South San Diego Bay
Coastal Wetland Restoration
and Enhancement Project

Year 1 Postconstruction Monitoring Report

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EXECUTIVE SUMMARY

Western Salt Ponds

The first 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.

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. Consolidation of sediment deposited in Pond 11 is expected to continue and elevations there are expected to change with time

Survival of planted salt marsh vascular plants, especially low marsh, was low. However, 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.

Preconstruction and postconstruction fish populations were not directly comparable as different gear was used. Preconstruction beach seines collected 15 species of fish including high numbers of topsmelt, gobies, California killifish, and slough anchovy. Postconstruction beam and otter trawls, minnow traps and enclosures collected 12 total species with otter trawls dominated by slough anchovy and topsmelt; minnow traps dominated by longjaw mudsucker and California killifish. Thus, although not directly comparable, the numerically dominant species were similar pre- and postconstruction. The occurrence of round stingray in the restored ponds, as well as the numerically dominant slough anchovy and topsmelt, demonstrates a trend toward a fish assemblage that is similar to that in south San Diego Bay. In research studies of the fishes of south San Diego Bay, collections were dominated by slough anchovy, round stingray and shiner perch (Pondella et al. 2009) and slough anchovy and topsmelt (Allen 2006). The number of species and abundance of fish is expected to increase as the sediment in the ponds consolidates and is colonized by invertebrates.

Macrobenthic invertebrate assemblages are similar to preconstruction conditions with the epibenthic California horn snail the numerical dominant for both conditions. Results of invertebrates collected using smaller cores and finer sieves were not available for this report as well as the isotopic food web analysis being conducted by California State University Long Beach. It is anticipated that these analyses will be presented in the next annual report.

Perhaps the most dramatic change in biological monitoring parameters was the postconstruction avian use. The overall mean number of birds species observed in wetland habitats of the western salt ponds preconstruction was 11 species compared to an overall mean of 19.3 species postconstruction. Relative abundance of birds increased dramatically postconstruction, primarily due to high numbers of western sandpiper.

Chula Vista Wildlife Reserve

The Chula Vista Wildlife Reserve has met some of the Project goals and objectives, but has fallen short in some areas.

Year 1 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.

Monitoring of tidal amplitude was plagued by equipment failure as pressures sensors were water-logged; however, several months of data indicate moderate to fairly severe truncation of the low tides, depending upon sampling station. Continued monitoring in year 2 will further define site conditions regarding tidal amplitude.

Cover by vascular plants planted from salvaged and nursery grown stock was sparse in Year 1 but is expected to spread rapidly in the 11-acre site that was actively restored. Other than California horn snails, few invertebrates were collected using large cores (50 cm long, 10 cm diameter core sieved through a 3 mm mesh). Additional effort may be needed in Year 2 to adequately assess the invertebrate assemblage. Fish collected using minnow traps were dominated by arrow goby while no fish were collected using enclosure traps. Additional effort may be needed in year 2 adequately assess fish use of the site.

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 and Coastal Program and National Coastal Wetland Conservation (NCWC) 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

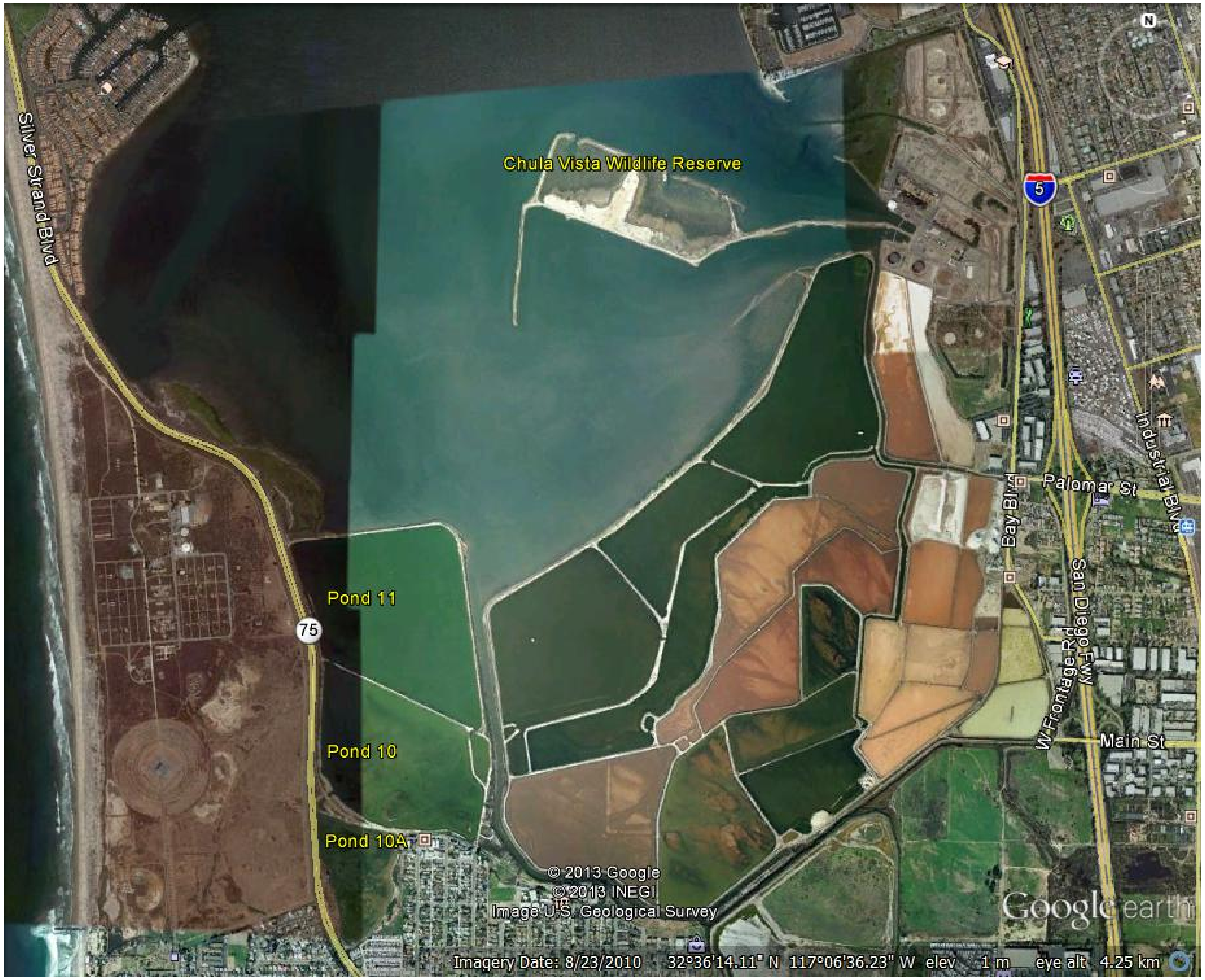


Figure 1. South San Diego Bay Coastal Wetland Restoration and Enhancement Project Locations.

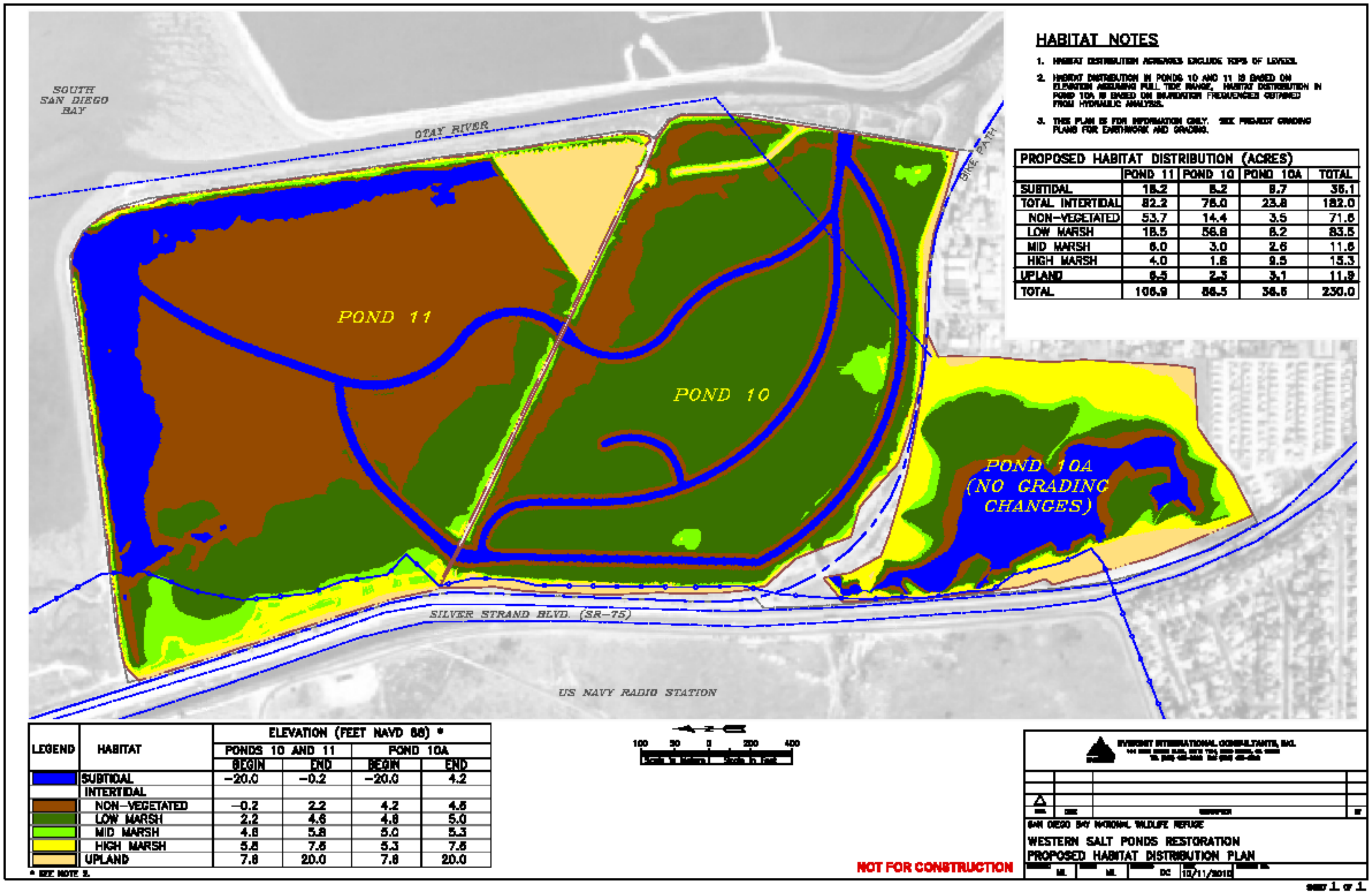
Bay within the South San Diego Bay Unit of the San Diego Bay NWR; and 2) the 43-acre Chula Vista Wildlife Reserve (CVWR) located with to the west of the South Bay Power Plant (Figure 1).

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 first annual postconstruction monitoring report of the Project covering the period of January to December 2012.

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. 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 which was restored to tidal influence thereby enhancing approximately 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 helped 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



PROPOSED HABITAT DISTRIBUTION (ACRES)	POND 11	POND 10	POND 10A	TOTAL
SUBTIDAL	18.2	8.2	8.7	35.1
TOTAL INTERTIDAL	82.2	76.0	23.8	182.0
NON-VEGETATED	53.7	14.4	3.5	71.6
LOW MARSH	18.5	56.8	8.2	83.5
MID MARSH	6.0	3.0	2.6	11.6
HIGH MARSH	4.0	1.8	9.5	15.3
UPLAND	6.5	2.3	3.1	11.9
TOTAL	106.9	86.5	36.6	230.0

LEGEND	HABITAT	ELEVATION (FEET NAVD 88) *			
		PONDS 10 AND 11		POND 10A	
		BEGIN	END	BEGIN	END
	SUBTIDAL	−20.0	−0.2	−20.0	4.2
	INTERTIDAL				
	NON-VEGETATED	−0.2	2.2	4.2	4.6
	LOW MARSH	2.2	4.6	4.8	5.0
	MID MARSH	4.6	5.8	5.0	5.3
	HIGH MARSH	5.6	7.6	5.3	7.6
	UPLAND	7.8	20.0	7.8	20.0

Figure 2. Proposed Habitats Western Salt Ponds.

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 11that 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 baythmetry 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.

1.2.2 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 sediments 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 baythmetry 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 species (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 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.

The 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 Kinematics (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.

The products of the photogrammetry were elevation contours 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

RTK GPS Surface Elevation Transects

RTK GPS surveys were performed on February 21 and 24, 2012 using a Trimble model R8 RTK rover unit. The RTK rover is a self-contained GPS, antenna and radio that receives real time corrections from a base station located on the roof of the Tijuana River National Estuarine Research Reserve Visitor Center, which was within the recommended distance for RTK topographic surveys.

The RTK data were taken along eight transects running roughly east to west (Figure 3). Four transects were located in Pond 11 and four transects were located in Pond 10. Tidal conditions prevented any data collection in Pond 10A. The survey was controlled for accuracy using two benchmarks located near the project that had previously been differentially leveled to NAVD88 vertical datum. The estimated accuracy of the equipment and procedure was +/- 3cm.

The GPS receiver was placed on a standard adjustable height GPS survey rod that was fitted with a plastic DVD to its foot to prevent sinking in soft sediment during the survey. All elevations were measured as an offset to the height of the rod to the GPS antenna. The survey rod was positioned at the sample points along the transects at evenly spaced intervals using a canoe or kayak at peak high tides on each survey date. Throughout the survey, the position of the elevation of the water level was also measured to help identify tidal muting and lag differences from predicted tides. The height of the survey rod restricted the range of depths that could be accurately surveyed using this method. Water depths which were too great caused radio drop outs between the receiver and the base station radios so this method was not adequate for channel bottom elevations.

Comparison of Preconstruction to Postconstruction Marsh Plain and Channel Elevations

Digital elevations of the preconstruction marsh surfaces and as-built channel bathymetry were obtained from the Everest International Consultants in CAD format containing elevation contours. The CAD format was converted to ArcGIS format to be used in analysis with the postconstruction elevations obtained from San-Lo. In order to analyze and compare elevation changes, surface models from each of the elevation contour files were generated using triangulated irregular network (TIN) using the "create TIN" module of ArcGIS 3D Analyst extension. Sample transects were then projected on both TINs allowing for sampled and interpolated points along each transect to be extracted into elevation profiles spanning across the project.

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

The surface area elevations as determined by the methods presented above are illustrated in Figure 4. Postconstruction elevations were higher than the preconstruction conditions in both Pond 10 and Pond 11. Elevations in Pond 11 were higher because of intentional sediment placement as a component of the Project. Higher elevations in Pond 10 were presumably due to movement of unconsolidated sediment following breaching of the levees. This trend is further evident in the cross-section plots of the pond elevations comparing preconstruction surveys with as-built surveys and postconstruction 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 ± 10% and those determined using RTK GPS have an accuracy of ± 3%.

The difference in preconstruction and postconstruction elevations was greatest in Transect 3 in Pond 10 and Transect 4 in Pond 11(Figures 5 and 6). Much of the sediment deposited in Pond 11 was deposited in the vicinity of Transect 4. Transect 3, located in the northern part of Pond 10, was also close to this sediment placement site. It appears that the sediment was redistributed by tidal action in the southern part of Pond 11 and the northern part of Pond 10.

Although the topography of the marsh plain has increased 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 +1 m to + 1.5 m NAVD88 (+ 3.3 ft to + 4.9 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 + 1.5 m to +2.0 m NAVD 88 (+4.9 ft to + 6.6 ft NAVD88) are within the predicted range of mid- to high salt marsh (+4.6 ft to + 7.6 ft NAVD88). These areas have been colonized by Pacific pickleweed and are expected to remain mid- to high salt marsh. Postconstruction 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 and bathymetric surveys during and immediately following construction demonstrated that the objective that the Project be within ±10% of the design was met. Topographic surveys during year 1 postconstruction monitoring indicate that 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 will be a major focus during Year 2 of the monitoring program.

