South San Diego Bay
Coastal Wetland Restoration
and Enhancement Project

Year 3 (2014) Postconstruction Monitoring Report

Prepared for:

Southwest Wetlands Interpretive Association
700 Seacoast Drive, Suite 108
Imperial Beach, CA 91932

Prepared by:

Nordby Biological Consulting
5173 Waring Road # 171
San Diego, CA 92120

and

Tijuana River National Estuarine Research Reserve
301 Caspian Way
Imperial Beach, CA 91932

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EXECUTIVE SUMMARY

Western Salt Ponds

The third year of the five-year monitoring program for the South San Diego Bay Restoration Project ("Project") has been completed. The western salt ponds site has met the Project goals and objectives for most physical and biological monitoring parameters, as demonstrated below.

Tidal amplitude within the western salt ponds mirrors that in south San Diego Bay. Similarly, water quality (specific conductivity, salinity, dissolved oxygen, temperature, turbidity, pH, and chlorophyll) within the restored ponds reflects the water quality parameters of south San Diego Bay.

The topography and bathymetry of the site continues to evolve with changes to both the excavated channels and marsh plain. These changes are the result of sediment movement within the western salt ponds associated with restored tidal influence. However, the targeted habitat distributions are expected to develop as anticipated with substantial areas of salt marsh, intertidal mudflat, and intertidal and subtidal habitat. The marsh plain in Pond 10 has consolidated over the last three years and many areas can support the weight of researchers conducting monitoring tasks. Consolidation of sediment deposited in Pond 11 is expected to continue and elevations there are expected to change with time.

Despite initial low survival of planted salt marsh vascular plants, cordgrass continues to expand vegetatively in Pond 10 and, to a lesser extent, in Pond 11. Based on other low marsh restoration projects in southern California, the surviving plantings are expected to expand exponentially in upcoming growing seasons. In addition, natural recruitment of Pacific pickleweed and Bigelow's pickleweed has occurred in the western salt ponds and is expected to continue in the future.

Year-3 (2014) fish monitoring included otter trawls, minnow traps and enclosure traps in Ponds 10 and 11, and minnow traps and enclosure traps in Pond 10A. The 1 m beam trawl was discontinued due to low numbers of fish captured in Year-1 (2012). Otter trawls conducted at nine stations within Ponds 10 and 11 yielded 888 individuals representing 11 species. This catch was compared to Year 2 (2013) when 1,915 individuals representing 11 species and 9 families were collected. During both years, slough anchovy were the dominant species numerically accounting for 93.2% of the catch in 2014 and 72.5% in 2013. Round stingray accounted for approximately 3% of the total fishes collected in both 2014 and 2013 and comprised 57.8% of the total biomass in 2014 compared to 72.5% in 2013. California halibut comprised 18.6% of the total biomass in 2014 compared to 5.2% in 2013 and 0% in 2012.

Minnow traps deployed on six dates throughout 2014 captured a total of 130 individual fish representing 4 species and 4 families at the 11 sampling sites within Ponds 10, 11 and 10A. This is down significantly from last year (2013) and 2012 totals of 262 and 642 individuals, respectively. The dominant species collected was California killifish representing 50% of the catch (31% in 2013). Longjaw mudsucker was the second most abundant species (most abundant in 2013) comprising 28%of the total catch (31% in 2013).

The fish assemblage continues to evolve as the channels and marsh plain in the ponds change in relation to sediment movement and consolidation. The predominant biomass contributed by round stingray and California halibut in the restored ponds, as well as the numerically dominant slough anchovy, demonstrates a trend toward a fish assemblage that is similar to that in south San Diego Bay. Although it was hypothesized that the number of species and abundance of fish would increase as the sediment in the ponds consolidates and is colonized by invertebrates, this has not proven to be the case during the first three years of monitoring. While species diversity has remained stable, overall numbers dropped 2014 relative to 2013. Causal factors could include the timing of spawning by slough anchovy. High numbers of young-of-the year of this species were collected in 2013 with far fewer in 2014. A delay in the peak spawning period for this species could explain the short-term decline in numbers collected. However, juvenile slough anchovy would not exploit benthic invertebrates.

Macrobenthic invertebrate assemblages continue to develop and provide food for migratory shorebirds and fish. Results from small cores (4.8 cm in diameter expressed 2 - 6 cm into the sediment) sieved through a 300 micron mesh during Year 3 (2014) demonstrated shifts in the benthic community to one primarily dominated by polychaetes and crustaceans, although there was spatial, seasonal and annual variability. Larger cores (10 cm in diameter and 50 cm deep) were dominated by California horn snail (78%), 31% of total in 2013, and California jackknife clam (13.6%), 43% of total in 2013. Sampling for smaller benthic invertebrates at Pond 10 revealed substantial seasonal and interannual variability in invertebrate community composition, although there is a trend for increasing densities in the ponds over time. The benthic invertebrate communities are meeting the objectives of providing an available food source for shorebirds and fish.

In 2014, a monthly average of 15.2 bird species was observed in wetland habitats in Pond 10. The number of bird species in Pond 10 ranged from a high of 41 species in November to a low of 9 species in May and June. The average number of species observed in Pond 10 was less than Pond 11 (24.6) which has more subtidal habitat and intertidal habitat and less than Pond 10A (17.8) which has less vegetated wetland habitat than Pond 10. The number of individual birds observed during monthly surveys was always greatest in Pond 11compared to Ponds 10 and 10A, with one exception. The patterns in number of individuals were heavily influenced by the numbers of western sandpiper and the timing of their migration, which was similar to the pattern observed in 2013. When compared to 2013, numbers of western sandpipers in wetland habitats Ponds 10, 11 and 10A were down by approximately 64%, although there were more individuals in the overall study area, which includes the eastern salt ponds and parts of south San Diego Bay. This suggests that western sandpipers are using areas other than the western ponds to a greater extent than previous years. It is postulated that this reduced activity is directly related to development of salt marsh habitats in all three ponds, thereby reducing the area of mudflat favored by western sandpipers as foraging habitat. This hypothesis will be tested further in the 2015 monitoring year.

Chula Vista Wildlife Reserve

The Chula Vista Wildlife Reserve has met some of the Project goals and objectives, but continues to fall short in terms of expectations of tidal amplitude. In 2012 and 2013, monitoring of tidal amplitude was plagued by equipment failure as the Solinst® level loggers deployed to monitor tidal amplitude failed repeatedly. Due to the high failure rate experienced with the Solinst® level loggers, Onset® HOBO® data loggers were deployed in late January 2014. Monitoring data collected using the new data loggers confirmed the moderate to fairly severe truncation of the low tides within the channels of the Chula Vista Wildlife Reserve observed in 2013 and 2012 using the faulty level loggers.

Year 3 (2014) monitoring of the Chula Vista Wildlife Reserve revealed water quality that was within expected parameters, based on a one-time sampling event. The increase in tidal influence provided by channel excavation is expected to continue to improve water quality relative to south San Diego Bay.

Cover by vascular plants planted from salvaged and nursery grown stock increased in Year 3 (2014) and is expected to further increase in Year 4. Vegetation was dominated by Bigelow's pickleweed which recruited naturally to the site. California horn snail (72%) and California jackknife clam (12%) dominated the benthic invertebrates sampled using large cores (50 cm long, 10 cm diameter core sieved through a 3 mm mesh). Zero fish were collected using minnow traps at six sampling sites. Fish collected using enclosure traps were dominated by arrow goby (92%) and fish collected by seine were dominated by California killifish (34%), arrow goby (23%) and topsmelt (22%). Fish and invertebrate assemblages are similar to other southern California bays and lagoons and provide food for foraging shorebirds and ground-nesting birds.

1.0 INTRODUCTION

The U.S. Fish and Wildlife Service (USFWS) San Diego National Wildlife Refuge (NWR) Complex and the Port of San Diego (Port) completed construction of the South San Diego Bay Coastal Wetland Restoration and Enhancement Project ("Project") in December 2011. Funding support was provided by the California Coastal Conservancy (Conservancy) and National Oceanic and Atmospheric Administration (NOAA)/National Marine Fisheries Service (NMFS) through the American Recovery and Reinvestment Act of 2009; the USFWS Wildlife and Sport Fish Restoration Program through the National Coastal Wetland Conservation (NCWC) Program, and the Coastal Program; and the U.S. Environmental Protection Agency (EPA). The Project included the restoration and enhancement of approximately 261 acres of coastal wetland habitat within the south end of San Diego Bay, San Diego County, California. The project consisted of restoration activities at two locations: 1) restoration of 230 acres (including 12 acres of upland) of solar salt evaporation ponds 10, 10A and 11 (western salt ponds) located at the southwestern edge of San Diego Bay within the South San Diego Bay Unit of the San Diego Bay NWR; and 2) the 43-acre Chula Vista Wildlife Reserve (CVWR) located to the west of the South Bay Power Plant (Figure 1).

Approximately one year prior to construction of the Project, monitoring of physical and biological parameters was conducted to compile baseline conditions for comparison with those parameters following construction. Postconstruction monitoring was based on a detailed Postconstruction Monitoring Plan. Postconstruction site conditions, e.g., unconsolidated muddy substrate, required modification of some of the proposed monitoring methods. These modifications are described by parameter. This report serves as the third annual postconstruction monitoring report of the Project covering the period of January to December 2014.

1.1 Western Salt Ponds Restoration

The western salt ponds component of the Project restored approximately 218 acres of wetlands by converting former solar salt evaporation ponds into subtidal and intertidal habitats. The conceptual restoration plan, including the proposed distribution of habitats, is presented in Figure 2. Restoration activities included dredging shallow subtidal channels (-2 ft NAVD88) in Ponds 10 and 11 and slurrying the dredged material to Pond 11 to raise its elevation from primarily subtidal to intertidal elevations. The dredged material was deposited into Pond 11 instead of Pond 10 because the pre-project elevation of Pond 10 was within the range of intertidal salt marsh at approximately +4 ft NAVD88. Overall, a total of approximately 140,000 cubic yards of material was dredged with about 120,000 cubic yards excavated in Pond 10 and an additional 20,000 cubic yards in Pond 11. Approximately 102 acres of low marsh was restored in Ponds 10 and 11 within the elevation range suitable for supporting California cordgrass (*Spartina foliosa*). Approximately 39 acres of subtidal habitat were dredged in Ponds 10 and 11. Dredging created major tidal creeks with the intention that second and third-order creeks would develop naturally through tidal action.

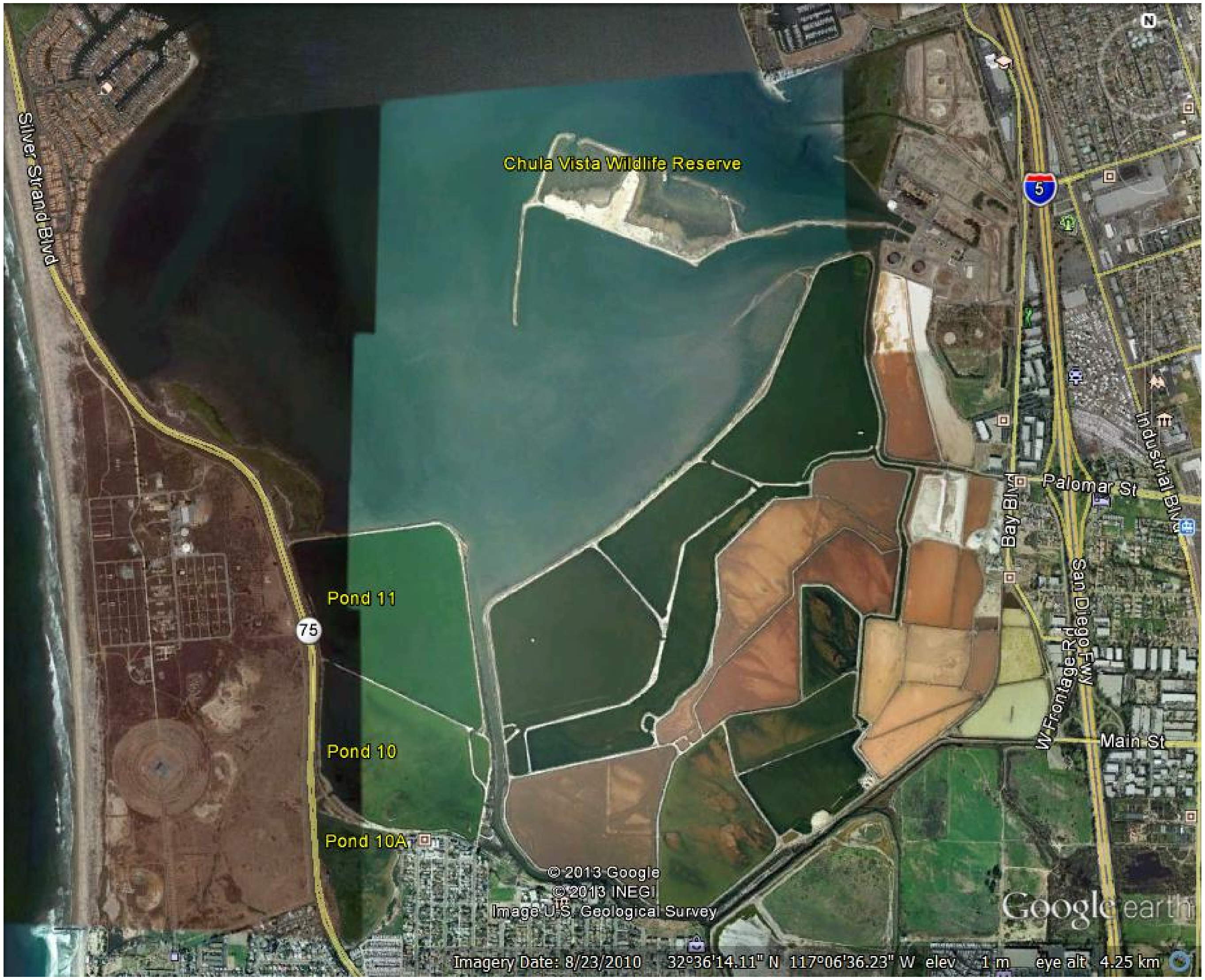


Figure 1. South San Diego Bay Coastal Wetland Restoration and Enhancement Project Locations

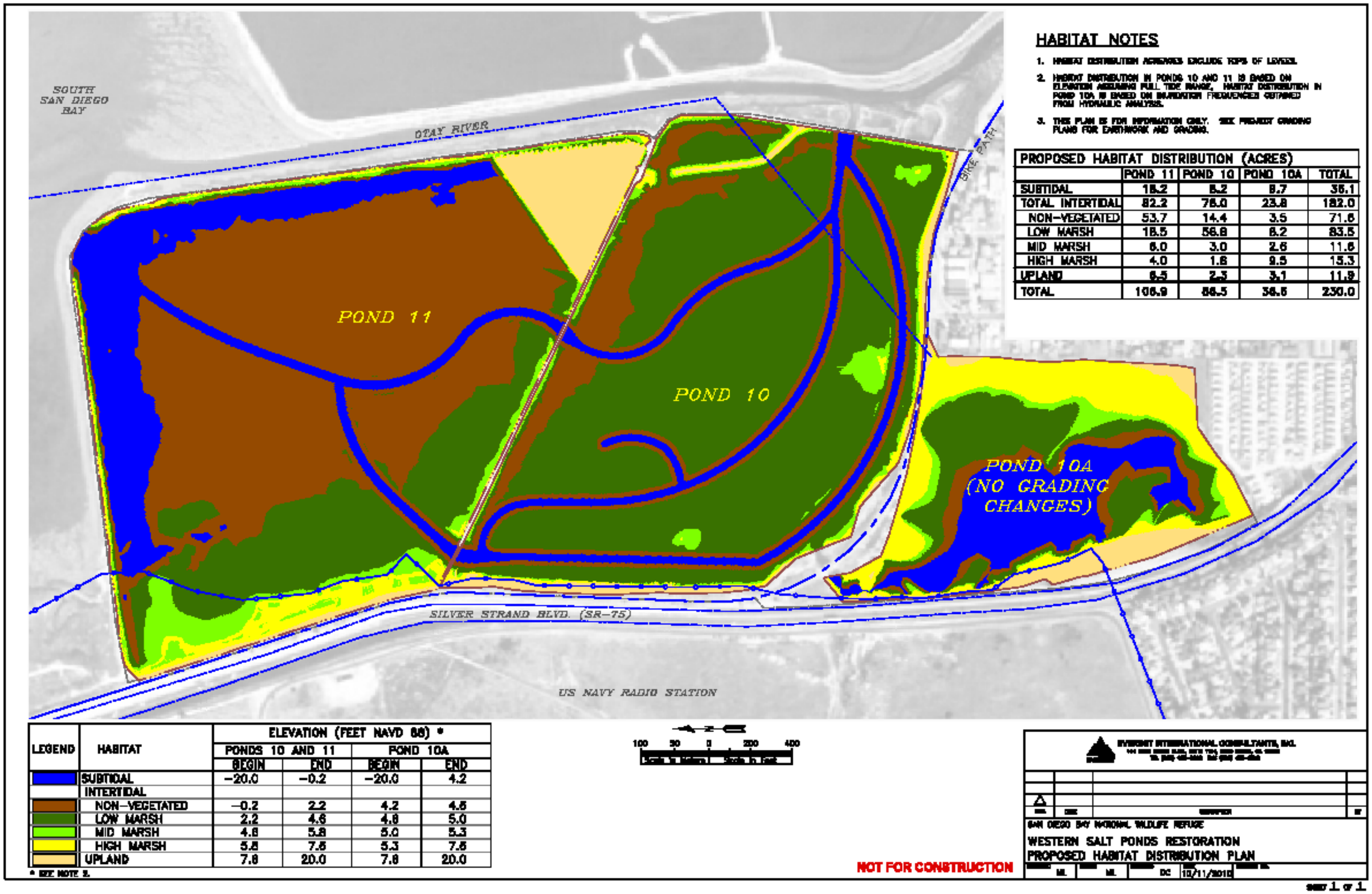


Figure 2. Habitat Restoration Plan for the Western Salt Ponds.

The remaining 77 acres of restoration was comprised of unvegetated flats and mid- and high-marsh habitat. No dredging or deposition occurred in Pond 10A, although restoration of tidal influence enhanced the existing 33 acres of former salt evaporation pond. Following the completion of the dredging operation within the salt ponds, the outer levees were breached to allow for tidal circulation and approximately 40 acres of low marsh habitat were planted with cordgrass and 4.8 acres of mid-high salt marsh were planted with a mosaic of species. The portions of the levees not affected by breaching were retained to provide roosting habitat for various avian species. An additional 67,000 cubic yards of material from the CVWR was slurried across San Diego Bay and deposited in the southeast corner of Pond 11 to create a nesting area with high-quality sandy material. A detailed account of the design of the western salt ponds is provided in the Basis of Design Report (Everest International Consultants, 2011).

Prior to beginning construction, a preconstruction monitoring program was implemented from January 2010 to September 2010. Monitoring of fish during the period revealed low diversity and abundance within the salt ponds. Low diversity of benthic invertebrates was also observed. Bird surveys were dominated by shorebirds (dowitcher sp., western sandpiper, willet and marbled godwit) in spring and early summer and by elegant tern and western sandpiper in late summer. Brown pelican and scaup sp. were also occasionally abundant. Preconstruction water quality data confirmed that the ponds were highly saline with static water temperature.

Postconstruction monitoring of the western salt ponds was initiated in January 2012 and will continue through 2016. Postconstruction monitoring includes both physical and biological components. Physical parameters monitored include tidal amplitude, bathymetry, topography, water quality and soils. Biological parameters include vascular plants, fish, benthic invertebrates and birds. Methodologies employed are presented by parameter below.

1.1.1 Goals and Objectives of the Western Salt Ponds Restoration

Two funding sources for the Project, the NCWC and NOAA grants, identified several objectives and metrics that will be assessed through the long-term monitoring program.

The overarching objectives for the NCWC grant were:

- Complete the permitting, final design, and site preparation, including all excavation, clean-up, and grading, necessary to restore and enhance 160 acres of coastal wetland and upland habitat in south San Diego Bay by March 1, 2011.

- By the end of 2016 achieve approximately 89 acres of functional estuarine intertidal emergent wetlands, approximately 41 acres of estuarine intertidal non-vegetated wetlands, approximately 28 acres of estuarine subtidal wetlands, and 10 acres of palustrine scrub-shrub vegetation.

However, these objectives also included acreage for the Emory Cove restoration site, which was not part of the NOAA grant and was not part of this monitoring program. The Emory Cove monitoring will be completed by the Port of San Diego and will be reported separately.

For the western salt ponds, the NCWC objectives were:

- By March 2013, achieve successful recruitment of benthic invertebrates and fish within Pond 11 to support migratory shorebirds and foraging ground-nesting seabirds.

- By March 1, 2011 complete the dredging and filling activities required to achieve elevations within Pond 11 that will support a mix of shallow subtidal, intertidal mudflat, cordgrass-dominated salt marsh, and pickleweed-dominated salt marsh habitats (estuarine intertidal emergent, non-vegetated, and subtidal wetlands) and breach the pond levee to restore tidal influence to the 106-acre pond.

- By the end of 2016, achieve 50 percent coverage of cordgrass (*Spartina foliosa*), with at least 25 percent of the plants in excess of 60 centimeters (cm) in height, over approximately 30 acres within the tidally restored pond.

- Between March 2011 and February 2012, monitor and record through monthly visual surveys, the recruitment of vegetation and benthic invertebrates, bird use, and any changes in bathymetry within the pond. Based on these observations, develop recommendations for how the design of future phases of salt pond restoration in San Diego Bay could be adjusted to more effectively achieve restoration objectives.

In addition, the following metrics were determined in conjunction with NOAA based on the draft Postconstruction Monitoring Plan for the western salt ponds:

- Restore wetland elevations and channel bathymetry in Ponds 10 and 11 to within plus or minus 10% of the design plan by June 2011;
- Restore tidal amplitude in Ponds 10 and 11 to approximately equal the tidal amplitude in the Otay River; restore tidal amplitude in Pond 10A to a slightly muted amplitude relative to the Otay River by 2012;
- Achieve 50% vegetation cover by wetland vascular plants in at least 30 acres of Pond 10 by June 2016;
- Demonstrate presence of one or more of the target species (flatfish and elasmobranchs) by 2013.

Postconstruction monitoring was conducted in order to demonstrate progress made toward achievement of these goals. Although postconstruction monitoring is planned through 2016, monitoring will extend far beyond the grant period(s) in order to understand the benefits of the project to the entire San Diego Bay ecosystem and to the South San Diego Bay Unit of the San Diego Bay National Wildlife Refuge.

1.2 Chula Vista Wildlife Reserve Restoration and Enhancement

Prior to restoration, the CVWR consisted of two shallow basins divided by a higher fill area managed for seabird nesting. The site suffered from poor tidal circulation, which impeded overall habitat quality within the basins. In addition, the high salinity levels occurring at higher tidal elevations impacted vegetation growth, resulting in the lack of vegetation in some areas and poor habitat quality in other areas.

Restoration of the CVWR was initiated on September 20, 2010 and completed on February 15, 2011, according to specifications. Approximately 11 acres of intertidal habitat were restored in the basins by excavating approximately 67,000 cubic yards of material and approximately 32 acres of wetland were enhanced by improving tidal circulation. The sediment that was dredged from the CVWR was pumped to the salt ponds to create a bird nesting area. The 11 acres of salt marsh habitat restored by the Project were planted by volunteer workers from the San Diego Audubon Society.

No site-specific preconstruction monitoring was conducted for the CVWR component of the Project. Postconstruction monitoring was initiated in April 2011 and includes monitoring of vegetation, water quality, fish and benthic invertebrates.

1.2.1 Goals and Objectives of the Chula Vista Wildlife Reserve

For the CVWR, the NCWC objectives were:

- By March 2013, achieve successful recruitment of benthic invertebrates and fish within the western basin of the Chula Vista Wildlife Reserve to support migratory shorebirds and foraging ground-nesting seabirds.

- By March 1, 2011, lower approximately 3 acres within the western basin of the Chula Vista Wildlife Reserve to achieve a typical marsh plain elevation of +4.5 feet Mean Lower Low Water (MLLW) (an elevation appropriate for supporting estuarine intertidal emergent wetlands) and expand the existing tidal channel by removing 3,000 cubic yards of sediment to create deeper, more well defined tidal creeks within the western basin, thus enhancing the remaining wetland habitat.

- By the end of 2016, achieve 50 percent coverage of cordgrass and pickleweed over the 3-acre excavation area and improve vigor and plant diversity throughout the remaining 16 acres of estuarine intertidal emergent wetlands within the basin.

At CVWR, the NOAA metrics were:

- Restore wetland elevations and channel bathymetry in the restored basin to within plus or minus 10% of the design plan by June 2011;
- Restore tidal amplitude to approximately equal the tidal amplitude in San Diego Bay by 2011;
- By 2016, restore typical marsh vegetation coverage, using marsh coverage at Tijuana Estuary as a target;
- Demonstrate presence of one or more of the target taxa (gobiidae and topsmelt) by 2013.

2.0 PHYSICAL PROCESSES

2.1 Topography/Bathymetry of Western Salt Ponds

Monitoring of the topography/bathymetry of the western salt ponds was a critical element in project design, during construction and during postconstruction. Elevations of the levees that separate the western salt ponds from San Diego Bay and from each other and the bathymetry of the ponds were assessed prior to construction to determine postconstruction habitat distributions and cut-and-fill volumes. During construction, the bathymetry of the ponds was measured frequently to determine achievement of target elevations and as a method of payment for the contractor. Postconstruction monitoring focused on the topography of the marsh plain and the bathymetry of the constructed channels.

2.1.1 Methods – Monitoring of Topography/Bathymetry of Western Salt Ponds

The preconstruction topography of the western salt ponds was assessed using existing topographic data generated by Ducks Unlimited, Inc. for the USFWS in 2000 as spot-checked by Psomas Engineering using conventional stadia rod and level methods tied to existing benchmarks in 2010. It was determined that the existing topographic data was accurate for project planning and those data were incorporated into the project plans. Preconstruction, the levees around the perimeter of ponds 10 and 11 and the internal levee between ponds 10 and 11 ranged from approximately +8 ft to +10 ft NAVD88 (Everest International Consultants 2011). During project planning, it was determined that both the internal and perimeter levees would be allowed to erode after tidal influence was restored to the ponds. Thus, postconstruction monitoring was focused on the elevations of the marsh plain and channels and not specifically focused on the levees that were breached during construction.

Year 1 (2012) postconstruction monitoring plan methodology for topography and bathymetry relied largely on determining elevations across a number of transects. The monitoring plan called for transects to be walked with elevations recorded using conventional surveying equipment, e.g., stadia rod and level. The muddy site conditions required modification of this plan and Real Time Kinematic (RTK) GPS were used to acquire elevations, latitude and longitude from a kayak or canoe. These data were supplemented by interpreting elevations from aerial photographs performed by San-Lo Aerial Surveys using photographs taken in October 2011

Surface elevations of all areas exposed at low tide in Pond 10 and approximately 50% of Pond 11 were determined by using stereoscopic aerial photographs taken immediately at the end of construction on October 26, 2011. Three separate photographic frames were taken at that time and it was determined that enough overlap between frames existed to use photogrammetric methods to extract elevation data for much of the restoration site. No ground control points were used as vertical and horizontal controls for this analysis.

