).

Level 1: Site Description and Mapping

Introduction

Wetland and adjacent habitat functions are not solely dependent on biological communities and chemical interactions but also physical position within larger landscape features. Level 1 is the broadest and most cost-efficient level of assessment across a large scale which relies primarily on office-based Geographic Information Systems (GIS) tools and aerial images to assess wetland condition based on landscape level analyses (USEPA 2006). Level 1 assessments can provide a sample framework for on-the-ground higher intensity Level 2 and Level 3 monitoring assessments. Level 1 was applied directly to this project through a broad characterization of the historical Ballona Creek Watershed and the Reserve and through compiling current information, including site impacts over time. Additionally, gross mapping of the extant wetland landscape elements through several forms of delineation was conducted.

Historical Information

Ballona Creek Watershed

The Ballona Creek Watershed encompasses approximately 130 square miles. Historical information included in this summary is replicated primarily from Dark et al. 2011 and Liu et al. 2001. The historical location and extent of wetlands in the Ballona Watershed was extensive compared to their contemporary distribution. Using historic records and maps, over 14,000 acres of wetland types were delineated including alkali meadow, valley freshwater marsh, brackish to salt marsh/tidal marsh, and alkali flats. Although discrete boundaries of historical wetlands can be challenging to identify in many instances, a few substantial wetland complexes were clearly evident, namely the Ballona Valley, La Cienega, the Ballona Lagoon, and the Santa Monica Mountain Foothills (Figure 2).

The Ballona Valley was the largest region of the Ballona Creek Watershed extending from Santa Monica to west, to downtown Los Angeles to the east, and from the Santa Monica Mountain Foothills to the north, to the Ballona Creek, Baldwin Hills, and present day Inglewood to the south. Wetland habitats included a valley freshwater marsh, wet meadow, alkali meadow, freshwater ponds, and vernal pools. There were approximately 120 miles of channels in the Ballona Valley, mostly ephemeral streams that either sank into the porous soil or recharged wetlands.

La Cienega was a complex and highly variable wetland complex northeastern side of the Baldwin Hills. Several miles of streams and sloughs were identified, but because of the dynamic nature of the system, channel locations changed constantly or disappeared entirely. Winter rains and perennial springs from the Santa Monica Mountain Foothills flowed into the Ballona Valley and recharged La Cienega.

Originally over 4,200 acres, the Ballona Lagoon system extended from the bluffs to the south, well into City of Santa Monica to the north, and east to Culver City. This complex marsh was a mix of freshwater and alkaline wetland habitats inland, with saltmarsh, brackish, and associated habitats along the coastline. The coastal wetlands in the western half of this system were historically considered a bar-built estuary with periodic seasonal or annual openings of the sand bar to allow full tidal processes. During periods or years with less rainfall, the sand bar would close the estuarine system to limit or block tidal exchange.

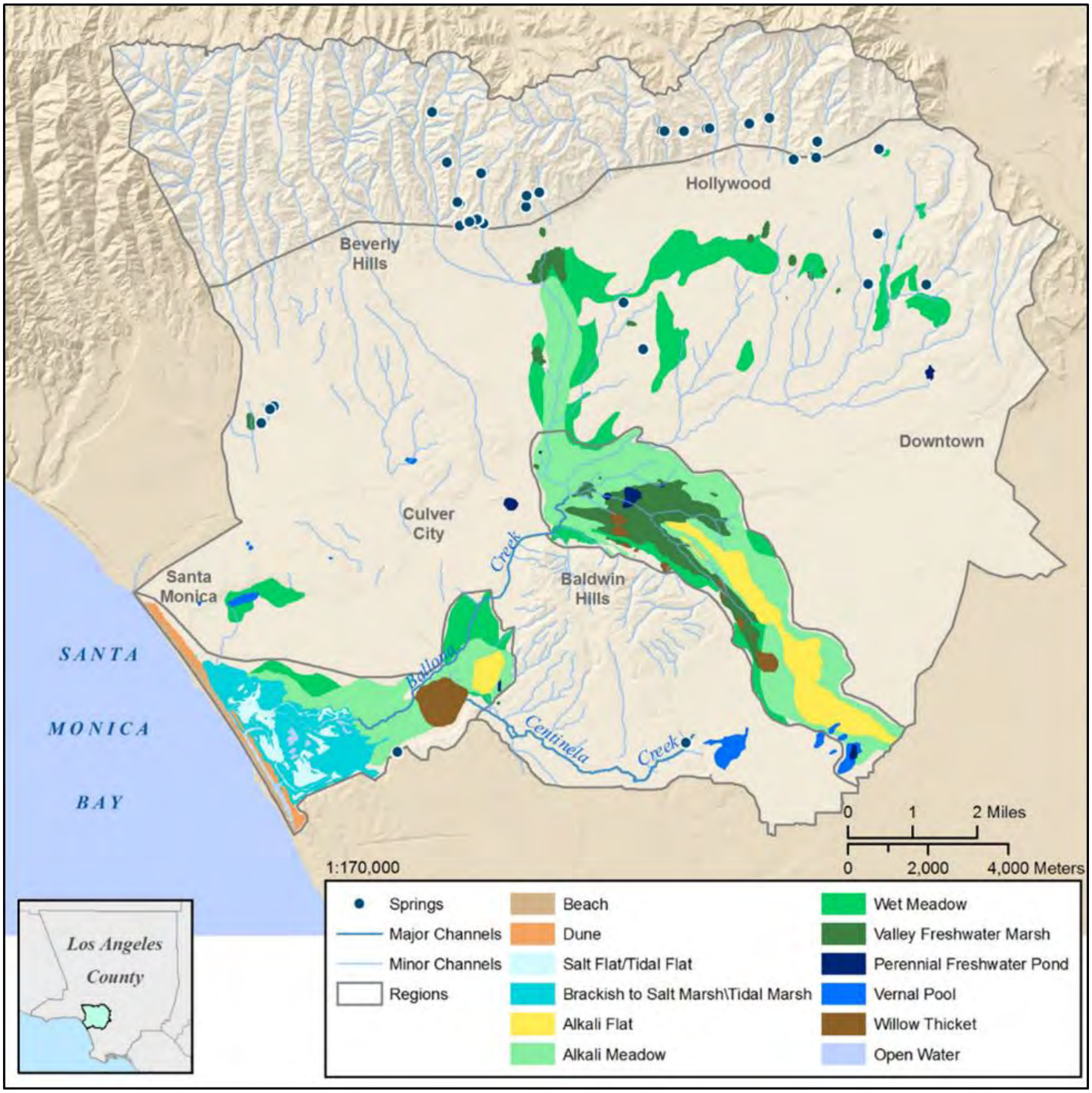


Figure 2. Map replicated from Dark et al. (2011) of the Ballona Creek Watershed (ca. late 1800's).

Ballona Wetlands Ecological Reserve

In the Los Angeles region, over 96% and 98% of the vegetated and unvegetated coastal estuarine wetlands, respectively, have been lost over the past century and a half; this loss is mainly attributed to conversion of wetland habitat to uplands through fill deposition or development (Stein et al. 2014). The Reserve is an example of this phenomenon, having suffered from over a century of abuse and land degradation. Historically a bar-built estuary of over 2,100 acres (Grossinger 2010, Dark et al. 2011), the original Ballona Wetlands ecosystem (western portion of the Ballona Lagoon, above) included a variety of habitats, dominated by vegetated wetland and salt pan habitat types (Grossinger et al. 2010) (Figure 3). Currently, the Reserve has been reduced in size to less than 600 acres of open space and only approximately one quarter of the site, 153 acres, is considered wetland habitat as delineated by Army Corps of Engineers (Corps) wetland delineation methods (WRA 2011). Only a small portion of the remaining wetland habitats are still exposed to tidal influence, including approximately 15 acres at the western edge of the Reserve and the Fiji Ditch in Area A (Medel et al. 2014).

Construction within the wetlands began in the 1880s with the construction of the Atcheson, Topeka, and Santa Fe Railways (WRA 2011). Another major impact in the 1800s occurred when the Corps diverted the Los Angeles River south to empty into Long Beach. By 1924, the wetlands had been reduced to approximately 1,150 acres as development adjacent to and within the marsh continued. Channelization of Ballona Creek through the installation of concrete levees in the 1930s effectively eliminated almost all tidal connectivity between the ocean and wetland habitats within the Reserve. These changes permanently altered the mouth of the Creek and converted the estuary from a periodically-open mouth to a perennially-open system.

Development and construction continued at a steady pace for the next three decades, including farming, road construction, adjacent development of residential and commercial areas, storm drains, oil extraction, and additional construction activities. In addition, significant major impacts such as the dredging of Marina del Rey in the 1950s and ‘60s and subsequent displacement of millions of cubic yards of sediment, as well as its disposal on the northern portion of the Reserve in combination with local developments, have converted the formerly estuarine marsh habitat to a system dominated by upland habitats interspersed with seasonal, depressional wetlands. Approximately 3.1 million cubic yards of sediment have been dumped on site since the 1800s. Agriculture on site continued through the 1980s (Shreiber et al. 1981).

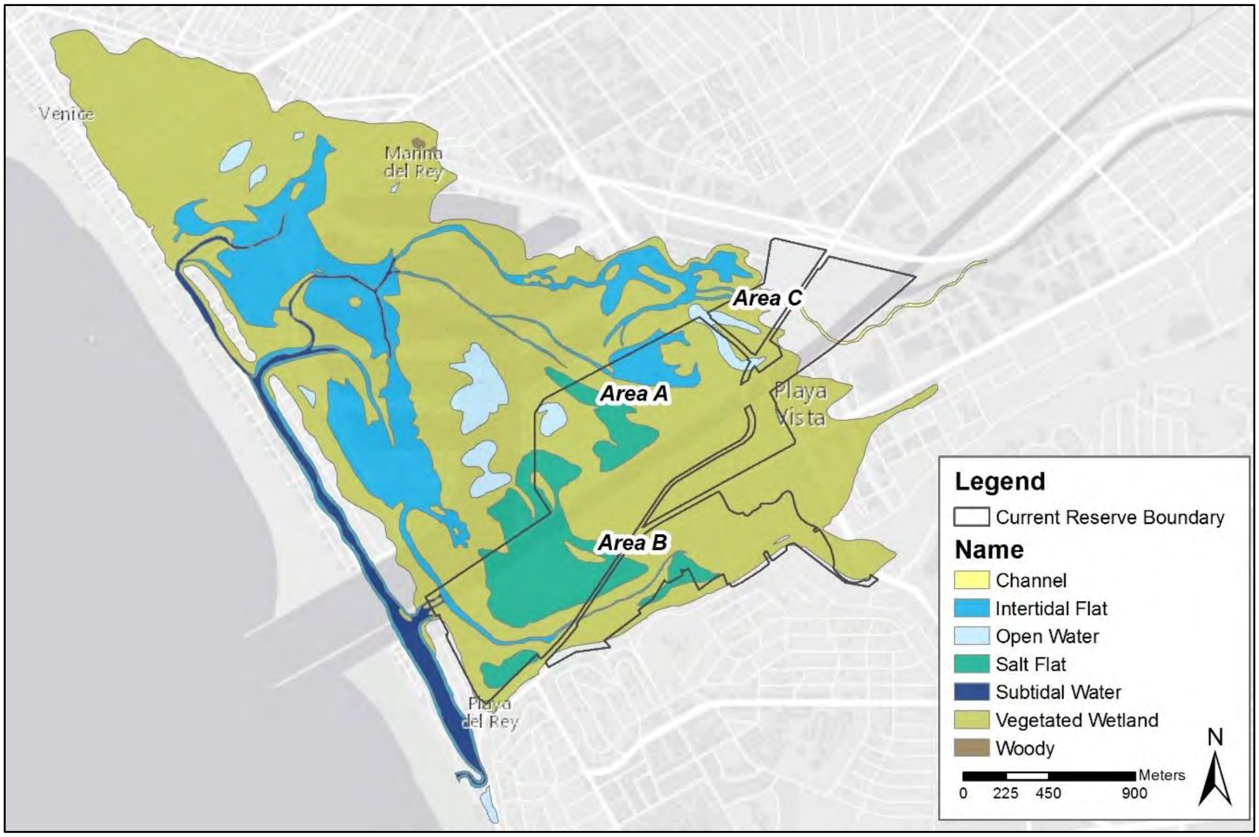


Figure 3. Historical Ballona Wetlands (circa late 1800s, modified from Dark et al. 2011) and current Reserve boundary (ESA 2015).

Present Day

Ballona Creek Watershed

The current Ballona Creek Watershed is comprised of all or parts of the cities of Beverly Hills, Culver City, Los Angeles, Santa Monica, West Hollywood, and other unincorporated cities (Figure 4). The major tributaries to Ballona Creek include the Centinela Creek Channel, Sepulveda Channel, Benedict Canyon Channel, and numerous storm drains. Land use in the watershed currently consists of approximately 64% residential, 8% commercial, 4% industrial, and 17% open space (Stanley R. Hoffman Associates 1998). With a population of more than 1.6 million people, the effects of urbanization on water quality, habitat, and open space have been extensive (Braa et al. 2001).

The expansion of urban and suburban development has increased the extent of impervious surfaces leading to increased runoff volumes from storm events and reduced infiltration of precipitation to groundwater (Stolzenbach 2001). There are approximately 72 square miles of impervious surfaces, covering approximately 55% of the land, in this watershed (Birosik 2011). Additionally, Ballona Creek is channelized for most of its length (LA County Department of Public Works 2005). The majority of the Ballona Creek drainage network has been modified into storm drains, underground culverts, debris basins, and open concrete channels (Brown and Caldwell 2006). Ballona Creek is a 9-mile flood protection channel designed for a 50-year frequency storm event, and drains the Los Angeles basin from the Santa Monica Mountains on the north, the Harbor Freeway (Interstate 110) on the east, and the Baldwin Hills on the south (Brown and Caldwell 2006). Additionally, riparian vegetation and aquatic habitat have been eliminated from most channels. This extensive modification of the creek and tributaries has significantly reduced natural hydrologic functions in the Ballona Creek Watershed.

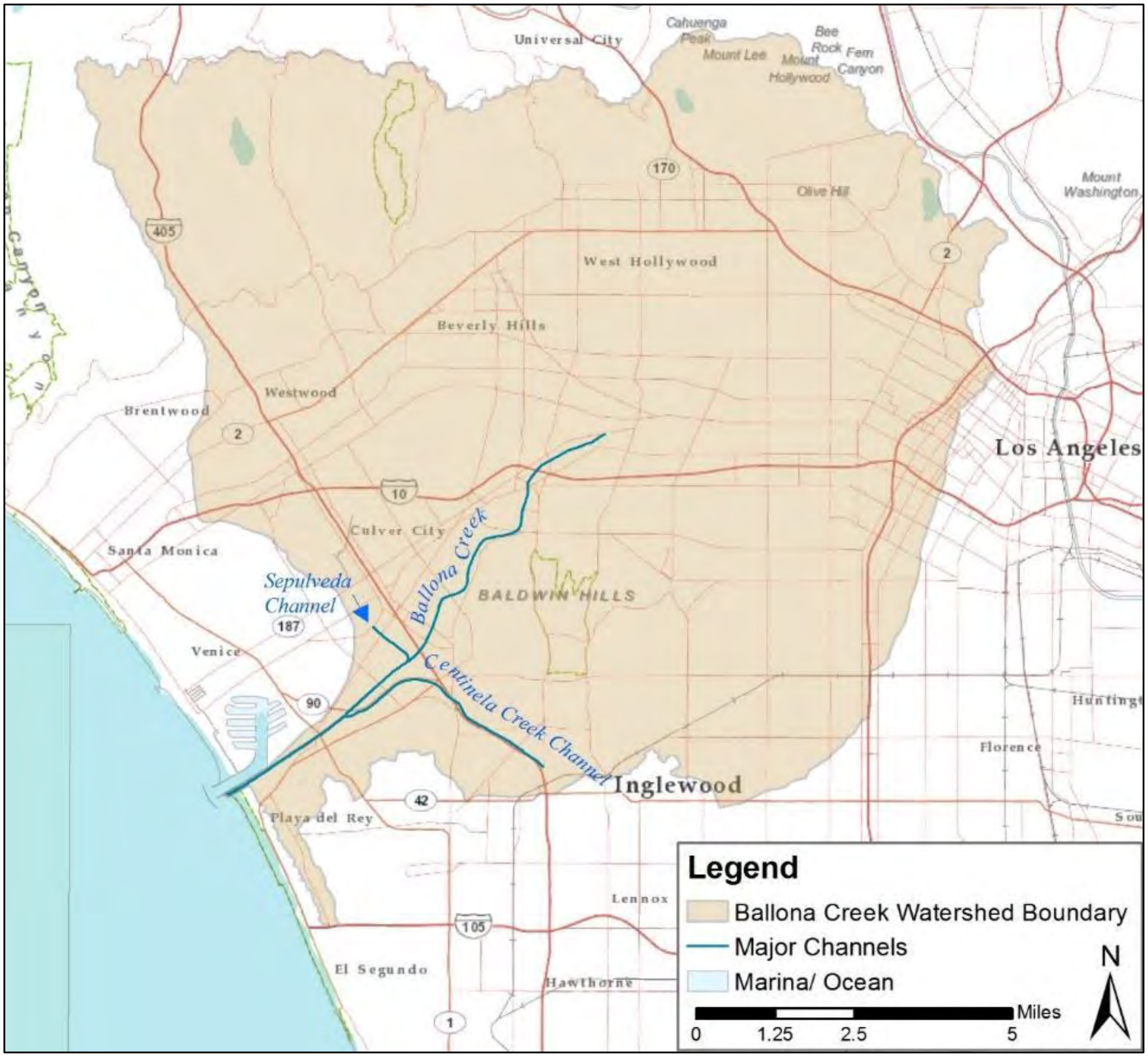


Figure 4. Current Ballona Creek Watershed map (replicated from NHD 2015).

Ballona Wetlands Ecological Reserve

The Ballona Wetlands Ecological Reserve (BWER or Reserve) is one of approximately 40 coastal wetlands along the 1,045 miles of the Southern California coast between Point Conception and Mexico. The current configuration of the Reserve differs drastically from its historic state. The remaining open land parcels encompassing approximately 577 acres were purchased by the State in pieces from 2003-2006 and designated as an Ecological Reserve. While the exact boundary of the Reserve has been interpreted in different ways over time in different reports, the current existing boundary extent was used for this report as it will be the same one used throughout the Draft Environmental Impact Report/Statement (ESA, November 2015, Figure 5). All new maps in this report (e.g. vegetation alliances) use the 2015 boundary. The California Department of Fish and Wildlife (CDFW) now manages the Reserve.

The Reserve is approximately 577 acres (ESA, November 2015) and is generally divided in three areas designated Areas A, B, and C (Figure 5). Area A is the approximately 139-acre portion of the Reserve that lies north of Ballona Creek, west of Lincoln Boulevard, and south of Fiji Way. Fill was placed on Area A during the excavations of Ballona Creek and Marina del Rey which resulted in elevations ranging between approximately nine and 17 feet above mean sea level (MSL). Development of Area A is limited to a parking area along the western boundary, a drainage channel (Fiji Ditch) along the northern boundary, and four monitoring well sites maintained by the Gas Company in the western end.

Area B is the approximately 281-acre portion of the Reserve that lies south of Ballona Creek and west of Lincoln Boulevard (Figure 6). Area B extends south to Cabora Drive and contains a utility access road near the base of the Playa Del Rey bluffs. To the west, Area B extends through the dunes to Playa Del Rey. Area B elevations generally range from approximately two to five feet MSL, extending up to 50 feet MSL at the Del Rey bluffs. Culver Boulevard and Jefferson Boulevard are major traffic thoroughfares that traverse Area B. Additionally, the Gas Company maintains an access road that connects its facility in southern Area B to Jefferson Boulevard. Area B contains the largest area of remnant unfilled wetlands with abandoned agricultural lands to the southwest, and the Freshwater Marsh to the northeast. The Gas Company maintains one inactive oil well in Area B.

Area C is the approximately 68-acre portion of the Reserve that is located north of Ballona Creek and east of Lincoln Boulevard. The 90 Freeway (Marina del Rey Freeway) forms the northeastern border of Area C, and Culver Boulevard bisects Area C in an east-west direction. Area C contains fill from the construction of the Ballona Creek flood channel, developments such as Marina del Rey, and the 90 Freeway. Elevations range from approximately 4.5 feet to 25 feet MSL. Area C also contains the Little League baseball fields.

Figure 5. Map of the Ballona Wetlands Ecological Reserve (boundary file from ESA 2015).

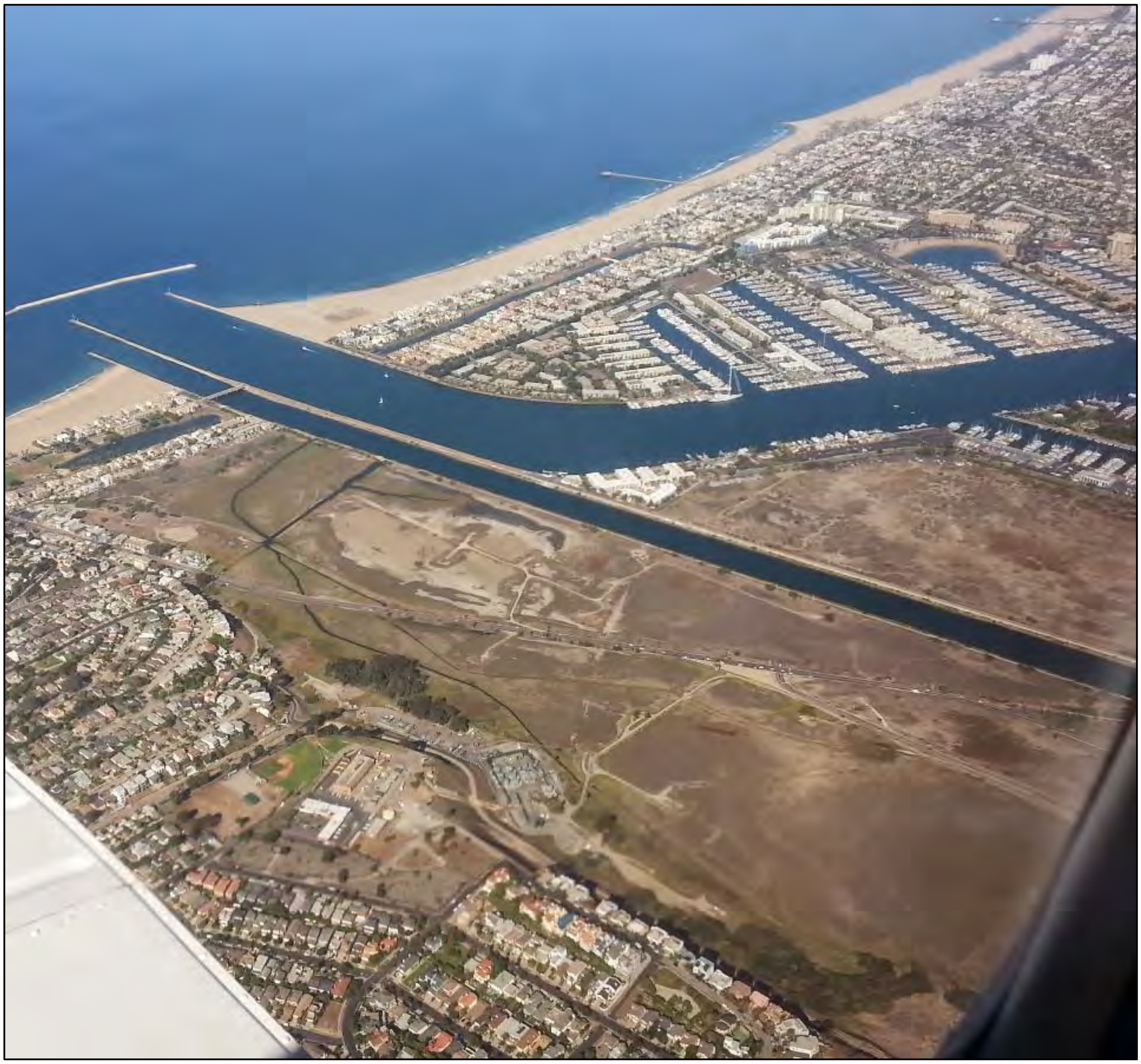


Figure 6. Aerial photograph of the western half of Ballona (courtesy LightHawk and I. Medel 2014).

Due to the straightening of tidal channels, development of oil and gas fields, agriculture, and filling of wetlands with dredged materials, the extent and quality of wetlands in the Reserve have progressively degraded over time (Figure 7a-d; WRA 2011).

Figure 7a. Aerial photograph of Area B – west (courtesy LightHawk and I. Medel 2013).

Wetland Delineation within the Reserve

While the word "wetlands" is in the official title of the Reserve, it's a slight misnomer as the majority of the habitats on site are not actually delineated wetlands. Of the delineated wetland areas, many do not meet the more rigorous delineation standards and are only classified as wetlands based on two out of the three characteristics (e.g. hydrology, hydric soils, hydrophytic vegetation). Figure 8 depicts the extent of the National Wetlands Inventory (NWI) wetland delineation accessed from the NWI database in 2014. Figure 9 depicts the extent of Army Corps of Engineers (Corps) jurisdiction within the Reserve based on a formal wetland delineation finalized in July 2010 after a site visit with the Corps (WRA 2011). Figure 10 depicts the extent of California Coastal Commission (CCC) jurisdiction delineated by WRA and finalized in September 2010 (WRA 2011).

Final NWI, CCC, and Corps wetland delineation acreage of the Reserve is shown in Table 2. Survey methods account for differences in wetland delineation acreage. The NWI wetlands delineation dataset is primarily determined through on-screen digitizing of high-altitude aerial photography, while the CCC and Corps wetland delineations were field-collection based.

Table 2. Comparison of NWI, CCC, and Corps Reserve wetland delineations and acreage.

Delineation Type or Agency	Tidal Waters (acres)	Wetland Type (acres)		Total Wetland Area (acres)
		Tidal Wetland	Non-tidal Wetland	
National Wetlands Inventory (NWI)	61.2	136.6	53.5	189.8
CA Coastal Commission (CCC)	83	205.2		205.2
Army Corps of Engineers (Corps)	83	153.2		153.2

Figure 7b-d. Photographs of delineated wetland habitat type at the Reserve: (B) tidal wetland in Area B – west, (C) non-tidal wetland in Area B – south of Jefferson, and (D) ruderal wetland in Area A (May 2014).

Figure 8. Delineated wetland map of Reserve using National Wetlands Inventory delineation (NWI 2014).

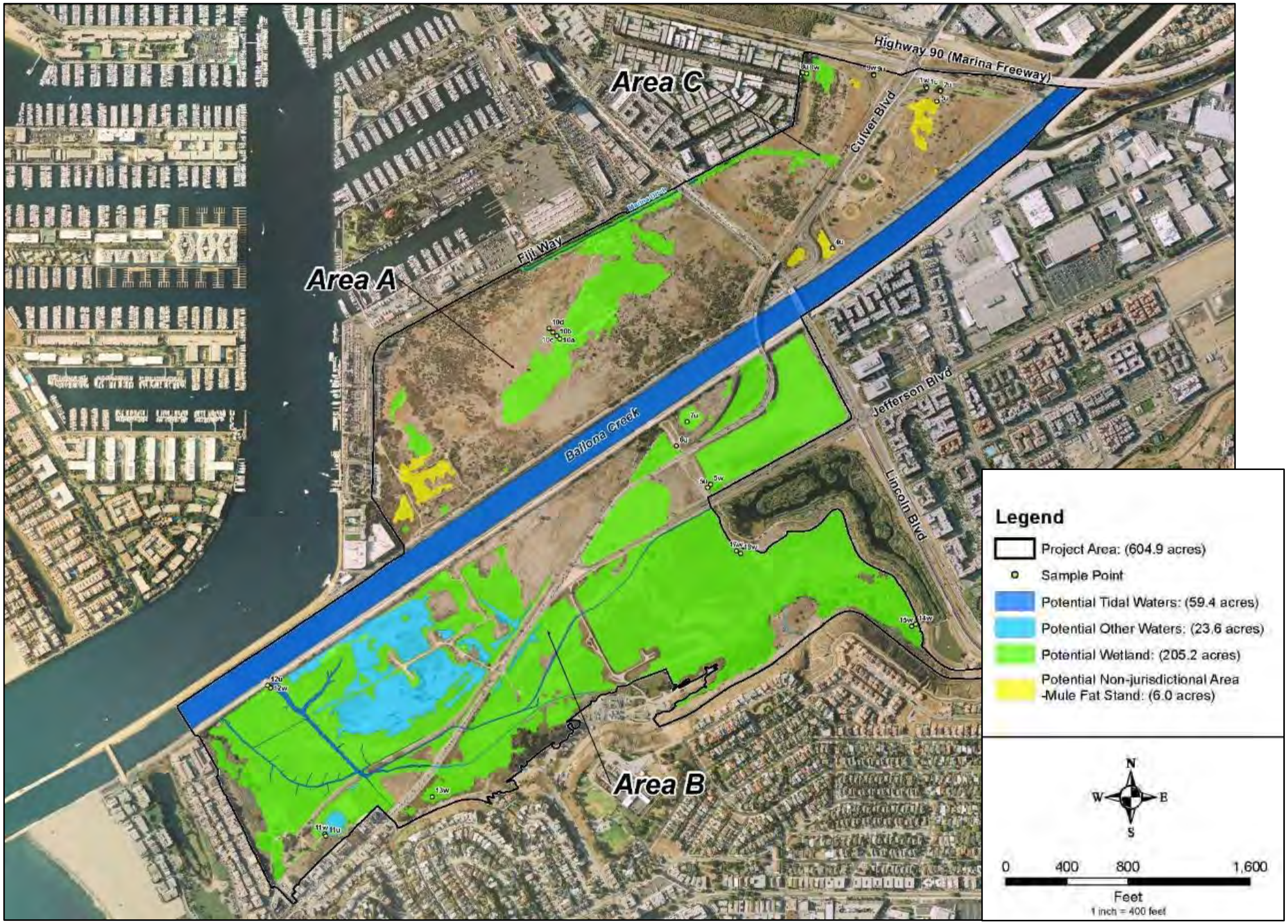


Figure 9. Delineated wetland map of Reserve (replicated from WRA 2011 using CA Coastal Commission delineation).

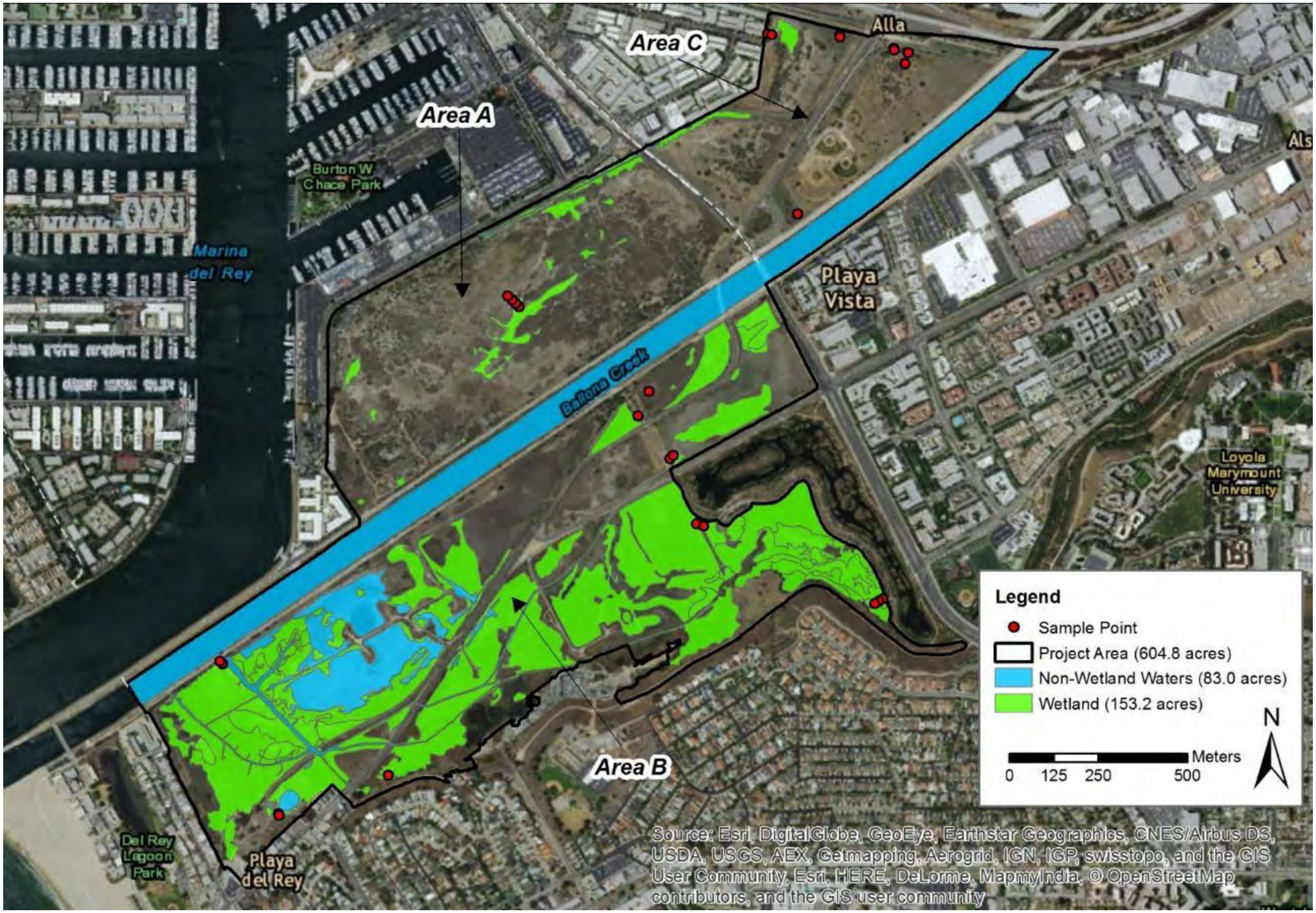


Figure 10. Delineated wetland map of the Reserve (U.S. Army Corps of Engineers delineation).

Level 2: Rapid Assessments

Introduction

CRAM can be used as a measure of general aquatic resource health and produces condition scores that are comparable and repeatable for all wetlands and regions in California, yet accommodates special characteristics of different regions and types of wetlands. For the purposes of CRAM, *condition* is defined as the state of a wetland assessment area's buffer and landscape context, hydrology, physical and biological structure relative to the best achievable states for the same type of wetland. Condition is evaluated based on observations made at the time of the assessment, the results of which can be used to infer the ability to provide various functions, services, values, and beneficial uses to which a wetland is most suited (CWMW 2013), although these are not measured directly by CRAM. CRAM also identifies key anthropogenic stressors that may be affecting wetland condition with a checklist.

CRAM was used to assess the condition of wetlands within the Reserve in 2012, 2014 and 2015, with a primary objective similar to those cited directly from the CRAM User's Manual (CWMW 2013): "… to provide rapid, scientifically defensible, standardized, cost-effective assessments of the status and trends in the condition of wetlands and the performance of related policies, programs and projects throughout California." The specific survey goal of this program was to use Level 2 estuarine CRAM data to provide condition assessments of the wetland habitat areas within the Reserve.

The primary purpose of the Photo Point sampling method was to qualitatively and visually capture broad changes in the landscape and vegetation communities over seasons or years. Photo Point surveys do not yield quantitative data but are informative for visual landscape-scale changes and can be useful as visual baselines for areas that have undergone significant changes from anthropogenic or natural events (e.g. post-restoration changes over time). Photo Point surveys are appropriate for all habitat types.

Rapid Assessments: California Rapid Assessment Method

Methods

Five distinct wetland sub-areas within the Reserve were identified based on differences in dominant hydrology, elevation, and historic general impacts such as hydrological modifications or fill sediment placement (Table 3). Multiple Assessment Areas (AAs) were established within each of three sub-areas, with a single AA established in each of the two remaining hydrologically distinct wetland sub-areas (Figures 11 and 12).

AAs one hectare each in size were mapped in ArcGIS 10.1 according to the CRAM guidelines (CWMW 2013). All CRAM surveys were conducted in late summer or early fall to coincide with the peak wetland growing season, and specific field methods followed the CRAM User Manual (CWMW 2013), CRAM Standard Operating Procedure and the Wetland Monitoring Manual (Johnston et al. 2015d, Appendix B – 7.1). CRAM assessments were conducted from 16 August – 16 October 2012 and again from 7 August – 26 September 2014 in "Area A", "Area B – tidally influenced", and "Area B – seasonal". In 2015, the Draft Environmental Impact Report/Statement (DEIR/S) project management team requested data from two additional supplemental AAs (i.e. "Area B – ruderal" and "Area B – north") to provide condition assessment data to fill identified data gaps. The two additional AAs were completed on 26 August 2015.

CRAM metrics are organized into four main attributes: landscape and buffer context, hydrology, physical structure, and biotic structure for each type of wetlands (i.e. depressional and estuarine wetlands) with multiple metrics and sub-metric assessments (Table 4). The attributes are all averaged to quantify a final assessment score for each wetland module and AA analyzed.

Basic summary statistics were calculated for the data based on individual Assessment Areas including averages, standard error, and one-way ANOVAs with a confidence level of $\alpha < 0.05$. CRAM scores occur on a 25-100 point scale, with 100 as the maximum possible score, indicating the highest possible wetland condition. Grand means were calculated by averaging AA scores by area and then averaging again at a site-level to compare across years. For additional detailed methods, refer to the "Technical Memorandum: Condition Assessment of the Wetland Habitats in the Ballona Wetlands Ecological Reserve" (Johnston et al. 2015b).

Table 3. Impact summaries and hydrological features of wetland sub-areas at the Reserve. Elevations are expressed in units of feet (NAVD 88).

Wetland Sub-Area	Dominant Hydrology	Elevation Range	Impact Summary	Year Surveyed
Area A	Seasonal stormwater ponding	12 – 15	Tidal disconnection; large volumes of fill sediments placed throughout Area A	2012, 2014
Area B – tidally influenced	Muted tidal	3 – 7	Muted tide and restricted hydrology; some man-made channels; some fill placement	2012, 2014
Area B – seasonal	Seasonal stormwater ponding	5 – 7	Tidal disconnection; previously used for agriculture; some fill placement	2012, 2014
Area B – ruderal	Seasonal stormwater ponding	4 – 7	Tidal disconnection; previously used for agriculture; some fill placement	2015
Area B – north	Seasonal stormwater ponding	5 – 7	Tidal disconnection; previously used for agriculture; some fill placement	2015

Figure 11. Map of CRAM Assessment Areas (AAs) within the Ballona Wetlands Ecological Reserve.

Table 4. Summary table of CRAM attributes and metrics; descriptions modified from the CRAM User Manual (CWMW 2013).

Attribute	Metric	Sub-metric	Description	Assessment Location
Landscape and Buffer Context	Aquatic Area Abundance	---	Spatial association to adjacent areas with aquatic resources	Office
	Buffer	Percent of AA with Buffer	Relationship between the extent of buffer and the functions it provides	Office
		Average Buffer Width	Extent of buffer width assesses area of adjacent functions provided	Office
		Buffer Condition	Assessment of extent and quality of vegetation, soil condition, and human disturbance of adjacent areas	Field
Hydrology	Water Source	---	Water source directly affects the extent, duration, and frequency of hydrological dynamics	Office / Field
	Hydroperiod	---	Characteristic frequency and duration of inundation or saturation	Office / Field
	Hydrologic Connectivity	---	Ability of water to flow into or out of a wetland, or accommodate flood waters	Office / Field
Physical Structure	Structural Patch Richness	---	Number of different obvious physical surfaces or features that may provide habitat for species	Field
	Topographic Complexity	---	Micro- and macro-topographic relief and variety of elevations	Field
Biotic Structure	Plant Community Composition	Number of Plant Layers	Number of vegetation stratum indicated by a discreet canopy at a specific height	Field
Biotic Structure	Plant Community Composition	Number of Co-dominant Species	For each plant layer, the number of species represented by living vegetation	Field
		Percent Invasion	Number of invasive co-dominant species based on Cal-IPC status	Field
	Horizontal Interspersion	---	Variety and interspersion of different plant “zones”: monoculture or multi-species associations arranged along gradients	Field
	Vertical Biotic Structure	---	Interspersion and complexity of plant canopy layers and the space beneath	Field

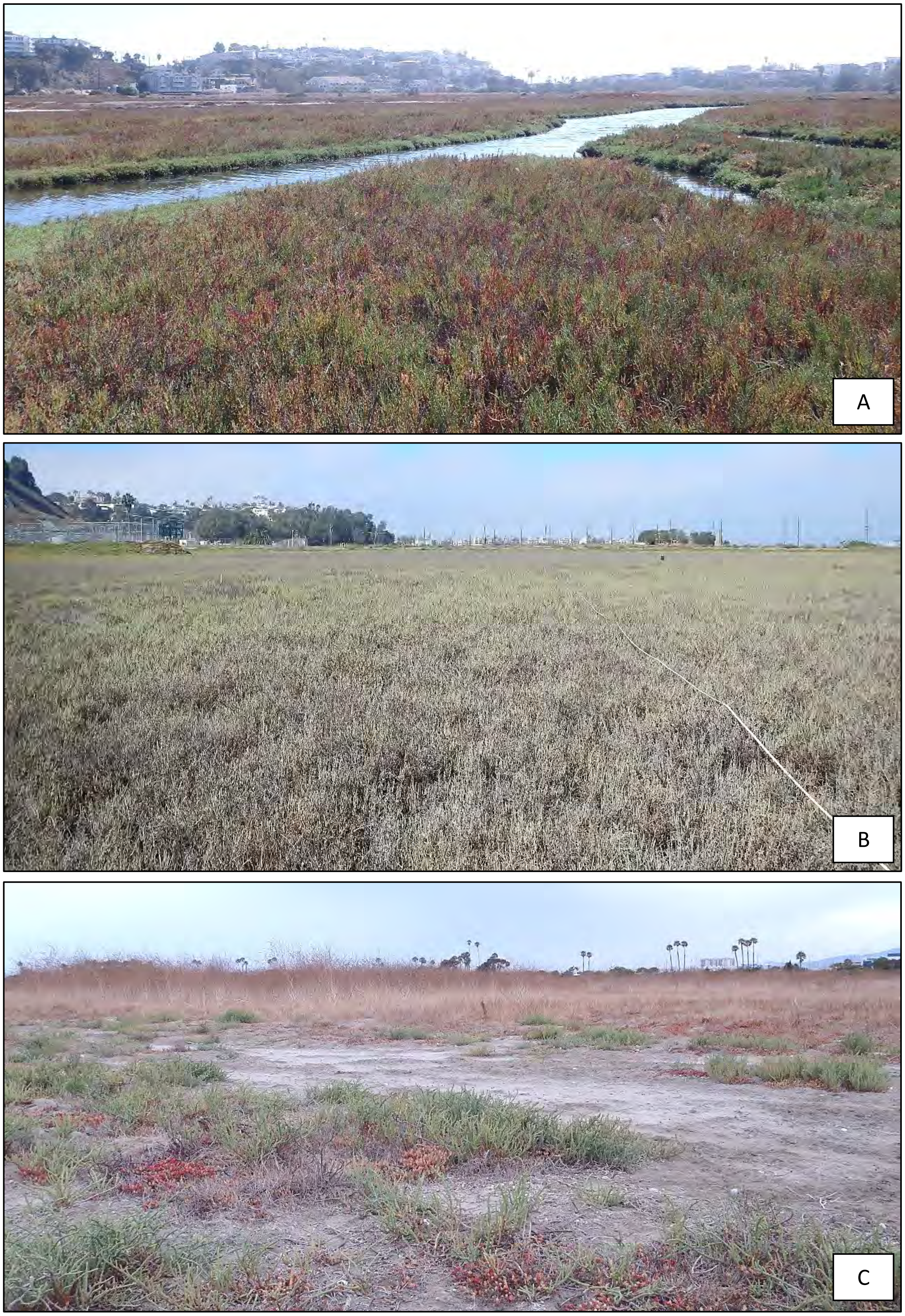

A
B
C

Figure 12. One representative photograph from the centroid of an AA at each wetland sub-area: (a) Area B – tidally influenced; (b) Area B – seasonal; (c) Area A – seasonal; (d) Area B – ruderal; (e) Area B - north.

Results

Reserve CRAM condition scores varied by attribute, sub-area, and year. Table 5 displays the overall grand mean CRAM scores and the scores for each attribute by wetland sub-area. When comparing the average final scores between 2012 and 2014 (for the three repeated sub-areas), the data were found to be similar between years, with 2012 results indicating a slightly higher final score (54.1 ± 3.4) than 2014 (53.5 ± 3.3) showing a slight drop in condition over the two-year period.

Additionally, for the three repeated sub-areas with multiple AAs, there was a significant difference by wetland sub-area for average final score ($F_{2, 15}$ = 28.111, $p < 0.001$), with Area A possessing the significantly lowest final score, followed by seasonal Area B; the highest scores occurred in the tidally influenced portion of Area B.

The two individual 2015 AAs both displayed severely low final scores, similar to those from Area A (Table 5; Figure 13). The AA north of Culver Boulevard (i.e. "Area B – north") had the lowest final score of any AA on site at 40.9, as well as the lowest buffer and landscape score and the lowest possible physical structure score (i.e. 25) (Figure 14). Similarly, the AA conducted in the ruderal wetland habitat type between Culver and Jefferson Boulevards (i.e. "Area B – ruderal") also displayed low scores for all attributes, including the lowest score for the biotic attribute. The average for Area A was 43.7 ± 0.7; the average for "Area B – seasonal" was 53.5 ± 1.4; the average for "Area B – tidally influenced" was 64.2 ± 3.0.

Table 5. Average CRAM scores for each attribute by sub-area. Note: "Area B – ruderal" and "Area B – north" only have one AA included in the evaluation and are, therefore, not reported as averages.

Sub-Area	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic	Final Score
Area A	54.2 ± 0	25.0 ± 0	39.6 ± 2.1	56.0 ± 2.5	**43.7 ± 0.7**
Area B – tidally influenced	75.0 ± 2.6	52.8 ± 3.5	62.5 ± 6.5	66.7 ± 2.8	**64.2 ± 3.0**
Area B – seasonal	79.2 ± 0	33.3 ± 0	39.6 ± 2.1	62.0 ± 4.0	**53.5 ± 1.4**
Area B – ruderal	63	33.3	25	53	**43.4**
Area B – north	50	33.3	25	56	**40.9**

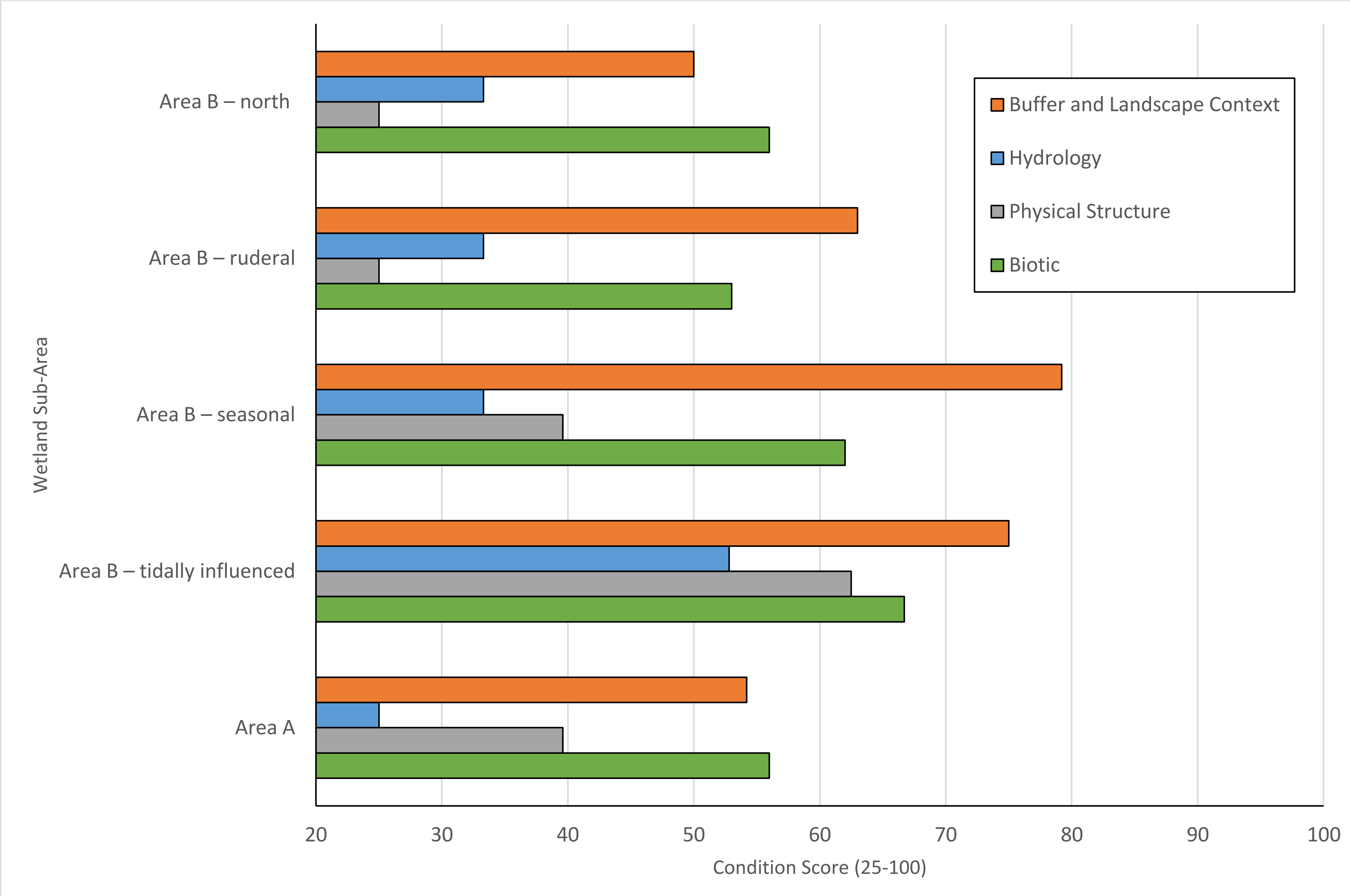


Figure 13. Average CRAM scores for each attribute by sub-area. Note: “Area B – ruderal” and “Area B – north” only have one AA included in the evaluation and are, therefore, not reported as averages.

