Regional Monitoring Report for Southern California Coastal Wetlands

Application of the USEPA Three-Tiered Monitoring Strategy

December 2015

The Bay Foundation
California State University Channel Islands
Southern California Coastal Water Research Project

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Southern California Coastal Water Research Project

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Table of Contents

LIST OF FIGURES

LIST OF TABLES

Executive Summary

In 2002, a consortium of scientists and managers from around the state began developing a monitoring and assessment program modeled after USEPA's Level 1-2-3 framework for monitoring and assessment of wetland resources. Assessments in this project span all three levels of the three-level framework for surface water monitoring and assessment issued to the state by the USEPA (2006). This project represents one effort to apply this framework at large coastal estuarine wetlands in southern California.

Level 1 assessments use broad landscape-level characterizations or wetland and riparian inventories (e.g. National Wetland Inventory) or to answer questions about wetland extent and distribution. Level 2 evaluations are rapid assessment methods which use cost-effective field-based diagnostic tools to assess the condition of wetland and riparian areas. Level 3 assessments are intensive site evaluations which provide data to validate rapid methods, provide more thorough or rigorous datasets, characterize reference conditions, and diagnose causes of wetland condition observed in Levels 1 and 2. Level 3 assessments can also be used to test hypotheses and provide insight into functions and processes.

There were two primary objectives of this project. The first was to increase knowledge of the health and functioning of regional estuarine wetlands while informing adaptive management opportunities and long-term restoration plans for several of the wetland systems (e.g. Ballona Wetlands Ecological Reserve, Ormond Beach Wetlands, Los Cerritos Wetlands complex). The second goal was to field-test a series of Level 3 site-intensive protocols to help guide the framework development of the Level 3 components of the "California Estuarine Wetland Monitoring Manual" (see companion document, Johnston et al. 2015).

The reports subsections are organized as follows:

Level 1: Site Description and Reference Site Selection
Level 2: California Rapid Assessment Method (CRAM)
Level 2: Photo Point
Level 3: Water and Soil Quality
Level 3: Vegetation
Level 3: Bird Abundance
Level 3: Terrestrial Invertebrates
Conclusions and Wetland Condition Assessments

Level 1 Summary

Data collection occurred at a subset of the following wetland sites (depending on the protocol being evaluated): Carpinteria Salt Marsh Reserve, Ormond Beach Wetlands, Mugu Lagoon, Ballona Wetlands Ecological Reserve, and Los Cerritos Wetlands. Level 1 analyses consisted of obtaining and reviewing existing site maps, GPS coordinates, site descriptions, previous monitoring reports (if available), and information compiled from local scientists or land managers. Additionally, the National Wetland Inventory was used to map wetland delineated habitats (NWI 2014). Based on the Level 1 assessment, each of the wetland sites was divided up into hydrologically-distinct sub-areas and summary descriptions were compiled. Additionally, reference sites were categorically evaluated as *a priori* assessments based on the level of impacts to each of the wetland sites over time as well as Level 1 assessments and literature reviews; these sites were later validated using Level 2 and 3 data and used in analyses (Table ES-1).

Table ES-1. Classification of sub-area condition pre-survey (A priori) to compare to post-hoc data.

Full Wetland Name	Abbreviated Wetland Name	Wetland Sub-Area	*A priori* Classification
Carpinteria Salt Marsh Reserve	Carpinteria	Carp-Ash	Restoration
		Carp-Main	Reference
Ormond Beach Wetlands	Ormond	Orm-Arnold	Degraded
		Orm-Halaco	Degraded
Mugu Lagoon	Mugu	Mugu-Central	Reference
		Mugu-West	Restoration
		Mugu-West Arm	Degraded
Ballona Wetlands Ecological Reserve	Ballona	Ballona A	Degraded
		Ballona B-E	Degraded
		Ballona B-W	Degraded
Los Cerritos Wetlands	Los Cerritos	LCW-Hellman	Degraded
		LCW-Steamshovel	Reference

Level 2 Summary

Final California Rapid Assessment Method (CRAM) scores were statistically significantly different by sub area, with Ballona A as the significantly lowest scoring category and Carp-Main in the highest scoring category for overall final score. The data displayed a second tier of high scoring wetlands, including Carp-Ash, Mugu-Central, and LCW-Steamshovel. Similarly, several of the degraded sites fell into a second-lowest tiered category, including Orm-Arnold, Ballona B-E, LCW-Hellman, and Mugu-West Arm. The maximum and minimum assessment area final scores for each site displayed a similar pattern, with the individual minimum final score recorded in Ballona A and the individual maximum final score recorded in Carp-Main.

Several of the wetland sub-areas were found to be significantly degraded when compared to the reference locations, and clear patterns emerged consistently by sub-area across multiple attributes. Combining the Level 1 and Level 2 data identify clear patterns in watershed-level stressors and CRAM scores. For example, many of the degraded sites had hydrological modifications such as armored levees or concrete culverts (e.g. Ballona, Mugu-West Arm, LCW-Hellman) which reduced their hydrology scores, leading to lower overall final CRAM scores. Three clear reference sites emerged from these analyses: Carp-Main, Mugu-Central, and LCW-Steamshovel.

Attribute-level results varied by individual attribute, but displayed some common condition categorizations across all AAs. While all attributes correlated to some extent to the final condition score for each wetland sub-area, the highest degree of correlation was seen in the connection between the hydrology attribute and the final condition score.

Level 3 Summary

Water and Soil Quality

Dissolved oxygen concentrations were variable across both temporal scales and geographic location; however, an overarching trend within both wetland sites was that extremely low dissolved oxygen levels (i.e. < 1mg/L) occurred less than two percent of the time across all years and locations.

Soil salinity values followed expected patterns based on dominant hydrology regimes. Areas subject to daily tidal inundation (i.e. Ballona B-W and LCW-Hellman) displayed salt concentrations slightly higher than those of marine water (29 – 32 ppt) as soil salts were replenished daily and accumulated in more poorly drained areas as the salt water evaporated.

Vegetation

Overarching vegetation cover results reflected accurate *a priori* categorizations of the individual wetland sites. There was a significantly higher average native vegetation cover at the *a priori* reference wetlands than the degraded wetlands. Similarly, there was significantly higher average non-native vegetation cover at the degraded wetlands than either the reference or restoration sites. Restoration sites had slightly lower average native vegetation cover and slightly higher average bare ground cover in the vegetated habitats.