During Year 2 (2013) monitoring, aerial imagery was again employed to determine site topography. False color aerial imagery of all three ponds was taken using a Red (R), Green (G), Blue (B) and Near Infrared (NIR) model UltraCam-X by Vexcel digital camera (Figure 3). This imagery was then converted to open water, vegetated areas and bare ground using Normalized Difference Vegetation Index (NDVI). Vegetated areas include both salt marsh vascular plants and algae. Work continues on refining the vegetation category to differentiate between algae and vascular plants.

An orthophotograph of the western ponds was generated from the R, G, B, NIR digital image and elevation contours were generated in digital computer aided design (CAD) format and mosaiced georeferenced digital imagery within the extents of the overlapping aerial photographs (Figure 4). The resulting CAD file containing elevation contour data was converted to ArcGIS format for further processing and analysis.

Topography of the western salt ponds was not monitored in 2014 as monitoring efforts were directed towards contracting for LIDAR to be flown for the project in summer of 2015. The results of the LIDAR survey will not be available until the Year 4 (2015) monitoring report. The results of the 2013 topographic monitoring are presented below.

2.1.2 Results - Monitoring of Topography/Bathymetry of Western Salt Ponds

The surface area elevation contour as generated from the 2013 orthophotograph of the western salt ponds is illustrated in Figure 3. Digital terrain models of the ponds generated using the methods presented above immediately after construction in 2011 and in 2013 are illustrated in Figure 4. Channels are shown in white as the aerial photogrammetry method does not penetrate the water and, therefore, cannot determine channel bathymetry. Apparent migration of sediment is evident in both Pond 10 and Pond 11 in the 2013 model. Deeper areas in the southwestern portion of Pond 10 appear to have been filled and some of the higher areas in the southwestern portion of Pond 11 have become lower. The marsh plain between the two channels in southern Pond 11 appears to have accreted sediment.

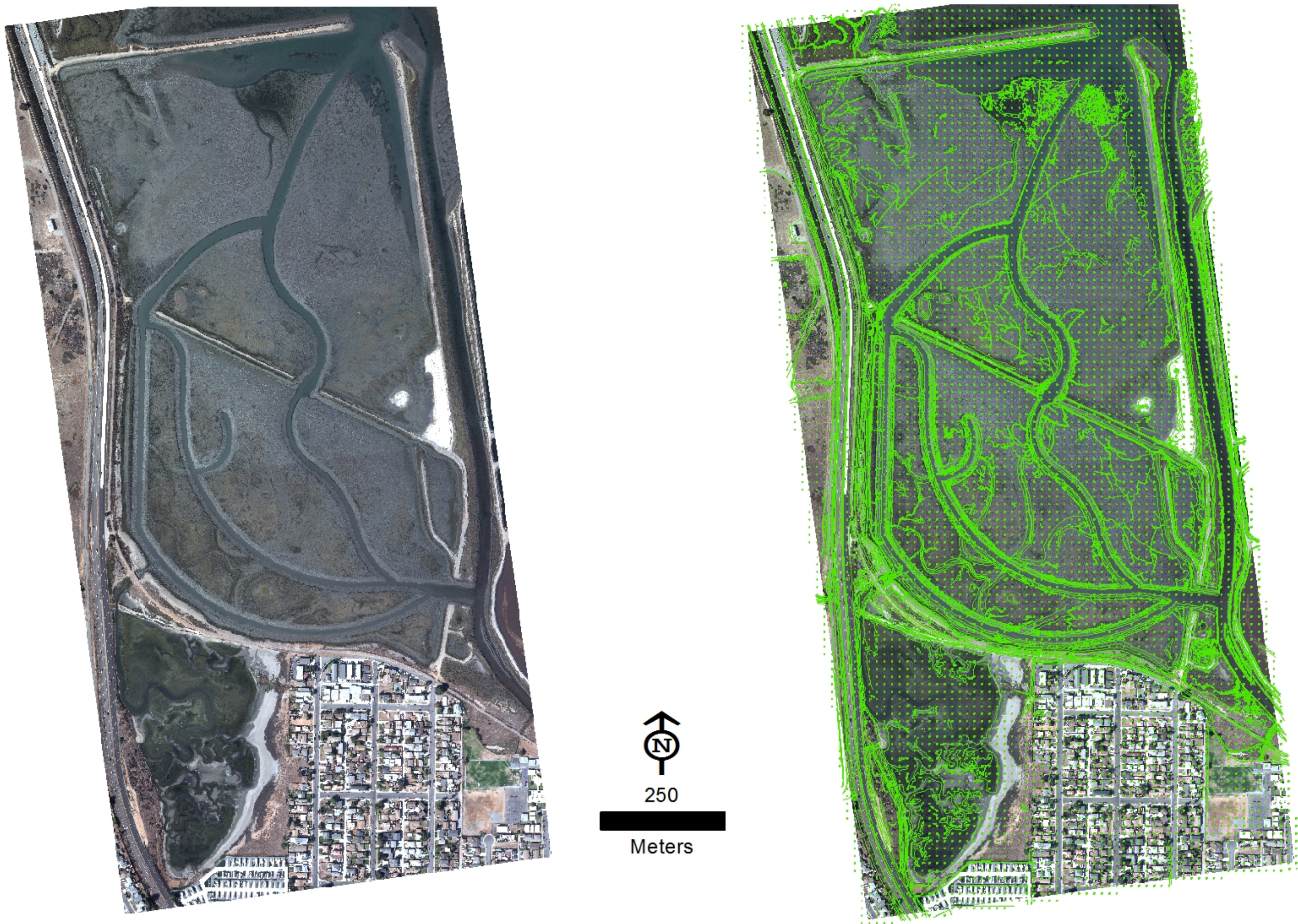
The trends in sediment migration are further evident in the cross-section plots of the pond elevations comparing 2013 aerial photogrammetry and RTK GPS transects (Figures 5 and 6). The correlation of the postconstruction contours derived from aerial photogrammetry and RTK GPS transects suggests that these elevation changes are accurate within tolerances of each method. The elevations determined by photogrammetry have an accuracy of $\pm$ 10% and those determined using RTK GPS have an accuracy of $\pm$ 3%. The difference in elevation in southern Pond 10 is evident in Figure 5, Transect 1 and Transect 2. The slightly lower marsh plain in southwestern Pond 11 is illustrated by Transect 4 (Figure 6.). It appears that the sediment continues to be redistributed by tidal action in both ponds.

Although the topography of the marsh plain has increased and/or decreased in some areas relative to predicted elevation based on preconstruction surveys, the project is expected to attain the range of habitats included in the project goals and objectives. In addition, higher elevations will allow for marsh evolution and migration in the face of predicted sea level rise. The majority of the marsh plain in Pond 10 is at the elevation contour of +3.0 ft to + 5.0 ft NAVD88 which is within the predicted elevation range for cordgrass-dominated salt marsh (+2.2 ft to + 4.6 ft NAVD88). Higher areas within Pond 10 with an elevation range of +4.9 ft to + 6.6 ft NAVD88) are within the predicted range of mid- to high salt marsh +5 ft to + 7.0 ft NAVD88. These areas have been colonized by Pacific pickleweed and are expected to remain mid- to high salt marsh.

Elevations in Pond 11 demonstrate a similar pattern; however, continuing consolidation and movement of sediments deposited as dredge slurry in Pond 11 render predictions of final elevations and habitats premature.

In summary, topographic analyses conducted in 2013 demonstrated that the objective that the Project be within $\pm$10% of the design has been met. Some areas of the marsh plain are higher and some are lower. However, the elevations are within the tolerances of the habitats of the Project design.

The evolution of topography of the marsh plain will be monitored throughout the 5-year monitoring program using methods similar to those used in this report, as well as supplemental data provided using LIDAR. The monitoring of the bathymetry of the tidal channel in Ponds 10 and 11 using LIDAR will be a major focus during Year 4 of the monitoring program.



October 2013 Orthophoto

Derived from R,G,B and NIR digital imagery
taken on October 04, 2013

October 2013 Elevation Contours

Digital elevation contours created using photogrammetry from R,G,B
and NIR digital photos taken on October 04, 2013

Figure 3. Orthophotograph and Elevation Contours of the Western Salt Ponds – 2013.

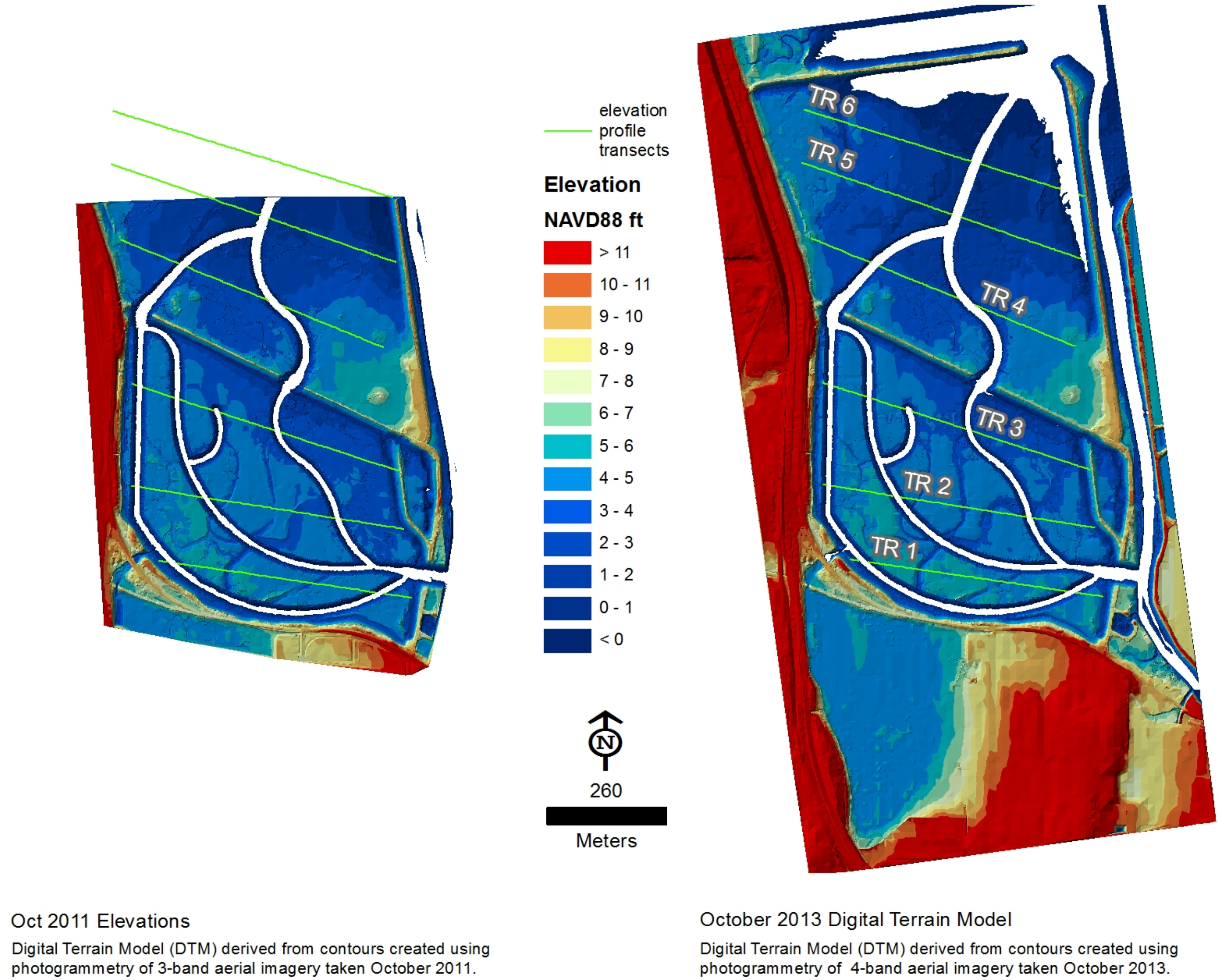


Figure 4. Digital Terrain Model of Ponds 10 and 11 October 2011 and October 2013.

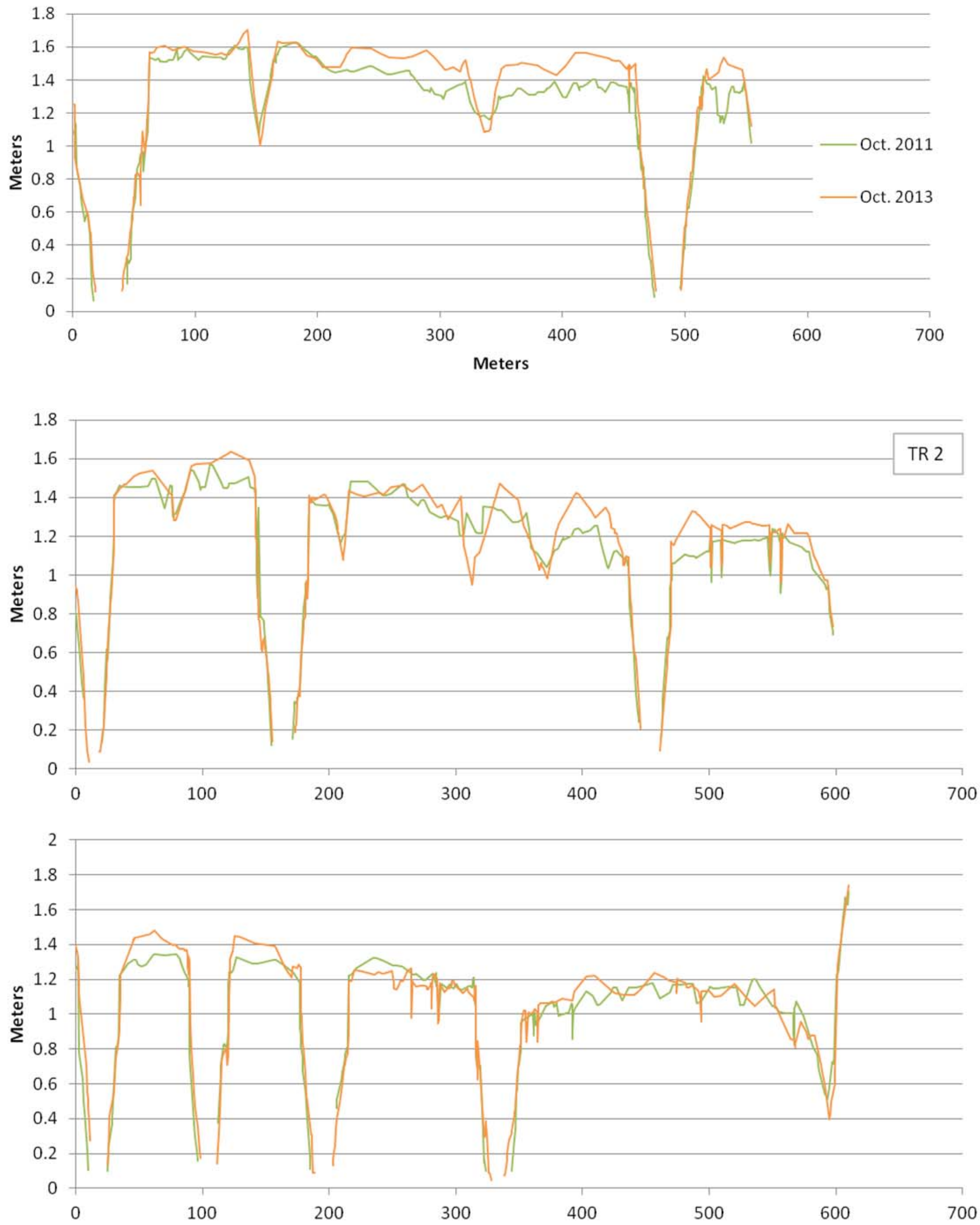


Figure 5. Elevations Along Transects in Pond 10 2013. (X Axes Represent Length in Meters of the Transect From West to East).

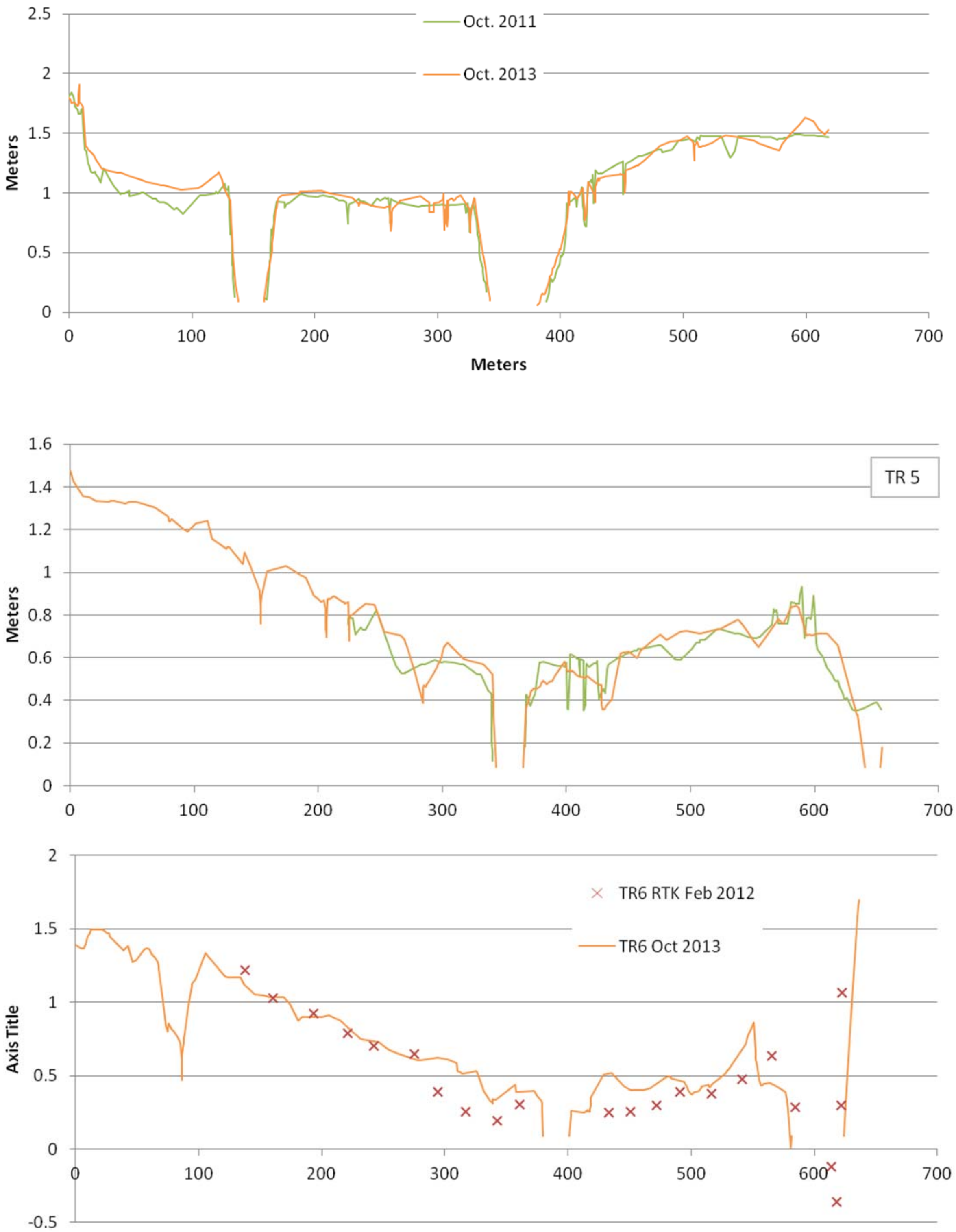


Figure 6. Elevations Along Transects in Pond 11 2013. (X Axes Represent Length in Meters of the Transect From West to East).

2.2 Topography/Bathymetry of the Chula Vista Wildlife Reserve

Like the western salt ponds, monitoring of the topography/bathymetry of the CVWR was conducted during project design, during construction and postconstruction. Preconstruction elevations of the marsh plain and constructed channels were assessed to determine postconstruction habitat distributions and dredge volumes. During construction, the elevations of the marsh plain and constructed channels were measured frequently to determine achievement of target elevations and as a method of payment for the contractor. Postconstruction monitoring focused on the topography of the marsh plain and the bathymetry of the constructed channels.

2.2.1 Methods – Monitoring of Topography/Bathymetry of the Chula Vista Wildlife Reserve

Following completion of construction in mid-February 2011, a survey was conducted of the topography of the CVWR using aerial photogrammetry.

2.2.2 Results – Monitoring of Topography/Bathymetry of the Chula Vista Wildlife Reserve

The photogrammetry survey confirmed that the elevations were within the project specifications of ± 10% of design. Restoration activities at the CVWR lowered elevations in the 11-acre restoration area to between +3 and +6 ft MLLW.

2.3 Tidal Amplitude

Project objectives regarding tidal amplitude for both the western salt ponds and CVWR components of the Project included matching tidal amplitude at existing reference sites. For the western salt ponds, that reference was tidal amplitude at the mouth of the Otay River immediately adjacent to Pond 11. For the CVWR, that reference was the tidal amplitude of south San Diego Bay as measured at the NOAA tide gauge located on the Broadway Pier in San Diego.

Prior to construction, the western ponds were used as water storage ponds for solar salt evaporation and, thus, were not tidal. Water level and depth in the western salt ponds varied with water import and export associated with the solar evaporation activities. Water depth within Pond 11 between 2008 and 2010 varied from approximately +3 ft to +0.5 ft relative to the bottom of the pond. Prior to construction of the CVWR component, tidal amplitude was limited by existing elevations, however, there were no preconstruction data on tidal amplitude at the CVWR site.

2.3.1. Methods – Monitoring of Tidal Amplitude of the Western Salt Ponds

Tidal amplitude of the western salt ponds was measured using YSI model 6600 EDS Sonde dataloggers deployed at the eastern breach of the internal levee between Ponds 10 and 11 and at the mouth of the Otay River (Figure 7). The datalogger at the Pond 11 station was deployed using a 4-inch diameter PVC pipe that was strapped vertically to two "rail" style fence posts driven into the sediment. Multiple 1.5 inch holes were drilled around the bottom of the tube to permit unrestricted water flow to the sensors. During deployment the datalogger unit was placed into the PVC pipe and rested on a bolt fixed across the bottom of the tube. The datalogger at the mouth of the Otay River was deployed in a similar manner.

The deployment time varied from approximately two to four weeks. Measurements for water level (converted to tidal amplitude) were taken at 15 minute time intervals along with water quality data (specific conductivity, salinity, dissolved oxygen (percent saturation), dissolved oxygen (mg/l), temperature, turbidity, pH, and chlorophyll). At the end of each sampling period, the YSI dataloggers were retrieved and taken to the laboratory for data downloading, cleaning and recalibration. There are two designated dataloggers for both Pond 11 and the Otay River mouth. While one logger is in the field the other is in the laboratory.

In September 2013, a Solinst® level logger was deployed near Pond 10A sampling site 1 (see Figure 7). This depth logger measures only pressure and temperature. Pressure readings were converted to depth after being compensated for atmospheric pressure, which was recorded by the barometer at the CVWR (see Section 2.3.3). The Solinst® level logger failed during deployment and was replaced by a more reliable HOBO® level logger. The data from the HOBO® level logger is presented in this report.

2.3.2 Results - Monitoring of Tidal Amplitude of Western Salt Ponds

Tidal amplitude comparisons of the South Bay (Otay River) logger site, NOAA's San Diego Bay site, the Pond 10A and 11 logger sites, and the CVWR 3L logger site are shown in Figure 8. Figure 9 shows comparisons of the three CVWR logger sites with NOAA's San Diego Bay site in 2014. Comparisons included a typical 2-week spring tide series representing the higher tide scenario and a typical 2-week neap tide series representing the lower tidal cycle. During both the neap and spring tide series, tidal amplitude within the western salt ponds closely mirrors tides at both reference sites. On February 25, 2015, the South Bay (Otay River) and Pond 11 dataloggers were tied into the NAVD88 using RTK GPS. Note that, because the HOBO® depth loggers (sites Pond 10A, CVWR 1, CVWR 2, and CVWR 3L) are not tied to any vertical datum, the values have been shifted manually along the y-axis so that comparisons can be made.

Figure 7. Monitoring Stations - Western Salt Ponds. Locations of water quality data-loggers are shown in black. Green dots = corners of experimental vegetation plots. Blue circles = enclosure traps and invertebrates. White circles = invertebrates only, both channel-bottom and tidal flat. Brown circles = sediment.

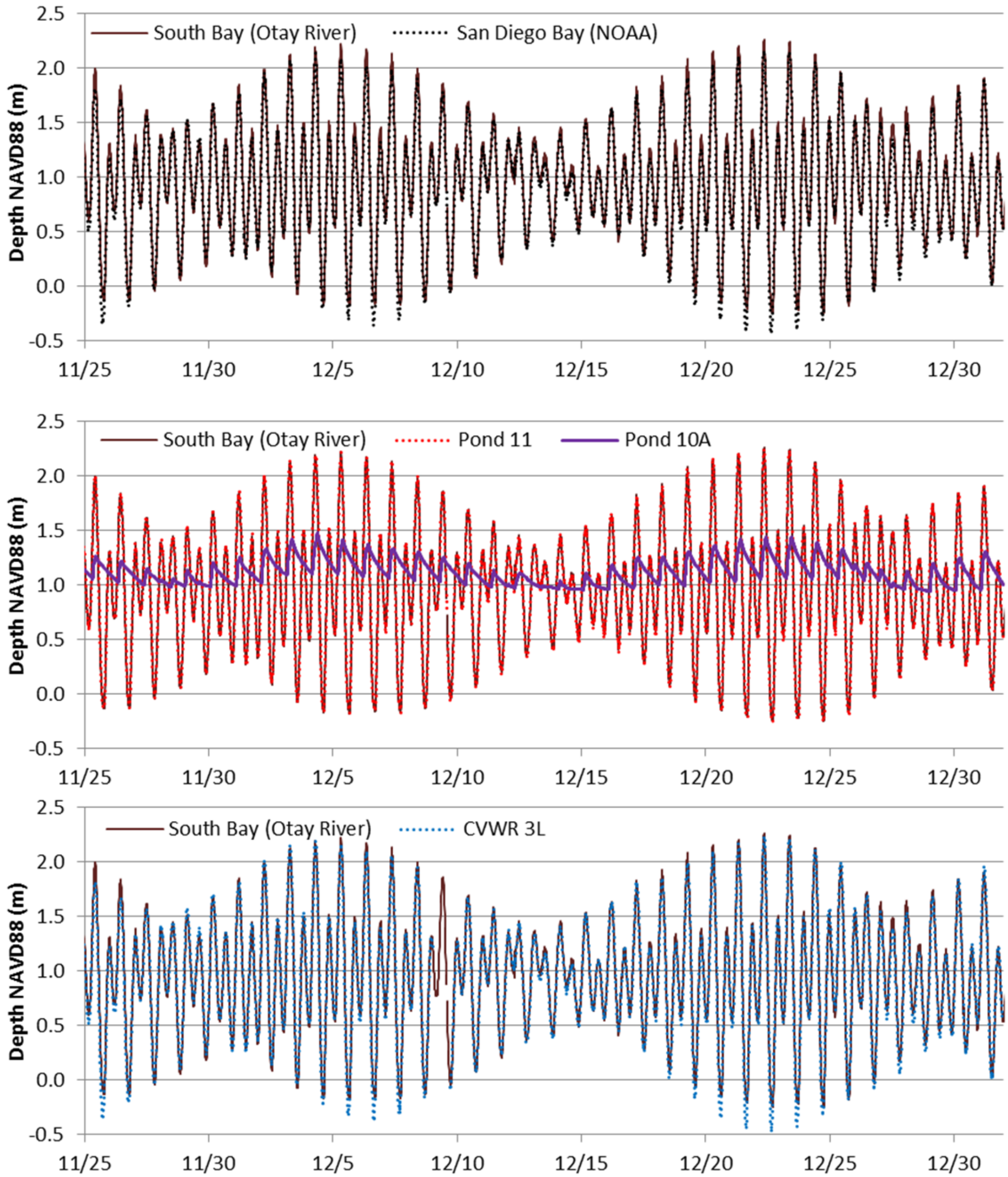


Figure 8. Comparison of the tidal amplitudes of the South Bay (Otay River) logger site to the NOAA's San Diego Bay site, the Pond 10A and Pond 11 logger sites, and the CVWR 3L logger site.