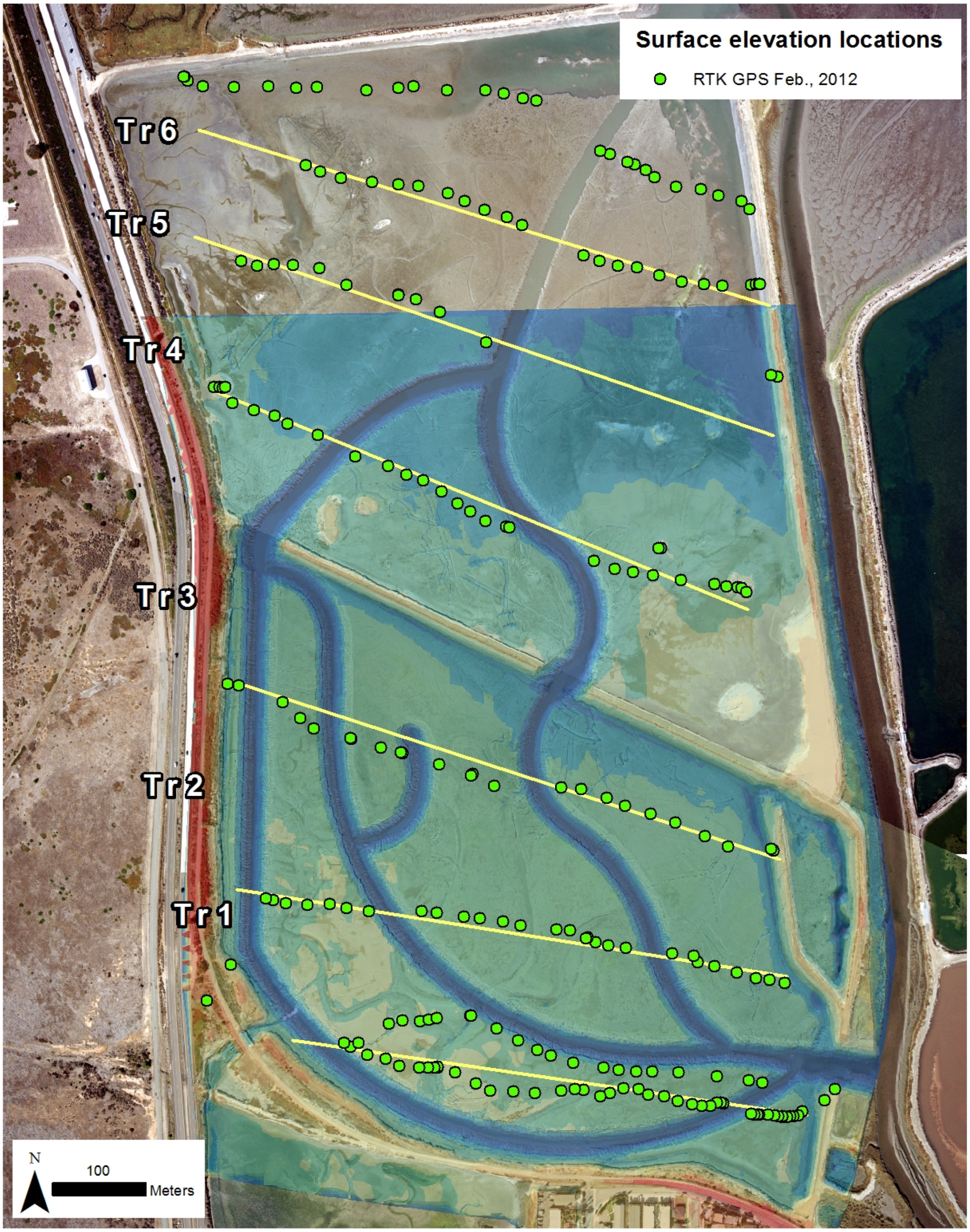


Figure 3. Real Time Kinematics Transects and Data Points Taken for Marsh Plain Topography February 2013.

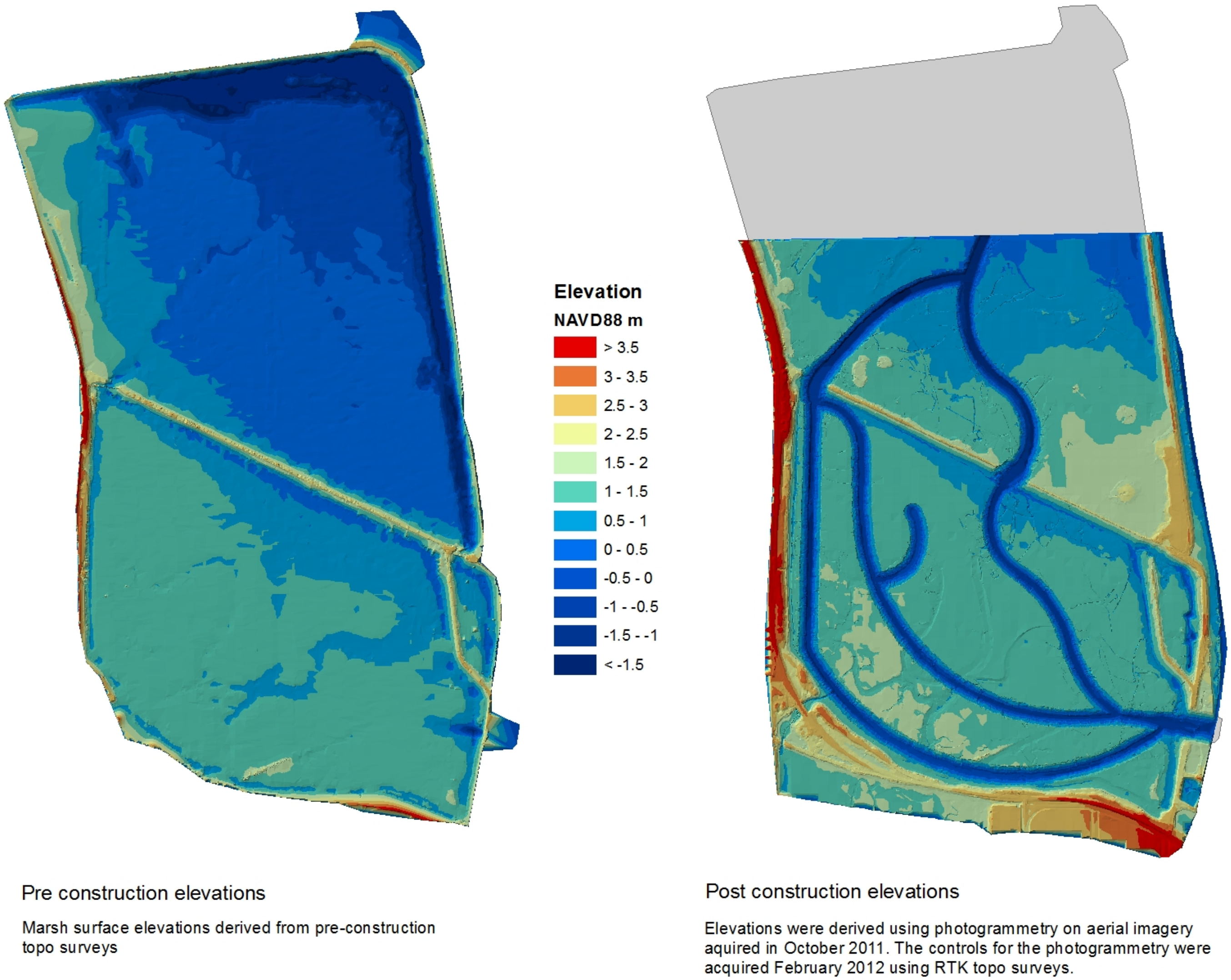


Figure 4. Digital Terrain Model of Ponds 10 and 11 Pre- and Postconstruction.

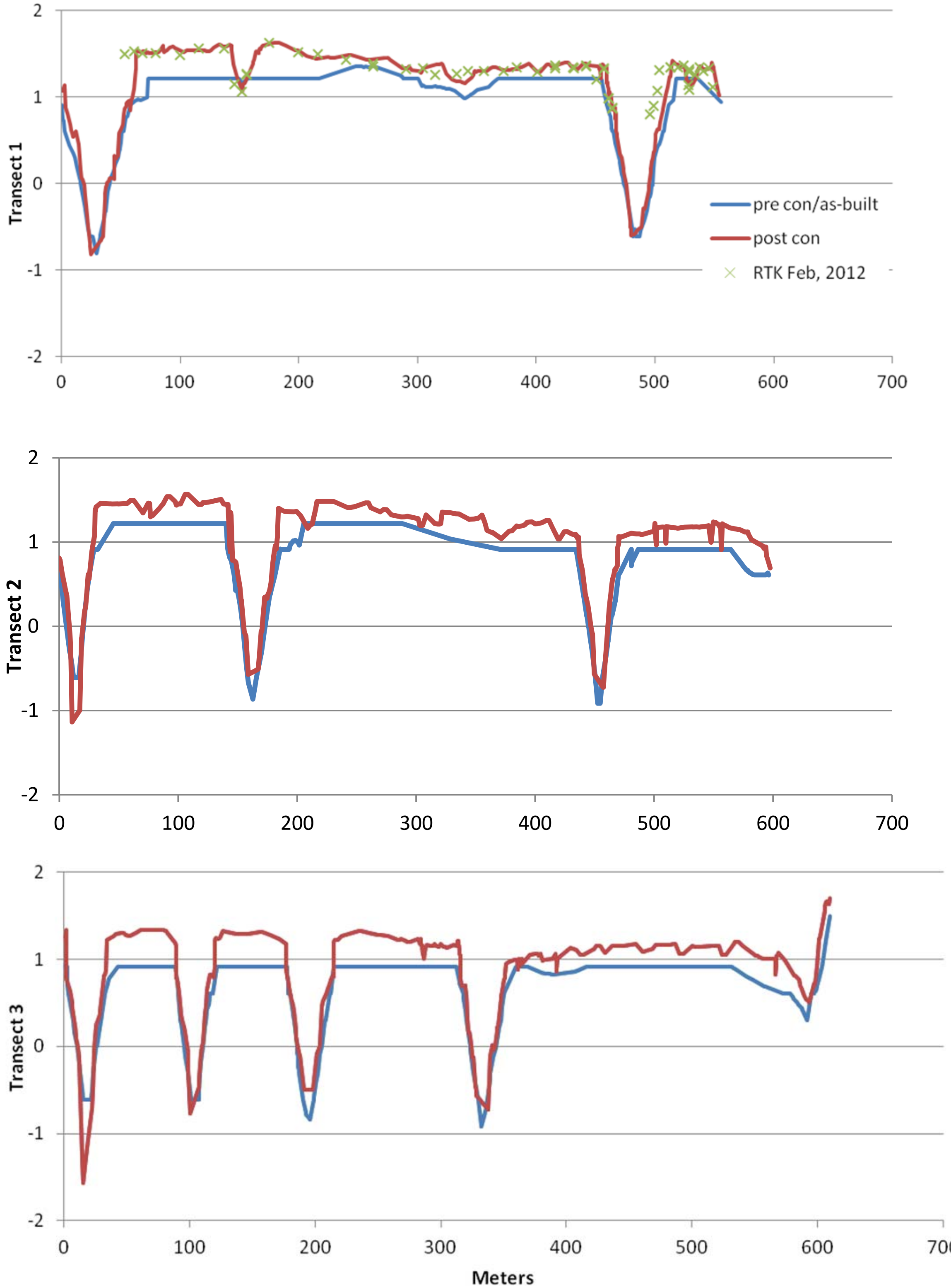


Figure 5. Elevations Along Transects in Pond 10. (X Axes Represent Length in Meters of the Transect From West to East).

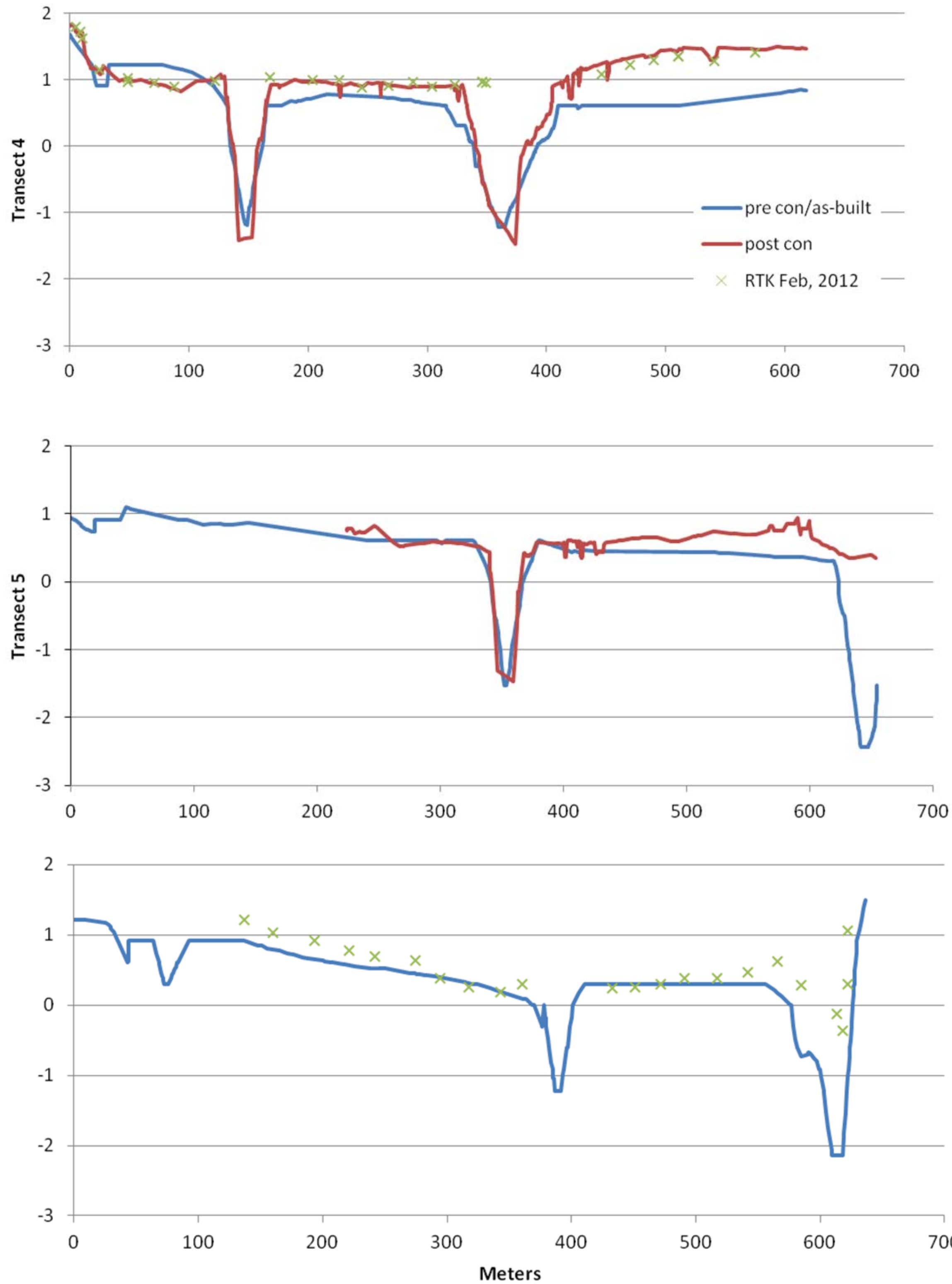


Figure 6. Elevations Along Transects in Pond 11. (X Axes Represent Length in Meters of the Transect From West to East).

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

Beginning January 2012, 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

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.**

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, with measurements taken every 15 minutes. 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.

2.3.2 Results - Monitoring of Tidal Amplitude of Western Salt Ponds

A comparison of the tidal amplitude in the breach between Pond 10 and Pond 11 with that at the mouth of the Otay River and the NOAA tide gauge at the Broadway Pier in mid-San Diego Bay is presented in Figure 9**.** 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 tide situation. During the neap tide series, tidal amplitude within the western salt ponds closely mirrors tides at both reference sites with a slight truncation of the low tides within the restored ponds. During the peak of the spring tide, this low tide truncation is more pronounced indicating that ponds do not completely drain relative to low tide in the Otay River. Tidal amplitude within the western salt ponds at high tide is similar to the reference sites during both the neap and the spring series.

2.3.3 Methods – Monitoring of Tidal Amplitude Measurement Methods of Chula Vista Wildlife Reserve

Tidal amplitude at the CVWR was assessed using Solinst© level loggers deployed at Stations 1, 2, and 3, as depicted in Figure 8. Level loggers detect pressure changes associated with water depth that can be converted to tidal amplitude. The loggers were deployed in February 2012 and functioned through March 2012 until they failed at two of the stations, apparently from water leakage. The third logger failed later in 2012. Replacement loggers were deployed in March 2013**.** Data collected by those loggers will be reported in the Year 2 monitoring report.

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

A comparison of the tidal amplitude at the CVWR with that in south and mid-San Diego Bay and the western salt ponds is presented in Figure 9**.** Two of the sensors (1 and 2) were located on the south end of the Reserve while sensor 3 was located in a tidal inlet immediately adjacent to the bay. All three sensors showed some truncation of low tides with station 3 more closely resembling the bay, station 1 less so and station 2 the least. The level sensor at station 2 showed marked truncation of the high 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.

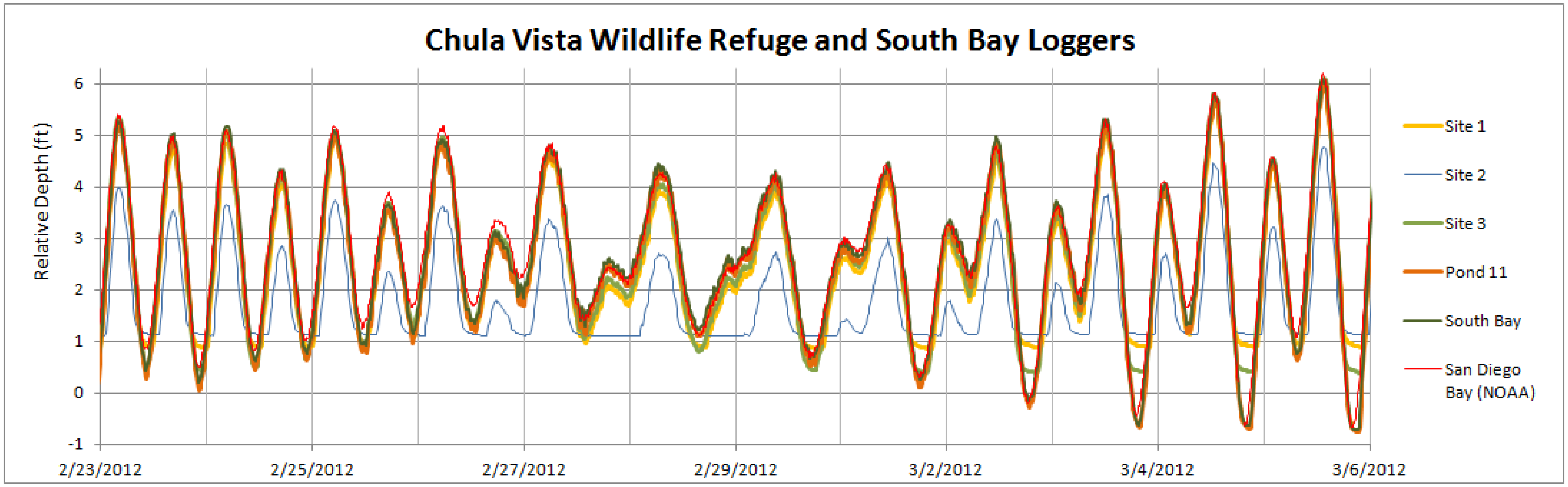
In summary, neither the western salt ponds nor CVWR met the Project objectives for tidal amplitude. Low tides at both sites were truncated relative to tides at reference sites within San Diego Bay. Monitoring in subsequent years may determine a need for remedial measures.