Vegetation data were further analyzed by wetland sub-area. Patterns displayed by wetland sub-area followed *a priori* classifications and generally reflected similar patterns as the CRAM data final scores. The sites with the most degradation (e.g. Ballona, Ormond, and LCW-Hellman) displayed higher percentages of non-native vegetation species invasion and in general, lower overall nativity. Carp-Ash and Mugu-Central were the sub-areas with the highest average native vegetation cover.

The highest average native species richness occurred at LCW-Steamshovel, and the lowest at Ballona A with only one native species (*Salicornia pacifica*) identified within the sampling area. Mugu-West and Ballona B-E also displayed relatively low native species richness by sub-area. The three most prevalent native species (by cover) across the regional dataset were *Jaumea carnosa*, *S. pacifica*, and *Distichlis spicata*. At two locations, Mugu-West and Ballona A, the cover of *S. pacifica* alone was the sole contributor to the native plant cover out of the top three most prevalent species.

The algae community for both survey sites (i.e. Ballona and Los Cerritos) was primarily unattached or floating algal mats. However, there was a noticeable difference between the specific algae species between the two evaluated project sites. Los Cerritos transects were dominated by *Ulva lactuca*. Conversely, Ballona transects were mostly bare ground with some *Ulva intestinalis*.

Birds

Except for the spring surveys, Los Cerritos had a slightly higher overall bird species richness by season, as well as the highest overall species richness per hectare and abundance (LCW-Steamshovel). However, the number of species identified within each wetland site was relatively similar across all seasons. Data indicate high variability in species presence within each wetland site and may be partially attributed to the presence and distribution of adjacent habitats. Increased species richness within winter surveys indicate that all wetland sites are being utilized by a variety of bird species as an over wintering migratory stopover location.

Terrestrial Invertebrates

The highest invertebrate biomass was found at Orm-Arnold followed closely by LCW-Steamshovel. The lowest biomass values were both within salt pan habitat areas of Los Cerritos and Mugu Lagoon. The highest frequency of captured aerial invertebrates by size class was found in the smallest category (i.e. 0.5 mm or smaller).

A total of 24 invertebrate orders were identified within the surveyed wetland sites (i.e. Ballona, Los Cerritos, and Ormond). Six orders of taxa were identified ubiquitously within all the wetland sub-areas, including: Araneae, Coleoptera, Diptera, Hemiptera, Hymenoptera, and Isopoda.

Conclusions

As there are no wetlands in southern California devoid of impacts, no single system will likely present the full suite of potential ecological functions. This was confirmed by proxy from a lack of final CRAM scores anywhere in the region that exceeded 89.2 at any wetland sub-area. In fact, only two site sub-areas (Carp-Main and Mugu-Central) had individual CRAM AA scores over 80. Several of the wetland sub-areas were found to be significantly degraded when compared to the *a priori* reference locations, and patterns emerged consistently by sub-area across multiple attributes. Combining the Level 1 and Level 2 data also identified clear patterns in watershed-level stressors and CRAM scores. For example, many of the degraded sites had hydrological modifications such as armored levees or concrete culverts (e.g. Ballona, Mugu-West Arm, LCW-Hellman) which reduced their hydrology scores, leading to lower overall final CRAM scores. Three higher condition sites emerged from these analyses: Carp-Main, Mugu-Central, and to a lesser extent, LCW-Steamshovel.

To some degree, hydrology (based on Level 1 and Level 2 assessments) seemed to be the best predictor of variability in overall wetland condition (final CRAM score). In addition to having the highest correlation value, it is to some extent the driving mechanism for the other attributes (except for landscape and buffer condition). Thus, the sites with the most significant alteration of the natural hydrology (e.g. Ballona and Ormond) also had comparatively lower CRAM final scores. These findings are supported by similar studies in other systems (e.g. Anderson 2013).

Detailed sub-area summaries of data evaluations can be found in the conclusions section: Site-Specific Wetland Condition Assessments. These analyses should provide a starting point for additional site-specific evaluations to inform restoration planning efforts (especially at several of the sub-areas at Ballona, Ormond, and Los Cerritos) and to inform current land management practices.

Introduction

Project Summary

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

Level 1: Wetland Mapping and Landscape Level Assessments

Level 1 assessments use broad landscape-level characterizations or wetland and riparian inventories (e.g. National Wetland Inventory) or to answer questions about wetland extent and distribution. Assessment results can also provide a coarse gauge of geology and hydrology of a watershed, broad impacts, or wetland type. Level 1 was applied directly to this project by gross mapping of the extant wetland landscape elements as well as a broad characterization of the watersheds for each site and compiling information about site impacts.

Level 2: California Rapid Assessment Method

Level 2 evaluations are rapid assessment methods which use cost-effective field-based diagnostic tools to assess the condition of wetland and riparian areas. Level 2 assessments answer questions about general wetland health along a gradient through qualitative assessments and "stressor checklists". Level 2 was applied directly to this project through the implementation of the California Rapid Assessment Method (CRAM). CRAM has been designed as a cost-effective and scientifically defensible, standardized Level 2 assessment and is used widely as an assessment tool for wetlands across California.

Level 3: Site-Intensive Assessments

Intensive site assessments provide data to validate rapid methods, provide more thorough or rigorous datasets, characterize reference conditions, and diagnose causes of wetland condition observed in Levels 1 and 2. Level 3 assessments can also be used to test hypotheses and provide insight into functions and processes. Level 3 assessments applied for this project included a broad suite of parameters chosen to comparatively supplement Level 2 CRAM scores as well as to identify pre-restoration baseline conditions at several wetlands in Southern California. Specific sampling protocols included permanent water quality monitoring, soil salinity, vegetation cover, algae and submerged aquatic vegetation, germinated seed bank, bird abundance, aerial invertebrate traps, and terrestrial pitfall traps.