Figure 14. Final average CRAM scores by sub-area. Note: "Area B – ruderal" and "Area B – north" only have one AA included in the evaluation and are, therefore, not reported as averages.

5-Year Summary Conclusions

Several clear patterns are evident based on the CRAM condition assessment data. Firstly, while not statistically significant, final CRAM scores indicate that the wetland habitats at the Reserve evaluated from 2012 – 2014 were experiencing slowly deteriorating conditions. Declining CRAM scores can be primarily attributed to several sub-metrics, including a decrease in biotic structure characteristics and an influx of annual, non-native plants. As no significant management actions (e.g. restoration, tide gate modifications) occurred within the sampling period, the landscape-buffer and hydrological attributes remained the same.

Additionally, these data are the first comparative rapid condition assessments evaluating the wetland habitats across the site. Area A, Area B – ruderal, and Area B – north were the most degraded sub-areas on site, with extremely low final condition scores on par with the lowest publically recorded scores in the state of California (www.cramwetlands.org, accessed August 2015). These sub-areas were followed by seasonal Area B; the tidally influenced portion of Area B exhibited the highest condition scores. This breakdown of scores was likely heavily influenced by the level of invasion in the plant communities of the three highly degraded sub-areas, as well as a lack of hydrological connections to an estuarine water source resulting from historic anthropogenic soil disturbances and the construction of water impoundment structures.

These data serve as a baseline pre-restoration assessment of the condition of the site; they could be compared to post-restoration data in the future to evaluate the change in wetland condition based on management actions. Repeated surveys at the same AAs over a longer period of time will serve to evaluate if any of the specific metrics or attributes continue to decline over time.

Rapid Assessments: Photo Point Monitoring

Methods

This method collected georeferenced photographs for use in site management (e.g. invasive species tracking) and long-term data collection. Thirty-seven permanent, photograph-monitoring ("Photo Point" or PP) locations were established to visually document vegetation change and large-scale landscape changes. Stations were located using GPS, baseline photographs, and bearing. Surveys were conducted seasonally from November 2012 to August 2014. Locations in the following figures were selected to characterize a subset of sampling areas within the Reserve, representing a range of habitat types (Table 6, Figures 15 and 16-22). Several photographs were lightened to increase visual clarity. In addition to fixed Photo Points, over 4,300 geotagged photos were taken from a variety of locations on-site from November 2012 to February 2014 and were provided to the DEIR/S restoration planning team.

Table 6. Representative Photo Point stations and dominant habitat-type.

Area	Station ID	Dominant Habitat	# of Photos	Date Range
Area A	PP25	Ruderal marsh	6	November 2012 to August 2014
Area B	PP12	Non-tidal salt marsh	6	
	P01	Salt pan	6	
	P03	Subtidal	6	
	BP N	Subtidal and tidal salt marsh	5	
Area C	PP30	Non-native "tall" herbaceous	4	
	PP32	Non-native "tall" herbaceous	5	

Figure 15. Map of Photo Point stations at the Reserve (subset).

Results

The following photographs (Figures 16 through 22) display qualitative seasonal variations over time at specific locations throughout the Reserve. Locations were chosen at representative visual sites, including subtidal, tidal salt marsh, salt pan, non-tidal salt marsh, ruderal marsh, and non-native "tall" herbaceous habitat types. For all survey locations, seasonal variations in the vegetation are apparent; however, no large-scale changes occurred during the two survey years.

Figure 16a-e displays the confluence of muted tidal channels in the western portion of Area B from the Boy Scout Platform facing north. Native vegetation can be seen in the salt marsh habitats, with non-native vegetation along the berms.

Figure 17a-e displays the main tide channel in Area B from the south-side of the Ballona Creek levee facing south. The Photo Point Standard Operating Procedure (Johnston et al. 2015d, Appendix B – 7.2) suggests that photos should be taken around low tide to capture the most visibility of surface area. Timing at this location for low tide was difficult due to the tide gate operations and maintenance (often closed for most of the tidal cycle). Thus, photos "a" through "e" visually appear to be a high tide, although they could have been at any point in the upper portion of the tidal cycle. Photo F represents a low tide photo outside of the sampling period.

Figure 18a-e displays Area B, east of the main tide channel, from Culver Boulevard facing north. A berm with invasive plants frames the bottom of each photo, predominantly native plants can be identified in the center, and the salt pan can be identified in the distance.

Figure 19a-e displays an ephemeral, non-tidal channel in Area B from the Gas Company access road north of Jefferson Boulevard facing east. The drainage channel depression in the center is dominated by the native salt marsh vegetation, *Salicornia pacifica* (pickleweed), while the berm on the left is seasonally dominated by non-native annual mustard [*Brassica nigra* (black mustard)].

Figure 20a-e displays a delineated wetland in highly impacted Area A, north of the Ballona Creek and south of Fiji Way facing east. The reddish vegetation that can be identified throughout the area is a non-native iceplant, *Mesembryanthemum nodiflorum* (slender-leaved ice plant).

Figure 21a-d displays highly impacted Area C, east of Lincoln Boulevard and north of Culver Boulevard facing east. No large-scale changes occurred within the survey years with the exception that evidence of anthropogenic impacts can be seen, including dumped refuse, in photos "b" through "d", center-left.

Figure 22a-e displays highly impacted Area C south of Culver Boulevard, north of the Ballona Creek, and west of the 90 Freeway facing east. Seasonal variations of non-native annual vegetation species are present in this set of photographs.

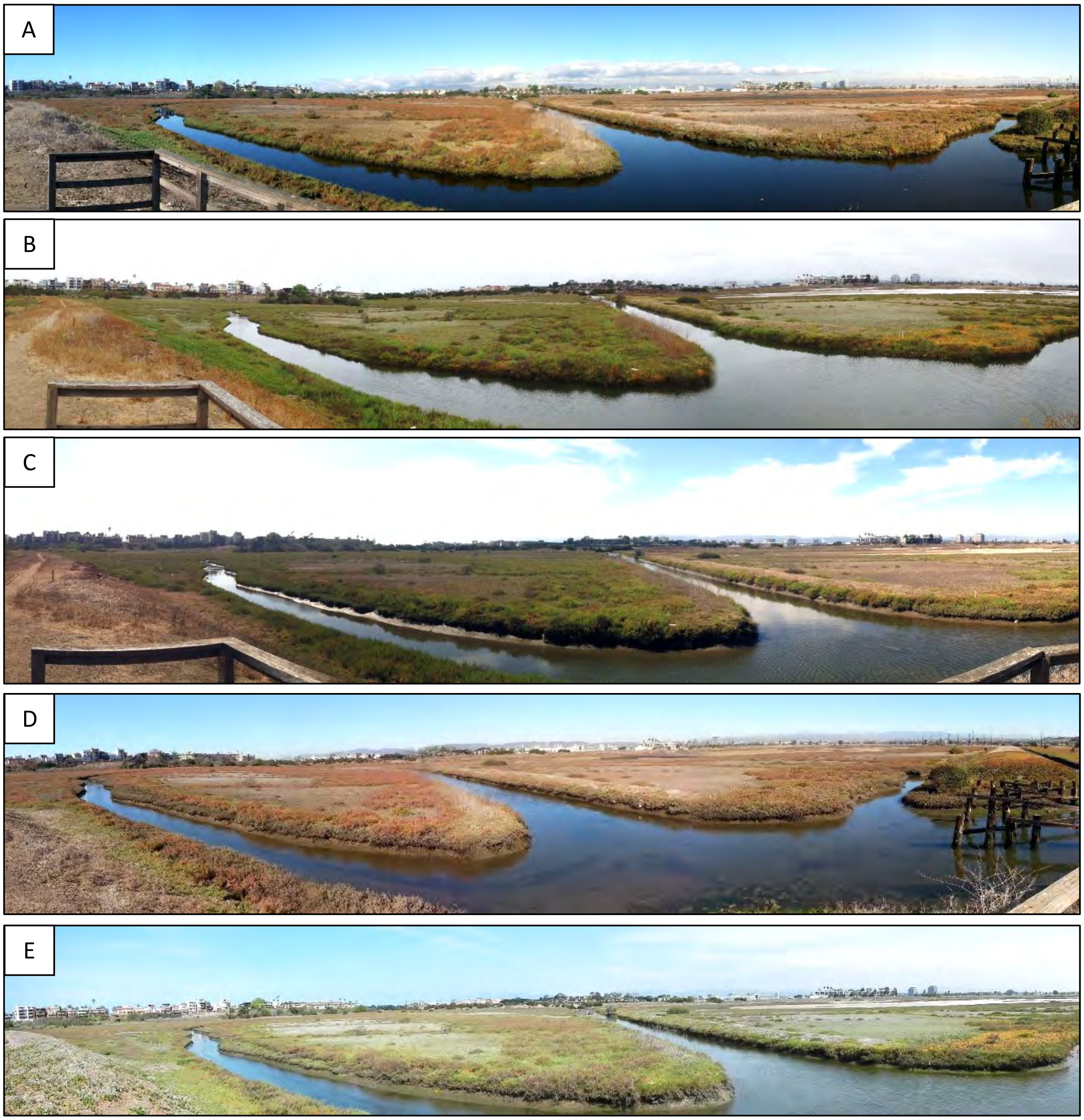


Figure 16. Photo Point station BP N: (A) November 19, 2012; (B) June 5, 2013; (C) August 6, 2013; (D) November 13, 2013; and (E) May 9, 2014.

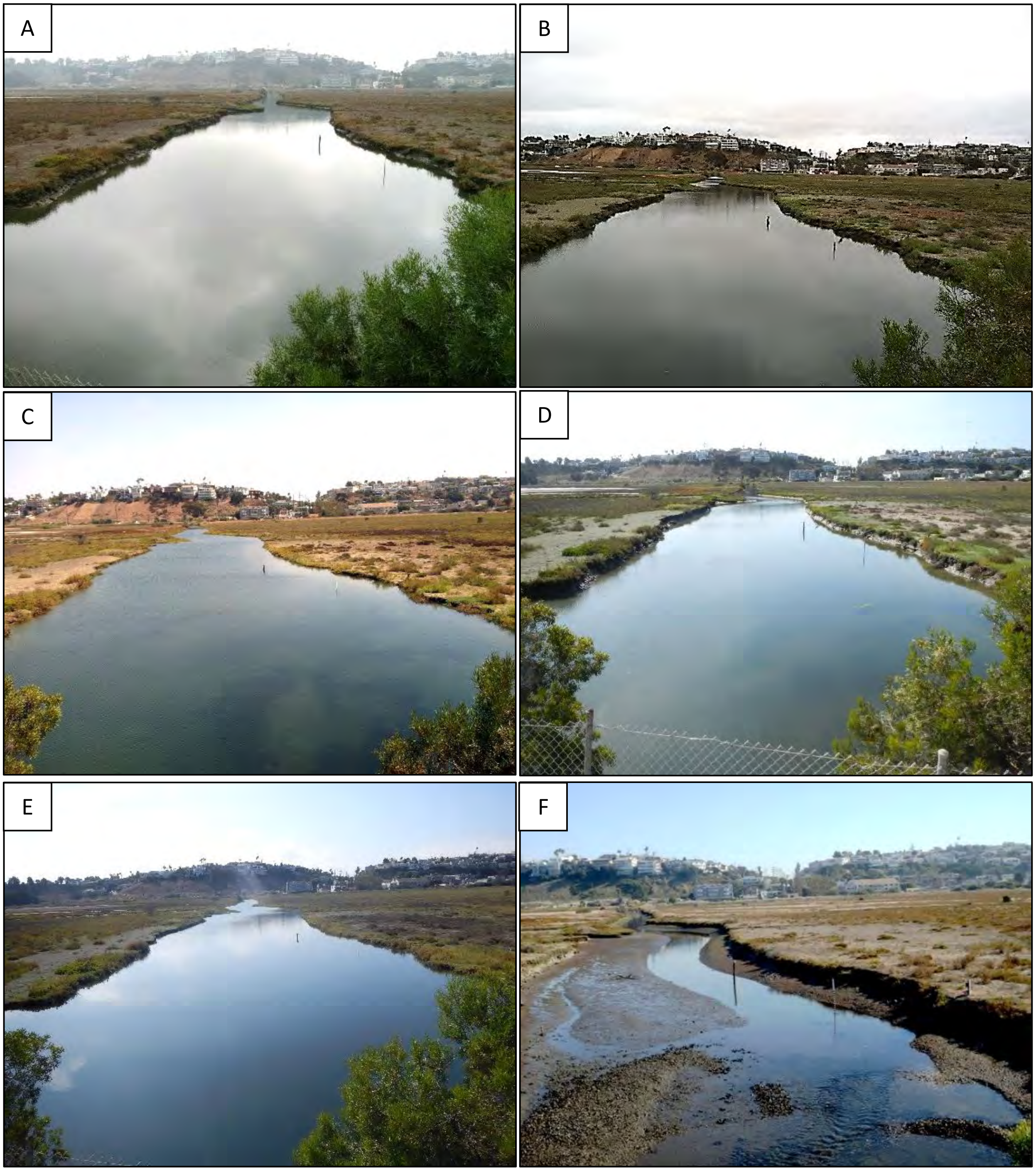


Figure 17. Photo Point station P03: (A) November 7, 2012; (B) June 5, 2013; (C) August 12, 2013; (D) May 9, 2014; (E) May 9, 2014; and (F) October 27, 2011. Note: (F) was not part of the survey but represents a low tide.

Figure 18. Photo Point station P01: (A) November 7, 2012; (B) June 5, 2013; (C) August 15, 2013; (D) November 13, 2013; (E) May 6, 2014; and (F) August 21, 2014.

Figure 19. Photo Point station PP12: (A) June 5, 2013; (B) August 12, 2013; (C) November 13, 2013; (D) May 9, 2014; and (E) August 21, 2014.

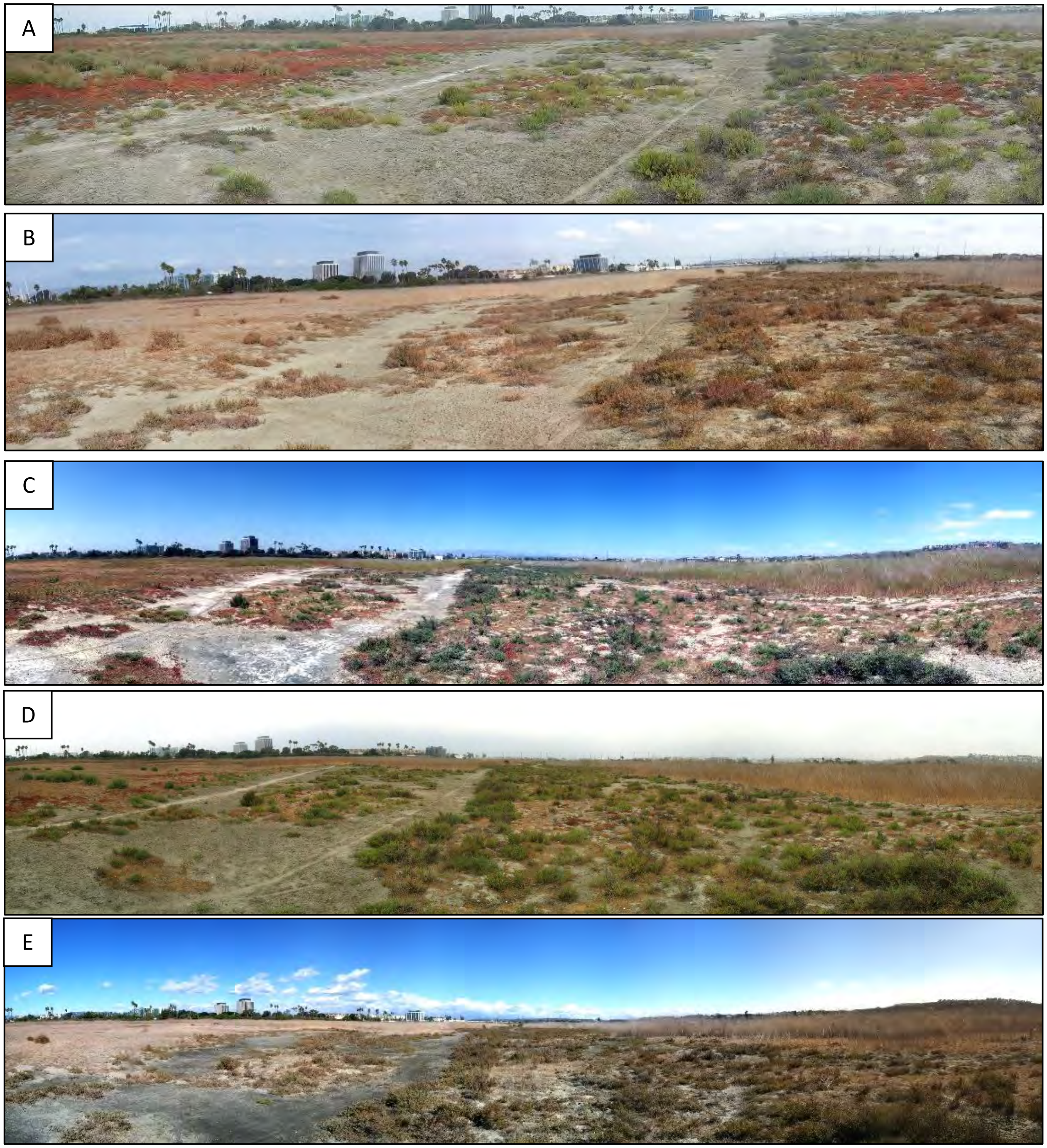


Figure 20. Photo Point station PP25: (A) November 9, 2012; (B) June 24, 2013; (C) August 14, 2013; (D) November 19, 2014; (E) May 15, 2014; and (F) August 22, 2014.

Figure 21. Photo Point station PP30: (A) November 9, 2012; (B) June 24, 2013; (C) August 14, 2013; and (D) August 22, 2014.

Figure 22. Photo Point station PP 32: (A) November 9, 2012; (B) May 21, 2013; (C) September 5, 2013; (D) May 21, 2014; and (E) August 22, 2014.

5-Year Summary Conclusions

Throughout the monitoring period, the Photo Point surveys documented slight changes over time. Notable examples of the changes include seasonality of vegetation alliances (especially for annual species), non-native plant cover expansion in disturbed areas, and anthropogenic effects such as illegal dumping of waste. As the site changes over time, Photo Point surveys will continue to be a valuable qualitative visual tracking tool that could be used to compare pre- and post-restoration habitats. Photo Point surveys are an effective, low cost visual observation series.

Level 3: Site-Intensive Assessments

Introduction

Level 3 assessment methods are a collection of more rigorous monitoring methods that provide high resolution information on the condition of habitats within an assessment area, often employing intensive plant, soil, or water quality analysis.

The robust measures used in Level 3 assessments produce information that can be used to:

1) Refine or validate rapid assessment methods (Level 1 and 2 assessments) based on a characterization of reference condition and specific functions;
2) Diagnose the causes of wetland or habitat degradation;
3) Develop design and performance standards for restoration projects; and
4) Provide detailed information and data at a species-level or constituent-level.

Within this Level 3, or site-intensive monitoring section, there are three broad subsections, including: water and soil quality, biological communities, and physical characteristics. Detailed parameters were assessed for each subsection. In the water and soil quality subsection, water quality data are provided, including: general water quality parameters, bacteria, nutrients, isotopes, amphipod toxicity, phytoplankton community surveys, and data for constituents such as heavy metals. Additionally, soil and sediment quality data include: soil salinity, grain size, and data for constituents such as heavy metals. In the biological communities subsection, data results are provided for surveys of habitat types, vegetation mapping of alliances, associations, and species associations, vegetation cover, germinated seed bank, submerged aquatic vegetation and algae, ichthyofauna, herpetofauna, mammals, avifauna, and invertebrates. In the physical characteristics subsection, data results are provided for surveys of elevation, channel cross-sections, and inundation.

The Level 3 subsections briefly outline the methods implemented for each parameter, but the focus of this report is to provide overarching trends in data accumulated since the inception of the baseline monitoring program in August 2009. The specific goals of the Level 3 assessments include:

1) Validate the rapid assessment method (e.g. CRAM) condition score results;
2) Provide comprehensive site-intensive baseline and supplemental datasets to the CDFW land managers to inform restoration and site management processes;
3) Fill data gaps, including data on rare species and trends over time; and
4) Inform both a site-specific and regional long-term monitoring program.

Water and Sediment Quality

Introduction

Urban wetlands can be contaminated by a wide variety of constituents and sources (Comeleo et al. 1996, Bay et al. 2010). Water quality measurements may be used as indicators of both human health concerns and the overall chemical and physical conditions of a site. Reduced wetland water quality suggests poor circulation, lack of tidal flushing, or increased sediment transport in wetlands (Zedler 2001). Additionally, prevailing wetland vegetation communities are often directly linked to dominant hydrologic regimes, soil salinity, and composition (James-Pirri et al. 2002). Water and sediment quality sampling was conducted with the principal objective of assessing the baseline conditions in and around the Reserve (e.g. also including Ballona Creek and Estuary).

Several areas for evaluation within the Reserve were identified based on water input to the estuarine system. The Fiji Ditch in Area A is the tidal area that receives water through a culvert connected to Basin H in Marina del Rey. The tidal channels of Area B receive water from the Ballona Creek estuary; during the wet season, they also receive freshwater runoff from the surrounding environs. Ballona Creek receives dry and wet season freshwater from the surrounding watershed through the storm drain system. The estuarine portion of Ballona Creek within the Reserve is also fully tidal with salt water input from Santa Monica Bay.

Water quality surveys across the five monitoring years included general parameters such as dissolved oxygen and salinity, fecal indicator bacteria (FIB), nutrients, constituents of concern such as heavy metals, and water isotope analyses. Soil and sediment surveys focused on salinity, constituents of concern such as heavy metals, and amphipod toxicity. Additional surveys were conducted to determine FIB and nutrient fluctuations within the tide channels of Area B, the Fiji Ditch in Area A, and the estuary portion of Ballona Creek as well as loading and stratification of FIB and turbidity in the tidal channels.

Detailed methods and results for the water quality subsections of FIB, nutrients, and constituents of concern (e.g. heavy metals) can be found in the first two baseline reports and subsequent water quality publications (e.g. Johnston et al. 2011, 2012, 2015a). Similarly, detailed methods and results for constituents of concern in soils and sediments can be found in the first two baseline reports (Johnston et al. 2011, 2012). Two soil quality analysis protocols (i.e. grain size and organic content) were developed as part of a complimentary project working towards the standardization of Level 3 protocols across California. Data reported for those two protocols in this report are, therefore, preliminary results only conducted at a subset of monitoring locations within the Reserve. For details on the protocol development, refer to the “CA Estuarine Wetland Monitoring Manual” (Johnston et al. 2015d).

Water Quality: Automated Water Quality Monitoring

Methods

A Yellow Springs Instruments (YSI) 6600 XLM multi-parameter data logger was deployed continuously in the main inflow channel adjacent to the tide gates to monitor water depth, dissolved oxygen (mg/L), temperature, salinity, conductivity, and pH at 15-minute intervals. Detailed user manuals were used for calibration and maintenance; in-depth descriptions of the specifications and operations of these instruments can be found at www.ysi.com.

Data were collected between August 2009 and September 2014 at the permanent deployment station in the northern portion of the main tidal channel of Area B of the Reserve (Figure 23). Dates of deployment varied across years due to probe malfunctions, servicing, or calibration glitches. Data were downloaded, and the sonde was calibrated, cleaned, and redeployed approximately once monthly. YSI calibration instructions (www.ysi.com) were followed for each calibration and each probe. Data output from the sondes were exported into a spreadsheet and quality control check procedures were performed by removing inaccurate data from the analyses, including: data from probes not meeting full calibration or operating standards, data that were acquired when the sonde was not submerged, data that were outside of user manual range specifications, and data that were collected when the battery voltages were insufficient based on manufacturer criteria. Malfunctioning probes and sondes were sent back to the manufacturer for maintenance. Data are displayed for this report as representative graphs, and the dissolved oxygen (DO) data are also displayed as percent of readings above several minimum thresholds.

Figure 23. Photograph of data sonde deployment in the main muted tidal channel at Ballona B-W.

Results

One permanent data sonde station collected data for multiple parameters across all five years of the baseline monitoring program. Given the substantial number of recordings (over 175,000 for each of the five parameters), representative results are presented below as line graphs by day and month, respectively. In general, parameters followed expected and predictable trends. Additional DO data are presented in a subsequent subsection, below, measured against several water quality thresholds (e.g. 1 mg/L), due to the importance of this parameter to the biological community.

Summary Sonde Data

All parameters followed expected and predictable trends such as average temperature increases in summer months and decreases in winter months, relatively consistent pH levels, and depth range changes tracking tidal oscillations. Additionally, Figures 24 through 31 display representative results by day and month for DO (Figures 24 and 25), salinity (Figures 26 and 27), turbidity (Figures 28 and 29), and DO plotted against temperature (Figures 30 and 31). Depth and DO displayed a parallel association, with increases in depth corresponding to higher tides generally revealing higher readings of DO and vice-versa. One example is displayed in Figure 24, where a reduction in DO can be seen between 10:31 and 17:16 which corresponded to a -0.6 foot low tide at 12:47. Similar to the DO-depth relationship, salinity and depth also corresponded (Figures 26 and 27). When the tides were higher and the water depth increased, the salinity was reflective of oceanic waters at around 33 or 34 ppt. Heavier saline waters were found at the deeper water depths. As the water receded during an outgoing or low tide, the water dropped in the tide channels and the readings at the lowest tides of relatively brackish salinities suggest that the sensor was recording a lens of fresh or mixed brackish water at that time.

Turbidity was inversely proportional to depth (Figures 28 and 29). As the outgoing tides emptied from the channels, the water movement mixed and re-suspended the channel sediments, causing an increase in turbidity. In some cases, significant spikes in turbidity were associated with low spring tides. Lastly, similarly to turbidity and depth, DO and temperature were also inversely proportional, as increased water temperatures reflected lower DO readings and vice-versa (Figures 30 and 31).

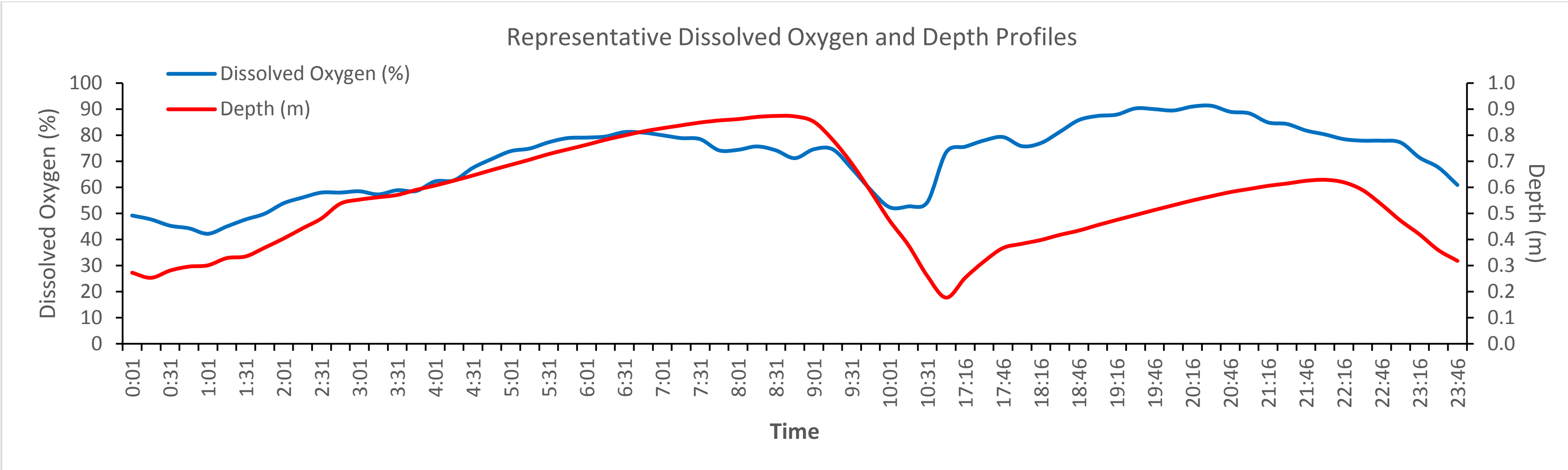


Figure 24. Dissolved oxygen and depth profiles on 7 March 2013.

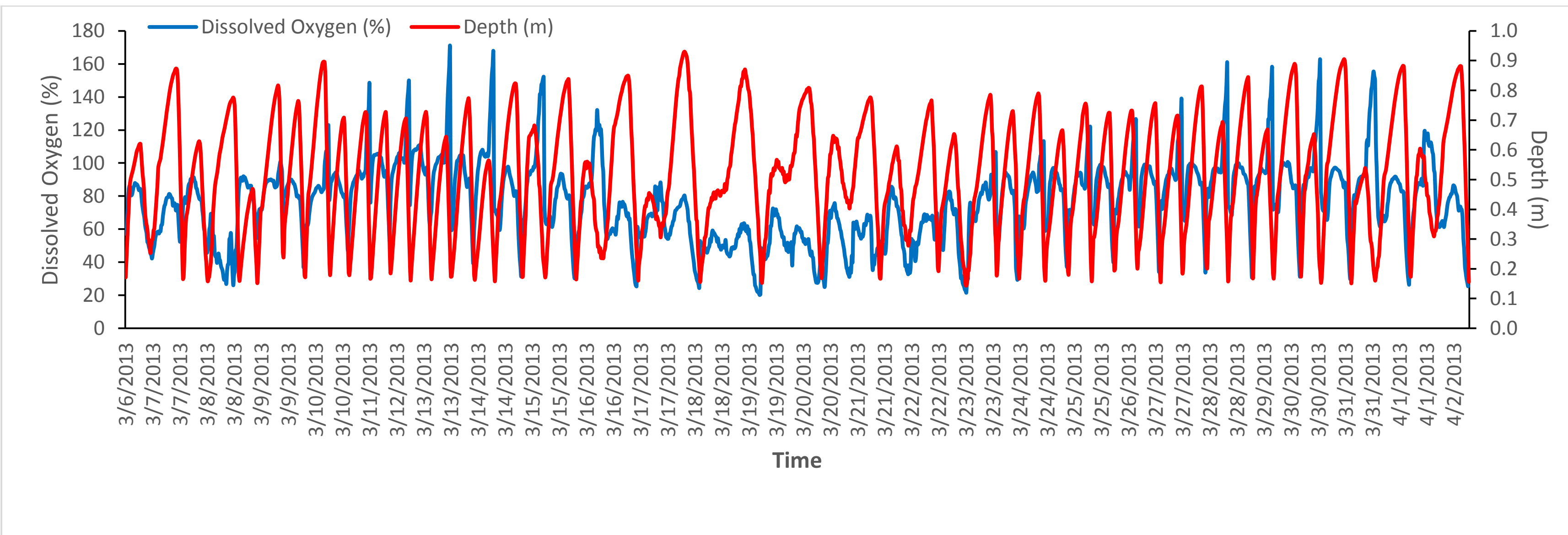


Figure 25. Dissolved oxygen and depth profiles from 6 March to 2 April 2013.

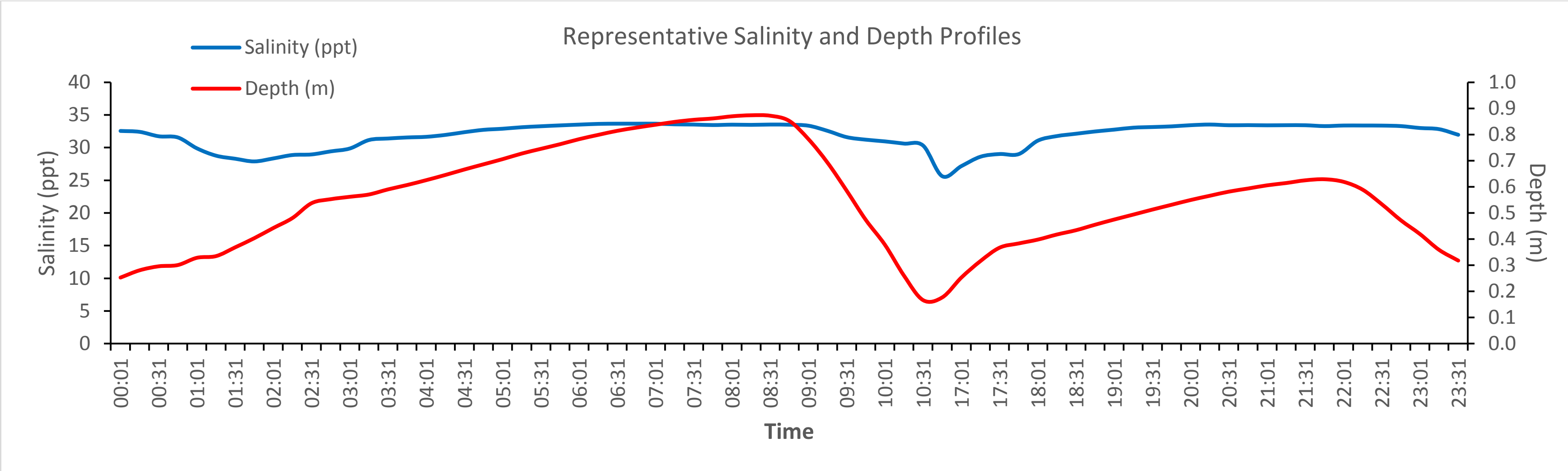


Figure 26. Salinity and depth profiles on 7 March 2013.

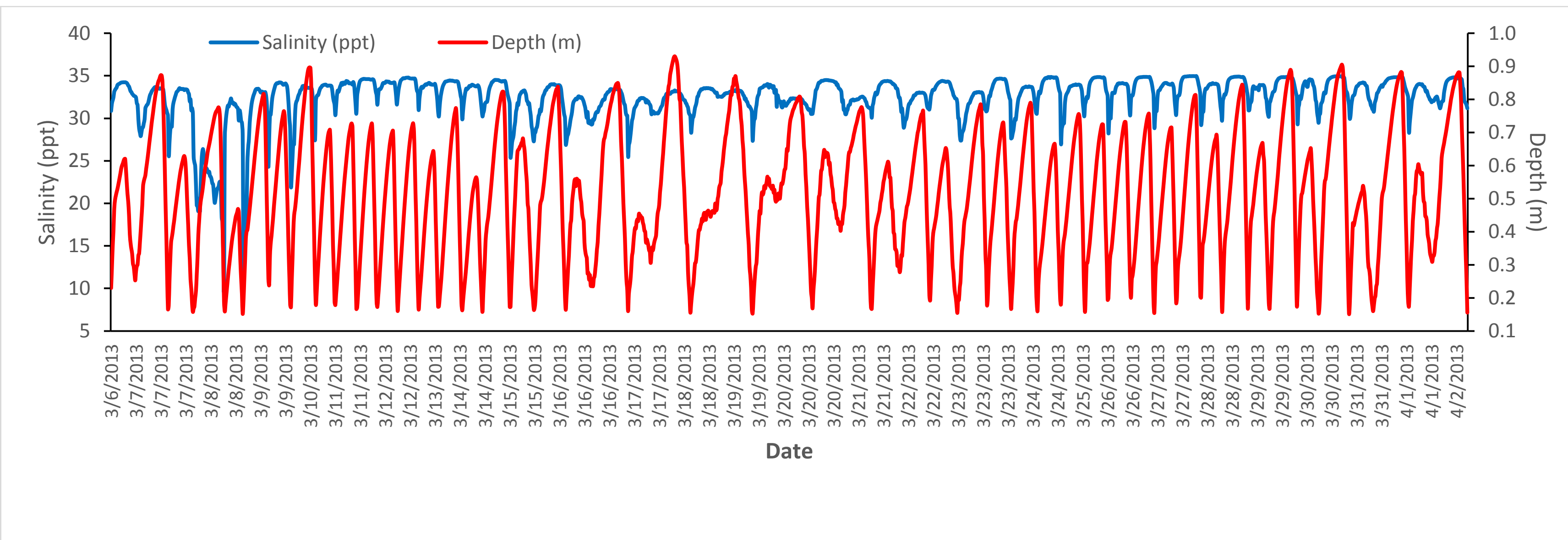


Figure 27. Salinity and depth profiles from 6 March to 2 April 2013.

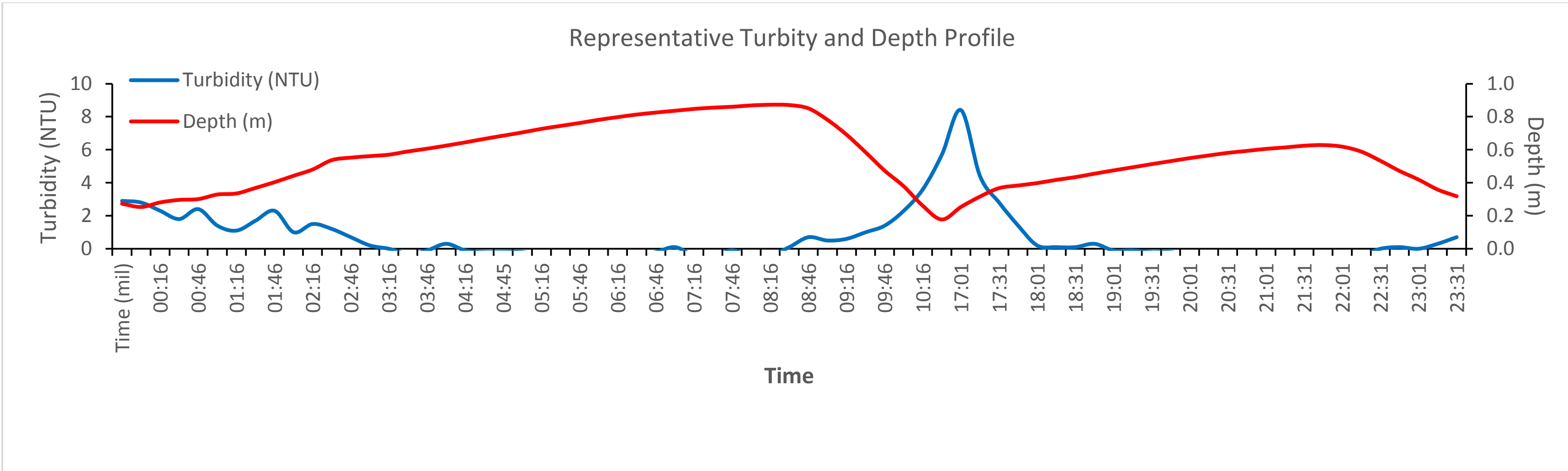


Figure 28. Turbidity and depth profiles on 7 March 2013.

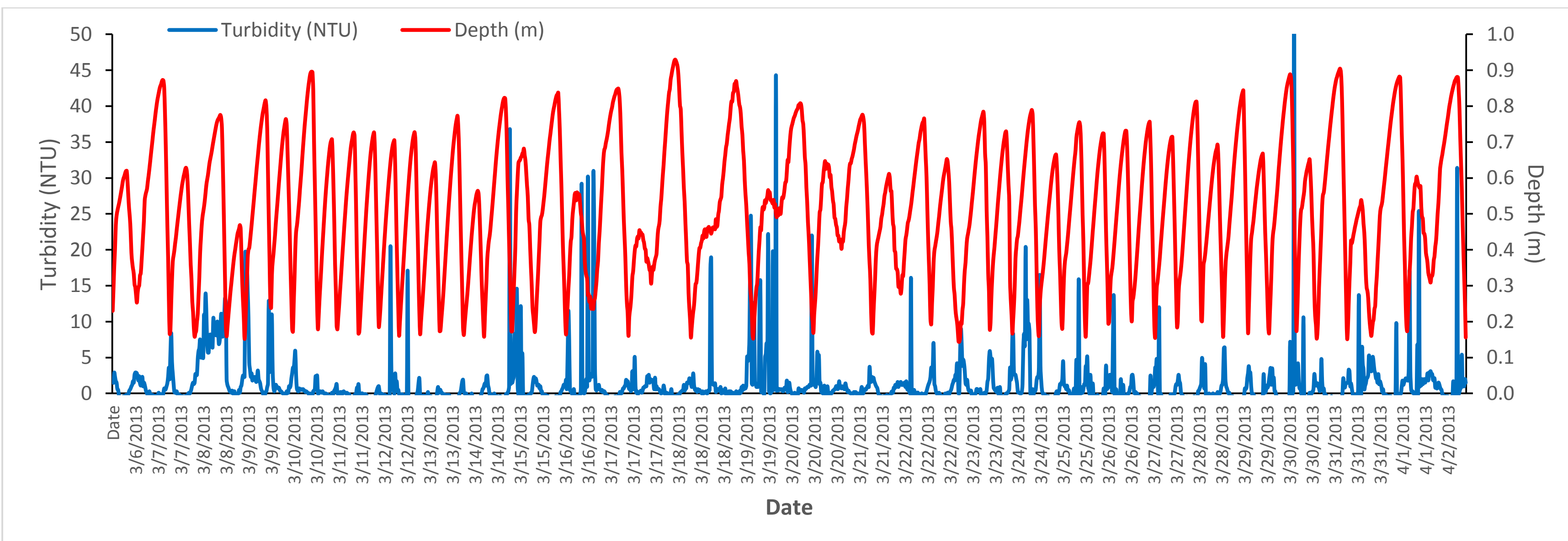


Figure 29. Turbidity and depth profiles from 6 March to 2 April 2013.

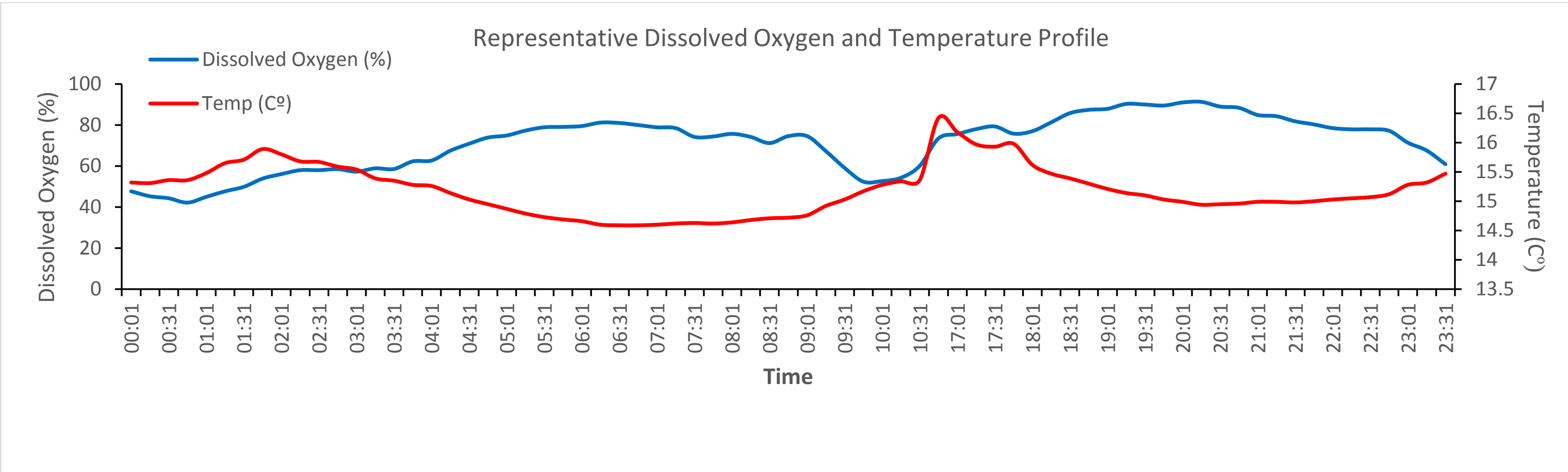


Figure 30. Dissolved oxygen and temperature profiles on 7 March 2013.

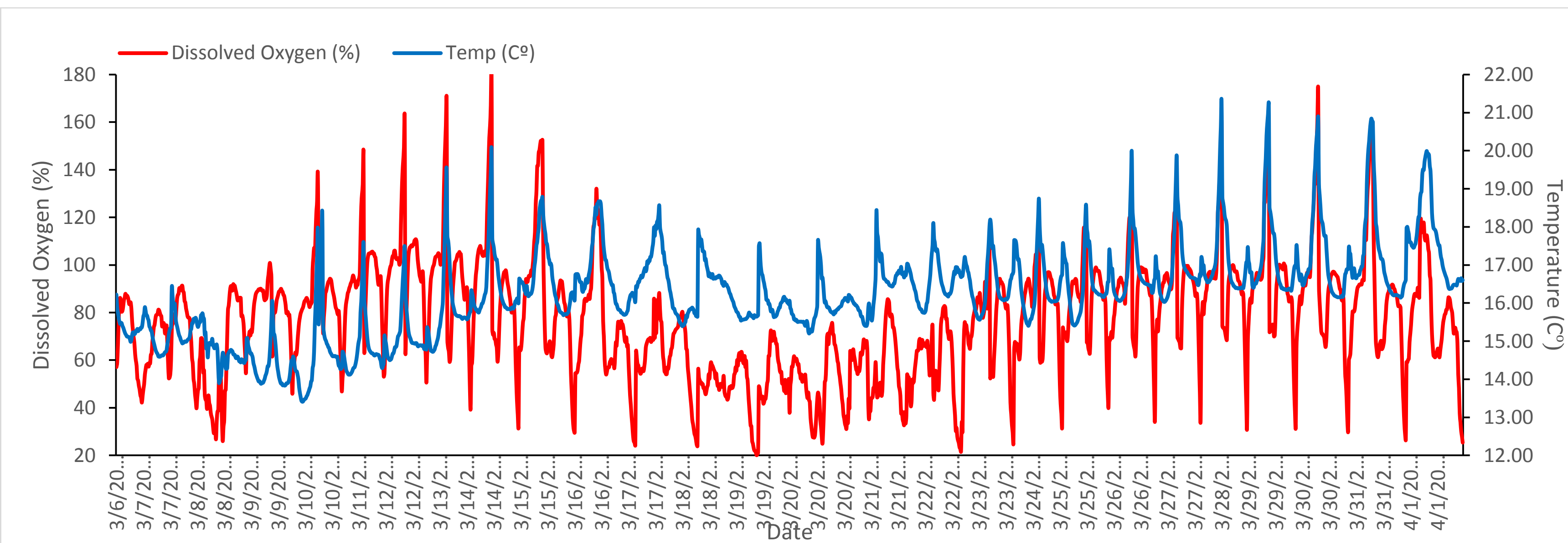


Figure 31. Dissolved oxygen and temperature profiles from 6 March to 2 April 2013.

Dissolved Oxygen Data

DO readings displayed high inter-annual variability. Table 7 presents the percent of readings above specific DO thresholds identified as important biological thresholds by multiple monitoring and restoration projects (McLaughlin et al. 2012, Abramson et al. 2015). More than 95% of all readings were above 1.5 mg/L of dissolved oxygen across all years ranging from 95.36% – 99.91%. Even at higher dissolved oxygen thresholds (i.e. 5 mg/L), the majority of readings (greater than 70%) across all years ranged from 71.64% - 88.43%. Additional DO summary statistics by month are presented for Ballona between the period of October 2013 – August 2014, to show representative data on the average, maximum, and minimum DO readings during those time periods (Table 8). Figure 32 displays the monthly average and standard error for the same location and time period.

Table 7. Percent of readings (%) above DO threshold (mg/L) by year.

	Dissolved oxygen threshold (% of readings)			
Year	**1 mg/L**	**1.5 mg/L**	**3 mg/L**	**5 mg/L**
2010 – 2011	99.98%	99.91%	98.55%	88.43%
2011 – 2012	97.92%	95.36%	82.84%	71.64%
2012 – 2013	99.88%	99.65%	96.49%	82.76%
2013 – 2014	99.67%	99.49%	94.96%	78.10%

Table 8. Basic monthly statistics for DO (mg/L) at Ballona from October 2013 – August 2014.