Figure 8. Monitoring Stations 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 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 monitoring within Pond 11, conducted from 2008 to 2010, showed variations in salinity, dissolved oxygen and temperature associated with water import and export and season.



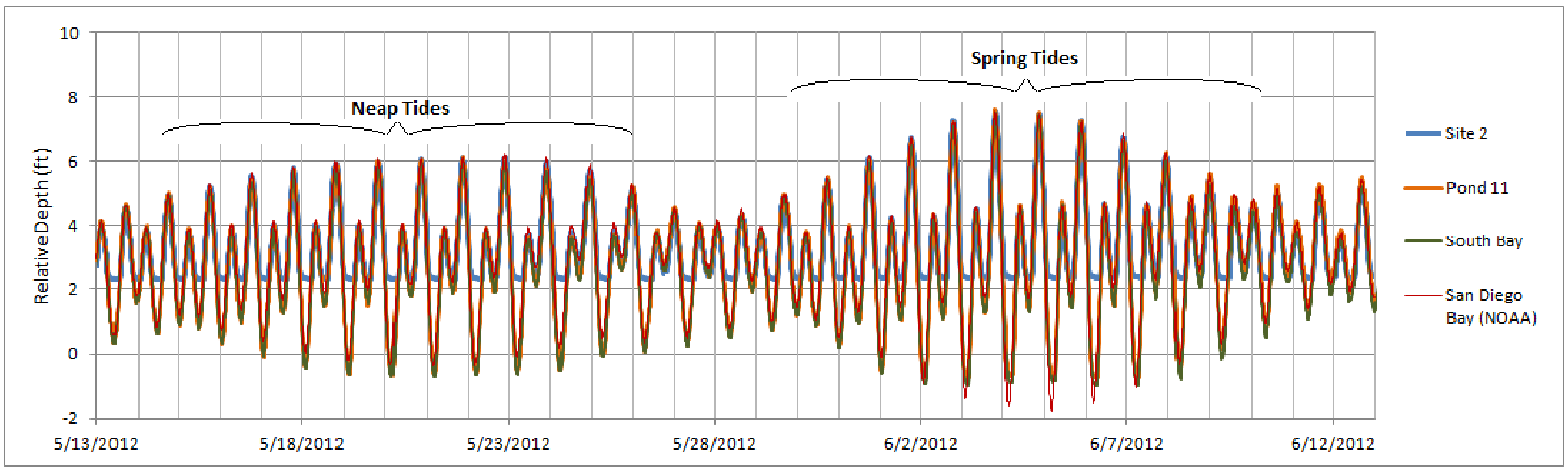


Figure 9. Tidal Amplitude at the CVWR and WSP. Above Tidal Amplitude Compared to the Otay River Mouth (South Bay) and Mid-bay (NOAA); Below Tidal Amplitude Compared to the Otay River and Mid-bay for Typical Neap and Spring Tide Series

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 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 (Otay River) during 2012 are presented in figures 10 through 18. Water depths were similar at both sites with similar maximum and minimum readings (Figure 10). Gaps in Otay River water quality data during January and February were the result of failure of the temperature/conductivity probe. This probe affects all other sensors and all data collected during that time period were rejected.

Salinity was similar at both monitoring stations, although minimum salinities were generally somewhat lower at the Otay River site, likely due to conveyance of freshwater during and after rainfall events (Figure 11). A salinity reading near zero was recorded in Pond 11 in October with no analogous reduction recorded at the Otay River. Given that minimum salinities were usually lower at the Otay River this reading appears to be an instrument error.

Water temperature varied seasonally with the highest temperatures occurring in July and August and lowest in December (Figure 12). Maximum and minimum temperatures varied only by approximately 5° C. 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 13) and maximum turbidity levels were substantially higher in Pond 11 than in the Otay (Figure 14). Higher turbidity within Pond 11 might be expected as the sediment deposited in the pond as slurry during construction has not yet consolidated and is subject to suspension in the water column by tidal action. However, elevated turbidity levels were attributed to biofouling of the LED sensor on the Pond 11 datalogger (5/11-6/7) as well as failure (loss) of the LED sensor wiper (6/7-7/5, 8/2-8/31, 8/31-9/28). With the removal of those peaks, turbidity levels in Pond 11 more closely resemble the turbidity levels in the Otay River, although levels in the ponds remained higher.

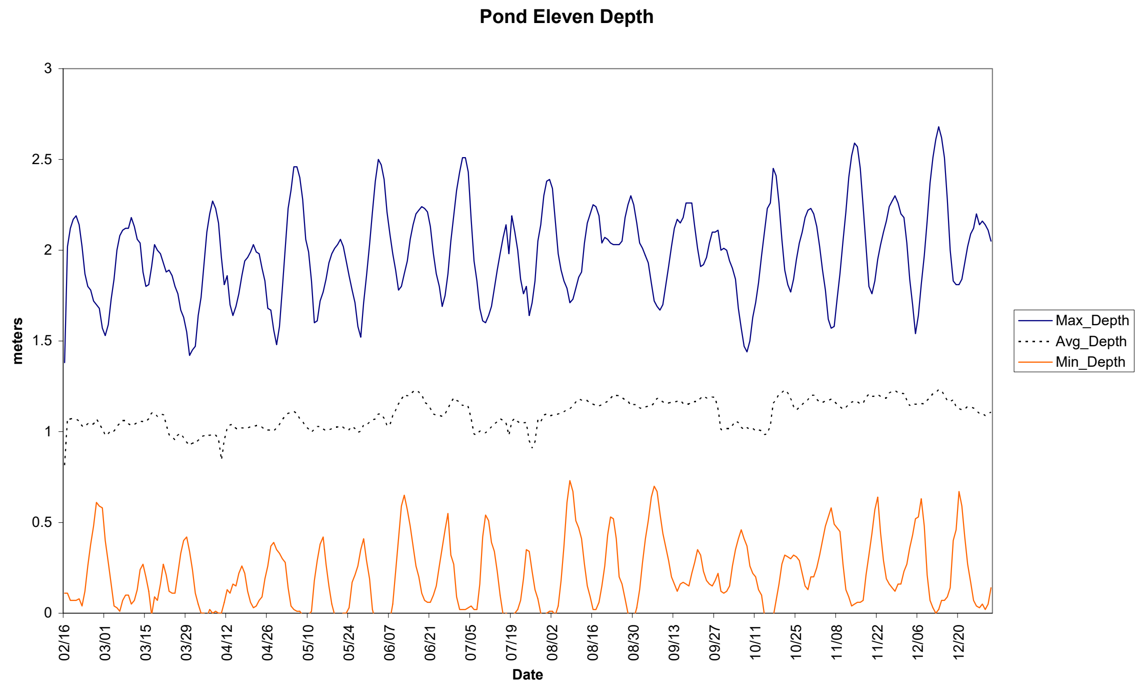
Dissolved oxygen levels varied seasonally and inversely with water temperature (Figure 15). Dissolved oxygen was highest during the cool winter months and lowest during summer and fall.

This parameter was similar for Pond 11 and the Otay River Mouth. Minimum dissolved oxygen levels near zero mg/l were recorded for both sites in fall 2012. During the deployment from 8/30 through 9/27 the wiper on the probe became detached as a result of sediment that accumulated at the bottom of the guard. This may have resulted in inaccurate dissolved oxygen readings.

Recorded pH levels were similar at both datalogger locations (Figure 16). Maximum pH in Pond 11 was generally around 8.0 with the minimum at 7.5-8.0. In the Otay, maximum pH levels ranged from about 7.5 to 8.0 with the minimum dropping to near 7 on one occasion.

Orthophosphate, ammonia and nitrate/nitrite levels varied considerably but were generally similar in Pond 11 and the Otay River (Figures 17 and 18). Chlorophyll levels as measured in the laboratory also varied substantially but with no apparent pattern between the two sites.

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.



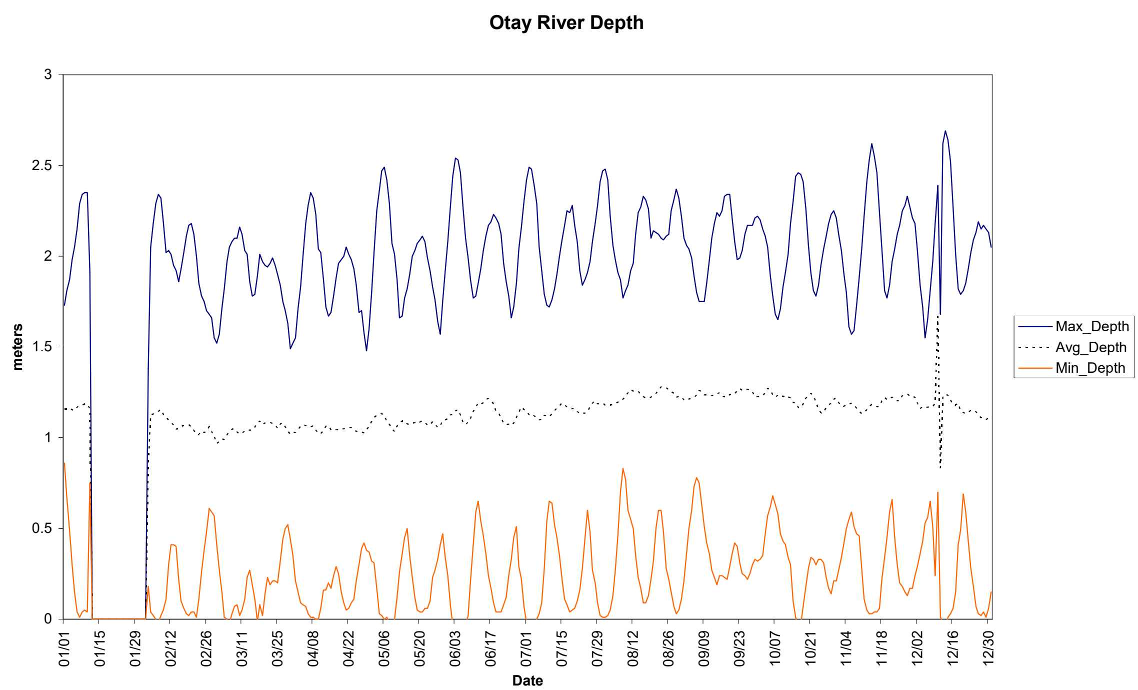
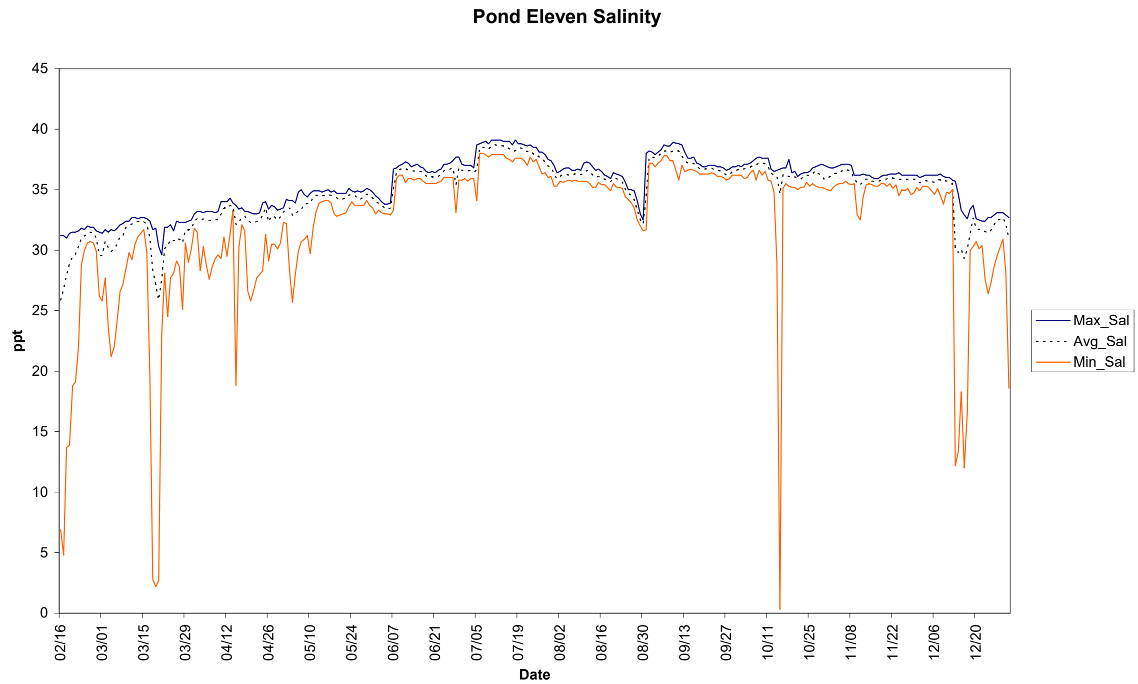


Figure 10. Water Depth in Pond 11 (above) and at the Otay River Mouth (below).



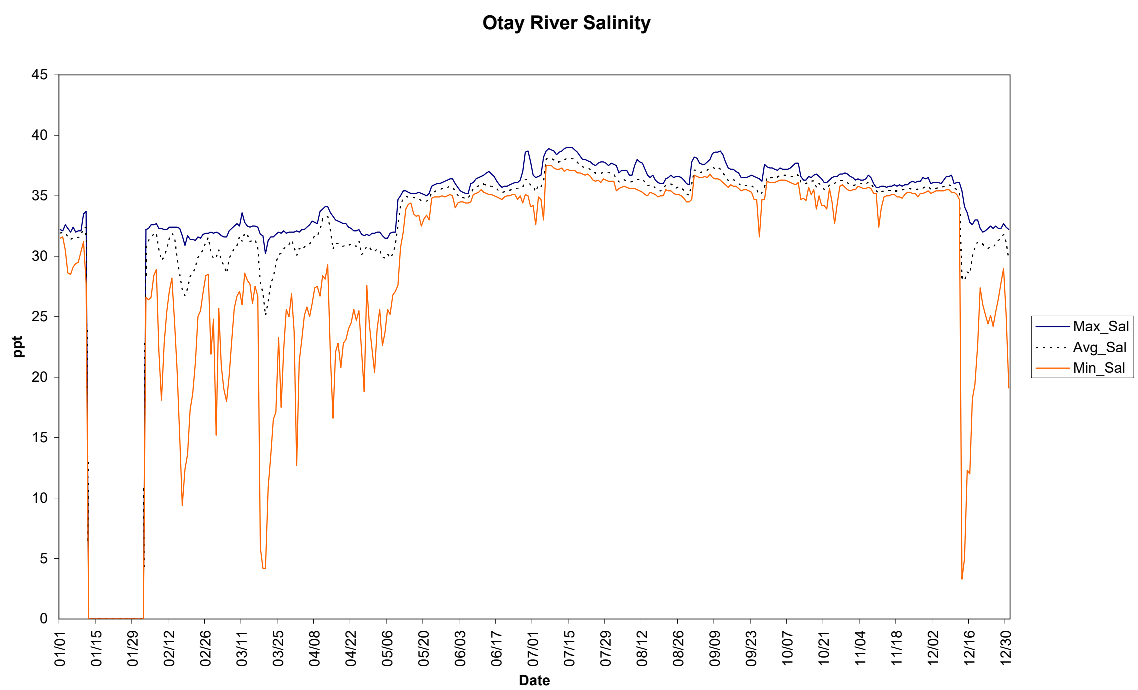
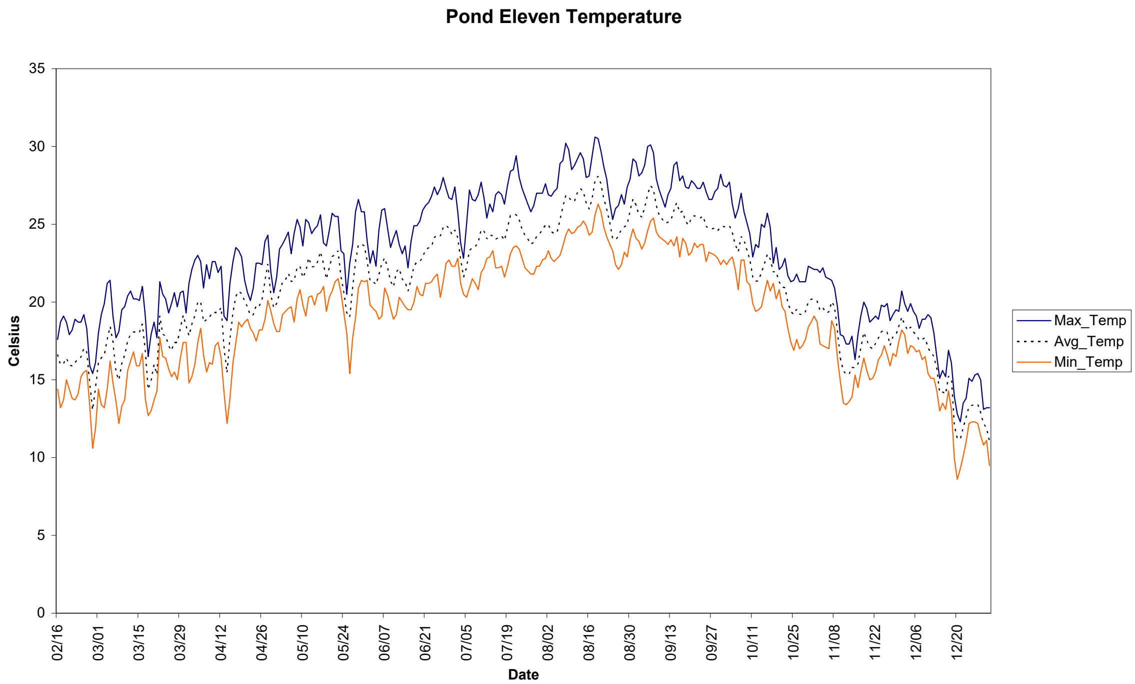


Figure 11. Water Salinity in Pond 11 (above) and the Otay River Mouth (below).