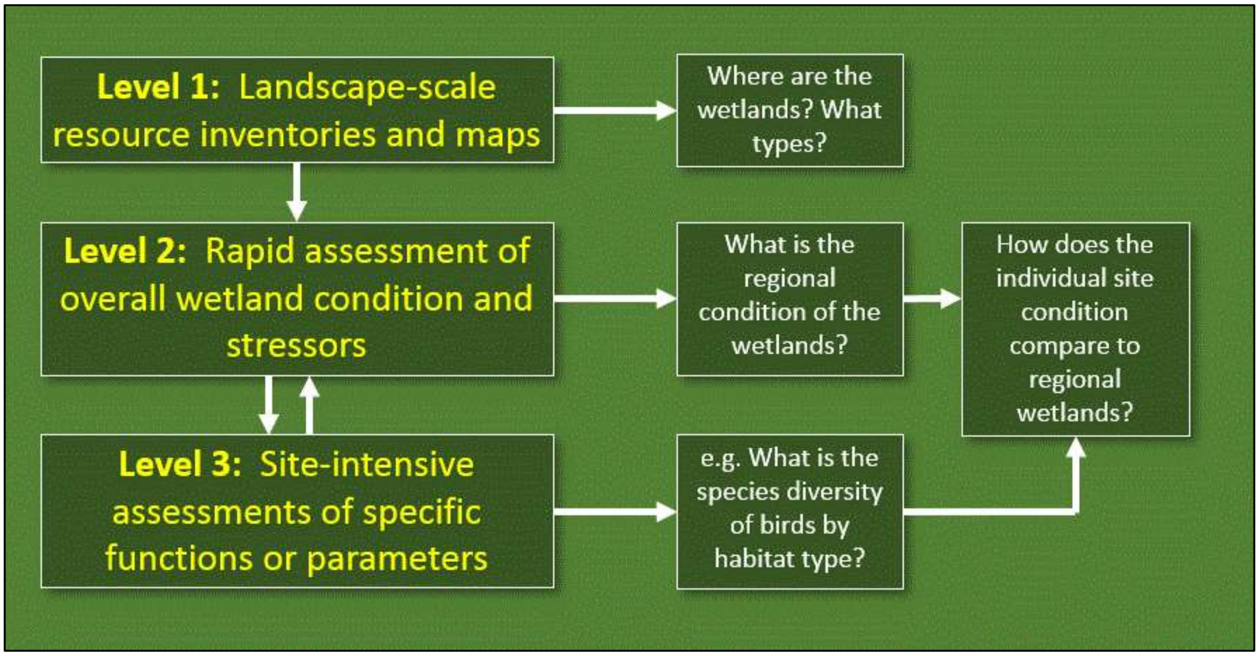

Figure 1. Graphic illustrating the three Levels of the EPA tiered monitoring program and connections.

Project Goals

There were two primary objectives of this report. The first was to increase knowledge of the health and functioning of regional estuarine wetlands while informing adaptive management opportunities and long-term restoration plans for several of the wetland systems (e.g. Ballona Wetlands Ecological Reserve, Ormond Beach Wetlands, Los Cerritos Wetlands complex). The second goal was to field-test a series of Level 3 site-intensive protocols to help guide the framework development of the Level 3 components of the "California Estuarine Wetland Monitoring Manual" (see companion document, Johnston et al. 2015).

Sampling Design

Prior to implementation of the field research and analyses for this report, a literature review of 71 California wetland monitoring programs and resulting documents was conducted. Monitoring focus was on a subset of broad parameters (e.g. vegetation, birds) measured by most monitoring programs that were evaluated as part of the program development.

Sampling efforts were designed as part of a broad regional program to field test and refine site-intensive monitoring methods for estuarine wetlands in California in a broad range of habitats and site conditions. Thus, several wetlands had higher sampling efforts and a more rigorous sampling design than others, if they represented a broader range of potential habitat types to survey. Additionally, pre-restoration wetland sites were prioritized to add baseline data to aid in restoration planning. This project takes another step towards the standardization of Level 3 wetland monitoring for California, and the strategies, protocols, and data summaries will be shared with other monitoring programs in the region such as the San Dieguito Restoration SONGS wetland mitigation monitoring and the Tijuana Estuary National Estuarine Research Reserve.

Organization of this Report

This report is organized into several sections focused on the three tiers of the USEPA monitoring program, with emphasis placed on the rigorous, Level 3 site-intensive data evaluations. For ease of interpretation and consistency, all data are presented by wetland in order from the furthest northern site (i.e. Carpinteria Salt Marsh Reserve) to the furthest southern site (i.e. Los Cerritos Wetlands); this is true for sub-sections, graphs, and tables.

Within the Level-3, or site-intensive monitoring section, there are subsections pertaining to each of the focus parameters, including: water and soil quality, vegetation, birds, and terrestrial invertebrates. Protocols were prioritized based on frequency of use in other monitoring programs throughout the State of California (see Appendix A in Johnston et al. 2015), and data gaps identified at the primary assessment wetlands (e.g. lack of vegetation data for Los Cerritos Wetlands complex made that a priority). The reports subsections are organized as follows:

Level 1: Site Description and Reference Site Selection
Level 2: California Rapid Assessment Method (CRAM)
Level 2: Photo Point
Level 3: Water and Soil Quality
Level 3: Vegetation
Level 3: Bird Abundance
Level 3: Terrestrial Invertebrates
Conclusions: Regional Wetland Condition

A brief introduction is given for each parameter surveyed and analyzed, along with methods that highlight the sampling frequency and duration; however, detailed implementation-level protocols and methods, along with summaries of protocol comparison matrices, can be found in the Standard Operating Procedure (SOP) Appendices in the Monitoring Manual. This report focuses on the data results collected and analyzed from Fall 2012 to Fall 2014 at each of the wetlands, and analyses of the comparable protocols that were implemented as part of this program.

When data from multiple sites exist, data are analyzed and presented as regional site comparisons. When a regional comparison was not possible due to targeted data collection by individual site, data are presented as site-specific assessments and/or trends over time. Site-specific datasets have also been provided to land managers to inform the implementation of restoration and management activities.

Lastly, the report begins to characterize the connections of the Level 3 data results with Level 2 CRAM data results and provides broad conclusions about the health of each of the wetlands evaluated and the health of wetlands in the overall sub-region of the Southern California Bight.

Vegetation nomenclature occurs in the report in the format of "*Genus species* (common name)" and as "*G. species*" when mentioned subsequently. Bird species nomenclature is identified initially as "common name (*Genus species*)" and as "common name" when mentioned subsequently.