Month	Average DO	Standard Error	Maximum DO	Minimum DO
October	5.552	0.046	17.66	0.13
November	6.991	0.076	12.00	0.27
December	7.041	0.031	13.71	4.05
January	7.670	0.104	10.65	5.01
February	6.695	0.041	16.36	1.93
March	6.749	0.040	19.36	2.11
April	7.082	0.054	26.73	0.47
May	6.334	0.039	12.19	0.64
June	6.325	0.035	10.48	0.85
July	6.650	0.036	12.76	1.19
August	5.847	0.083	11.65	1.99

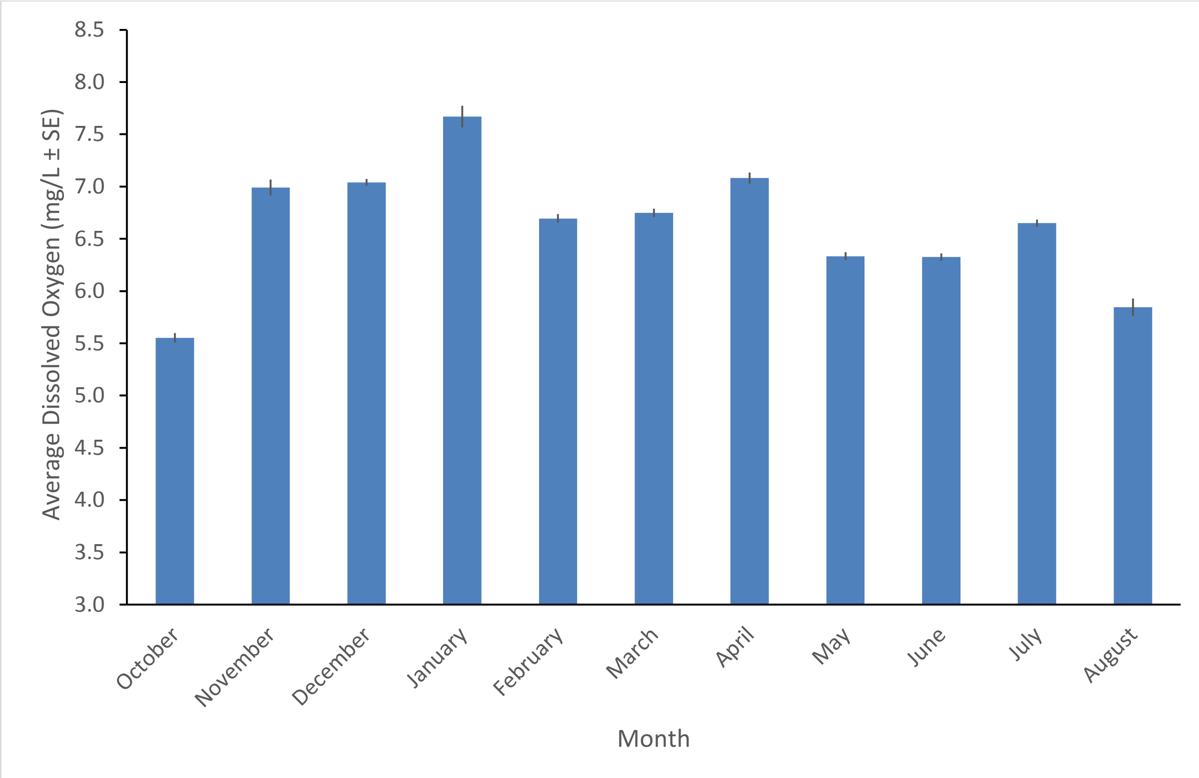


Figure 32. Monthly averages (± standard error) for dissolved oxygen at Ballona from October 2013 – August 2014.

5-Year Summary Conclusions

All parameters followed expected and predictable trends such as average temperature increases in summer months and decreases in winter months, relatively consistent pH levels, and depth range changes tracking tidal oscillations. Depth was relatively proportionally parallel with DO and salinity results and inversely proportional to turbidity and temperature. Resuspension of sediments on outgoing tides in the tidal channels caused spikes in turbidity. DO and temperature were also inversely proportional. Long-term data across the five monitoring years suggest that general water quality parameters followed expected trends of muted tidal conditions in the tidal channels, e.g. restricted depth, consistent pH, consistently high levels of DO.

Dissolved oxygen concentrations were variable across a wide temporal scale; however, an overarching trend was that extremely low dissolved oxygen levels (i.e. < 1mg/L) occurred less than approximately two percent of the time across all years. This indicates that tidal energies within the muted Area B tidal channels were sufficient to promote a well-mixed water column, and dissolved oxygen levels were likely capable of supporting robust benthic invertebrate and fish populations.

Water Quality: Bacteria and Nutrients

Methods

A diverse set of water quality surveys were performed to assess fecal indicator bacteria (FIB) and nutrients in and around the Reserve. Stratification studies were conducted to investigate the tidally-influenced movement of bacteria in the wetlands and the relationship to turbidity and sediment resuspension. New analyses were conducted as part of a scientific, peer-reviewed journal publication by Johnston et al. (2015a) in Environmental Monitoring and Assessment: "Stratification and Loading of Fecal Indicator Bacteria (FIB) in a Tidally Muted Urban Salt Marsh."

No new water quality nutrient data were collected as part of the baseline program since the publication of the last baseline report (Johnston et al. 2012). For details on bacteria and nutrient water quality data collection at the Reserve, refer to the first two baseline reports and the upcoming Draft Environmental Impact Report/Statement for the Ballona Wetlands Restoration Project.

5-Year Summary Conclusions

Overall, the Reserve experienced highly variable concentrations of FIB ranging within three orders of magnitude. There was contaminated FIB input both from Marina del Rey (to the Fiji Ditch) and from Ballona Creek (to the tidal channels). FIB concentrations in the Ballona Creek estuary during the baseline years fairly consistently exceeded Total Maximum Daily Load (TMDL) numeric targets (especially for total coliform FIB), sometimes by two orders of magnitude. The City of Los Angeles' TMDL monitoring and implementation plans are available for download from the Bureau of Sanitation website (http://www.lacitysan.org/).

Baseline data from both years and publications (Dorsey 2006, Dorsey et al. 2010, Johnston et al. 2011, 2012, 2015a) suggest that the wetlands are acting as a sink for FIB. Overall concentrations in the estuary (Ballona Creek) were typically greater than those in the wetlands, sometimes by several orders of magnitude, suggesting that even the spikes in FIB concentrations ebbing from the wetlands were diluting the estuary to the extent that a small volume of outflowing wetland water could dilute the much larger, contaminated volume of the Ballona Creek estuary (Johnston et al. 2015a). This consequence shows a significant ecosystem service, water purification, for the Reserve, even in its degraded state. Additionally, significant stratification of both FIB concentrations and loading occurred in the water column during all but the most highly-mixed portions of the tidal cycle. Loading was found to be greatest during flood flows from the contaminated estuary waters and diminished during low tide periods (Johnston et al. 2015a).

Nutrient concentrations from both baseline years and additional eutrophication studies (McLaughlin et al. 2014) indicate that the Reserve does not currently experience substantial eutrophication, or excess nutrient inputs to the system, though there are periods of lower dissolved oxygen associated with muted tidal conditions and tidal fluctuations.

Water Quality: Constituent Sampling

Methods

Dissolved metals were sampled as part of the baseline monitoring program during both dry and wet weather surveys. Resulting data were evaluated using the US Ambient Water Quality Criteria of the USEPA for acute and chronic marine toxicity, and TMDL limits (USEPA 2009). No new water quality constituent data (e.g. heavy metals) were collected as part of the baseline program since the publication of the last baseline report (Johnston et al. 2011, 2012). For details on constituent sampling water quality results, refer to the first two baseline reports, Total Maximum Daily Load reports, and the upcoming Draft Environmental Impact Report/Statement for the Ballona Wetlands Restoration Project.

5-Year Summary Conclusions

Several metals consistently exceeded various toxicity recommended levels (USEPA 2009) and TMDL numeric targets, including copper, cadmium, zinc, lead, and selenium (for the full list, see Results section in the first and second year baseline reports; Johnston et al. 2011, 2012). Water quality samples were collected as single surface grab samples and are only representative of that surface location at one point in time. As evaluated in the FIB stratification and loading study, significant stratification of the water column does occur in the tide channels. The Southern California Coastal Water Research Project (SCCWRP) has conducted several studies on constituents and contaminants in the Ballona Creek estuary under both dry and wet weather conditions across a larger temporal scale (Brown et al. 2011, Stein and Tiefenthaler 2004, 2005; Stein and Ackerman 2007). These and additional reports are available for download on their website (www.sccwrp.org) and provide supplemental information regarding water quality in Ballona Creek. Similarly, additional detailed data on dissolved metals in Ballona Creek are available through reports for TMDL monitoring in the Creek and estuary.

While exceedances of different thresholds are common in urban environments, especially during wet weather sampling events, wetland vegetation species often provide significant water quality services, including reductions of heavy metals (Brown et al. 2012). More data are needed to thoroughly evaluate the specific water quality benefits of the tidal areas of the Reserve, but it is likely they are performing similar functions.

Water Quality: Isotope Analysis

Methods

Stable isotopes of oxygen and deuterium (^2H or D) can be used to identify water sources based on the unique isotopic signature of each water body. New isotope analyses were conducted as part of a water chemistry study in 2013 by Erum Razzak and her colleagues as part of her Master's Thesis for California State University, Los Angeles. This pilot study used water quality parameters, major ions, and water isotope ratios to identify possible sources of water that contributed to the saltwater marsh, analyzing the mixing of seawater and freshwater within the Ballona Creek Estuary (Razzak 2013). For detailed sampling and laboratory methods, see Razzak 2013.

Results and Conclusions

The following results are a summary of Ms. Razzak's thesis; for more details and additional data, refer to her thesis directly. Water isotope and dissolved major ion concentration data indicate that upper (eastern) Ballona Creek and Dockweiler Beach (DB) were both found to contribute to the Ballona Estuary (BE, tidal portion of Ballona Creek) and the western channels of the Reserve, with oceanic water as the primary contributor (Figure 33). Although upper Ballona Creek contributions to BE increased after a precipitation event, contributions of Ballona Creek to the Reserve remained about the same.

Water isotopes δD and $\delta^{18}O$ were graphed and compared to the Global Meteoric Water Line to distinguish different water sources by isotopic signatures (Figure 33). Isotope values for DB, which is seawater, plot near $\delta D = \delta^{18}O = 0$. DB and upper Ballona Creek (ST, freshwater) are the end-members and all other sites fall on an apparent mixing line with an equation of $\delta D = 7.0041\delta^{18}O - 0.7493$, with $r^2 = 0.9904$. The more negative isotopic signatures seen for BE, and the two wetland tide gate locations (EG and WG), relative to DB, are a result of seawater mixing with freshwater. The negative isotopic signatures of upper Ballona Creek (ST) and freshwater sources in the wetlands (FB/FF) are consistent with meteoric water from inland sources.

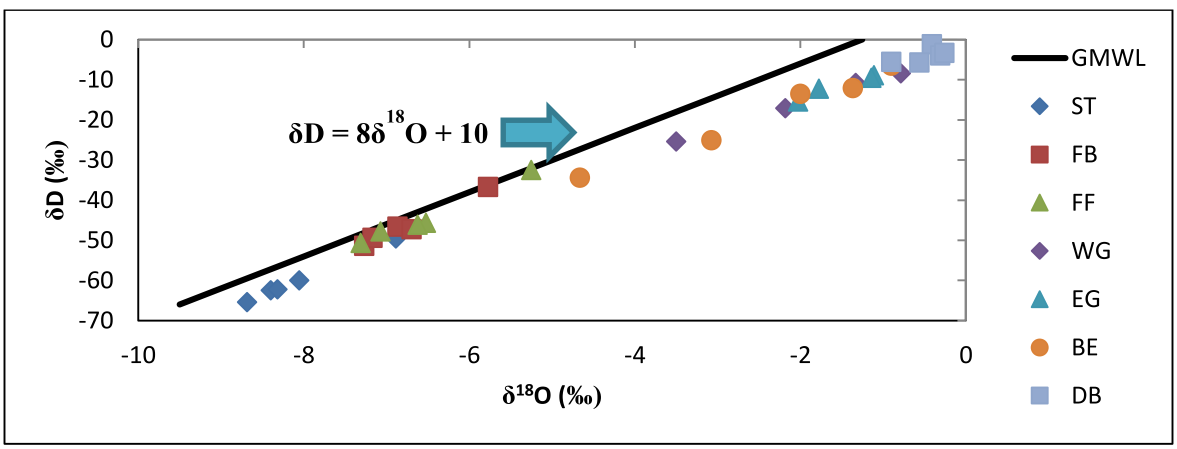


Figure 33. Water isotopes for the study area. GWML = Global Meteoric Water Line.

Water Quality: Phytoplankton Surveys

Methods

In 2014, a student group from the University of California, Los Angeles' (UCLA) Institute of the Environment and Sustainability led a phytoplankton community assessment at the Reserve. The goal of this study was to determine baseline phytoplankton taxa present in the intertidal channels and adjacent Ballona Creek. Three sampling locations were selected, including a location in the main tidal channel, the western branch channel, and a location just outside the tide gates in Ballona Creek. A full spring tide was sampled on March 6 and 7, 2014, with surface water samples collected and general water quality parameters monitored at each location once per hour for 24 hours. Phytoplankton genera were identified through observation of gross morphology under light microscopy. Results below are summarized from the final UCLA phytoplankton report (De Anda et al. 2014).

Results and Conclusions

Similar communities and proportions of dominant species were found in all three sites, though specific phytoplankton abundances were highly variable in all locations across the 24-hour period. Fifty-two different genera of phytoplankton were identified (54 total taxa), as shown in Table 9. The majority of the genera were diatoms within the Bacillariophyceae class. Seven of the genera were identified as harmful. Most of the harmful genera belong to the class of Dinophyceae. Although *Prorocentrum* was the most common harmful algal genera with abundances ranging from 90 to 2,100 cells/L in the west channel and Ballona Creek, abundances of harmful species were relatively low, overall.

Some of the less common genera were found to be unique to one particular sampling location. For example, *Alexandrium* was only found within the wetland tidal channels. *Amphora*, *Bacillaria*, *Chroomonas*, *Ditylum*, *Eucampia,* and *Grammatophora* were only present in the main (east) tidal channel. *Akashiwo*, *Asteromphalus*, *Guinardia Striata*, *Leptocylindrus*, *Lingulodinium*, *Phaeoplaca*, *Meuniera* and *Rhizosolenia* were found only in Ballona Creek and not in the wetlands. Since the scope of this project only considered the phytoplankton community changes across a twenty-four hour period, future studies are recommended to track changes in the community over a larger temporal and/or spatial scale.

Table 9. Phytoplankton genera occurrence from March 6-7, 2014 survey.

Centric Diatom Taxa	Pennate Diatom Taxa
Amphiprora	Cylinderotheca
Amphora	Diploneis
Asteromphalus	Gyrosigma
Bacillaria	Haslea
Bacteriastrum	Manguinea
Biddulphia	Navicula
Cerataulina	Nitzschia
Chaetoceros	Pleurosigma
Coscinodiscus	Rhaphoneis
Cymbella	Synedra
Dactyliosolen	Tropidoneis
Ditylum	Harmful Algae Taxa
Eucampia	Akashiwo
Fragilaria	Alexandrium
Fragilariopsis	Dinophysis
Grammatophora	Gymnodinium
Guinardia cylindrus	Lingulodinuim
Guinardia flaccida	Prorocentrum
Guinardia striata	Pseudonitzschia
Hemidiscus	Dinoflagellate Taxa
Lauderia	Chroomonas
Leptocylindrus	Pyrocystis
Melosira	Ceratium
Meuniera	Karlodinium
Rhizosolenia	Silicoflagellate Taxon
Skeletonema	Dictyocha
Stephanopyxis	Chyrsophyte Taxa
Thalassionema	Dinobryon
Thalassiosira	Phaeoplaca

Sediment Quality: Amphipod Toxicity

Methods

Sediment samples were collected during baseline year two using individual sterile scoops, syringes, and gloves to a depth of approximately 10 cm at each station. One sampling station (BW1) was located in the Fiji Ditch, and six stations were located in the tidal channels of Area B (BW4-9) for sample collection during the second baseline year. Sediment quality samples were collected at each sampling station once on 30 March 2011. No new sediment quality data for amphipod toxicity were collected as part of the baseline program since the publication of the last baseline report (Johnston et al. 2011, 2012). For details on sediment quality results, refer to the first two baseline reports, Total Maximum Daily Load reports, and the upcoming Draft Environmental Impact Report/Statement for the Ballona Wetlands Restoration Project.

Amphipod toxicity was conducted using *Eohaustorius estuarius* 10-day survival sediment bioassay under guidelines prescribed in Methods for Assessing the Toxicity of Sediment-associated Contaminants with Estuarine and Marine Amphipods, EPA/600/R-94/025. Five repetitions were assessed for each station and results are summarized below.

Results and Conclusions

Amphipod toxicity results from sediment bioassay testing were reported in the year two baseline report (Johnston et al. 2012) and are summarized in Table 10. Two stations (BW4 and BW9) had confirmed 'low toxicity' results (CRWQCB and USEPA 2005; ASTM 2006). The rest of the stations had 92% or higher survival. Additional information can be extrapolated from the results of the benthic invertebrate community surveys (see "Biological Communities – Invertebrates").

Table 10. Summary data from amphipod toxicity testing. Low toxic results are identified with red print.

Station	Survival	F value	p value	Significant Effect	Soil Toxicity
BW1	96.0%	0.5698	0.4720	No	N/A
BW4	87.0%	8.5650	0.0191	Yes	low toxicity
BW5	95.0%	0.1419	0.7162	No	N/A
BW6	88.0%	4.2800	0.0723	No	N/A
BW7	94.0%	0.0000	1.0000	No	N/A
BW8	92.0%	0.3018	0.5977	No	N/A
BW9	82.0%	13.8000	0.0059	Yes	low toxicity

Sediment Quality: Constituent Sampling

Methods

Survey methods were the same locations and collection protocols as the amphipod toxicity section, above. The first baseline year samples were processed by Wallace Laboratories, Inc., using a gentle extraction method (extractable ammonium bicarbonate diethylene triamine pentoacetic acid or DTPA), to assess bioavailability of trace metals within the sediments. Detailed laboratory and processing methods can be found in the first year baseline report (Johnston et al. 2011). The second year samples were processed using an acid digestion method to evaluate the soluble, exchangeable, and bulk mineral forms of the metals for comparison. Second year sediment samples were processed and analyzed by IIRMES Laboratory, California State University, Long Beach, according to EPA certified methods. Detailed laboratory and processing methods can be found in the second baseline report (Johnston et al. 2012).

No new sediment quality data for constituents were collected as part of the baseline program since the publication of the last baseline report (Johnston et al. 2011, 2012). For details on sediment quality results, refer to the first two baseline reports, Total Maximum Daily Load reports, and the upcoming Draft Environmental Impact Report/Statement for the Ballona Wetlands Restoration Project.

5-Year Summary Conclusions

Trace metals and elements were evaluated against ERL limits (USEPA 1996). Only one station (BW8) and one constituent (lead) had exceedances in the first baseline year using the bioavailable extraction method. Several of the evaluated constituents had non-detect results (effectively a ‘zero’ reading) (e.g. chromium, mercury, silver). In the second baseline year, using the strong acid digestion method, trace metals and elements results had at least one metal exceedance at each station. BW5, BW7, and BW9 exceeded limits for all elements evaluated (i.e. arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc). BW1 and BW8 exceeded for one metal each (copper and lead, respectively). Copper and lead exceeded limits at six stations each.

The two different survey methods implemented in each of the first two baseline years resulted in significantly different data and exceedance outcomes. Comparing bioavailable trace metals to the bulk mineral forms yielded significantly higher values of the constituents when the acid digestion method was implemented. These results provide different forms of evaluation for the various biological communities that are affected by trace metals and elements in the sediments.

Lastly, the stations with the highest degree of tidal circulation (i.e. BW1 and BW4) tended to have lower values for each constituent evaluated, suggesting that water circulation and sediment resuspension may reduce the amount of trace metals in the tidal channels.

Soil Quality: Constituent Sampling

No new soil quality constituent data were collected as part of the baseline program since the publication of the first baseline report (Johnston et al. 2011). Due to access permit modifications and restrictions by CDFW in the second baseline year to no longer allow soil disturbance of any kind for the duration of the monitoring program, soil quality surveys were not undertaken subsequent to the first baseline year. Data presented in the subsequent two sections, "Soil Quality: Salinity" and "Soil Quality: Grain Size and Organic Content" were analyzed on a subset of the same existing and preserved samples from the first baseline year. For additional details on soil quality, refer to the first baseline report and the upcoming Draft Environmental Impact Report/Statement for the Ballona Wetlands Restoration Project.

Soil Quality: Salinity

Methods

The objective of the soil salinity surveys was to determine concentrations of salts within terrestrial soil samples of existing collected material from the first baseline year using transect and habitat-level assessments. Soil salinity surveys were conducted according to methods outlined in the "Soil Salinity, Texture, and Pore Water Standard Operating Procedure" (Johnston et al. 2015d, Appendix B – 2.1) using 1:1 ratios of water and soil measured using a refractometer. Soil samples were collected from a total of 26 transects within seven habitat types. Habitat-level soil salinity concentrations were averaged by transect and then again by habitat type; therefore, habitat type averages represent grand means.

Results

Grand means for each habitat type are displayed in Figure 34 (± standard error). Salt pan transects demonstrated the highest average soil salinity concentrations with a grand mean of 92.27 ± 5.19 ppt. However, this average may not reflect the highest salinity outliers, as some readings exceeded the maximum range of the refractometer (i.e. 100 ppt) and the maximum value of 100 ppt was used for analyses. Tidal wetland habitat areas displayed the second highest average soil salinity values followed by non-tidal salt marsh with concentrations of 41.91 ± 4.31 and 34.98 ± 4.77 ppt, respectively. The lowest average soil salinity concentrations were found within dune areas and regions which support high vegetative cover of non-native species: dune, non-native dune, non-native "tall" herbaceous, and iceplant stand. Each of these habitat types displayed soil salinities of less than 10 ppt on average.

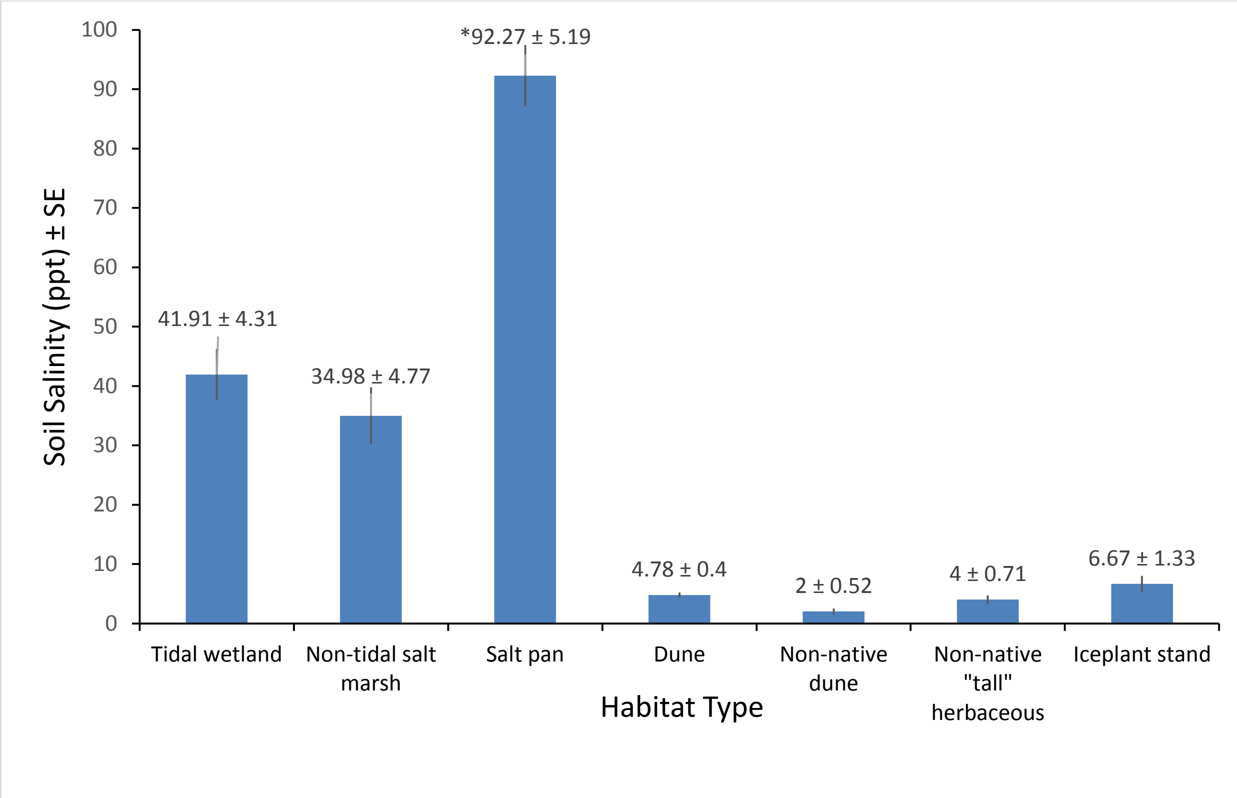


Figure 34. Grand means and standard error of soil salinity concentrations by habitat. Asterisk indicates some readings were above the range of the refractometer.

Geospatial results display similar patterns as the grand mean results by habitat type, above. Transect-level average soil salinity concentrations are shown geospatially overlain onto a map of western Area B in Figure 35. The highest soil salinities (red) were found within the salt pan; mid-range soil salinity concentrations (orange and yellow) were typically found in areas receiving tidal inundation or adjacent to tidal channels. Lower soil salinity (dark green) concentrations were found in areas relatively tidally-disconnected; the hydrology of these areas is dominated by freshwater influenced inputs including direct precipitation and/or stormwater runoff.

Figure 35. Map of soil salinity concentrations in western Area B.

5-Year Summary Conclusions

Soil salinity concentration data followed patterns predicted through the assessment of dominant vegetation assemblages, hydrology, and historic impacts. Salt pan areas displayed the highest concentrations as portions of these areas are only inundated during the highest spring tides (Figure 36). The lack of vertical relief in elevation promotes pooling of saline water which then evaporates, precipitating dissolved salts onto the soil. Soil salinities within tidal wetland areas displayed values close to coastal oceanic salt water (i.e. 30 – 33 ppt); however, the grand mean for the tidal wetland habitat type was likely skewed by higher values along transects which receive less frequent tidal inundation or are poorly draining and thus subjected to more evaporation of salt water. Non-tidal salt marsh habitat areas, once connected to tidal waters, continue to support euryhaline vegetation; however, their disconnection from tidal inundation as a result of anthropogenic impacts (e.g. levees, roads) have lowered their salinity concentrations below tidal wetland levels, as freshwater inputs slowly dissolved and leached salts from the soils over time. The lack of halophytic species within the dune, non-native dune, non-native "tall" herbaceous, and iceplant stand habitat areas is likely correlated to the fact that soil salinity concentrations are relatively low in those habitats as well as grain size and hydrologic factors.

Figure 36. Photograph of the salt pan habitat type in Area B (16 December 2009).

Soil Quality: Grain Size and Organic Content

Methods

The objective of the soil particle analysis procedure was to conduct a protocol evaluation of a combination of traditional and advanced technology to analyze soil type and total organic content on previously collected first baseline year soils. Soil particle analysis was conducted on 11 replicates of three soil samples collected from three transects in one habitat type, tidal wetland. Organic content was conducted on five soil samples collected from five transects across three habitat types.

Soil Particle Grain Size

For the soil particle analysis, sand was separated from fine-grained sediments for each sample using a 62 micron sieve and using traditional sieving methods. Fine sediments were mixed and tested in the LISST Particle Analyzer three or four times, averaged, and results were recorded. Because of technical problems and inconsistent results, only three samples were processed to completion. Detailed methods followed descriptions from the "CA Estuarine Wetland Monitoring Manual" (Johnston et al. 2015d) with specific reference to the individual "Soil Grain Size and Organic Content" Standard Operating Procedure (Appendix B – 2.2).

Organic Content

The first step to determine the percentage of organic matter in soil samples was to remove large pieces of debris that might contaminate the results of the soil sample (e.g. twigs, roots, grasses, etc.). Soil aggregates were then thoroughly ground with mortar and pestle, and the sample was weighed. The prepared sample was placed in a furnace for 15 minutes at a temperature of 500 °C to burn off organic matter and subsequently reweighed. The post-processing sample weight was divided by the initial sample weight to determine organic matter as a percentage. Detailed methods followed descriptions from the "CA Estuarine Wetland Monitoring Manual" (Johnston et al. 2015d) with specific reference to the individual "Soil Grain Size and Organic Content" Standard Operating Procedure (Appendix B – 2.2).

Results

Soil Particle Grain Size

The samples shown in Table 11 were all processed on the same day using the same grain size protocol; however, despite the specificity of the protocols, the results displayed a considerable amount of intra-sample variability. For example, the variability in the total clay percentage in the three replicates of the sample processed from Transect 378 displayed a range of 7.74 – 39.09 %. Similarly, the range in sand percentage in the sample replicates from Transect 370 was between 7.15 – 25.06 %. Conversely, several replicates had relatively lower ranges and standard errors (e.g. Transect 370, clay percentage). These examples and other results were similar, showing inconsistencies despite being taken from the same reference sample and following mixing protocols. Because it was not clear if additional replications would yield a higher degree of accuracy, further analyses were not conducted using this method.

Table 11. Particle size percentage results for each individual replicate and sample (average ± standard error). Note: despite using a 62 µm sieve, sand particles greater 62 µm were detected in the analysis.

Habitat Type / Transect Number	Single Sample Replication #	Clay (%)	Silt (%)	Sand (%)*
Tidal Wetland (Transect 369)	1	4.45	20.48	74.98
	2	14.90	65.37	19.73
	3	13.24	64.69	22.07
	4	6.73	33.97	59.30
	Average ± SE	9.83 ± 2.51	46.13 ± 11.26	44.02 ± 13.74
Tidal Wetland (Transect 370)	1	16.62	58.32	25.06
	2	15.24	65.7	19.06
	3	19.45	73.4	7.15
	4	18.59	65.81	15.60
	Average ± SE	17.48 ± 0.95	65.81 ± 3.08	16.72 ± 3.74
Tidal Wetland (Transect 378)	1	39.09	47.16	13.75
	2	7.74	64.99	27.27
	3	9.50	74.54	15.96
	Average ± SE	18.78 ± 10.17	62.23 ± 8.02	18.99 ± 4.19

Organic Content

The percent of total organic matter in five individual soil samples from three habitat types ranged from a minimum of 8.70 % in the salt pan to a maximum of 31.05 % in the tidal wetland habitat type (Table 12). Additionally, the within-habitat range between the two samples processed for the tidal wetland habitat type was 20.55 % and the difference in the two salt pan habitat type samples was 4.53 %. Only five samples were analyzed because the parameter was added late in the development of the Soil Particle Analysis protocol. Because the particle analyses proved to be fairly inconsistent, including a high within-sample variability in the results, no additional soil samples were processed using either protocol.

Table 12. Total organic matter results in the five processed soil samples.

Habitat Type	Processed	Organic Matter
Non-tidal Salt Marsh	7/23/2014	16.91 %
Tidal Wetland	7/29/2014	10.50 %
Tidal Wetland	7/23/2014	31.05 %
Salt Pan	7/29/2014	8.70 %
Salt Pan	7/23/2014	13.23 %

5-Year Summary Conclusions

After several rounds of testing the soil particle analysis methods using the LISST analyzer, replication results revealed too much variability within a single sample to provide useful data to the monitoring program. A substantial amount of water was required to separate the sand from the fines (> 1 L on average), and from this quantity, the LISST Particle Analyzer only required a very small amount (approximately 1 mL) per replication. Because larger particles settled more quickly, it was challenging to make sure samples were consistently well-mixed to assure a representative sample. Several mixing methods were evaluated, including continuous hand-stirring, the use of a stirrer plate, and continuous hand-stirring while using a stirrer plate. None of the mixing methods suitably reduced intra-sample variability. Additionally, the data were skewed when the replicate sample was drawn from a different part of the reference sample container. When the sample was collected towards the bottom of the container, the results skewed towards heavier sands and/or silts; when the collection was towards the surface of the container, results skewed towards lighter clays or fine-grained sediments.

Additionally, a significant amount of effort was needed per replicate, resulting in a high cost-effort ratio. Thus, alternate methods are recommended for future monitoring programs such as hand texture, sieving, or sedimentation (Kettler et al. 2001). As total organic matter in the soil can be affected by surrounding detritus and plant communities, it was found to be highly variable. Thus, no conclusions can be derived from the data analysis limitations of only evaluating five samples.

Biological Communities – Vegetation

Introduction – Vegetation

The Reserve has experienced hydrological restrictions, dumping of dredge spoils, non-native species invasions, habitat fragmentation, and development. Long-term monitoring of vegetation cover is one of the most common methods of evaluating the health and functioning of a wetland system (Zedler 2001); changes in the relative presences of native and non-native plant species may affect the distributions of associated wildlife species. Additionally, increases in vegetation cover and complexity following restoration events are one of the most common indicators of the return of many wetland habitat functions. Non-native plant species are present throughout the Reserve (PWA 2006); these non-native species are indicators of past disturbances to the wetland and have potentially reduced the value of the site as habitat for native plants and native wildlife (PWA 2006).

Information about the seed bank of a habitat type is another indicator of site functions and may, in some cases, provide supplemental or new information to add to the presence of adult plants (i.e. plant canopy) alone. The presence of a viable and diverse seed bank indicates recent well-functioning ecological and hydrological dynamics of the site (Johnston et al. 2011). Seed bank surveys provide information on past plant vegetation and can contribute to predictive understanding of plant community composition (Adams et al. 2008). Additionally, excess sediment loads resulting from watershed cultivation can result in an altered plant community composition through burial of seed banks (Jurik et al. 1994). However, it should be noted that a limitation of this method is its exclusion of species that do not rely on seed-based propagation processes.

Algae and submerged aquatic vegetation (SAV) surveys provide important information about primary productivity within a system and trophic structure. Algae abundance and growth can also be useful indicators of eutrophication and tidal flushing (Zedler 2001).

Program Goals

Due to the diverse array of vegetation habitats and communities within the BWER, vegetation surveys of the monitoring program are divided into four distinct types: habitat and alliance/association mapping, cover surveys, seed bank surveys, and submerged aquatic vegetation (SAV) and algae surveys. Specific program goals for each survey are listed below.

Habitat and alliance/association mapping:

1) Identify current vegetation alliance distribution and extents;
2) Cross-walk vegetation alliance and association data with hydrological information to describe habitat types;
3) Assess broad shifts in habitat distributions and vegetation alliances from 2007 to 2013;
4) Evaluate non-native vegetation species' trends and shifts in distribution and extent; and

5) Evaluate native vegetation species' trends and shifts in distribution and extent.

Cover surveys:

1) Determine areas with high non-native species presence;
2) Summarize the prevalence of native and non-native plant cover in each habitat to support the vegetation alliance/association results;
3) Define dominant species in each habitat.

Seed bank surveys:

1) Summarize the occurrence of native and non-native germinated plant seedlings;
2) Determine the potential for future recruitment of plant species within habitat types;
3) Evaluate species propagation at a transect level under ideal conditions.

Algae and submerged aquatic vegetation (SAV) surveys:

1) Continue the long-term monitoring program developed by the Southern California Bight Monitoring Program to assess the algal and SAV cover in the tidal channels of the Reserve;
2) Compare results to other southern California estuaries.

Vegetation: Habitat and Vegetation Alliance/Association Mapping

Methods

Surveys were conducted at the Reserve from May – October 2013 in accordance with methods developed by the California Department of Fish and Wildlife's (CDFW) Vegetation and Classification Mapping Program with supplemental information derived from previous monitoring surveys (2009–2013) conducted throughout the site (Johnston et al. 2011, 2012). When applicable, alliance and association types were assigned to vegetation polygons in accordance with the Manual of California Vegetation (2nd Edition). As a result of habitat fragmentation, hydrological restrictions, and dumping of dredge spoils on site, many non-native species assemblages occur which are not documented in the Manual of California vegetation (2nd Edition). For these areas, polygons are classified by the dominant or co-dominant vegetation species and referred to as 'mapping units'.

To compare an accurate depiction of change between years for both habitat types and vegetation alliances, the 2007 crosswalk survey and 2013 survey were clipped to the current Reserve boundary (ESA 2015), resulting in datasets equal in both project area extent and total acreage. It is important to note that different survey teams performed the 2007 and 2013 surveys and that higher resolution aerial imagery and more accurate geospatial tools were available for the 2013 surveys. For detailed methods, habitat types, descriptive characteristics, and dominant vegetation types, refer to the "Ballona Wetlands Ecological Reserve Vegetation Alliance and Habitat Crosswalk" (Medel et al. 2014).

Results

Habitat Types

Habitat categories were highly variable from subtidal to high elevation upland and are classified on an individual basis based on georeferenced polygons classifying dominant vegetation community and physical characteristics such as soil and hydrology. Habitat categories represent functionally distinct ecological communities and are described in this document specifically for the Reserve in 2007 (Figure 37) and 2013 (Figure 38). The summary of habitat types and their corresponding 2007 and 2013 survey acreages as well as the percent change in acreage from 2007 to 2013 is shown in Table 13 and Figure 39.

A notable increase of non-native "tall" herbaceous habitat, defined by fast growing monocultures or co-dominant mixes of invasive herbs, accounts for the conversion, and subsequent loss, of a portion of annual/ruderal grassland habitat. Additionally, Area A showed some conversion of ruderal marsh and brackish scrub habitat types to non-native "tall" herbaceous habitat, indicating that fast-growing invasive species of that habitat type continue to propagate and expand within remaining native habitat areas, especially in Area A. The loss of non-tidal salt marsh habitat in portions of Area B shows a conversion, in part, to ruderal marsh habitat. The primary difference between the two habitat types is that the ruderal habitat type is often dominated by non-native vegetation. Species level results discussed below provide additional detail on vegetation alliance shifts.

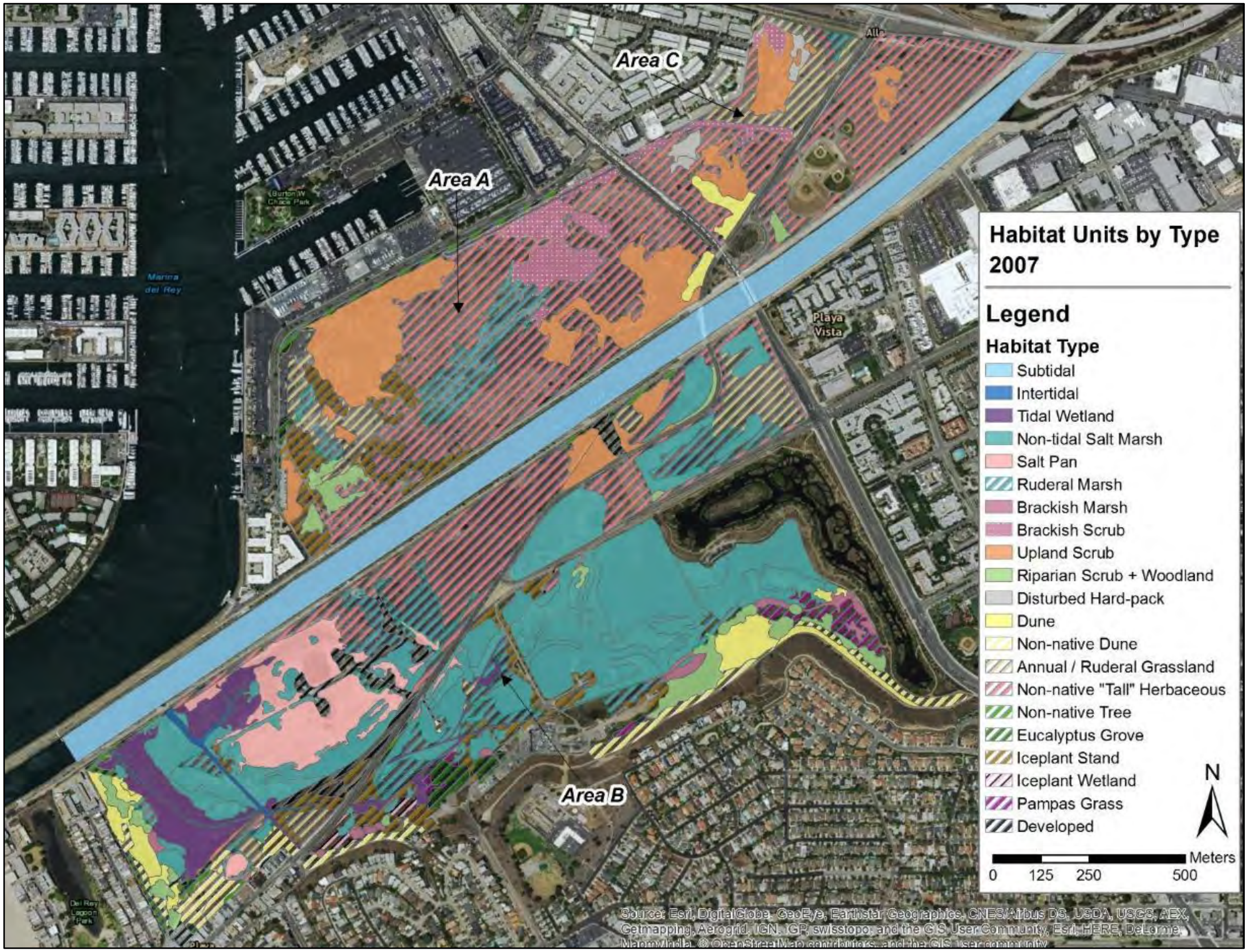


Figure 37. Habitat unit map of the Reserve from 2007 surveys (modified and cross-walked from CDFW 2007).

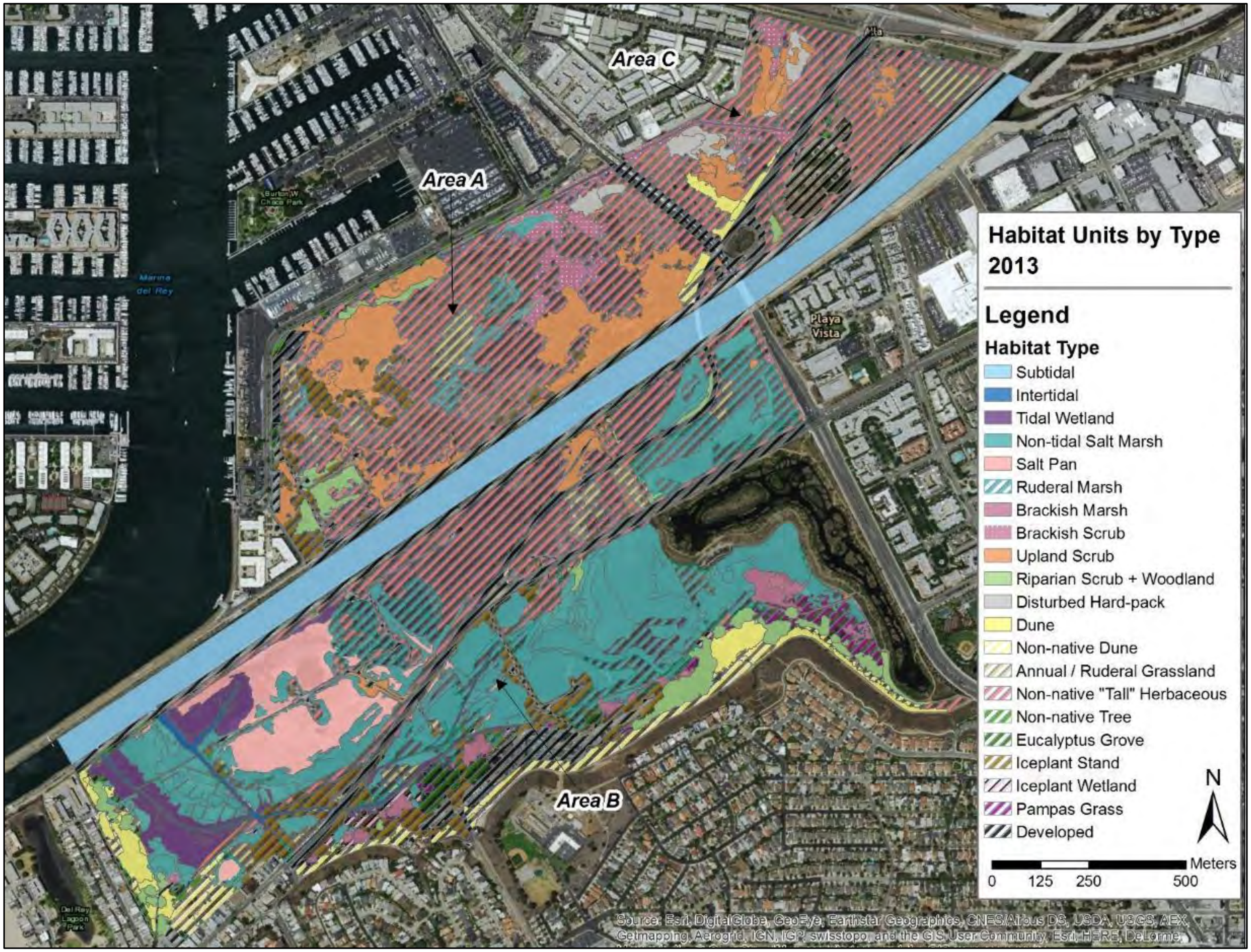


Figure 38. Habitat unit map of the Reserve from 2013 surveys.

Table 13. Habitat type comparison from 2007 and 2013 vegetation surveys. Asterisk indicates acreage within the Reserve boundary that were not included in surveys.

Habitat Type	2007 (acres)	2013 (acres)	Change in acres (2007 to 2013)	Percent Change (2007 to 2013)
Subtidal Channel	54.07	53.69	- 0.38	- 0.70
Intertidal	2.60	3.47	0.87	33.46
Tidal Wetland	17.95	18.23	0.28	1.56
Non-tidal Salt Marsh	99.59	85.25	- 14.34	- 14.40
Salt Pan	23.14	22.81	- 0.33	- 1.43
Ruderal Marsh	33.93	38.53	4.6	13.56
Brackish Marsh	3.69	6.45	2.76	74.80
Brackish Scrub	13.91	10.55	- 3.36	- 24.16
Upland Scrub	42.10	41.72	- 0.38	- 0.90
Riparian Scrub and Woodland	12.44	13.94	1.5	12.06
Disturbed Hard-pack	2.20	4.96	2.76	125.45
Dune	11.44	9.45	- 1.99	- 17.40
Non-native Dune	9.97	8.98	-0.99	-9.93
Annual/ Ruderal Grassland	25.16	14.44	- 10.72	- 42.61
Non-native "Tall" Herbaceous	131.71	154.92	23.21	17.62
Non-native Tree	4.28	4.19	- 0.09	- 2.10
Eucalyptus Grove	2.76	2.81	0.05	1.81
Iceplant Stand	22.32	22.16	- 0.16	- 0.72
Iceplant Wetland	1.75	2.03	0.28	16.00
Pampas Grass Stand	4.40	5.53	1.13	25.68
Developed	35.78	35.78	0.00	0.00
Not Surveyed *	18.94	14.19		
Total Acreage	**574.1**			

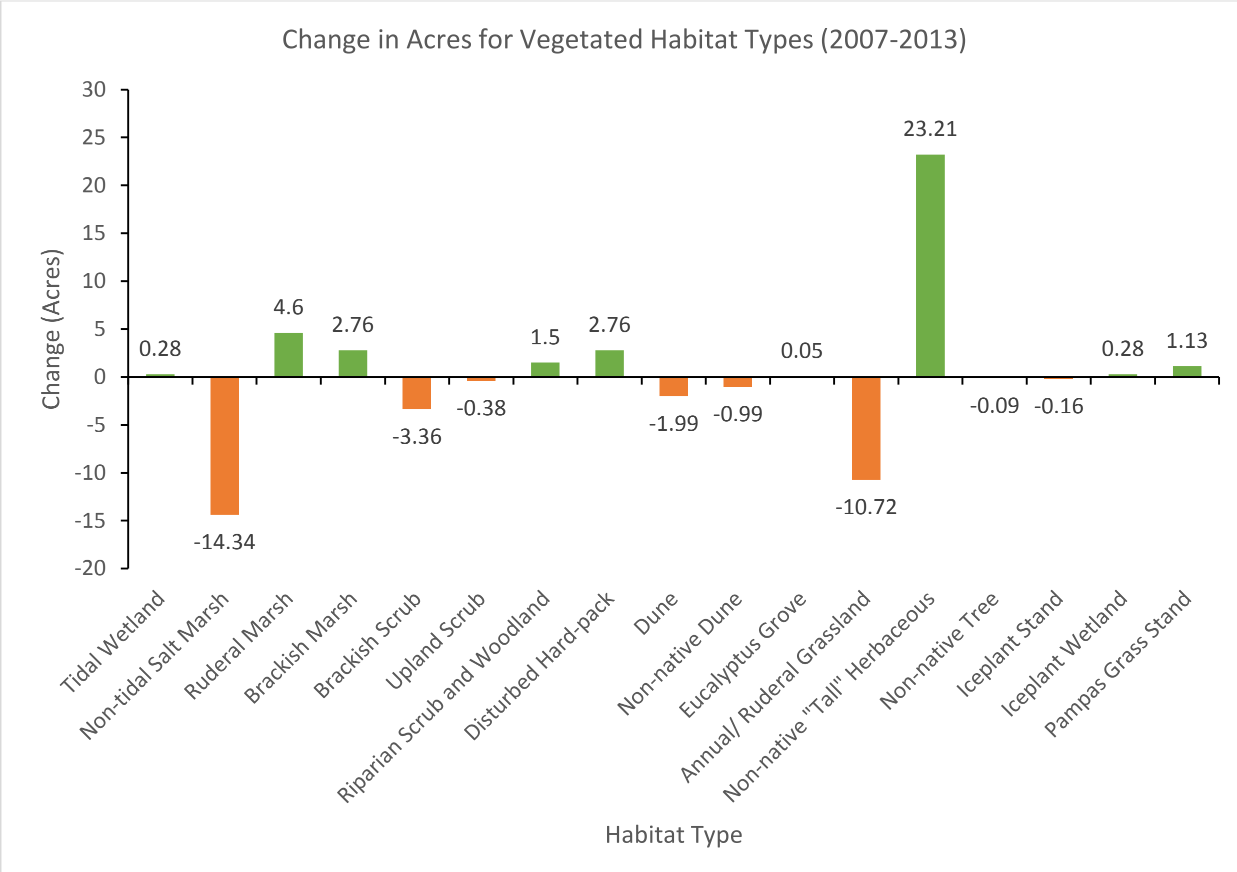


Figure 39. Change in acres of vegetated habitat types between the 2007 and 2013 surveys.

Native and Non-Native Vegetation Cover

Figure 40 displays broad categorizations of vegetation nativity by area from the 2013 surveys based on the dominant vegetation within each evaluated polygon. Mixed nativity indicates that there were co-dominant native and non-native vegetation species present in that area. The tidal and non-tidal wetland habitat types correspond primarily with a native-dominant classification of alliance/association, while the upland habitat types tended to have mixed or non-native dominant vegetation classifications.