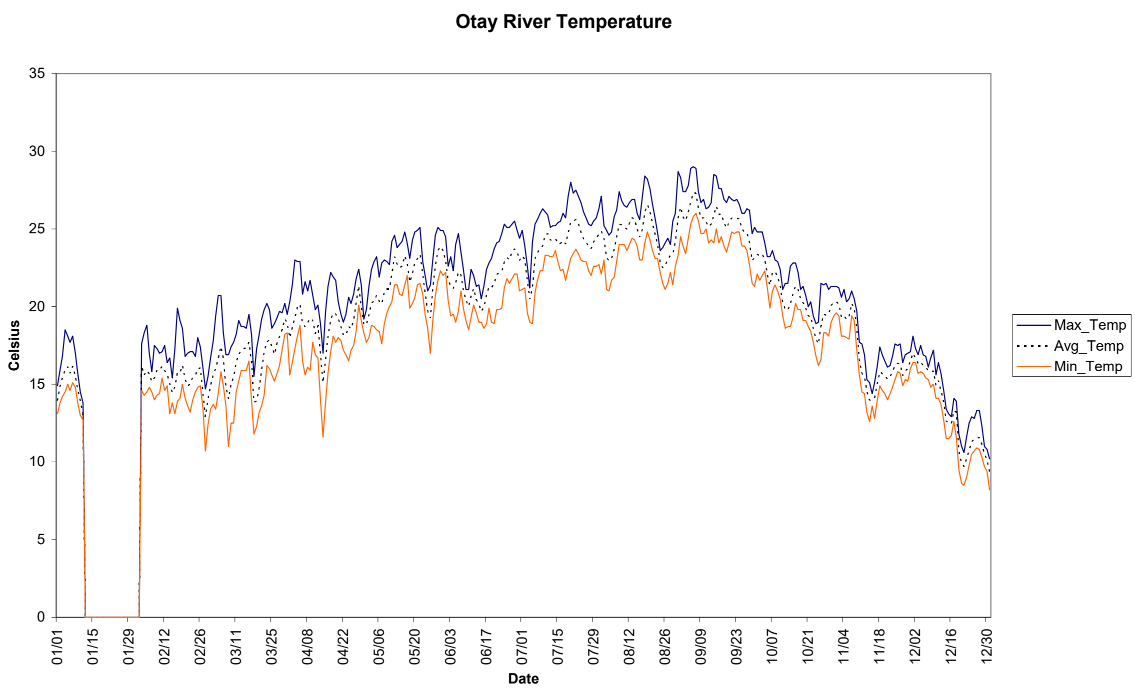
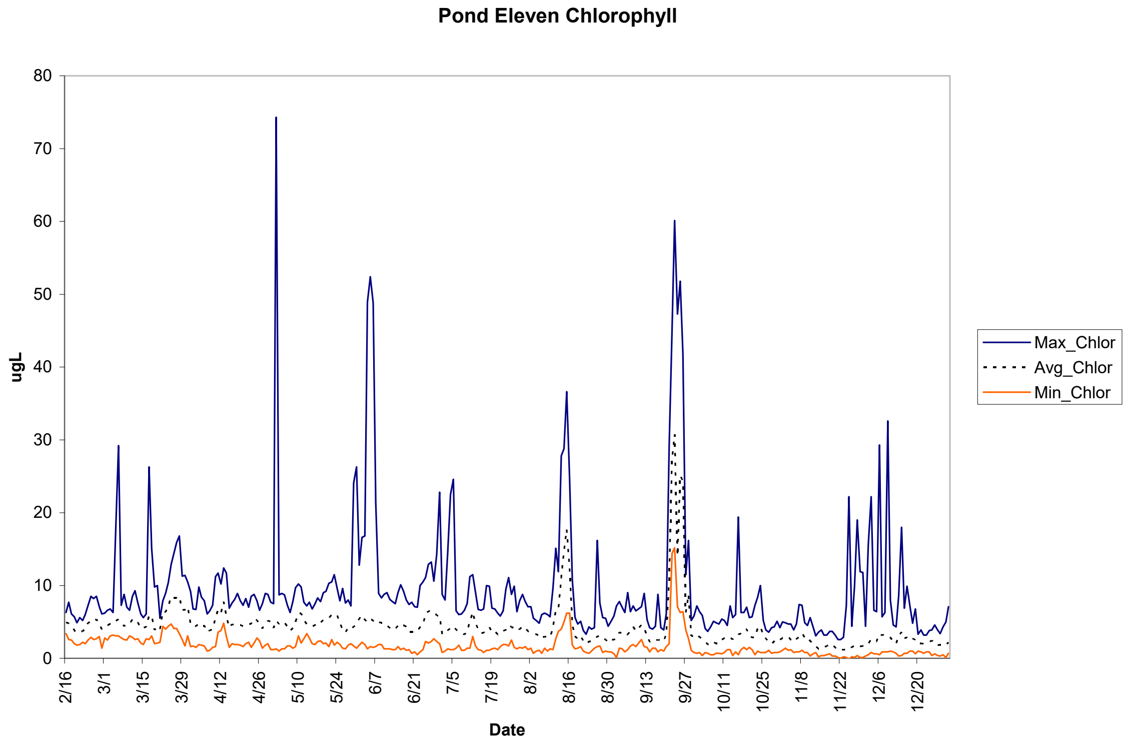


Figure 12. Water Temperature in Pond 11 (above) and the Otay River Mouth (below).



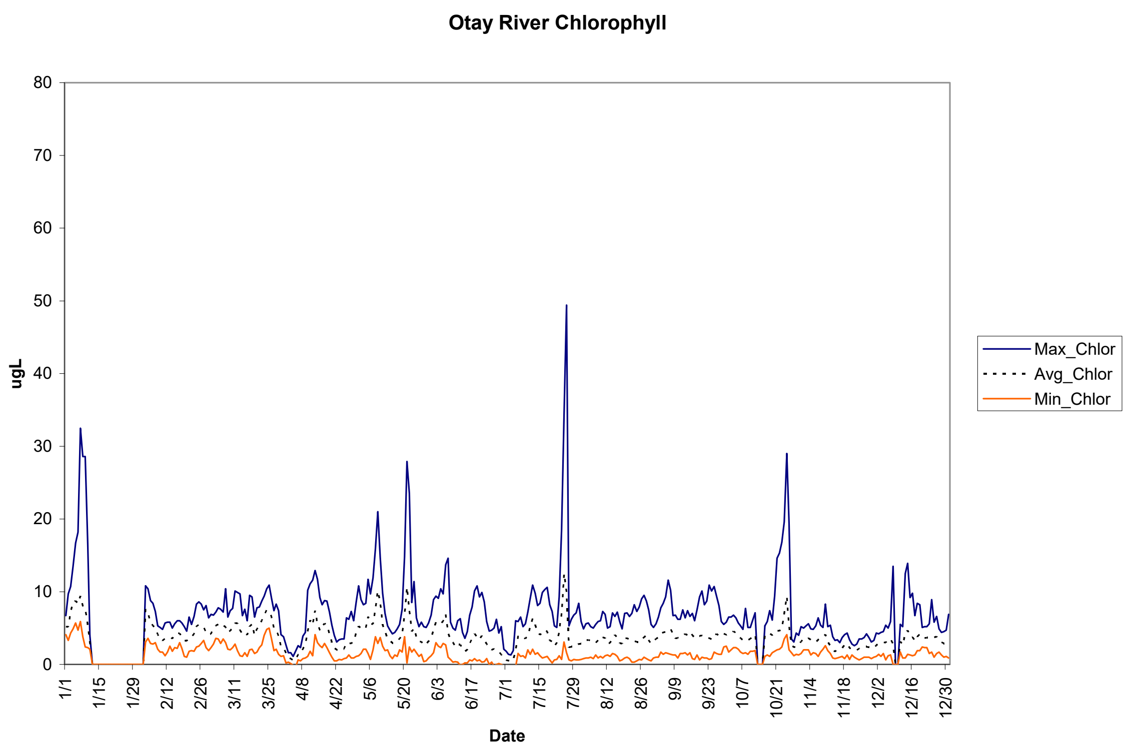
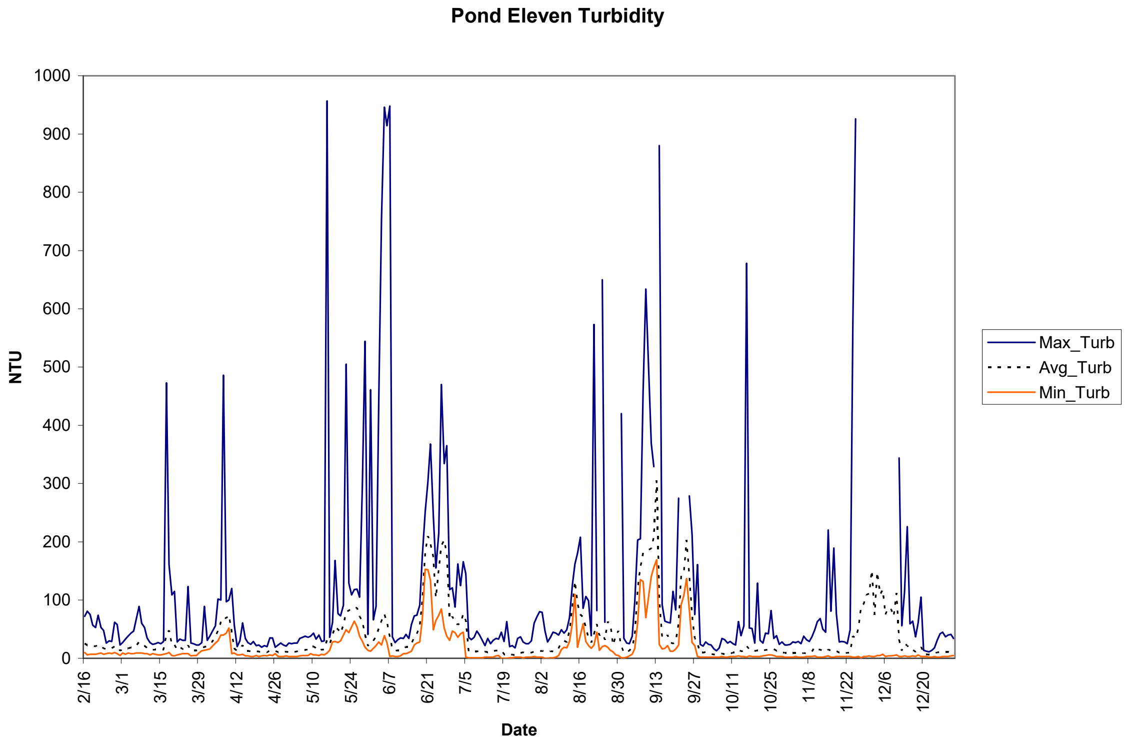


Figure 13. Chlorophyll in Pond 11 (above) and the Otay River Mouth (below).



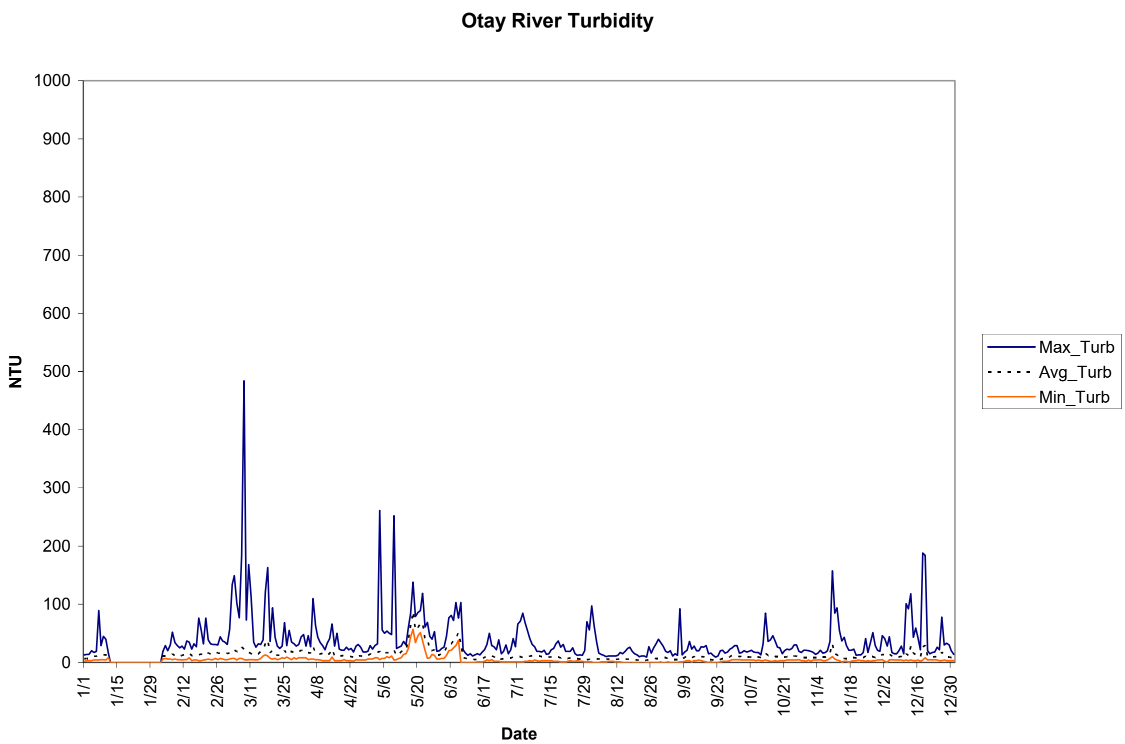
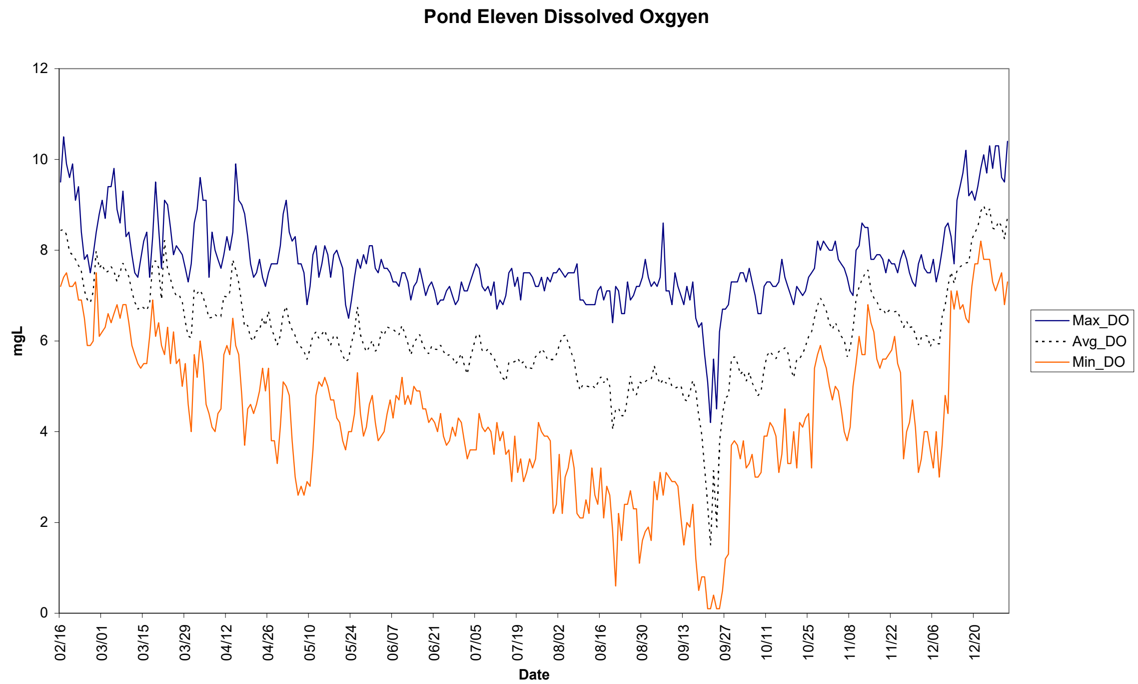


Figure 14. Water Turbidity in Pond 11 (above) and the Otay River Mouth (below).