LEVEL 1: Site Descriptions and Reference Site Selection

Introduction

Wetland functions are not solely dependent on biological communities and chemical interactions but also physical position within larger landscape features. Level 1 is the broadest and most financially efficient level of assessment across a large scale which relies primarily on office-based Geographic Information Systems (GIS) tools and aerial images to assess wetland condition based on landscape level analyses (USEPA 2006). Level 1 assessments can provide a sample framework for on-the-ground higher intensity Level 2 and Level 3 monitoring assessments.

Methods

The geographic setting for this project includes the coastal wetlands that fall within the Southern California Bight from Point Conception to Tijuana. The southern California region is highly urbanized, with land uses ranging from residential, commercial and industrial, recreational, agriculture, and open space. Large, perennial estuaries were the target wetland type for this project. Primary field testing of protocols and data collection occurred at a subset of the following wetland sites (depending on the protocol being evaluated): Carpinteria Salt Marsh Reserve, Ormond Beach Wetlands, Mugu Lagoon, Ballona Wetlands Ecological Reserve, and Los Cerritos Wetlands (Table 1, Figure 2). Additional opportunistic monitoring occurred when possible at wetlands throughout the Bight, and reporting information and data were shared with individual land managers for each site.

Site Selection

Prior to sampling events, information obtained on each of the sampling wetland sites included maps, GPS coordinates, site descriptions, and written directions. Previous monitoring reports were obtained for each site, when available, and information compiled from local scientists or land managers. The National Wetland Inventory (NWI) was downloaded for each site. Photos were taken during each of the site visits and added to a database for future sampling events.

Results

Table 1 lists each of the wetland sites, the hydrologically distinct sub-areas that were analyzed separately (based on CRAM), and a brief summary description of that location. Additionally, Table 1 should be referred to for abbreviations for each of the wetland sub-area names (e.g. “Orm-Arnold”) to be used throughout the document. Figure 2 is a map displaying the general location of each of the primary wetland site locations. Detailed maps are included for each wetland site in subsequent subsections along with more detailed site descriptions.

Table 1. Wetland sites, sub-area codes, and summary descriptions.

Wetland Name	Wetland Sub-Area	Summary Description
Carpinteria Salt Marsh Reserve	Carp-Ash	Restoration site on the eastern edge of the main salt marsh. This area is known as the Ash Avenue Wetland Project and was Phase 1 of a multi-tiered restoration plan. Restoration occurred in the late 1990's, including re-grading, excavation of tidal channels, and significant re-vegetation.
	Carp-Main	Most of the rest of the approximately 230-acre property, bisected by Sandyland Cove Rd and bordered by Carpinteria Ave and the 101 freeway to the north. Limited impacts have occurred to this wetland area, although some fill placement has occurred for roads, berms, and adjacent residential housing. Predominantly undisturbed salt marsh habitat types. Minor impacts.
Ormond Beach Wetlands	Orm-Arnold	Southern, pre-restoration trapezoidal area adjacent to the Ventura County Naval Base (Mugu Lagoon) and bordered by Arnold Rd. Highly disturbed and large areas with little-to-no vegetation. Bordered by the Reliant Power Plant to the northwest. Significant impacts.
	Orm-Halaco	Bordered by the Reliant Power Plant to the southeast and the Halaco site to the northwest. Pre-restoration mix of habitat types present and two small brackish lagoons. Watershed and adjacent areas dominated by agriculture and residential development. Significant impacts.
Mugu Lagoon	Mugu-Central	The central-eastern contiguous area (i.e. Central Basin) of relatively undisturbed salt marsh within the Ventura County Naval Base. Part of one of the largest lagoon systems in southern California and drains the Calleguas Creek watershed. Minor impacts.
	Mugu-West	Located in between the Central Basin (Mugu-Central) and the far western reaches of the salt marsh habitats, this area is bisected by the Western Lagoon and contains predominantly salt marsh habitat types. Immediately adjacent to the Naval Base complex and bordered by Laguna Rd. and L Ave. Medium level of impacts, comparatively to the other site locations.
	Mugu-West Arm	The most impacted and hydrologically restricted area of the Mugu Lagoon complex, including multiple hydrology constriction points (e.g. culverts, roads, an airstrip, etc), previous agricultural use of the site, fill deposits, and large areas devoid of vegetation. Significant impacts.

Wetland Name	Wetland Sub-Area	Summary Description
Ballona Wetlands Ecological Reserve	Ballona A	Area A of the Reserve is hydrologically cut off from the Ballona Creek floodplain tides and has approximately 2.1 million cubic yards of fill placed on top of it. Additionally, it is bordered by levees to the south and Marina del Rey to the north. Significant impacts.
	Ballona B-E	The eastern portion of Area B of the Reserve receives little to no tidal influence, was historically used for agriculture, and is now bordered by Jefferson Blvd. to the north and the Gas Company Rd to the west. It is adjacent to the Ballona Freshwater Marsh, a freshwater treatment wetland for the adjacent residential/commercial community of Playa Vista. Significant impacts, although far fewer than Area A.
	Ballona B-W	The western portion of Area B of the Reserve receives muted tidal inflow from self-regulating tide gates, was previously an agricultural field, and has undergone varying degrees of restoration activities since the 1990's. Hydrologically impacted through the southern Ballona Creek levee bordering the area to the north. Medium level of impacts, comparatively to the other site locations.
Los Cerritos Wetlands	LCW-Hellman	Hydrologically disconnected through multiple culverts and 1st Street from the San Gabriel River. Some remnant salt marsh vegetation and native habitat types present. Restoration planning is underway. Significant impacts.
	LCW-Steamshovel	Adjacent land use drilling activities and the development of the levee along the northern border are some of the only causes of degradation of this site. This is the last remnant contiguous set of natural salt marsh habitat types in the LCW complex and is often referred to by local scientists as the reference area for the complex. Low-to-minor impacts, comparatively.

Figure 2. General location of the wetland sites targeted for this project. Border lines for local Counties overlain using GIS.