Non-native vegetation cover data were further analyzed across the site for each of the two survey years based on cover class categories comprising a range of values. For example, the 60-100% cover class category was the highest categorical range of percent cover. Overall, the largest difference in change of cover class categories between the two survey years was an increase in area of the highest non-native cover class (i.e. “60-100% cover”) and a decrease in area of the non-native cover class “10-39% cover” (Figures 41 and 42). The increases in area of the “60-100% cover” class between the 2007 and 2013 surveys occurred in areas of the site with fill soils (Figure 42). However, an increase in area of the categories with the least non-native vegetation cover (i.e. 0% and < 2%) occurred in the western portion of Area B experiencing tidal exchange and in several other non-tidal salt marsh habitat areas.

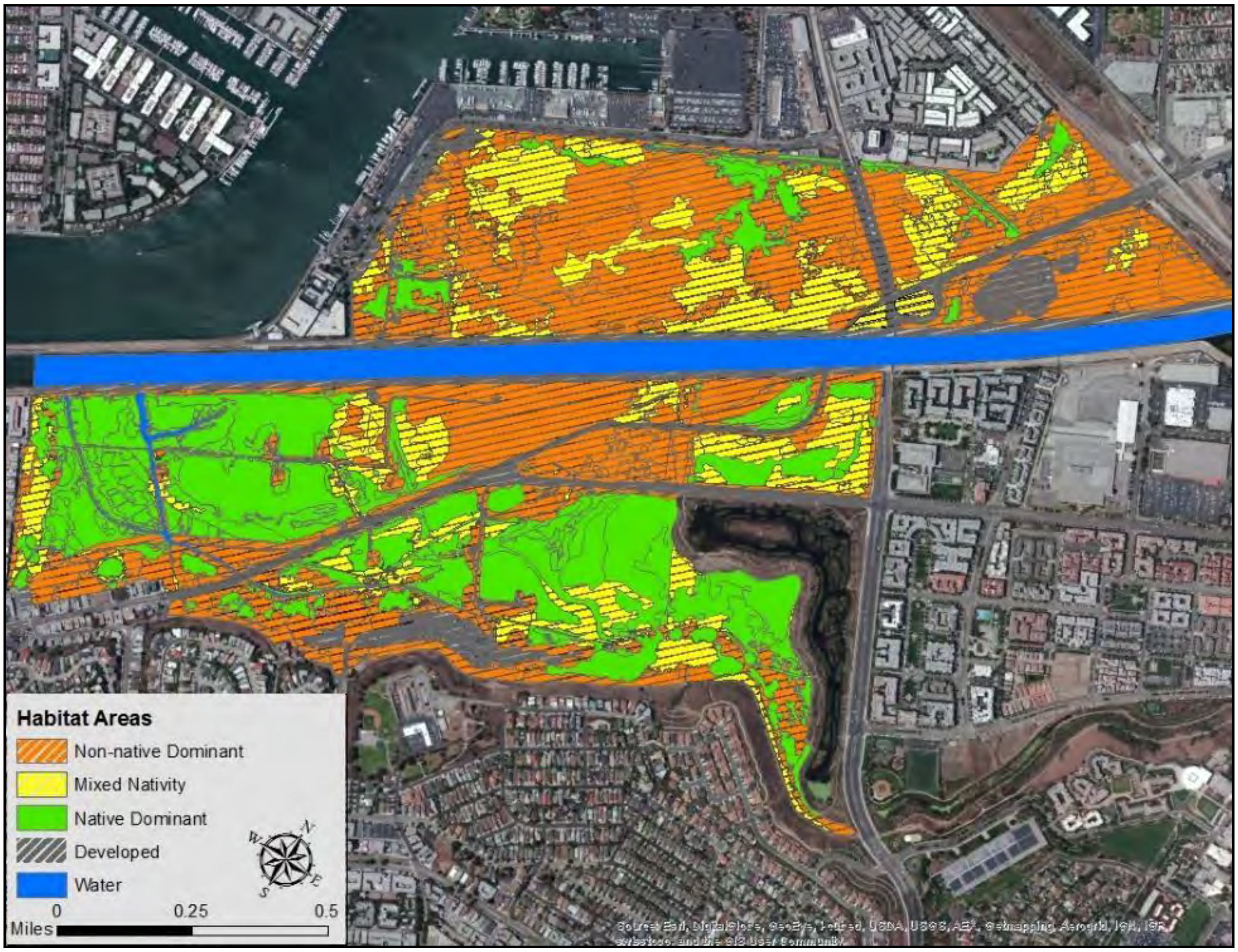


Figure 40. Existing (2013) vegetation alliance unit map for native/non-native dominant vegetation.

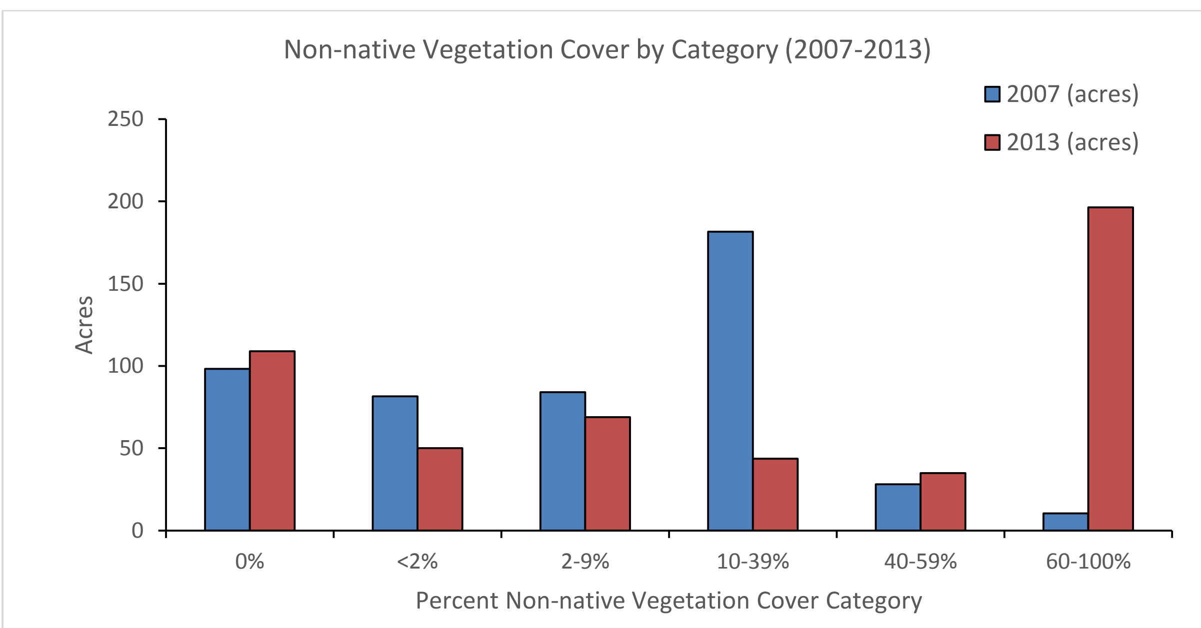


Figure 41. Non-native vegetation cover by category for 2007 and 2013.

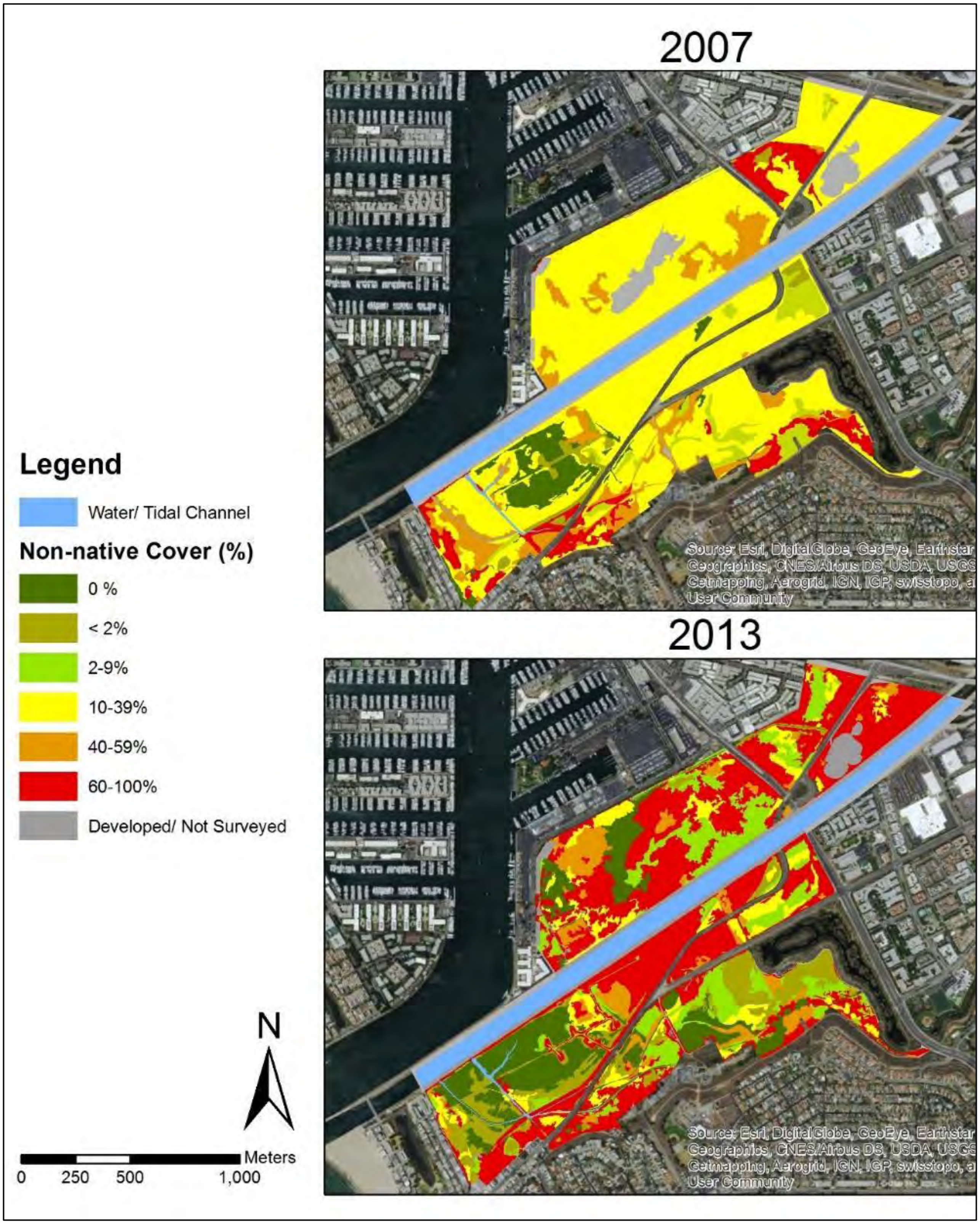


Figure 42. Map of relative percent cover categories for non-native vegetation in 2007 (top) and 2013 (bottom).

Vegetation Alliance and Association Mapping

Inter-annual climate variability during the months of data collection was relatively comparable for both the 2007 and 2013 mapping efforts; however, the winter months preceding each of the surveys showed a notable difference in precipitation. Winter rains can influence the growth of vegetation, particularly for invasive annual herbs including *B. nigra* and ruderal non-native grasses which are known to occur on site. Comparison of total monthly rainfall (inches) for the months of November to February preceding both the 2007 and 2013 vegetation surveys show that there was significantly more rainfall in the months of November to January preceding the 2013 survey than the 2007 survey (Figure 43). Winter precipitation from the months of November to February preceding each survey totaled 2.23 inches for the 2007 dataset and 5.42 inches for the 2013 dataset.

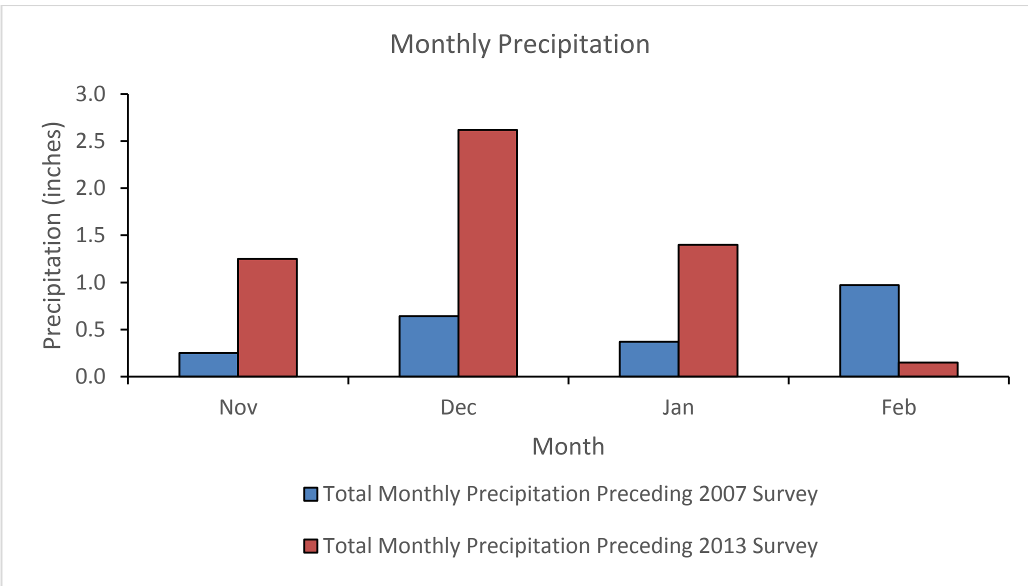


Figure 43. Total monthly precipitation during the winter months preceding the 2007 and 2013 vegetation surveys (NCDC).

Figures 44 through 54 illustrate changes in vegetation alliance or association polygons between the 2007 survey and the 2013 survey in both non-native vegetation species [e.g. *B. nigra*, *Glebionis coronaria* (crown daisy), and *Euphorbia terracina* (Geraldton carnation weed)] and native vegetation species [e.g. *Cressa truxillensis* (alkali weed) and *S. pacifica*]. A decrease of 26.67 acres of vegetation alliance polygons dominated by native *C. truxillensis* was observed with large areas replaced by non-native species such as *B. nigra* and *Bromus spp.*, as well as ruderal herbaceous habitat (Figure 49). The non-native plant *B. nigra* displayed a net increase of 53.92 acres (Figure 44). Areas of *B. nigra* "loss" were often just conversions to another non-native, such as the berm along the south levee in Area B that shows a shift from *B. nigra* to *G. coronaria* (Figures 44 and 46). In addition to the displayed species, non-native *Carpobrotus edulis* (iceplant) showed a 20% increase, with over 35 acres mapped in the 2013 survey. Areas in the tidal inundation zone show replacement of *C. truxillensis* with another native, *S. pacifica* (Figure 50). There were minor changes in aerial extent of the native species *Distichlis spicata* (saltgrass), *Jaumea carnosa* (fleshy jaumea), and *F. salina*, but not in overall acreage (Figures 51-53).

Figure 44. Spatial extent change of non-native *B. nigra* (2007-2013).

Figure 45. Spatial extent change of non-native *Bromus spp.* (2007-2013).

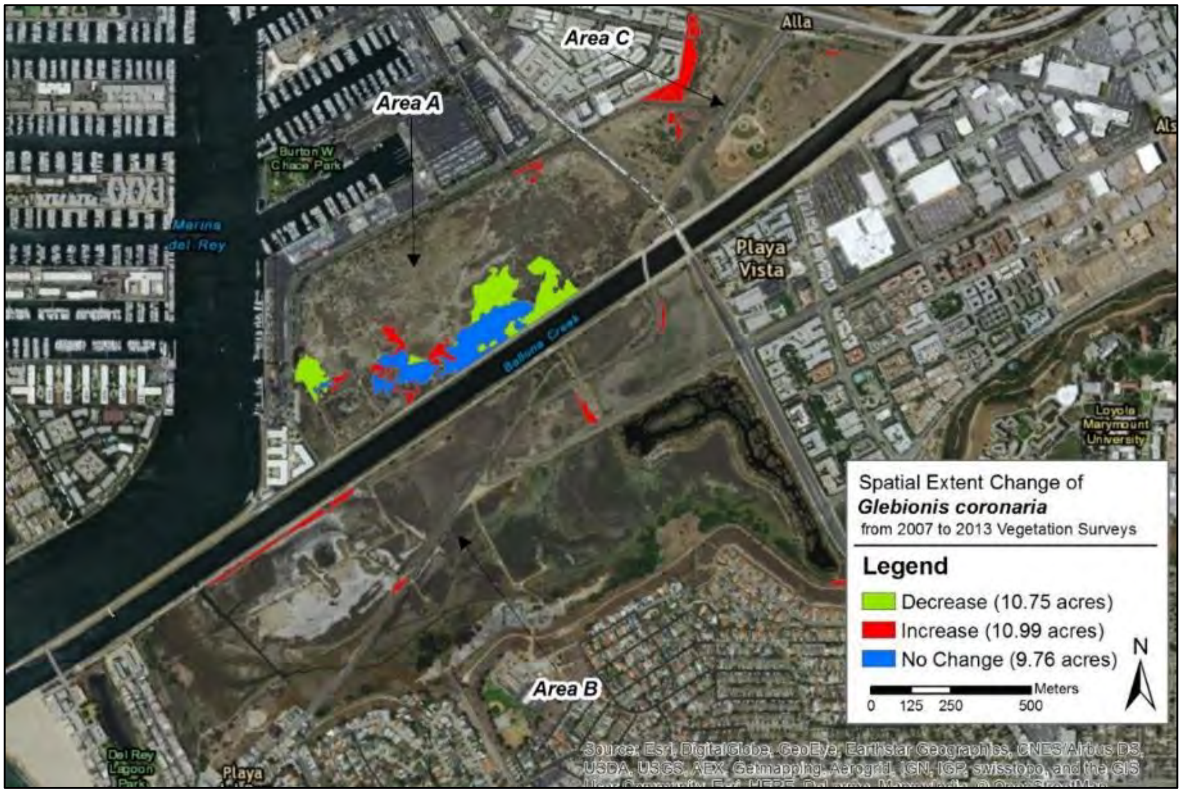


Figure 46. Spatial extent change of non-native *G. coronaria* (2007-2013).

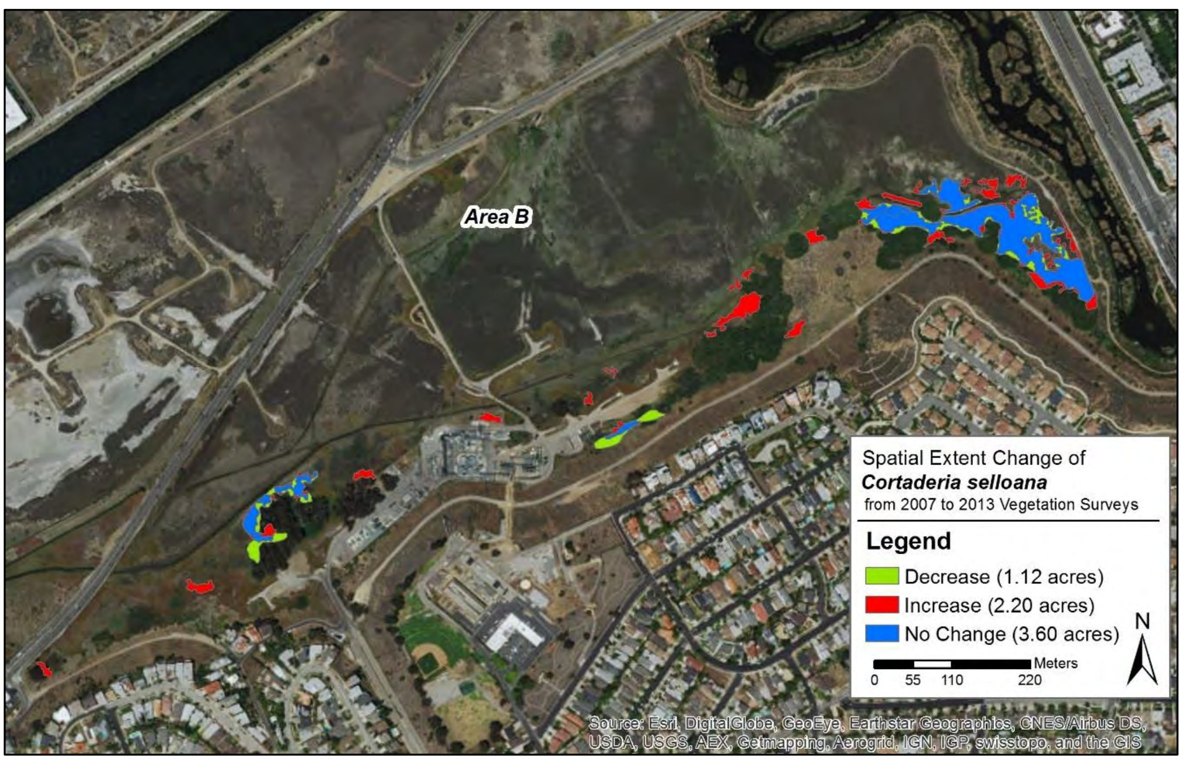


Figure 47. Spatial extent change of non-native *C. selloana* (2007-2013).

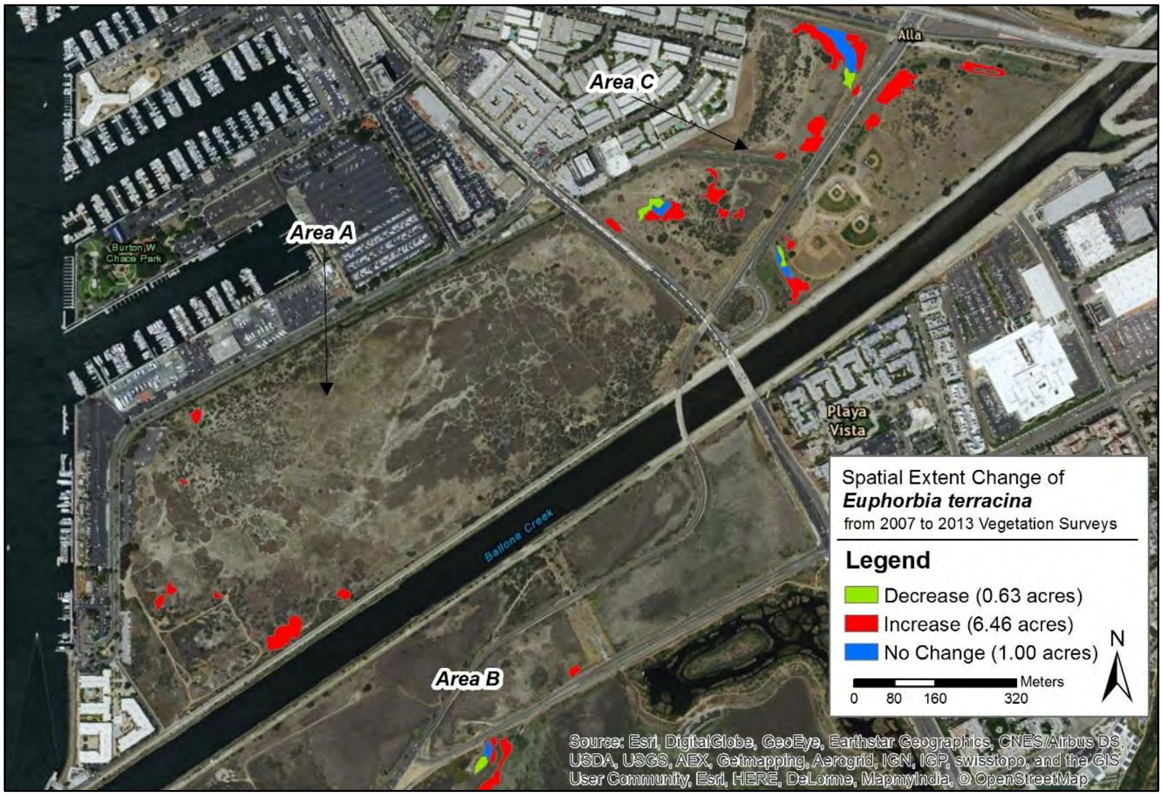


Figure 48. Spatial extent change of non-native *E. terracina* (2007-2013).

Figure 49. Spatial extent change of native *C. truxillensis* (2007-2013).

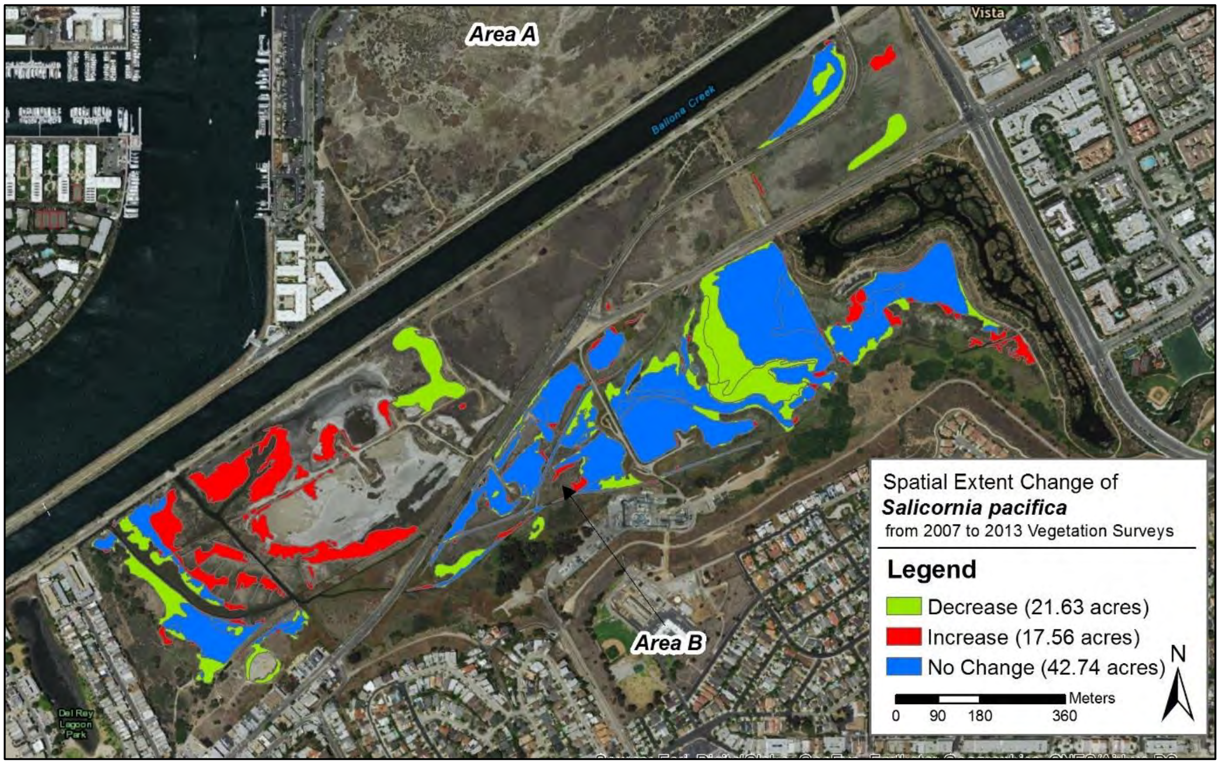


Figure 50. Spatial extent change of native *S. pacifica* (2007-2013).

Figure 51. Spatial extent change of native *D. spicata* alliance (2007-2013).

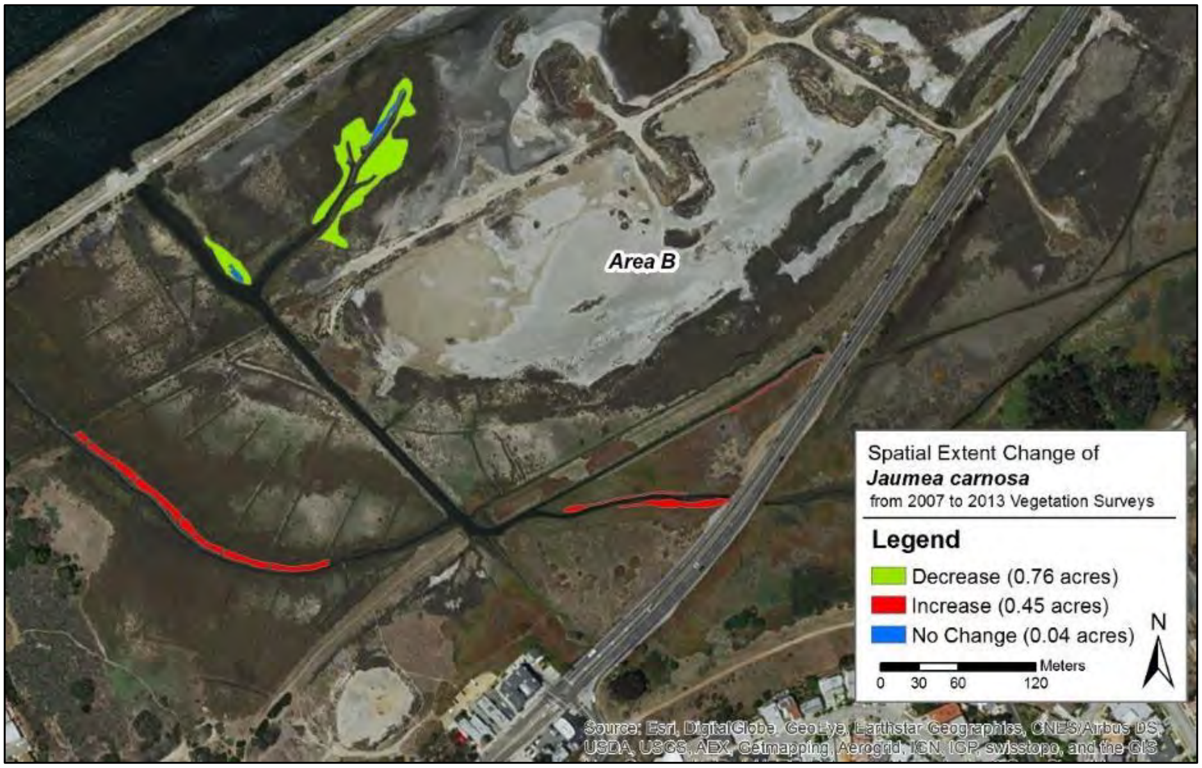


Figure 52. Spatial extent change of native *J. carnosa* (2007-2013).

Figure 53. Spatial extent change of native *F. salina* (2007-2013).

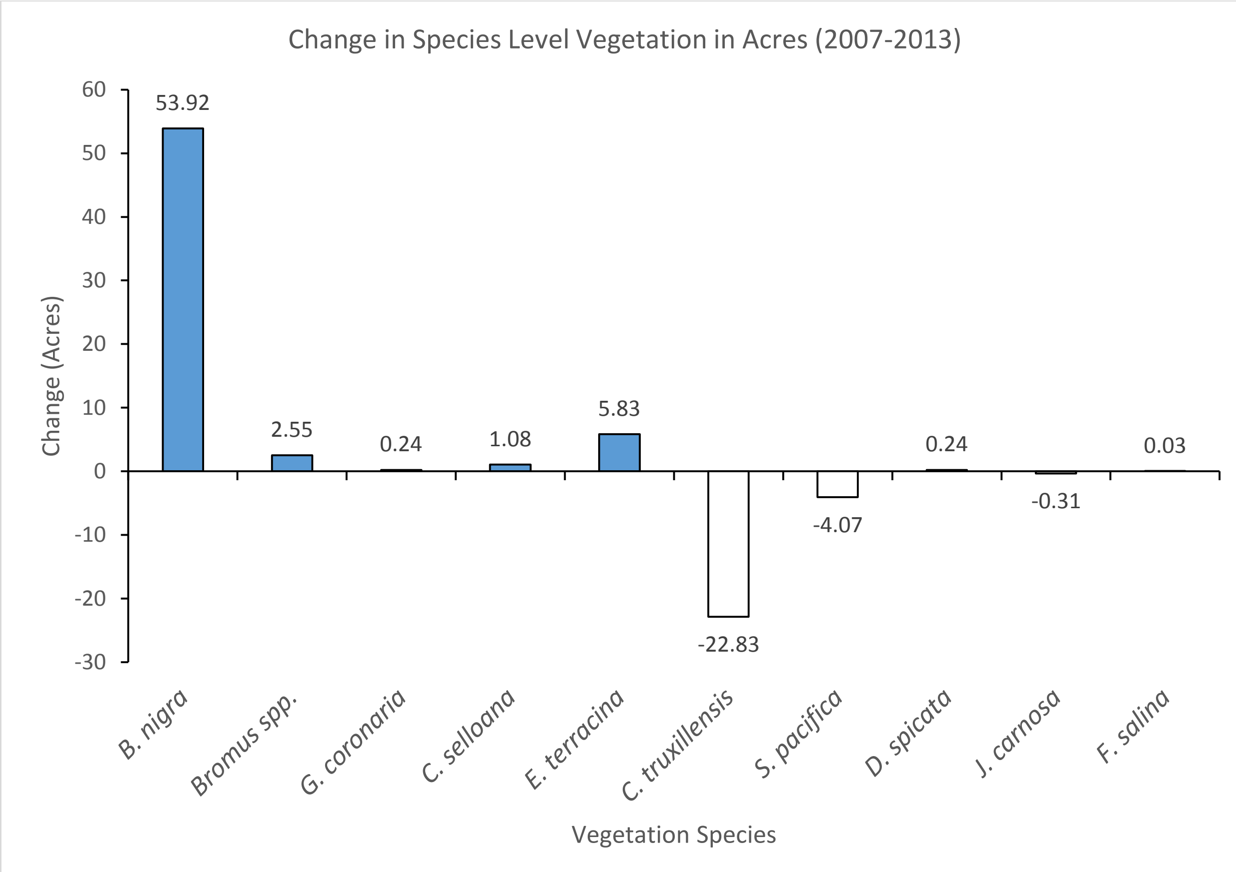


Figure 54. Change in species-level vegetation assemblages in acres between the 2007 and 2013 surveys.

5-Year Summary Conclusions

Because the 2007 and 2013 habitat/vegetation alliance mapping efforts were conducted by different survey teams, it is important to recognize potential variability when evaluating the datasets. However, as the data are categorized into cover class categories, error is minimized relative to a survey performed for exact cover; therefore, the trends are likely descriptive of general change across the Reserve between the surveyed years. Areas with the largest historic fill impacts displayed the most drastic habitat transformations. Additionally, non-native plants continue to invade areas disconnected from tidal influence, which was visualized in both the non-native habitat area maps and the non-native vegetation alliance data. Fourteen acres of formerly native non-tidal salt marsh became primarily 'ruderal' marsh (including non-native plants that are among the first to colonize disturbed land) and monocultures of invasive species.

Invasive plants in wetlands have a consequential and persistent effect on habitat structure, biodiversity, and food web functioning (Zedler et. al. 2004). One of the most significant invading vegetation species (net increase of 53.9 acres), *B. nigra*, grew profusely between the survey years, and it produces allelopathic chemicals that prevent germination of native plants (Holloran et al. 2004). Results show that some areas where native *C. truxillensis* once dominated are being taken over by *B. nigra*, especially in portions of Area B between Culver and Jefferson Boulevards and south of Jefferson Boulevard. Climate variability, including winter precipitation amounts, can affect dominant vegetation cover especially for opportunistic invasive vegetation species such as *B. nigra* (Robinson et al. 2010). Some areas simply displayed a trade-off between different non-native invading species. For example, *B. nigra* outcompeted *G. coronaria* in the central section of Area A, but the reverse trend occurred along the south Ballona Creek levee in Area B.

Spatial-temporal changes in native species (i.e. *S. pacifica* and *J. carnosa*) whose distribution is highly dependent on characteristics like tidal influence and salinity may be representative of small hydrological and channel morphology shifts. For example, while *S. pacifica* and *C. truxillensis* are both native salt marsh vegetation species, *S. pacifica* tends to have a higher range of tolerance to salinity and direct tidal influence (Baye 2007). Thus, the vegetation shift adjacent to the eastern branch channel in Area B from *C. truxillensis* dominance to *S. pacifica* dominance may indicate a slight corresponding shift in the localized hydrological regime.

Some changes, such as the relatively small increase in acreage of *C. selloana* (1.1 acres), should still be evaluated carefully from a management perspective, as that particular species is very difficult to eliminate and is often labor-intensive to completely extirpate from an area (Cal-IPC, accessed December 2015). Similarly, the net gain in acreage (5.8 acres) of the non-native invasive plant *E. terracina* represents a 360% increase between the surveyed years. This species also has toxic sap and allelopathic properties that reduce germination of native plants; it has the potential to spread rapidly (Cal-IPC, accessed December 2015).

Vegetation: Plant Cover Transect Monitoring

Methods

The objective of the vegetation surveys was to determine average percent cover of species over time using habitat-level assessments. Vegetation cover surveys for absolute cover were conducted on a total of 356 randomly allocated transects throughout 11 habitat types across all five monitoring years (Table 14). Laser quadrat transects for years one through three and all percent cover transects were initially distributed within habitat types according to the 2007 Vegetation Map (CDFG 2007) and were subsequently cross-walked into the 2013 habitat categories (Medel et al. 2014) for the final analyses. Laser quadrat surveys for years four and five were allocated within the 2013 vegetation categories. As a result, surveyed transects may be inconsistent across years, and not all habitat types were surveyed in all monitoring years.

Multiple survey methods (i.e. laser quadrats and percent cover quadrats, Figure 55a and 55b) were used to assess percent cover and diversity in different habitat types because of the differing conditions across multiple habitats (e.g. plant height and density, species diversity, topography). Percent cover quadrat surveys were conducted within the brackish marsh, dune, non-native dune, annual ruderal grassland, non-native “tall” herbaceous, iceplant stand, and upland scrub habitats. Laser quadrat surveys were conducted within the tidal wetland, non-tidal salt marsh, ruderal marsh, and salt pan habitats. The fifth monitoring year saw the highest reduction in sampling effort to assess targeted areas only.

Table 14. Number of transects surveyed per monitoring year within all habitat types.

	Year					
Habitat	**1**	**2**	**3**	**4**	**5**	**Total**
Laser Quadrat	69	54	26	24	10	183
Percent Cover	71	67	22	13	0	173
Total	140	121	48	37	10	356

Each transect location was recorded with a global positioning system (GPS) unit and photographed at each end (Figure 56). Exact survey methods were conducted according to the first baseline report (Johnston et al. 2011) and the “CA Estuarine Wetland Monitoring Manual” (Johnston et al. 2015d) with specific reference to the individual “Vegetation Cover Surveys” Standard Operating Procedure (Appendix B – 3.2). Cover data were calculated at the species-level and subsequently classified into native, non-native, and bare ground categories. Bare ground was combined with ‘other’ ground cover types (e.g. trash) to compare vegetated versus unvegetated categories. Plant cover was averaged by transect and then again by habitat type; therefore, habitat type averages represent grand means.

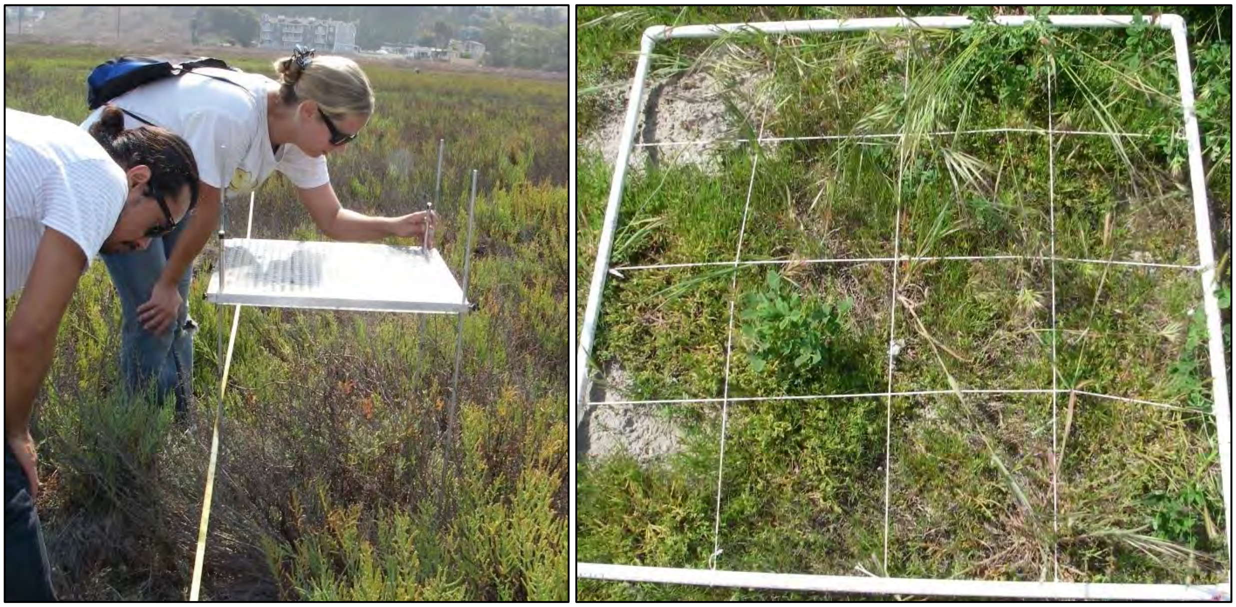


Figure 55. Representative photographs of the deployed laser quadrat (left) and percent cover quadrat (right).

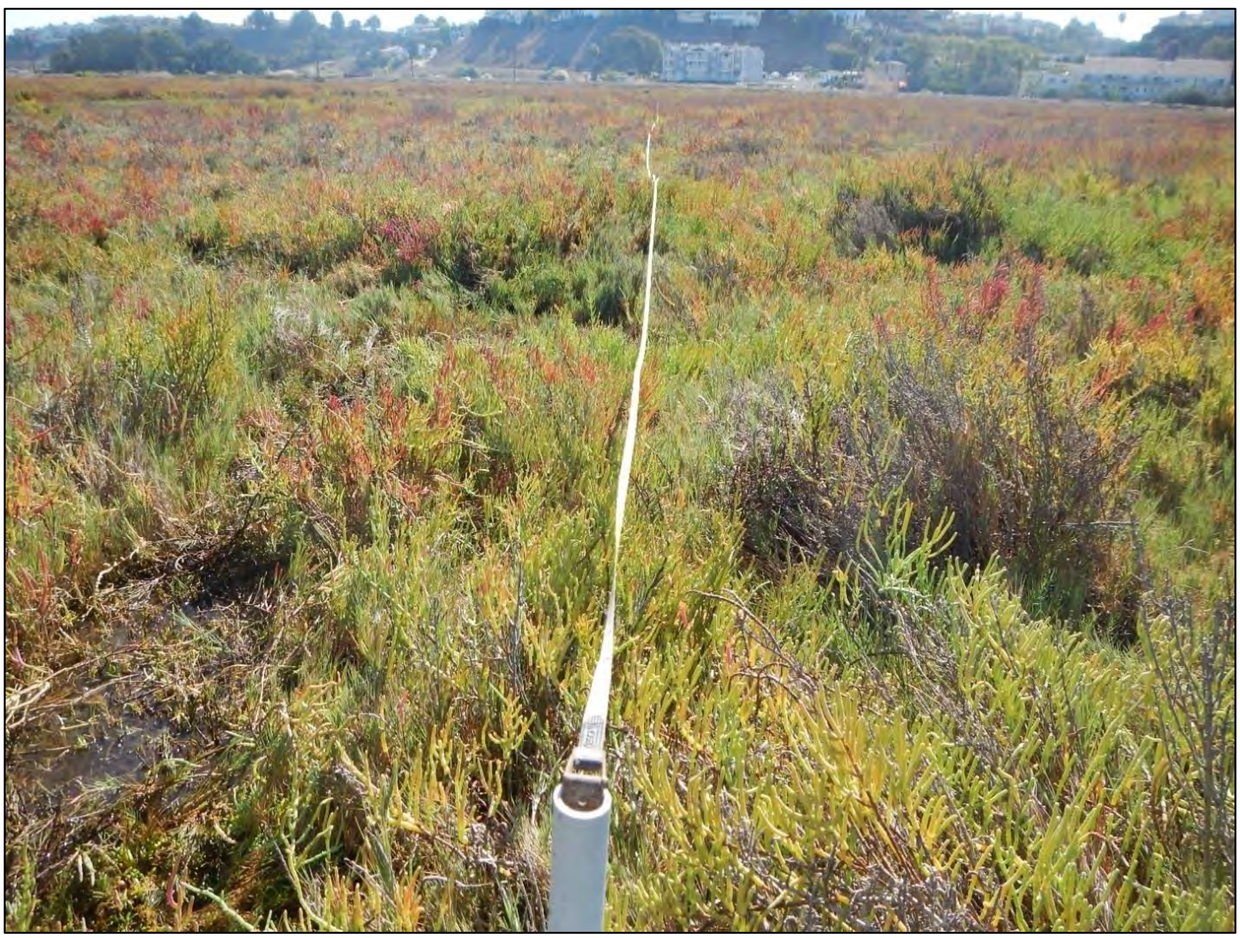


Figure 56. Photograph of deployed transect in Area B – west (09-25-2014).

Results

The average (grand mean) cover of native vegetation (± standard error, SE) for all habitats combined across monitoring years 1 and 2 was 36.3 ± 2.3% (Figure 57); the average (grand mean) cover of non-native vegetation (± SE) for all habitats combined was 44.9 ± 2.2%; with bare ground or "other" making up the remaining 19.9 ± 1.4% (Figure 57). Averages should be regarded as generally representative based on the evaluated transects. Only monitoring years 1 and 2 were combined for the first analysis due to the reduction in sampling design for the duration of the monitoring program. As Figure 57 conflates all habitat types together, succeeding graphs display trends with additional levels of detail at the habitat-level and habitat- and year-level. In the subsequent graphs and figures, green bars represent average cover of native vegetation recorded along transects in identified habitats, red represents average non-native vegetation cover, and grey represents bare grand or "other" cover. "Other" cover is a group of unvegetated categories such as trash, wrack, and woody debris.

Frequently identified native species on the transects included: *S. pacifica*, *D. spicata*, *J. carnosa*, *C. truxillensis*, and *Arthrocnemum subterminale* (Parish's pickleweed). Frequently identified non-native species on the transects included: *B. nigra*, *G. coronaria*, and *C. edulis*. Additionally, many berms and elevated areas also had a high prevalence of non-native annual grasses and herbaceous vegetation such as *Polypogon monspeliensis* (annual beard grass), *Bromus diandrus* (ripgut brome), and *Melilotus indicus* (yellow sweetclover). Full species lists can be found in the appendices of the first and second baseline reports; see Johnston et al. 2011, Appendix C.1 through C.6 and Johnston et al. 2012, Appendix C.1 and C.2.

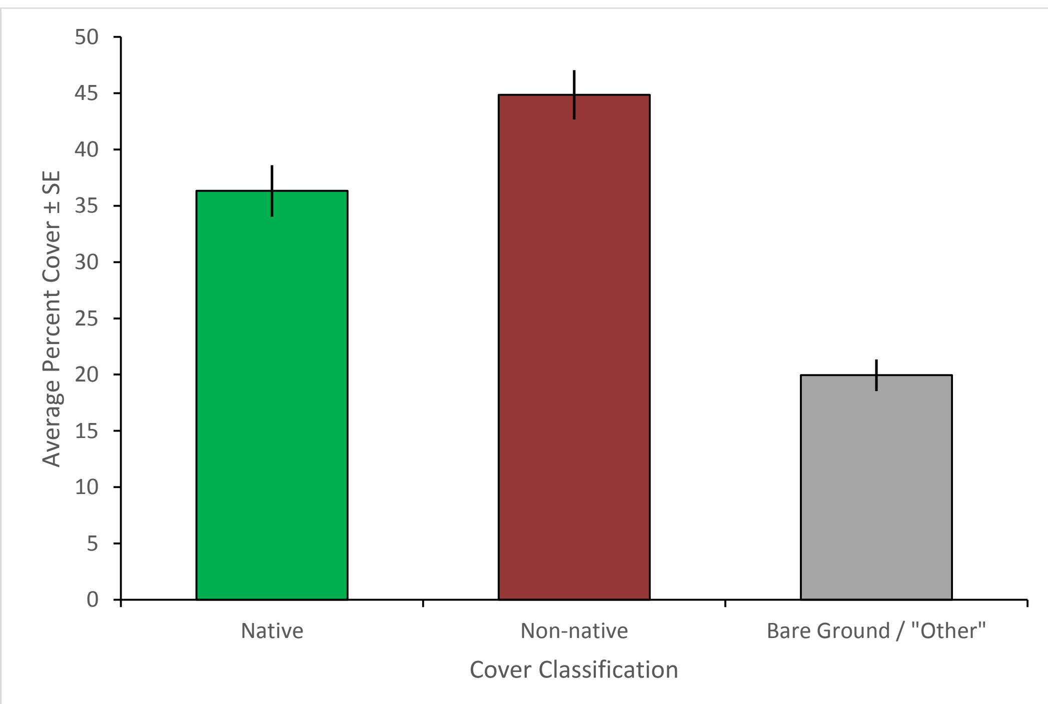


Figure 57. Grand mean averages for all habitat types together (± SE) from monitoring years 1 and 2 combined.

Results evaluated at the habitat-level for all years of data combined indicated an overall average dominant cover of non-native plant species in the upland habitats (e.g. annual ruderal grassland, upland scrub, non-native "tall" herbaceous, etc.) and average dominant cover of native species within the salt and brackish marsh habitats (e.g. tidal wetland and non-tidal salt marsh) (Figure 58). Additionally, the ruderal marsh habitat had an average cover of non-native vegetation that exceeded native vegetation (i.e. 46% versus 28%, respectively), and the salt marsh habitat type was generally identified as bare ground (95%, Figure 58).