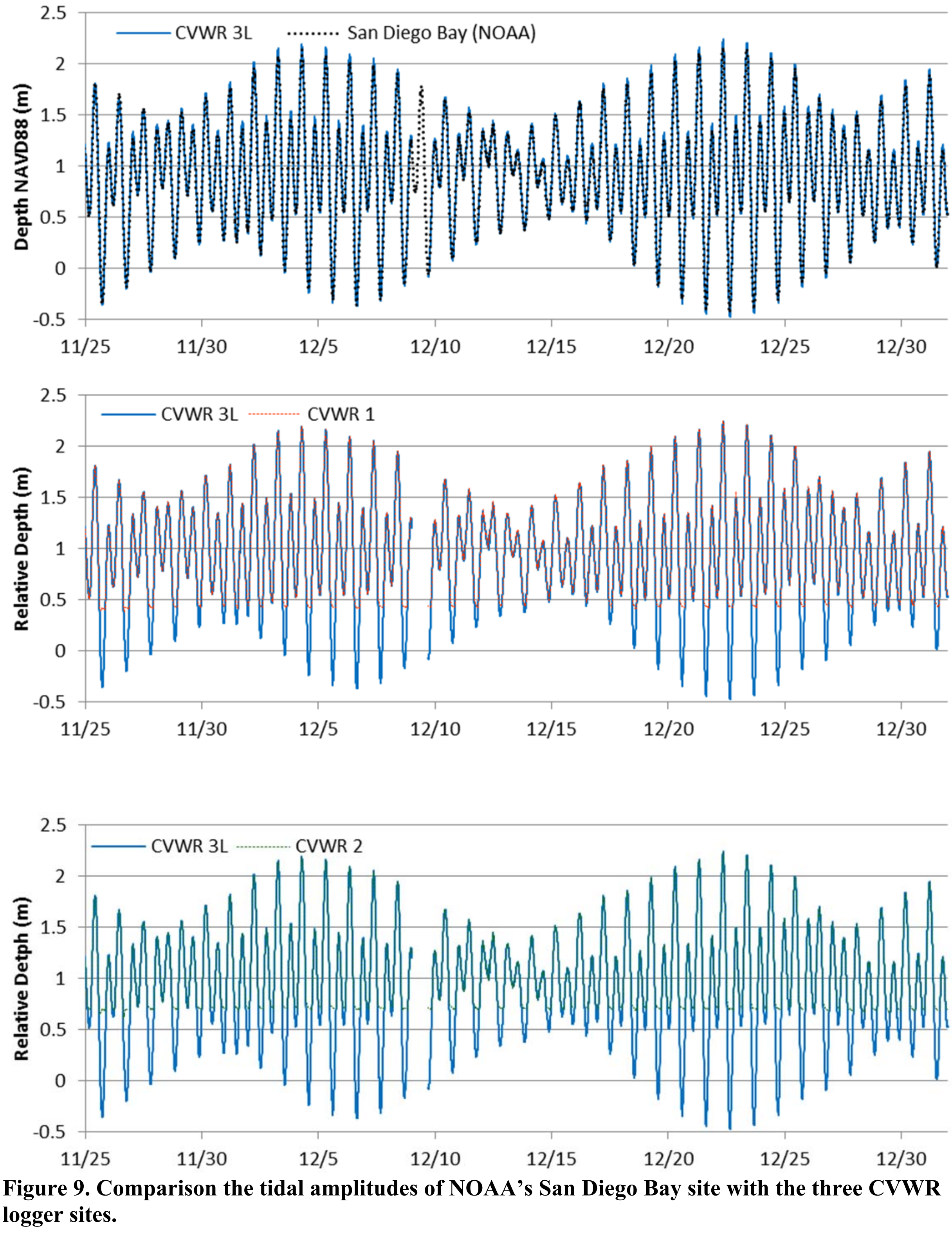


Figure 9. Comparison the tidal amplitudes of NOAA's San Diego Bay site with the three CVWR logger sites.

2.3.3 Methods - Monitoring of Tidal Amplitude of Chula Vista Wildlife Reserve

From 2012 through 2013, tidal amplitude at the CVWR was assessed using Solinst® level loggers deployed at Stations 1, 2, and 3, as depicted in Figure 9. In February 2013, the level logger at Station 3 was moved outside of the wildlife refuge (labeled 3L in Figure 10) in order to compare the tidal amplitudes inside the marsh to that of the adjacent bay. Level loggers detect pressure changes associated with water depth that can be converted to tidal amplitude after barometric compensation. As happened in 2012, failures with the loggers occurred that resulted in missing data, however, enough data was obtained to show spring and neap tidal series at each site. Due to the high failure rate experienced with the Solinst® level loggers, Onset® HOBO® data loggers were deployed in late January 2014.

2.3.4 Results - Monitoring of Tidal Amplitude of Chula Vista Wildlife Reserve

A comparison of the tidal amplitude at site 3L just outside of the CVWR with that in mid-San Diego Bay is presented in Figure 9**.** Two of the sensors (1 and 2) are located on the south end of the Reserve while sensor 3L is located just outside of the tidal inlet to the bay. The sensor at site 3L experiences almost an identical inundation pattern as NOAA's mid-bay sensor; however, it experiences a slightly greater range. The other two sensors still show substantial truncation of low tides. Thus, while tidal influence may have been increased through excavation of channels at the CVWR, tides are somewhat muted relative to the open bay.

In summary, the western salt ponds met the Project objectives for tidal amplitude while the CVWR did not. Low tides at the CVWR were truncated relative to tides at reference sites within San Diego Bay. Monitoring in subsequent years may determine a need for remedial measures.

Figure 10. Monitoring Stations at the Chula Vista Wildlife Reserve.

2.4 Water Quality

Water quality objectives for the western salt ponds included developing water quality within Ponds 10 and 11 (referred to as Salt Ponds in the figures presented below) that is similar to that at the mouth of the Otay River and developing a more variable water quality in Pond 10A which has a muted tidal condition. There were no specific water quality objectives for the CVWR.

Preconstruction water quality monitoring within Pond 11, conducted from 2008 to 2010, showed variations in salinity, dissolved oxygen and temperature associated with water import and export and seasonality. Water salinities in Pond 11 varied from a high of approximately 51 ppt to a low of about 41 ppt. Dissolved oxygen varied inversely with salinity, dropping when salinities were higher and rising when salinities were lower. Water temperature varied seasonally with temperatures as high a 40 °C in summer and as low as 12 ° C in winter. Nutrients in the water also varied widely and were affected by rainfall, turbidity, temperature, dissolved oxygen and other physical factors.

2.4.1 Methods – Monitoring of Water Quality of Western Salt Ponds

As presented above, water quality monitoring of the western salt ponds and mouth of the Otay River was conducted using YSI model 6600 EDS Sonde dataloggers. The dataloggers measure depth, specific conductivity, salinity, dissolved oxygen (percent saturation), dissolved oxygen (mg/l), temperature, turbidity, pH, and chlorophyll at 15 minute intervals for a sampling period of 2-4 weeks before retrieval, downloading, cleaning, recalibration and redeployment.

2.4.2 Results – Monitoring of Water Quality Monitoring of Western Salt Ponds.

Water Quality monitoring results as measured by the datalogger in the eastern breach between Ponds 10 and 11 (Pond 11) and the Otay River Mouth (South Bay – [Otay River]) during 2014 are presented in figures 11 through 17. Water depths were similar at both sites with similar maximum and minimum readings (Figure 11). The gaps in the chlorophyll (at Salt Ponds) and pH (at South Bay) water quality data are the result of probe malfunctions. The gaps in the Pond 11 pH water quality data were removed due to sensor drift.

Salinity was similar at both monitoring stations (Figure 12). Salinity readings near zero were recorded in response to rain events.

Water temperature varied seasonally with the highest temperatures occurring in July, August, and September and lowest in December and January (Figure 13). Trends in water temperature at both monitoring stations were very similar over the 12-month monitoring period.

Maximum chlorophyll levels as measured by the data logger were generally higher within Pond 11 compared to the Otay River (Figure 14) and maximum turbidity levels in Pond 11 were similar, although highly variable, to those in the Otay (Figure 15).

Dissolved oxygen levels varied seasonally and inversely with water temperature (Figure 16). Dissolved oxygen was highest during the cool winter months and lowest during summer. This parameter was similar for Pond 11 and the Otay River Mouth.

Recorded pH levels were similar at both datalogger locations (Figure 17). Minimum, average and maximum pH at both dataloggers were generally around 8.0. Orthophosphate levels varied considerably but were generally similar in Pond 11 and the Otay River (Figure 18). Ammonia and nitrate levels in Pond 11 were similar to those in the Otay River than Pond 11, although there were numerous data gaps (Figures 18 and 19.

In summary, the Project objective that water quality within Ponds 10 and 11 be similar to water quality at the mouth of the Otay River has been met. Variations in certain parameters, e.g., chlorophyll, may be attributed to the physical differences in the two monitoring stations. Higher chlorophyll levels in Pond 11 may be associated with higher turbidity at that monitoring station.

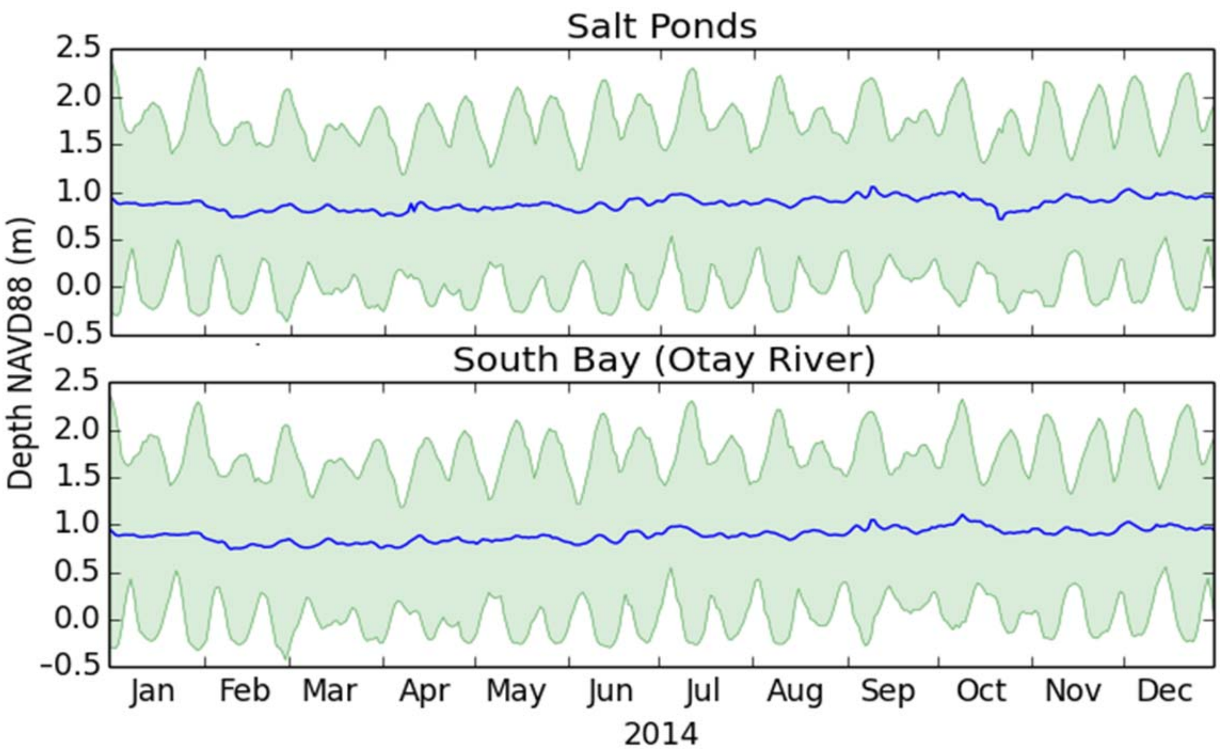


Figure 11. Daily averages, minimums and maximums of water depth in Pond 11 (above) and at the Otay River Mouth (below).

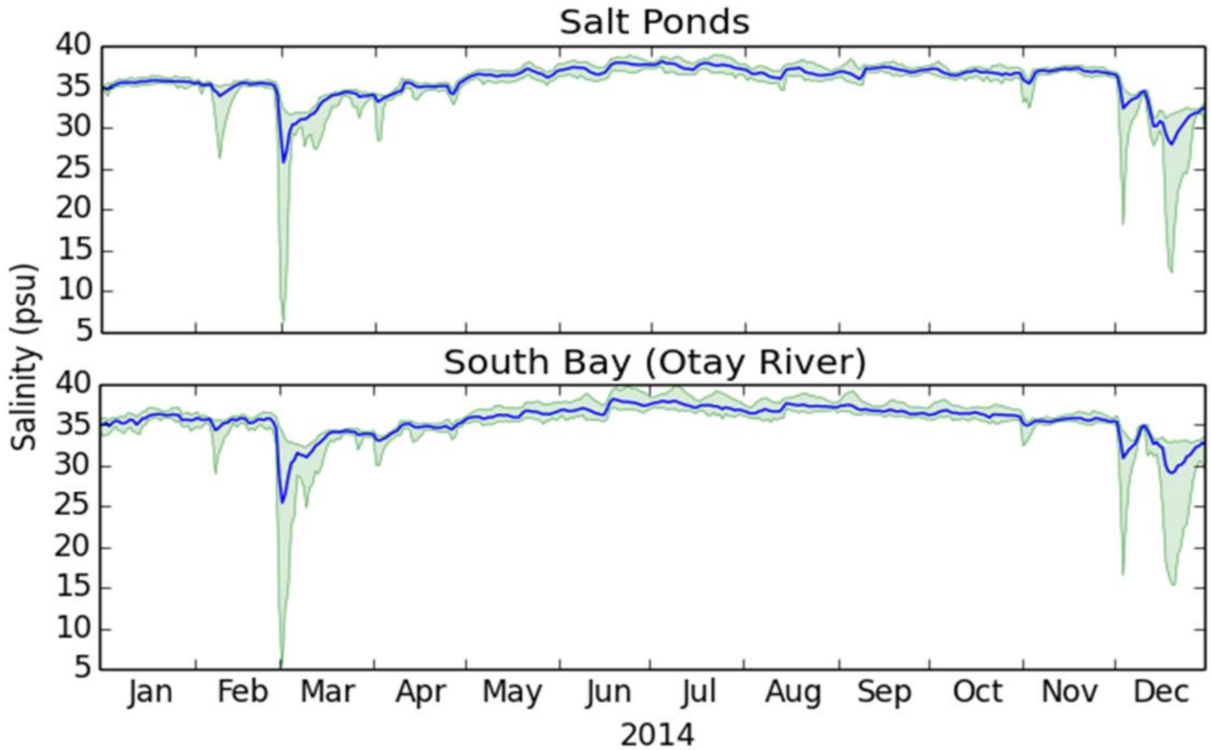


Figure 12. Daily averages, minimums and maximums of salinity in Pond 11 (above) and at the Otay River Mouth (below).

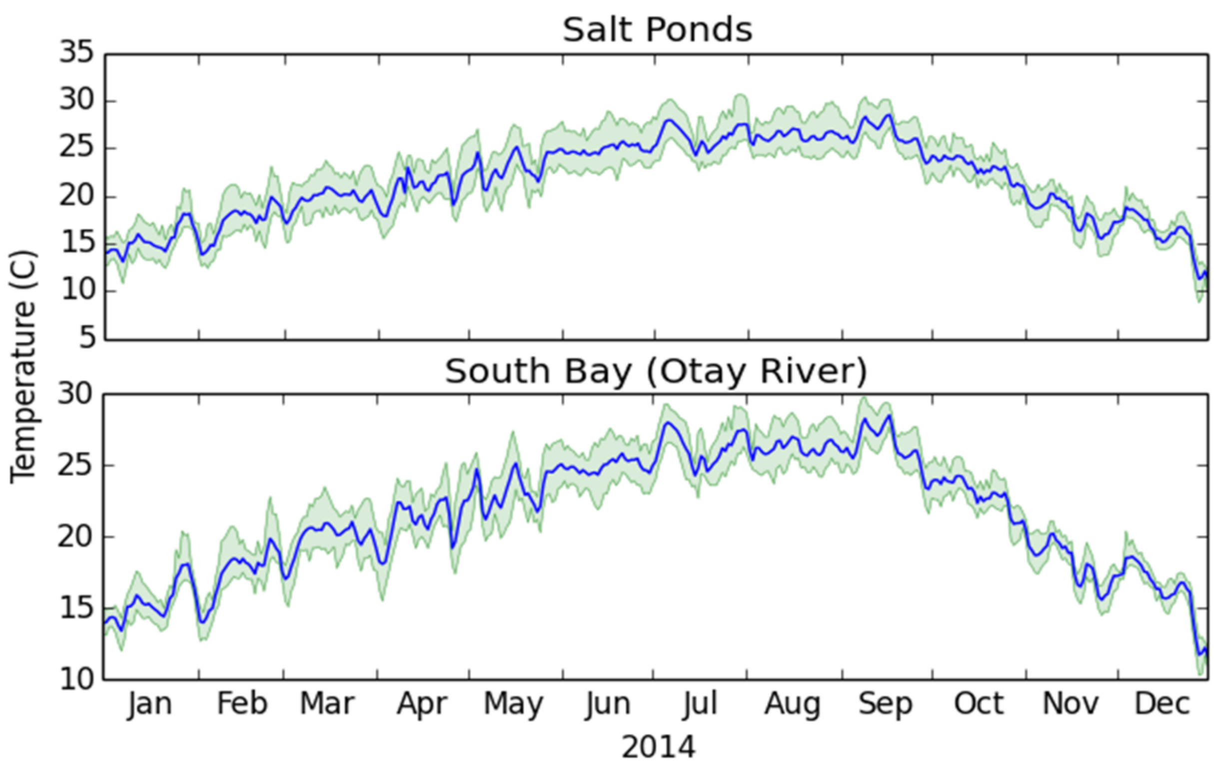


Figure 13. Daily averages, minimums and maximums of water temperature in Pond 11 (above) and the Otay River Mouth (below).

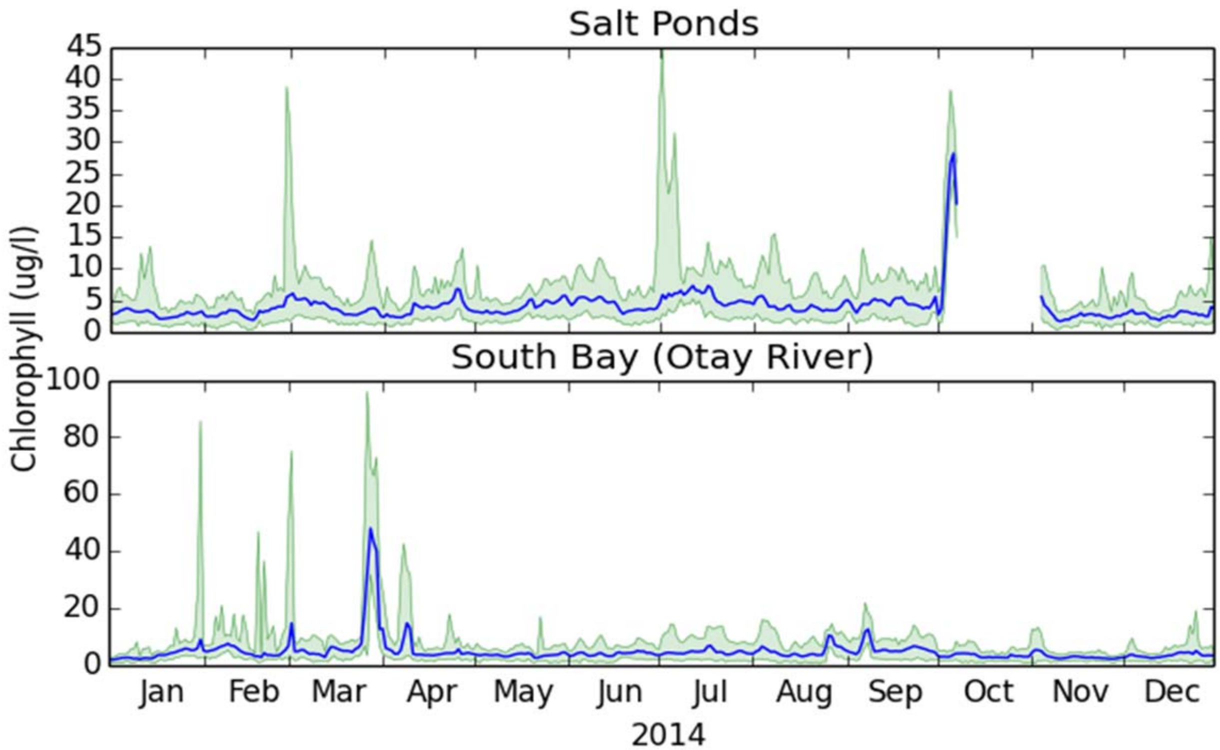


Figure 14. Daily averages, minimums and maximums of chlorophyll in Pond 11 (above) and the Otay River Mouth (below).

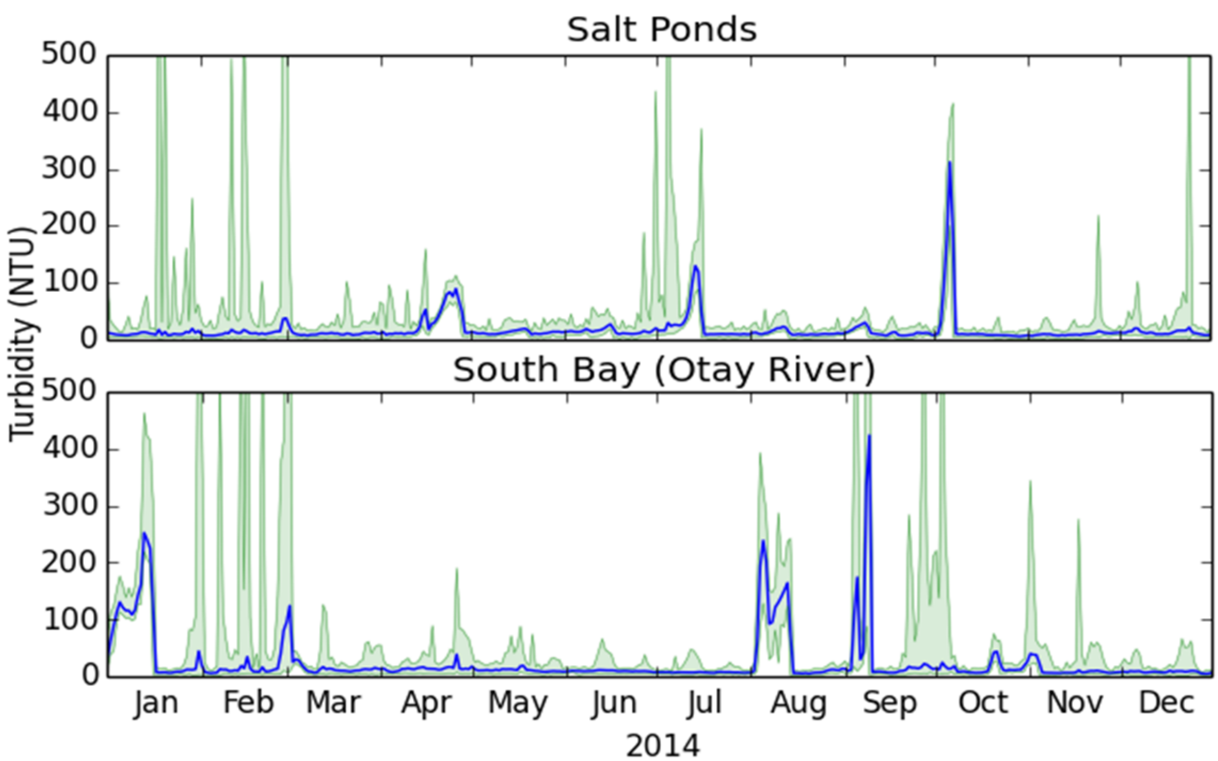


Figure 15. Daily averages, minimums and maximums of water turbidity in Pond 11 (above) and the Otay River Mouth (below).

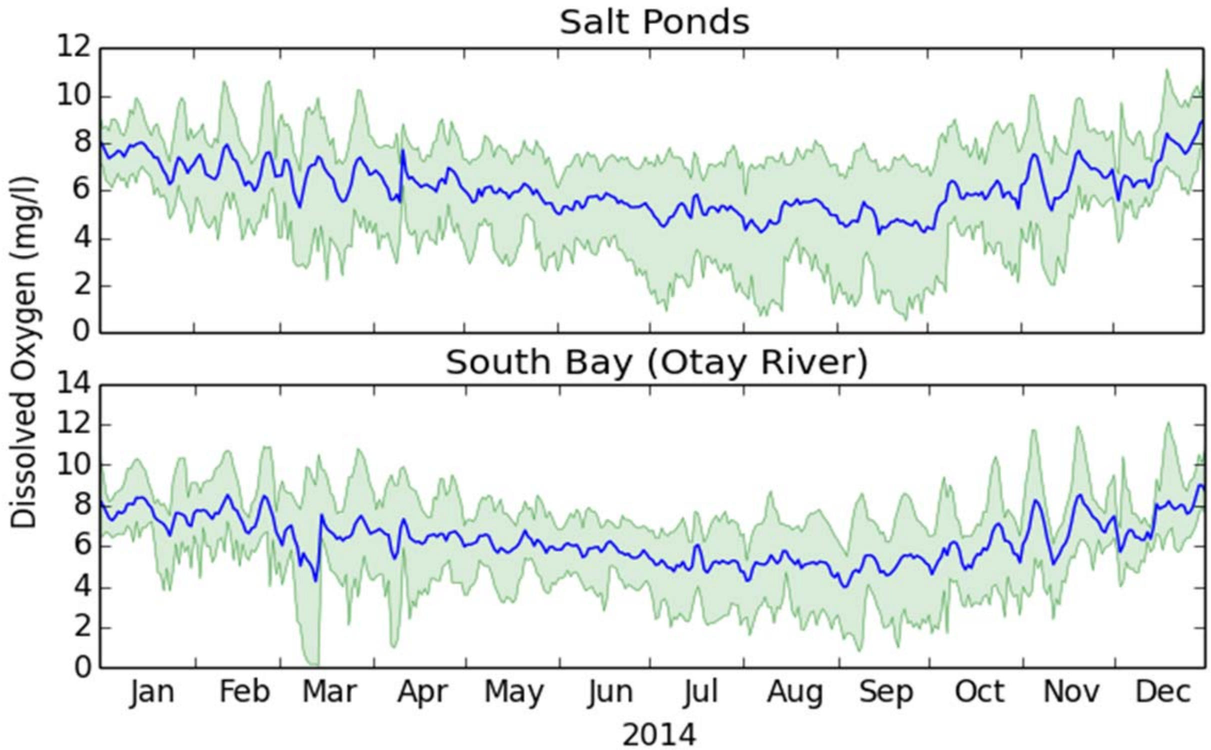


Figure 16. Daily averages, minimums and maximums of dissolved oxygen in Pond 11 (above) and the Otay River Mouth (below).