Carpinteria Salt Marsh Reserve

Carpinteria Salt Marsh Reserve is an estuary located in southern Santa Barbara County and managed by the University of California, Santa Barbara. It covers approximately 230 acres and includes intertidal estuarine wetlands, and some subtidal deep water habitat. The estuary provides habitat for a rich assemblage of native plants and animals including many species of special interest such as endangered plants (e.g., Salt Marsh Bird's-beak) and animals (e.g., Light-footed Clapper Rail). Acquisition of 120 acres (49 hectares) occurred in June 1977, following which the Carpinteria Salt Marsh Reserve became the 23rd reserve added to the University of California Natural Reserve System (Figure 3). The site includes extensive wetland, sub-tidal channel and emergent upland habitats. The Reserve is adjacent to a sandy beach, subtidal rocky reef, and kelp beds.

The Carpinteria Salt Marsh Reserve watershed is the smallest of all the project sites at approximately eight square miles of primarily undeveloped land draining into Franklin and Santa Monica Creeks. A detailed discussion of the land use of Carpinteria Valley in terms of 20th century impacts to Carpinteria Salt Marsh has been covered in detail by Ferren (1985).

Source: http://carpinteria.ucnrs.org/

Figure 3. Map of Carpinteria Salt Marsh with salt marsh habitats identified (NWI 2014).

Ormond Beach Wetlands

The Ormond Beach Wetland complex located just north of and adjacent to Mugu Lagoon in southwestern Ventura County once covered approximately 1,100 acres. Fragmentation and degradation of once-contiguous wetlands within the Study Area have left remnant wetland segments hydrologically isolated and significantly reduced in size. As neighboring agriculture and industrial lands expanded, the wetlands have been drained, filled, degraded, and shrunk over the past century to the current size of approximately 250 acres (Figures 4a and 4b). Over the last century, the degradation of the Ormond Beach Wetlands has ranged from its use as city dump, developed with a magnesium smelting plant, to being drained for agriculture. As a result of drainage and developments, the Ormond Beach Wetlands have become hydrologically isolated and significantly reduced in size. The remaining wetlands on site suffer from compaction due to dumping, contamination from runoff, and hyper-salinity due to lack of tidal influence across the majority of the site.

Restoration and enhancement of the Ormond Beach Wetlands would significantly expand habitat area and function for at least four bird, one fish, and two plant species that are State- and/or Federally-listed as Threatened or Endangered species, notably including California least tern (*Sterna antillarum browni*), western snowy plover (*Charadrius alexandrius nivosus*), tidewater goby (*Eucyclogovius newberryi*), and the hemiparasitic saltmarsh bird's beak (*Chlorophyron maritimus ssp. maritimus*).

Source: http://scc.ca.gov/2010/01/07/ormond-beach-wetlands-restoration-project/ and Anderson (2013).

Figure 4a. Photograph of Ormond Beach Wetland (07-18-2013).

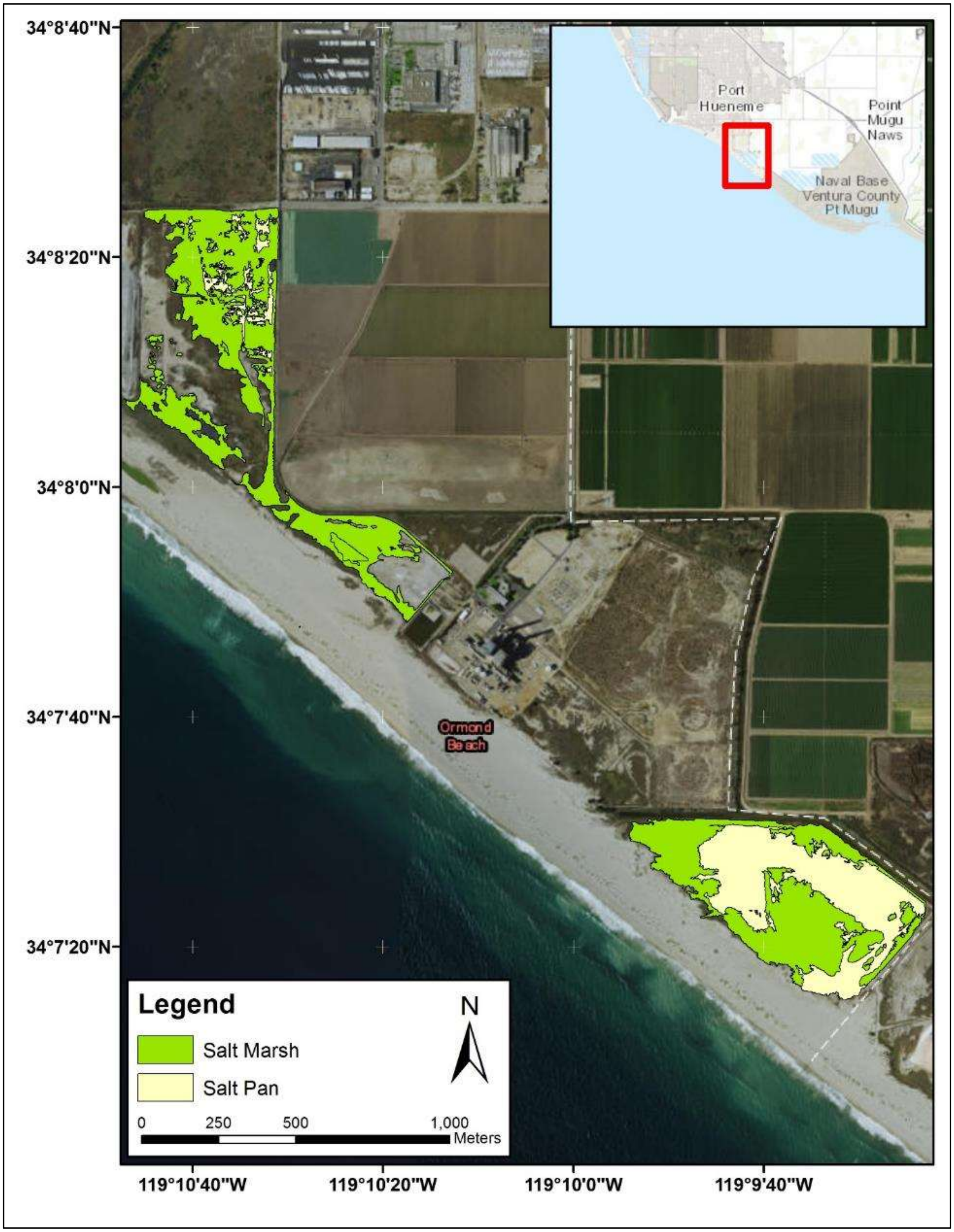

Figure 4b. Map of Ormond Beach Lagoon with salt marsh habitats identified (NWI 2014).