Several of the habitat types that were dominated by large monocultures of non-native species also periodically had intermixed areas with some native vegetation species. For example, the iceplant stand habitat type had an average of 9% native vegetation cover and 89% non-native vegetation cover; non-native "tall" herbaceous had an average of 3% native cover and 70% non-native cover. The highest average cover of native vegetation was seen in the tidal wetland at 86%, and in the brackish marsh at 80% cover. The highest average cover of non-native vegetation was seen in the iceplant stand (89%), annual ruderal grassland (77%), non-native dune (74%), and non-native "tall" herbaceous (70%) habitat types.

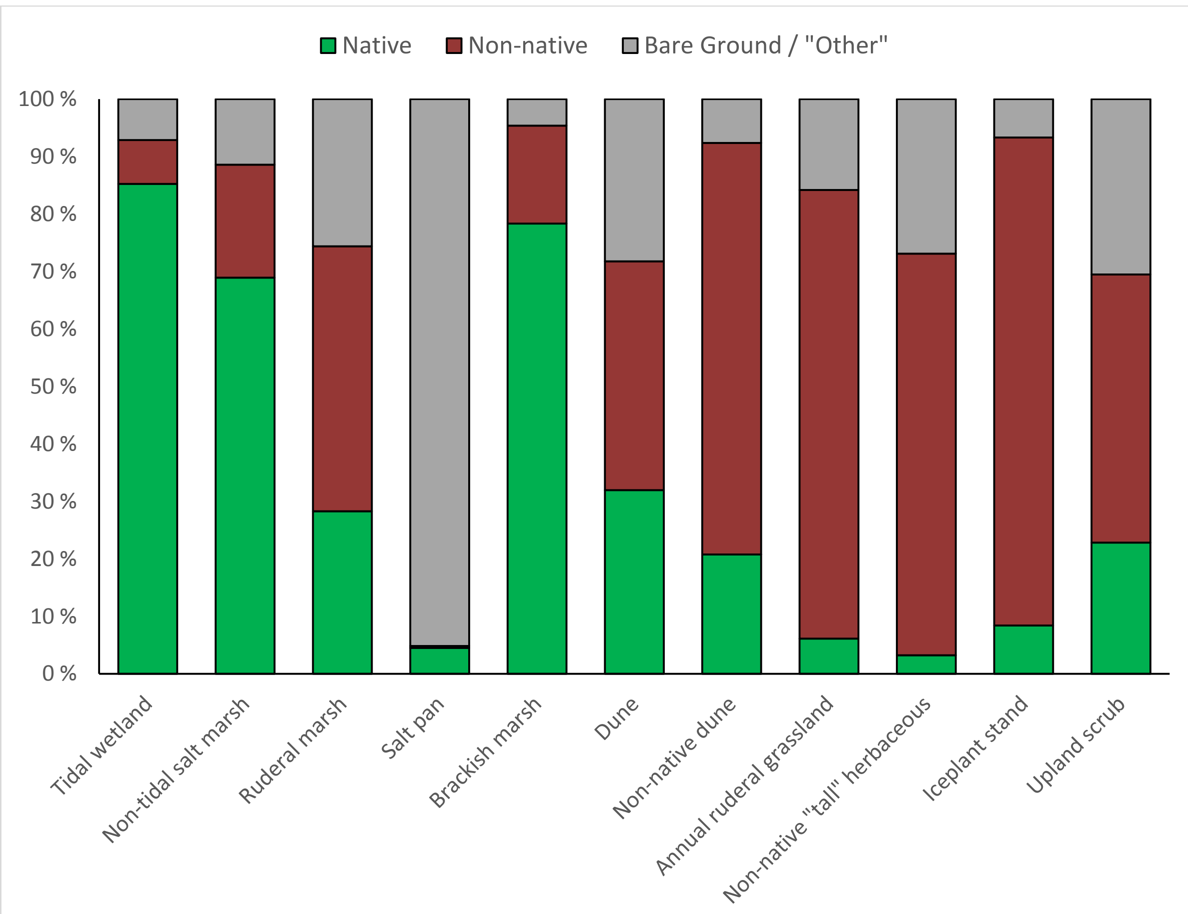


Figure 58. Average (grand mean) cover of native and non-native vegetation and bare ground by habitat type for all monitoring years combined.

The remaining graphs are divided up by survey method to extract trends at a more precise level. Vegetation percent cover by habitat by year for laser quadrat surveys are presented in Figure 59 (i.e. habitat types including tidal wetland, non-tidal salt marsh, ruderal marsh, and salt pan), and percent cover surveys are presented in Figure 60. Native species cover within habitat types surveyed using the laser quadrat method was highest within the tidal wetland habitat, ranging between an average of 84% and 88% for all five monitoring years (Figure 59). The second highest average native species cover was found within the non-tidal salt marsh ranging between 64% and 76%. Ruderal marsh consistently displayed the highest non-native percent cover ranging between 25% and 55% across the three surveyed monitoring years. The salt pan habitat consistently displayed predominantly bare ground.

Within habitat types surveyed using the percent cover method, brackish marsh showed the highest native species cover ranging between 72% and 87% across all monitoring years (Figure 60). Dune and upland scrub showed the next highest native cover with ranges between 18% and 40%, and 20% and 40% across years, respectively. Other habitat types surveyed using percent cover methods (i.e. non-native dune, annual ruderal grassland, non-native "tall" grassland, and iceplant stand) all displayed greater than 60% non-native species cover across all years.

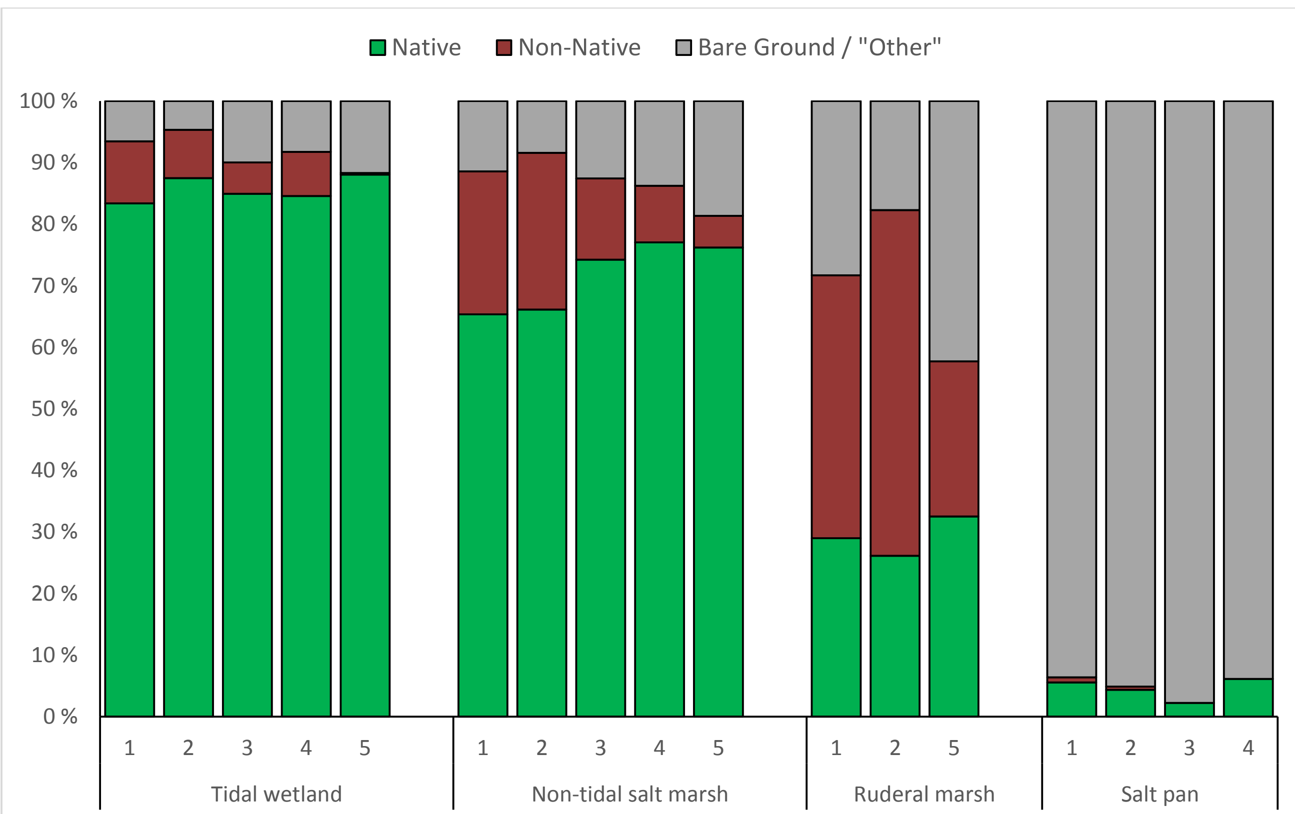
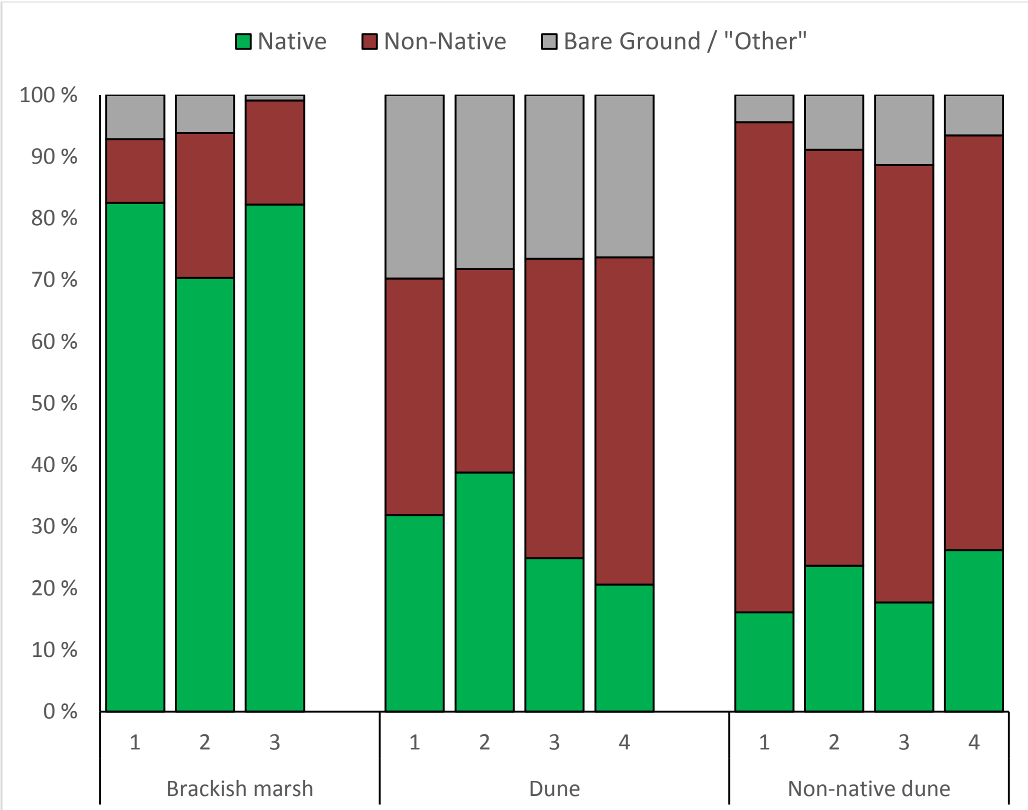


Figure 59. Vegetation cover of native versus non-native species averaged for all transects across each habitat type by year surveyed using the laser quadrat method.



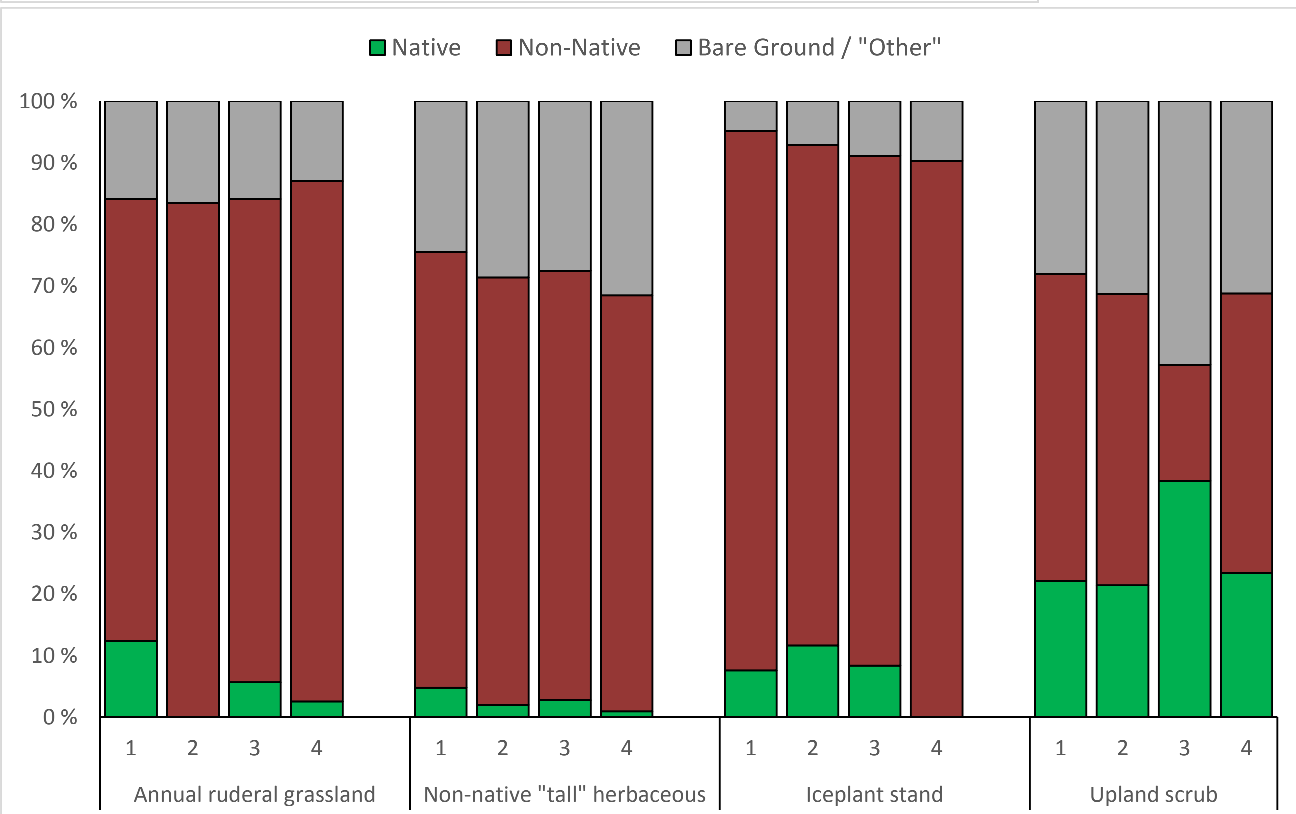


Figure 60. Vegetation cover of native versus non-native species averaged for all transects across each habitat type by year surveyed using the percent cover method.

5-Year Summary Conclusions

The fact that specific transect locations had some variability across years within individual habitat types accounts for some of the observed variation between years, particularly for year 2 surveys within the ruderal marsh areas and year three within the upland scrub. Both of those example habitat types had transects that were in significantly different areas of the Reserve in those monitoring years. However, some broad trends remain, and the variability adds to the categorical nativity discussion, overall. The habitat trends reflected similar patterns as the mapping data (i.e. vegetation alliance and species-level mapping analyses, in subsections above).

In general, results evaluated at the habitat level indicate predominately native vegetation within saline influenced areas (i.e. tidal wetland, non-tidal salt marsh, and brackish marsh), which consistently displayed the highest native percent cover across all years. However, areas impacted by historic fill placements (e.g. non-native "tall" herbaceous, annual ruderal grassland) displayed the highest non-native percent cover across all years. Additionally, the remaining native species populations within these areas appear to be declining, as demonstrated by a decrease from over four percent in year one to less than one by year four within the non-native "tall" herbaceous habitat areas. These data also confirm the mapping results, above.

There are several rare vegetation species present in the Reserve, primarily within the dune habitat type. These species-level analyses will be included in the upcoming Draft Environmental Impact Report/Statement for the Ballona Wetlands Restoration Project.

Vegetation: Germinated Seed Bank

Methods

To survey the seed bank of the Reserve, soil cores were collected and grown out in a greenhouse and germinated seedlings were identified to species (Figure 61). Surface cores were collected at ten equally spaced points along 25-m vegetation transects, with three additional 100-m "wrack line" transects along high tide lines for several tidal channel banks. As most wetlands seeds are positively buoyant, the channel banks represent the current seed bank within the wrack lines and are seed accumulation zones. Soil cores were collected during late fall (November – December), after the first rain of the wet season to capture the seed bank at its peak (S. Anderson, pers. comm. 2009) and grown for up to three months in a controlled greenhouse setting at Loyola Marymount University. New data results from surveys in 2012 and 2014 are presented from five targeted wetland habitat types: intertidal, tidal wetland, non-tidal salt marsh, ruderal marsh, and salt pan. Additionally, data trends across the five monitoring years for the three repeated channel bank "wrack line" transects are also reported.

Specific field and greenhouse methods followed those described in the first Baseline Assessment Report (Chapter 4: Vegetation; Johnston et al. 2011). Cores were analyzed by number of germinated seedlings per m² and averaged across each habitat type. Additionally, maximum and minimum numbers of germinated seedlings were calculated for each habitat type and wrack line transect. For additional details on methods and results from previous baseline years, refer to the first two baseline reports (Johnston et al. 2011, 2012).

Figure 61. Photographs in the greenhouse of the Ballona seed bank germination study.

Results

The seed bank of the wetland habitat types surveyed at Ballona was dominated by native seedlings in the tidal habitats and non-native seedlings in the non-tidal and ruderal habitats (Table 15, Figure 62). The salt pan, ruderal marsh, and intertidal habitats had the fewest average germinated seedlings per transect overall. The tidal wetland habitat type had over four times the average number of native germinated seedlings per transect than the non-tidal salt marsh and over five times the number of native germinated seedlings as the ruderal marsh habitat type. The non-tidal salt marsh had over four times the number of non-native germinated seedlings per transect than the tidal wetland, and the ruderal had almost twice as many on average as the tidal wetland, yet less than half of the non-tidal salt marsh. Native seedlings were predominantly *S. pacifica* and *J. carnosa*. Non-native seedlings were primarily annual grasses such as *P. monspeliensis*, which was also the second most common species, overall.

Table 15. Number of native/non-native germinated seedlings by surveyed habitat type. Averages are at the habitat-level per transect and minimum/maximum data are shown as total number of seedlings per core.

	# Native Germinated Seedlings				# Non-native Germinated Seedlings			
Habitat Type	Min	Max	Range	Average Count / Transect	Min	Max	Range	Average Count / Transect
Intertidal	0	11	11	44.0	0	4	4	12.0
Tidal Wetland	0	162	162	101.5	0	42	42	12.8
Non-tidal Salt Marsh	0	52	52	25.6	0	179	179	50.8
Ruderal Marsh	0	62	62	19.7	0	18	18	20.9
Salt Pan	0	2	2	1.0	0	1	1	0.3

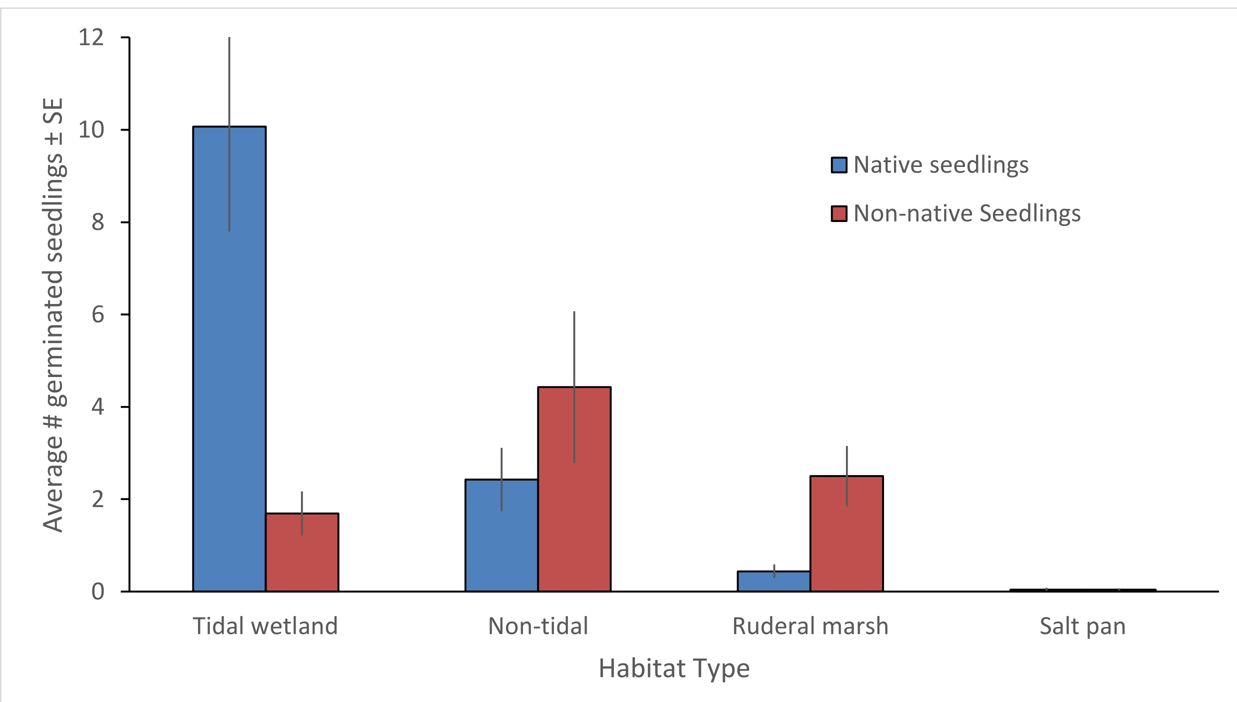


Figure 62. Average germinated seedling density per transect (± SE) for multiple habitat types at Ballona.

Additionally, three transects targeted at the intertidal wrack lines along the tidal channels were surveyed at the same transect locations across a five-year period (2010-2014). These data display trends over time, and demonstrate high annual variability (Table 16, Figure 63). The majority of the native germinated seedlings were found to be *S. pacifica*.

When comparing the average number of germinated seedlings per core between the habitat transects and the total count per transect for the wrack line transects (Figure 62 and Figure 63), the overall transect counts for Wrack Line 1 are much higher than the averages across even the tidal wetland transects (which had the highest average number of native germinated seedlings out of all of the habitat types). The highest number of native seedlings was found in Wrack Line 1 in year 4 (373) followed by the same transect in year 3 and year 1 (174 and 158, respectively).

Table 16. Number of native and non-native germinated seedlings by transect, by year. Totals are at the transect-level and minimum/maximum data are total number of seedlings per core.

		# Native Germinated Seedlings				# Non-native Germinated Seedlings			
Transect	Year	Min	Max	Range	Total Count / Transect	Min	Max	Range	Total Count / Transect
Wrack Line 1	1	3	38	35	158	0	0	0	0
	2	4	43	39	128	0	1	1	2
	3	0	58	58	174	0	0	0	0
	4	8	98	90	373	0	5	5	9
	5	1	40	39	126	0	0	0	0
Wrack Line 2	1	0	3	3	14	0	5	5	16
	2	0	25	25	62	0	17	17	59
	3	1	30	29	82	0	5	5	6
	4	0	11	11	31	0	4	4	4
	5	0	8	8	25	0	4	4	4
Wrack Line 3	1	0	27	27	54	0	2	2	5
	2	0	5	5	12	0	2	2	6
	3	1	62	61	140	0	2	2	7
	4	0	7	7	10	0	8	8	14
	5	0	52	52	91	0	2	2	3

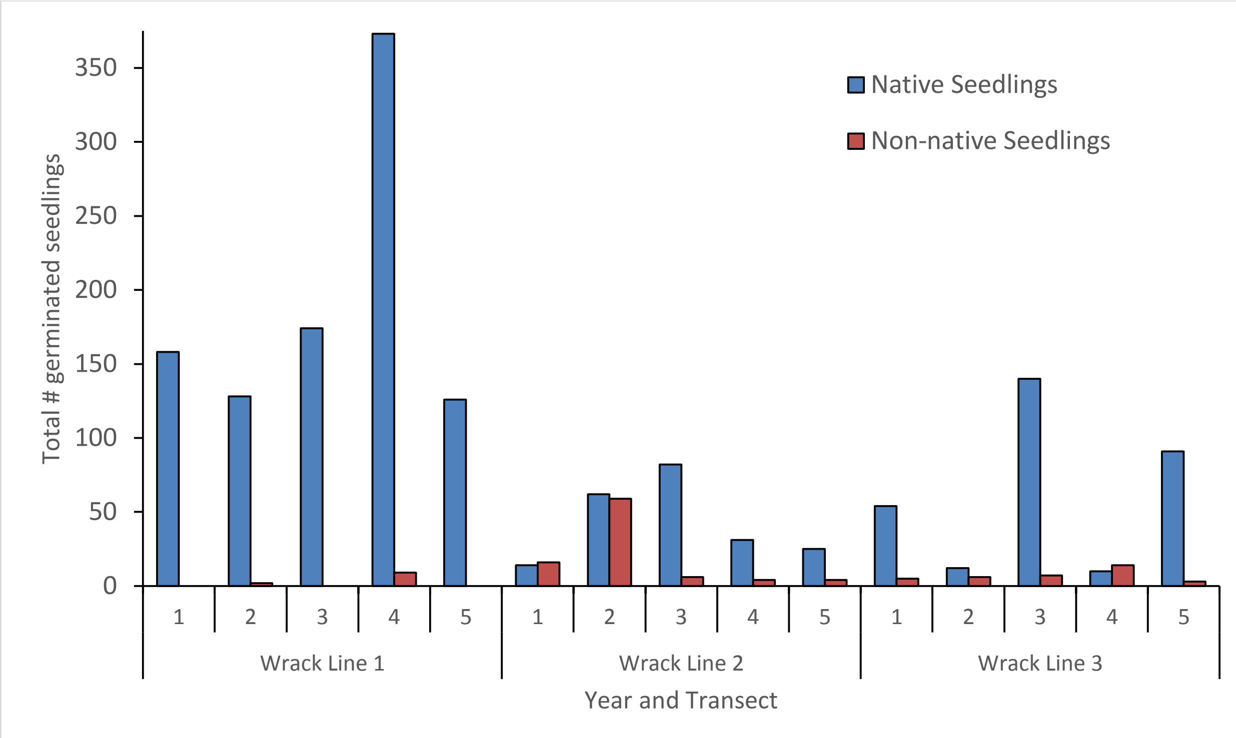


Figure 63. Total germinated seedling density for wrack line transects at Ballona. Note: Year 1-5 corresponds to surveys between 2010-2014.

5-Year Summary Conclusions

Based on these studies and the baseline results from previous years, the seed bank of transects surveyed in the tidal wetland habitat type was predominantly native, with approximately five times as many native germinated seedlings on average than non-native. The nativity of seedlings shifted to predominantly non-native for the habitat types with restricted or absent tidal hydrology (i.e. non-tidal salt marsh and ruderal marsh, also identified as “high marsh” in the first two baseline reports). This pattern reflects, to some extent, the nativity of the vegetative cover of the adult species along similar representative transects. Additionally, the hypothesis that the wrack line seed bank transects had the highest proportion of natives and higher germination rates was supported by comparative analyses. Lastly, the germinated seed bank at the Reserve was found to be highly spatially variable, and dominated by a few native species in the tidal habitats and non-native annual grasses in the non-tidal and ruderal wetland habitat types.

Vegetation: SAV/Algal Percent Cover Monitoring

Methods

Algae and submerged aquatic vegetation (SAV) cover surveys (henceforth, 'algae surveys') were conducted along four 30-m transects deployed parallel to the channel bank with the same elevation contour as the muted tidal channel. SAV and algae were identified to species (Abbot and Hollenberg 1976). The algae sampling protocol followed methods described in detail in the "CA Estuarine Wetland Monitoring Manual" (Johnston et al. 2015d) and SOP 3.1 (Submerged Aquatic Vegetation and Algae; Figure 64a and 64b). Sampling was conducted quarterly, four times per year for five years, starting in March 2010 through September 2014, except for September 2012. Data are averaged and presented as percent cover bar graphs, organized by transect, month, year, and several combinations for analyses.

Figure 64. Field photographs of SAV/algae surveys in the Area B tidal channels of the Reserve.

Results

The algae/SAV community in the tide channels of the Reserve was primarily unattached or floating algal mats, with the occasional presence of attached submerged aquatic vegetation (i.e. *Ruppia* sp., or ditch grass). Most of the algae present was identified as *Ulva intestinalis* (green alga), with *U. lactuca* (sea lettuce) also present throughout the survey years. When all years and months were combined and analyzed by transect only, Transects 1, 2, and 3 were relatively similar, with Transect 4 consistently displaying the highest percent cover of bare ground, and the most frequent occurrence of trash (Figure 65). Transect 4 was a small connector branch channel spanning between the two main tide channels. When averaged by year, results for 2010 through 2012 displayed relatively similar patterns, with a reduction in overall algal cover in 2013, and the least algae / most bare ground in 2014 (Figure 65). The January data displayed the least average algae cover when analyzed by month (Figures 66 and 67).

Figure 65. Graphs of algae cover by transect (left) across all years and by year (right) across all transects.

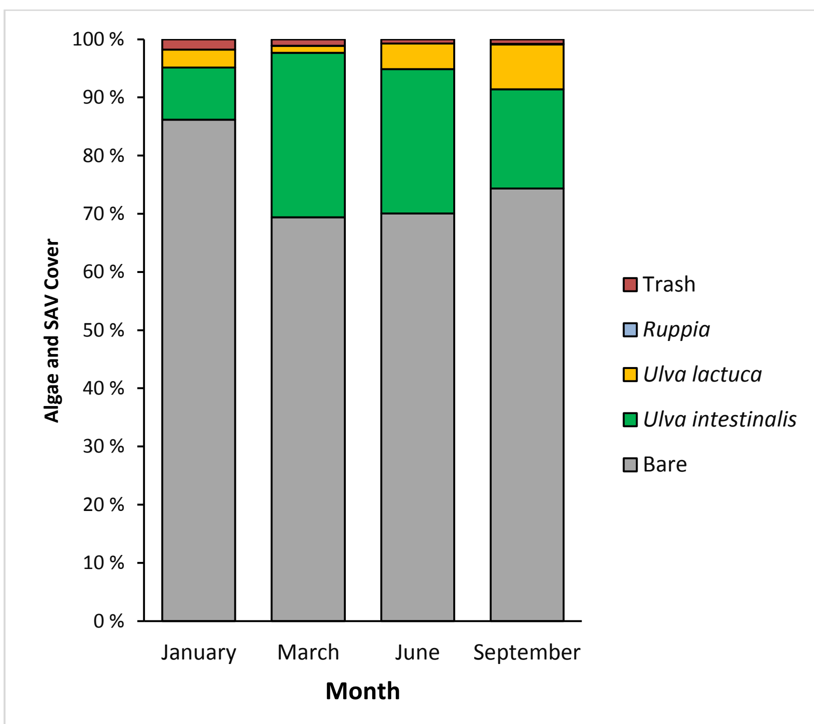


Figure 66. Graphs of average algae cover by month combined across all transects and years.

When analyzing at a finer scale, clear patterns are not immediately evident (Figures 69 and 70). With the exception of the reduction in overall algal cover in 2013 and again in 2014, the first three years of surveys have fairly consistent algal cover, dominated by *U. intestinalis.* Outliers of relatively high *U. intestinalis* cover (e.g. March 2010, June 2012; Figure 68) were present intermittently throughout the duration of the survey.

Figure 67. Field photograph of Transect 1 in the Area B main tidal channel.

Figure 68. Field photograph along Transect 3 in the Area B outflow tidal channel.

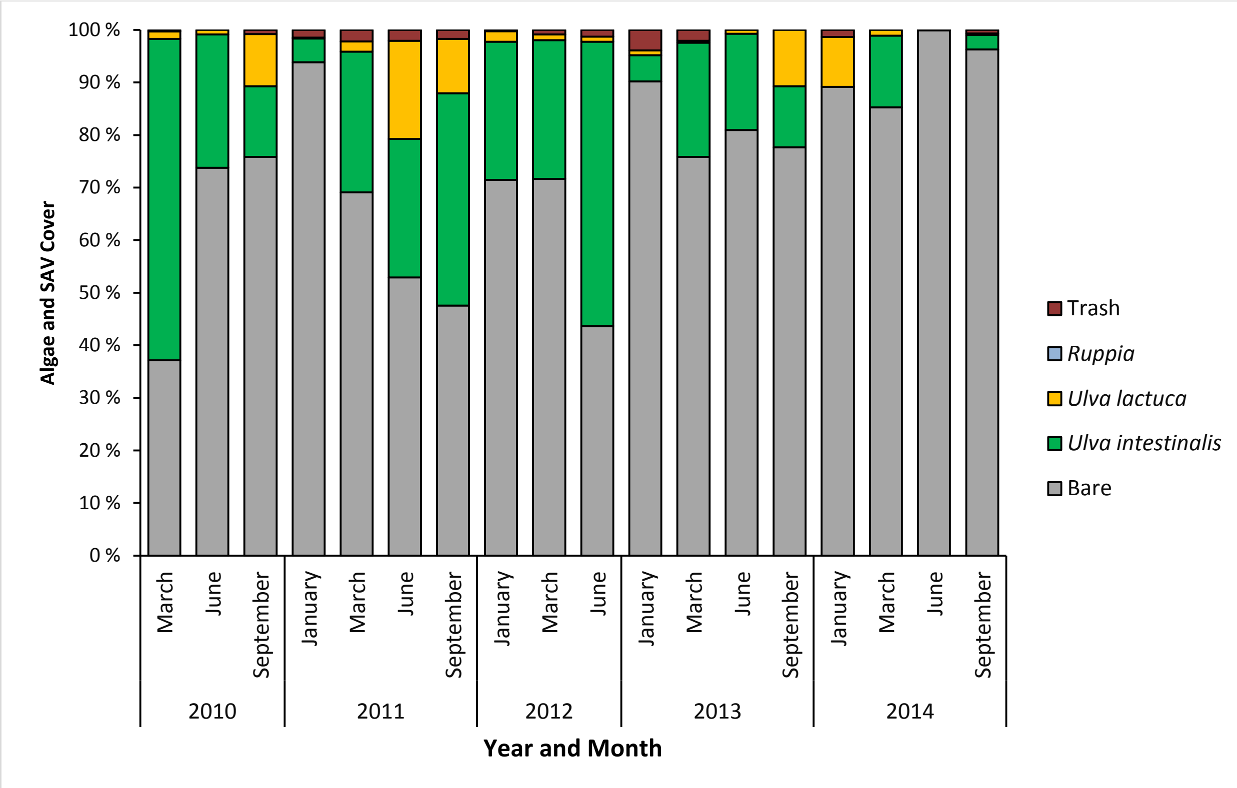


Figure 69. Graphs of average algae cover by year and month, with all stations combined.

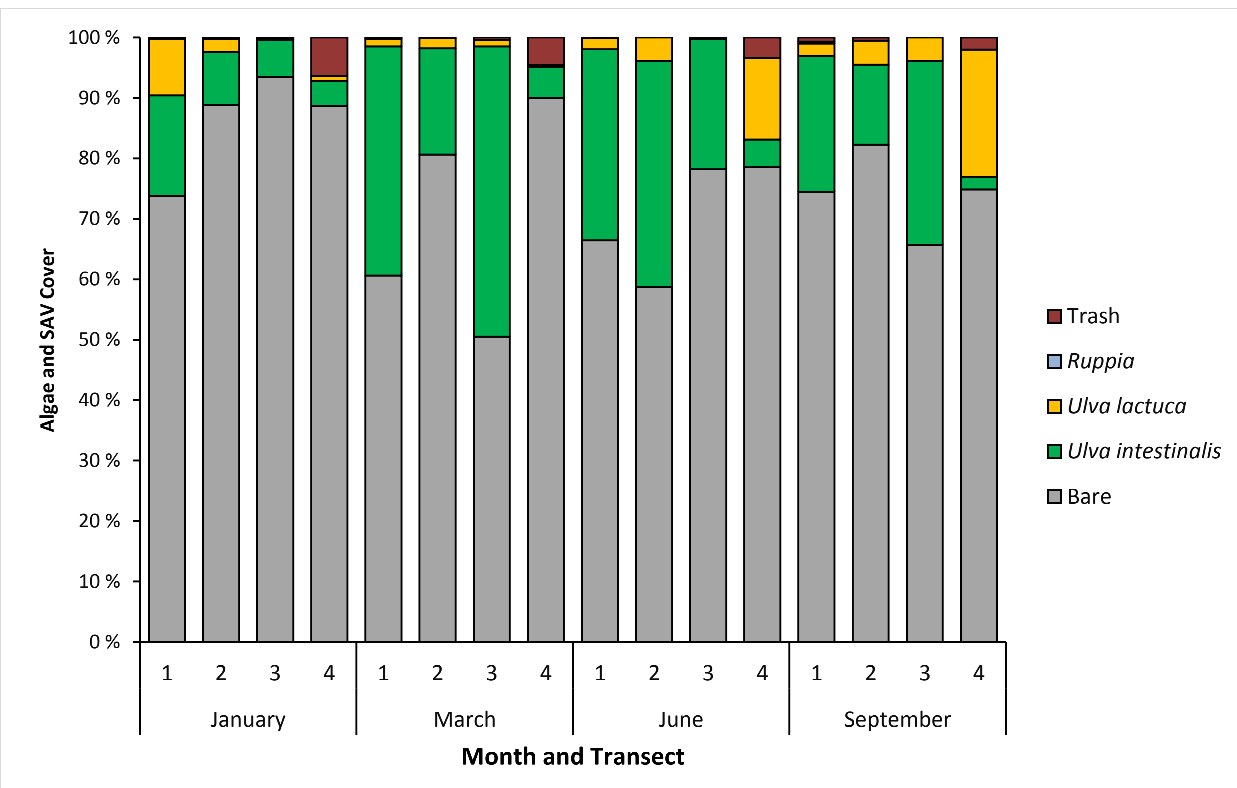


Figure 70. Graphs of average algae cover by month and station, with all years combined.

5-Year Summary Conclusions

Overall, the Reserve does not experience excessive eutrophication, which would lead to significant algal blooms and have the potential to affect dissolved oxygen levels as well as the benthic invertebrate community and so on further up the wetland food web (Bight '08, Johnston et al. 2015c). Thus, the Reserve experiences a relatively consistent, low average cover of algae (compared to wetlands such as Los Cerritos, see Johnston et al. 2015c) that is variable in space and time and may be reflective of broader climate and weather patterns such as drought/rainfall. The months of March and June tended to have higher average algal cover. Lastly, several areas had ditch grass present as a form of attached submerged aquatic vegetation, particularly on Transect 1 and in the small branch channel (Figure 71).

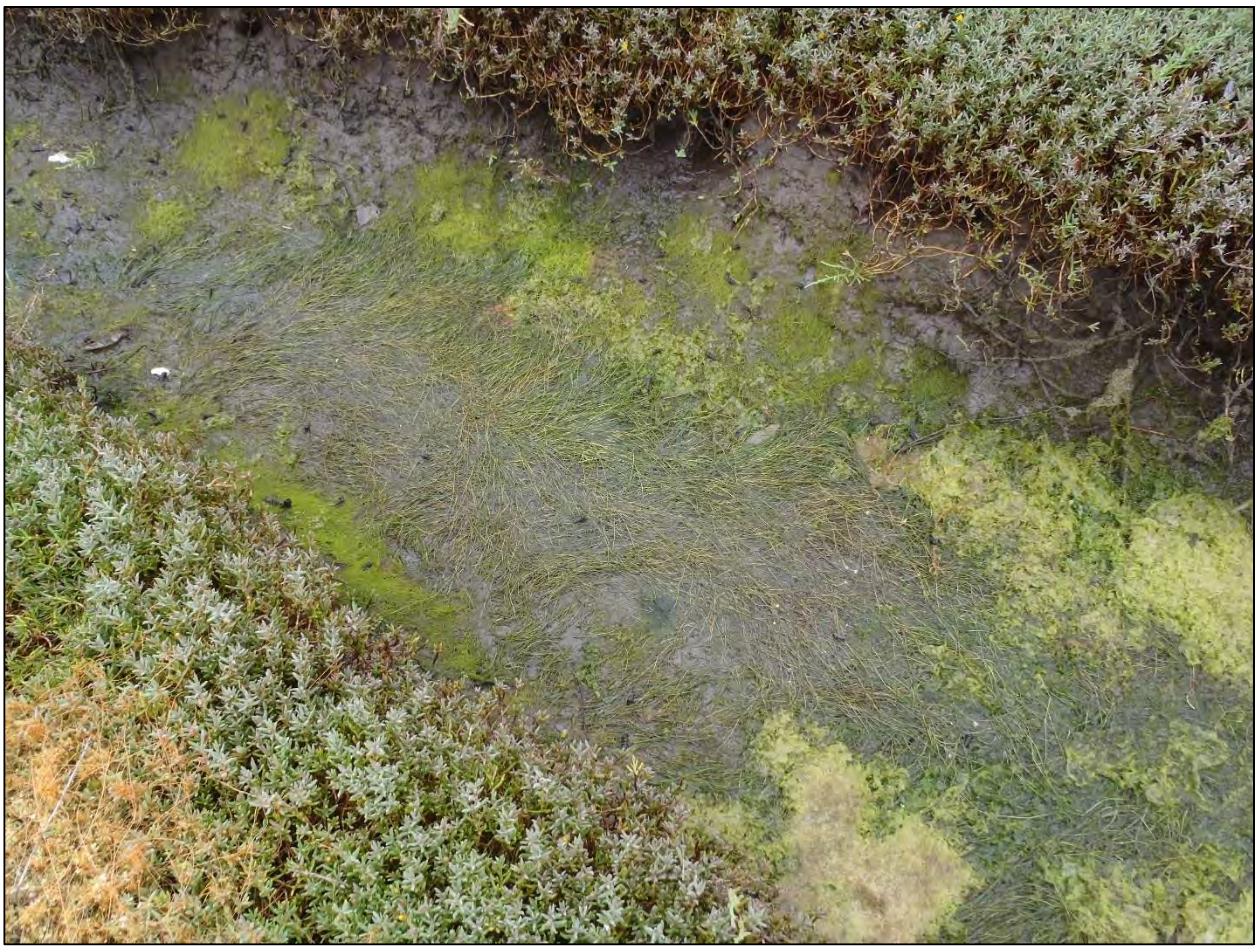


Figure 71. Photograph of ditch grass (*Ruppia sp.*) in the western tide channels of Area B.

Biological Communities – Vertebrates

Introduction

The Ballona Wetlands region and the Reserve have suffered a decline in native vertebrate populations, a reduction in species ranges, and an increase in the types and population sizes of introduced species throughout the last century (Friesen et al. 1981). Comprehensive vertebrate surveys are imperative to the establishment of current ranges and species present within the Reserve (Figure 72).

Ichthyofauna

Defining the fish assemblage of a wetland can be difficult due to the highly mobile nature of the fauna. However, it is this mobility that often allows them to rapidly colonize restored habitats (Zedler 2001). The goal of the fish community surveys of the monitoring program at the Reserve was to temporally track changes in uses of the tidal habitat areas by different fish species.

Herpetofauna

Herpetofauna (amphibians and reptiles) are integral but often undervalued components of natural ecosystems (Gibbons et al. 2000, Meyers and Pike 2006). Gibbons et al. (2000) reflect that declines of herpetofauna species diversity and population size can be attributed in part to causes including: anthropogenic factors, habitat loss, presence of invasive and introduced species, pollution, and disease. Site-specific lists of species' presence are important in the development of baseline information for a site, especially when directing conservation or management efforts (Tuberville et al. 2005); this information can also provide indicators of the health of a site. The goal of the herpetofauna surveys for the baseline monitoring program was to determine species presence by habitat type throughout the Reserve and to contribute baseline information for future abundance and long-term monitoring surveys.

Mammals

Mammals are an important link to functioning wetland and upland ecosystems within a complex food web (Mayfield et al. 2000). They can indicate change in overall vertebrate populations within a system, thereby serving as indicators of the overall health of the system (Manley et al. 2004). Tracking mammalian inhabitation of the Reserve through traps and cameras provides an indication of the overall use of the site by area. Additionally, roads have become ubiquitous features on our landscapes, with approximately 20% of all land within the conterminous United States within 150 meters of a roadway (Riitters and Wickham 2003). Within these areas, the movement of cars at medium and high speeds may negatively affect wildlife populations and behavior through direct mortalities, habitat fragmentation, and behavior change (Forman and Alexander 1998, Coffin 2007, Charry and Jones 2009). Vertebrate mortality surveys of frequently-traveled roadways help identify wildlife movement patterns and the impacts of habitat fragmentation on a given area. The principle goals of the mammal surveys were to identify mammal species inhabiting or utilizing the Reserve and evaluate vertebrate mortality along roadways bisecting the Reserve.

Avifauna

The presence and distribution of avifauna within an ecosystem is often used as an index of habitat quality because of their diet and vulnerability to environmental conditions (Conway 2008). Bird communities are in constant flux. Because turnover in isolated sites can be high from decade to decade with new species colonizing and rare species becoming extirpated (MacArthur and Wilson 1967, Cooper 2006), regular, repeated surveys are needed to maintain a clear picture of bird communities on a site. The goal of the avifauna surveys at the Reserve was to identify species richness and use of the site over time.

Figure 72. Photographs of representative vertebrates found in the Reserve.

Ichthyofauna Community Surveys

Methods

Ichthyofauna (or fish) sampling using beach seines occurred six times across the first and second year of baseline assessment for both day and night surveys, and sampling occurred four times using shrimp trawls deployed from a boat in Ballona Creek. Due to effort and cost limitations, fish surveys were not completed after the second baseline year. For detailed methods and results, refer to Chapter 5: Ichthyofauna in the first and second Baseline Assessment Reports (Johnston et al. 2011, 2012). However, Alexandre Balcerzak, Scientific Aid for the California Department of Fish and Wildlife (CDFW), duplicated a subset of the survey efforts in 2015 as part of a Master's thesis project and provided an ancillary 2015 species list; those data are presented below (A. Balcerzak, pers. comm. December 2015). All surveys were catch and release.

Results

Fifteen species of fish were caught in the Reserve or in Ballona Creek across all survey years (Table 17). The most common fish caught was topsmelt (*Atherinops affinis*); California killifish (*Fundulus parvipinnis*) and gobies (*Clevelandia ios* or *Ilypnus gilberti*) were the next most abundant species'. Within the tide channels and Fiji Ditch, the beach seine surveys identified a total of seven native species and one non-native species, the western mosquitofish (*Gambusia affinis*) (Table 18). The round stingray (*Urobatis halleri*) was found exclusively within the Fiji Ditch. The mean length and range for each species caught in the beach seines are presented in Figure 73.

Table 17. Fish species identified during the monitoring program. Note: asterisk denotes non-native species.

COMMON NAME	SPECIES
Arrow goby	*Clevelandia ios* or *Ilypnus gilberti*
Bat ray	*Myliobatis californica*
California halibut	*Paralichthys californicus*
California killifish	*Fundulus parvipinnis*
California lizardfish	*Synodus lucioceps*
Diamond turbot	*Hypsopsetta guttulata*
Giant kelpfish	*Heterostichus rostratus*
Kelp bass	*Paralabrax clathratus*
Longjaw mudsucker	*Gillichthys mirabilis*
Pacific staghorn sculpin	*Leptocottus armatus*
Round stingray	*Urobatis halleri*
Specklefin midshipman	*Porichthys myriaster*
Striped mullet	*Mugil cephalus*
Topsmelt	*Atherinops affinis*
Western mosquitofish *	*Gambusia affinis*

Table 18. Fish species identified during the monitoring program by year, for the Reserve surveys only (i.e. tide channels and Fiji Ditch, but not Ballona Creek). Asterisk indicates survey completed by CDFW.