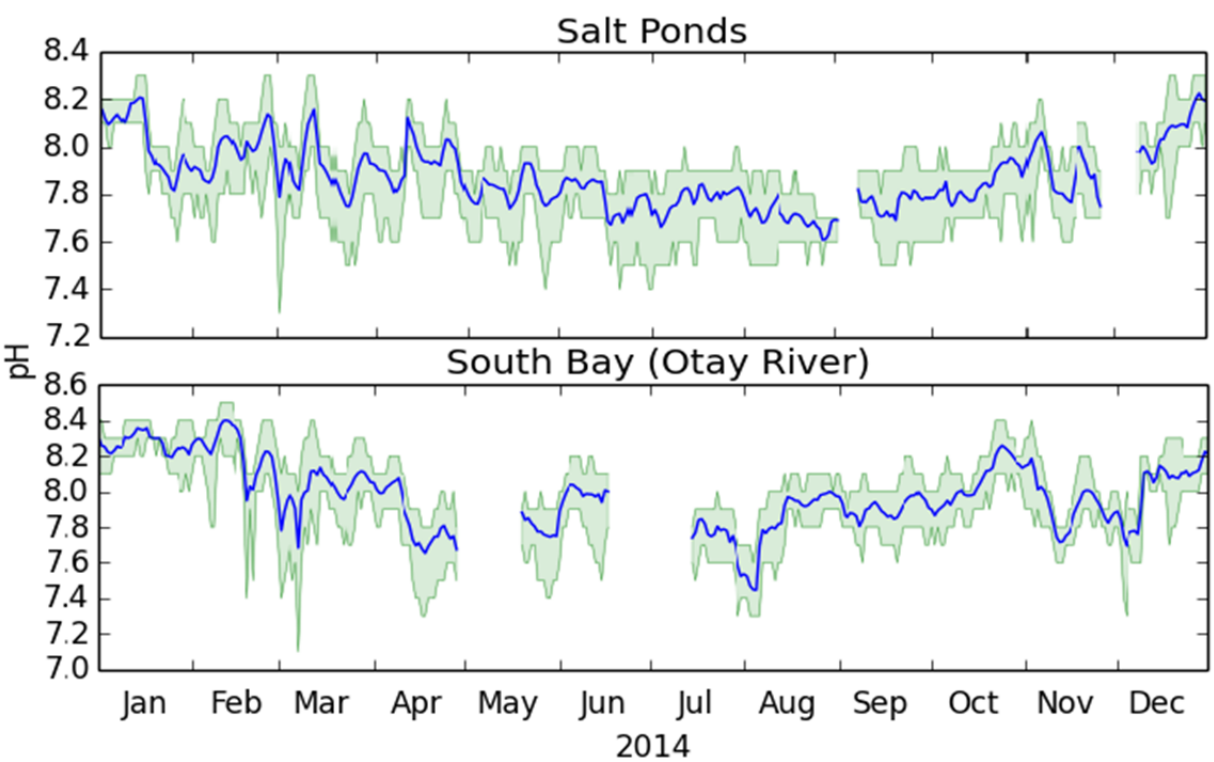
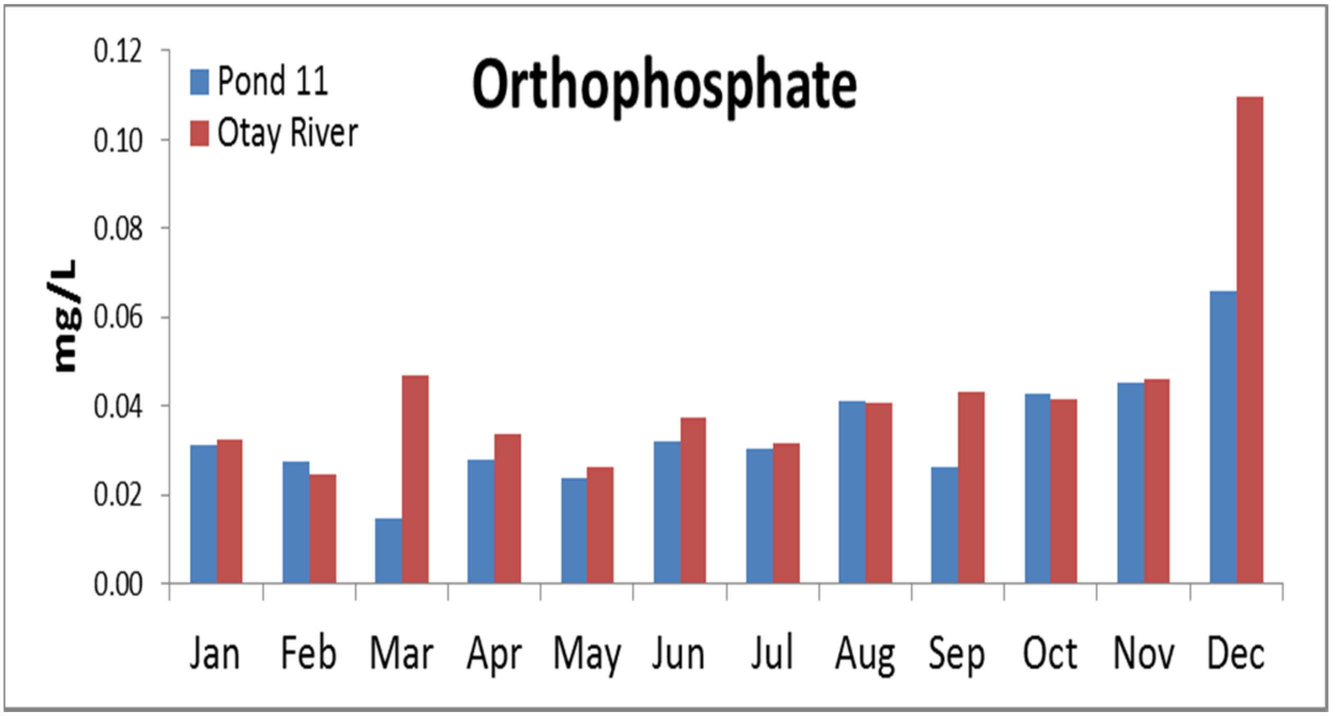


Figure 17. Daily averages, minimums and maximums of water pH in Pond 11 (above) and the Otay River Mouth (below).



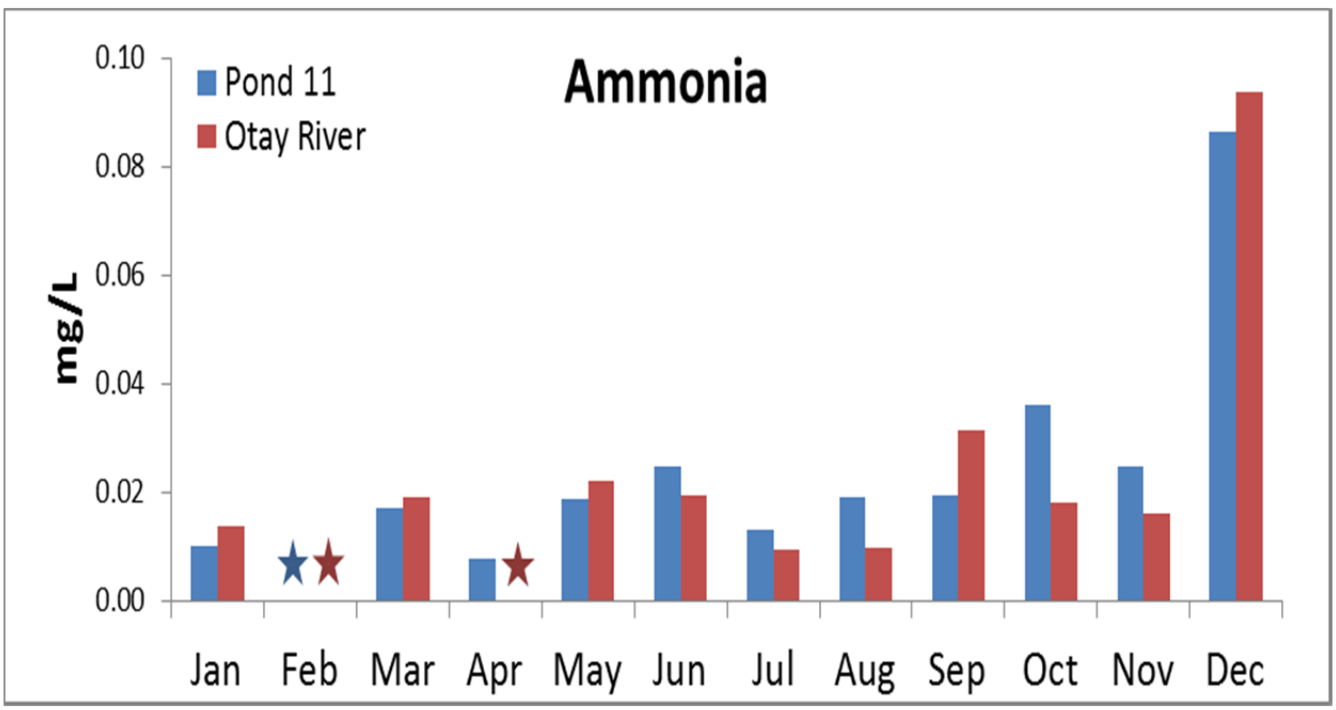
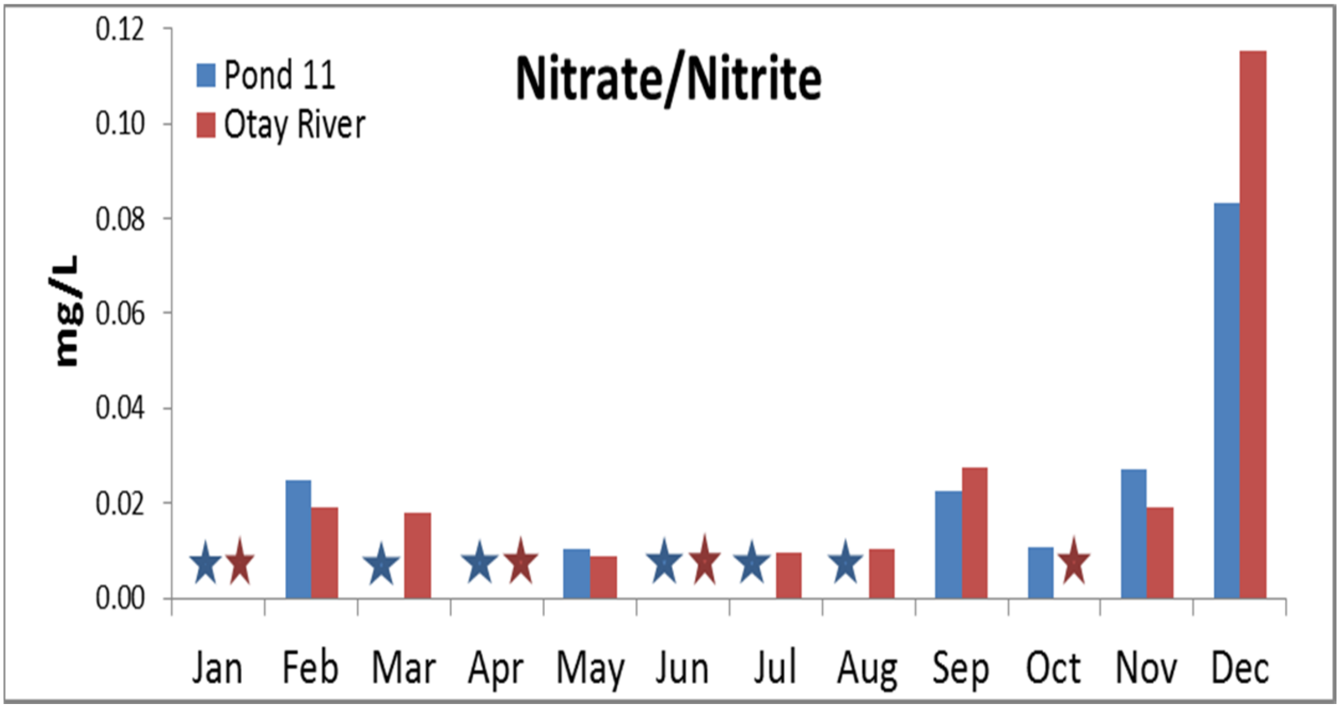


Figure 18. Orthophosphate and Ammonia in Pond 11 and the Otay River Mouth.



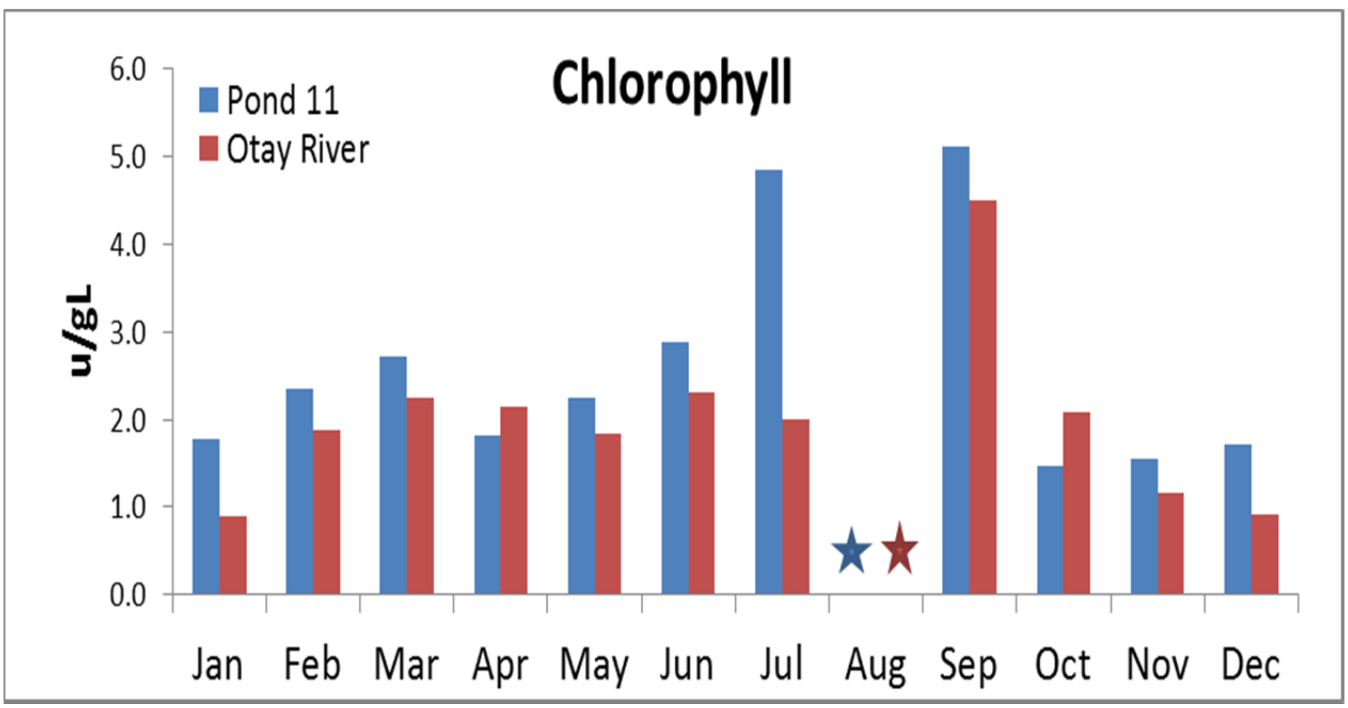


Figure 19. Nitrate/Nitrite and Chlorophyll in Pond 11 and the Otay River Mouth.

2.4.3 Methods – Monitoring of Water Quality Monitoring of Chula Vista Wildlife Reserve

Water quality data at the CVWR were collected by Merkel & Associates under contract to the San Diego Unified Port District. Data on dissolved oxygen, temperature, turbidity, pH were collected from five tidal channel stations (Figure 20) just prior to low tide on April 22, 2014 using a Hydrolab Quanta multiprobe water quality meter. Water samples were collected from tidal channels on the same date prior to low tide for laboratory analysis of nitrogen (as total Kjeidahl Nitrogen), total phosphorus and ammonia.

2.4.4 Results – Monitoring of Water Quality Monitoring Results of Chula Vista Wildlife Reserve

The results of water quality monitoring at the CVWR are summarized in Table 1. All parameters were within the expected ranges. It was concluded that there was no evidence of ponding or poor tidal circulation that could result in extremes in temperature or dissolved oxygen.

Table 1. Water Quality Data Collected from the Chula Vista Wildlife Reserve 2014

March 7, 2013									
Station	**Time**	**Depth (m)**	**Temp. (C)**	**Dissolved Oxygen (mg/l)**	**Salinity (ppt)**	**Turbidity (NTU)**	**Nitrogen TKN (mg/l)**	**Total Phosphorous (mg/l)**	**Amonia (mg/l)**
1	10:00	0.1	20.8	4.2	37.8	6.5	0.6	0.069	0.087
2	10:15	0.1	20.3	6.4	37.0	5.8	0.50	0.064	0.069
3	10:20	0.1	20.7	6.7	37.3	30.3	0.69	0.066	0,096
4	10:30	0.1	24.4	8.4	37.8	3.5	0.52	0.062	0.076
5	10:45	0.1	20.6	6.3	37.8	3.8	0.53	0.053	0.075

2.5 Soils Monitoring

There were no specific Project goals and objectives for either the western salt ponds or CVWR regarding soils and their development over the life of the monitoring program.

2.5.1. Methods – Monitoring of Soils of Western Salt Ponds

Soils of Ponds 10A, 10, and 11 were collected at the stations shown in Figure 7 in September 2014. Soil sampling locations were designed to correlate with monitoring of the experimental planting blocks in Pond 10 and fish enclosure traps/invertebrate sampling stations. Soils were collected using a 6 cm long PVC pipe with an interior diameter of 4.8 cm and were analyzed in the laboratory for grain size, salinity, and organic matter content..

Figure 20. Monitoring Stations Chula Vista Wildlife Reserve.

Two samples were taken at each site and dried in an oven at 105°C. One sample was wet-sieved through 2-mm and 63-µm mesh screens to obtain weight percentages of silt/clay, sand, and pebbles/shell hash

The second sample was homogenized using a coffee grinder, and, from this sample, soil salinity and loss-on-ignition organic matter content were measured. Soil salinity was measured by rehydrating a portion of the homogenized sediment with deionized water to form soil pastes, and then expressing interstitial water onto a handheld, temperature-compensated optical salinity refractometer that measures salinity (primarily sodium chloride) in parts per thousand (ppt).

Percent weight of organic matter was estimated by heating a portion of the homogenized sediment at 550°C for 4 hours in a muffle furnace, and weighing the remainder of the sediment that did not combust after it was allowed to cool to room temperature in a desiccator. It is important to note that the method of loss-on-ignition tends to overestimate the organic carbon content in sediments due to various occurrences and losses of volatile salts, organic compounds, structural water, sulfide oxidation and/or inorganic carbon. Generally, studies have shown that the organic carbon content is approximately half the amount of organic matter determined by loss-on-ignition. It has been shown, however, that geochemical properties and grain size of the sediment strongly affects this method's reliability. More specifically, a rise in clay content leads to a larger discrepancy (Veres, 2002). For a more thorough explanation on the method of loss-on-ignition and its accuracy in determining organic carbon content, see Veres 2002 and references therein.

Lastly, *in-situ* measurements of sediment stability were conducted using a Torvane shear strength gauge that measures soil stability in units of kg/cm.

2.5.2. Results - Monitoring of Soils of Western Salt Ponds

The results of the sediment analyses are presented in Table 2. Soils of all three ponds were dominated by silts and clays. Percent silts and clays by weight were highest in Ponds 10 and 11, with means of 87% and 91%, respectively, and lower in Pond 10A, with a mean of 75%. Average weight percentages of silts and clays within Ponds 10A, 10, and 11 were 81%, 86%, and 89%, respectively. Average weight percentages of organic matter were fairly consistent among the three ponds: 12.0%, 11.0%, and 9.5% in Ponds 10A, 10, and 11, respectively.. Soil salinity ranged from 81 to >160 ppt in Pond 10A, 78 to 136 ppt in Pond 10, and 80 to 129 ppt in Pond 11. It should be noted that the method used here to measure salinity often results in salinity values that are elevated relative to the method of extracting interstitial pore water in the field and expressing it directly onto the refractometer. Thus, salinities measured using the latter method during the October 6 2014 survey of experimental planting blocks of California cordgrass (*Spartina foliosa*) in Pond 10 (see section 3.1.3) had a mean value of 46 ppt. The homogenizing and rehydrating method was adopted in order to compare upland soils with little or no pore water to wetland soils that in some cases are saturated. It provides a basis for comparison but results in elevated readings.

Table 2. Sediment Grain Size, Organics and Salinity Results 2014– Western Salt Ponds

South San Diego Bay Salt Ponds Soil Analyses - September 2014						
		pebbles/ shell hash (> 2mm)	weight percentages sand (2mm>x>63µm)	silt and clay (< 63µm)	Loss-on-Ignition Organics	Salinity (‰)
Pond 10A	1 - 1	0.1	10.4	89.5	10.5	105
	1 - 2	29.0	57.0	13.9	3.5	90
	1 - 3	2.3	58.7	39.0	4.2	102
	2 - 1	5.3	11.7	83.0	13.3	134
	2 - 2	0.0	1.5	98.5	8.9	85
	2 - 3	3.5	4.8	91.8	15.7	115
	3 - 1	0.9	7.7	91.4	20.5	>160
	3 - 2	7.3	18.9	73.8	7.0	98
	3 - 3	6.7	6.3	87.0	11.5	108
	4 - 1	0.3	4.1	95.7	17.0	>160
	4 - 2	0.4	36.4	63.2	6.5	90
	4 - 3	3.5	28.5	68.0	7.6	97
	4 - 4	3.0	15.5	81.5	12.5	130
	4 - 5	4.3	10.7	85.1	12.6	112
	5 - 1	6.7	1.1	92.2	16.2	81
	5 - 2	0.6	6.1	93.3	11.5	>160
	5 - 3	6.6	6.0	87.4	16.2	>160
	1	1.2	6.0	92.8	10.1	155
	2	0.1	5.0	94.9	10.5	116
	3	2.5	6.6	91.0	21.8	>160
	4	0.5	2.7	96.8	14.1	135
Pond 10	1 - 1	0.0	2.3	97.7	14.2	127
	1 - 2	1.1	18.4	80.5	12.9	115
	1 - 3	1.3	27.6	71.1	7.5	78
	5 - 1	0.0	1.5	98.5	11.3	122
	5 - 2	0.1	9.8	90.1	11.1	136
	5 - 3	6.9	43.3	49.8	6.4	105
	7 - 1	0.0	4.5	95.5	11.4	133
	7 - 2	0.2	2.9	96.9	11.6	96
	7 - 3	3.7	11.7	84.6	10.1	119
	8 - 1	0.1	3.7	96.2	9.4	112
	8 - 2	0.0	1.3	98.7	12.1	135
	8 - 3	17.9	14.4	67.7	13.4	124
Pond 11	1 - 1	0.0	13.5	86.5	7.9	100
	1 - 2	6.1	36.2	57.7	5.4	80
	1 - 3	0.6	16.3	83.0	10.6	114
	3 - 1	0.0	1.6	98.4	10.9	92
	3 - 2	0.0	1.3	98.7	11.0	99
	3 - 3	0.0	2.4	97.6	9.9	118
	3 - 4	0.0	2.6	97.4	9.3	128
	3 - 5	0.0	0.3	99.7	14.4	129
	6 - 1	0.0	3.4	96.6	11.1	91
	6 - 2	0.2	1.7	98.1	9.0	95
	6 - 3	0.0	7.2	92.8	9.7	93
	6 - 4	0.0	34.1	65.9	6.6	92
	6 - 5	0.0	17.6	82.4	8.4	107

The results of the Torvane shear strength gauge (Table 3) provide a general comparison of the stability of the soils in each pond. Shear strengths were again highest in Pond 10A (0.28 kg/cm^2

average), intermediate in Pond 10 (0.18 kg/cm^2 average) and lowest in Pond 11 (0.05 kg/cm^2 average). These values can be compared to observations in the field over the sampling period. Soils in 10A can support foot traffic in almost all areas except for remnant channels. Soils in Pond 10 are softer than those in 10A and researchers often sunk knee or thigh deep when conducting field work. The soils in Pond 11, the recipient of dredge slurry from Pond 10, are unconsolidated and may remain unconsolidated for up to 5 years following deposition.

Table 3. Soil Torvane Shear Strength 2014 – Western Salt Ponds

Site Number	Average Shear Strength of Soil kg/cm^2	Standard Error of Mean	Percent Change
Pond 10A			
1	0.12	0.036	0.17
2	0.22	0.014	-0.43
3	0.45	0.024	1.25
4	0.22	0.014	0.00
5	0.25	0.000	-0.35
6	0.27	0.014	-0.27
Pond 10			
1	0.15	0.024	0.25
*2	0.18	0.014	0.38
*3	0.27	0.014	3.68
4	0.27	0.014	-0.43
5	0.05	0.000	2.48
*6	0.23	0.027	2.33
7	0.22	0.014	-0.30
8	0.10	0.000	0.76
9	0.22	0.014	-0.12
*10	0.10	0.009	2.03
Pond 11			
1	0.01	0.003	0.30
2	0.01	0.003	3.33
3	0.02	0.003	1.30
4	0.04	0.007	5.14
5	0.10	0.003	-0.12
6	0.12	0.007	0.03

*Shear strength was not measured at these sites in 2012, percent change based on 2013 measurements.

3.0 BIOLOGICAL PROCESSES

3.1 Vascular Plants

Project goals for the western salt ponds included achieving 50% cover by wetland vascular plants in at least 30 acres of Pond 10 by June 2016 and achieving a height of California cordgrass of 60 cm or more for 25% of the cordgrass population within the minimum 30 acres of such habitat in Pond 10 by June 2016. Project goals for the CVWR included: by the end of 2016, achieve 50 percent coverage of cordgrass and pickleweed over the 3-acre excavation area and improve vigor and plant diversity throughout the remaining 16 acres of estuarine intertidal emergent wetlands within the basin; and, by 2016, restore typical marsh vegetation coverage, using marsh coverage at Tijuana Estuary as a target.

In an effort to achieve these goals, salt marsh vascular plants were planted in low, mid- and high marsh elevation zones in Pond 10 and similar habitats at the CVWR as described below.

3.1.1 Mid-Salt Marsh, High Salt Marsh and Transition Zone Plantings in Pond 10

The perimeter of Pond 10, consisting primarily of the slopes and tops of the levees, was planted with 12 species of mid- and high salt marsh and transition zone species (Table 4). Plants were grown in 2.25 by 3-inch rosepot containers by Tree of Life nursery in San Juan Capistrano, California. Pond 11 was not planted as the sediment disposed there during channel dredging was unconsolidated and therefore was subject to change in elevation over time. In addition, the unconsolidated sediments could not support foot traffic nor were they solid enough to retain plants. Pond 10A was not planted due to the high salinity of the soil. In both Pond 10A and Pond 11, natural recruitment by Pacific pickleweed (*Salicornia pacifica*) and Bigelow's pickleweed (*S. bigelovii*) has established relatively large areas of the low and mid-marsh. California cordgrass has become established on mudflat areas of appropriate elevation in Pond 11. It is assumed that cordgrass was established from bare root ramets that were planted in Pond 10 and not from seed. All three ponds are expected to recruit salt marsh species as the physical conditions in each pond change over time.