Mugu Lagoon

Mugu Lagoon is one of the largest coastal wetland systems in Southern California. Pre-degradation, it encompassed approximately 1,000 ha of wetland and 450 ha of high marsh-upland transition (Beller et al. 2011). Mugu Lagoon is located within Naval Air Weapons Station in Southern Ventura County, eight miles southeast of the City of Oxnard (Figure 5). The United States Navy restored the approximately 1,500 acres of the Mugu Lagoon in 1999, and UCLA monitored six of the wetland sites (CBC, Eastern Arm Firing Range, L Avenue 1, L Avenue 2, Laguna Road, South J Avenue, and Ponds Restoration) until 2005.

The largest contiguous extent of tidal salt marsh is in the Central Basin, immediately east of the main lagoon (Figure 5). The adjacent Eastern Arm is also relatively intact, with both of these regions experiencing unrestricted tidal dynamics. The tidal connection is through an inlet in the sand barrier beach, which migrates seasonally but is fixed open through armoring (Anderson 2013). The tidal prism is described as large relative to the volume of water remaining in the lagoon at low tide. Mugu Lagoon is situated at the terminus of the roughly 343 square mile Calleguas Creek watershed and is characterized by approximately 25% agriculture, 25% urban development, and 50% open space.

Figure 5. Map of Mugu Lagoon with salt marsh habitats identified (NWI 2014).

Ballona Wetlands Ecological Reserve

The Ballona Wetlands Ecological Reserve is one of approximately 40 coastal wetlands along the 1,045 miles of the Southern California coast between Point Conception and Mexico. The original Ballona Wetlands ecosystem was approximately 2,100 acres and included a variety of habitats, dominated by vegetated wetland and salt pan habitat types (Grossinger et al. 2010). Since then, the site has been impacted by agriculture, roads, railways, a marina, industry, housing, and the channelization of Ballona Creek. Approximately 3.1 million cubic yards of sediment have been dumped on site since the 1800's, primarily from the excavation of Marina del Rey and Ballona Creek. The remaining open land parcels encompassing approximately 600 acres were purchased by the State in pieces from 2003-2006 and designated as an Ecological Reserve (Figures 6 and 7). The California Department of Fish and Wildlife now manages the Reserve. Comprehensive monitoring has been conducted on site since 2009 and will continue in partnership with this project.

Figure 6. Map of Ballona Wetlands Ecological Reserve with salt marsh habitats identified (NWI 2014).

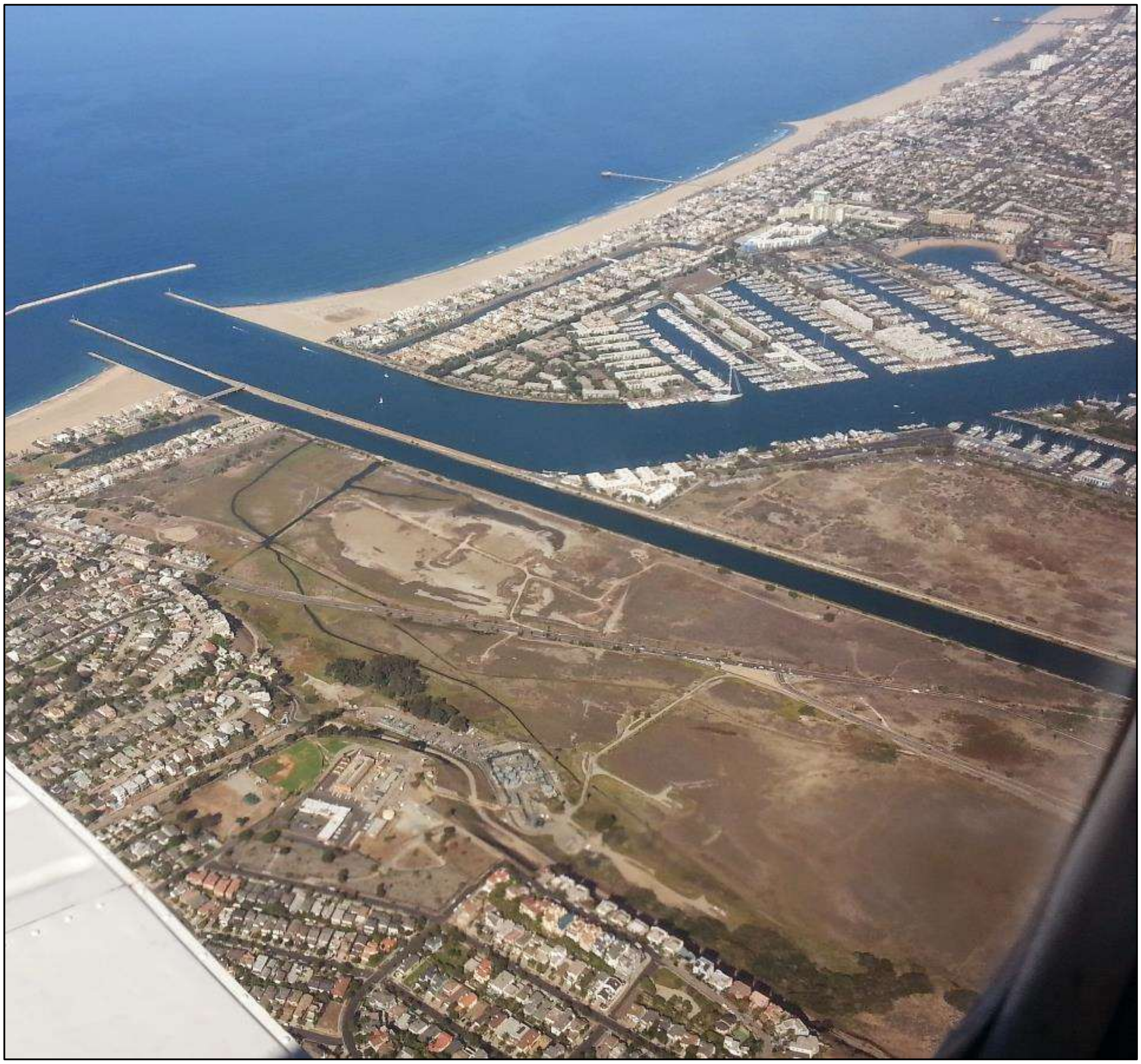

Figure 7. Aerial photograph of the western half of Ballona (courtesy LightHawk and I. Medel 2014).