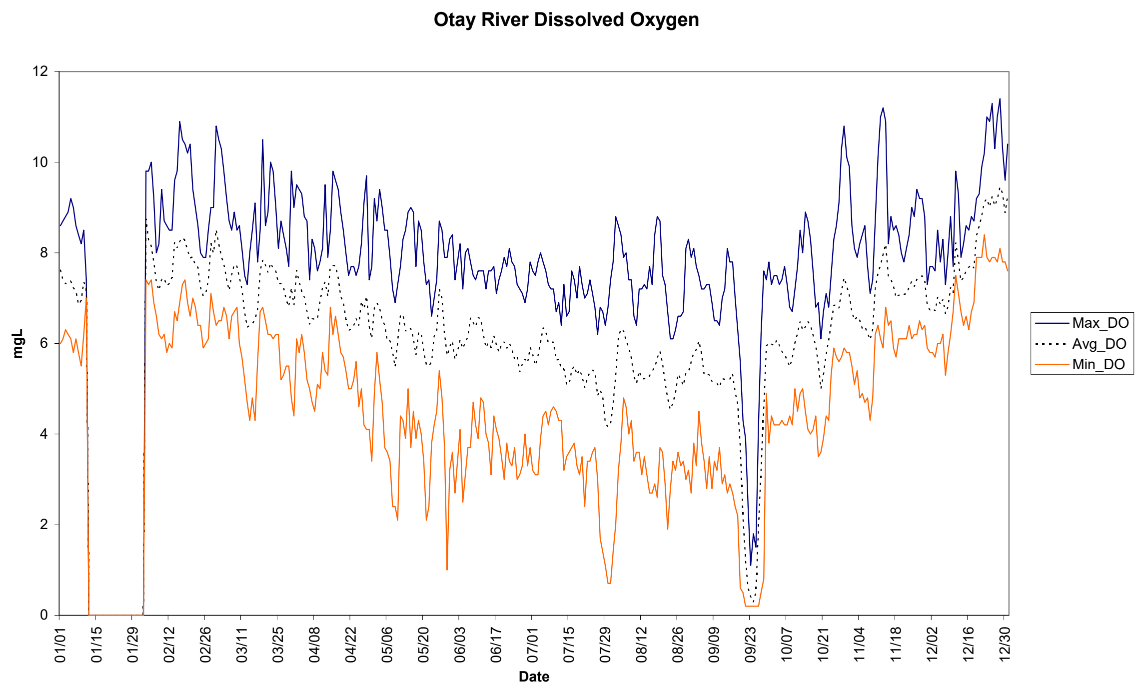
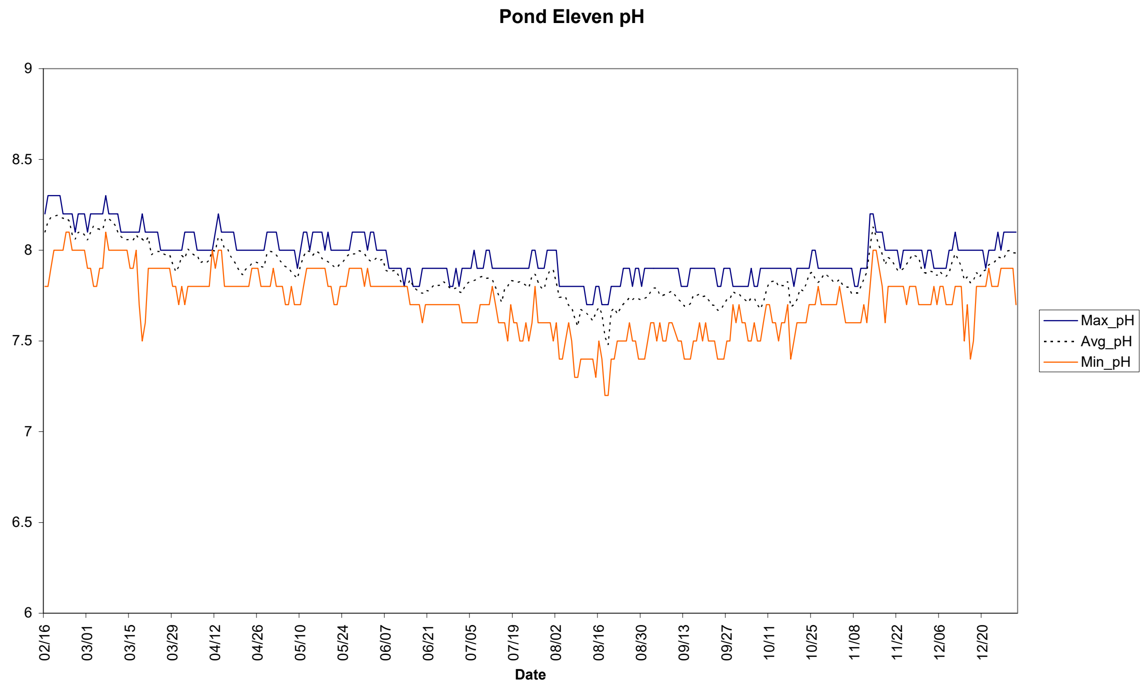


Figure 15. Dissolved Oxygen in Pond 11 (above) and the Otay River Mouth (below).



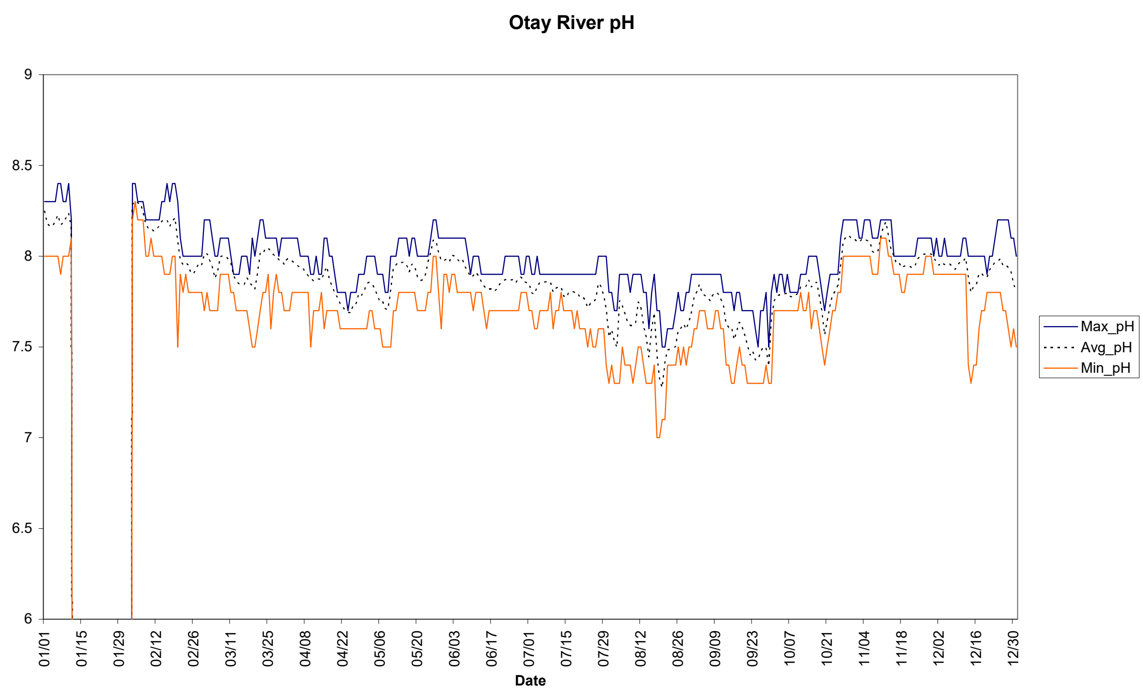
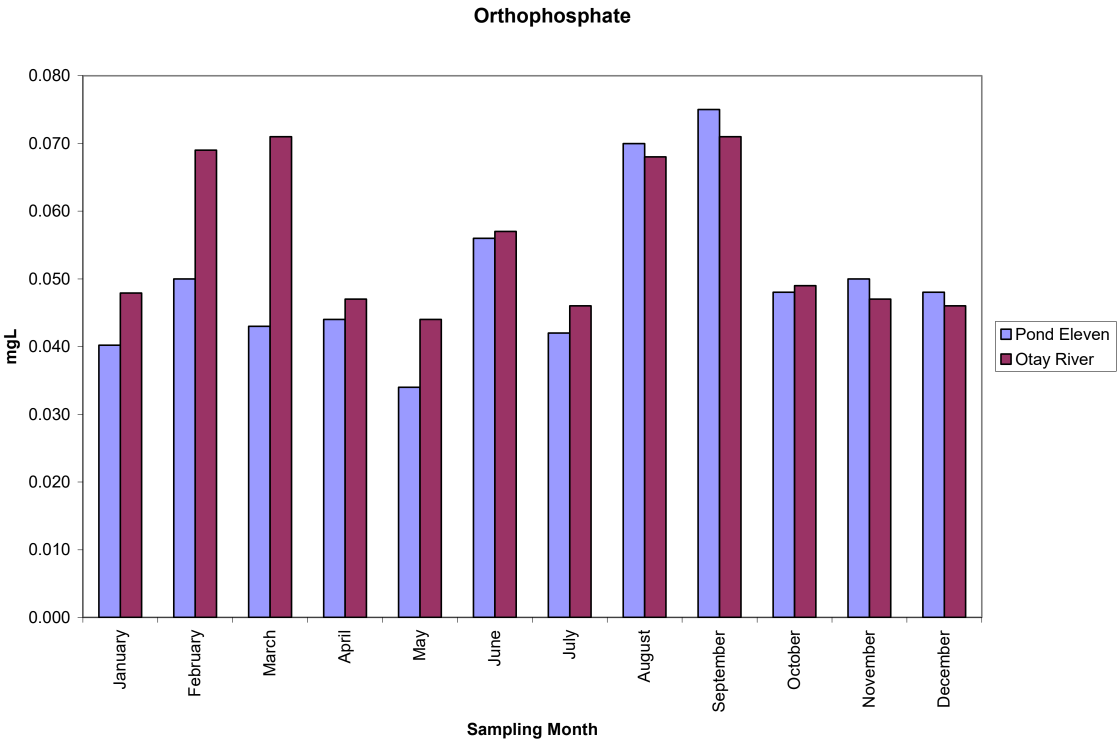


Figure 16. Water pH in Pond 11 (above) and the Otay River Mouth (below).



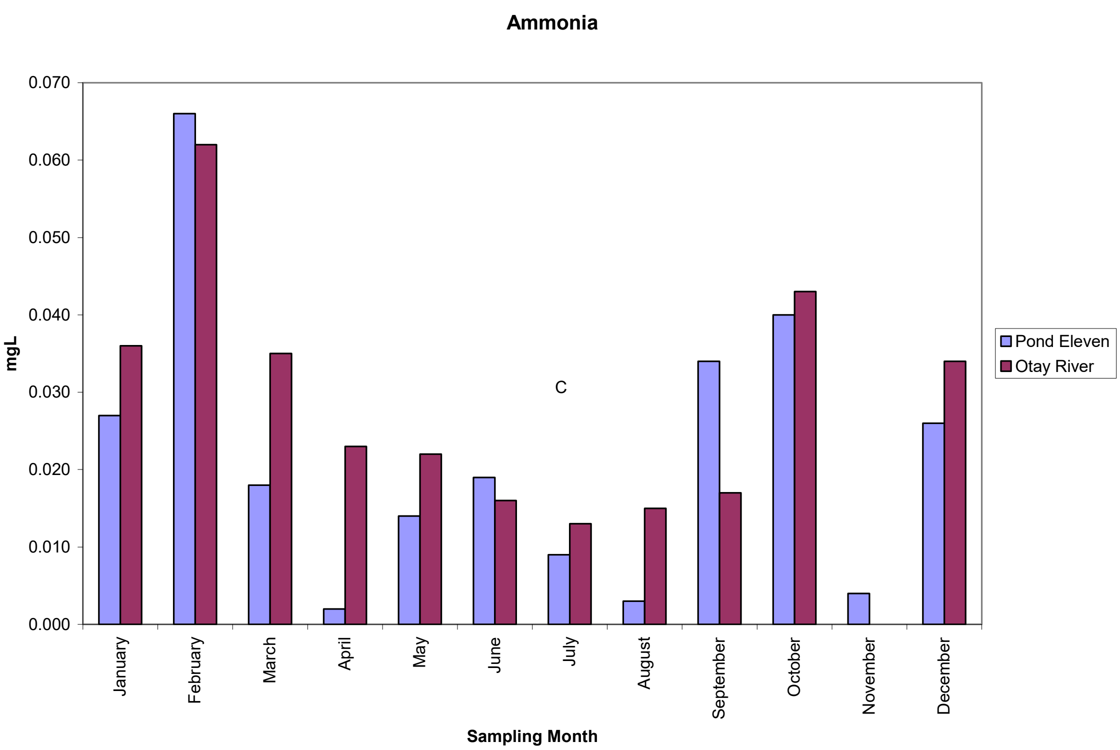
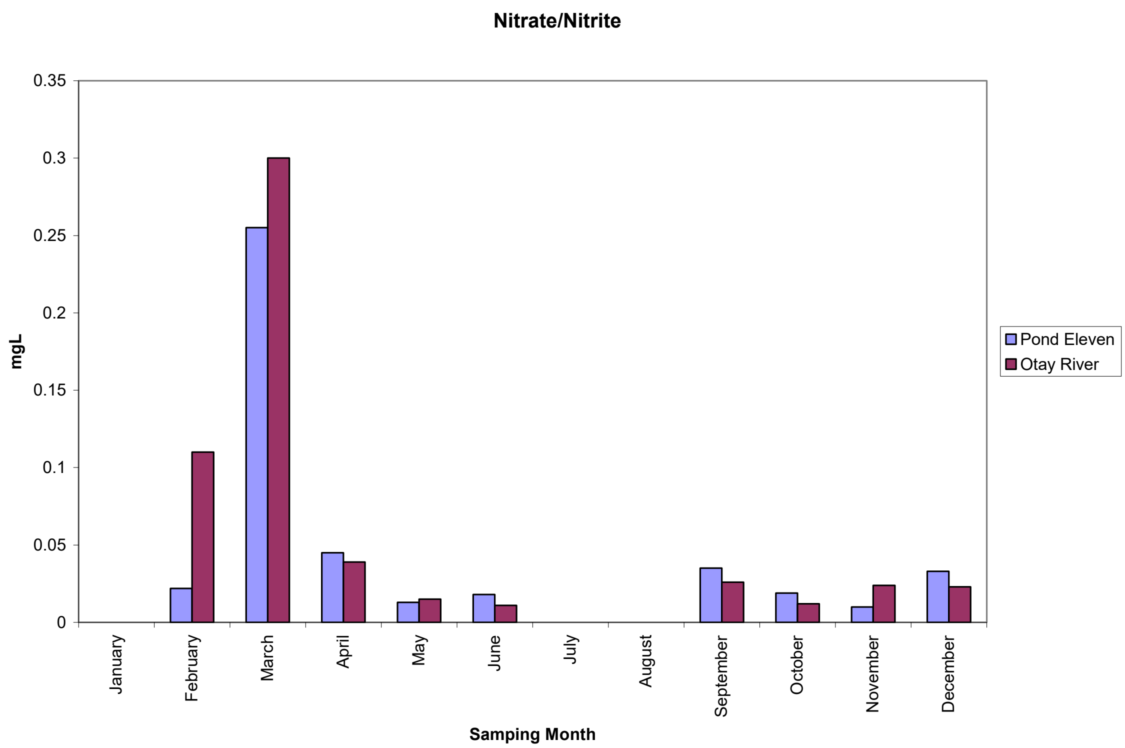


Figure 17. Orthophosphate (above) and Ammonia (below) in Pond 11 and the Otay River Mouth.



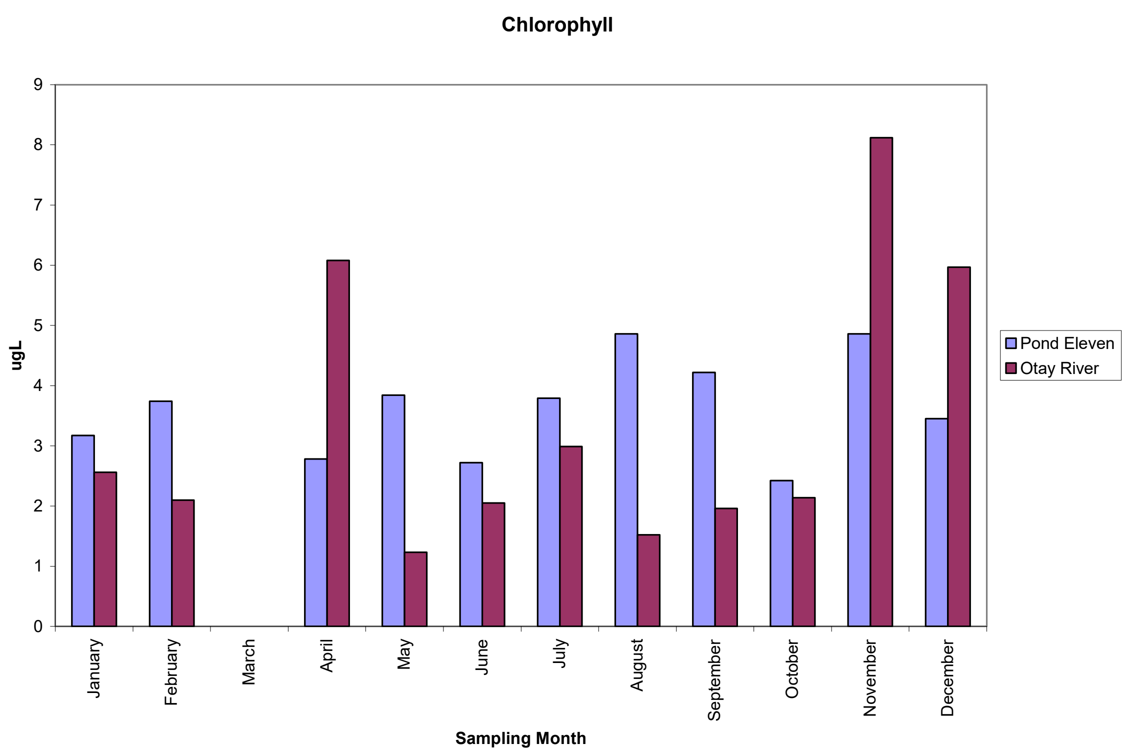


Figure 18. Nitrate/Nitrite (above) and Chlorophyll (below) in Pond 11 and the Otay River mouth.