COMMON NAME	SPECIES	2009-2010	2010-2011	2015 *
Arrow goby	*Clevelandia ios or Ilypnus gilberti*	X	X	X
California killifish	*Fundulus parvipinnis*	X	X	X
Diamond turbot	*Hypsopsetta guttulata*	X	X	X
Longjaw mudsucker	*Gillichthys mirabilis*	X	X	X
Pacific staghorn sculpin	*Leptocottus armatus*	X	X	X
Round stingray	*Urobatis halleri*	X	X	
Striped mullet	*Mugil cephalus*	X		
Topsmelt	*Atherinops affinis*	X	X	X
Western mosquitofish *	*Gambusia affinis*	X	X	X

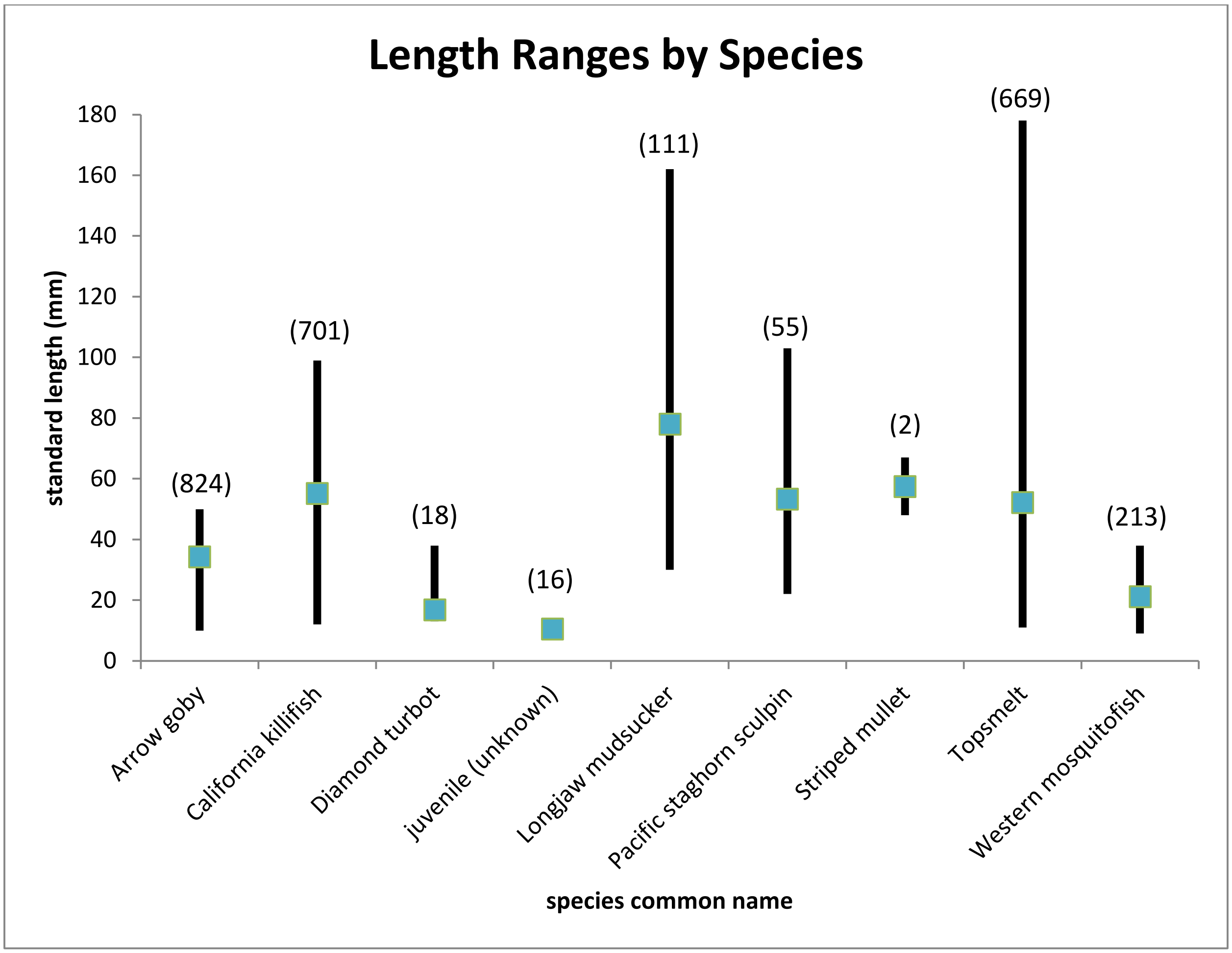


Figure 73. Minimum, maximum, and mean lengths of each species caught in the beach seines. Note: the blue box indicates the average overall mean standard length, the vertical line indicates the minimum and maximum lengths. The number in parenthesis indicates the number of individual fish included in the length analyses.

5-Year Summary Conclusions

All fish species found during the monitoring program are representative of southern California estuarine marsh systems (Miller and Lea 1972, Moyle et al*.* 1995, Allen et al*.* 2006). Several fish species were ubiquitous across all survey stations, including the topsmelt and the arrow goby; the California killifish was also found at most stations. Those three species also represented the highest total counts for both survey years, indicating that the beach seine survey method was effective for fish species that are demersal, or bottom-dwelling (e.g. arrow gobies), and those that live within the water column (e.g. topsmelt). All stations within the BWER also had relatively similar species richness, although the round stingray was found exclusively in the Fiji Ditch and the diamond turbot was found exclusively in the western Area B tide channel stations.

Similar patterns of spatial and temporal variations at the beach seine stations (i.e. not the Ballona Creek shrimp trawls) emerged across both years of fish surveys, although some fluctuations were identified. The closest stations to the self-regulating tide gates likely experience the highest amount of fluctuations in fish numbers entering and leaving the wetlands.

Overall, the muted nature of the tides allows several typical salt marsh fish species of southern California to access the tide channels of Area B, but prevents them from accessing and foraging the marsh plain habitats (e.g. high marsh); therefore the muted tides do not support the same fish nursery functions as a fully tidal system. Such habitat restrictions may impact the overall diversity and abundance of fish species. West and Zedler (2000) found that killifish in the Sweetwater Marsh National Wildlife Refuge consumed significantly more food when allowed access to the marsh plain in addition to tide channels. In the BWER, salt marsh fish populations may be limited by the smaller areas they are able to utilize (tide channels only). Various management objectives could significantly improve the habitat area, including opportunities to restore habitats used by rare or endangered species such as the steelhead trout or the tidewater goby.

Herpetofauna Community Surveys

Methods

A diverse set of field methods were implemented across the five monitoring years and were intentionally varied to assess a wider potential diversity of herpetofauna species and to address potential data gaps identified in the first baseline year. Driftnet and pitfall arrays were implemented during the first monitoring year, but were not repeated due to high effort, ground disturbance, low species richness, and low capture rates. Instead, after a brief pilot test during the second baseline year to make sure that cover board arrays would capture both lizards and snakes, cover board arrays were used in combination with site searches and were conducted from November 2010 to May 2014 (Figure 74). Specific methods for driftnet and pitfall arrays are described in the first baseline report (Johnston et al. 2011) and methods for cover board surveys can be found in the second baseline report (Johnston el al. 2012). Habitats surveyed included non-tidal salt marsh, ruderal marsh, dune, non-native dune, annual grassland, non-native "tall" herbaceous, iceplant stand, and upland scrub.

Additionally, targeted surveys for the California legless lizard (*Anniella pulchra*), a California Species of Special Concern, were conducted in the dune habitats of Areas B and C in the first monitoring year (Johnston et al. 2011). Surveys were not repeated at the request of the California Department of Fish and Wildlife (CDFW) to avoid disturbance in subsequent years. Specific methods are described in Johnston et al. 2011. All surveys were catch and release.

Figure 74. Photograph of coverboard survey (23 January 2012).

Results

For all surveys combined, a total of ten herpetofauna species were captured or observed on site, including two species previously unidentified at the Reserve prior to baseline surveys: garden slender salamander (*Batrachoseps major*) and San Bernardino Ring-necked snake (*Diadophis punctatus modestus*) (Table 19). Table 19 lists all species present during each survey year using all methods, including: visual observations, cover board arrays, and pitfall and driftnet arrays.

Great Basin fence lizard (*Sceloporus occidentalis longipes*), western side-blotched lizard (*Uta stansburiana helleri*), and San Diego alligator lizard (*Elgaria multicarinata webbii*) were all very common and found on all cover board and pitfall array surveys (Figure 75, A and B). They were also frequently visually observed on site throughout all survey years. California kingsnakes (*Lampropeltis getula californiae*) of several color variations (Figure 75, D and Figure 76) and San Diego gopher snakes (*Pituophis catenifer annectens*) were also ubiquitous throughout the surveyed habitats, based on the cover board array results, though not found on every survey. Additionally, several Southern Pacific rattlesnakes (*Crotalus oreganus helleri*) were identified on site, but were not present beneath the cover board arrays. Ancillary reports and photographs from the Friends of Ballona Wetlands confirmed their presence on site in 2013 and 2014. The California legless lizard was confirmed on site in the dune habitats of Area B in the first baseline year (Johnston et al. 2011) (Figure 75, C). Many Baja California treefrogs (*Pseudacris hypochondriaca hypochondriaca*) were seasonally present and breeding in flooded portions of Area B. Additionally, red-eared slider turtles and American bullfrogs have been found in the adjacent Ballona Freshwater Marsh (FWM) system. Both species are non-native and have been introduced to the southern California region (Stebbins 2003).

Table 19. Herpetofauna species identified during the five-year monitoring period. Species marked with an 'X' were present during surveys. Asterisk indicates California Species of Special Concern.

COMMON NAME	SCIENTIFIC NAME	2010	2011	2012	2013	2014
Baja California treefrog	*Pseudacris hypochondriaca hypochondriaca*	X	X	X	X	X
California kingsnake	*Lampropeltis getula californiae*	X	X	X	X	X
California legless lizard *	*Anniella pulchra*	X	X			
Garden slender salamander	*Batrachoseps major*		X	X		
Great Basin fence lizard	*Sceloporus occidentalis longipes*	X	X	X	X	X
San Bernardino Ring-necked snake	*Diadophis punctatus modestus*		X			
San Diego alligator lizard	*Elgaria multicarinata webbii*	X	X	X	X	X
San Diego gopher snake	*Pituophis catenifer annectens*	X	X	X	X	X
Southern Pacific rattlesnake	*Crotalus oreganus helleri*	X	X		X	X
Western side-blotched lizard	*Uta stansburiana elegans*	X	X	X	X	X

Figure 75. (A) Great Basin fence lizard; (B) California legless lizard (photo: Jack Goldfarb); (C) San Diego alligator lizard; (D) California kingsnake (brown color variant, photo: Jack Goldfarb).

Figure 76. Photograph of California kingsnake held by herpetologist Jack Goldfarb.

5-Year Summary Conclusions

Several reptile species were ubiquitous throughout the Reserve, especially in the non-tidal habitats, and across all five survey years; these five reptiles were found on almost every survey (i.e. Great Basin fence lizard, Western side-blotched lizard, San Diego alligator lizard, San Diego gopher snake, and California kingsnake). Further population level analyses are not possible from these data; however, data collected using the cover board array method appeared to reflect even the rare herpetofauna species present at the Reserve (i.e. garden slender salamander, San Bernardino ring-necked snake, and California legless lizard).

The overall success of both of the primary survey methods (i.e. pitfall and driftnet arrays and cover board arrays) was highly variable. Lizards were adequately represented by both survey types; however, data on snakes and amphibians were only collected via the cover board array method. Due to the higher number of species successfully captured on the cover board arrays and the high degree of variability in the capture rates of the pitfall and driftnet arrays from the first year (a range of 2.3% to 34.6%), an adaptive monitoring strategy retained the sampling methods from the second baseline year and continued this throughout the rest of the survey years (Johnston et al. 2011).

Relative herpetofauna abundances from cover board array surveys within the Reserve were not possible. Seasonal differences affect overall numbers of herpetofauna species, especially due to the need for precipitation events to perform an accurate survey using the cover board method, but an additional reason was the presence of illegal poaching activities on site. The cover board surveys at the Reserve have been affected strongly by trespassers both through removal of kingsnakes and by disrupting the boards (Marsh and Goicochea 2003). Until illegal activities cease, these data will not be comparable to other areas.

Mammal Community Surveys

Methods

Mammal community surveys were conducted at the Reserve using four different types of survey methods, including: Sherman live traps, motion camera stations, acoustic Chiroptera (bat) surveys, and road mortality surveys. Implementing multiple methods across the years allowed for an identification and evaluation of different groups of mammals varying in lifestyle and distribution. Methods and results for the Sherman live trap, acoustic, and road mortality surveys are summarized here, but additional details can be found in the first two baseline reports (Johnston et al. 2011, 2012), the road mortality technical memorandum (Johnston et al. 2014), and the upcoming Draft Environmental Impact Report/Statement for the Ballona Wetlands Restoration Project. The motion camera results include new data subsequent to the first two baseline reports. The acoustic surveys were conducted by Environmental Science Associates (ESA) with field assistance from The Bay Foundation staff.

Sherman Live Traps

Small mammals were surveyed throughout non-tidal Reserve habitat types in the first two monitoring years using baited Sherman live traps deployed as both arrays and transects. Sherman traps were 12" x 3.75" x 3.5" in size, made of folding aluminum, and labeled with a unique trap number. Sampling was conducted in fall 2009, summer 2010, and fall 2011 and took place within each major habitat comprising more than 40 acres (e.g. high marsh, seasonal wetland, upland grassland, and upland scrub). All surveys were catch and release.

Motion Cameras

Medium and large mammal sampling was conducted using Scout Guard camera stations ("Critter Cams") and visual and auditory site searches during the first four survey years. Forty four 'Critter Cam' stations were deployed throughout the site for a total deployment of 1,636 days from 2010 to 2013 (Figure 77a). Deployment ranged from four to 142 days based on trap success and vandalism. For example, the North East Trail camera during the third monitoring year was subjected to destructive vandalism on the seventh day of deployment and was immediately removed. Additionally, several targeted surveys were conducted in Area A at the request of the Mountains Recreation and Conservation Authority (MRCA) to determine human activity within those habitats of the Reserve. Critter Cam station methods followed detailed protocols described in the first baseline report (Johnston et al. 2011).

Acoustic Surveys

Three locations were surveyed for resident and migratory Chiroptera (bat) species utilizing non-invasive acoustic monitoring that detected and recorded bat echolocation calls in flight (Figure 77b). An ultrasonic bat detector was deployed for a total of six nights to determine if any bat species were present within the Reserve during the time of the survey. Each location was surveyed for two nights. Survey Location #1 (adjacent to the Freshwater Marsh) was surveyed on November 17 and 18, 2014 from 1645 hours to 1945 hours. Survey Location #2 (Eucalyptus trees in Area B East) and #3 (Area B West) were surveyed from December 8 through December 11, 2014 from 1645 hours to 1945 hours.

Figure 77. Photo of (a) motion camera station installation, and (b) acoustic monitoring station at the Reserve.

Road Mortality Surveys

The Reserve is bisected by three major roadways, resulting in three easily delineated road mortality transects for surveys. Each transect was approximately one mile in length (Figure 78). The "Lincoln Transect" (Transect 1) extended along Lincoln Boulevard from Loyola Marymount University Drive to Fiji Way; the "Culver-East Transect" (Transect 2) extended along Culver Boulevard from its intersection with West Jefferson Boulevard to the 90 Freeway; the "Culver/Jefferson Transect" (Transect 3) began on Culver Boulevard in Playa del Rey and extended to the intersection of Culver and Jefferson Boulevards, and then on to Lincoln Boulevard (Figure 1). Surveys were conducted biweekly from October 2010 through September 2013 and all vertebrate mortality was recorded. For detailed methods, refer to the "Technical Memorandum: Patterns of Vehicle-Based Vertebrate Mortality in the Ballona Wetlands Ecological Reserve, Los Angeles, CA" (Johnston et al. 2014).

Figure 78. Map of survey transects bisecting the Ballona Wetlands Ecological Reserve.

Results

Sherman Live Traps

Over the entire monitoring period, 64 small mammals were captured using the Sherman live traps. During the fall 2009 and summer 2010, 16 small mammals were caught in the Sherman live traps: 12 western harvest mice (*Reithrodontomys megalotis*) and four South Coast marsh voles (*Microtus californicus stephensi*) (Table 20). All mammals were captured during the fall; none were captured in the summer targeted transect surveys of the upland scrub areas, possibly due to trap disturbance by crows and coyotes. In fall 2011, 48 total captures of western harvest mice occurred (Figure 79). No voles were captured, despite a targeted set of surveys in the appropriate habitat type.

However, in 2011 the South Coast marsh vole was identified as present in Area B through visual observation in the appropriate habitat (high salt marsh). The vole was observed and identified in the field to species (*Microtus californicus*), and understood to be the subspecies (*Microtus californicus stephensi*) as identification of the subspecies requires accurate skull measurements to be conducted. Confidence in the vole identification as the rare subspecies was high due to the habitat, historical presence, type locality, and voucher specimens of the subspecies housed in the Natural History Museum of Los Angeles. However, full taxonomic identification of the subspecies in the field is virtually impossible without sacrifice and conducting skull measurements (Jim Dines, Natural History Museum of Los Angeles; pers. comm., 2011).

Figure 79. Photograph of western harvest mouse collected on the Sherman live trap surveys.

Motion Cameras

Forty four camera trap stations recorded a total of 22 total species across all monitoring years (Table 20). Ten species were mammals and ten species were birds; additionally, one reptile (unidentified lizard species) and one marsupial species (Virginia opossum, *Didelphis virginiana*) were also identified. Species presence by area across all four survey years is displayed in Table 20. Five of the 22 species were non-native (Table 20). Desert cottontail rabbits (*Sylvilagus audubonii*, Figure 80) were fairly ubiquitous throughout the site; they were observed the most frequently of all mammals and were recorded at the highest number of stations. California ground squirrels (*Spermophilus beecheyi*) were also frequently observed through visual observations and recorded on the Critter Cams. Several bird species were seen on the cameras exclusively within Area B: Canada Goose (*Branta canadensis*), Hummingbird *sp*. (*Trochilidae spp.*), and Mourning dove (*Zenaida macroura*). Several species of mammal were observed visually in an Area but not captured at a Critter Cam station (e.g. domestic cats were seen on several occasions in Area C, but not recorded).

Table 20. Total number of years each species was observed by Reserve Area. Asterisk indicates a non-native species.

Common Name	Scientific name	Area A	Area B	Area C
California ground squirrel	*Spermophilus beecheyi*	0	4	1
Cottontail	*Sylvilagus audubonnii*	3	4	3
Coyote	*Canis latrans*	3	3	1
Eastern gray squirrel *	*Sciurus niger*	0	1	1
Lizard	Order: squamata	0	1	0
Raccoon	*Procyon lotor psora*	1	2	0
Rat *	*Rattus* sp.	2	1	1
Striped skunk	*Mephitis mephitis*	1	3	1
Virginia opossum *	*Didelphis virginiana*	1	3	3
American crow	*Corvus brachyrhynchos*	3	3	1
Canada Goose	*Branta canadensis*	0	1	0
Egret	*Ardea* sp.	1	0	0
Great blue heron	*Ardea herodias*	2	2	0
Great Egret	*Ardea alba*	1	1	0
Hummingbird sp.	*Trochilidae*	0	1	0
Mourning dove	*Zenaida macroura*	0	1	0
Northern Harrier	*Circus cyaneus*	1	0	0
Rock Pigeon	*Columba livia*	0	1	1
Sparrow	*Passerculus sandwichensis* (spp.)	3	1	1
Domestic cat *	*Felis cattus*	2	2	0
Domestic dog *	*Canis familiaris*	2	4	1
Human	*Homo sapien*	3	4	1

Figure 80. Photographs of the most common vertebrate mortality species (desert cottontail rabbit) from Critter Cam stations within the Reserve.

Acoustic Surveys

The following results are summarized from the ESA 2014 bat survey memorandum (ESA 2014). Based on the six nights of surveys, 98 total acoustic recordings of bats occurred on or adjacent to the Reserve. This relatively high level of bat activity during the fall season suggests that resident bats are present on the Reserve or in immediately adjacent areas and regularly forage on the Reserve. Table 21 displays the results of the four species that were detected during the fall 2014 surveys, including silver-haired bat (*Lasionycteris noctivagans*), hoary bat (*Lasiurus cinereus*), Yuma myotis (*Myotis yumanensis*), and Mexican free-tailed bat (*Tadarida brasiliensis*). Mexican-free tailed bat and Yuma myotis are very common in southern California and often occur near fresh water sources, often roosting in structures typically observed in urban settings such as bridges and buildings (ESA 2014). Hoary bat and silver-haired bat are tree roosting species that typically occur in woodland and forest areas in the vicinity of fresh water sources; Mexican free-tailed bat, Yuma myotis, and hoary bat are typically resident species in the region and silver-haired bat was the only migrant species detected (ESA 2014).

Table 21. Chiroptera (bat) survey results by location.

Bat Species Detected	Location 1 (Freshwater Marsh)	Location 2 (Eucalyptus trees)	Location 3 (Area B West)
Mexican free-tailed bat (*Tadarida brasiliensis*)	79	3	1
hoary bat (*Lasiurus cinereus*)	7	2	0
silver-haired bat (*Lasionycteris noctivagans*)	3	0	0
Yuma myotis (*Myotis yumanensis*)	3	0	0

Road Mortality Surveys

The following results are summarized from the vehicle-based vertebrate mortality memorandum (Johnston et al. 2014). A high rate of vertebrate mortality was documented with kills found regularly and frequently along all three transects. In three years of surveys, a total of 654 kills were recorded during 70 surveys of each of the three transects. A fairly consistent number of kills was recorded across all survey years, with 231 kills during the first survey year; 208 in the second survey year; and 215 in the third survey year. For all data years combined, a significantly higher number of kills were found on both the Culver-East and the Culver/Jefferson Transects than the Lincoln Transect (ANOVA, $F = 31.48$, $p < 0.001$; Table 22).

Table 22. Frequency of kills by transect and averaged over the total number of surveys (± SE). The kill rates can be inferred as either kill rates per day (liberal) or per week (conservative). Replicated from Johnston et al. 2014.

Transect	Total # of Kills / mile	# of Surveys	Average # per Survey	Standard Error
1: Lincoln	106	70	1.51	0.148
2: Culver-East	297	70	4.24	0.309
3: Culver/Jefferson	251	70	3.59	0.245

The species with the highest mortality throughout the evaluation period was desert cottontail rabbits for a total of 192 kills or approximately 30% of the aggregate mortality (Figure 81). It is probable that a significant portion of the "unknown" and "small mammal" category (i.e. too damaged to definitively identify) were also cottontails. This would indicate that an estimate closer to 50-70% of the total kills were cottontails. Other vertebrates frequently sighted included squirrels (family Sciuridae) and the Virginia opossum (*Didelphis virginiana*). When analyzed by month, the highest average mortality was seen during the warmer late spring and summer months from approximately May through June, consistent with broader regional patterns of kills (S. Anderson, *unpublished data*, 2014; Johnston et al. 2014).

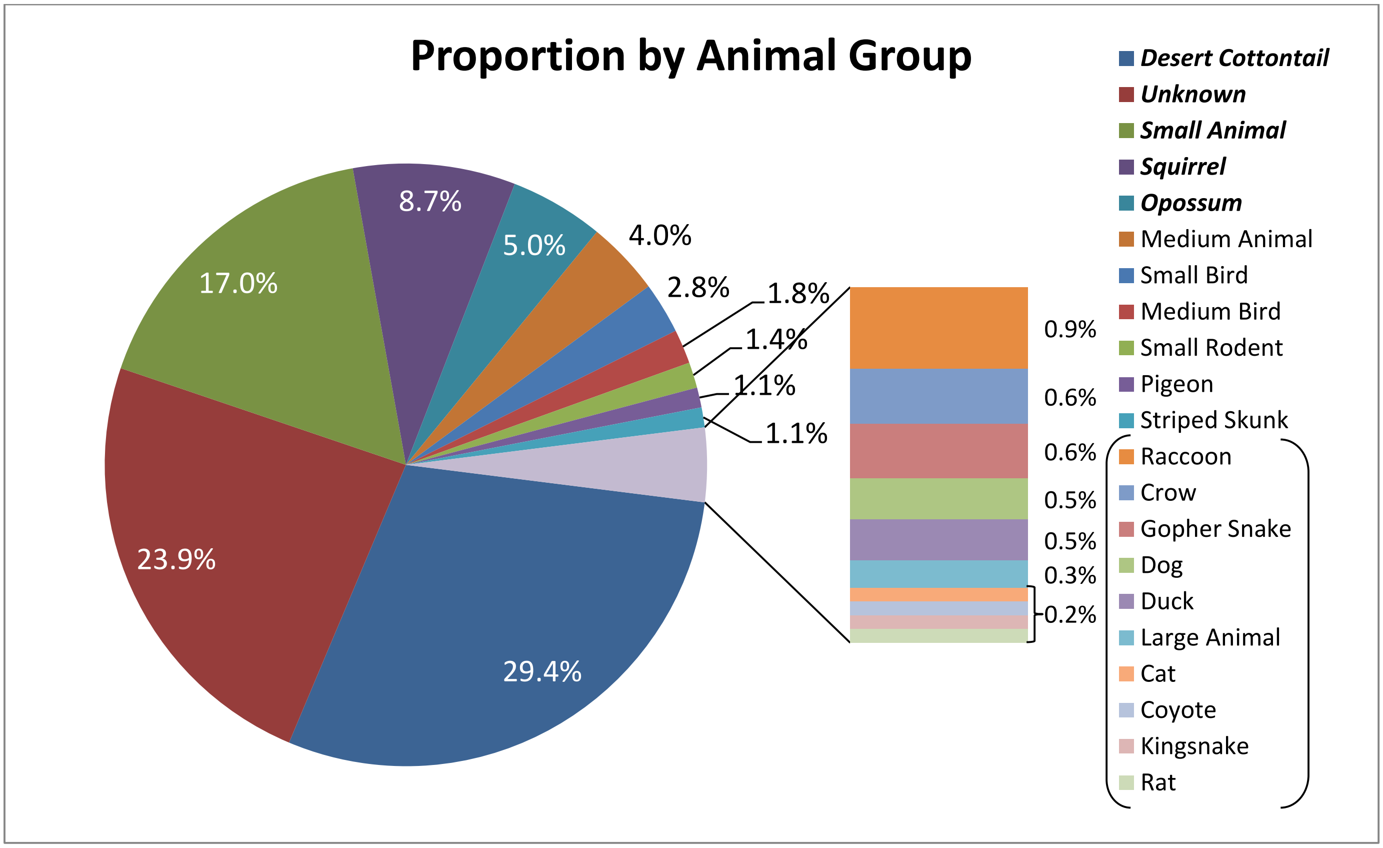


Figure 81. Proportion of animal mortality by group. Bold and italicized animal groups were the most common; animal groups in parenthesis each accounted for less than 1% of the total proportion.

Figure 82 displays variable mortality rates (kills per tenth of a mile) based on transect, specific location, and side of the road. It also shows that the parallel sections of Culver and Jefferson along the perimeter of the "triangle" roughly in the center of the graph, are particularly hazardous to wildlife (Figure 82). Additionally, the bidirectional survey methodology allows us to independently assess the vulnerability of vertebrates along both directions of car travel within a given stretch of road. Animals using the road adjacent to the North Area C parcel (along eastern Culver Boulevard) seem to be more susceptible to traffic collisions than those along the opposite direction. A similar trend is noticeable for wildlife crossing eastern Culver Boulevard from the south-eastern corner of Area B towards the salt pan habitat.

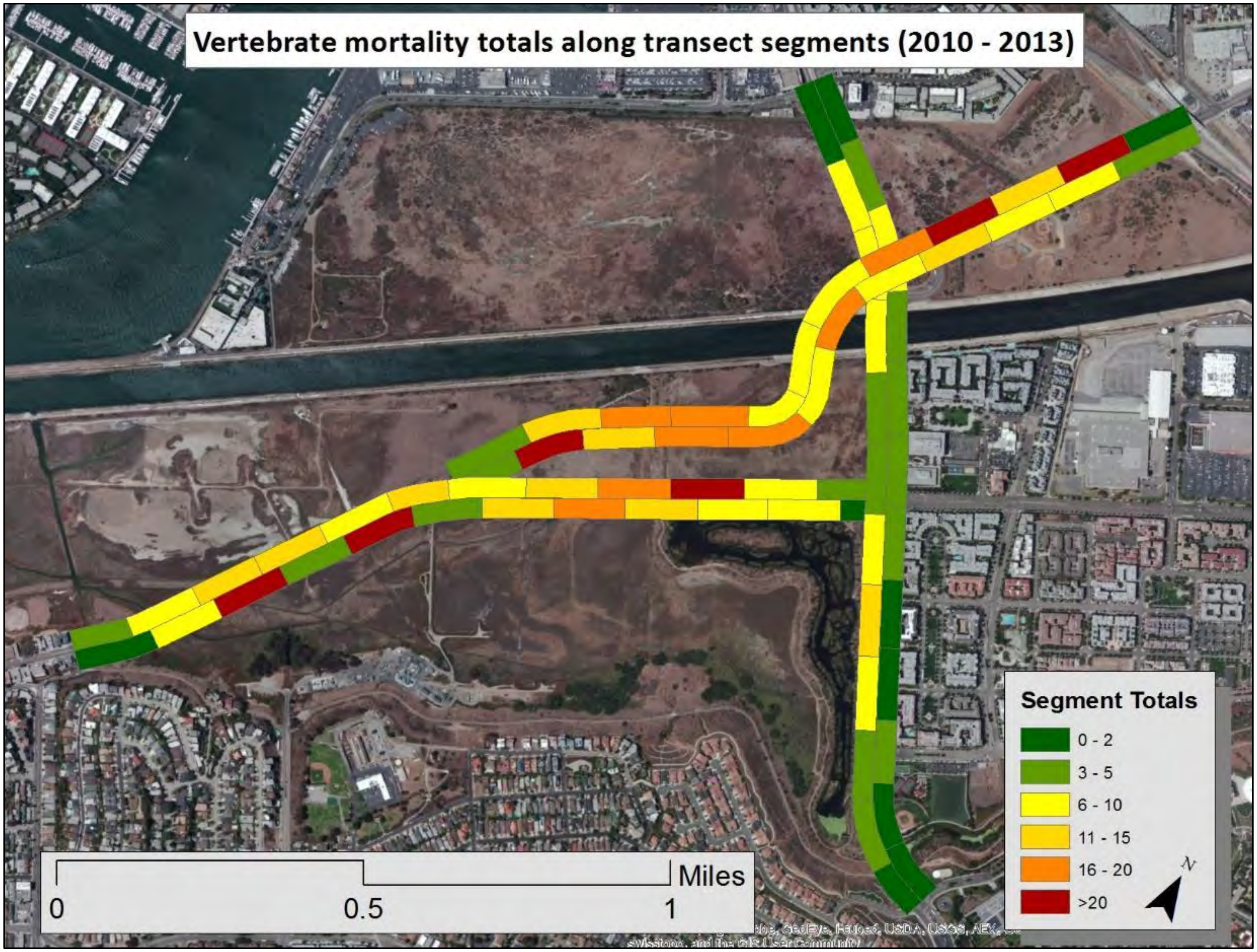


Figure 82. Map of total vertebrate mortality in 0.1-mile segments during the 2010-2013 surveys.

5-Year Summary Conclusions

Sherman Live Traps

When comparing 2009, 2010, and 2011 Sherman trap data for small mammals, the western harvest mouse was present in all areas and habitats except upland scrub. The lack of presence in the scrub may be due to the high degree of trap tampering in that habitat by both coyotes and crows and not necessarily because they are not present. Very few successful trapping nights were possible during the first year within scrub habitat in Areas A and C. Sherman trap sampling was also used to identify habitat use by the South Coast marsh vole within the marsh habitats of Area B. While the vole was not identified in trap surveys during the second year, it was visually confirmed to be present in the high marsh habitat. Survey results obtained using the Sherman trap method appear to under-represent the true mammal species diversity at the Reserve. An analysis of this survey method found that for the sampling effort required, the results indicated low species diversity of capture, trap tampering, and a substantial difference in capture success rates (i.e. range of 0.0 – 4.17% in year 1 compared to 1.7 – 63.3% in year 2). Therefore, the Sherman trap method was removed from the monitoring program when using an adaptive strategy to transition to long-term monitoring.

Motion Cameras

The camera trap data yielded a range of groups of species across all areas and years. The highest overall species richness was consistently observed within Area B, with Area C exhibiting the lowest relative number of species observed each year. Cottontail rabbits and humans were the most frequently observed species across all years followed by the non-native Virginia opossum and domestic dog. Adaptive monitoring allows programs to evolve iteratively (Lindenmayer and Likens 2009); in this case, it allowed for comparative assessments of sampling effort versus the information gained from each method. When assessing the first two years of baseline data collected at the BWER, the Critter Cam data more clearly answered the question of mammal species' use of the BWER, with a much smaller sampling effort required for implementation; thus, it was continued into future monitoring years.

Acoustic Surveys

Based on the results of the fall surveys, bats are considered present on and adjacent to the Reserve and any activities that would result in the disturbance or removal of roosting habitat in native and non-native trees, and riparian scrub habitat in areas such as the Freshwater Marsh, Eucalyptus Grove, and West Area B, will need to consider bat occupancy, particularly maternity roosts, prior to any habitat disturbance to avoid direct impacts to bats. Due to the time of year surveys were conducted, bat activity and species diversity is lower than during the spring/summer months and the results may not represent all species that can occur on the Reserve; additionally pre-restoration surveys are recommended.

Road Mortality Surveys

Roadways bisecting the BWER present a major obstacle to wildlife mobility, with specific segments of the roadways depicting higher kills rates than other segments. During 70 surveys over a three-year period, 654 road kills were recorded. This survey, which identified roadway segments with higher kill rates and likely groups of impacted animals, could be used to inform future studies to identify or increase our understanding of the factors that differentiate the segments' rates of mortality. Warmer months corresponded with increasing mortality for vertebrates along the road transects surveyed. The species with the highest number of roadkill incidences overall, the cottontail rabbit, was also the species most frequently identified in the Critter Cam motion camera stations.

Additionally, underestimations of mortality may have occurred for some of the organism groups. Antworth el at. 2005 estimated that scavenging results in the removal of 60 – 97% of roadkill carcasses within the first 36 hours, with snakes exhibiting the highest disappearance rates. Additionally, the City of Los Angeles, Bureau of Sanitation removes large carcasses that may impact motorists.

The application of these data could be used to identify the specific locations that have the most frequent number of mortalities, as well as those areas that may have the greatest number of large mammal mortalities. For example, both coyote collisions recorded occurred along Lincoln Boulevard. Although it had the lowest overall kill rate, it tended to have a higher proportion of the total larger size-class mammals. The proximity of these major roadways to the Reserve, an undeveloped open space, increase the possibility of vehicle-related mortalities on wildlife and increase the potential costs and environmental effects associated with those incidences. These data will be important in identifying areas that would be the most appropriate for the creation of protected wildlife crossings and corridors and/or traffic modifications.

Avian Community Surveys

Methods

While birds are one of the most commonly observed groups of animals at the BWER, they are seldom surveyed comprehensively. Multiple methods were implemented over several days for different monitoring years. A complete list of survey methods and dates by year are shown in Table 23. Reserve-wide surveys were conducted quarterly during monitoring years one through three within all habitat types of the Reserve following specific methods described in the first baseline year report (Chapter 8: Avifauna; Johnston et al. 2011). Waterbird surveys on the Ballona Creek channel were conducted bi-monthly during monitoring years one and two only, following specific methods described in the first baseline year report (Chapter 8: Avifauna; Johnston et al. 2011).

To test an alternate protocol and achieve consistency with other regional monitoring programs, box count surveys were conducted within the salt marsh habitats of Area B during three months (April, September, and January) across one calendar year spanning monitoring years four and five (Table 23). Specific protocols for box count surveys are described in the "CA Estuarine Wetland Monitoring Manual" (Johnston et al. 2015d, Appendix B – 5.1). Surveys were conducted during the morning and evening for each survey type during each sampling season, with one exception due to poor survey conditions.

Table 23. Sampling frequency for the three types of bird surveys performed across all five monitoring years.

Survey Type	Monitoring Year	Months	# Days per survey
Reserve-wide	1	January, April, July, October	5 - 7
Reserve-wide	2	January, April, July, October	5 - 7
Reserve-wide	3	January, April, July, October	5 - 7
Waterbird	1	February, April, June, August, October, December	2
Waterbird	2	February, April, June, August, October, December	1
Box Count	4	April, September	2
Box Count	5	January	2

Results

Across all monitoring years, 167 bird species and distinct subspecies[1] (hereafter "species") were recorded, including all survey types (Table 24). The highest numbers of bird species were recorded during monitoring years one and two (135 and 140), respectively. Quarterly Reserve-wide surveys not including Ballona Creek conducted during monitoring year three recorded 83 bird species. The box count surveys, conducted only within salt marsh habitats, resulted in the lowest number of recorded

[1] An effort was made to distinguish between the more distinctive subspecies where possible, e.g., "Audubon's" vs. "Myrtle" Yellow-rumped Warbler. These were treated as separate entities in the surveys and analyses. This total excludes incidental reports made outside the scope of the BAP surveys.

species across the three implemented surveys (N = 44). Eighteen bird species were recorded as present during all five monitoring years, regardless of survey type. Species included a variety of waterbirds, shorebirds, raptors, and landbirds including, but not limited to: American Kestrel (*Falco sparverius)*, Anna's Hummingbird (*Falco sparverius)*, Belding's Savannah Sparrow (*Passerculus sandwichensis beldingi)*, Common Yellowthroat (*Passerculus sandwichensis beldingi)*, Great Blue Heron (*Ardea herodias*) (Figure 83b), Great Egret (*Ardea alba*), Least Sandpiper (*Calidris minutilla*), Western Sandpiper (*Calidris mauri*), and Snowy Egret (*Egretta thula*) (Figure 83a).

Twenty-eight species afforded some level of protection (regional, state, or federal) were recorded throughout the monitoring program. Only two special status species, the Belding's Savannah Sparrow (State Endangered) and Western Meadowlark (*Sturnella neglecta*, Los Angeles County Bird Species of Special Concern), were recorded during all monitoring years. Belding's Savannah Sparrow was the only special status species recorded nesting and was largely confined to areas dominated by *S. pacifica* (pickleweed) in the western portion of Area B still retaining some tidal hydrological connectivity. Five additional special status species were recorded in four monitoring years. Because many species are only afforded protection when performing specific activities (e.g. overwintering, nesting), only two federally-protected special-status species detected are typically afforded protection year-round: Burrowing Owl (*Athene cunicularia*) and California Gnatcatcher (*Polioptila californica*).

Figure 83. Photographs of (a) snowy egrets in Area B (top) and (b) great blue heron in Area B (bottom).

Table 24. List of species recorded during each monitoring year. Asterisk indicates the combination of both Reserve-wide and waterbird surveys.

		* Combined Surveys		Reserve-wide	Box Count		# Years Recorded
Common Name	Scientific Name	Yr1	Yr2	Yr3	Yr4	Yr5	
Allen's Hummingbird	*Selasphorus sasin*	X	X	X			3
American Coot	*Fulica americana*	X	X	X		X	4
American Crow	*Corvus brachyrhynchos*	X	X	X	X		4
American Goldfinch	*Carduelis tristis*		X				1
American Kestrel	*Falco sparverius*	X	X	X	X	X	5
American Pipit	*Anthus rubescens*	X	X	X		X	4
American Robin	*Turdus migratorius*	X					1
American Wigeon	*Anas americana*	X	X			X	3
Anna's Hummingbird	*Calypte anna*	X	X	X	X	X	5
Ash-throated Flycatcher	*Myiarchus cinerascens*	X	X	X			3
Audubon Warbler	*Setophaga coronata auduboni*	X	X	X			3
Baird's Sandpiper	*Calidris bairdii*		X		X		2
Barn Owl	*Tyto alba*	X					1
Barn Swallow	*Hirundo rustica*	X	X	X	X	X	5
Belding's Savannah Sparrow	*Passerculus sandwichensis beldingi*	X	X	X	X	X	5
Belted Kingfisher	*Ceryle alcyon*	X	X		X	X	4
Bewick's Wren	*Thryomanes bewickii*		X				1
Black Oystercatcher	*Haematopus bachmani*	X	X				2
Black Phoebe	*Sayornis nigricans*	X	X	X		X	4
Black Skimmer	*Rynchops niger*			X			1
Black Turnstone	*Arenaria melanocephala*	X	X				2
Black-and-white Warbler	*Mniotilta varia*		X				1
Black-bellied Plover	*Pluvialis squatarola*	X	X		X	X	4
Black-crowned Night-Heron	*Nycticorax nycticorax*	X	X				2
Black-headed Grosbeak	*Pheucticus melanocephalus*	X	X	X			3
Black-necked Stilt	*Himantopus mexicanus*	X	X	X			3
Black-throated Grey Warbler	*Dendroica nigrescens*			X			1
Blue - grey Gnatcatcher	*Polioptila caerulea*	X	X	X			3
Blue-winged Teal	*Anas discors*	X	X				2
Bobolink	*Dolichonyx oryzivorus*	X					1
Bonaparte's Gull	*Larus philadelphia*	X		X			2

Common Name	Scientific Name	* Combined Surveys Yr1	* Combined Surveys Yr2	Reserve-wide Yr3	Box Count Yr4	Box Count Yr5	# Years Recorded
Brandt's Cormorant	*Phalacrocorax penicillatus*	X	X				2
Brown-headed Cowbird	*Molothrus ater*	X	X	X			3
Brown Pelican	*Pelecanus occidentalis*	X	X		X		3
Bufflehead	*Bucephala albeola*	X	X			X	3
Bullock's Oriole	*Icterus bullocki*	X	X	X			3
Burrowing Owl	*Athene cunicularia*		X	X			2
Bushtit	*Psaltriparus minimus*	X	X	X	X		4
California Least Tern	*Sterna antillarum browni*	X	X				2
California Gnatcatcher	*Polioptila californica*		X				1
California Gull	*Larus californicus*	X	X				2
California Thrasher	*Toxostoma redivivum*	X					1
California Towhee	*Pipilo crissalis*	X	X	X			3
Canada Goose	*Branta canadensis*	X	X	X		X	4
Caspian Tern	*Hydroprogne caspia*	X	X	X	X		4
Cassin's Kingbird	*Tyrannus vociferans*	X	X	X		X	4
Cattle Egret	*Bubulculus ibis*	X	X				2
Chipping Sparrow	*Spizella passerina*		X	X			2
Cinnamon Teal	*Anas cyanoptera*	X	X	X	X		4
Clark's Grebe	*Aechmophorus clarkii*		X				1
Cliff Swallow	*Petrochelidon pyrrhonota*	X	X		X		3
Common Poorwill	*Phalaenoptilus nuttallii*	X					1
Common Raven	*Corvus corax*	X	X	X			3
Common Yellowthroat	*Geothlypis trichas*	X	X	X	X	X	5
Cooper's Hawk	*Accipiter cooperii*	X	X	X		X	4
Double-crested Cormorant	*Phalacrocorax auritus*	X	X		X		3
Downy Woodpecker	*Picoides pubescens*		X				1
Dunlin	*Calidris alpina*	X	X		X	X	4
Eared Grebe	*Podiceps nigricollis*	X	X				2
Elegant Tern	*Thalasseus elegans*	X		X			2
European Starling	*Sturnus vulgaris*	X	X	X			3
Fox Sparrow	*Passerella iliaca*		X				1
Gadwall	*Anas strepera*	X	X	X			3
Glaucous-winged Gull	*Larus glaucescens*	X	X				2
Golden-crowned Sparrow	*Zonotrichia atricapilla*	X					1

		* Combined Surveys		Reserve-wide	Box Count		# Years Recorded
Common Name	Scientific Name	Yr1	Yr2	Yr3	Yr4	Yr5	
Grasshopper Sparrow	*Ammodramus savannarum*	X					1
Great Blue Heron	*Ardea herodias*	X	X	X	X	X	5
Great Egret	*Ardea alba*	X	X	X	X	X	5
Greater Yellowlegs	*Tringa melanoleuca*	X	X				2
Great-horned Owl	*Bubo virginianus*		X				1
Great-tailed Grackle	*Quiscalus mexicanus*			X			1
Green Heron	*Butorides virescens*	X	X				2
Green-winged Teal	*Anas crecca*	X	X	X		X	4
Heermann's Gull	*Larus heermanni*	X	X				2
Hermit Thrush	*Catharus guttatus*	X	X	X			3
Herring Gull	*Larus argentatus*	X	X				2
Hooded Oriole	*Icterus cucullatus*	X	X	X			3
House Finch	*Carpodacus mexicanus*	X	X	X	X		4
House Sparrow	*Passer domesticus*	X	X	X			3
House Wren	*Troglodytes aedon*	X	X	X	X	X	5
Killdeer	*Charadrius vociferus*	X	X	X	X	X	5
Lazuli Bunting	*Passerina amoena*	X	X	X	X		4
Least Sandpiper	*Calidris minutilla*	X	X	X	X	X	5
Lesser Goldfinch	*Carduelis psaltria*	X	X	X			3
Lesser Scaup	*Aythya affinis*	X	X				2
Lincoln's Sparrow	*Melospiza lincolnii*	X	X	X		X	4
Loggerhead Shrike	*Lanius ludovicianus*	X	X	X	X		4
Long-billed Curlew	*Numenius americanus*		X		X		2
Long-billed Dowitcher	*Limnodromus scolopaceus*	X	X		X	X	4
Mallard	*Anas platyrhynchos*	X	X	X	X	X	5
Marbled Godwit	*Limosa fedoa*	X	X		X	X	4
Marsh Wren	*Cistothorus palustris*	X	X	X		X	4
Merlin	*Falco columbarius*		X			X	2
Mew Gull	*Larus canus*	X	X				2
Mourning Dove	*Zenaida macroura*	X	X	X	X	X	5
Myrtle Warbler	*Setophaga coronata coronata*	X	X	X			3
Nashville Warbler	*Oreothlypis ruficapilla*		X	X			2
Northern Harrier	*Circus cyaneus*	X			X	X	3
Northern Mockingbird	*Mimus polyglottos*	X	X	X			3
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	X	X	X			3

Common Name	Scientific Name	* Combined Surveys Yr1	Yr2	Reserve-wide Yr3	Box Count Yr4	Yr5	# Years Recorded
Northern Shoveler	*Anas clypeata*	X	X			X	3
Nuttall's Woodpecker	*Picoides nuttallii*		X	X			2
Orange Bishop	*Euplectes franciscanus*	X					1
Orange-crowned Warbler	*Vermivora celata*	X	X	X			3
Oregon Junco	*Junco h. oregonus*		X	X			2
Oriole spp.	Oriole spp.	X					1
Osprey	*Pandion haliaetus*		X			X	2
Pacific-slope Flycatcher	*Empidonax difficilis*	X	X	X			3
Palm Warbler	*Setophaga palmarum*		X	X			2
Peregrine Falcon	*Falco peregrinus*	X	X		X		3
Pied-billed Grebe	*Podilymbus podiceps*	X	X				2
Red Knot	*Calidris canutus*		X				1
Red-tailed Hawk	*Buteo jamaicensis*	X	X	X			3
Red-breasted Merganser	*Mergus serrator*	X	X				2
Red-necked Phalarope	*Phalaropus lobatus*				X		1
Red-shafted Flicker	*Colaptes a. cafer*			X			1
Red-tailed Hawk	*Buteo jamaicensis*	X	X		X		3
Red-throated Loon	*Gavia stellata*	X	X				2
Red-winged Blackbird	*Agelaius phoeniceus*	X	X	X			3
Ring-billed Gull	*Larus delawarensis*	X	X				2
Rock Pigeon	*Columba livia*	X	X	X			3
Royal Tern	*Thalasseus maximus*	X	X				2
Ruby-crowned Kinglet	*Regulus calendula*		X	X			2
Ruddy Duck	*Oxyura jamaicensis*	X	X	X			3
Ruddy Turnstone	*Arenaria interpres*	X	X				2
Saffron Finch	*Sicalis flaveola*	X					1
Sanderling	*Calidris alba*	X			X		2
Savannah Sparrow	*Passerculus sandwichensis*	X	X	X	X	X	5
Say's Phoebe	*Sayornis saya*	X	X	X		X	4
Semipalmated Plover	*Charadrius semipalmatus*	X	X	X	X	X	5
Sharp-shinned Hawk	*Accipiter striatus*		X				1
Short-billed Dowitcher	*Limnodromus griseus*	X					1
Snowy Egret	*Egretta thula*	X	X	X	X	X	5
Solitary Sandpiper	*Tringa solitaria*		X				1
Song Sparrow	*Melospiza melodia*	X	X		X	X	4

		* Combined Surveys		Reserve-wide	Box Count		# Years Recorded
Common Name	Scientific Name	Yr1	Yr2	Yr3	Yr4	Yr5	
Sora	*Porzana carolina*	X					1
Spotted Sandpiper	*Actitis macularius*	X	X				2
Spotted Towhee	*Pipilo maculatus*		X				1
Surf Scoter	*Melanitta perspicillata*	X					1
Surfbird	*Aphriza virgata*	X	X				2
Swainson's Thrush	*Catharus ustulatus*		X				1
Thayer's Gull	*Larus thayeri*	X	X				2
Townsend's Warbler	*Dendroica townsendi*	X					1
Tree Swallow	*Tachycineta bicolor*	X	X	X	X		4
Vaux's Swift	*Chaetura vauxi*	X	X				2
Vermilion Flycatcher	*Pyrocephalus rubinus*	X					1
Vesper Sparrow	*Pooecetes gramineus*	X	X				2
Violet-green Swallow	*Tachycineta thalassina*	X					1
Wandering Tattler	*Heteroscelus incanus*	X	X				2
Western Grebe	*Aechmophorus occidentalis*	X	X				2
Western Gull	*Larus occidentalis*	X	X				2
Western Kingbird	*Tyrannus verticalis*	X	X	X			3
Western Meadowlark	*Sturnella neglecta*	X	X	X	X	X	5
Western Sandpiper	*Calidris mauri*	X	X	X	X	X	5
Western Scrub-Jay	*Aphelocoma californica*		X				1
Western Tanager	*Piranga ludoviciana*			X			1
Whimbrel	*Numenius phaeopus*	X	X	X	X	X	5
White-crowned Sparrow	*Zonotrichia leucophrys*	X	X	X		X	4
White-faced Ibis	*Plegadis chihi*	X	X	X			3
White-tailed Kite	*Elanus leucurus*	X	X	X			3
White-throated Swift	*Aeronautes saxatalis*	X	X		X		3
Willet	*Catoptrophorus semipalmatus*	X	X		X	X	4
Wilson's Snipe	*Gallinago delicata*	X	X	X		X	4
Wilson's Warbler	*Wilsonia pusilla*	X	X	X			3
Wrentit	*Chamaea fasciata*	X	X	X			3
Yellow Warbler	*Setophaga petechia*			X			1
Yellow-rumped Warbler	*Dendroica coronata*	X	X			X	3
TOTAL SPECIES		135	140	83	44	44	

5-Year Summary Conclusions

Monitoring data combined across all five years suggest that the assorted range of habitats within the Reserve support a diverse bird community – from water-associated birds to urban-adapted species. These range from vagrant species stopping over during a larger migration (e.g. wintering, roosting) to established year round populations for which the Reserve appears to provide needed resources (e.g. food) to the regional avian assemblages. The first two monitoring years (using Reserve-wide surveys) contributed the highest number of species to the overall recorded species list. This followed an expected trend, as that survey type included all habitats and provided an opportunity to record cryptic or less frequently seen species. However, it should not be assumed that the number of bird species on site has decreased over time as consistent long-term temporal trend data are limited. Additionally, based on the effort needed to record all areas of the Reserve and the post-processing time to digitize field maps, it will be important to prioritize specific management goals to formulate a long-term monitoring plan for birds at the Reserve.