Planting of mid- and high salt marsh species and transition zone was conducted by Merkel & Associates under contract to SWIA. These plantings were completed on October 17, 2011. The areas planted are depicted in Figure 21 (Figure 2 of the as-built report Merkel & Associates, December 2011). Mid-marsh species were planted between +4.6 and +5.8 ft NAVD88. High marsh species were planted between +5.8 and + 7.6 ft NAVD88. Transition zone plantings were installed above +7.6 ft NAVD88. All transition zone plants were installed with two quart size DriWater© time release gel packs to provide moisture for approximately 90 days. All plants were installed on approximately 6-foot centers.

3.1.2 Monitoring of Mid-Salt Marsh, High Salt Marsh and Transition Zone Plantings in Pond 10

Mid-salt marsh, high salt marsh and transition zone plantings were not monitored in 2013 due to low initial survival in 2012 and the inability to access the mid-marsh plain. Casual observations in 2012 suggested a survival rate in mid-high marsh of less than 50% and less than 25% in the transition zone. Mid- and high salt marsh plantings were not surveyed in 2013 (Year 2) or 2014 (Year 3).

Table 4. Mid- and High Salt Marsh and Transition Zone Plant Species Planted in Pond 10

Common Name	Scientific name	Quantity	Planting Zone
Saltwort	*Batis maritima*	885	Mid-marsh
Jaumea	*Jaumea carnosa*	885	Mid-marsh
Bigelow's Pickleweed	*Salicornia bigelovii*	885	Mid-marsh
Sea-Blite	*Suaeda esteroa*	885	Mid-marsh
Saltgrass	*Distichlis spicata*	405	High marsh
Alkali Heath	*Frankenia salina*	405	High marsh
Watson's saltbush	*Atriplex watsonii*	425	High marsh
Sea Lavender	*Limonium californicum*	405	High marsh
Shoregrass	*Distichlise littoralis*	830	High marsh/Transition
Parish's Pickleweed	*Arthrocnemum subterminale*	830	High marsh/Transition
Boxthorn	*Lycium californicum*	425	Transition zone
Palmer's Frankenia	*Frankenia palmeri*	425	Transition zone
	Total	**7,690**	

3.1.3. Monitoring of Low Marsh Plantings in Pond 10

Low salt marsh elevations dominated by California cordgrass were planted in two phases. Phase I occurred between October 17 and October 21, 2011 during which 4,000 nursery grown cordgrass plants (2.25 x 3-inch rose pots) were planted on approximately 6-foot centers and arrays as illustrated in Figure 21 (Figure 2 of the as-built report; Merkel & Associates 2011). Each array was comprised of approximately 30 individual cordgrass plants and were planted at the appropriate elevations along the constructed channels and extended onto the marsh plain for a distance of approximately 20 feet.

Arrays were staggered along the channels approximately every 100 feet. In addition to the arrays, ten 60 ft by 60 ft randomized block study plots were planted with 100 cordgrass plants each on 6-ft centers (Figure 21). These study plots were expanded in Phase II as discussed below.

During Phase II, conducted between November 17 and December 3 2011, 35,700 individual cordgrass were planted. These consisted of additional nursery grown plants as well as plants harvested from a donor site immediately adjacent to Ponds 10 and 11 in the salt marsh of the Otay River. Of these 35,700 individuals 2,800 were nursery grown; 1,000 were harvested "plugs" of cordgrass and sediment defined as a small sod-like block about 6 inches deep and 4 – 6 inches in diameter containing substantial amounts of rhizomes and native soil that serves to buffer the plants during transplanting; and 31,900 plants were planted as "bare root planting units" defined as a ramet of 2 - 3 aerial stems of cordgrass with 2 – 6 inches of rhizome with a minimal amount of native soil attached to the rhizomes.

Phase II planting included expansion of the study blocks to include ten 60 by 60 ft randomized study plots with cordgrass plugs each planted with 100 cordgrass plants on 6-ft centers for a total of 1,000 plugs; ten 60 by 60 ft study plots planted with bare root cordgrass on 6-ft centers for a total of 1,000 bare root plants; ten 60 by 60 ft study plots planted with cordgrass grown from seed in the nursery on 6-ft centers for a total of 1,000 bare root plants; and ten unplanted control plots. Thus, each of the 10 study plots included equal size randomized blocks of the three propagation methods (nursery, plugs and bare roots) plus a control plot. The remaining 30,900 bare root plants were planted as shown in Figure 21. Those nursery plants not planted in study plots were planted in area K.

The project originally called for planting approximately 52 acres of low marsh habitat in Pond 10 with 56,874 nursery-grown cordgrass propagated from seed. This decision was based on the restoration team's desire to minimize impacts to existing cordgrass populations associated with the more standard practice of harvesting plugs of cordgrass and transplanting them to the restoration site. The low yield of plants propagated from seed required a change in the planting and also suggested the experimental planting blocks designed to test the effectiveness of each planting and transplantation method. The canopy cover of planted individuals through Year 3 (2014) of the Project was monitored as described below. Future monitoring of cordgrass expansion and, potentially, recruitment into control plots, will be conducted using aerial photography and ground-truthing.

3.1.4 Methods - Monitoring of Randomized Block Cordgrass Study Plots in Pond 10

Cordgrass canopy development within each treatment block was assessed on October 6, 2014 and consisted of estimating percent cover of live individuals within each block. Treatment blocks were accessed by canoe. The soil salinity of each block was measured by expressing a sample of soil at approximately 5 – 10 cm below surface through a syringe with filter paper onto a salinity refractometer.

3.1.5 Results – Monitoring of Randomized Cordgrass Study Plots in Pond 10

The results of the Year 3 (2014) survey are summarized in Table 5. Nursery-grown plants and transplanted plugs achieved similar estimated mean coverage by cordgrass at 25.1% and 25.8%, respectively, compared to 13% and 12%, respectively in 2013. . Percent cover of nursery grown cordgrass ranged from 1% to 45% while cover by plugs ranged from 3.5% to 50%. Bare root plantings had an estimated mean cover of 5.3% with a low of <1% and a high of 25% compared to mean cover of 2.9% ranging from 0% cover to 21% cover in 2013.. .

Figure 21. As-built Salt Marsh Planting in Pond 10 (Figure 2 from As-built Report

Table 5. Estimated Percent Cover of *Spartina foliosa* in Pond 10 October 6, 2014. Cover of *S. foliosa* and *Salicornia bigelovii* combined in parentheses.

Plot	Bare Root	Nursery Grown	Plugs	Control	Salinity
1	2% (40%)	20% (35%)	50% (70%)	<1% (40%)	42
2	4% (45%)	15% (40%)	35% (55%)	5% (40%)	ND
3	10% (45%)	45% (60%)	3.5% (20%)	2.5% (60%)	42
4	25% (65%)	30% (60%)	25% (60%)	2% (40%)	58
5	1% (45%)	30% (45%)	20% (40%)	2% (40%)	46
6	1% (40%)	25% (60%)	15% (50%)	1% (40%)	63
7	3.5% (65%)	25% (65%)	20% (65%)	<1% (55%)	40
8	<1% (12%)	1% (12%)	25% (50%)	2% (40%)	40
9	3% (10%)	20% (40%)	25% (45%)	2% (50%)	42
10	3% (45%)	40% (60%)	40% (41%)	5% (55%)	41
Mean	5.3% (41.2%)	25.1% (47.7%)	25.8% (49.6%)	2.25% (46%)	

* Estimated coverage values of <1% were assigned a value of 0.5% for determination of mean

It should be noted that cordgrass did occur at low percent cover in the control plots in Year 2 (2013). This appeared to be the result of vegetative spread of the planted cordgrass (bare roots, plugs and nursery) in adjacent plots and not from germination from seed.

There was substantial natural recruitment of both the perennial Pacific pickleweed (*Salicornia pacifica*) and the annual Bigelow's pickleweed (*S. bigelovii*) during the Year 3 (2014) growing season. Pacific pickleweed continued to colonize the mid-high marsh plain while Bigelow's pickleweed continued to colonize the low marsh intended for cordgrass. This is typical of south San Diego Bay where cordgrass and Bigelow's pickleweed co-occur; however, it is unclear at this time whether cover by Bigelow's pickleweed during the growing season will inhibit the formation of monotypic stands of cordgrass favored by the light-footed clapper rail. Thus, beginning in Year 2 (2013), cover by Bigelow's pickleweed was monitored in all treatments of the randomized block planting experiment. Estimated cover of both cordgrass and pickleweed has expanded through time as demonstrated in Figure 22. Total estimated cover (cordgrass and pickleweed combined) was relative uniform across all study plots in 2014 ranging from approximately 41% to 50%. Nursery grown cordgrass and cordgrass plugs contributed approximately 25% of that cover while in bare root and control plots, cordgrass contributed little to total cover. As stated in the Year 2 (2013) annual report, Bigelow's pickleweed becomes senescent at the end of each growing season while cordgrass continues to grow below ground during fall and winter. It is possible that this life history strategy could impart a competitive advantage to cordgrass leading to successful establishment of dense monotypic stands. Future monitoring will focus on the interaction of these two species as well as estimates of cover using aerial photography.

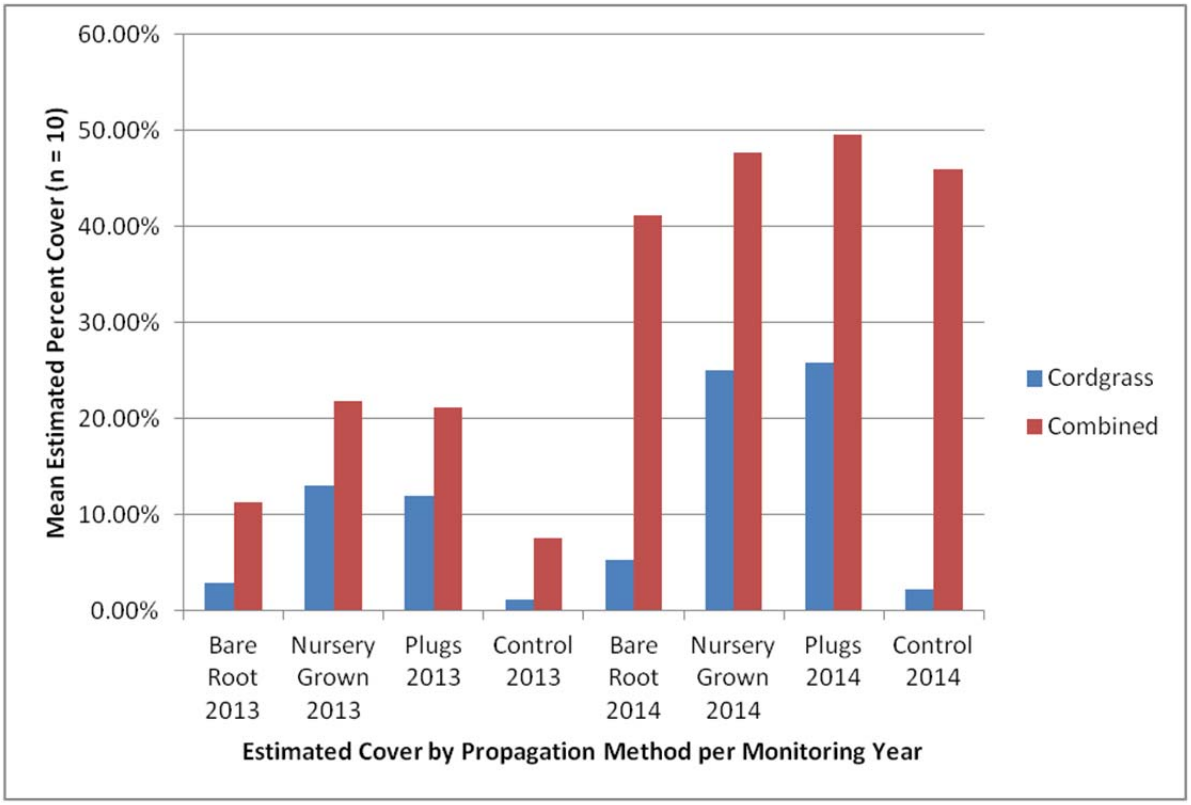


Figure 22. Mean Estimated Percent Cover of Cordgrass and Cordgrass and Pacific Pickleweed Combined at 10 Randomized Block Study Plots Year 2 (2103) and Year 3 (2014).

3.1.6 Monitoring of Vascular Plants in the Chula Vista Wildlife Reserve

The CVWR component of the Project restored 11 acres of salt marsh habitat and enhanced 32 acres of salt marsh through improved tidal influence at the site. The restored habitats included low, mid- and high salt marsh planted from existing marsh that was salvaged prior to construction impacts and supplemented with nursery grown plants. The enhanced habitats were expected to benefit from increased tidal circulation associated with a series of new tidal channels excavated in the existing marsh plain.

Nine species of salt marsh vascular plants were planted at the CVWR. These were salvaged from existing salt marsh on-site and supplemented with nursery stock as presented in Table 6. All species were replanted following completion of construction.

Table 6. Salt Marsh Plant Species Planted in the Chula Vista Wildlife Reserve

Habitat Zone	Species	Planting Unit	Count
Low Salt Marsh	*Batis maritima*	Plugs	181 Salvaged Plugs
	Salicornia pacifica	72” X 36” X 10” sods	129 Salvaged Sods
	Spartina foliosa	Bare Root Plugs	1,432 Bare Root Plugs
Mid Salt Marsh	*Batis maritima*	Plugs	96 Salvaged Plugs
	Frankenia salina	1-Gallon	214 Containers
	Spartina foliosa	Bare Root Plugs	190 Bare Roots Plugs

	Salicornia pacifica	72" X 36" X 10" sods	137 Salvaged Sods
	Suaeda taxifolia	1-Gallon	69 Containers
High Salt Marsh	*Distichlis spicata*	Plugs	74 Nursery Plugs
	Frankenia salina	1-Gallon	74 Containers
	Distichlise littoralis	Plugs	132 Salvaged Plugs
	Suaeda taxifolia	1-Gallon	47 Containers
	Salicornia subterminalis = Arthrocnemum subterminale	1-Gallon	81 Salvaged Containers
Total			2,856 Units

3.1.7 Methods – Monitoring of Vascular Plants in the Chula Vista Wildlife Reserve

The success of the salt marsh plantings at the CVWR was assessed at four monitoring stations: three restoration stations and one reference station (see Figure 20). At each station a baseline was established perpendicular to the tidal channel, extending from the low marsh up to the mid-marsh. Four 50-m transects were established perpendicular to the baseline. Two transects extended across low marsh plain and two across the mid-marsh plain. Point intercept data were recorded along each transect at 1-m intervals and data was presented as percent cover.

3.1.8 Results – Monitoring of Vascular in the Chula Vista Wildlife Reserve

Monitoring of planted salt marsh habitats in Year 1 using the point intercept method revealed that the planted area was largely bare with an average of 4% cover (Merkel & Associates, May10, 2012). The dominant species was naturally recruited Bigelow's pickleweed (2.3%) followed by Pacific pickleweed (0.7%), naturally recruited sea-blight (0.3%) and shoregrass (0.2%). Additional species present included California cordgrass, saltwort and alkali heath – all of which were planted. Low percent cover is common following planting of wetland restoration sites and is not necessarily indicative of poor survival.

In Year 2 (2013), mean percent cover in the planted marsh was 25.5% By comparison, mean percent cover in the reference marsh was 96.0% (SD = 3.2%) in Year 1 and 99.5 % (SD = 1) during Year 2. Like Pond 10 salt marsh habitat, planted species at the CVWR are expected to expand in cover in subsequent years.

During Year 2, the dominant species observed was Bigelow's pickleweed. Mean cover of this species at the three monitoring stations ranged from 5.5% to 34.0%. Pacific pickleweed mean cover ranged from 0.5% to 3.5%.

During Year 3 (2014), the dominant species observed continued to be Bigelow's pickleweed with mean cover of this species of approximately 34% and 32% in low and mid-marsh transects, respectively. Mean cover by Pacific pickleweed was 4.5% along all transects combined. Cordgrass comprised 2% cover along all transects combined. Algerian sea lavender (*Limonium ramosissimum*), which was first observed on the CVWR in 2009, has spread and may invade the restoration area. Currently, this invasive species occurs adjacent to the restoration site at CVWR.

In summary, initial plantings of low, mid- and high salt marsh vascular plant species in Pond 10 had low to moderate survival. However, natural recruitment by Pacific pickleweed in the mid-high marsh and by Bigelow's pickleweed in the low marsh, along with survival of planted cordgrass indicates that Project goals for vascular plants and salt marsh habitats will be achieved by 2016. Similarly, planted species at the CVWR are expected to benefit from improved tidal influence and expand in subsequent years to meet the 2016 goals for this portion of the Project.

3.2 Fish Monitoring

The NOAA metric for fish at the western salt ponds was to demonstrate presence of one or more of the target taxa (flatfish and elasmobranchs) by 2013. At CVWR, the NOAA metric for fish was to demonstrate presence of one or more of the target taxa (gobiidae and topsmelt) by 2013. At both sites, NCWC objectives were to achieve successful recruitment of benthic invertebrates and fish within Pond 11 to support migratory shorebirds and foraging ground-nesting seabirds by 2013.

In Year 3 (2014), fish were monitored using a variety of sampling gear, including minnow traps, enclosure traps and otter trawls in the western salt ponds and minnow traps, enclosure traps and seines with blocking nets at the CVWR. The Project monitoring plan had specified the use of beach seines and blocking nets in the western salt ponds; however, the soft substrate in Ponds 10 and 11 precluded this method and the trawls, traps and enclosures were used exclusively in western salt ponds during Years 1 – 3 (2012 – 2014).

3.2.1 Methods - Fish and Invertebrates Collected Using Otter Trawls in the Western Salt Ponds

Otter trawls were conducted in Ponds 10 and 11 on October 17, 2014. The otter trawl was a 12-foot semi-balloon otter trawl with 1-inch mesh netting lined with 0.25-inch knotless mesh netting.

The trawls were towed behind a small, shallow-draft vessel at approximately 2.5 – 3.5 knots. All trawls were towed for approximately 100 meters once the net was on the bottom. All collected trawls were towed within a tide range of approximately +3.0 to +4.5-ft MLLW (+2.82 to +4.32-ft NAVD88). This tidal range allowed most trawls to be performed with mudflats visible to aid navigation. Weather conditions were good for the survey with clear skies, light winds and calm water.

A total of 9 otter trawls were collected (Figure 23). The otter trawls were designated as stations 15 - 23. Stations 1 – 12 were sampled with a beam trawl in 2012. That methodology was dropped for the current effort.

All captured fish were identified to species, weighed, and measured. Fish lengths were measured as total length. For stingrays, length measurements consisted of disc length. When more than 30 individuals of a given species were captured, the remaining individuals were counted and weighed. In the event that there were very high numbers of a species captured, 100 individuals were counted and weighed; the data allowed the remaining number of individuals to be estimated by weighing the remaining fish as a batch.

In addition to the captured fish, data were collected for invertebrates and marine debris captured within each trawl. Marine debris was simply noted as present in the trawls. Marine debris generally consisted of pieces of drift or unattached algae and were not part of the investigation. Invertebrates were noted for presence.

3.2.2 Results – Monitoring of Fish and Invertebrates Using Otter Trawls in the Western Salt Ponds

Fish

A total of 888 individuals representing 11 species and 8 families were collected using otter trawls in 2014 (Table 7). In terms of relative abundance, otter trawls were dominated by juvenile slough anchovy (*Anchoa delicatissima*; 828) which combined comprised 93.2% of the catch. The majority of the slough measured approximately 2-5 cm and weighed approximately 0.1 to 0.5 gm. Round stingrays (*Urobatis halleris*) dominated the otter trawls in terms of biomass. Photographs of representative fish species collected during the trawling effort are presented in Figure 24.

By comparison, otter trawls conducted in Year 2 (2013) captured total of 1,915 individuals representing 11 species and 9 families. Trawls were dominated by juvenile slough anchovy (1,388) and juvenile deepbody anchovy (*Anchoa. compressa;* 454) which combined comprised 96.2% of the catch. In Year 1 (2012), trawls captured a total of 501 individuals representing 7 species and 7 families. The trawls were dominated by juvenile slough anchovy (267; 53.3%) and juvenile topsmelt (*Atherinops affinis*; 40; 42.3%). Round stingrays dominated the otter trawls in terms of biomass on all monitoring years.

The presence of round stingray, California halibut (*Paralichthys californicus*) and diamond turbot (*Hypsopsetta guttulata*) in the 2014 surveys, as well as bat ray and gray smoothound in Year 2 (2013) meets the NOAA metric for fish (elasmobranchs and flatfishes). Recruitment of fish species that provide forage for ground nesting seabirds meets the NCWC Project objectives. Thus, the Project goals for fish in Ponds 10 and 11 are considered met.

Invertebrates and Marine Algae

Eight species of invertebrates were collected in the trawls, including gastropods, bivalve molluscs, decapod crustaceans, and one species of squid (Table 8). Two species of marine algae were also collected. The sessile invertebrate *Zoobotryon verticillatum* and marine algae gracillaria (*Gracilaria* sp.) were the most common.

Figure 23 — MTS, Marine Taxonomic Services, Ltd. — **Otter Trawl Sampling Locations – Western Salt Ponds.**

Table 7. Fish Collected Using Otter Trawls Western Salt Ponds 2014.

Family	Species	Common Name	Total Collected	% of Total
Engraulidae	*Anchoa delicatissima*	slough anchovy	828	93.2%
	Anchoa compressa	deepbody anchovy	8	0.9%
	Engraulis mordax	northern anchovy	12	1.4%
Dasyatidae	*Urobatis halleris*	round stingray	24	2.7%
Bothidae	*Paralichthys californicus*	California halibut	8	0.9%
Pleuronectidae	*Hypsopsetta guttulata*	diamond turbot	1	0.1%
Sciaenidae	*Cynoscion parvipinnis*	shortfin corvina	1	0.1%
	Cheilotrema saturnum	black croaker	1	0.1%
Serranidae	*Paralabrax maculatodasciatus*	Spotted san bass	1	0.1%
Gobiidae	Goby sp	goby	3	0.3%
Atherinidae	*Atherinops affinis*	topsmelt	1	0.1%

Table 8. Invertebrates and Algae Collected Using Otter Trawls Western Salt Ponds 2014

Hemigrapsus oregonensis	yellow shore crab	Decapod crustacean
Loligo opalecens	market squid	Cephalopod
Portunus xantusii	swimmer crab	Decapod crustacean
Tagelus californicus	California jackknife clam	Bivalve mollusc
Penaeus californicus	brown shrimp	Decapod crustacean
Aphrocallistes sp.	cloud sponge	Porifera
Zoobotryon verticillatum.	zoobotryon	Bryozoa
Gracillaria sp.	gracillaria	Algae
Ulva lactuca	sea lettuce	Algae

Figure 24. Photographs of Trawl Results 2014 [California halibut (top), brown shrimp (middle) and black croaker (bottom)]

3.2.3 Methods - Fish and Invertebrates Collected Using Minnow Traps in the Western Salt Ponds

In order to provide a general characterization of fish populations in the salt ponds, minnow traps were deployed in Ponds 10A, 10, and 11 (Figure 25). The traps were deployed just offshore at low tide to a depth of complete submersion and left for 24 hours. Due to the traps resting on the substrate, the fish sampled were primarily limited to those that reside or feed in the benthic zone. The locations of trap deployment were based on the availability to safely walk without disturbing bird nesting areas along the levees and ease of accessing the site without significantly sinking in the mud. Due to the transport of fine sediment, resulting in local shoaling in the northwest corner of Pond 11 it was impossible, on foot, to deploy a minnow trap at site 9 and have it submerged during low tides. Site 9 was abandoned and moved to a location between sites 10 and 11 (see Figure 24).

Minnow traps were deployed on 6 occasions – once each in January, March, May, July, September and November, 2014. Sampling consisted of retrieving the traps at low tide, emptying the trap in a bucket of site water, measuring to the nearest mm the lengths of the first 20 fish of each species to the nearest centimeter, and counting the remaining fish, grouped by species. Most of the species were identified in the field and the majority was released alive. Those species not identified in the field were brought back to the lab, identified, and released.

3.2.4 Results – Monitoring of Fish and Invertebrates Using Minnow Traps in the Western Salt Ponds

Throughout 2014, a total of 130 individual fish representing 4 species and 4 families were collected at the 11 sampling sites within the western salt ponds using minnow traps (Table 9). This is down significantly from 2013 and 2012 totals of 262 and 642 individuals, respectively. The numerically dominant species collected was California killifish (*Fundulus parvipinnis*) with 65 individuals representing 50% of the catch (31% last year). Longjaw mudsucker (*Gillichthys mirabilis*) was the second most abundant species with 36 individuals collected over the 6 monitoring dates (28%; 31% last year). Topsmelt (*Atherinops affinis*) was also abundant in one trap in May, accounting for 22% of the total catch (28 individuals). One arrow goby (*Clevelandia ios*) was also caught.

The majority of all individuals, 58%, were collected from Pond 10A, compared to 42% in Pond 10. No fish were caught in Pond 11. This bias was likely caused by the location of the traps. The traps in Pond 10A were restricted to the narrow inlet in the northwest corner through which fish must traverse to enter the pond. Three of the 4 traps in Pond 10 were located in the farthest southeast corner of the pond and all of the Pond 11 traps were located along the northern most shore of the pond. Fish populations, particularly benthic fishes, are likely still adjusting to the sediment movement in both ponds. Populations are expected to increase as the sediment consolidates. Future monitoring will determine whether this hypothesis is valid.

Figure 25. Minnow Trap Sampling Stations Western Salt Ponds.

Invertebrates collected using minnow traps in the western salt ponds included 4 species of decapod crustaceans (Table 9). Decapod crustaceans were dominated by yellow shore crab (*Hemigrapsus oregonenisis*) and striped shore crab (*Pachygrapsus crassipes*). Of the 35 individuals collected, approximately 63% were yellow shore crab and 29% were striped shore crab. The remainder consisted of 2 California green shrimp (*Hippolyte californiensis*) and 1 California pistol shrimp (*Alpheus californiensis*). The majority (97%) of invertebrates were collected in Ponds 10A and 10.

3.2.5 Methods – Monitoring of Fish and Invertebrates Using Minnow Traps in the Chula Vista Wildlife Reserve

Minnow traps were deployed within the CVWR at sampling sites 2, 3, 4 and 6 (see Figure 10) on September 18, 2014. Like the traps set at the western salt ponds, traps were deployed in the channels at low tide to a depth of complete submersion and left for 24 hours.

3.2.6 Results – Monitoring of Fish and Invertebrates Using Minnow Traps in the Chula Vista Wildlife Reserve

No fish were captured in the minnow traps at the CVWR (Table 9). Only 1 California green shrimp and 2 yellow shore crabs collected In 2013, a total of 17 fish were captured in the minnow traps at the CVWR. California killifish had the highest total, representing 94% of the total catch..