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

Water quaity 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 j (Figure 19) ust prior to low tide on February 6, 2012 using a Hydrolab Quanta multiprobe water quality meter. Water samples were collected from tidal channels on March 14, 2012 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 2012

	February 6, 2012						March 14, 2012		
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	15.11	0.1	17.8	8.5	35.4	17.6	0.39	ND	0.053
2	15.27	0.1	18.1	9.9	35.6	8.5	0.27	0.068	0.061
3	15.33	0.1	18.4	10.8	36.0	29.5	0.33	ND	0,078
4	15.37	0.1	17.9	8.7	36.3	29.0	0.27	ND	0.061
5	15.44	0.2	17.5	9.1	36.1	8.2	0.25	ND	ND

ND = None detected

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 10, 11 and 10A were collected at the stations shown in Figure 7 on DATE. Soil sampling locations were designed to correlate with 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 content. Dried sediment was wet-sieved through 2 mm and 63 µm mesh screens to obtain percent weight of silt-clay, sand, and cobbles/ shell hash. Soil salinity was

Figure 19. Monitoring Stations Chula Vista Wildlife Reserve.

Measured by homogenizing the dried samples using a coffee grinder, rehydrating them with deionized water to form soil pastes, and then expressing interstitial water onto a handheld, temperature-compensated, optical salinity refractometer which measures salinity (primarily sodium chloride) in parts per thousand (ppt). Percent weight of organic material was obtained by heating a portion of each sample at 450°C for 4 hours in a muffle furnace and weighing the remainder of the non-combustible sediment. *In-situ* measurements of sediment stability was conducted using a Torvane shear strength gauge which measures soil stability in units of kg/cm.

2.5.2. Results - Monitoring of Soils of Western Salt Ponds

The results of sediment grain size analysis 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 a mean of approximately 85% and lower in Pond 10A with a mean of 72%. Organic content was fairly consistent among the three ponds with a mean of 9.7% in Ponds 10A and 10 and 7.9% in Pond 11. Soil salinity ranged from 52 - >160 ppt in Pond 10A to approximately 50 – 95 ppt in Ponds 10 and 11. It should be noted that the method used to measure salinity, often results in salinity values that are elevated relative to extracting interstitial pore water in the field and expressing directly onto the refractometer. Thus, salinities measured using the latter method during the August 2012 survey of experimental planting blocks of *Spartina foliosa* in Pond 10 (see section 3.1.3) had a mean value of 42.6 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.

The results of the Torvane shear strength gauge (Table 3) provides a general comparison of the stability of the soils in each pond. Shear strengths were highest in Pond 10A, intermediate in Pond 10 and lowest in Pond 11. 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 2. Sediment Grain Size Analysis Western Salt Ponds

South San Diego Bay Salt Ponds Soil Analyses - September 2012						
		weight percentages				
		Shell hash (> 2mm)	sand (2mm>x>63µm)	silt and clay (< 63µm)	Organics	Salinity (‰)
Pond 10A	1 - 1	18.17	70.74	11.09	3.11	80
	1 - 2	10.92	53.02	36.05	3.05	52
	1 - 3	2.01	22.43	75.55	8.15	60
	2 - 1	5.15	21.95	72.90	11.98	134
	2 - 2	10.50	11.05	78.44	10.87	84
	2 - 3	7.45	7.53	85.02	8.34	90
	3 - 1	1.38	5.07	93.55	15.83	>160
	3 - 2	9.54	8.92	81.54	10.75	84
	3 - 3	7.17	35.03	57.80	8.89	111
	4 - 1	1.76	44.54	53.70	6.85	101
	4 - 2	3.28	11.15	85.57	14.48	136
	4 - 3	0.00	4.95	95.05	14.94	>160
	4 - 4	1.16	49.46	49.38	5.67	80
	4 - 5	1.18	33.94	64.88	10.04	104
	5 - 1	0.16	12.78	87.05	14.64	>160
	5 - 2	14.36	13.41	72.23	10.16	80
	5 - 3	3.04	21.08	75.89	7.28	82
	1	0.62	14.39	84.98	10.20	68
	2	0.87	11.85	87.28	14.08	142
	3	0.34	13.88	85.78	17.13	155
	4	0.77	14.00	85.23	14.57	94
Pond 10	1 - 1	0.52	0.76	98.72	10.88	82
	1 - 2	0.62	9.17	90.21	10.59	95
	1 - 3	4.37	47.26	48.36	4.27	50
	5 - 1	0.00	2.43	97.57	12.66	94
	5 - 2	0.00	12.19	87.81	11.85	64
	5 - 3	6.68	44.86	48.46	7.08	61
	7 - 1	0.15	2.53	97.32	9.90	79
	7 - 2	0.69	0.96	98.34	9.87	76
	7 - 3	9.40	15.16	75.44	8.70	60
	8 - 1	0.33	0.45	99.22	9.73	72
	8 - 2	0.09	0.14	99.77	10.19	62
	8 - 3	5.23	8.32	86.45	10.63	85
Pond 11	1 - 1	1.23	30.48	68.29	6.78	50
	1 - 2	0.11	21.63	78.27	6.44	63
	1 - 3	0.19	14.27	85.54	6.02	69
	3 -1	1.64	1.35	97.01	9.35	88
	3 - 2	0.04	0.34	99.62	8.98	95
	3 - 3	0.02	6.23	93.75	7.34	65
	3 - 4	0.00	0.03	99.97	10.27	95
	3 - 5	0.00	0.19	99.81	10.46	63
	6 - 1	0.00	1.04	98.96	9.11	73
	6 - 2	0.00	18.08	81.92	7.31	54
	6 - 3	0.00	33.93	66.07	6.77	73
	6 - 4	0.00	17.37	82.63	8.24	70
	6 - 5	0.88	45.42	53.70	5.15	74

Table 3. Soil Torvane Shear Strength –Western Salt Ponds

Site Number	Average Shear Strength of Soil kg/cm^2	Standard Error of Mean
Pond 10A		
1	0.100	0.005
2	0.383	0.036
3	0.200	0.024
4	0.217	0.014
5	0.383	0.036
6	0.367	0.014
Pond 10		
1	0.120	0.005
4	0.087	0.003
5	0.067	0.007
7	0.143	0.010
8	0.123	0.010
9	0.113	0.011
Pond 11		
1	0.010	0.005
2	0.003	0.003
3	0.010	0.005
4	0.007	0.003
5	0.117	0.003
6	0.120	0.005

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 (*Spartina foliosa*) 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. These plantings have become established during Year 1 of the Project and are expected to expand in the 2013 growing season.

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. Both 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 19 (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.

Project delays resulted in the plants being delivered approximately 7 months after the intended April 2011 date. Thus, many of the plants were root bound. Although root bound, the decision was made to install the plants without trimming the roots as it was felt that this would increase transplant shock.

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

The postconstruction monitoring plan prepared for the Project specified that survival and development of the mid- and high marsh species would be determined by surveying along permanent transects. However, it was not anticipated that the sediments around the perimeter of Pond 10 would be too unstable to support foot traffic. During installation, workers were often thigh to hip deep in the soft sediments. Therefore, monitoring using transects was abandoned. Further complicating assessment of survival was the natural recruitment of Bigelow's pickleweed and Pacific pickleweed around the perimeter and on the marsh plain of Pond 10 in spring of 2012 which obscured many of the planted species. As a result, assessment of initial survival was not conducted. Casual observations suggest a survival rate of less than 50%. The development of mid- and high salt marsh in all ponds will be monitored using aerial photography beginning in Year 2 of the Project.

The transition zone plantings were impacted by vandalism and foot and bicycle traffic, despite construction of a fence to protect the site. Plants were trampled and the buried time release gel packs were unearthed. As a result, survival was low, estimated at less than 25%. Given the vandalism and trampling, quantitative monitoring was not conducted in Year 1.

The development of surviving transition zone plantings will be monitored using aerial photography beginning in Year 2 of the Project.

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
Watsons' 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 (*Spartina folisa*) 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 20 (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 20). 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.

Figure 20. As-built Salt Marsh Planting in Pond 10 (Figure 2 from As-built Report)

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; 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 20. 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 survival of planted individuals through Year 1 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.

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

Survival of cordgrass within each treatment block was assessed on August 30, 2012 and consisted of counting 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 survey are summarized in Table 5. Both nursery-grown plants and transplanted plugs achieved mean survival rates exceeding 30%. Bare root plantings had a low survival rate (3.4%). Soil salinities were typical of natural low marsh habitats in late summer.

Table 5. *Spartina* Survival in Pond 10 August 30, 2012. (100 Plants per Treatment. Survival by Number [Percent])

Plot	Bare Root	Nursery-Grown	Plugs	Control	Soil Salinity
1	3 (3%)	27 (27%)	50 (50%)	0 (0%)	50 ppt
2	1 (1%)	17 (17%)	46 (46%)	0 (0%)	46 ppt
3	6 (6%)	15 (15%)	44 (44%)	0 (0%)	45 ppt
4	14 (14%)	42 (42%)	39 (39%)	1* (1%)	48 ppt
5	3 (3%)	48 (48%)	25 (25%)	0 (0%)	46 ppt
6	0 (0%)	45 (45%)	22 (22%)	0 (0%)	50 ppt
7	6 (6%)	62 (62%)	31 (31%)	0 (0%)	45 ppt
8	1 (1%)	2 (2%)	36 (36%)	1* (1%)	42 ppt
9	0 (0%)	17 (17%)	27 (27%)	22* (22%)	54 ppt
10	0 (0%)	52 (52%)	57 (57%)	0 (0%)	45 ppt
Mean	3.4 (3.4%)	32.7% (32.7%)	37.7% (37.7%)	2.4* (2.4%)	42.6 ppt
Standard Deviation	4.37	19.67	11.56		

* Plants in control plots 4, 8 and 9 were survivals of arrays of nursery-grown cordgrass planted on the edge of the treatment blocks in Phase I of the planting plan. These plants did not recruit naturally and will not be considered in further analyses.

Based on the results of the randomized block planting experiment, nursery grown cordgrass plants are a cost effective propagation method for salt marsh restoration projects; however, considerable lead time and, potentially, contracts with multiple nurseries would be required for large-scale efforts. Viable cordgrass seed comprises a small fraction of the flowering culms. An analysis of the percent live seed collected for the Project conducted by Ransom Seed Laboratory concluded that live seed comprised 5.49% of the total collected with 11% germination. Thus, large quantities of seed must be collected and large areas devoted to germination trays. Once the cordgrass has germinated and rooted, it can be split in ramets with each split doubling the number of plants. During the 7 months that the salt marsh plants were held at Tree of Life Nursery only 7,225 cordgrass plants were propagated using the germinate and split method. Therefore, a lead time of 1 to 2 years would be required to produce the quantities necessary for large-scale restoration, a time frame that is not feasible in many cases. However, contracting with multiple nurseries could reduce that time frame. In terms of cost to the Project, each plant delivered by Tree of Life cost $2.00 compared to a range of $5.75 - $9.13 for collection and installation of plugs as contracted with Merkel & Associates.

3.1.6 Monitoring of Vascular Plants at 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 at 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 at the Chula Vista Wildlife Reserve

The success of the salt marsh plantings at the CVWR was assessed along three 50-meter transects extending across the marsh plain from low to high marsh (see Figure 19). 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 at 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. Like Pond 10 salt marsh habitat, planted species at the CVWR are expected to expand in cover in subsequent years. Future monitoring will be conducted using aerial photography.

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 species (flatfish and elasmobranchs) by 2013. At CVWR, the NOAA metric for fish was to demonstrate presence of one or more of the target species (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.

Fish were monitored using a variety of sampling gear, including minnow traps, enclosure traps, beam trawls and otter trawls. The Project monitoring plan had specified the use of beach seines and blocking nets; however, the soft substrate in Ponds 10 and 11 precluded this method and the trawls, traps and enclosures were used exclusively in Year 1. Should the sediment consolidate over time, seining may be included in future monitoring efforts. Because different sampling gears were used to evaluate fish use of Ponds 10 and 11 during pre- and postconstruction surveys, quantitative comparisons of the results of those surveys were not feasible. However, qualitative comparisons between preconstruction and postconstruction use by fish are presented below.

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

Trawls were conducted in Ponds 10 and 11 on September 17 and September 18, 2012. Two types of trawls were used to sample demersal fishes and invertebrates: 1) a 1-m beam trawl with 0.5-cm delta netting and 0.1-cm heavy delta chafing netting on the cod end; and 2) 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. Beam trawls were towed at approximately 2 knots and otter trawls were towed at approximately 3.5 knots. All trawls were towed for approximately 100 meters once the net was on the bottom. . All successful trawls were towed within a tidal range of +1.9 to +6.7-ft MLLW (+ 1.72 to + 6.52 ft NAVD88). This tidal range was wider than originally proposed. This restricted sampling to the channels while allowing the vessel to operate over a wider time period and at higher tides.

A total of 12 beam trawls and 11 otter trawls were completed. The beam trawls were towed at stations labeled 1-12 (Figure 201. The otter trawls were towed at stations 13-23 (Figure 21). The otter trawl at station 13 was discarded due to the net being tangled. The net was re-deployed nearby at station 14.

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

Fish

A total of 12 species of fish, representing 8 families were collected (Table 7). The beam trawl captured a total of 22 individuals representing 5 families in 12 trawls for an average capture of 1.8 fish per effort. In terms of relative abundance, beam trawls were dominated by gobiids (14 individuals). In terms of biomass, beam trawls were dominated by round stingray.

Otter trawls captured a total of 501 individuals representing 7 families in 11 trawls for an average capture of 45.5 fish per effort. In terms of relative abundance, otter trawls were dominated by juvenile slough anchovy (267) and juvenile topsmelt (212). The majority of slough anchovy and topsmelt measured approximately 3 - 4 cm and weighed approximately 0.5 gm. Round stingrays dominated the otter trawls in terms of biomass. The two beam trawls conducted in the bay captured two shiner surfperch, one bay pipefish and one slough anchovy. No shiner surfperch or bay pipefish were collected within the ponds. Similarly, the 2 otter trawls conducted in the bay captured 5 slough anchovy, 4 round stingray, 1 diamond turbot and 172 topsmelt. Thus, only 40 of the total 212 topsmelt were collected in the ponds and the only diamond turbot collected was from the bay. Photographs of representative fish species collected during the trawling effort are presented in Figure 22.

By comparison, preconstruction beach seines deployed in Ponds 10 and 11 collected 15 species of fish including high numbers of topsmelt, gobies, California killifish, and slough anchovy. Thus, although different sampling gears were used during preconstruction and postconstruction surveys, similar assemblages were collected with the exception of round stingray. The presence of round stingrays in the postconstruction surveys 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

A total of 29 invertebrates representing 10 taxa were collected in the trawls, including gastropods, bivalve molluscs, decapod crustaceans, and one species of sponge (Table 8). Approximately twice as many individual invertebrates were collected using the beam trawl (20) than the Otter trawl (9). The non-native *Zoobotryon verticullatum*, was collected using both trawls. The two beam trawls and two otter trawls attempted in the bay captured one mantis shrimp, one *Navanax* and the sole bubble snail collected during the sampling effort.

Figure 21

Beam Trawl and Otter Trawl Sampling Locations – Western Salt Ponds.

Table 7. Fish Collected Using Beam Trawls and Otter Trawls Western Salt Ponds.

Family	Species	Total Collected Beam Trawl	Total Collected Otter Trawl	% of Total Beam Trawl	% of Total Otter Trawl
Engraulidae	*Anchoa delicatissima* (slough anchovy)	1	267	4.5%	53.3%
Atherinidae	*Atherinops affinis* (topsmelt)	0	212	0	42.3%
Dasyatidae	*Urobatis halleris* (round stingray)	3	15	13.6%	3%
Gobiidae	*Clevelandia ios* (arrow goby)	5	3	22.7%	0.6%
	Ilypnus gilberti (cheekspot goby)	6	0	27.2%	0
	Quietula y-cauda (shadow goby)	3	0	13.6%	0
	Tridentiger trigonocephalus (chameleon goby)	1	0	4.5%	0
Embiotocidae	*Cymatogaster aggregata* (shiner surfperch)*	2	0	9.0%	0
Syngnathidae	*Syngnathus leptorynchus* (bay pipefish)*	1	0	4.5%	0
Pleuronectidae	*Hypsopsetta guttulata* (diamond turbot)*	0	1	0	<0.5%
Sciaenidae	*Umbrina roncador* (yellowfin croaker)	0	2	0	<0.5%
	Cynoscion parvipinnis (shortfin croaker)	0	1	0	<0.5%

*Collected in bay only

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

Species	Total Collected Beam Trawl	Total Collected Otter Trawl	% Collected Beam trawl	% Collected Otter Trawl
Muscalista senhousia (Japanese oyster)	6	1	30%	11%
Tagelus californinus (California jackknife clam)	0	1	0	11%
Alpheus californiensis (pistol shrimp)	3	1	15%	11%
Hemisquilla californiensis (mantis shrimp)	1	0	5%	0
Hippolyte californiensis (California glass shrimp)	0	1	0	11%
Hemigrapsus oregonensis (yellow shore crab)	3	1	15%	11%
Cerithidia californica (California hornsnail)	4	1	20%	11%
Navanax inermis (navanax)	1	2	5%	22%
Bulla gouldiana (bubble snail)*	0	1	0	11%
Aphrocallistes sp. (cloud sponge)	1	0	5%	0

* Collected in bay only.

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 23). 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 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.

Minnow traps were deployed on 6 occasions – once each in March, May, July and September and on 2 dates in November, 2012. Sampling consisted of retrieving the traps at low tide, submerging half the trap in an ice chest full of site water, measuring the lengths of the first 20 fish of each species to the nearest centimeter, and counting the remaining fish grouped by species. All species were identified in the field and the majority was released alive. Water quality data, including temperature, salinity, and dissolved oxygen, were measured for each station.