Los Cerritos Wetlands

The Los Cerritos Wetlands complex, as identified by the Los Cerritos Wetlands Authority (LCWA), consists of approximately 500 acres. The site is split by the San Gabriel River, with the western portion lying in the City of Long Beach and the eastern portion in the City of Seal Beach. This wetland system also crosses two counties, the west belonging to the County of Los Angeles and the east belonging to Orange County. The site supports a complex of uplands and wetlands with some tidal connections to Alamitos Bay, just west of Seal Beach National Wildlife Refuge in Anaheim Bay (Tidal Influence 2012). The LCWA has commissioned a conceptual restoration plan made possible by two recent grants from the California Coastal Conservancy and Mountains Recreation Conservation Authority. The two (east and west) areas of wetland habitat types were the focus survey areas for this project and report (Figure 8).

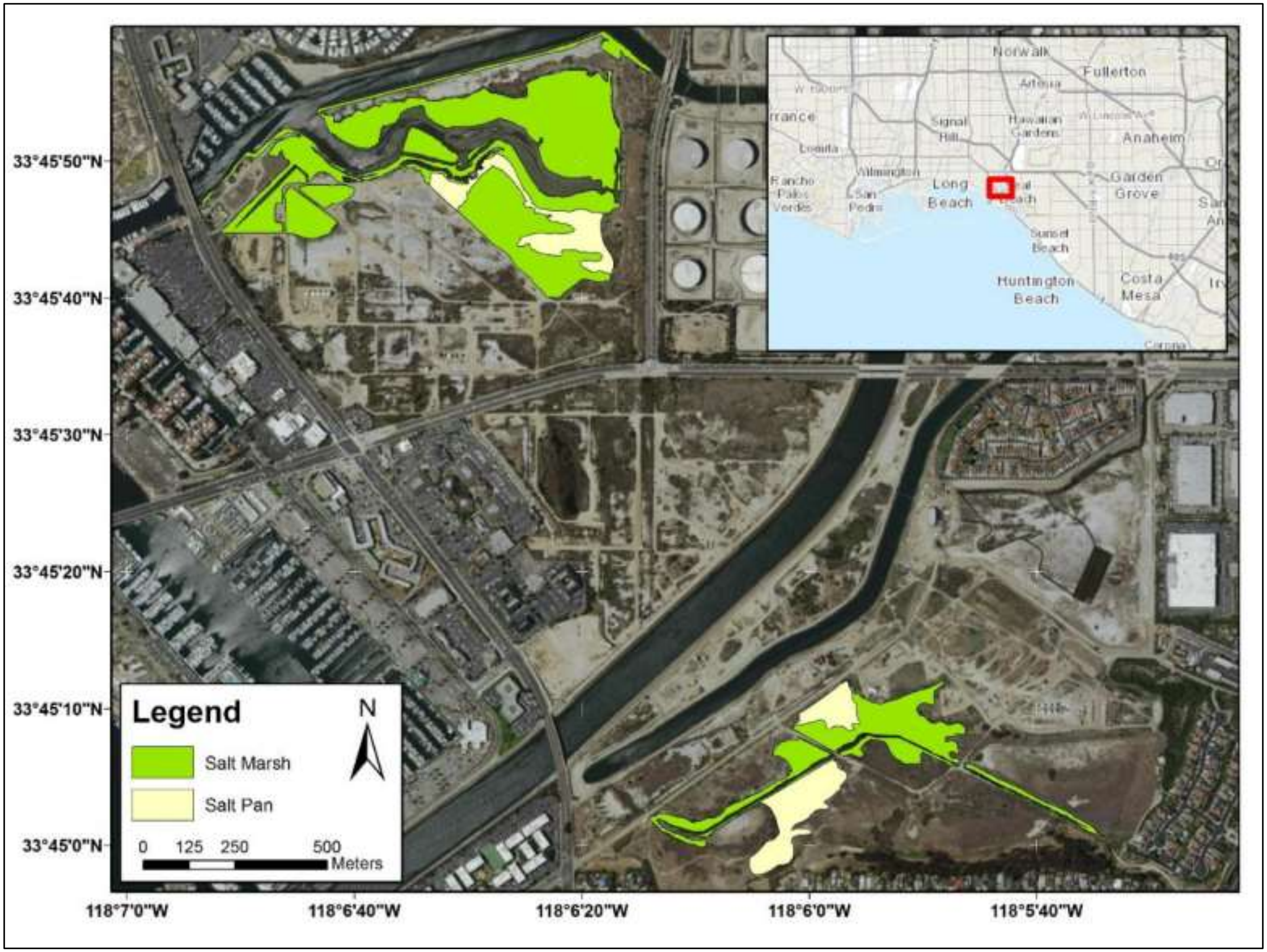

Figure 8. Map of Los Cerritos Wetlands with salt marsh habitats identified (NWI 2014).

Reference Site Selection

Reference sites were categorically evaluated as *a priori* assessments based on the level of impacts to each of the wetland sites over time as well as Level 1 assessments and literature reviews. The categorization was subsequently further evaluated in the Level 2 CRAM analyses. Coastal California estuarine wetlands have extremely limited options for high quality reference wetland sites with low levels of impacts or stressors. This is partly due to the fact that coastal wetlands have historically been fairly small and isolated compared to wetlands along many other shorelines (Gulf of Mexico, Eastern Seaboard of North America, etc.). However, southern California has more flood control dams, debris basins, and miles of concrete-encased stream channels than any other region in the nation (WRP 2001). According to Stein et al. (2014)'s historical evaluation of topographical mapping data from the 1800's, the Southern California Bight has lost approximately 75% of its vegetated coastal wetland habitat types and approximately 78% of unvegetated wetland habitat types such as salt pan and mudflat. Los Angeles County has suffered a disproportionately high percentage of loss, comparatively to the region, with approximately 96% loss of vegetated coastal wetland habitat types and 98% loss of unvegetated, with Orange County following close behind. Much of that loss was due to type conversion of those wetlands into upland or subtidal habitat types.