Table 9. Fish and Invertebrates Collected Using Minnow Traps Western Salt Ponds 2014.

Species		Minnow Traps - 2014																							
		Pond 10A																							
Scientific Name	Common Name	January				March				May				July				September				November			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Fundulus parvipinnis	California Killifish									3			12												25
Atherinops affinis	Topsmelt																								
Clevelandia ios	Arrow Goby																								
Gillichthys mirabilis	Longjaw Mudsucker									6	6	3	9	7		2	1							1	
Alpheus californiensis	Californial Pistol Shrimp																								
Hippolyte californiensis	California Green Shrimp																								
Pachygrapsus crassipes	Striped Shore Crab																					6	3	1	
Hemigrapsus oregonensis	Yellow Shore Crab		1		3		1	1	2				1	1						3	1			1	4
Total ***Fish*** Abundance per Site		0	0	0	0	0	0	0	0	9	6	3	21	7	0	2	1	0	0	0	0	0	0	1	25
Mean ***Fish*** Abundance per Site		0.0				0.0				9.8				2.5				0.0				6.5			
Mean ***Fish*** Abundance per Site per Pond, All Surveys		3.1																							
Fish Species Richness per Pond, All Surveys		2																							
Total ***Invertebrate*** Abundance per Site		0	1	0	3	0	1	1	2	0	0	0	1	1	0	0	0	0	0	3	1	6	3	2	4
Mean ***Invertebrate*** Abundance per Site		1.0				1.0				0.3				0.3				1.0				3.8			
Mean ***Invertebrate*** Abundance per Site per Pond, All Surveys		1.2																							
Invertebrate Species Richness per Site per Pond, All Surveys		2																							

Species		Minnow Traps - 2014																							
		Pond 10																							
Scientific Name	Common Name	January				March				May				July				September				November			
		5	6	7	8	5	6	7	8	5	6	7	8	5	6	7	8	5	6	7	8	5	6	7	8
Fundulus parvipinnis	California Killifish									25															
Atherinops affinis	Topsmelt									28															
Clevelandia ios	Arrow Goby							1																	
Gillichthys mirabilis	Longjaw Mudsucker				1																				
Alpheus californiensis	Californial Pistol Shrimp												1												
Hippolyte californiensis	California Green Shrimp	1				1																			
Pachygrapsus crassipes	Striped Shore Crab																								
Hemigrapsus oregonensis	Yellow Shore Crab	1																	1						
Total ***Fish*** Abundance per Site		0	0	0	1	0	0	1	0	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean ***Fish*** Abundance per Site		0.3				0.3				17.7				0.0				0.0				0.0			
Mean ***Fish*** Abundance per Site per Pond, All Surveys		2.4																							
Fish Species Richness per Pond, All Surveys		4																							
Total ***Invertebrate*** Abundance per Site		2	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
Mean ***Invertebrate*** Abundance per Site		0.5				0.3				0.3				0.0				0.3				0.0			
Mean ***Invertebrate*** Abundance per Site per Pond, All Surveys		0.2																							
Invertebrate Species Richness per Site per Pond, All Surveys		3																							

Species		Minnow Traps - 2014																					
		Pond 11																		CVWR			
Scientific Name	Common Name	January			March			May			July			September			November			September			
		9	10	11	9	10	11	9	10	11	9	10	11	9	10	11	9	10	11	2	3	4	6
Fundulus parvipinnis	California Killifish																						
Atherinops affinis	Topsmelt																						
Clevelandia ios	Arrow Goby																						
Gillichthys mirabilis	Longjaw Mudsucker																						
Alpheus californiensis	Californial Pistol Shrimp																						
Hippolyte californiensis	California Green Shrimp																					1	
Pachygrapsus crassipes	Striped Shore Crab																						
Hemigrapsus oregonensis	Yellow Shore Crab																	1					2
Total ***Fish*** Abundance per Site		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean ***Fish*** Abundance per Site		0.0			0.0			0.0			0.0			0.0			0.0			0.0			
Mean ***Fish*** Abundance per Site per Pond, All Surveys		0.0																					
Fish Species Richness per Pond, All Surveys		0																		0			
Total ***Invertebrate*** Abundance per Site		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2
Mean ***Invertebrate*** Abundance per Site		0			0			0			0			0			1			0.75			
Mean ***Invertebrate*** Abundance per Site per Pond, All Surveys		0.1																					
Invertebrate Species Richness per Site per Pond, All Surveys		1																		2			

3.2.7 Methods - Monitoring of Fish Using Enclosure Traps in the Western Salt Ponds and Chula Vista Wildlife Reserve

Following the sampling protocol of the San Onofre Nuclear Generating Station (S.O.N.G.S.) Wetland Mitigation Program at San Dieguito Lagoon, an enclosure trap (Figure 26) was employed to sample primarily gobies (family *Gobiidae*), small, burrowing fishes that are often poorly sampled by other methods. The enclosure trap is composed of a polypropylene sheet fixed as a 1m-tall cylinder with a $0.4m^2$ sampling area. The trap is thrown away from the sampler in an attempt to minimize the startling of any fish nearby. A BINCKE net is then swept inside the trap and fish were identified by species, counted, measured for length, and released. This was repeated until no fish were caught a total of 3 times. The trap was deployed at 6 sites in each of ponds 10A and 10 (see Figure 7) and at the 6 sampling sites at the CVWR (see Figure 10).

3.2.8 Results – Monitoring of Fish Using Enclosure Traps in the Western Salt Ponds and Chula Vista Wildlife Reserve

The results of enclosure trap sampling at the western salt ponds and the CVWR are presented in Table 10. Pond 10A had a total of 33 individual fish, the majority (32 individuals) being California killifish. One longjaw mudsucker was captured. Only 2 invertebrate species were captured in the enclosure traps in Pond 10A, where California horn snail (*Cerithidea californica*) represented 98% of the 287 individuals. The remaining was the Asian mussel (*Musculista senhousia).*

Pond 10 had significantly fewer fish caught (a total of 8), including 4 arrow gobies 2 slough anchovies, 1 topsmelt and 1 longjaw mudsucker. Four invertebrate species were captured in low numbers, including the yellow shore crab, bent-nose clam (*Macoma nasuta*), California jackknife clam, and Asian mussel.

A total of 25 individual fish were collected from the 6 sampling sites located at the CVWR. Arrow goby was the dominant species collected with 23 individuals, comprising 92% of the catch (Table 10). One of each of the following species was also caught: California killifish and striped mullet (*Mugil cephalus*). Eight invertebrate species, for a total of 172 individuals, were also captured (Table 10). The dominant species was the California horn snail (87%), followed by bent-nose clam (*Macoma nasuta*; 4%) and California venus (*Chione californiensis*; 4%).

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Figure 26. Enclosure Trap

Table 10. Fish and Invertebrates Collected Using Enclosure Traps Western Salt Ponds and Chula Vista Wildlife Reserve 2014

Species		Enclosure Traps																
Scientific Name	Common Name	Pond 10A						Pond 10						Chula Vista Wildlife Reserve					
		1	2	3	4	5	6	1	4	5	7	8	9	1	2	3	4	5	6
Atherinops affinis	Topsmelt									1									
Clevelandia ios	Arrow Goby							1		1	1		1	15	5		2	1	
Acanthogobius flavimanus	Yellowfin Goby																		
Fundulus parvipinnis	California Killifish	30			2														1
Anchoa delicatissima	Slough Anchovy												2						
Gillichthys mirabilis	Longjaw Mudsucker		1										1						
Mugil cephalus	Striped Mullet																	1	
Syngnathus leptorhynchus	Bay Pipefish																		
Urobatis halleris	Round Stingray																		
Alpheus californiensis	Pistol Shrimp																		
Pseudosquilliopsis marmorata	Mantis Shrimp																		
Paleomon macrodactylus	Oriental Shrimp															1			
Hemigrapsus oregonensis	Yellow Shore Crab										2					1			
Uca crenulata	Fiddler Crab																1		
Cerithidea californica	California Horn Snail	2	98	21	159	2								2	7				140
Chione californiensis	California Venus														6				
Macoma nasuta	Bent-nosed Clam							3				2	2		1			7	
Protothaca staminea	Pacific littleneck Clam																		
Tagelus californianus	California Jackknife Clam											1	3					2	
Musculista senhousia	Asian Mussel		5					2			3		1	1	3				
	Total ***Fish*** Abundance per Site	30	1	0	2	0	0	1	0	2	1	0	4	15	5	0	2	2	1
	Mean ***Fish*** Abundance per Site	5.5						1.3						4.2					
	Fish Density per Pond (#/m^2)	13.8						3.3						10.4					
	Fish Species Richness per Pond	2						4						3					
	Total ***Invertebrate*** Abundance per Site	2	103	21	159	2	0	5	0	0	5	3	6	3	17	2	1	9	140
	Mean ***Invertebrate*** Abundance per Site	47.8						3.2						28.7					
	Invertebrate Density per Pond (#/m^2)	119.6						7.9						71.7					
	Invertebrate Species Richness per Pond	2						4						8					

3.2.9 Methods - Monitoring of Fish Using Seines in the Chula Vista Wildlife Reserve

Due to the lack of great success catching fish with either minnow traps or enclosure traps, it was deemed suitable to seine at two locations at the CVWR. Following the protocols of the monitoring plan of the S.O.N.G.S. Wetland Mitigation Program, a small purse seine (6m wide) and blocking nets were used to help better characterize the fish populations there. Blocking nets were spaced approximately 5 meters apart. The seine was hauled 5 times before closing and retrieving the blocking nets, for a total of 7 hauls. After each haul, organisms were retrieved from the nets, placed in buckets, identified, measured (first 30 of each species), counted, and released.

3.2.10 Results - Monitoring of Fish Using Seines in the Chula Vista Wildlife Reserve

Two sites were sampled at the CVWR using seines with blocking nets. At site 1, an approximately 22.5 m^2 area was sampled while at site 2 an approximately 35 m^2 area was sampled. The results are presented in Table 11. A total of 253 individuals were collected, averaging approximately 4 individuals/m^2. Arrow goby were the most abundant comprising 63% of the catch, followed by topsmelt (17%) and California killifish (12.6%). Four species of benthic invertebrates were collected including 3 species of shrimp and 1 species of crab.

The presence of gobies and topsmelt found in enclosure traps and purse seines at the CVWR meets the NOAA metric for target taxa (gobies and topsmelt). In addition, the recruitment of fish in the restored site demonstrates the NCWC objective for support of foraging shorebirds and ground-nesting birds.

Table 11.Fish and Invertebrates Collected Using a Purse Seine and Blocking Nets at the Chula Vista Wildlife Reserve 2014

Species		Seines CVWR	
Scientific Name	Common Name	1	2
Atherinops affinis	Topsmelt	14	29
Acanthogobius flavimanus	Yellowfin Goby	1	
Clevelandia ios	Arrow Goby	15	145
Fundulus parvipinnis	California Killifish	22	10
Gillichthys mirabilis	Longjaw Mudsucker	3	5
Syngnathus auliscus	Barred Pipefish	2	1
Urobatis halleris	Round Stingray		6
Alpheus californiensis	Pistol Shrimp	7	
Panaeus californicus	Brown Shrimp	1	2
Hippolyte californensis	California Green Shrimp		4
Hemigrapsus oregonensis	Yellow Shore Crab		2

Total ***Fish*** Abundance per Site	57	196
Fish Species Richness	6	6
Fish Density per Site (#/m^2)	2.3	5.6
Overall ***Fish*** Abundance	253	
Overall ***Fish*** Species Richness	7	
Overall ***Fish*** Density (#/m^2)	4.2	

Total ***Invertebrate*** Abundance per Site	8	8
InvertebrateSpecies Richness	2	3
Invertebrate Density per Site (#/m^2)	0.3	0.2
Overall ***Invertebrate*** Abundance	16	
Overall ***Invertebrate*** Species Richness	3	
Overall ***Invertebrate*** Density (#/m^2)	0.3	

3.3 Benthic Macroinvertebrates

NCWC grant objectives for both the CVWR and western ponds included: by March 2013, achieve successful recruitment of benthic invertebrates and fish to support migratory shorebirds and foraging ground-nesting seabirds. In order to demonstrate such a trend, benthic macroinvertebrate infauna and epifauna were monitored using the methods described below.

3.3.1 Methods – Monitoring of Benthic Macroinvertebrates in the Western Salt Ponds

Two sets of cores were collected to characterize the infaunal invertebrate assemblage at the western salt ponds. These included large cores for taxa, such as bivalves and large crustaceans, and small cores for smaller macrofuana. The large cores were 10 cm in diameter and were expressed into the sediment to a depth of 50 cm. The cores were then sieved through a 3-mm screen in the field with organisms identified, counted and released. Six channel-bottom sites were sampled in each pond using the large cores, and an additional 6 tidal flat sites (i.e. on the flat adjacent to the channel site) were sampled in Pond 11 (see Figure 7).

For the large infauna, two large cores were taken at each sampling site in 2012. Because very few invertebrates were sampled that year, it was decided to increase the number of cores taken per site. In 2013 and 2014, a total of 9 cores were taken at each site, 3 in the middle of the channel and 3 near the edges on either side of the channel.

The cores for the smaller infaunal invertebrates were collected at each site using a small push core (6 cm long, 4.8 cm diameter). The cores were preserved in the field in 8% buffered formalin and Rose Bengal and processed in that laboratory at California State University, Long Beach (CSULB). In the laboratory, the cores were sieved through a 300 micron mesh, identified, counted and preserved in 70% ethanol. All individuals in each replicate sample were sorted to the lowest practical taxonomic level. Sampling methodologies are the same used in the Huntington Beach Wetlands Restoration Project Monitoring Program, allowing for comparison across these two restoration efforts.

Sampling station locations for collection of smaller cores are illustrated in Figure 27. In fall 2011 (preconstruction), sampling was not completely replicated with six total samples collected, two each in Pond 10 subtidal, Pond 10 intertidal and Pond 11 panne (marsh plain). Cores were only 2 cm in depth. These were used as baseline comparisons with future years.

In fall 2012 (Year 1), 6 samples were collected at each of four sampling stations: Pond 10A subtidal; Pond 10 subtidal; Pond 11 subtidal and Pond 11 intertidal (mudflat). Cores included 0-6 cm depths, but only 0-2 cm depths were reported for comparison with preconstruction results. In spring 2013, fall 2014 and spring 2015 the 2012 methodology was replicated.

3.3.2 Results – Monitoring of Benthic Macroinvertebrates in the Western Salt Ponds

Large Cores. The results of infaunal monitoring at the western salt ponds are presented in Table 12. Pond 10A had a total of 125 individual invertebrates, with the majority (98%) of them being the California horn snail. A total of 23 individuals were sampled in Pond 10, with the majority being the California horn snail (57%) and the California jackknife clam (*Tagelus californianus*, 35%). Pond 11 had the highest species richness with respect to invertebrates, exhibiting 5 species and a total of 14 individuals. The California jackknife clam was the most abundant at 50% of the total catch. Mean densities per site for Ponds 10A, 10, and 11 were 295, 54, and 33 individuals/m^2, respectively.

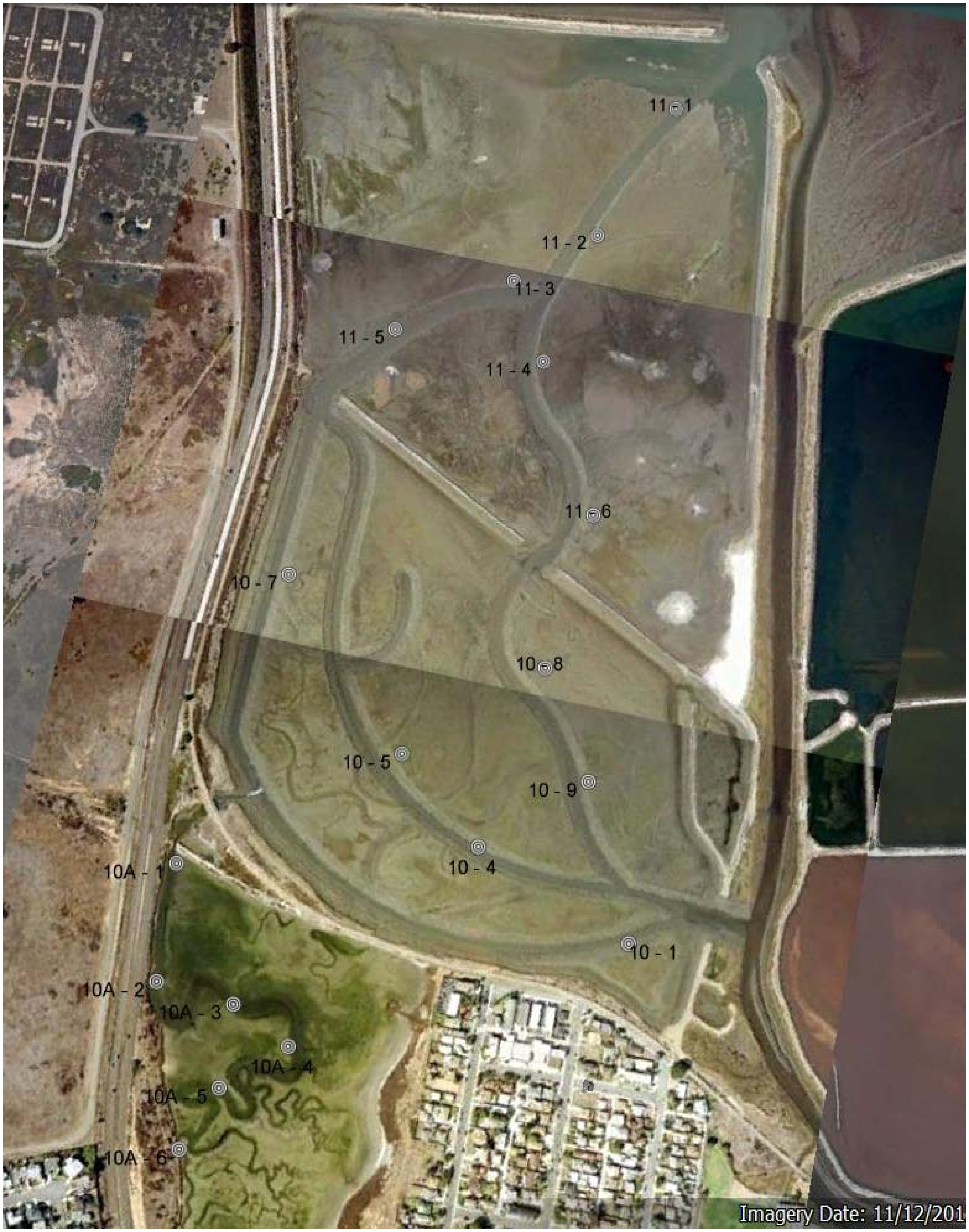

Figure 27. Locations of Sampling Stations – Small Cores.

Table 12. Infauna and Epifauna Collected at the Western Salt Ponds 2014.

Species		Pond 10A						Pond 10						Pond 11					
Scientific Name	Common Name	1	2	3	4	5	6	1	4	5	7	8	9	1	2	3	4	5	6
		Macroscopic Infauna - 10 cm Core* (# in all 9 cores)																	
Cerithidea californica	California Horn Snail	5	17	29	39	24	8	9		4									2
Protothaca staminea	Pacific littleneck clam																		
Tagelus californianus	California jackknife clam		2					2	2	3			1	3	1	1	1		1
Bulla gouldiana	California Bubble snail																		
Macoma balthica	Baltic macoma																		
Macoma nasuta	Bent-nose macoma								1								1		
Macoma secta	Sand clam																		
Mytilus galloprovincialis	Mediterranean mussel																		
Musculista senhousia	Asian Mussel															1			
Alpheus californianus	Pistol Shrimp																		
Neotrypaea californiensis	Bay Ghost Shrimp																		
Hemigrapsus oregonensis	Yellow Shore Crab	1											1						
Uca crenulata	Fiddler crab																		
Polychaete sp.																2		1	
	Density per Site (#/m^2)	85	269	410	552	340	113	156	42	99	0	0	28	42	14	57	28	14	42
	Mean Density per Site (#/m^2)	294.7						54.2						33.0					
	Species Richness per Pond	3						4						5					
		Epifauna - Two .25m x .25m Quadrats† (# in both quadrats)																	
Cerithidea californica	California Horn Snail	21	113	26	86	22	20	23	86	37	25	61	76	0	0	0	0	3	65
	Density per Site (#/m^2)	168	904	208	688	176	160	184	688	296	200	488	608	0	0	0	0	24	520
	Mean Density per Site (#/m^2)	384.0						410.7						90.7					

Small Cores. In 2011 (preconstruction) the subtidal habitat in Pond 10 was dominated by polychaetes although oligochaetes and crustaceans were well represented (Figure 28). Samples collected in intertidal areas of Pond 10 were nearly equally represented by polychaetes, oligochaetes, molluscs and crustaceans. The single sample collected from the marsh plain in Pond 11 was represented by a single taxon – molluscs.

Postconstruction monitoring in fall 2012 included infauna from Pond 10A which was dominated by polychaetes; Pond 10 subtidal dominated by crustaceans and polychaetes; Pond 11 subtidal dominated by polychaetes and insects; and Pond 11 intertidal dominated by polychaetes (Figure 29).

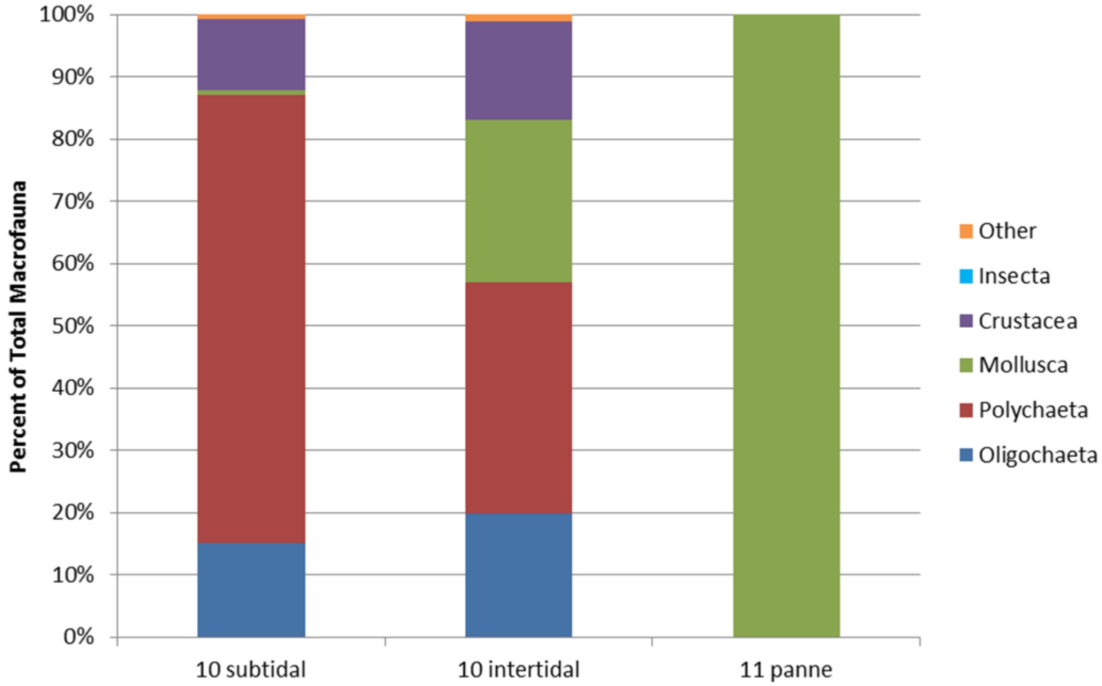

Figure 28. Relative Abundance of Macrofaunal Taxa Collected Using Small Cores - Fall 2011 Prerestoration

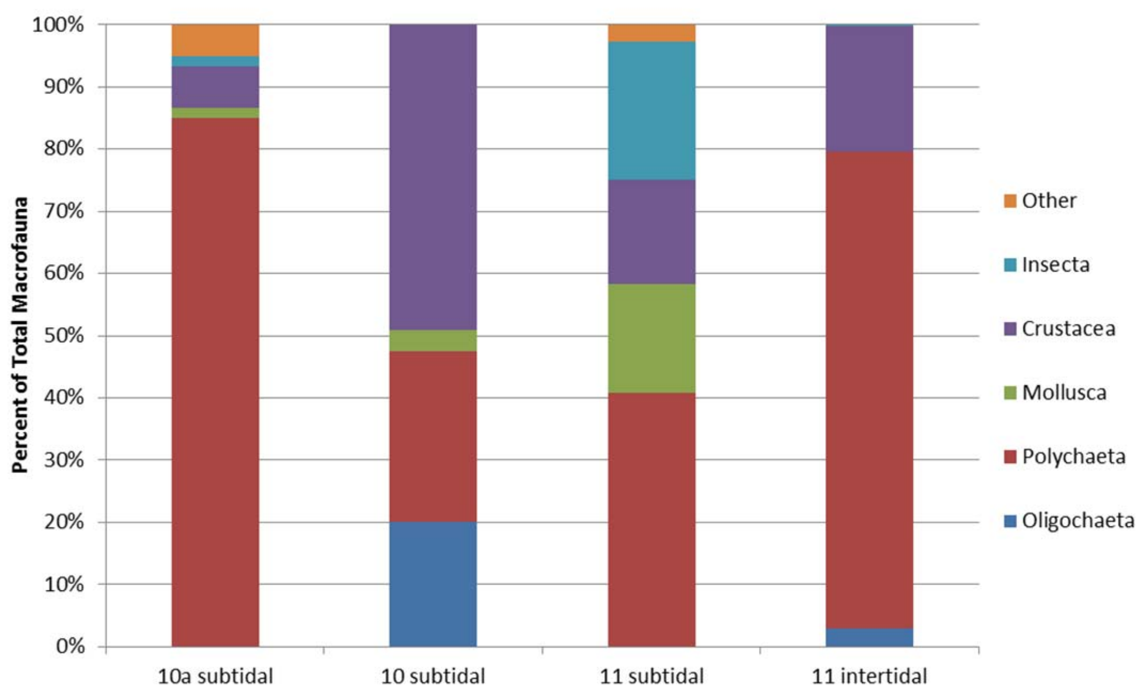

Figure 29. Relative Abundance of Macrofaunal Taxa Collected Using Small Cores – Fall 2012 Postconstruction

By spring 2013, the invertebrate communities of the salt ponds were strongly dominated by polychaetes with the exception of Pond 10A in which insects were the dominant taxa (Figure 30). Relative abundance continued to change through fall 2013 with polychaetes, oligochaetes, molluscs and crusteaceans well represented in all three ponds (Figure 31). By spring 2014, polychaetes once again dominated the invertebrate communities of all ponds except Pond 10 which was dominated by crustaceans (Figure 32). Density, expressed as number or organisms per unit area, has gradually increased through time with the highest densities occurring in spring 2014 (Figure 33).