Figure 22. Photograph of shortfin corvina top left, round stingrays and a diamond turbot (top right), chameleon goby (bottom left), and a trawl sample being sorted for fish and invertebrates (bottom).

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

A total of 642 individual fish representing 5 species and 3 Families were collected at the 11 sampling sites within the western salt ponds using minnow traps (Table 9). The dominant species collected was longjaw mudsucker with 353 individuals representing 55% of the catch. California killifish was the second most abundant species with 293 (46%) individuals collected over the 6 monitoring dates. Topsmelt, arrow goby and staghorn sculpin (*Leptocotttus armatus*) were collected in low numbers.

The majority of all individuals were collected from Pond 10A (97%) compared to approximately 2.9% in Pond 10 and approximately 0.1% (1 individual) 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.

Invertebrates collected using minnow traps in the western salt ponds included 4 taxa of decapod crusteaceans and one species of gastropod mollusc (Table 9). Decapod crusteaceans were dominated by oriental shrimp (*Palaemon macrodactylos*) and yellow shore crab (*Hemigrapsus oregonenisis*). Of the 81 individuals collected, approximately 50% were oriental shrimp, 46% were yellow shore crab and blue crab. *Callinectes* sp. (3 individuals; 3.7%) and horn snail (1 individual; 1%) were relatively rare. The majority 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 at sampling stations 2, 3, 4 and 6 (see Figure 8) on a single date in September 2012. 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 on the CVWR. Two oriental shrimp and 4 yellow shore crab (*Hemigrapsus oregonensis)* were collected.

Figure 23. Minnow Trap Sampling Stations Western Salt Ponds.

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

Species		Pond 10A																							
Scientific Name	Common Name	March 2012				May 2012				July 2012				September 2012				Nov. 6, 2012				Nov. 8, 2012			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Atherinops affinis	Topsmelt							1																	
Clevelandia io	Arrow Goby																								
Acanthogobius flavimanus	Yellowfin Goby																								
Fundulus parvipinnis	California Killifish	54	54		2	20	5	70	19		32	4	4		1	1			1		10		2		3
Gillichthys mirabilis	Longjaw Mudsucker	9	10		1	24	16	19	38	30	23	19	34	10	6	2	2	29	8		10	13	17	1	19
Leptocottus armatus	Staghorn Sculpin	1																							
Navanax inermis																									
Palaemon macrodactylos	Oriental Shrimp																				2				
Hemigrapsus oregonensis	Yellow Shore Crab									4	6	4	2	1	1		1	1	1		1	1	1	1	1
Callinectes sp.	Blue Crab																								
Cerithidea californica	Horn Snail									1															
Total Abundance per Station		64	64	0	3	44	21	90	57	35	61	27	40	11	8	3	3	30	10	0	23	14	20	2	23
Total Abundance per Pond per Survey		131				212				163				25				63				59			
Mean Abundance per Station per Survey		33				53				41				6				16				15			
Mean Abundance per Station per Survey, All Surveys		27																							

Species		Pond 10																							
Scientific Name	Common Name	March 2012				May 2012				July 2012				September 2012				Nov. 6, 2012				Nov. 8, 2012			
		5	6	7	8	5	6	7	8	5	6	7	8	5	6	7	8	5	6	7	8	5	6	7	8
Atherinops affinis	Topsmelt																								
Clevelandia io	Arrow Goby							1			1		1												
Acanthogobius flavimanus	Yellowfin Goby																								
Fundulus parvipinnis	California Killifish												1												
Gillichthys mirabilis	Longjaw Mudsucker	3						1		8				1											
Leptocottus armatus	Staghorn Sculpin																								
Navanax inermis													1												
Palaemon macrodactylos	Oriental Shrimp		7	1			4	6			4			1	1			1				9			
Hemigrapsus oregonensis	Yellow Shore Crab									10															
Callinectes sp.	Blue Crab																								
Cerithidea californica	Horn Snail																								
Total Abundance per Station		3	7	1	0	0	4	8	0	18	5	0	3	2	1	0	0	1	0	0	0	9	0	0	0
Total Abundance per Pond per Survey		11				12				26				3				1				9			
Mean Abundance per Station per Survey		3				3				7				1				0				2			
Mean Abundance per Station per Survey, All Surveys		3																							

Species		Pond 11																	
Scientific Name	Common Name	ch 2012			May 2012			July 2012			Sep. 2012			Nov. 6, 2012			Nov. 8, 2012		
		9	10	11	9	10	11	9	10	11	9	10	11	9	10	11	9	10	11
Atherinops affinis	Topsmelt																		
Clevelandia io	Arrow Goby																		
Acanthogobius flavimanus	Yellowfin Goby																		
Fundulus parvipinnis	California Killifish																		
Gillichthys mirabilis	Longjaw Mudsucker																		
Leptocottus armatus	Staghorn Sculpin	1																	
Navanax inermis																			
Palaemon macrodactylos	Oriental Shrimp														2		1	1	
Hemigrapsus oregonensis	Yellow Shore Crab																1		
Callinectes sp.	Blue Crab																		3
Cerithidea californica	Horn Snail																		
Total Abundance per Station		1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	1	3
Total Abundance per Pond per Survey		1			0			0			0			2			6		
Mean Abundance per Station per Survey		0			0			0			0			1			2		
Mean Abundance per Station per Survey, All Surveys		1																	

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

In order to compare fish populations with other wetlands, an enclosure trap (Figure 24) was employed following the methods used at San Dieguito Lagoon and three reference wetlands (Tijuana Estuary, Mugu Lagoon and Carpenteria Marsh) for the San Onofre Nuclear Generating Station Wetland Mitigation Program. The trap was deployed at 6 sites in each of ponds 10A and 10 (see Figure 7) and at the 6 sampling stations on the CVWR (see Figure 8). The enclosure trap is composed of a polypropylene sheet fixed as a 1m-tall cylinder with a $0.4m^2$ sampling area. The trap was thrown away from the sampler in an attempt to minimize startling of fish occurring nearby. A BINCKE net was 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.

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 in the western salt ponds are presented in Table 10. No fish were captured at the 6 stations within Pond 10A. The enclosure traps deployed in Pond 10 caught a total of 18 fish; 16 arrow goby (*Clevelandia ios*) and 2 slough anchovy (*Anchoa delicatissima*). There were also 14 Asian mussels (*Musculista senhousia*) captured in Pond 10.

Figure 24 - Enclosure Trap.

Table 10. Fish and Invertebrates Collected Using Enclosure Traps Western Salt Ponds

Species		Pond 10A						Pond 10					
		Enclosure Traps						Enclosure Traps					
Scientific Name	Common Name	1	2	3	4	5	6	1	4	5	7	8	9
Clevelandia ios	Arrow Goby							3	1	5	7		
Anchoa delicatissima	Slough Anchovy								2				
Alpheus californiensis	Pistol Shrimp										1		
Musculista senhousia	Asian Mussel							5		1	6		2
Total Abundance per Station		0	0	0	0	0	0	8	3	6	14	0	2
Total Abundance for Pond		0						33					

A total of 79 individual fish were collected from the 6 sampling stations located on the CVWR using enclosure traps. Arrow goby was the dominant species collected at 74 individuals and comprising 94% of the catch (Table 11). Three California killifish, one topsmelt (*Atherinops affinis*) and one slough anchovy were also captured.

Seven invertebrate species comprised of 49 individuals were captured at the 6 sampling stations (Table 11). The dominant species was the bivalve mollusc bent-nose macoma (*Macoma nasuta*) which comprised 76% of the total or 37 individuals. Five Asian mussels accounted for 10% of the total. The remaining 4 species accounted for 2% - 4% of the total each.

Table 11. Fish and Invertebrates Collected Using Enclosure Traps Chula Vista Wildlife Reserve

Species		Chula Vista					
		Enclosure Traps					
Scientific Name	Common Name	1	2	3	4	5	6
Atherinops affinis	Topsmelt		1				
Clevelandia ios	Arrow Goby	5	13	8	7	2	39
Acanthogobius flavimanus	Yellowfin Goby						
Fundulus parvipinnis	California Killifish	2				1	
Anchoa delicatissima	Slough Anchovy					1	
Syngnathus leptorhynchus	Bay Pipefish					2	
Palaemon macrodactylos	Oriental Shrimp						1
Hemigrapsus oregonensis	Yellow Shore Crab	1					
Cerithidea californica	California Horn Snail						1
Protothaca staminea	Pacific Littleneck Clam						2
Macoma nasuta	Bent-nose Macoma	2				15	20
Musculista senhousia	Asian Mussel	1	1			1	2
Total Abundance per Station		8	15	8	7	22	65
Total Abundance		125					

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

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 like bivalves and large crustaceans, and small cores for smaller macrofuana. Six channel-bottom sites were sampled in each pond, 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 macrofauna, two large cores (50 cm long, 10 cm diameter) were taken at each sampling site. These cores were sieved in the field using a 3 mm sieve. Invertebrates were identified by species and counted. For the western salt ponds, the cores for the smaller infaunal invertebrates were collected at each site using a small push core (6 cm long, 4.8 cm diameter).

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

The results of infaunal monitoring at the western salt ponds is presented in Table 12. Only one set of the large cores revealed living invertebrates within the sediment. The two cores at site 1 in Pond 11 captured 1 California jack-knife clam (*Tagelus californianus*) and 10 Asian mussels.

Small core samples were delivered to Dr. Christine Whitcraft of CSULB for sorting, identification and quantification. These samples will also be used for isotopic food web analyses being conducted by Dr. Whitcraft. Results were not available for this report.

3.3.3 Methods – Monitoring of Benthic Macroinvertertaes 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 8). 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. Like the western salt ponds, very few organisms were collected in the large cores. These included 1 California horn snail and one unidentified polychaete.

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 (*Cerithidea californica*) were the only epifaunal species encountered at both the western salt ponds and CVWR. Horn snails were present in relatively high densities at both sites (Tables 12 and 13). At the western salt ponds densities were highest in Pond 10 at 110.7 organisms/m^2. Densities in Pond 11 and Pond 10A were similar at about 25 organisms/m^2. Pond 11 has similar abundances as that of pond 10A with 19 individuals counted and 25.3 organisms/m^2. Mean horn snail densities at the CVWR was 72 organisms/m^2 (Table 13). Densities varied from 0 organisms/m^2 at stations 3 and 4 to 200/m^2 at station 5.

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

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 both cores)																	
Tagelus californianus	California jackknife clam													1					
Musculista senhousia	Asian Mussel													10					
Macrofauna Total Abundance per Site (#/dm^3)		0	0	0	0	0	0	0	0	0	0	0	0	1.40	0	0	0	0	0
Mean Abundance per Pond (#/dm^3)		0.0						0.0						0.23					
		Epifauana - Two .25m x .25m Quadrats† (# in both quadrats)																	
Cerithidea californica	California Horn Snail	7	11	0	0	0	0	3	38	30	0	6	6	0	0	1	0	18	0
Total Abundance per Site (#/m^2)		56	88	0	0	0	0	24	304	240	0	48	48	0	0	8	0	144	0
Mean Abundance for Pond (#/m^2)		24.0						110.7						25.3					

*core volume = 3.927dm^3 †quadrat area = .0625m^2

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

Species		Chula Vista					
Scientific Name	Common Name	1	2	3	4	5	6
		Macroscopic Infauna - 10 cm Core* ($\#^{\alpha}/m^3$)					
Cerithidea californica	California Horn Snail						1
Polychaete sp.						1	
Macrofauna Total Abundance per Site (#/dm^3)		0.00	0.00	0.00	0.00	0.13	0.13
Total Abundance for Pond (#/dm^3)		0.25					
		Epifauana - Two .25m x .25m Quadrats† (#/m^2)					
Cerithidea californica	California Horn Snail	2	12	0	0	25	15
Total Abundance per Site (#/m^2)		16	96	0	0	200	120
Mean Abundance for Pond (#/m^2)		72.0					

*core volume = 3.927dm^3 †quadrat area = .0625m^2 αnumber of individuals in both cores

The NCWC Project goal of demonstrating recruitment of infauna and epifauana for support of foraging shorebirds and ground-nesting seabirds by March 2013 met with mixed results during Year 1 monitoring. Infaunal assemblages of Ponds 10 and 11, as determined through the use of large cores, were depauperate and were dominated by the non-native Asian mussel. Infaunal assemblages as determined through use of small cores and 0.5 mm mesh sieve were not available for this report and may support the NCWC objective. By comparison, preconstruction surveys of ponds 10 and 11 using both large cores sieved through a 3 mm mesh and small cores sieved through a 0.5 mm mesh were dominated by polychaetes, crustaceans, molluscs and miscellaneous phyla. Benthic invertebrates collected in fish enclosure traps and fish trawls suggests a greater diversity of benthic invertebrates than those observed in the large cores. However, densities were low.

Infauna assemblages at the CVWR were likewise depauperate and were dominated by California horn snail, which occurred on the surface of the cores. The epifauna at both the western ponds and the CVWR were dominated by California horn snail. This species contributes to the diet of some shorebird species, most notably the endangered light-footed clapper rail.

3.4 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.

3.4.1 Methods – Monitoring of Avian Use of Western Salt Ponds

SDNHM and ARA conducted preconstruction 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 March 2010 to September 2010 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. Postconstruction surveys were conducted using the same methods from January 2012 to December 2012. 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 (Figures 25 and 26). 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.

3.4.2 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 25. Avian Monitoring Grid – South San Diego Bay and Salt Works - Preconstruction.

Figure 26. Avian Monitoring Grid– South San Diego Bay and Salt Works - Postconstruction .

The number of avian species observed in wetland habitat during the preconstruction surveys varied seasonally with peaks in April and September (Figure 27). A high of 23 species was recorded in April and September and low of 2 species was recorded in Pond 10 during July. The mean number of species over the seven-month preconstruction monitoring period was 13 species in Pond 10A, 10 species in Pond 10, and 7 species in Pond 11.

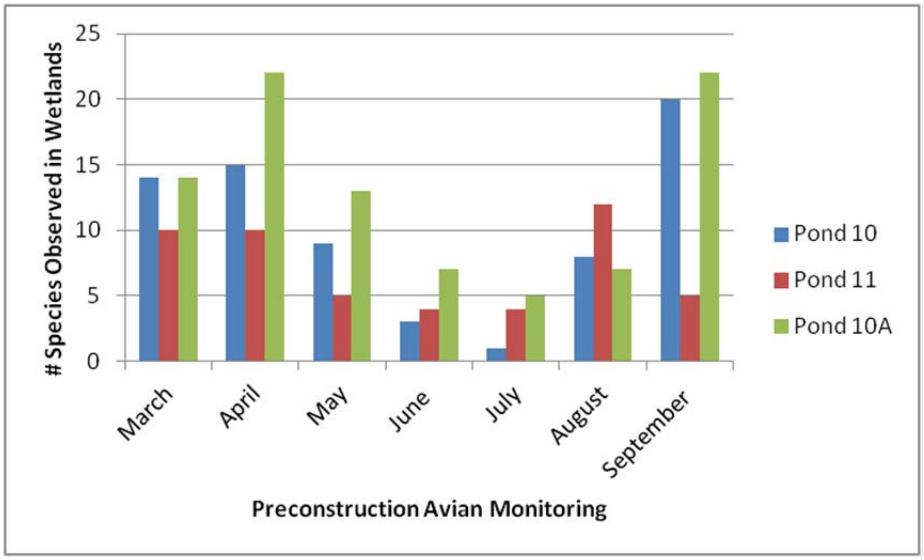


Figure 27. Number of Avian Species Observed in Wetland Habitats – Preconstruction

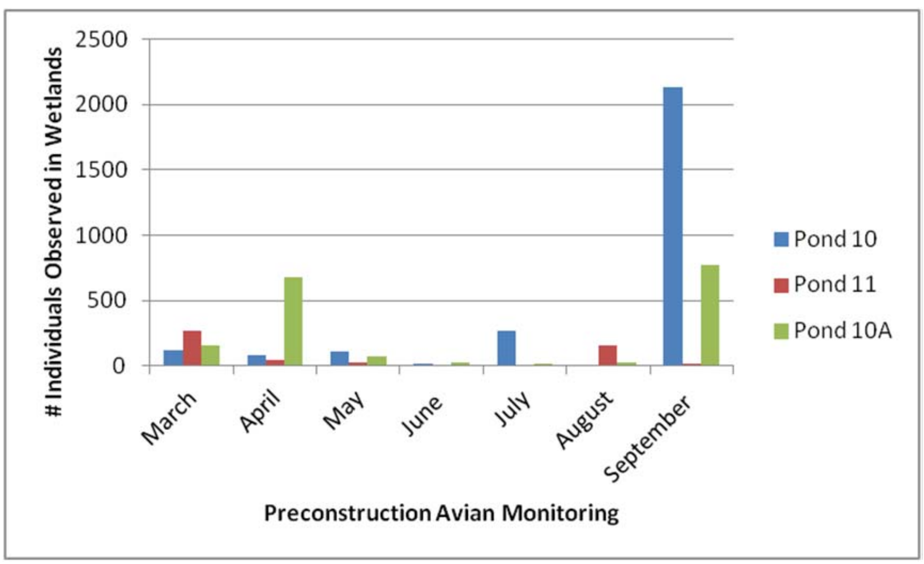


Figure 28. Number of Individual Birds Observed in Wetland Habitats – Preconstruction

The number of individuals observed in wetland habitat during preconstruction monitoring also varied seasonally with a strong peak in September 2010 (Figure 28). In general, numbers of individuals were highest in Ponds 10A and 10 and lower in Pond 11. The number of individuals varied greatly, from a low of five individuals observed in Pond 11 in July to a peak of 2,129 individuals observed in Pond 10 in September.