Consistent site usage by special-status bird species' can be challenging to evaluate, though the data provide useful management information. Special-status species recorded as simply flying over a site, or present only for a few days during migration, are generally not given protection. Only two recorded federally-protected special-status species are typically afforded year-round protection based on their activities on site: Burrowing Owl and California Gnatcatcher. Additionally, the Belding's Savannah Sparrow was consistently observed on site and was identified as nesting in the salt marsh habitats of Area B across all monitoring years. Increasing the acreage and quality of the salt marsh habitats on site for the Belding's Savannah Sparrow may provide an opportunity to increase the nesting pairs of this species. It will be important to conduct pre-restoration surveys for rare species and several others as part of the pre-construction monitoring plan. For additional information regarding special status species, refer to the upcoming Draft Environmental Impact Report/Statement for the Ballona Wetlands Restoration Project.

Biological Communities – Invertebrates

Introduction

Benthic Invertebrates

Benthic invertebrate taxa are useful ecological indicators; the presence or absence of certain infauna (i.e. burrow into and live in bottom sediments) or epifauna (i.e. live on the surface of bottom sediments) within tidal channels can serve as indicators of water quality, anthropogenic stressors to the estuary, and the potential to support other trophic levels (WRP 2006); these benthic communities provide essential ecosystem services and support (Ramirez and McLean 1981).

The goal of the benthic invertebrate surveys was to assess the types of taxa present across multiple years in the tidal channels of the Reserve by station and to compare taxa lists from the Fiji Ditch to the west Area B tide channels across multiple survey years.

Terrestrial Invertebrates

Terrestrial invertebrates are a vital link in wetland food webs and may be considered indicators of the overall health of a system (Zedler 2001). Ecosystem function has been measured by counting and identifying insects to species level to determine biodiversity; however, simpler and more rapid measures that describe functions or rates of productivity may be better indicators of ecosystem health (Anderson 2009). These metrics can often be employed rapidly and cost effectively across habitat types and are useful from a management perspective.

One objective of the baseline monitoring program invertebrate assessments of the Reserve was to estimate aerial arthropod productivity (as biomass) using length-fresh weight regressions for each habitat and to note observations of special status species. Additionally, pitfall traps were used with the objective of estimating epigeal order-level taxa present in several habitat types. Taxonomic nomenclature and conservation status for species in this report are from the Integrated Taxonomic Information System (ITIS; http://www.itis.gov/, searched January 2012).

Benthic Invertebrates: Infauna

Methods

Field methods for the second and third year of benthic invertebrate surveys were identical to the first baseline year. For detailed methods, refer to Johnston et al. 2011, Chapter 9 or the "CA Estuarine Wetland Monitoring Manual" (Johnston et al. 2015d, Appendix B – 6.1). Small cores were taken from the right, left, and thalweg at all stations (Figure 84).

Figure 84. Photograph of benthic invertebrate core sampling in the Area B tide channels.

The April samples of the second and third baseline years were subsequently processed by professional invertebrate taxonomists at Dancing Coyote Environmental (DCE) who sorted, counted, and identified all individuals to the lowest taxonomic level practicable. 'Practicable' was dictated by the extreme taxonomic difficulty of certain groups (e.g. Oligochaetes), juveniles, or damaged specimens (L. Lovell, pers. comm. 2012). The October samples from both years were sorted and analyzed using preliminary processing methods only and are therefore not included in the species-level results and evaluations.

The April data were analyzed to determine the taxonomic composition and density of the benthic infaunal community, which was recorded as the number of individuals per square meter for each station. Taxonomic composition refers to the lowest practicable taxon identified. Data for each station were analyzed separately for both large and small cores. Each type of core (i.e. small or large) consisted of combined data from the whole station (i.e. left, right, and thalweg samples combined). For consistency with previous Ballona reports (e.g. Chambers 1996, 1999, MEC 2005, Dorsey 2007, Johnston et al. 2011, 2012), each stations' results were analyzed as presence and density of organisms / m^2. Each station consisted of a total area (combining right, left, and thalweg) of 0.023562 m^2 for the large cores and 0.02544 m^2 for the small cores.

Results

The most common taxa by total density for all stations per meter squared (density / m²) for the small cores in the second monitoring year in descending order included two amphipods (i.e. *Monocorophium insidiosum* and *Grandidierella japonica*), a relatively pollution-tolerant group of polychaetes (i.e. *Capitella capitata Cmplx*) one gastropod (*Acteocina inculta*), unidentifiable oligochaetes, and another polychaete (*Streblospio benedicti*). Similar results were identified in the small cores in year three. The most common taxa (density / m²) in descending order included: unidentifiable oligochaetes, *C. capitata Cmplx*, *M. insidiosum*, *A. inculta*, *Exogone sp.*, *Fabricinuda limnicola*, and *G. japonica*. The four most common taxa identified in the large cores for the second year included the following, present in much smaller densities than the small cores: *A. inculta*, *Cirriformia sp.*, *M. insidiosum*, and *Solen rostriformis*. Similar results were found in the third monitoring year for the large cores: *F. limnicola*, *Pygospio elegans*, *A. inculta*, and *Cirriformia sp*. Table 25 lists all invertebrate taxa present in the samples across both monitoring years separated for the Fiji Ditch and the west Area B tide channels, which revealed slightly different taxa compositions. A total of 64 taxa within seven phyla were identified across both years. Additionally, *Cerithidea californica* were visually identified in the surface sediments across all stations and both years (Figure 85a) and mollusk beds were seen in the main tide channel of Area B (Figure 85b).

Figure 85. Photographs of (left) *C. californica* and (right) mollusk beds in Area B adjacent to the tide gates.

Table 25. List of benthic invertebrate taxa present in the second and third baseline monitoring year at the Fiji Ditch and Area B tide channels.

Phylum	Class	Order or Subclass	Family	Lowest Identifiable Taxon	YEAR 2 Fiji Ditch	YEAR 2 Tide Channels	YEAR 3 Fiji Ditch	YEAR 3 Tide Channels
Annelida	Oligochaeta	----	----	Oligochaeta	X	X	X	X
Annelida	Polychaeta	Aciculata	Dorvilleidae	*Dorvillea (Schistomeringos) annulata*				X
Annelida	Polychaeta	Aciculata	Eunicidae	*Marphysa sp*	X			
Annelida	Polychaeta	Aciculata	Glyceridae	*Hemipodia borealis*				X
Annelida	Polychaeta	Aciculata	Goniadidae	*Goniada littorea*			X	X
Annelida	Polychaeta	Aciculata	Nereididae	*Neanthes acuminata Cmplx*	X		X	
Annelida	Polychaeta	Aciculata	Syllidae	*Exogone lourei*	X			
Annelida	Polychaeta	Aciculata	Syllidae	*Exogone sp*		X	X	X
Annelida	Polychaeta	Canalipalpata	Cirratulidae	*Cirratulidae*		X		
Annelida	Polychaeta	Canalipalpata	Cirratulidae	*Cirriformia sp*	X	X		X
Annelida	Polychaeta	Canalipalpata	Cirratulidae	*Cirriformia sp HYP1*				X
Annelida	Polychaeta	Canalipalpata	Sabellidae	*Fabricinuda limnicola*		X	X	X
Annelida	Polychaeta	Canalipalpata	Spionidae	*Polydora nuchalis*	X	X	X	X
Annelida	Polychaeta	Canalipalpata	Spionidae	*Pseudopolydora paucibranchiata*				X
Annelida	Polychaeta	Canalipalpata	Spionidae	*Pygospio elegans*				X
Annelida	Polychaeta	Canalipalpata	Spionidae	*Scolelepis sp*				X
Annelida	Polychaeta	Canalipalpata	Spionidae	Spionidae	X	X		
Annelida	Polychaeta	Canalipalpata	Spionidae	*Streblospio benedicti*	X	X	X	X
Annelida	Polychaeta	Sedentaria	Capitellidae	*Capitella capitata Cmplx*	X	X	X	X
Annelida	Polychaeta	Sedentaria	Capitellidae	*Mediomastus sp*				X

					YEAR 2		YEAR 3	
Phylum	**Class**	**Order or Subclass**	**Family**	**Lowest Identifiable Taxon**	**Fiji Ditch**	**Tide Channels**	**Fiji Ditch**	**Tide Channels**
Annelida	Polychaeta	Sedentaria	Orbiniidae	*Naineris dendritica*				X
Annelida	Polychaeta	Sedentaria	Orbiniidae	*Scoloplos acmeceps*	X			
Arthropoda	Insecta	Diptera	----	(fly larvae)	X	X	X	X
Arthropoda	Malacostraca	Amphipoda	Ampithoidae	*Ampithoe lacertosa*		X		
Arthropoda	Malacostraca	Amphipoda	Ampithoidae	*Ampithoe plumulosa*		X		X
Arthropoda	Malacostraca	Amphipoda	Ampithoidae	*Ampithoe sp*		X		X
Arthropoda	Malacostraca	Amphipoda	Ampithoidae	*Ampithoe valida*		X		X
Arthropoda	Malacostraca	Amphipoda	Aoridae	*Grandidierella japonica*	X	X	X	X
Arthropoda	Malacostraca	Amphipoda	Corophiidae	*Monocorophium insidiosum*	X	X	X	X
Arthropoda	Malacostraca	Amphipoda	Corophiidae	*Monocorophium sp*	X	X		
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	*Allorchestes angusta*		X	X	X
Arthropoda	Malacostraca	Amphipoda	Hyalidae	*Protohyale frequens*		X		
Arthropoda	Malacostraca	Isopoda	Sphaeromatidae	*Paracerceis cordata*			X	
Arthropoda	Malacostraca	Isopoda	Sphaeromatidae	Sphaeromatidae		X		
Arthropoda	Ostracoda	Podocopida	----	Podocopida		X		X
Cnidaria	Anthozoa	Actiniaria	----	Athenaria		X		
Cnidaria	Anthozoa	Actiniaria	Diadumenidae	*Diadumene sp*		X		
Cnidaria	Anthozoa	Actiniaria	Edwardsiidae	*Drillactis sp*		X		X
Mollusca	Gastropoda	Heterobranchia	Acteonidae	*Rictaxis puctocoelatus*				X
Mollusca	Gastropoda	Heterobranchia	Haminoeidae	*Haminoea vesicula*				X
Mollusca	Gastropoda	Hypsogastropoda	Barleeidae	*Barleeia sp*				X
Mollusca	Gastropoda	Opisthobranchia	Aglajidae	*Melanochlamys diomedea*		X		
Mollusca	Gastropoda	Opisthobranchia	Cylichnidae	*Acteocina inculta*	X	X	X	X

Phylum	Class	Order or Subclass	Family	Lowest Identifiable Taxon	YEAR 2 Fiji Ditch	YEAR 2 Tide Channels	YEAR 3 Fiji Ditch	YEAR 3 Tide Channels
Mollusca	Gastropoda	Sorbeoconcha	Potamididae	*Cerithidea californica*		X		X
Mollusca	Pelecypoda	Mytilida	Mytilidae	Mytilidae	X			
Mollusca	Pelecypoda	Venerida	Solecurtidae	*Tagelus sp*				X
Mollusca	Pelecypoda	Venerida	Solenidae	*Solen rostriformis*		X		
Mollusca	Pelecypoda	Venerida	Veneridae	*Chione californiensis*	X			
Mollusca	Pelecypoda	Venerida	Veneridae	*Leukoma laciniata*		X		
Mollusca	Pelecypoda	Venerida	Veneridae	*Leukoma sp*				X
Mollusca	Pelecypoda	Venerida	Veneridae	*Leukoma staminea*				X
Mollusca	Pelecypoda	Venerida	Veneridae	*Macoma nasuta*				X
Mollusca	Pelecypoda	Venerida	Veneridae	*Tellina meropsis*		X		
Mollusca	Pelecypoda	Venerida	Veneridae	*Venerupis phillipinarum*		X		X
Nemertea	----	----	----	Nemertea		X		
Nemertea	Anopla	Heteronemertea	Lineidae	Lineidae			X	X
Nemertea	Anopla	Heteronemertea	Lineidae	*Lineus bilineatus*			X	
Nemertea	Anopla	Paleonemertea	----	Paleonemertea		X	X	X
Nemertea	Anopla	Paleonemertea	Carinomidae	*Carinoma mutabilis*		X		
Nemertea	Enopla	Hoplonemertea	Emplectonematidae	*Paranemertes californica*		X	X	
Phoronida	----	----	----	Phoronida		X		
Platyhelminthes	Turbellaria	Polycladida	Leptoplanidae	Leptoplanidae			X	
Platyhelminthes	Turbellaria	Rhabdocoela	----	Rhabdocoela			X	X
Platyhelminthes	Turbellaria	Rhabdocoela	Polycystididae	Polycystididae				X

5-Year Summary Conclusions

Refinement of sorting and reporting categories for benthic invertebrate results was made possible by sending samples to qualified professional taxonomists. Similar taxa were represented across monitoring years; however, differences in densities as well as species lists were detected between the two survey areas (i.e. Fiji Ditch and west Area B tidal channels). For example, 17 and 20 taxa were found in the Fiji Ditch in years two and three, respectively, while 36 and 39 taxa were found in the west Area B muted tide channels for both years, approximately twice as many. The differences in the benthic invertebrate communities is likely due to hydrological and water/sediment quality differences between the two areas. The Fiji Ditch receives water directly from Basin H in Marina del Rey, while the tide channels in Area B receive muted tidal input from the Ballona Creek estuary. However, it should be noted that a more significant sampling effort was conducted in the tide channels, as the area was significantly larger than the Fiji Ditch. Detailed analyses of the results may be conducted for future publications.

Terrestrial Invertebrates

Methods

Three traps for each of two survey methods (i.e. three sticky traps and three pitfall traps, Figure 86) were deployed equidistant along 30-m transects, which extended 2.5 meters past the start and end of the 25-m vegetation transects. Each trap was labeled with the individual transect number, date deployed, and replicate (1, 2, or 3) along the transect. Specific terrestrial invertebrate (i.e. pitfall and aerial traps) sampling and processing methods followed descriptions from the "CA Estuarine Wetland Monitoring Manual" (Johnston et al. 2015d), the individual SOP for terrestrial invertebrate monitoring (Appendix B – 6.2), and the first baseline report (Johnston et al. 2011).

Figure 86. Photograph of deployed aerial arthropod sticky trap with tomato cage removed (left) and covered pitfall invertebrate trap and deployed sticky trap (right).

It is important to note that a variable sampling design occurred, based on the habitat type cross-walk and shift in 2013 since the inception of the original monitoring program protocols in 2009. The original sampling design was to sample five transects in each of 10 habitat types; however, Table 26 contains the detailed final sampling plan by revised habitat type after the habitat cross-walk using the same transect locations as prior to the crosswalk. A total of 51 transects (sticky traps) and 40 transects (pitfall traps) were surveyed annually between 2009 and 2014 for sticky traps and 2010 to 2014 for pitfall traps. Several transects were not sampled in the last two pitfall monitoring years, so the comparative annual analysis only presents results from years 1-3. This variable sampling design may factor into the final analyses, possibly in the form of variability.

Table 26. Sampling design summary information for both survey methods. Traps listed below were deployed annually from 2009-2014 for aerial surveys and 2010-2014 for pitfall surveys. Asterisk denotes approximate count as several transects were missing from the final analyses.

	Aerial Arthropod Surveys		Pitfall Surveys	
Habitat	# of Transects	# of Traps	# of Transects	# of Cups
Tidal Wetland	10	30	10	30
Non-tidal Salt Marsh	12	36	11	33
Ruderal Marsh	1	3	----	----
Salt Pan	5	15	4	12
Brackish Marsh	4	12	----	----
Pampas Grass	2	6	1	3
Iceplant Stand	3	9	2	6
Annual / Ruderal Grassland	1	3	1	3
Non-native "Tall" Herbaceous	7	21	5	13
Non-native Dune	2	6	2	6
Dune	3	9	3	9
Upland Scrub	1	3	1	3
Total	**51**	**153**	**40**	**120**
4- or 5-Year Total	**255**	**765**	**160 ***	**480 ***

Laboratory Methods

Processing of the samples followed methods developed by Dr. Sean Anderson, California State University Channel Islands. All individual invertebrates on the sticky traps were counted and classed by operationally-defined size classes: <0.5 mm, 0.5-2 mm, 2-5 mm, 5-10 mm, or >10 mm. Size-weight regressions for arthropods allowed for the derivation of fresh weight from measuring the approximate length of trapped individuals (S. Andersons, pers. comm. 2009). Invertebrates found in the pitfall traps were preserved in ethanol, identified to the lowest possible taxonomic level using a variety of identification guides and microscope settings (see literature cited), counted, average length for each taxon in each pitfall trap was estimated, and the largest individual of each taxon was measured individually to a millimeter-level accuracy.

Analysis Methods

Grand means (average of the transect-level average) were calculated annually by habitat type and additionally as one average across all years. Proportions of contributions of each habitat type to the overall invertebrate biomass by survey year was calculated. Size class evaluations of the aerial arthropod data were calculated for biomass proportions of size class categories by frequency of number of individuals and proportion by weight in grams. Length-weight regression and size class data followed protocols detailed in the first and second baseline reports (Johnston et al. 2011, 2012).

Lepidoptera Notes

Several anecdotal research notes regarding special status Lepidoptera invertebrates present on site are included in the results and conclusions, specifically for the Federally Endangered El Segundo blue butterfly (*Euphilotes battoides allyni*, ESBB) and the 'near threatened' wandering skipper (*Panoquina errans*) (IUCN Red List, December 2015). Since overwintering monarch butterfly (*Danaus plexippus*) habitats are generally protected and the US Fish and Wildlife Service is currently reviewing their status, this species is also mentioned.

Results

Both the aerial arthropod and pitfall invertebrate sampling methods produced highly variable results across temporal scales but displayed overarching habitat-level patterns and trends. For the purposes of this report, data were summarized to highlight habitat-level biomass availability and size class distributions. A qualified invertebrate taxonomist may be consulted to perform future taxa-specific analyses.

Aerial Arthropod Surveys

Figure 87 displays the average per transect aerial arthropod biomass data across all five survey years combined for each habitat type as a grand mean. The highest biomass of average grams of aerial arthropod invertebrates per transect ± standard error (g/t ± SE) was identified in the brackish marsh habitat type (10.73 ± 2.35 g/t) with second highest identified in the annual ruderal grassland habitat type (9.53 ± 4.20 g/t). The lowest biomass was identified in the non-native dune and salt pan habitat types at 1.51 ± 0.59 g/t and 2.12 ± 0.84 g/t, respectively. Many of the other habitat types (e.g. tidal wetland, non-tidal salt marsh, iceplant stand, and dune) were between 3 and 5 g/t on average. Two other habitat types, i.e. ruderal marsh and upland scrub, were just above an average of 5 g/t. The highest degree of variability as measured by standard error was seen in the annual ruderal grassland (± 4.20 g/t) and the brackish marsh (± 2.35 g/t) habitat types, with the least variability found in the non-native "tall" herbaceous and non-native dune habitat types (± 0.53 g/t and 0.59 g/t, respectively).

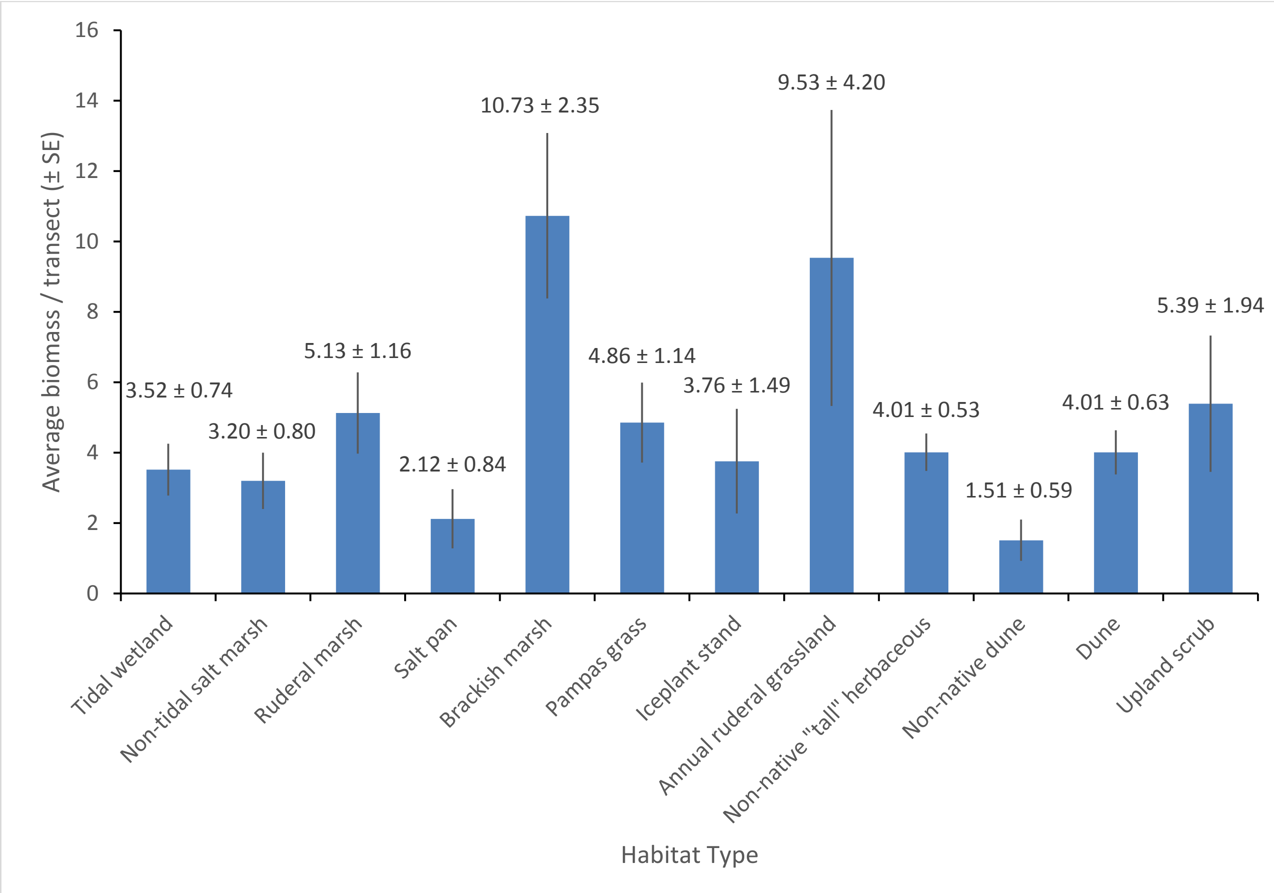


Figure 87. Relative average aerial arthropod biomass per transect (g/t ± SE) for each habitat type evaluated.

Figure 88 displays the relative proportion (by overall average percentage contribution) of the total biomass that was contributed by each habitat type surveyed to the total aerial arthropod biomass found on the sticky traps for each of the first three survey years. Only the first three survey years were evaluated for this graph because data for several habitat types were not collected in the fourth and fifth monitoring years. Similarly to Figure 87, the data of Figure 88 reflect a substantial contribution to the overall average aerial arthropod biomass by the annual ruderal grassland and the brackish marsh habitat types. The upland habitats appear to contribute more substantially to the overall proportion in the third survey year, with the non-native dune, salt pan, non-tidal salt marsh, and iceplant stand each contributing relatively less to the overall arthropod biomass results for each year.

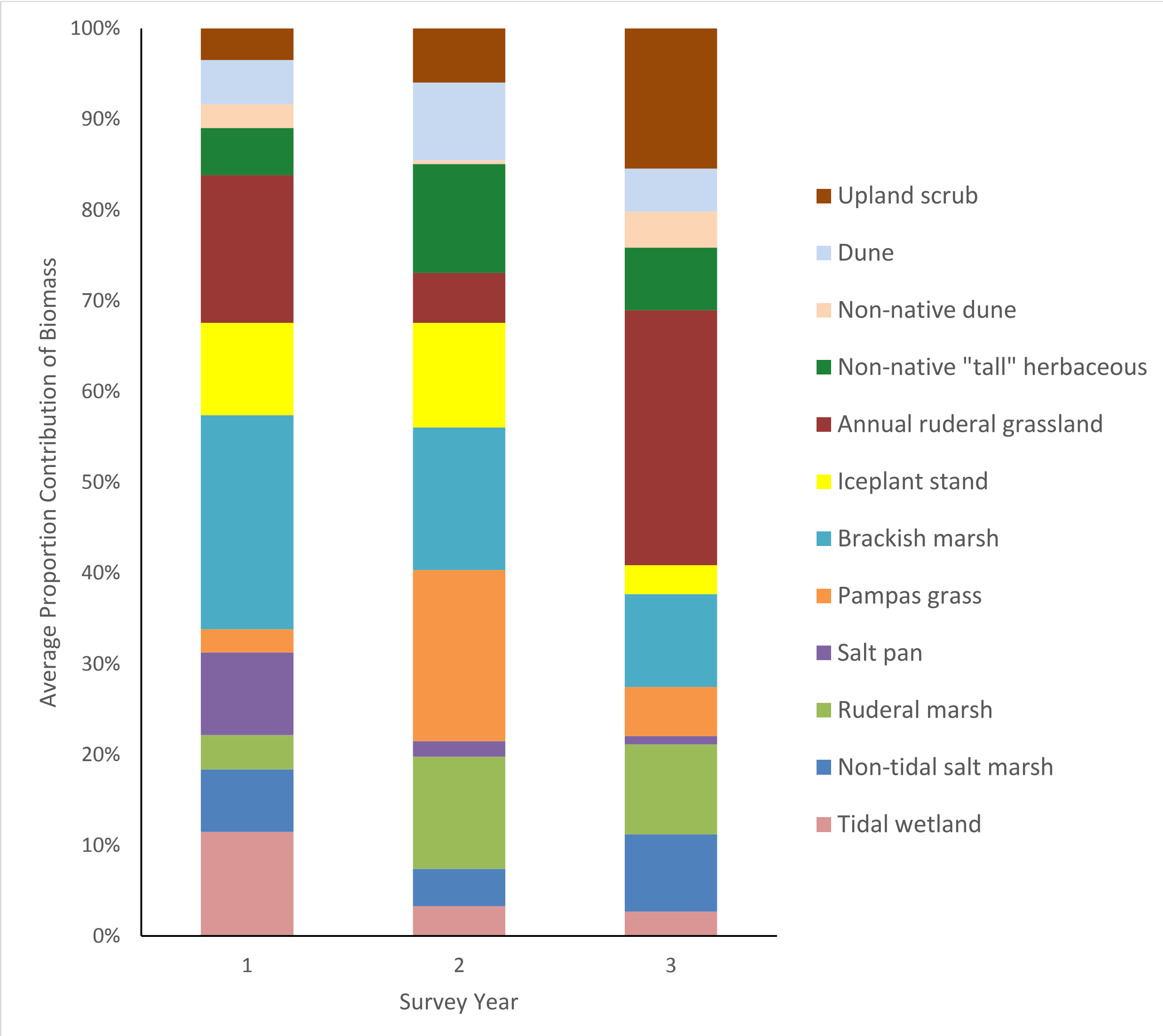
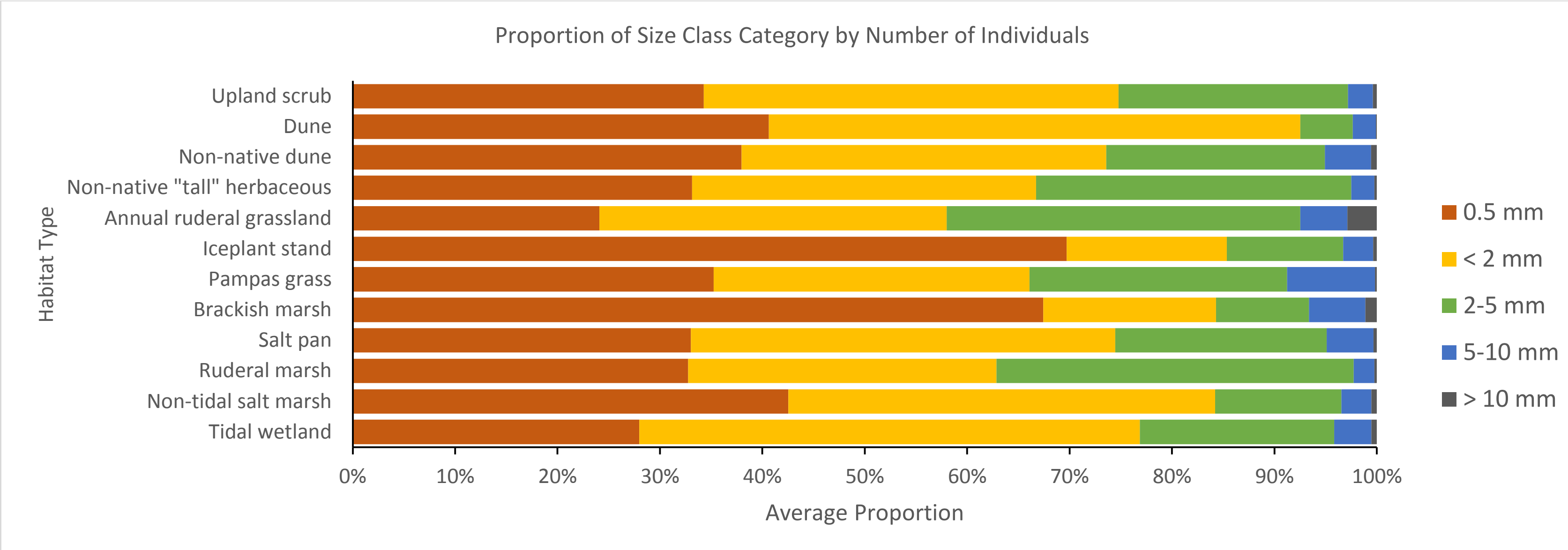


Figure 88. Relative proportion biomass contribution by percentage for each of the first three survey years for each habitat type surveyed.

Figure 89 displays the results from the biomass size class proportional analyses broken down by habitat type and averaged for all survey years across all habitat types. The top half of Figure 89 reflects the size class proportions based on the number of individual invertebrates in each size class, while the bottom half reflects the biomass proportion of each size class category by weight in grams. Weight was estimated using length-fresh weight regressions. These data suggest that some habitat types have a disproportionately higher number of individuals in the smaller size classes (e.g. iceplant stand and brackish marsh), while others (e.g. annual ruderal grassland) have a higher number of the largest size class category (i.e. "> 10 mm", top graph) contributing significantly to the overall biomass increase of that size class and the overall habitat type (Figure 89, bottom, and Figure 87).



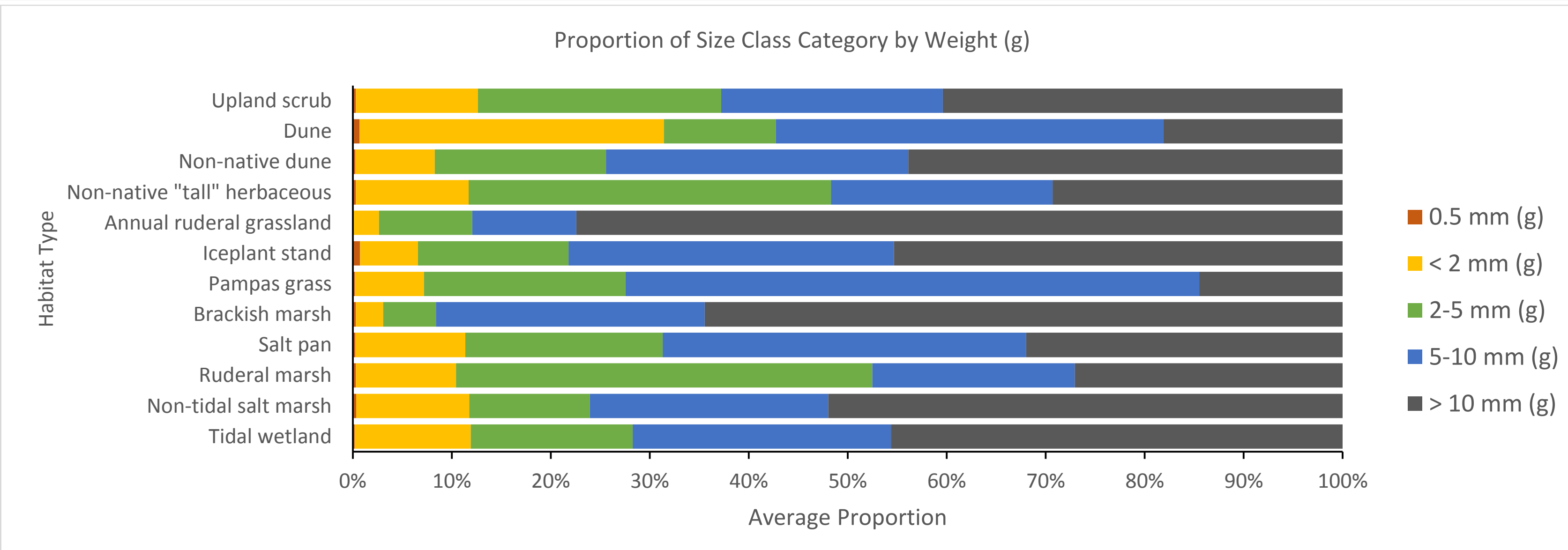


Figure 89. Aerial arthropod proportional size class category data organized by habitat type for number of individuals (top) and weight (g) (bottom).

Epigeal Pitfall Surveys

Over 9,000 individual epigeal (or surface) invertebrates (N = 9,257, Table 27) encompassing twenty-six orders (or the equivalent taxonomic level) were identified in the pitfall traps across ten habitat types in the Reserve across all survey years (Table 28a and 28b). One order, Araneae, was identified across all survey years and all habitat types. Coleoptera, Diptera, and Hymenoptera were identified in all habitat types in most years with the exception of one or two sightings. Several orders were only identified in one habitat type in one survey year (i.e. Neuroptera, Mantodea, and Megadrilacea). Many of the other orders were identified in every habitat type in multiple, but not all survey years (e.g. Acari, Collembola, Orthoptera).

Table 27. Total number of counted and identified individual invertebrates for all survey years by habitat type.

Habitat	Individual Specimen Count	Average Count per Transect
Tidal Wetland	4,370	437
Non-tidal Salt Marsh	1,511	137
Salt Pan	44	11
Pampas Grass	85	85
Iceplant Stand	75	38
Annual / Ruderal Grassland	337	337
Non-native "Tall" Herbaceous	1,116	223
Non-native Dune	241	121
Dune	902	301
Upland Scrub	576	576
Total	**9,257**	**231**

Figure 1 displays the relative abundance (average count per transect) of epigeal invertebrates sorted by order for each habitat type. The upland scrub and tidal wetland habitat types have the highest average number of invertebrates per transect overall (576 and 437, respectively; also Table 27) and the salt pan habitat type had the lowest (11). The tidal wetland habitat type was dominated by Amphipoda and many of the upland habitat types (e.g. upland scrub, pampas grass, dune) were dominated by Hymenoptera (Figure 90 and 91). The annual / ruderal grassland was dominated by Collembola, and the non-native dune by Coleoptera. Figures 90 and 91 display additional details for all orders by habitat type averaged across all years for relative abundance and relative percent composition of epigeal invertebrates. Additionally, high-resolution photographs were taken as part of the taxonomic identification of several high-quality individual specimens of each order with the objective of facilitating future identification through the development of an invertebrate identification guide. Several of these photographs by M. Wong Yau are represented here (Figures 92-95).

Table 28a. Pitfall invertebrate taxa present across all four survey years in each habitat type. Asterisk denotes non-spider taxon. Note: there were no transects completed in the "Iceplant Stand" habitat type in Year 1.

	Tidal Wetland				Non-tidal Salt Marsh				Salt Pan				Pampas Grass				Iceplant Stand		
Taxon	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**2**	**3**	**4**
Acari	X	X	X	X	X	X	X	X		X		X	X	X		X	X	X	X
Amphipoda	X	X	X	X	X	X	X	X					X	X					
Arachnida *	X	X	X	X	X	X													X
Araneae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Blattodea	X		X	X	X		X	X	X		X								X
Coleoptera	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X
Collembola	X	X	X	X	X	X	X	X			X	X	X	X	X	X		X	X
Dermaptera	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X
Diptera	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Embiidina	X			X	X			X										X	
Gastropoda	X	X	X	X	X	X	X						X	X					
Hemiptera	X	X	X	X	X	X	X	X	X		X	X	X			X	X	X	
Hymenoptera	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
Immature			X	X		X		X		X									X
Isopoda	X	X	X	X	X	X	X	X		X			X	X			X	X	
Lepidoptera	X	X	X	X	X	X	X	X	X	X	X		X						X
Mantodea							X												
Megadrilacea																		X	
Microcoryphia	X	X	X	X	X	X	X	X	X	X	X					X	X	X	X
Myriapoda						X								X				X	
Neuroptera																			
Opiliones							X												
Orthoptera	X	X	X	X	X	X	X	X			X		X			X	X	X	X
Psocodea	X	X	X	X	X		X	X	X	X		X	X			X			
Thysanoptera						X		X					X						
Zygentoma			X	X	X	X	X	X				X							
Count	18	16	19	20	19	19	19	19	10	11	11	10	15	11	4	9	9	14	13

Table 28b. Pitfall invertebrate taxa present across all four survey years in each habitat type. Asterisk denotes non-spider taxon. Note: there were no transects completed in the “Annual / Ruderal Grassland” habitat type in Year 1.

	Annual / Ruderal Grassland			Non-native "Tall" Herbaceous				Non-native Dune				Dune				Upland Scrub			
Taxon	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Acari	X	X	X	X		X	X			X	X		X	X	X			X	X
Amphipoda				X								X	X	X		X			
Arachnida *					X	X	X							X	X				
Araneae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Blattodea					X						X				X				
Coleoptera	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Collembola	X	X	X	X	X	X	X	X		X	X	X	X	X	X			X	X
Dermaptera		X	X	X	X	X	X	X	X	X	X	X		X	X				
Diptera	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Embiidina							X												
Gastropoda	X	X				X								X					
Hemiptera	X	X	X		X	X	X					X	X	X	X		X	X	X
Hymenoptera	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Immature			X			X	X												X
Isopoda		X	X	X	X	X	X			X	X	X	X	X	X		X	X	X
Lepidoptera				X		X	X		X				X	X	X			X	X
Mantodea																			
Megadrilacea																			
Microcoryphia	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Myriapoda					X						X		X	X	X				X
Neuroptera															X				
Opiliones		X																	
Orthoptera	X	X	X	X	X	X	X	X		X	X		X	X	X			X	X
Psocodea		X	X	X		X	X				X		X		X				X
Thysanoptera		X	X	X		X	X				X				X			X	
Zygentoma		X		X						X	X		X	X	X				
Count	10	16	14	15	13	17	17	8	7	11	15	10	15	17	19	4	7	12	14

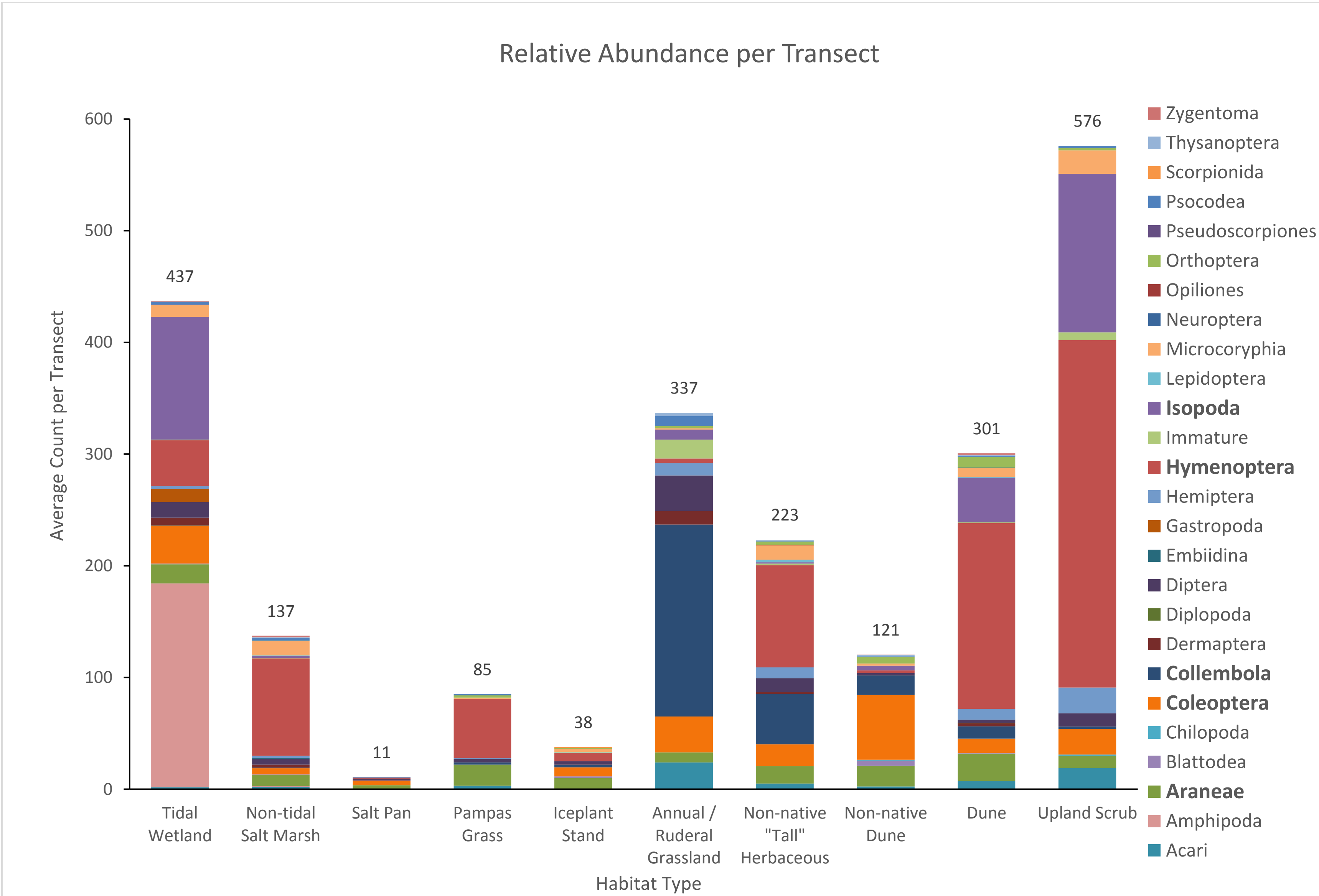


Figure 90. Relative abundance (average count per transect) of epigeal invertebrates sorted by order for each habitat type.

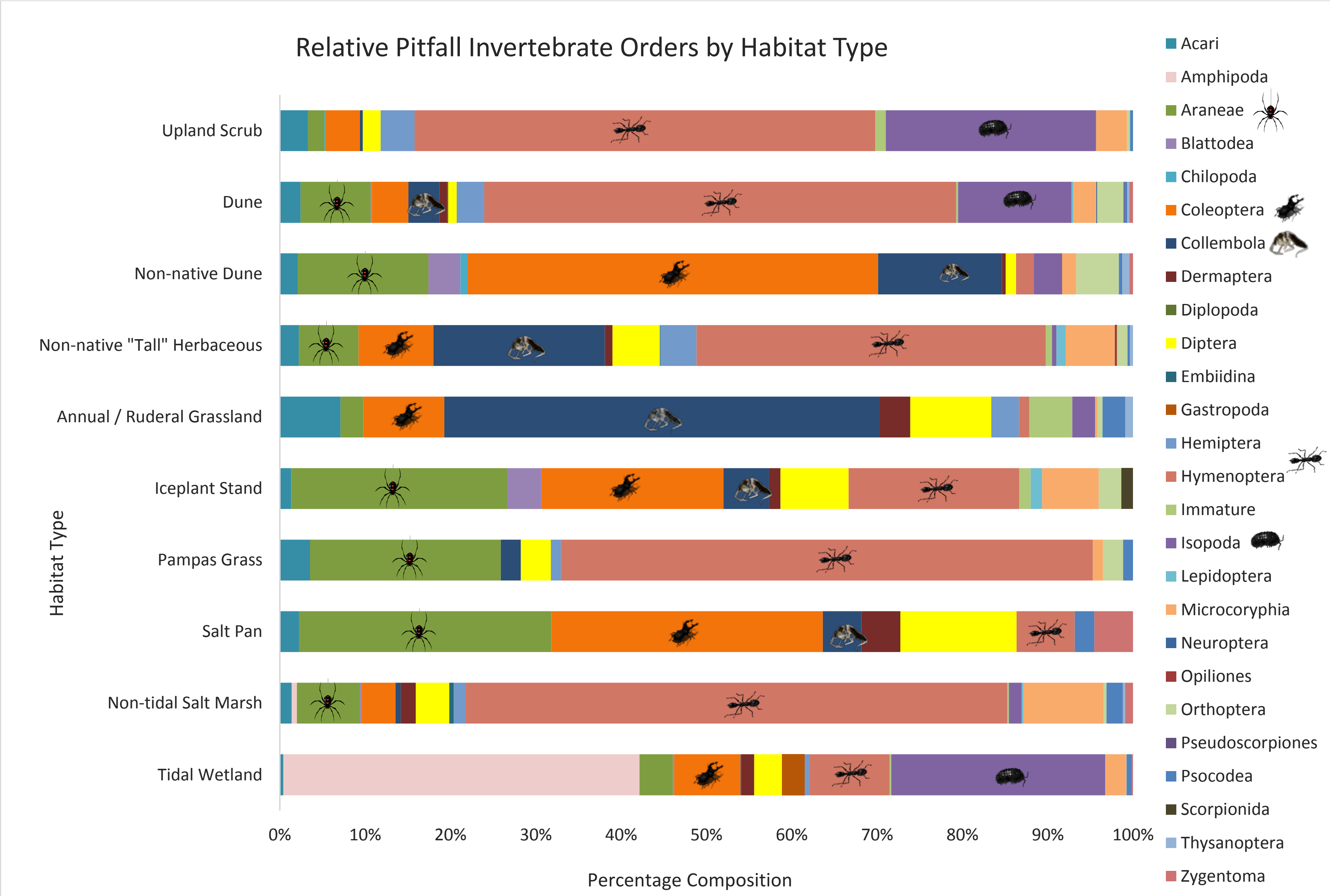


Figure 91. Relative pitfall invertebrate composition of orders by percentage for each habitat type surveyed.

Figure 92. Photo of order Coleoptera invertebrate as dorsal view (M. Wong Yau, 2014).

Figure 93. Photo of order Diptera invertebrate as lateral view (M. Wong Yau, 2014).

Figure 94. Photo of order Blattodea invertebrate as lateral view (M. Wong Yau, 2014).

Figure 95. Photo of order Blattodea invertebrate as ventral view (M. Wong Yau, 2014).

Lepidoptera Notes

ESBB have been identified annually at the Reserve during the appropriate survey time (i.e. late spring – summer) every year in the Friends of Ballona Wetlands (FBW) dune restoration area from 2011 through 2015. The population, although previously extirpated from the area, appears to now be fairly well established in the appropriate habitat for the species, i.e. *Eriogonum parvifolium* (coast buckwheat), due to restoration activities by FBW. All four life stages of ESBB depend on coast buckwheat; the adult stage typically ranges from four days to two weeks from approximately mid-June until early September (Psomas 2013). ESBB methods and data for detailed repeat surveys conducted in 2013 can be found in the memorandum: "Results of 2013 Presence/Absence Surveys for El Segundo Blue Butterfly at the Ballona Wetlands Ecological Reserve" (Psomas 2013).

Starting in 2010 and annually thereafter, visual observations were made of monarch butterflies overwintering in the eucalyptus grove in the southwestern portion of Area B. They were confirmed as present between 2010 and 2014; surveys were not conducted in 2015, but they are assumed present. Additionally, ancillary observations of the wandering skipper and monarch butterfly were visually confirmed in the marsh habitats of western Area B during vegetation surveys.

5-Year Summary Conclusions

Both the aerial arthropod and pitfall invertebrate sampling methods produced highly variable results leading to some habitat-level overarching patterns and trends. However, additional taxa-specific data analyses could be performed by qualified invertebrate taxonomists in the future to further analyze the data. Additionally, sampling design factored into the final analyses, primarily in the form of higher variability when the number of transects surveyed for a particular habitat was only one or two, repeated annually. New vegetation and habitat mapping in 2013 reflected more recent, accurate habitat types; however, this shifted the sampling design such that some habitat types only had one or two transects evaluated. Thus those results may not be reflective of the actual average invertebrate biomass or density within that habitat type across the whole Reserve.

The relative abundances of specimens from one order or taxon in respect to others were found to vary considerably by habitat type. Although different taxa were found to be more prevalent in specific habitats, consistent with their life histories, some groups – such as the Argentine ants (*Linepithema humile*), an aggressive invader – were found to have a strong presence across the Reserve regardless of the habitat type in which they were collected. With more specific analyses, diversity, abundance, and distribution of different taxa may serve as an indication of their fitness and the state of the environment. Furthermore, monitoring arthropod diversity and their abundances may serve as a metric for degradation and the progress made by conservation efforts in the area.

Information and data regarding the Lepidoptera notes were reported to the DEIR/S consultant team. For additional details on special status invertebrates, refer to the first two baseline reports and the upcoming Draft Environmental Impact Report/Statement for the Ballona Wetlands Restoration Project.

Physical Characteristics

Introduction

Many of the biological and chemical processes that occur in wetlands are driven by the physical and hydrologic characteristics of the site (Nordby and Zedler 1991, Williams and Zedler 1999, Zedler 2001). Physical surveys of hydrology, topography, and tidal inundation regimes (Zedler 2001, PWA 2006) can be used to assess temporal changes to a site, including erosion and sedimentation over time. The goals of the physical subsections of this report were to determine average elevations within specific habitat types, analyze a 10-foot Digital Elevation Model (DEM) including site-wide cross-sections, survey Area B topographic channel cross-sections, and identify the aerial extent of inundation within the Area B muted tidal habitat types, including a separate evaluation of the salt pan habitat type.