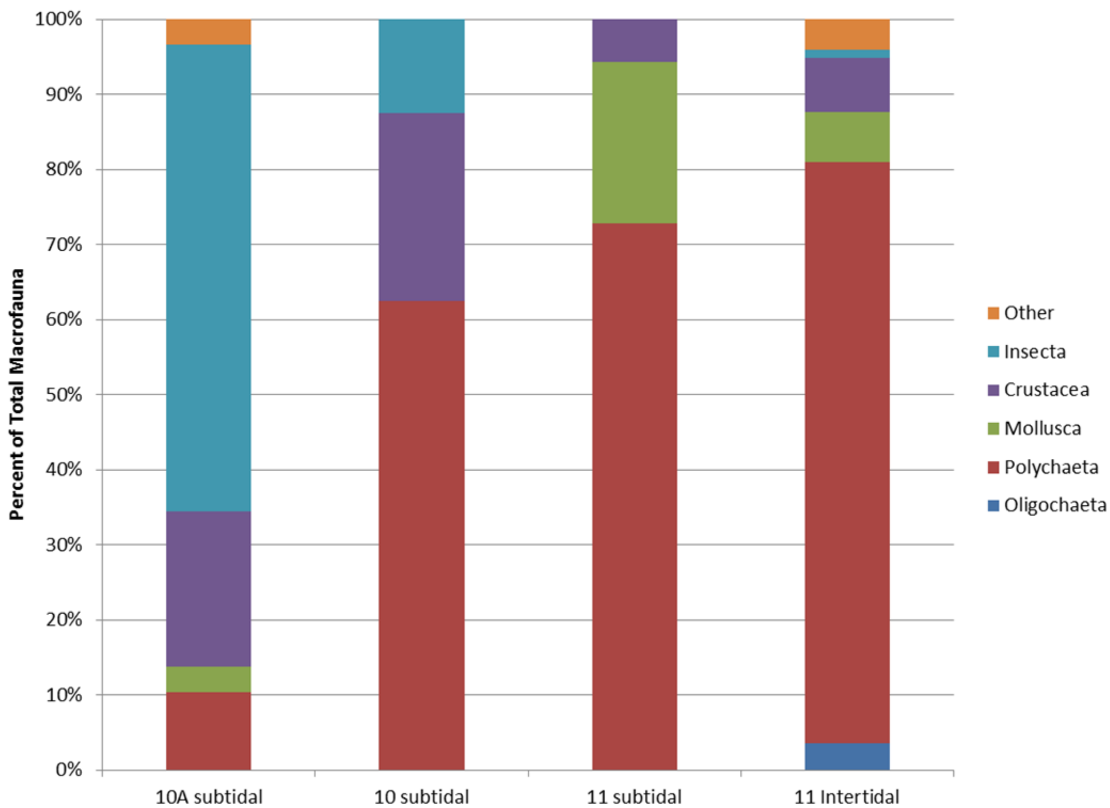

Figure 30. Relative Abundance of Macrofaunal Taxa Collected Using Small Cores – Spring 2013 Postconstruction

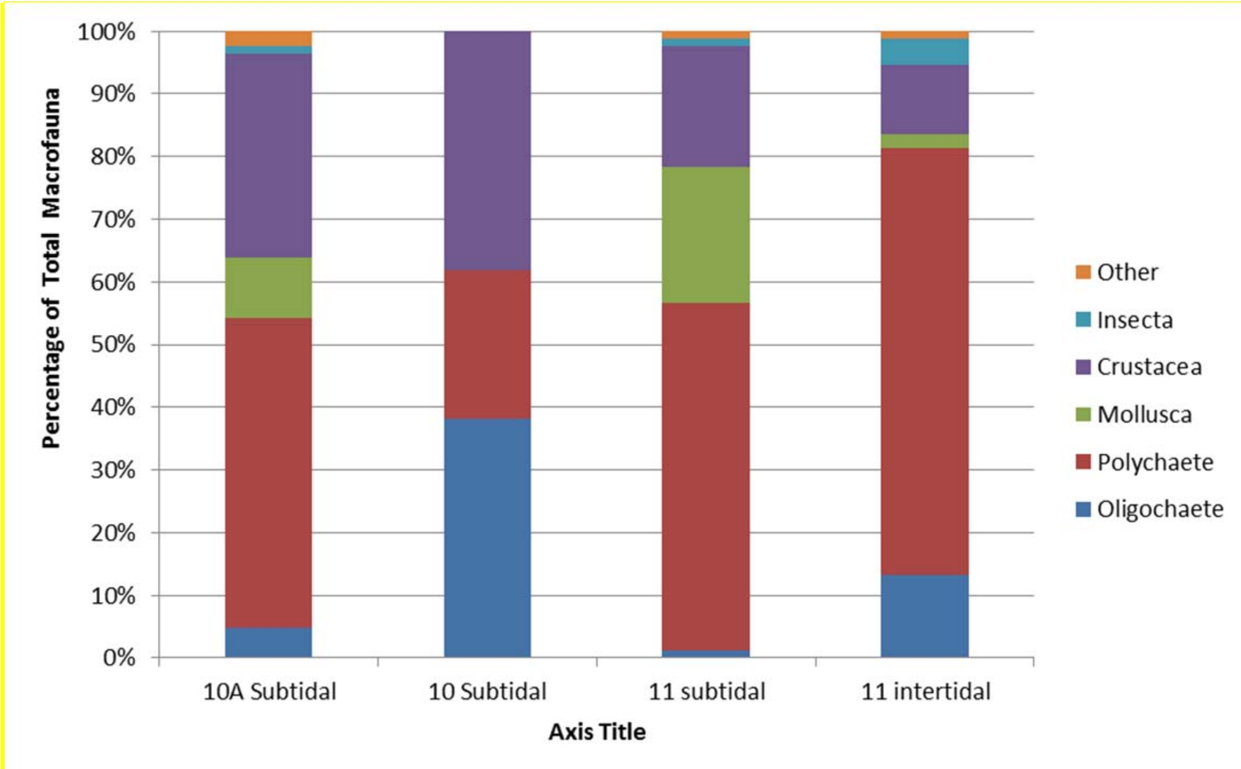

Figure 31. Relative Abundance of Macrofaunal Taxa Collected Using Small Cores – Fall 2013 Postconstruction.

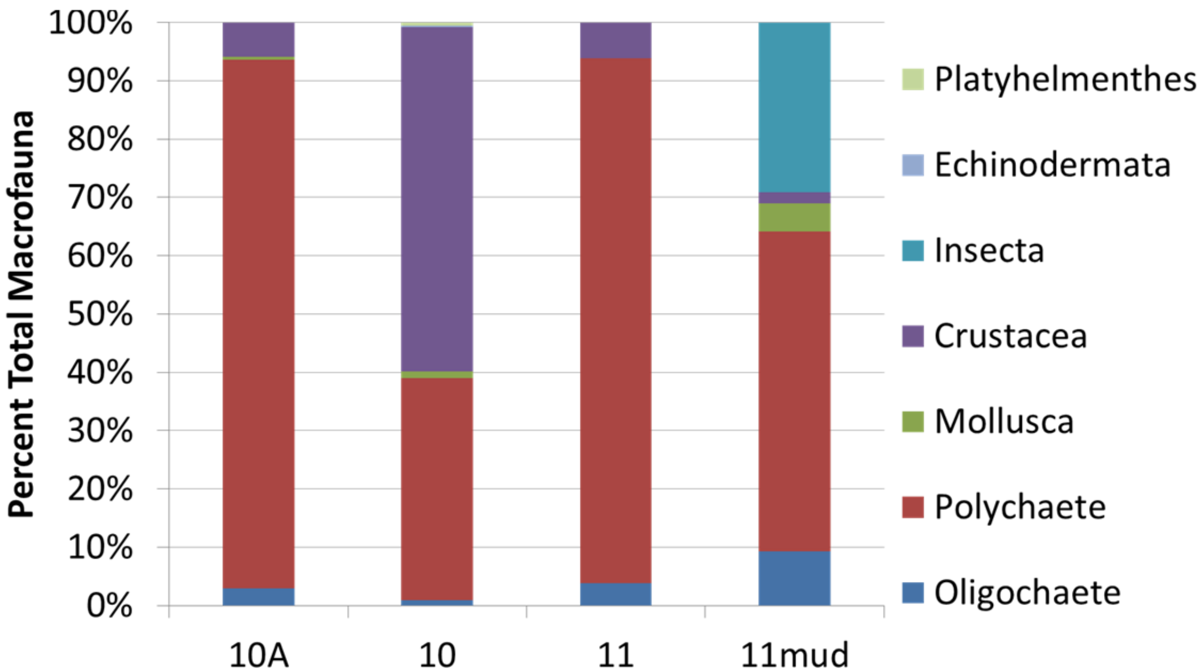

Figure 32. Relative Abundance of Macrofaunal Taxa Collected Using Small Cores – Spring 2014 Postconstruction

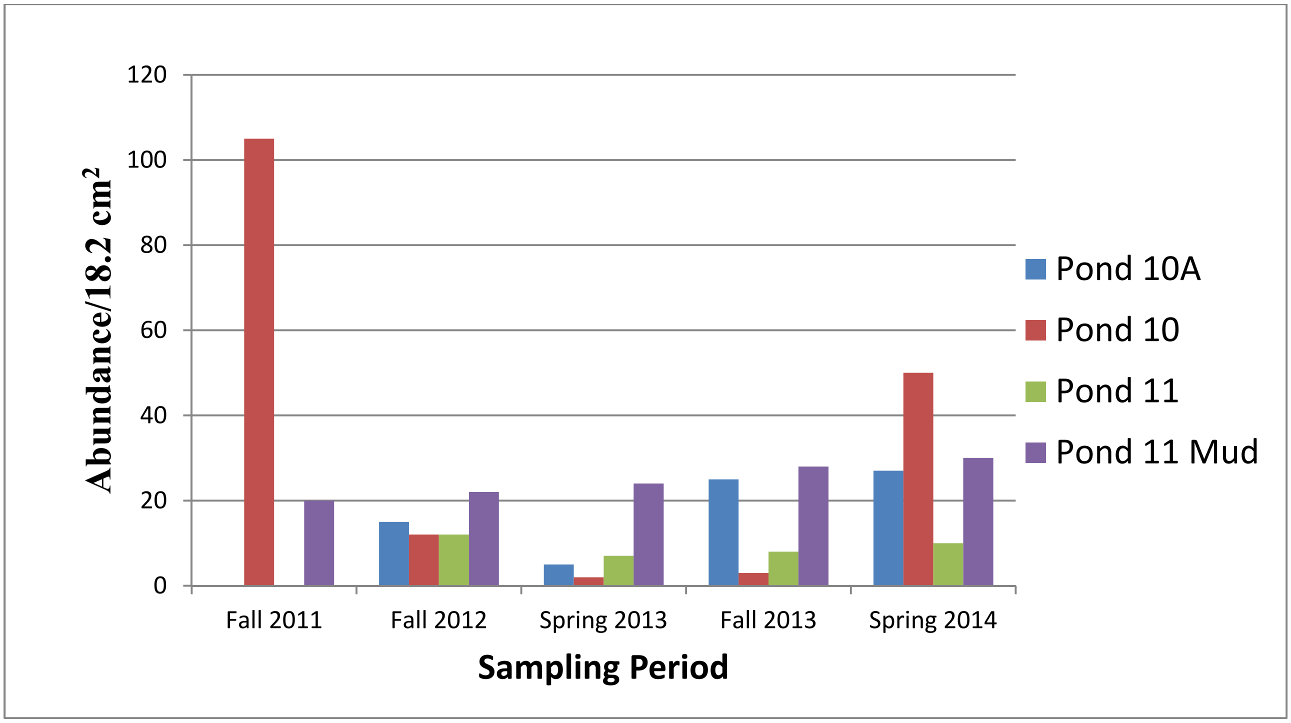

Figure 33. Density (Abundance/18.1 cm^2) of Macrofaunal Taxa Collected Using Small Cores – 2011 – 2014.

3.3.3 Methods – Monitoring of Benthic Macroinvertebrates in the Chula Vista Wildlife Reserve

At the CVWR, two sets of the large cores (50 cm long, 10 cm diameter) were taken at the 6 sampling stations (see Figure 9). Smaller cores were not collected at the CVWR.

3.3.4 Results – Monitoring of Benthic Macroinvertebrates in the Chula Vista Wildlife Reserve

The results of infaunal monitoring at the CVWR are presented in Table 13. A total of 75 individuals, representing 8 species of invertebrates, were sampled in the cores. California horn snail was the numerical dominant (67%), with the California jackknife clam the second most abundant (12%). Mean density per site was approximately 177 individuals/m^2.

By comparison, a total of 119 individuals, representing 6 species of invertebrates, were collected in 2013 California horn snail was the most abundant organism (76%), with the California jackknife clam second most abundant (11%). Mean density per site was 281 individuals/m^2.

3.3.5 Methods – Monitoring of Epifauna in the Western Salt Ponds and Chula Vista Wildlife Reserve

At each sampling site (6 sites in each salt pond and 6 sites at the CVWR), a .25 m x .25 m quadrat was used to sample epifauna assemblages. The quadrat was thrown near the channel's edge and those species found alive were counted. The quadrat was then flipped along one of its edges and the sampling was repeated.

3.3.6 Results – Monitoring of Epifauna in the Western Salt Ponds and Chula Vista Wildlife Reserve

California horn snails were the only epifaunal species encountered at both the western salt ponds and CVWR (Tables 12 and 13). At the western salt ponds, mean densities per site were again highest in Pond 10 at 411 individuals/m^2, up from 111 individuals/m^2 in 2012. Densities in Pond 10A and Pond 11 were 384 and 91 individuals/m^2, respectively. Mean horn snail density per site at the CVWR was 207 individuals/m^2, up from 72 individuals/m^2 in 2012 (Table 13).

Table 13. Infauna and Epifauna Collected at the Chula Vista Wildlife Reserve 2014.

Species		Chula Vista Wildlife Reserve					
Scientific Name	Common Name	1	2	3	4	5	6
		Macroscopic Infauna					
Cerithidea californica	California Horn Snail	5	5			2	38
Protothaca staminea	Pacific littleneck clam						
Tagelus californianus	California jackknife clam				3	4	1
Bulla gouldiana	California Bubble snail						
Macoma balthica	Baltic macoma					1	
Macoma nasuta	Bent-nose macoma	5				1	
Macoma secta	Sand clam				2		
Mytilus galloprovincialis	Mediterranean mussel						
Musculista senhousia	Asian Mussel						
Alpheus californianus	Pistol Shrimp						
Neotrypaea californiensis	Bay Ghost Shrimp						
Hemigrapsus oregonensis	Yellow Shore Crab	1			1		
Uca crenulata	Fiddler crab					1	
Polychaete sp.		1				4	
	Density per Site (#/m^2)	170	71	0	85	184	552
	Mean Density per Site (#/m^2)	176.8					
	Species Richness at CVWR	8					
		Epifauna					
Cerithidea californica	California Horn Snail	37	22	0	0	56	40
	Density per Site (#/m^2)	296	176	0	0	448	320
	Mean Density per Site (#/m^2)	206.7					

3.4 Food Web Analyses Through the Use of Stable Isotopes

Although not a specific restoration goal of the grants supporting the restoration of the western slt ponds, the analysis of food web development of the ponds was included as a means of measuring the evolution of this aspect of the project. Analysis of stable isotopes of elements such as Carbon and Nitrogen in plant and animal tissues allow for assessment of food web patterns, under the principle "you are what you eat." Primary producers have differing isotopic signatures based on their respective photosynthetic pathways, and consumers will have isotopic signatures that relate in a predictable way to their food sources.

Stable isotopic analyses were used to assess (a) whether signatures of the primary producers and consumers change with time and restoration state, and (b) whether consumer species rely on different food sources in different restoration states.

3.4.1. Methods – Stable Isotope Analysis – Western Salt Ponds

Sampling methodologies are the same used in the Huntington Beach Wetlands Restoration Project Monitoring Program, allowing for comparison across these two restoration efforts. Samples of sediment organic matter, microalgae, macroalgae, and macrofauna were collected at each sampling time point in each pond (with the exception of pond 10a in Fall 2011) using collection methods described above and were analyzed for d13C and d15N signatures. Microalgae were collected using density centrifugation with ludox (colloidal silica), providing a pure algal sample (devoid of sediment). Macrofaunal invertebrates were sieved on a 0.3 mm mesh, sorted live, and identified to species. All animals were kept alive in seawater and allowed to evacuate guts for up to 24 hrs. Animal material was washed in Milli-Q water (Millipore, Billerica, Massachusetts, USA) and frozen in combusted vials (500°C for 4 h) or tin boats until analysis. Larger organisms were removed from the shell or carapace, dried at 658C, and then ground with a mortar and pestle. Isotopic composition of animal and algal samples was analyzed using a PDZ Europa 20-20 mass spectrometer connected to an elemental analyzer (PDZ Europa ANCA-GS, Northwich, UK) at UC Davis Stable Isotope Facility. Stable isotope abundance is expressed in parts per thousand in a ratio of heavy to light isotope content (15N:14N or 13C:12C). Working standards, sucrose and ammonium sulfate, were d13C¼23.83ø vs. Vienna Pee Dee Belemnite Standard or d 15N ¼þ1.33ø vs. air N2.

Data for the Stable Isotope Analysis (SIA) are still being gathered and processed, but intitial patterns are discussed below. Samples of fish tissue and gut contents, benthic invertebrates, sediment, microalgae, macroalgae, and plants from throughout the wetland system continue to be collected for further analysis. These are being processed at CSULB and sent to UC Davis for analyses.

3.4.2 Results -Stable Isotope Analysis – Western Salt Ponds

Stable isotope analysis was utilized to characterize the functional restoration metric of trophic structure. Potential food sources and thus consumers can be differentiated from one another using stable isotope ratios among the ponds. To date, monitoring of the western salt ponds demonstrates that initial fish signatures (and aggregated food source signatures) were different among marshes both pre-restoration (2011) and three years post-restoration (2014). Two important factors drive this pattern; first, actual abundances of invertebrates and community composition differ between the ponds and two the actual isotopic signatures of invertebrate species differ between ponds due to different physical and biological conditions. These conditions will be explored in future analyses through correlations with plant cover and water quality parameters. It is hypothesized that as invertebrate and plant communities continue to develop within the restored ponds, there will be a convergence of the stable isotope signatures of both consumers (fish) and food sources.

At each sampling period (fall 2011 – present), samples of fish tissue, benthic invertebrates, sediment, microalgae, macroalgae, and plants were collected from each pond (10a, 10, 11).

Currently, all samples have been processed isotopic analysis run for fall 2011, fall 2012, fall 2013 and spring 2014. Samples from fall 2014 and spring 2015 are currently being processed at UC Davis Stable Isotope Facility.

Initially, in fall 2011 (pre-restoration), there were no differences between Ponds 10 and 11 Pond 10A was not sampled in fall 2011. In fall 2012, isotope signatures were distinct between Ponds 10 and 11 and Pond 10A (Figure 34). Again, in fall 2013, isotope signatures were distinct between Ponds 10 and 11 and Pond 10A (Figure 34). In spring 2014, the overall isotopic signature, representative of trophic structure, of the restored ponds (10, 11) differs from the reference pond, 10A. Through all sampling time points, Ponds 10 and 11 have significantly more variability in signatures than in Pond 10A. Across all seasons, Pond 10A had lower δC13 than Pond 11 (with Pond 10 intermediate) and lower δ N15 than Ponds 10 & 11. Temporally, all ponds differ with time as spring 2014 is significantly different than fall 2012. The overall food web structure (Figure 34) is significantly different among all 3 ponds due to altered community composition among ponds and due to differences in actual signatures of the same organisms. However, as the ponds are now experiencing more similar physical conditions, the trajectories appear to be following similar shapes and directions (Figure 35). A more detailed analysis, including a mixing model, with species-level groupings will be conducted in 2015.

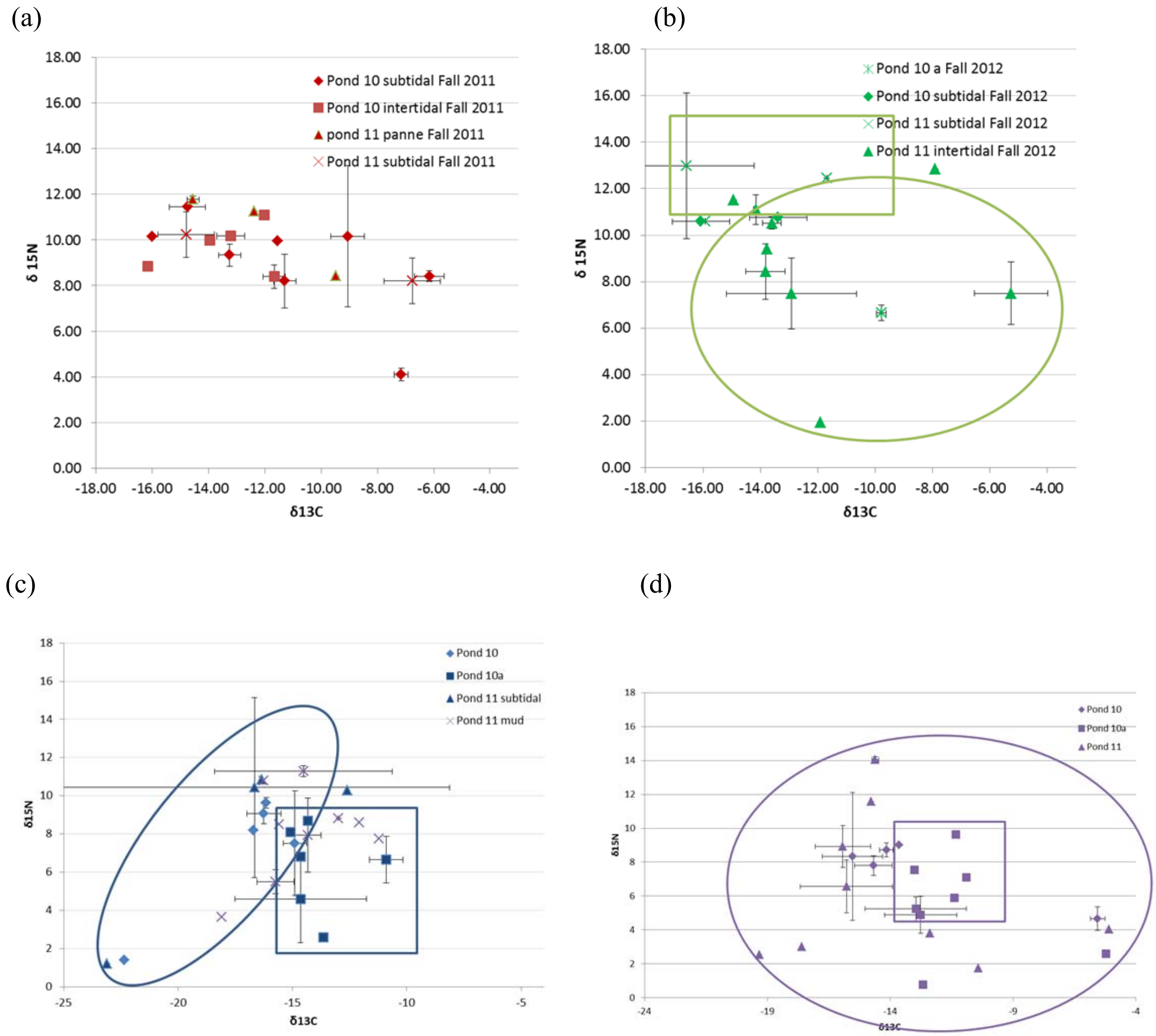

Figure 34. Dual Isotope Plots for Invertebrates Collected from the Western Salt Ponds. [(a) Fall 2011, (b) Fall 2012, (c) Fall 2013, and (d) Spring 2014. Note: Pond 10a not sampled in Fall 2011. Error bars indicated standard error around the mean. Shapes indicate significant differences among sites (ANOSIM)].

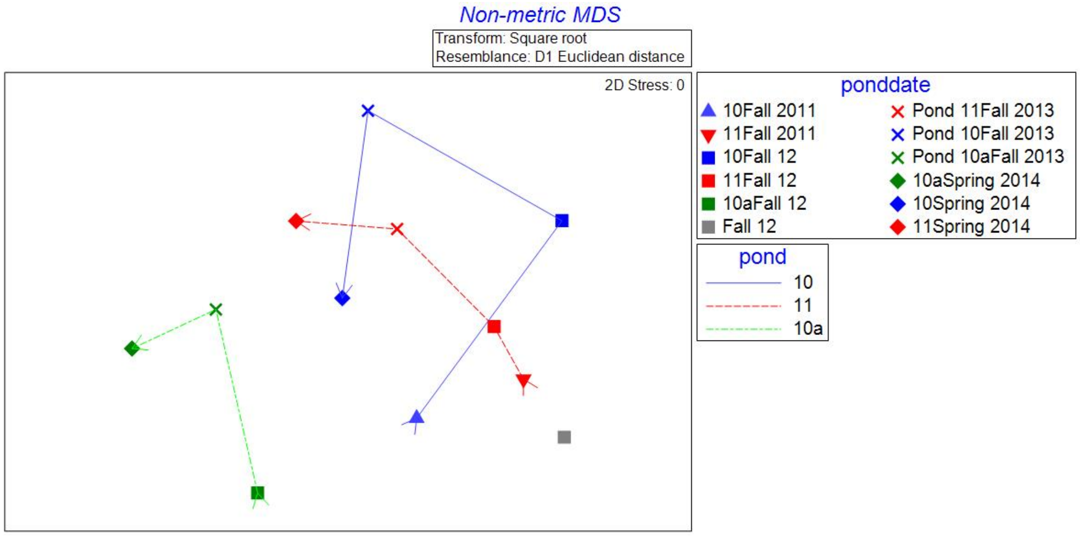

Figure 35. Averaged Non-metric MDS Plot with Individual Invertebrate Species in Western Salt Ponds by Season. (Fish from Fall 2012 are shown as grey square)

In summary, the NCWC Project goal of demonstrating recruitment of infauna and epifauana for support of foraging shorebirds and ground-nesting seabirds by March 2013 has been met. Relatively high densities of infauna and epifauna were collected using a variety of sampling techniques. Small cores revealed high densities of polychaetes, crustaceans, molluscs and insects available as food sources for foraging birds. Benthic invertebrates collected in fish enclosure traps and fish trawls included motile organisms, such as shrimp and crabs, demonstrating a greater diversity of benthic invertebrates than those collected in the large cores. Stable isotope analysis indicate that invertebrate and plant communities continue to develop within the restored ponds with a convergence of the stable isotope signatures of both consumers (fish) and food sources.

3.5 Monitoring of Avian Use of the Western Salt Ponds

There were no specific objectives or metrics for avian use at the western salt ponds. However, it was postulated that the avian assemblage would shift from one dominated by species that prefer open water habitat to one that included shorebirds and wading birds during low tide combined with species that utilize open water during high tides. In order to assess this predicted trend, avian use of the western salt ponds was monitored by the San Diego Natural History Museum (SDNHM) and Avian Research Associates (ARA) prior to and following construction of the Project.

3.5.1 Methods – Monitoring of Avian Use of Western Salt Ponds

SDNHM and ARA conducted surveys of the general use of the western ponds by water-dependent birds, including shorebirds, waterfowl, gulls, terns and others, and their behaviors. Surveys were conducted monthly from January 2014 to December 2014 and included the shallow water habitat and berms of the ponds as well as the shallow tidal habitats of the adjacent bay as far north as Emory Cove. Monthly monitoring will continue through 2016. Surveys were conducted using the methods employed in the multi-year bay-wide survey of avian species (Tierra Data Incorporated 2009). Those methods included:

- Surveys were conducted in the four hours before low tide to capture bird use of foraging habitats, such as mudflats and other habitats, that become exposed by receding water;
- Surveys conducted using a system of grids (= cells) previously established for the bay-wide survey (Tierra Data Incorporated 2009);
- Data collected included species abundance and diversity; general location/habitat categories, including wetland, upland, and aerial; and noted general behavior categories, including foraging, resting/rafting, courting/breeding.