The number of species observed in wetland habitats during the 2012 postconstruction monitoring is illustrated in Figure 29. The number of species peaked again in April with a lesser peak in December. Numbers of species observed ranged from 44 in Pond 11 in April to 4 species in Pond 10A in January. 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 24 with a mean of 23 in Pond 11. The mean number of species in Pond 10A was 11. A comparison of the 7-month preconstruction monitoring period with the same months postconstruction indicates that the number of species observed in ponds 10 and 11 were higher following pond restoration. These data suggest that avian usage was improved by converting ponds 10 and 11 to intertidal and subtidal habitats. The number of species observed in Pond 10A were similar during both 7-month intervals with the exception of September 2010.

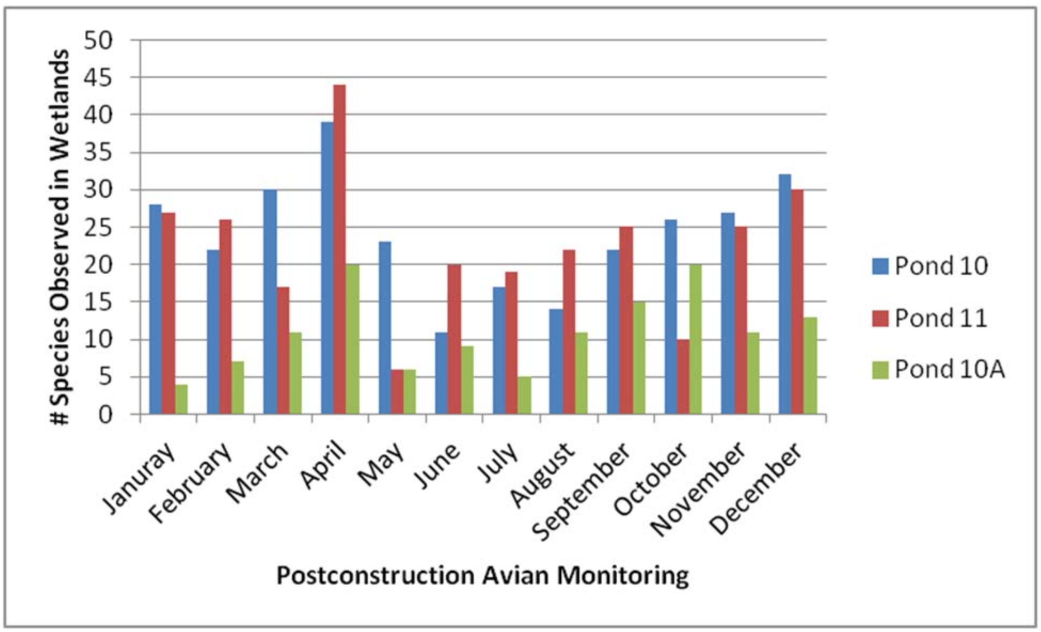


Figure 29. **Number of Avian Species Observed in Wetland Habitats – Postconstruction**

The number of individuals observed during postconstruction monitoring is presented in Figure 30. The number of individuals was highest in October in Pond 10 (5,988) and lowest in Ponds 10A and 11 in May (83 and 68, respectively). In a pattern similar to the number of species observed, the number of individuals observed was typically highest in Ponds 10 and 11 and lower in Pond 10A. This represents a shift in usage from the preconstruction monitoring when numbers observed were generally highest in ponds 10A and 10. When the 7-month period representing surveys conducted March through September are compared, numbers observed were higher during postconstruction monitoring, again suggesting that bird usage was improved by converting ponds 10 and 11 to intertidal and subtidal habitats.

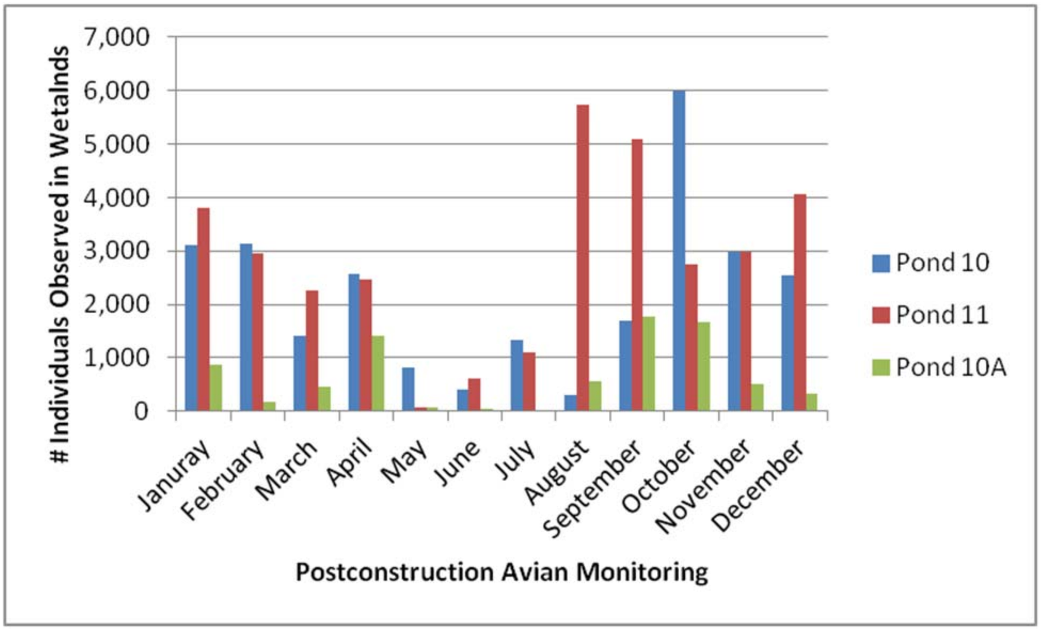


Figure 30. Number of Individual Birds Observed in Wetland Habitats – Postconstruction

The numerically dominant species observed in wetland habitats of the western salt ponds during preconstruction monitoring are summarized in Table 14. During the 7-month preconstruction monitoring period, the numerically dominant species were shorebirds, including dowitcher species, western sandpiper, willet, marbled godwit and black-necked stilt. Notable exceptions were scaup in Ponds 10 and 11 in March 2010 and elegant terns in Ponds 10A and 10 in September 2010.

The numerically dominant species observed in wetland habitats of the western salt ponds during postconstruction are summarized in Table 15. The anticipated shift in use from open water species, such as scaup, to shorebirds was not observed as shorebirds dominated both preconstruction and postconstruction surveys. Western sandpiper was observed in the highest numbers in most months during postconstruction surveys, particularly in Ponds 10 and 11. Other shorebird species observed in high numbers postconstruction were least sandpiper, black-bellied plover, black-necked stilt, willet and dunlin.

The numbers of western sandpiper observed postconstruction in Ponds 10 and 11 closely mirrored the overall numbers of individuals observed (Figures 31 and 32). This species was by far the numerically dominant species during postconstruction surveys (Table 15). While western sandpipers were also among the numerically dominant species in 2010, numbers observed in Ponds 10 and 11 during postconstruction monitoring were an order of magnitude greater.

Table 14. Total Numbers and Numerically Dominant Species of Birds Observed in Wetland Habitats of the Western Salt Ponds During Preconstruction Surveys 2010.

	Month Surveyed						
	March	April	May	June	July	August	September
Pond 10A	Total = 162 dowitcher sp. 57 long-billed dowitcher 50	Total = 680 dowitcher sp. 252 west sandpiper 93	Total = 70 snowy egret 24 marbled godwit 14	Total = 25 black-necked stilt 18	Total = 15 black-necked stilt 8	Total = 27 gadwalls & mallards 19	Total = 768 elegant tern 180 dowitcher sp. 152 marbled godwit 143
Pond 10	Total = 123 lesser scaup 49	Total = 85 west sandpiper 32 dunlin 21	Total = 110 dowitcher sp. 60	Total = 21 snowy egret 8	Total = 270 willet 270	Total = 12 brown pelican 15	Total = 1,129 elegant tern 1,000 west sandpiper 770
Pond 11	Total = 270 west. sandpiper 134 scaup sp. 111	Total = 48 west sandpiper 22	Total = 31 brown pelican 15	Total = 9 Snowy egret 3 blk-necked stilt 3	Total = 5 No dominant	Total = 153 brown pelican 105	Total = 16 Pie-billed grebe 8 double-crested cormorant 5

Table 15. Total Numbers and Numerically Dominant Species of Birds Observed in Wetland Habitats of the Western Salt Ponds During Postconstruction Surveys 2012.

	Month Surveyed					
	January	February	March	April	May	June
Pond 10A	Total = 870 west sandpiper 850	Total = 179 Northern shoveler 91 west sandpiper 72	Total = 452 west sandpiper 380	Total = 1,397 least sandpiper 620 west sandpiper 500	Total = 83 semipalm plover 59 west sandpiper 22	Total = 52 cliff swallow 15 blk-necked stilt 10
Pond 10	Total = 3,103 west sandpiper 1,950 willet 190 semipalm plover 172 dowitcher sp. 125	Total = 3,126 west sandpiper 2,012 blk-bellied plover 194 dowitcher sp. 188 dunlin 111	Total = 1,399 west sandpiper 460 long-billed dowitcher 210	Total = 2,560 west sandpiper 1,668 short-billed dowitcher 167 willet 113	Total = 816 west sandpiper 271 red knot 178 blk-bellied plover 99	Total = 418 blk-bellied plover 230 dowitcher sp. 85 red knot 46
Pond 11	Total = 3,793 west. sandpiper 2,625 blk-bellied plover 194 northern shoveler 299 dowitcher sp. 108	Total = 2,944 least sandpiper 2,190 west sandpiper 265 dunlin 222	Total = 2,263 west sandpiper 2,100	Total = 2,461 west sandpiper 2,050	Total = 68 west sandpiper 33 semipalm plover 30	Total = 599 willet 139 dowitcher sp. 74

Table 15. Continued.

	Month Surveyed					
	July	**August**	**September**	**October**	**November**	**December**
Pond 10A	Total = 10 No dominants	Total = 551 black-necked stilt 161 marbled godwit 152 red-necked phalarope 95 willet 84	Total = 1,759 west sandpiper 1,250 black-neck stilt 158	Total = 1,670 west sandpiper 665 willet 208 marbled godwit 438 dowitcher sp. 215	Total = 508 willet 277 marbled godwit 93 dowitcher sp. 77	Total = 317 west sandpiper 229 semipalm plover 47
Pond 10	Total = 1,331 willet 562 black-bellied plover 332 short-billed dowitcher 125 marbled godwit 103	Total = 303 western sandpiper 126 willet 54	Total = 1,695 west sandpiper 1,483	Total = 5,988 west sandpiper 5,025 red knot 294 willet 201	Total = 2,977 west sandpiper 2,331 semipalm plover 160 red knot 112	Total = 2,532 west sandpiper 1,483 northern pintail 197 semipalm plover 125 black-bellied plover 220
Pond 11	Total = 1,101 western sandpiper 555 willet 371	Total = 5,729 west sandpiper 4,855 semipalm plover 313 black-bellied plover 238	Total = 5,090 west sandpiper 4,400 blk-bellied plover 195 red knot 167	Total = 2,759 west sandpiper 2,370 sandpiper sp. 300	Total = 2,977 west sandpiper 2,460 blk-bellied plover 202	Total = 4,065 west sandpiper 3,260 black-bellied plover 309 dunlin 296

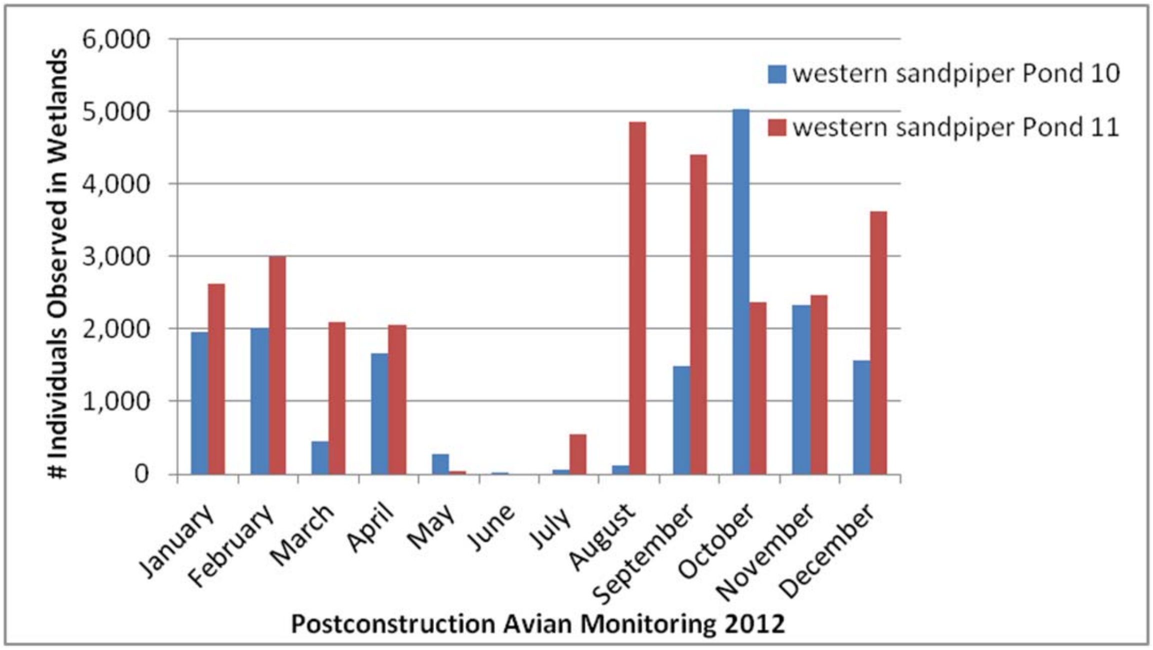


Figure 31. Number of Individual Western Sandpiper Observed in Wetland Habitats in Ponds 10 and 11 Postconstruction.

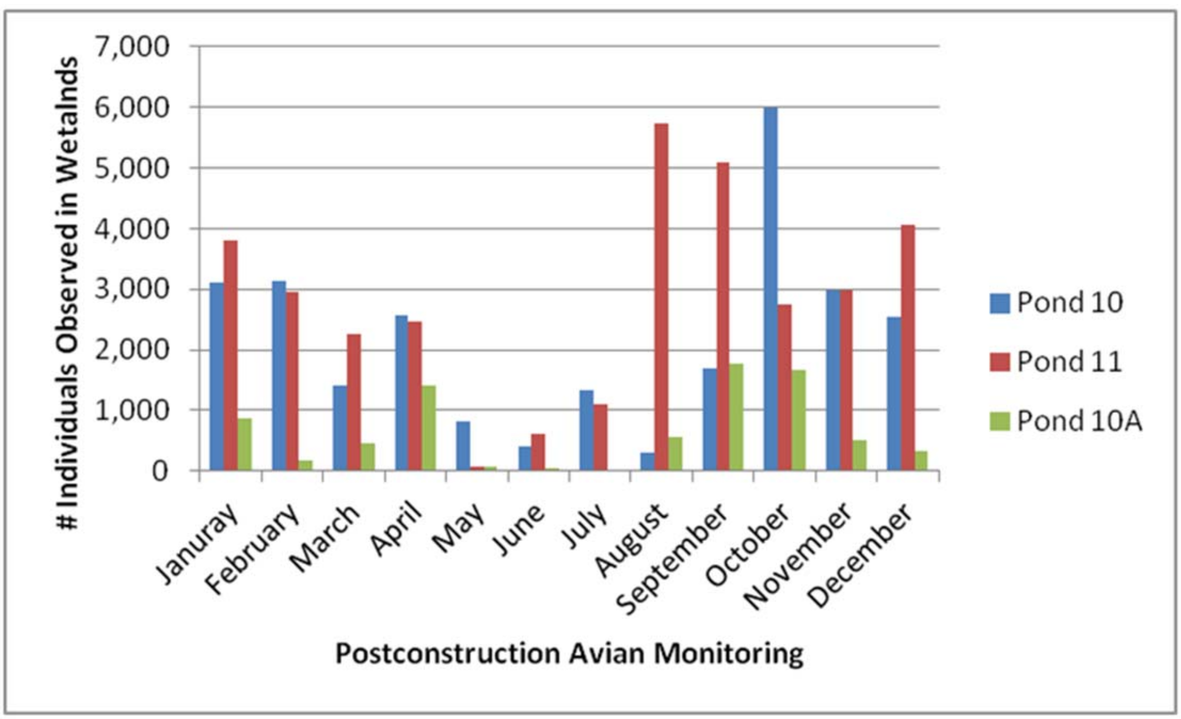


Figure 32. Number of Individual Birds Observed in Wetland Habitats – Postconstruction.

5.0 CONCLUSIONS

The majority of the goals and objectives developed for the Project were either met in Year 1 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 for fish and is expected to be met for invertebrates as sediment in the western salt ponds consolidates and stabilizes.

- Within the western salt ponds, by March 1, 2011 complete the dredging and filling activities required to achieve elevations within Pond 11that 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 Year 1 monitoring occurred between January 2012 and January 2013.

- 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 baythmetry 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 baythmetry 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.

Some goals and objectives were considered only partially achieved and may require greater level of monitoring and/or remedial actions. These are presented below.

- 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.

Benthic infuana surveys of the CVWR yielded low numbers and diversity of infuana. Infaunal densities are expected to increase as the project matures.

- 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.

Tidal amplitude within Ponds 10 and 11 is similar to that of the Otay River during high tide events. However, low tide event are moderately truncated, suggesting that the channels do not drain completely. This may be caused by shoals forming at the breaches to the bay. Further monitoring will assess the presence of shoals and the effect on Project success.

- 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. Like the western salt ponds, 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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