Physical Characteristics: Elevation

Methods

The 2006 U.S. Geological Survey (USGS) 10-foot Digital Elevation Model (DEM) was analyzed in ArcMap 10.3 Geographic Information Systems (GIS) software to characterize general landscape level elevation and derive site-wide cross-sectional profiles. Additionally, on-the-ground elevation surveys were completed on the same subset of vegetation transects used for soil, terrestrial invertebrates, and seed bank surveys (Figure 96; see Ch. 4, Vegetation, Johnston et al. 2011). The surveys used USGS benchmarks provided by the City of Los Angeles (Bureau of Engineering) and other published benchmarks and included measurements every five meters along each 25-meter transect, for a total of five elevation points per transect. Benchmark leveling (vertical control survey) was conducted using a Trimble GPS, tilting level, a tripod and No. 1 SK rod (ft), 10ths and 100ths. Elevation was averaged by transect and then again by habitat type; therefore, habitat type averages are grand means. For details regarding the functionality of the self-regulating tide gates along the Ballona Creek levee in Area B, refer to Chapter 11 of the first year Baseline Report (Johnston et al. 2011).

Figure 96. Photograph of engineering students doing an elevation survey in upland habitat types.

Results

Five landscape scale elevation profiles were extracted from the 2006 USGS 10-ft DEM dataset (Figure 97 to represent general topological variation and features within BWER (Figures 98-102). Note the variable x-axis and y-axis distance and elevation ranges, respectively, in each graph. DEM cross-section 1 shows the varying topography over the tidal wetland in Area B, with the dunes to the west followed by the west, main, and branch channels, the salt pan and a gas company road and berms to the east. DEM cross-section 2 represents a west to east profile of Area A starting at the Fiji Ditch and ending at the northern edge of the Ballona Creek levee. Aside from the pronounced difference in elevation observed with the Fiji Ditch, a gradual depression can be seen in the central Area A ruderal marsh habitat. DEM cross-section 3 represents a 1000-ft profile centered across the Ballona Creek Channel and clearly shows the difference in elevation of Area A and Area B-tidal wetlands. DEM cross-section 4, spanning north to south in Area B, distinguishes man-made structures including the south Ballona Creek levee, Culver and Jefferson Blvd, followed by a drop in elevation encompassing the non-tidal salt marsh of Area B. DEM cross-section 5 shows a north to south elevation profile of Area C that features Culver Blvd and installed baseball fields.

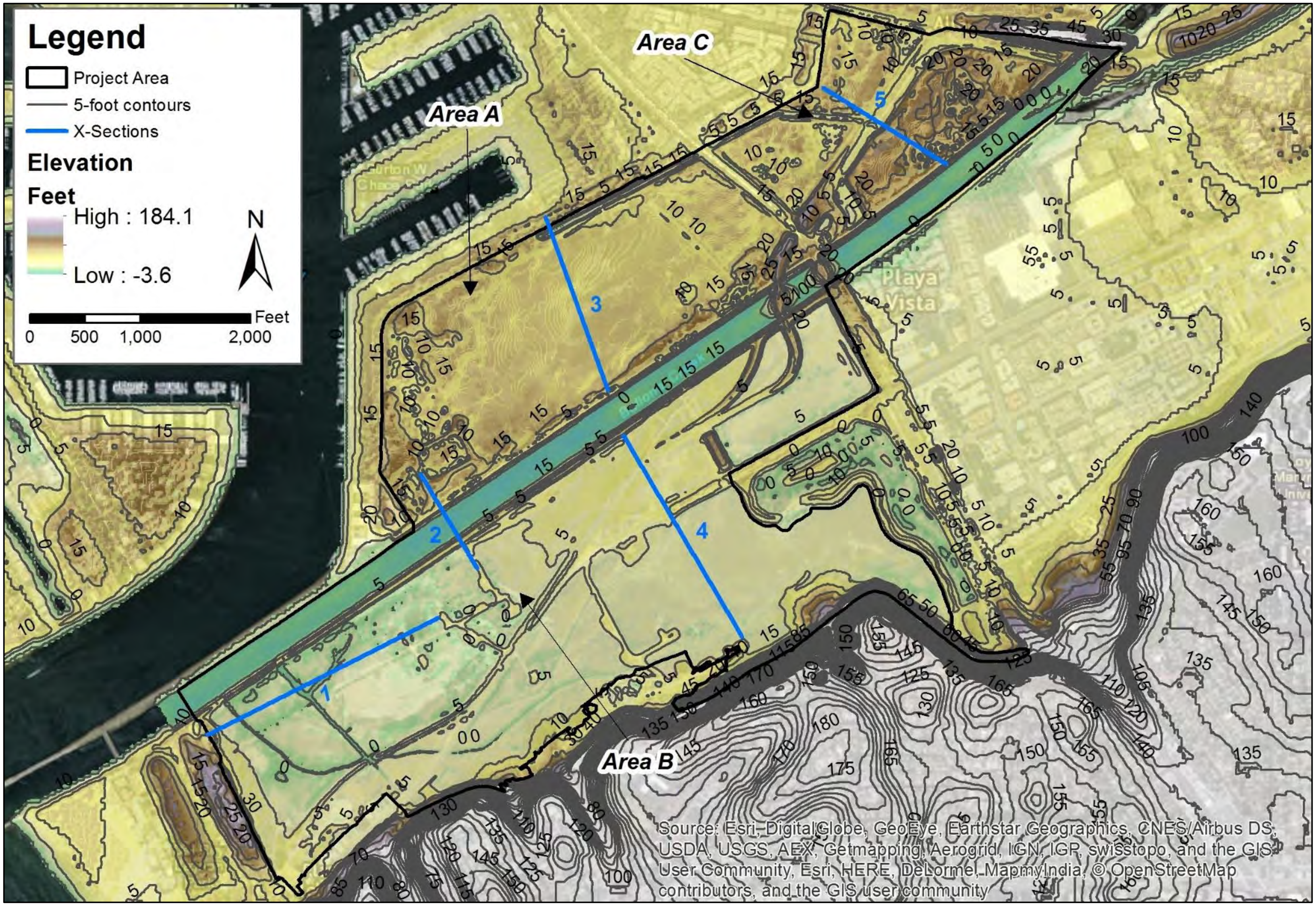


Figure 97. 2006 U.S. Geological Survey 10-foot Digital Elevation Model (DEM) modified in ArcMap 10.3.

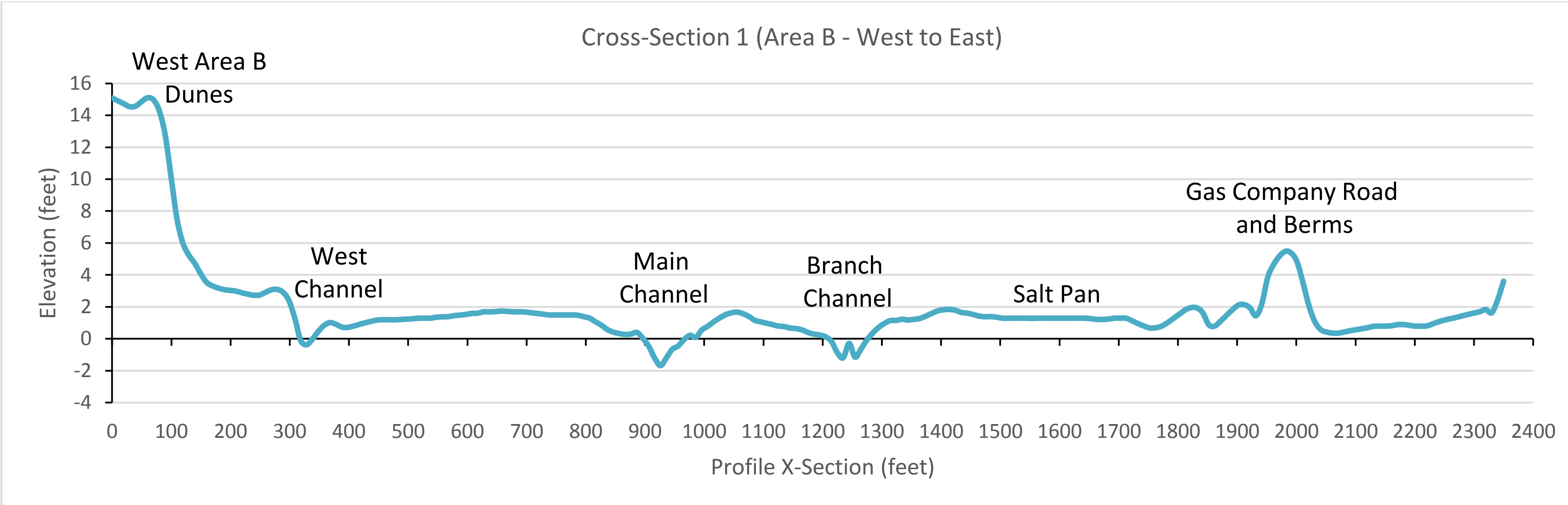


Figure 98. Cross-section 1 – Area B (West to East).

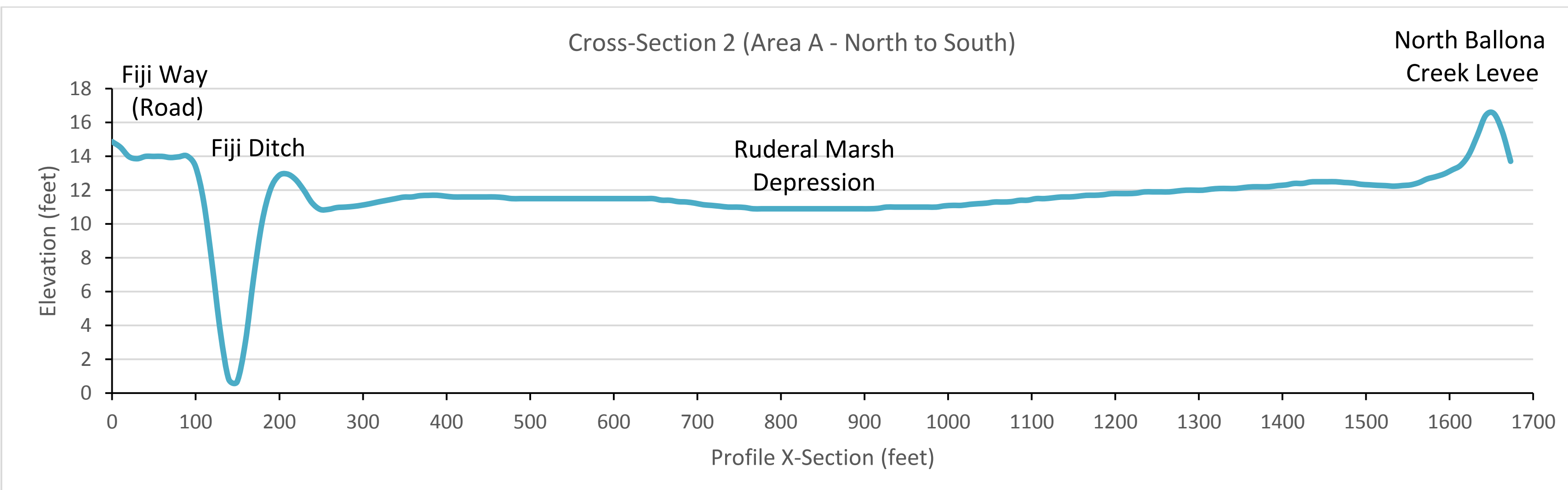


Figure 99. Cross-section 2 – Area A (North to South).

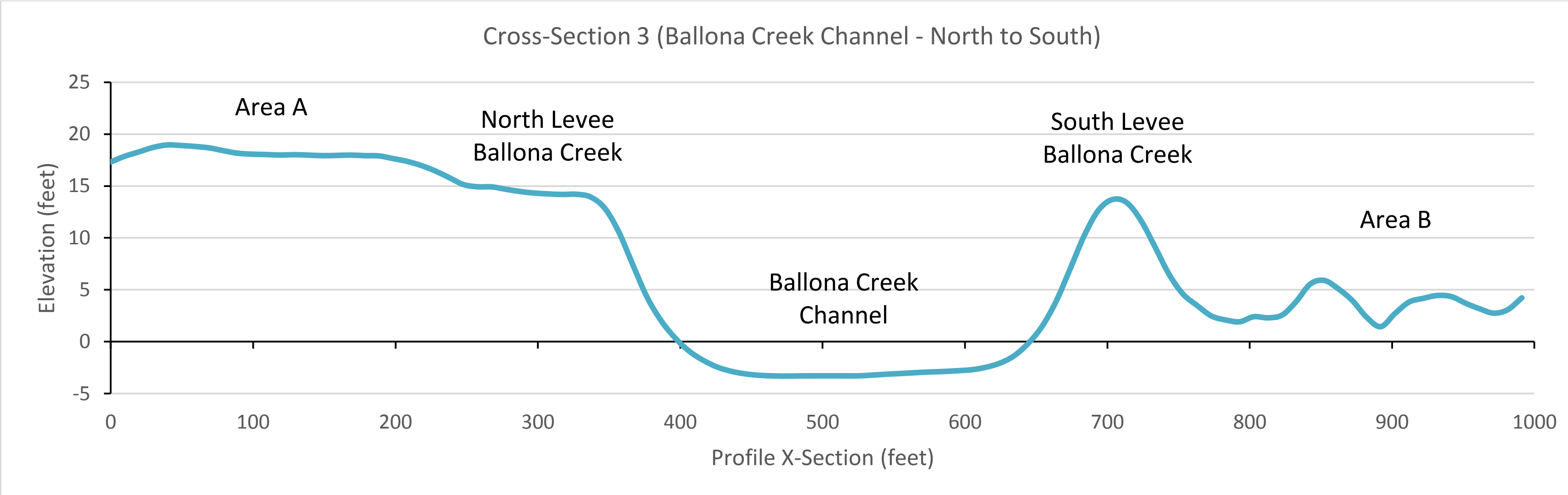


Figure 100. Cross-section 3 – Ballona Creek Channel (North to South).

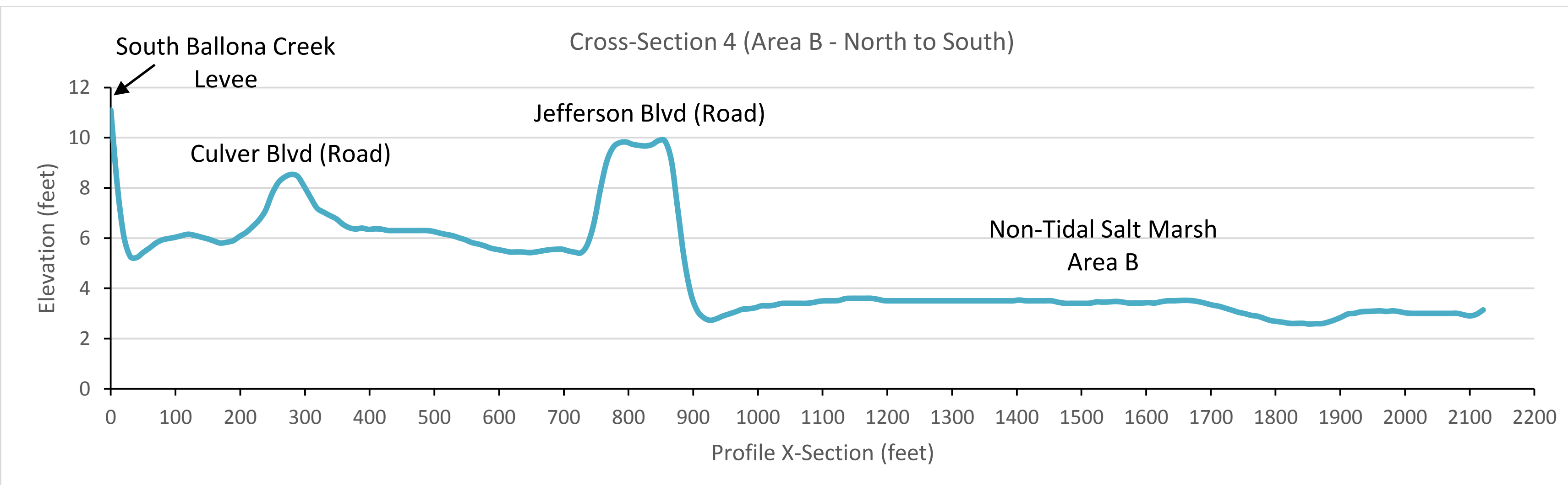


Figure 101. Cross-section 4 – Area B (North to South).

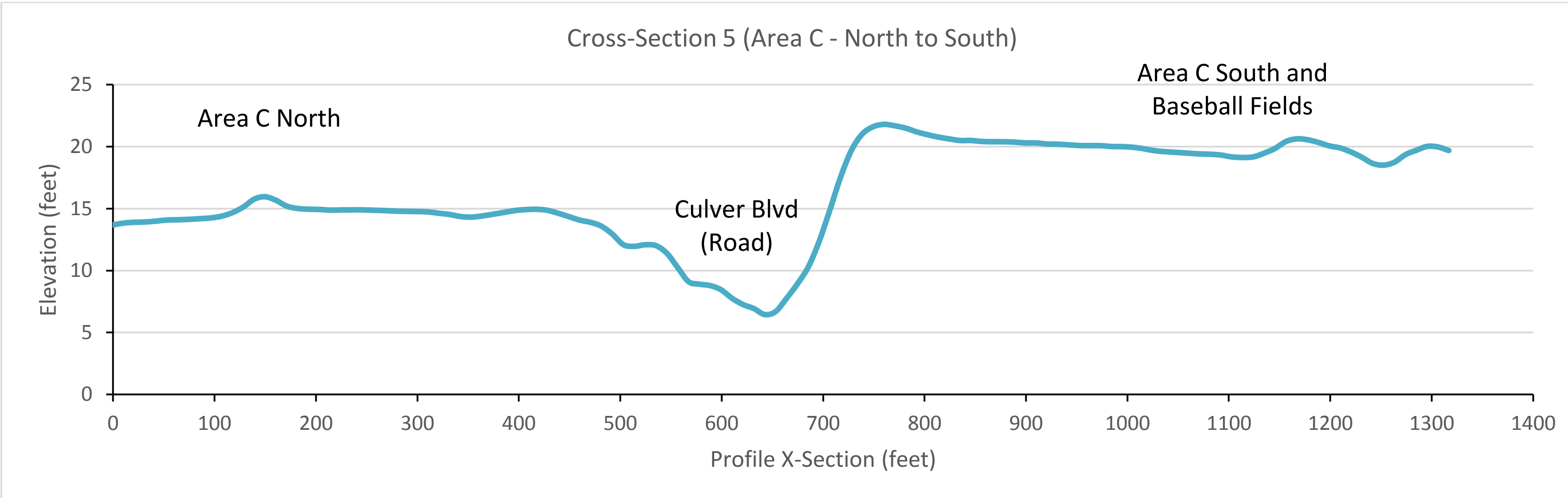


Figure 102. Cross-section 1 – Area C (North to South).

As expected, the upland habitat types had higher overall average elevations than did the marsh habitat types when assessed by transect averages (Figure 103). However, the tidal wetland (5.49 ± 0.23 ft) habitat had approximately the same average elevation as the non-tidal salt marsh (5.10 ± 0.55 ft), and salt pan (5.65 ± 0.72 ft) (Figure 103). Habitats were defined primarily by vegetation alliances based on the 2013 habitat and alliance/association mapping efforts (Medel et al. 2014). The error, or variation between transects, was the highest in the iceplant stand, dune, non-native dune, and brackish marsh habitats.

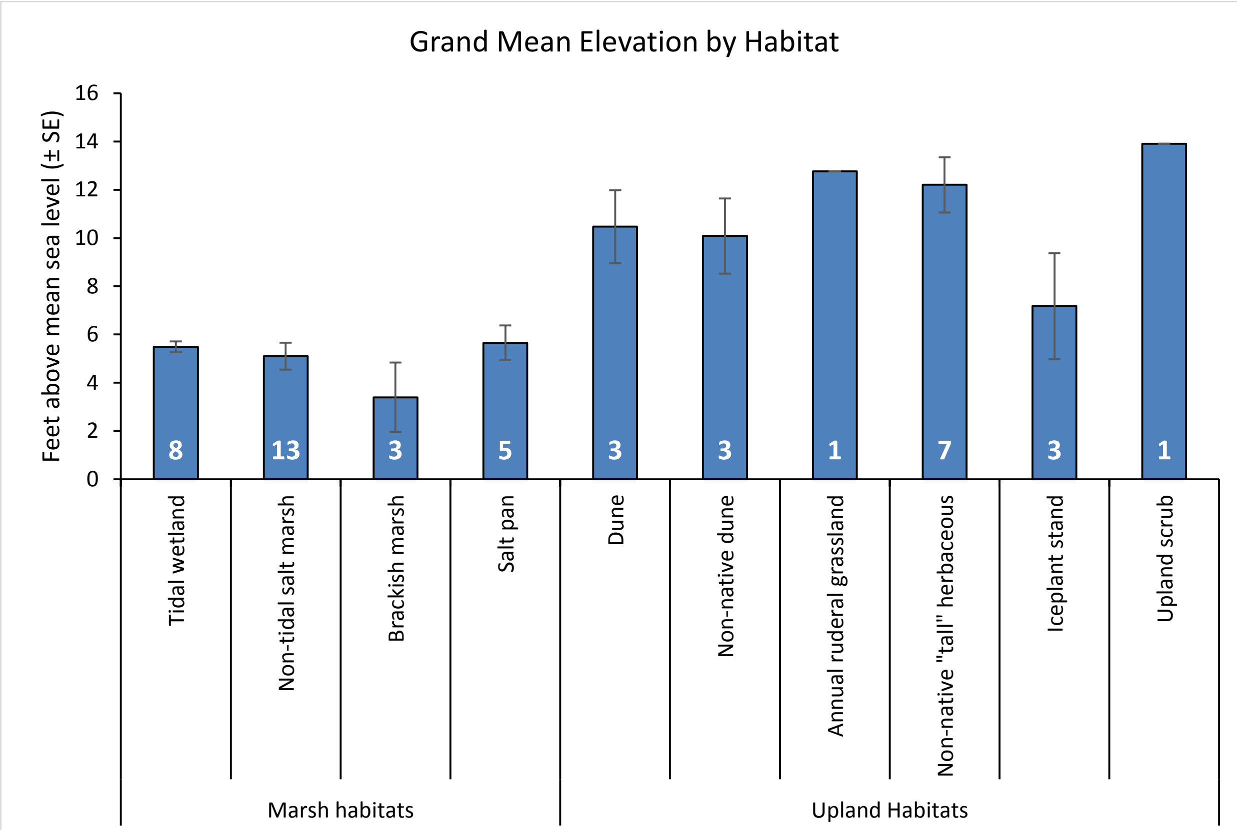


Figure 103. Grand mean elevation (m) by habitat type. Numbers inside bars indicate the number of transects surveyed per habitat type.

5-Year Summary Conclusions

Habitat-level elevation assessments indicate that while the contrast between upland and marsh habitat elevations follows predictable patterns, historic hydrologic impacts to the Reserve have resulted in atypical results within marsh habitat elevations. Hydrologic impacts (e.g. levees, tide gates) within marsh habitats have resulted in similar elevation values between the tidal wetland and salt pan habitats in contrast to a predicted result of slightly higher elevations within salt pan areas. However, similarities between tidal wetlands and non-tidal salt marsh areas were expected as they were once contiguous portions of a larger salt marsh system and have only become separate habitat types as a result of the tidal disconnection from non-tidal salt marsh areas by roads and levees. Evaluations of the site-wide cross-sections and DEM analyses produced similar results, showing areas of historic fill placement and a wide variety of impacts to the original wetland elevation soils.

Physical Characteristics: Channel Cross-Sections

Methods

Channel cross-sections were surveyed within the tidal channels of Area B and the Fiji Ditch during the summer of 2011 on a subset of the same permanent survey locations from a survey conducted in 2006 (PWA 2006). A survey tape was attached to station endpoint pins on the right and left banks and stretched taut. Using a level transit and stadia rod, measurements were taken every 50 cm and at every break in slope. Distance and elevation data were recorded on a datasheet. Elevation data were surveyed in the National Geodetic Vertical Datum of 1988 (NAVD88). The main channel was periodically re-surveyed using the same methods by engineering students from LMU. For additional details on cross-section data from the Reserve, refer to the second baseline report and the upcoming Draft Environmental Impact Report/Statement for the Ballona Wetlands Restoration Project.

5-Year Summary Conclusions

In general, channel cross-sections within the Reserve remained relatively stable across years with the exception of a slight widening within higher tidal energy environments (e.g. adjacent to the main tide gate) as the result of bank undercutting and sloughs. The cross-section surveys showed steep channel banks often surrounded by an upland berm (Figure 104). Individual cross-sections varied based on location, but all expressed a similar overall pattern. Channel cross-sections were not representative of the classic shallow sloped profile exhibited by more natural or reference wetlands. The steep banks and channel bank berms restrict floodplain inundation by confining tidal waters to the channels and eliminating the vertical zonation of vegetation from most of the adjacent areas.

Figure 104. Photograph from inside the main (eastern) tidal channel in Area B (5 February 2014).

Physical Characteristics: Inundation

Methods

The objective of the inundation surveys was to determine maximum areal extent of tidal inundation on a king (high spring) tide. The inundation extent of a 7.0 and 6.9 ft king tide was tracked with a submeter Trimble GeoXH handheld unit within Area B on 3 and 4 December 2013, respectively. The surveys were implemented immediately following a rain event when soils were already at maximum saturation and were unlikely to quickly absorb and infiltrate incoming tidal waters. The combination of large tides and pre-saturated conditions resulted in an ideal setting to assess maximum tidal inundation. An additional evaluation of stormwater ponding in the salt pan habitat areas through a Google Earth photograph assessment was conducted.

Results

King tides inundated 15.07 acres of intertidal channel, tidal wetland, and salt pan habitats. Figure 105 identifies the maximum extent of inundation captured during the surveys. The percent cover of *S. pacifica, J. carnosa*, and two physical habitat types (i.e. tidal channels and salt pan) within the maximum inundation area is displayed in Figure 106. 15.07 acres inundated approximately 53% *S. pacifica*, 21% tidal channel, 20% salt pan, and 2% *J. carnosa*. Other vegetation types were also present but encompassed less than 1% of the overall inundated area.

Figure 105. Map displaying the maximum tidal extent observed in Area B on December 3rd and 4th, 2013.

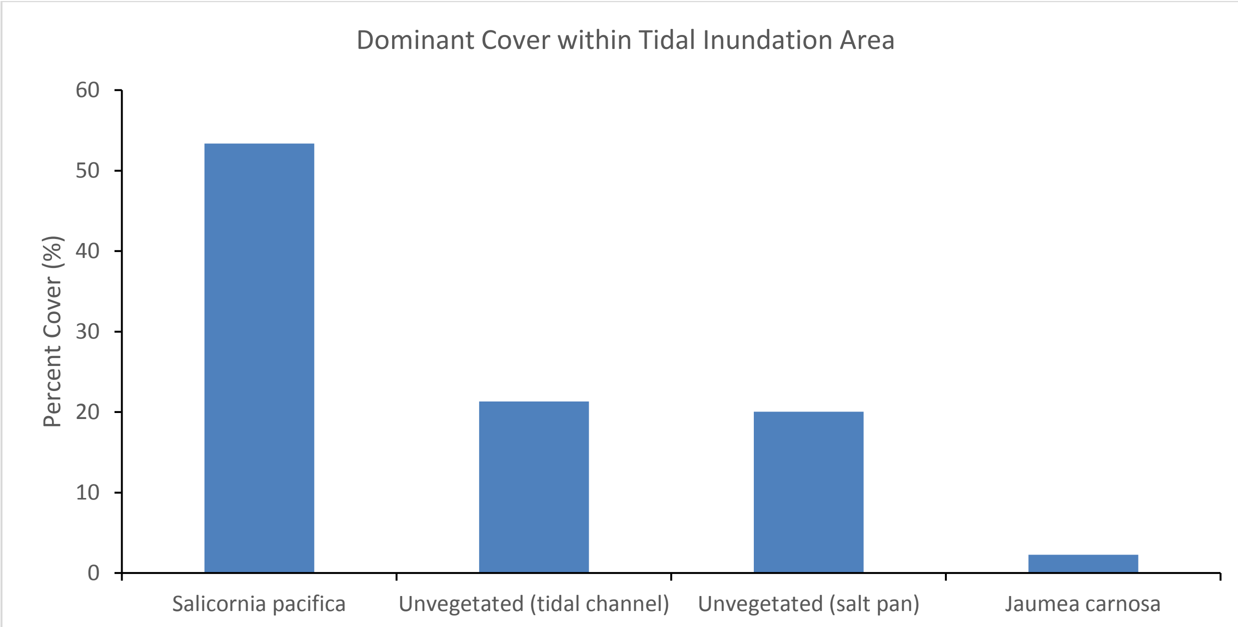


Figure 106. Approximate cover of vegetation polygons and habitat types within the inundated area.

Based on an assessment of historical Google Earth aerial images from 2002 – 2014, stormwater ponding occurred in approximately 33% of the salt pan habitat at the BWER, or between 7-8 acres, depending on the year of assessment. A baseline extent of ponding was digitized using a high resolution aerial image from 3 March 2011 with ideal water-to-land contrast and captured at an optimal time of year to portray ponding. Additional aerial images were incorporated into the analysis to capture the maximum potential extent of ponding, including an image captured on 27 July 2008 which displayed significant ponding atypical for that time of year. Additional images were evaluated, but were not incorporated into the analysis due to a lack of visible ponding, no new areas of ponding, or poor image quality (Table 29). This method was used as a proxy for maximum stormwater ponding acreage extent over time as seasonal and annual variations were high.

Three acres of the salt pan habitat, or approximately 13% of the total salt pan acreage at the site, were observed to be inundated tidally on walking surveys conducted using a sub-meter GPS during a 7.0 and 6.9 king tide on 3 and 4 December 2013, respectively (Figure 107).

Table 29. Dates of Google Earth aerial images evaluated for the stormwater ponding acreages.

Dates Included	Dates Not Included
12/30/2002	3/5/2002
4/24/2007	11/2/2005
7/27/2008	3/15/2006
11/14/2009	7/30/2007
3/7/2011	4/26/2011
12/10/2013	8/26/2012
----	10/13/2012

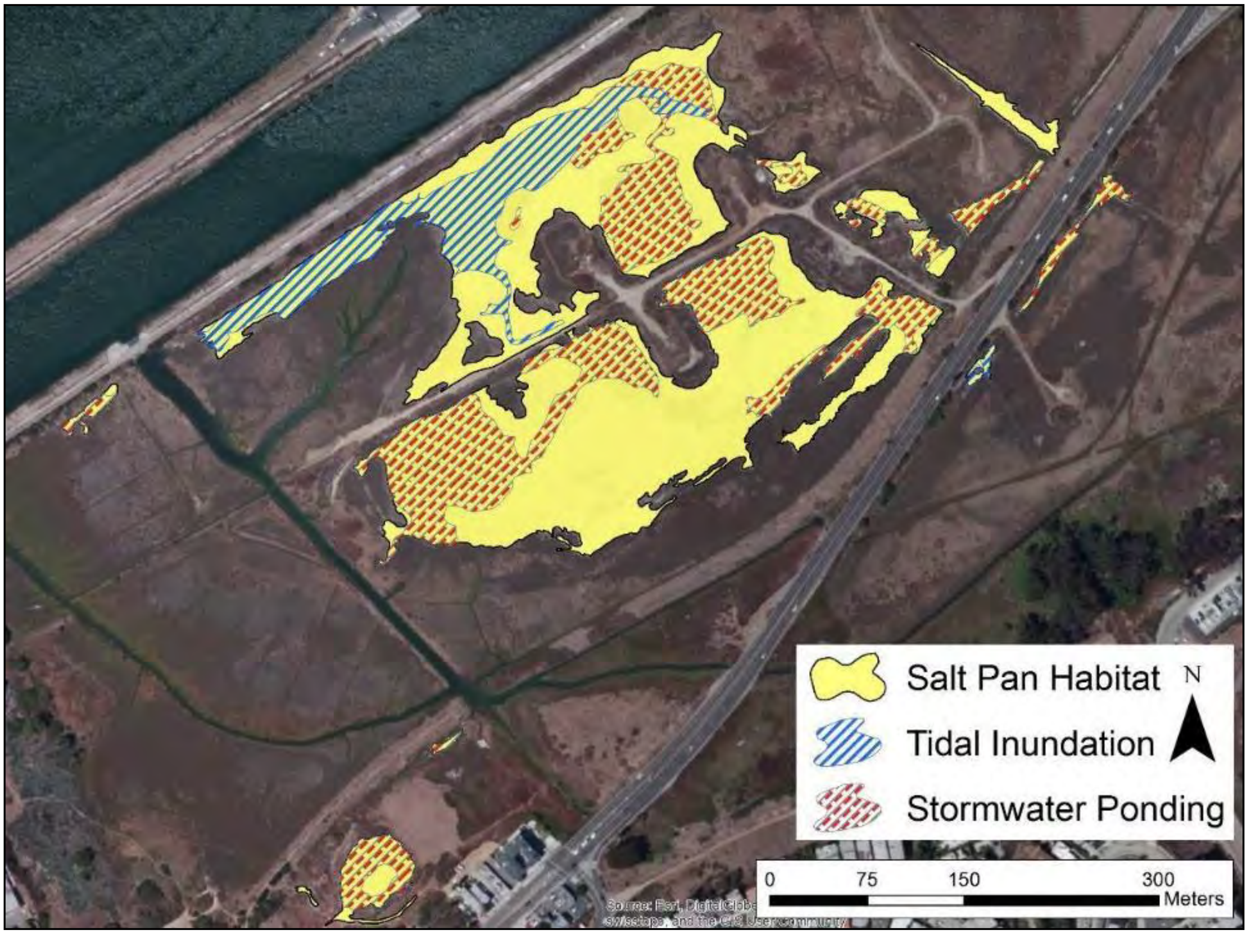


Figure 107. Map of salt pan habitat (yellow), and the tidal inundation extent (blue stripes) and stormwater ponding extent (red dashes) within salt pan habitat in the BWER.

5-Year Summary Conclusions

While the inundation surveys captured the maximum extent of tidal inundation within Area B, inundation from a neap tide would cover a much smaller area. The large areas within the salt pan and south of Culver Boulevard do not normally receive extensive tidal inundation except for occasional king tides (very large spring tide events).

Final Conclusions

In the Los Angeles region, over 96% and 98% of the vegetated and unvegetated coastal estuarine wetlands, respectively, have been lost over the past century and a half; this loss is mainly attributed to conversion of wetland habitat to uplands through fill deposition or development (Stein et al. 2014). The Ballona Wetlands Ecological Reserve (Reserve) is an example of this phenomenon, having suffered from over a century of abuse and land degradation (Shreiber et al. 1981). Historically a bar-built estuary of over 2,100 acres (Grossinger 2010, Dark et al. 2011), the original Ballona Wetlands ecosystem included a variety of habitats, dominated by vegetated wetland and salt pan habitat types (Grossinger et al. 2010). Currently, the Reserve has been reduced in size to less than 600 acres of open space and only approximately one quarter of the site, (153 acres), is considered delineated wetland. Only a small portion of the remaining wetland habitats are still exposed to tidal influence, including approximately 15 acres at the western edge of the Reserve and the Fiji Ditch in Area A. The Reserve is the largest opportunity for significant coastal wetland restoration in the Los Angeles region; the goal of these surveys, this report, and related technical reports and memoranda was to provide accurate scientific data to aid in restoration planning efforts by CDFW.

Several clear conclusions emerge based on more than five years of data collection at the Reserve, literature reviews of previous site evaluations, and input from scientists throughout California. As no significant management actions (e.g. full-scale restoration, tide gate modifications) occurred within the sampling period, these results are likely indicative of long-term trends until significant restoration commences. Ultimately, these data serve as a pre-restoration baseline assessment of the condition of the site; they could be compared to post-restoration data in the future to evaluate the change in wetland condition as a result of management actions.

Firstly, both the Level 2 and Level 3 data corroborate that the Reserve is experiencing slowly deteriorating conditions across most of the areas hydrologically disconnected from tidal influence. This disconnection due to the presence of the Ballona Creek levees, in combination with the substantial amount of fill placement, are generally agreed upon as the most significant negative impacts to the historic wetlands. Perpetual impairments caused by the modifications include the continued influx of non-native and invasive vegetation and a lack of connection to estuarine water sources. Based on the wetland condition assessments, Area A, Area B – ruderal, and Area B – north were the most degraded sub-areas on site. Despite the fact that some delineated wetland habitat types still exist in these areas, they received extremely low condition scores, comparable with the lowest publically recorded scores in the state of California (www.cramwetlands.org, accessed August 2015).

Conversely, the tidal channels and salt marsh habitats in the western portion of Area B received the highest relative condition scores and were dominated primarily by native vegetation. These areas and several portions of the non-tidal salt marsh habitat areas have retained several of the functions of a relatively healthy estuarine marsh system, including water quality improvements, habitat for several rare species, and muted hydrological connectivity. The presence of native salt marsh species in this area can be attributed to the installation and maintenance of tide gates allowing muted tidal inflow to the western channels and subsequent outflow.

The following subsections summarize conclusions from each of the broader Level 3, site-intensive, surveys, including: water and sediment quality, biological communities – vegetation, biological communities – fauna, and physical characteristics, respectively. For an evaluation of the condition of the Reserve in the context of a larger, regional monitoring program, refer to conclusions in the "Regional Monitoring Report for Southern California Coastal Wetlands" (Johnston et al. 2015c).

Water and Sediment Quality

Although the Reserve has been largely cut off from its historic water supply, the small portion of the Reserve still experiencing tidal influence produced highly variable water quality results. Levels of FIB, nutrients, general water quality parameters, and constituents of concern were found to vary, sometimes up to several orders of magnitude, both temporally and spatially. This variability was evident not only on the smallest temporal scales evaluated, i.e. single tidal cycles, but also on larger scales, i.e. monthly or annual surveys. Importantly, however, evaluations of the overall water quality data as a whole showed a consistent lack of eutrophication. Eutrophication is a problem for estuaries as it often leads to excess algal growth and subsequent anoxia. Low dissolved oxygen levels (i.e. < 1mg/L) occurred less than approximately two percent of the time across all monitoring years (2010-2014) at the permanent sonde located within the main tidal channel. This indicated that tidal energies within the muted Area B tidal channels were sufficient to promote a well-mixed water column, and dissolved oxygen levels were generally capable of supporting benthic invertebrate and fish populations. Both the fish and invertebrate data support this analysis.

Contaminated FIB input to the tidal portions of the Reserve occurs from both Marina del Rey (to the Fiji Ditch only) and from Ballona Creek (to the tidal channels of Area B). However, baseline monitoring data from these and additional studies (e.g. Dorsey 2006, Dorsey et al. 2010, Johnston et al. 2011, 2012, 2015a) suggest that the wetlands are largely acting as a sink for FIB. Overall FIB concentrations in the estuary (Ballona Creek) were typically greater than those in the wetlands (Johnston et al. 2015). This shows that the tidal wetlands at the Reserve provide a significant ecosystem service in the form of water purification, even in a degraded state. Additionally, significant stratification of both FIB concentrations and loading occurred in the water column during all but the most highly-mixed portions of the tidal cycle. Loading was found to be greatest during flood flows from the contaminated estuary waters and diminished during low tide periods (Johnston et al. 2015a).

While exceedances of water quality thresholds from varying constituents of concern are common in urban environments, especially during wet weather sampling events, wetland vegetation species often provide significant water quality services, including reductions of heavy metals (Brown et al. 2012). More data are needed to thoroughly evaluate the specific water quality benefits of the tidal areas of the Reserve for constituents other than FIB, but it is likely they are performing similar functions. Similarly, soil and sediment data should be further analyzed, especially from deep cores, to evaluate the placement of fill and dredge spoils in the restoration process.

Biological Communities – Vegetation

In general, habitat-level results from throughout the monitoring program displayed predominately native vegetation within saline influenced areas, i.e. tidal wetland, non-tidal salt marsh, and brackish marsh. Conversely, areas impacted by historic fill placements displayed predominately non-native or invasive vegetation cover, e.g. non-native "tall" herbaceous, annual ruderal grassland. Areas with more freshwater input were a mix of non-native (e.g. pampas grass) and native (e.g. mulefat) vegetation.

Trends identified from the two site-wide vegetation mapping years (i.e. 2007 and 2013) were generally descriptive of change across the Reserve. Non-native plants continued to invade areas disconnected from tidal influence, which was visualized in both the non-native habitat area maps and the non-native vegetation alliance data. Fourteen acres of formerly native non-tidal salt marsh converted to 'ruderal' marsh and monocultures of invasive vegetation species. One of the most significant invading vegetation species within higher elevation areas, *Brassica nigra* (black mustard), grew profusely between the survey years, and it produces allelopathic chemicals that prevents germination of native plant seeds (Holloran et al. 2004). Areas with the largest historic fill impacts displayed the most drastic habitat transformations. Some changes, such as the relatively small increase in acreage of pampas grass, should still be evaluated carefully as that particular species is very difficult to extirpate.

Seed bank results reflected a pattern of vegetation nativity similar to that of the mature vegetation identified on both transect percent cover and mapping surveys. The seed bank of transects surveyed in the tidal wetland habitat type was predominantly native, with approximately five times as many native germinated seedlings on average than non-native. The nativity of seedlings shifted to predominantly non-native for habitat types with restricted or absent tidal hydrology (i.e. non-tidal salt marsh and ruderal marsh). These analyses support conclusions that the germinated seed bank at the Reserve is highly spatially variable, and dominated by a few native species in the tidal habitats and non-native annual grasses in the non-tidal and ruderal wetland habitat types.

There are several rare vegetation species present in the Reserve, primarily within the dune habitat type. Rare species-level analyses will be included in the upcoming Draft Environmental Impact Report/Statement for the Ballona Wetlands Restoration Project.

Biological Communities – Fauna

The Ballona Wetlands region and the Reserve have suffered a decline in native vertebrate populations, a reduction in species' ranges, and an increase in the types and population sizes of introduced species throughout the last century (Friesen et al. 1981). Comprehensive faunal surveys were imperative to inform the restoration process by identifying species present within the Reserve and establishing ranges.

Ichthyofauna

Overall, the muted nature of the tides allows several typical coastal estuarine fish species of southern California to access the tide channels of Area B and the Fiji Ditch, but prevents them from accessing and foraging the upper marsh plain habitats; therefore, the muted tides do not support the same fish nursery functions as a fully tidal system. Such habitat restrictions may impact the overall diversity and abundance of fish species; however, fish species commonly found during the monitoring program, such as topsmelt, California killifish, and arrow gobies, are representative of southern California estuarine marsh systems (Miller and Lea 1972, Moyle et al. 1995, Allen et al. 2006). All stations within the Reserve had relatively similar species richness, although the round stingray was found exclusively in the Fiji Ditch and juvenile diamond turbot were found exclusively in the western Area B tide channel stations.

Herpetofauna

Several reptile species were ubiquitous throughout the Reserve, especially in the non-tidal habitats, and across all five survey years, including five reptiles found on almost every survey (i.e. Great Basin fence lizard, Western side-blotched lizard, San Diego alligator lizard, San Diego gopher snake, and California kingsnake). Several rare herpetofauna species were also identified as present at the Reserve including garden slender salamander, San Bernardino ring-necked snake, and California legless lizard, thus providing specific species-level data to inform restoration planning.

Relative herpetofauna abundances from cover board array surveys within the Reserve were not possible. Seasonal differences affect overall numbers of herpetofauna species, especially due to the need for precipitation events to perform an accurate survey using the cover board method, but an additional reason was the presence of illegal poaching activities on site. The cover board surveys at the Reserve have been affected strongly by trespassers both through removal of kingsnakes and by disrupting the boards (Marsh and Goicochea 2003). Until illegal activities cease, these data will not be comparable to other areas.

Mammals

Data collected from both motion cameras and Sherman live traps provided a general idea of species-specific mammal usage of different areas of the Reserve. Several mammalian species were fairly ubiquitous throughout the site, including western harvest mice, cottontail rabbits, coyotes, and trespassing humans. The highest overall species richness was consistently observed within Area B, with Area C exhibiting the lowest relative number of species observed each year. Several non-native or invasive species were frequently observed, such as Virginia opossum and domestic cats and dogs. Sherman trap sampling was also used to confirm habitat use by the rare South Coast marsh vole within the salt marsh habitats of Area B.

Lastly, results from vertebrate mortality surveys indicated that roadways bisecting the Reserve present a major obstacle to wildlife mobility, with higher rates of mortality concentrated along specific road segments, especially along Culver Boulevard and between Culver and Jefferson Boulevards. Warmer months corresponded with increasing vertebrate mortality. The species with the highest number of roadkill incidences overall, the cottontail rabbit, was also the species most frequently identified at the motion camera stations. The proximity of these major roadways to the Reserve, an undeveloped open space, increases the possibility of vehicle-related mortalities on wildlife and increases the potential costs and environmental impacts associated with those incidences. These data will be important in identifying areas that would be the most appropriate for the creation of protected wildlife crossings and corridors and/or traffic modifications.

Birds

Monitoring data combined across all five years suggest that the assorted range of habitats within the Reserve support a diverse bird community – from water-associated birds to urban-adapted species. These range from vagrant species stopping over during migration events (e.g. wintering, roosting) to established year round populations for which the Reserve appears to provide needed resources (e.g. food) to the regional avian assemblages. The first two monitoring years (using Reserve-wide surveys) contributed the highest number of species to the overall recorded species list. This followed an expected trend, as the survey types implemented in those two years included all habitats and provided an opportunity to record cryptic or less frequently identified species. However, it should not be assumed that the number of bird species on site has decreased over time as consistent long-term temporal trend data are limited.

Special-status species recorded as simply flying over a site, or present only for a few days during migration, are generally not given protection. Only two recorded federally-protected special-status species are typically afforded year-round protection based on their activities on site: Burrowing Owl and California Gnatcatcher. Additionally, the Belding's Savannah Sparrow was consistently observed on site and was identified as nesting in the salt marsh habitats of Area B across all monitoring years. Increasing the acreage and quality of the salt marsh habitats on site for the Sparrow may provide an opportunity to increase the nesting pairs of this species. It will be important to conduct pre-restoration surveys for rare species and several others as part of the pre-construction monitoring plan.

Invertebrates

Benthic invertebrate taxa are useful ecological indicators; the presence or absence of certain infauna (i.e. burrow into and live in bottom sediments) or epifauna (i.e. live on the surface of bottom sediments) within tidal channels can serve as indicators of water quality, anthropogenic stressors to the estuary, and the potential to support other trophic levels (WRP 2006). Similar taxa were represented across monitoring years; however, differences in densities as well as species lists were detected between the two survey areas (i.e. Fiji Ditch and west Area B tidal channels). Overall, the benthic invertebrate community was representative of typical southern California estuarine species assemblages; however, regional surveys were not performed for comparison.

Terrestrial invertebrates are a vital link in wetland food webs and may be considered indicators of the overall health of a system (Zedler 2001). Both the aerial arthropod and pitfall invertebrate sampling methods produced highly variable results revealing some habitat-level patterns and trends. Although different taxa were found to be more prevalent in specific habitats consistent with their life histories, some groups – such as the Argentine ants (*Linepithema humile*), an aggressive invader – were found ubiquitously throughout the Reserve within all habitat types.

Physical Characteristics

Habitat-level elevation assessments indicate that while the contrast between upland and marsh habitat elevations followed predictable patterns, historic hydrologic impacts to the Reserve have resulted in several atypical patterns within marsh habitat elevations. Hydrologic impacts (e.g. levees, tide gates) within the marsh habitats of the Reserve have resulted in similar elevations between the tidal wetland and salt pan habitats in contrast to a predicted pattern of slightly higher elevations within salt pan areas. However, similarities between tidal wetlands and non-tidal salt marsh areas were seen as expected as they were once contiguous portions of a larger salt marsh system and have only become separate habitat types as a result of the tidal disconnection from non-tidal salt marsh areas by roads and levees. Evaluations of the site-wide cross-sections and DEM analyses produced similar results, showing areas of historic fill placement and a wide variety of impacts to the original wetland elevation soils.

Cross-section surveys of the tide channels showed steep channel banks often surrounded by an upland berm, which was not representative of the classic shallow sloped profile exhibited by more natural or reference wetlands. The steep banks and channel bank berms restrict floodplain inundation by confining tidal waters to the channels and eliminating the vertical zonation of vegetation from most of the adjacent areas. This confinement was shown through inundation surveys which captured the maximum extent of tidal inundation within Area B of approximately 15 acres out of the 577 total Reserve acres.

Recommendations

Data and results from this monitoring program support comparable analyses conducted at the Reserve since the early 1980's identifying areas in poor condition that would benefit from management and restoration actions with the goal of increasing the health and functions of a range of native estuarine and adjacent habitat types (e.g. Shreiber et al. 1981). Recommendations based on these data include restoring estuarine and tidal connections to increase wetland ecosystem functions (e.g. water filtration, habitat connectivity, etc.), native species use of the site, and a diverse range of native habitat types. Gradual transition zones, buffer zones, and adjacent upland habitats would increase the health and diversity of habitat types and provide accommodations for habitat transgressions due to climate change and sea level rise. Reducing habitat fragmentation and anthropogenic impacts where feasible would also support these goals. Adaptive management and long-term monitoring programs should also be key components of restoration planning efforts. The Ballona Reserve is one of the few coastal areas in the region capable of supporting a large estuary with a range of marsh habitat types and native vegetation, providing a unique opportunity to incorporate climate change planning into a restoration with both local and regional importance.

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