Avian surveys of the entire South San Diego Bay Unit of the San Diego Bay National Wildlife Refuge were conducted as part of the monitoring project. These included surveys of the general use of the interior salt ponds by water-dependent birds, including shorebirds, waterfowl, gulls, terns and others, and their behaviors. Surveys were conducted monthly as described above and included the shallow water habitat and berms of the ponds, and adjacent upland habitats. Surveys also included the Otay River channel, tidal mudflats adjacent to the outer salt pond levees, and the grids of the bay within practical viewing range of those levees. Surveys were conducted using the methods described above for the western ponds, including use of the grid system, species abundance and diversity, location/habitat, and behavior (Figure 36). In addition, data from surveys of the same protocol conducted at adjacent Pond 20A were included in the data set for analysis since birds regularly shift between Pond 20A, the western ponds, and interior ponds.

3.5.2 Results – Monitoring of Avian Use of Western Salt Ponds

In order to assess shifts in bird usage following restoration of the salt ponds, a subset of the data collected during pre- and postconstruction monitoring was analyzed. Specifically, all birds observed using wetland habitats, defined as occurring below the high tide line, were summarized and compared. Birds observed using upland habitats, i.e., above the high tide line, were excluded as these habitats, primarily pond levees, remained following restoration and it was assumed that their use was not changed significantly following restoration. Furthermore, birds observed flying overhead (aerial) were excluded as it was assumed that many were in transit to other habitats, such as the open bay and ocean. In general, the majority of the birds observed during the monthly surveys were wetland species.

Figure 36. Avian Monitoring Grid – South San Diego Bay and Salt Works

The number of avian species observed in wetland habitat during the 2014 surveys peaked in November with more than 40 species observed in all ponds (Figure 37). During 2013 monitoring, the number of species observed in wetlands peaked in the winter months of January, February, November and December although none of those peaks greater than 35 species observed per monthly monitoring survey. In 2014, Pond 11 had the greatest number of species during all monitoring surveys and Pond 10A generally had more species than Pond 10. The mean number of species over the 2014 monitoring period was 17.8 species in Pond 10A, 15.2 species in Pond 10, and 25.6 species in Pond 11.

By comparison, in 2013 the number of species present was generally greatest in ponds 10 and 11 and less in Pond 10A. The mean number of species in Pond 10 was 18.8 with a mean of 20.9 in Pond 11. The mean number of species in Pond 10A was 11.1.

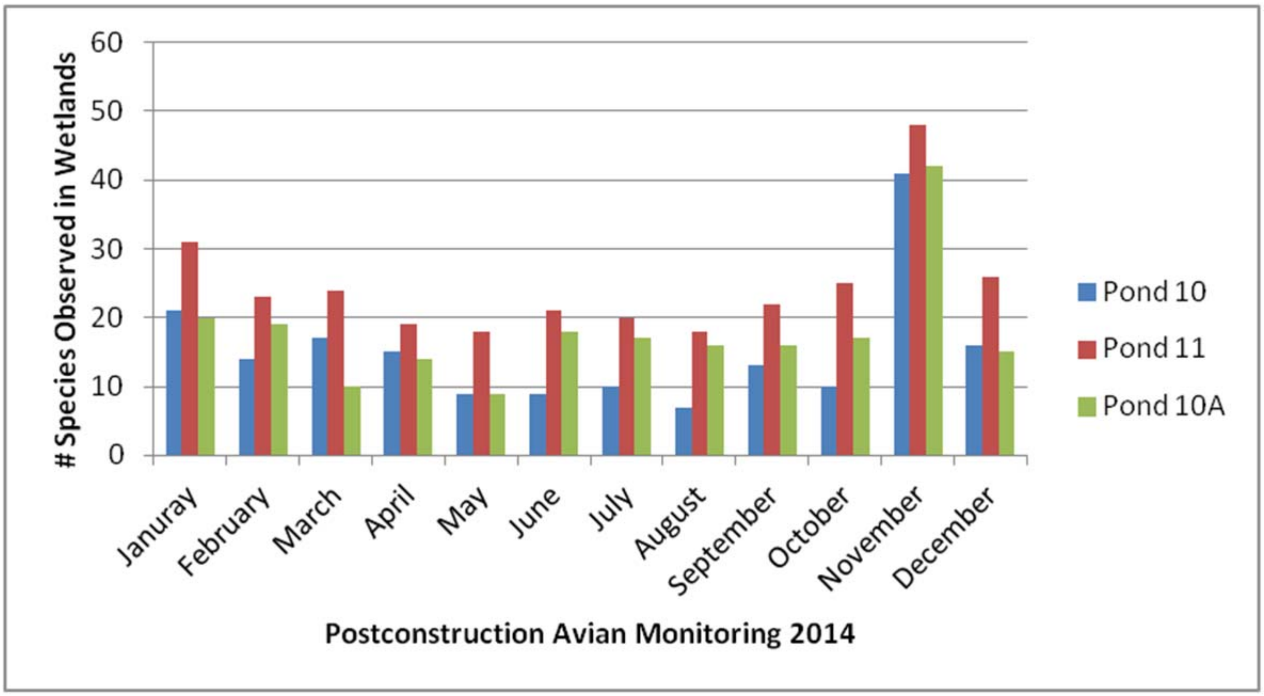

Figure 37. Number of Avian Species Observed in Wetland Habitats – 2014.

The number of individuals observed in wetland habitat during 2014 monitoring also varied seasonally with the greatest numbers occurring in fall and winter and the fewest in spring and early summer (Figure 38). A peak of 4,307 individuals was recorded in Pond 11 in December 2014 and a low of 45 individuals were observed in June in Pond 10. The highest number of individuals occurred in Pond 11 with one exception while ponds 10 and 10A were more variable.

Both the number of species and number of individuals observed in 2014 support a trend of increased use of Pond 11 and decreased use of Pond 10, presumably in response to the developing salt marsh vegetation in Pond 10. In 2012, the number of individuals observed was typically highest in Ponds 10 and 11 and lower in Pond 10A. By 2013, the number of individuals was nearly always highest in Pond 11. By 2014, the number of individuals was clearly highest in Pond 11. Despite the seasonal and annual variability, bird usage of the ponds increased in all three years postconstruction relative to preconstruction surveys in 2011, demonstrating that restoration of intertidal habitats was beneficial to resident and migratory species.

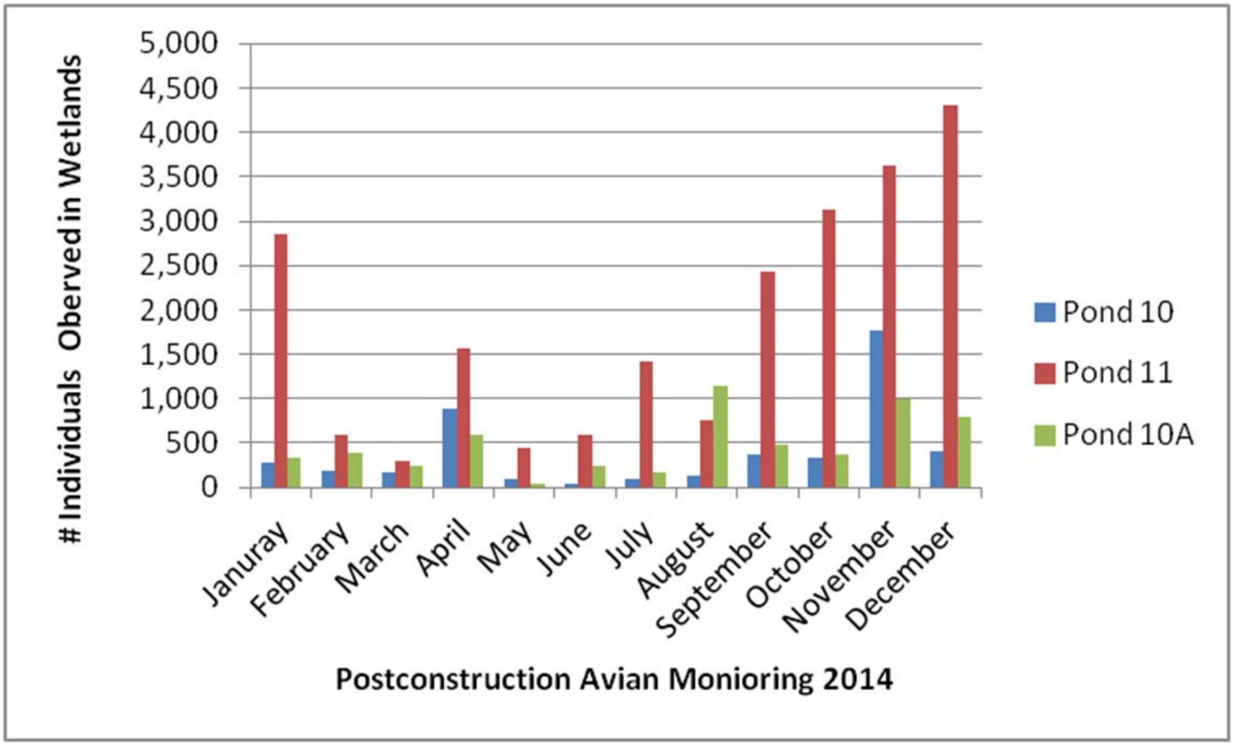

Figure 38. Number of Individual Birds Observed in Wetland Habitats – 2014

The numerically dominant species observed in wetland habitats of the western salt ponds during 2014 monitoring are summarized in Table 14. The numerically dominant species were shorebirds, including western sandpiper, least sandpiper, semipalmated plover, dowitcher species, willet, marbled godwit and dunlin. Notable exceptions were American widgeon and northern pintail in Pond 10 in winter, and brant and elegant tern in Pond 11 during the summer months It should be noted that the state-listed endangered Belding's savannah sparrow was among the top three species numerically in Pond 10 on 7 survey dates and 1 survey in Pond 11, albeit during periods of low absolute abundance. Nonetheless, the developing mid-elevation salt marsh in Pond 10 appears to be providing breeding habitat for this species. Belding's savannah sparrow did not rank among the top 3 species numerically in any pond at any time prior to 2014.

The numbers of western sandpiper observed in 2014 in Pond 11 closely mirrored the overall numbers of individuals observed (Figures 39 and 40). This species was by far the numerically dominant species during 2014 surveys (Table 14). However, use of Pond 10 by western sandpipers has declined relative 2013 as the planted salt marsh develops displacing mudflat habitat favored by this species as foraging habitat (Figures 40 and 41). When compared to 2013, numbers of western sandpipers in wetland habitats Ponds 10, 11 and 10A were down by approximately 64% (49,164 in 2013; 17,514 in 2014), although there were more individuals in the overall study area which includes the eastern salt ponds and parts of south San Diego Bay (129,590 observations in 2014; 123,931 observations in 2013). This suggests that western sandpipers are using areas other than the western ponds to a greater extent. It is postulated that this reduced activity is directly related to development of salt marsh habitats in all three ponds, thereby reducing the area of mudflat favored by western sandpipers as foraging habitat.

Table 14. Total Numbers and Numerically Dominant Species of Birds Observed in Wetland Habitats of the Western Salt Ponds During Postconstruction Surveys 2014.

	Month Surveyed					
	January	**February**	**March**	**April**	**May**	**June**
Pond 10A	Total = 1,151 west sandpiper 1,025	Total = 392 least sandpiper 170 green-wing teal 43 west sandpiper 40	Total = 241 west sandpiper 125 least sandpiper 37 semipalm plover 25	Total = 584 west sandpiper 360 least sandpiper 136 semippalm plover 34	Total = 30 No dominants	Total = 241 semipalm plover 76 west sandpiper 75 marbled godwit 37
Pond 10	Total = 134 least sandpiper 102 Am. widgeon 233 dunlin 226 black bellied plover 119	Total = 187 northern pintail 69 Am. widgeon 64	Total = 161 least sandpiper 85 Belding's savannah sparrow 30	Total = 886 west sandpiper 780 least sandpiper 50 Belding's savannah sparrow 22	Total = 92 west sandpiper 45 Belding's savannah sparrow 24	Total = 46 Belding's savannah sparrow 16 Black-necked stilt 14
Pond 11	Total = 764 west. sandpiper 355 black-bellied plover 109 short-billed dowitcher 223 least sandpiper 197 brant 165	Total = 586 brant 159 marbled godwit 112 willet 112 least sandpiper 70	Total = 289 marbled godwit 131 willet 60 Belding's savannah sparrow 20	Total = 1,566 west sandpiper 1,370 brant 45 semipalm plover 32	Total = 452 west sandpiper 316 semipalm plover 26 black-bellied plover 24	Total = 590 elegant tern288 marbled godwit 55 dowitcher sp. 80

	Month Surveyed					
	July	**August**	**September**	**October**	**November**	**December**
Pond 10A	Total = 163 semipalm plover 35 dowitcher sp 28 snowy egret 27	Total = 1,151 west sandpiper 1,025 least sandpiper 32	Total = 492 Dowitcher sp. 239 west sandpiper 75 black-necked stilt 37	Total = 373dowitcher sp 244 willet 35 red-necked phal 27	Total = 990 west sandpiper 385 least sandpiper 139 semipalm plover 84	Total = 788 dowitcher sp 363 Am widgeon 310 willet 55
Pond 10	Total = 95 willet 57 Belding's savannah sparrow 20	Total = 134 least sandpiper 102 Belding's savannah sparrow 27	Total = 373 least sandpiper 220 peep sp 50 west sandpiper 35	Total = 329 west sandpiper 158 least sandpiper 63 willet 35	Total = 1,775 Am. widgeon 758 northern pintail 1,396 least sandpiper 100	Total = 411 Am. widgeon 312 Belding's savannah sparrow 33 brant 32
Pond 11	Total = 1,414 western sandpiper 905 dowitcher sp. 120 willet 99	Total = 746 west sandpiper 355 elegant tern 99 semipalm plover 54	Total = 2,439 west sandpiper 1,200 peep sp 900 dowitcher sp. 77	Total = 3,132 west sandpiper 2,230 least sandpiper 255 semipalm plover 151	Total = 3,629 west sandpiper2,204 dowitcher sp 126 dunlin 125 willet 120	Total = 4,307 west sandpiper 3,735 least sandpiper 100 dunlin 92

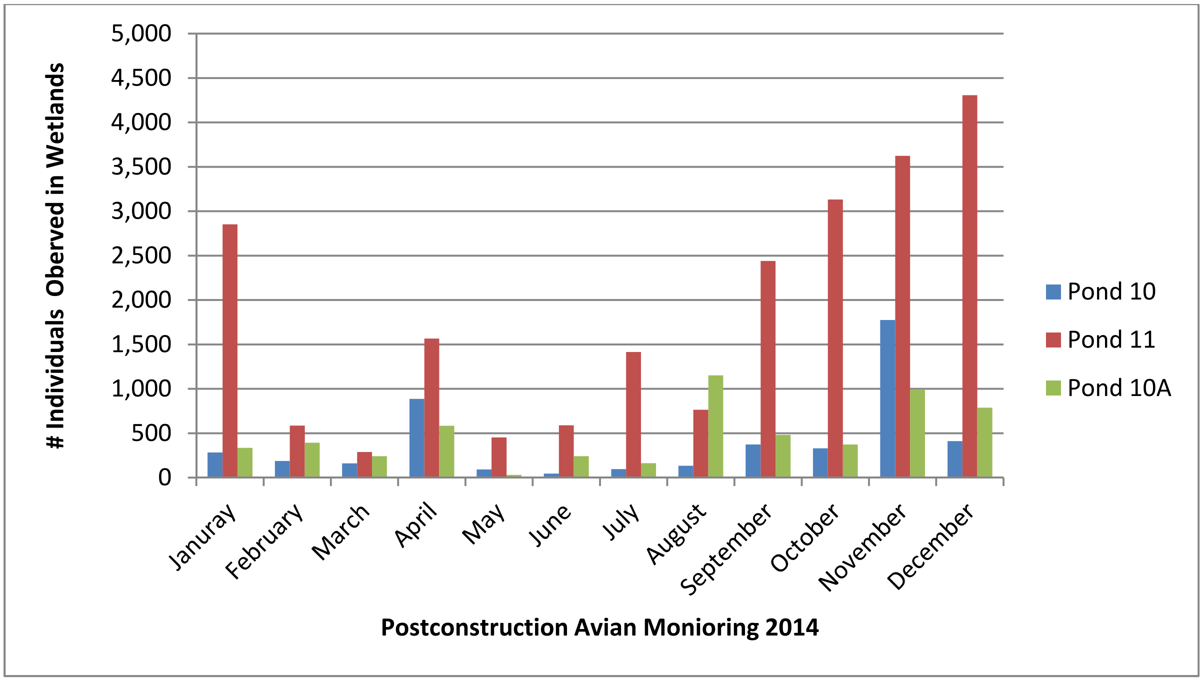

Figure 39. Number of Individual Birds Observed in Wetland Habitats – 2014

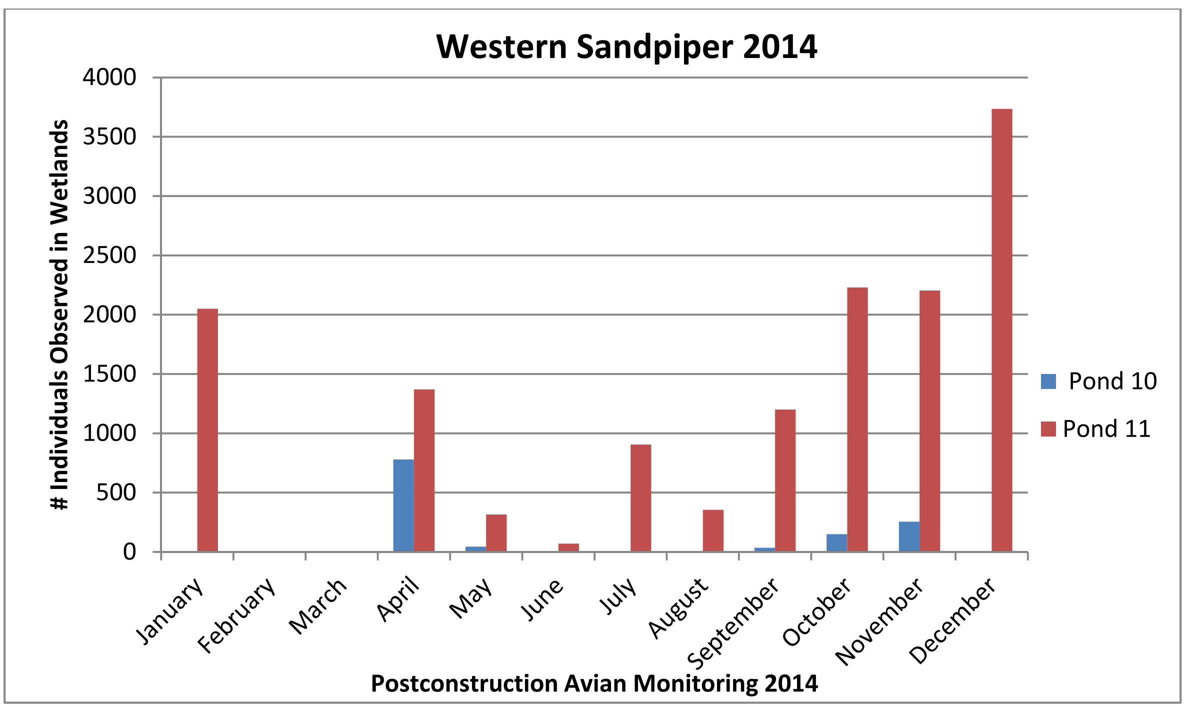

Figure 40. Number of Individual Western Sandpiper Observed in Wetland Habitats In Ponds 10 and 11 - 2014

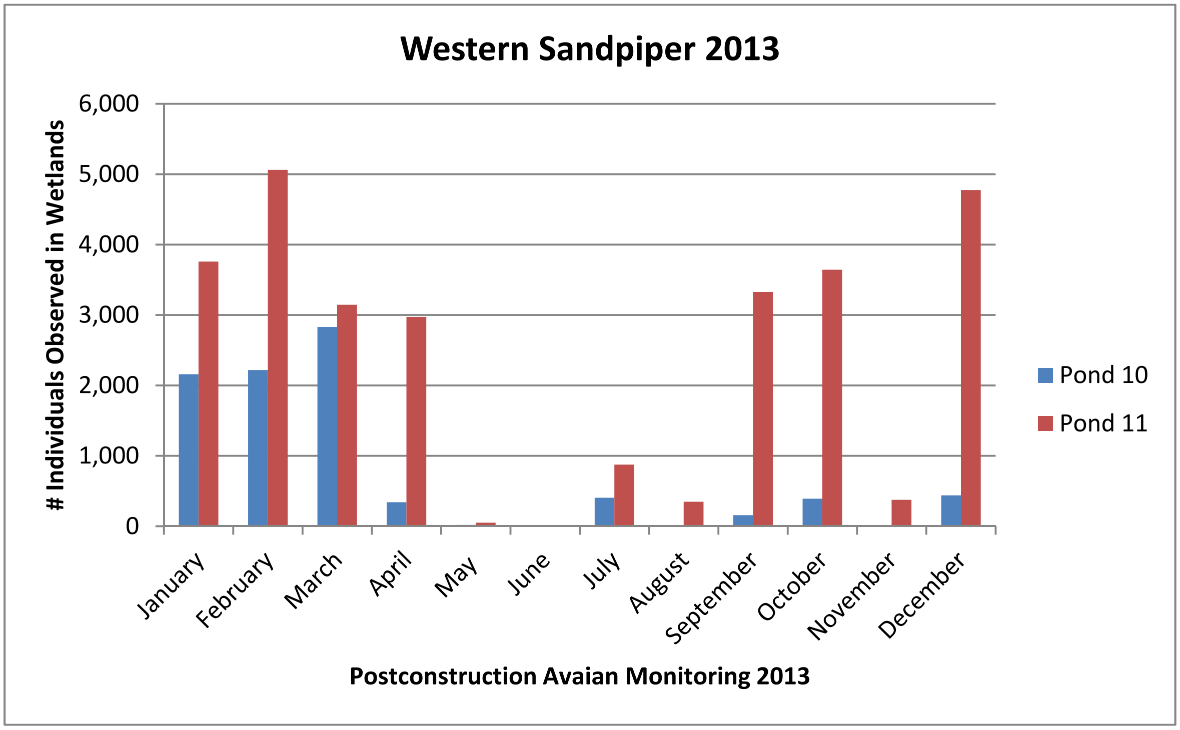

Figure 41. Number of Individual Western Sandpiper Observed in Wetland Habitats In Ponds 10 and 11 - 2013

4.0 CONCLUSIONS

The majority of the goals and objectives developed for the Project were either met in Year 3 (2014) or are expected to be met in subsequent years. Goals and objectives that are considered met include:

- Complete the permitting, final design, and site preparation, including all excavation, clean-up, and grading, necessary to restore and enhance 160 acres of coastal wetland and upland habitat in south San Diego Bay by March 1, 2011.

This overarching goal is considered met with the exception that project delays resulted in a completed project by December 2011.

- By the end of 2016 achieve approximately 89 acres of functional estuarine intertidal emergent wetlands, approximately 41 acres of estuarine intertidal non-vegetated wetlands, approximately 28 acres of estuarine subtidal wetlands, and 10 acres of palustrine scrub-shrub vegetation.

This overarching goal is considered to be on track for achievement by the end of 2016.

- Within the western salt ponds, by March 2013, achieve successful recruitment of benthic invertebrates and fish within Pond 11 to support migratory shorebirds and foraging ground-nesting seabirds.

This objective has been met.

- Within the western salt ponds, by March 1, 2011 complete the dredging and filling activities required to achieve elevations within Pond 11 that will support a mix of shallow subtidal, intertidal mudflat, cordgrass-dominated salt marsh, and pickleweed-dominated salt marsh habitats (estuarine intertidal emergent, non-vegetated, and subtidal wetlands) and breach the pond levee to restore tidal influence to the 106-acre pond.

This objective is considered met with the exception that project delays resulted in a project completion date of December 2011.

- Within the western salt ponds, by the end of 2016, achieve 50 percent coverage of cordgrass (*Spartina foliosa*), with at least 25 percent of the plants in excess of 60 centimeters (cm) in height, over approximately 30 acres within the tidally restored pond.

This objective is considered to be on track for achievement by the end of 2016.

- Within the western salt ponds, between March 2011 and February 2012, monitor and record through monthly visual surveys, the recruitment of vegetation and benthic invertebrates, bird use, and any changes in bathymetry within the pond. Based on these observations, develop recommendations for how the design of future phases of salt pond

- restoration in San Diego Bay could be adjusted to more effectively achieve restoration objectives.

This objective is considered met with the exception that annual monitoring is conducted between January and December. Recommendations for future phases of salt pond restoration in San Diego Bay will be developed at the end of the monitoring program.

- By March 1, 2011 lower approximately 3 acres within the western basin of the Chula Vista Wildlife Reserve to achieve a typical marsh plain elevation of +4.5 feet Mean Lower Low Water (MLLW) (an elevation appropriate for supporting estuarine intertidal emergent wetlands) and expand the existing tidal channel by removing 3,000 cubic yards of sediments to create deeper, more well defined tidal creeks within the western basin, thus enhancing the remaining wetland habitat.

This objective has been met.

- By the end of 2016, achieve 50 percent coverage of cordgrass and pickleweed over the 3-acre excavation area of the Chula Vista Wildlife Reserve and improve vigor and plant diversity throughout the remaining 16 acres of estuarine intertidal emergent wetlands within the basin.

This objective is considered to be on track for achievement by the end of 2016.

- Restore wetland elevations and channel bathymetry in Ponds 10 and 11 to within plus or minus 10% of the design plan by June 2011.

This objective has been met.

- Achieve 50% vegetation cover by wetland vascular plants in at least 30 acres of Pond 10 by June 2016.

This objective is considered to be on track for achievement by the end of 2016.

- Within Ponds 10 and 11 demonstrate presence of one or more of the target species (flatfish and elasmobranchs) by 2013.

This objective has been met.

- Restore wetland elevations and channel bathymetry the restored Chula Vista Wildlife Reserve basin to within plus or minus 10% of the design plan by June 2011.

This objective has been met.

- By 2016, restore typical marsh vegetation coverage at the Chula Vista Wildlife Reserve, using marsh coverage at Tijuana Estuary as a target;

This objective is considered to be on track for achievement by the end of 2016.

- At the Chula Vista Wildlife Reserve demonstrate presence of one or more of the target species (gobiidae and topsmelt) by 2013.

This objective has been met.

- By March 2013, achieve successful recruitment of benthic invertebrates and fish within the western basin of the Chula Vista Wildlife Reserve to support migratory shorebirds and foraging ground-nesting seabirds.

This objective has been met.

- Restore tidal amplitude in Ponds 10 and 11 to approximately equal the tidal amplitude in the Otay River; restore tidal amplitude in Pond 10A to a slightly muted amplitude relative to the Otay River by 2012.

This objective has been met.

One Project objective has not been fully met. That objective is presented below.

- At the Chula Vista Wildlife Reserve, restore tidal amplitude to approximately equal the tidal amplitude in San Diego Bay by 2011.

Low tides are moderately to severely truncated within the channels of the restored basins, suggesting that these channels do not drain completely. This may be caused by shoals forming at the connections to the bay. Further monitoring will assess the presence of shoals and the effect on Project success.

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