A final complicating factor is that some level of impact has occurred to all wetlands within the Southern California Bight, even if it is just development of the surrounding watershed (Anderson 2013). As such, no single remnant wetland is likely to foster high levels of ecological functioning across all possible metrics of performance. Thus, wetland sites were evaluated at the hydrologically distinct sub-area level to have a finer-scale evaluation and then as a whole at the site level. The conclusions of this report discuss the results of each type of evaluation as compared to the *a priori* classifications.

Wetland Condition Categorization (*a priori*)

Broad, *a priori* categorizations were allocated to each hydrologically distinct sub-area of each wetland (Table 2). These three categories included potential high-functioning "reference" locations (e.g. Carp-Main) to severely impacted and "degraded" locations (e.g. Ballona A, Orm-Arnold) based on broad, landscape-level understanding of impacts over time and hydrological disconnect from the floodplain. A third category was assigned, "Restoration", for those sites which had previously undergone restoration. The conclusions of this report will evaluate each level of assessment compared to the *a priori* classification. The classification system is not meant to assume that all sites of a particular category are subject to the same level of degradation or are even hydrologically or functionally the same, but is meant to provide a template for categorical grouping of sites for evaluations.

Additionally, Table 2 identifies the abbreviated name and sub-area name for each wetland site that will be used throughout this report for consistency.

Table 2. Classification of sub-area condition pre-survey (*A priori*) to compare to *post-hoc* data.

Full Wetland Name	Abbreviated Wetland Name	Wetland Sub-Area	*A priori* Classification
Carpinteria Salt Marsh Reserve	Carpinteria	Carp-Ash	Restoration
		Carp-Main	Reference
Ormond Beach Wetlands	Ormond	Orm-Arnold	Degraded
		Orm-Halaco	Degraded
Mugu Lagoon	Mugu	Mugu-Central	Reference
		Mugu-West	Restoration
		Mugu-West Arm	Degraded
Ballona Wetlands Ecological Reserve	Ballona	Ballona A	Degraded
		Ballona B-E	Degraded
		Ballona B-W	Degraded
Los Cerritos Wetlands	Los Cerritos	LCW-Hellman	Degraded
		LCW-Steamshovel	Reference

LEVEL 2: California Rapid Assessment Method

Introduction

California has adopted Level 2 rapid wetland assessment methods to facilitate standardized monitoring and condition assessments (CWMW 2010, USEPA 2006), including to facilitate information transfer between projects, while allowing for a condition-level comparison to reference or more 'natural' wetland sites (Sutula et al. 2006). In California, the California Rapid Assessment Method (CRAM) was developed by the California Wetland Monitoring Workgroup (CWMW) as a field-based diagnostic tool that can be used to cost-effectively monitor the condition of streams and wetlands throughout California (CWMW 2013). According to the CRAM User Manual (CWMW 2012): "The overall goal of CRAM is to provide rapid, scientifically defensible, standardized, cost-effective assessments of the status and trends in the condition of wetlands and the performance of related policies, programs and projects throughout California..."

CRAM can be used as a measure of general aquatic resource health and produces condition scores that are comparable and repeatable for all wetlands and regions in California, yet accommodates special characteristics of different regions and types of wetlands. For the purposes of CRAM, condition is defined as the state of a wetland assessment area's buffer and landscape context, hydrology, physical and biological structure relative to the best achievable states for the same type of wetland.

The specific survey goal of this program was to use the Level-2 estuarine wetland CRAM module to collect and evaluate the condition of regional estuarine wetlands in the northern portion of the Southern California Bight.

Methods

For the purposes of this report the regional CRAM evaluations are conducted for all estuarine wetlands using the estuarine CRAM module (CWMW 2012). CRAM analyses were conducted on hydrologically-distinct sub-areas of each wetland (e.g. 'Carp-Main' and 'Carp-Ash'). The CRAM metrics are organized into four main attributes: landscape and buffer context, hydrology, physical structure, and biotic structure with multiple metrics and sub-metric assessments (Table 3). The attributes were all averaged to quantify a final assessment score for each wetland Assessment Area (AA) analyzed. CRAM analyses were conducted both on the attribute-level and comparing final overall condition score data. One-way ANOVAs were conducted on final score sub-area data and non-parametric Spearman rank correlations were conducted on attribute-level data.

Assessment Areas (AAs) one hectare each in size were mapped in ArcGIS 10.1 according to the CRAM guidelines (CWMW 2013). All CRAM surveys were conducted in late summer or early fall to coincide with the peak wetland growing season, and specific field methods followed the CRAM User Manual (CWMW 2013; Figure 9), CRAM Standard Operating Procedure (CWMW 2013), and the Wetland Monitoring Manual (Johnston et al. 2015). Table 4 displays summary sampling frequency information.

Each wetland was surveyed using a different number of AAs, depending on the size of the wetland and following the standardized AA guidelines including the error assessments between AAs (Figures 10-14).

Table 3. Summary table of CRAM attributes; descriptions modified from the CRAM User Manual (CWMW 2013).

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

Figure 9. Photograph of field technician conducting CRAM surveys at LCW-Hellman (09-18-2014).

Table 4. Number of AAs surveyed and survey years for each wetland sub-area.

Wetland Name	Wetland Sub-Area	Number of AAs	Survey Years
Carpinteria	Carp-Ash	1	2012
	Carp-Main	2	2012
Ormond	Orm-Arnold	1	2012
	Orm-Halaco	2	2012
Mugu	Mugu-Central	9	2012
	Mugu-L Ave	1	2012
	Mugu-West	3	2012
	Mugu-West Arm	2	2012
Ballona	Ballona A	3	2012, 2014
	Ballona B-E	3	2012, 2014
	Ballona B-W	3	2012, 2014
Los Cerritos	LCW-Hellman	3	2013, 2014
	LCW-Steamshovel	3	2013, 2014

Figure 10. Map of Level 2 surveys at Carpinteria Salt Marsh (i.e. CRAM AAs).

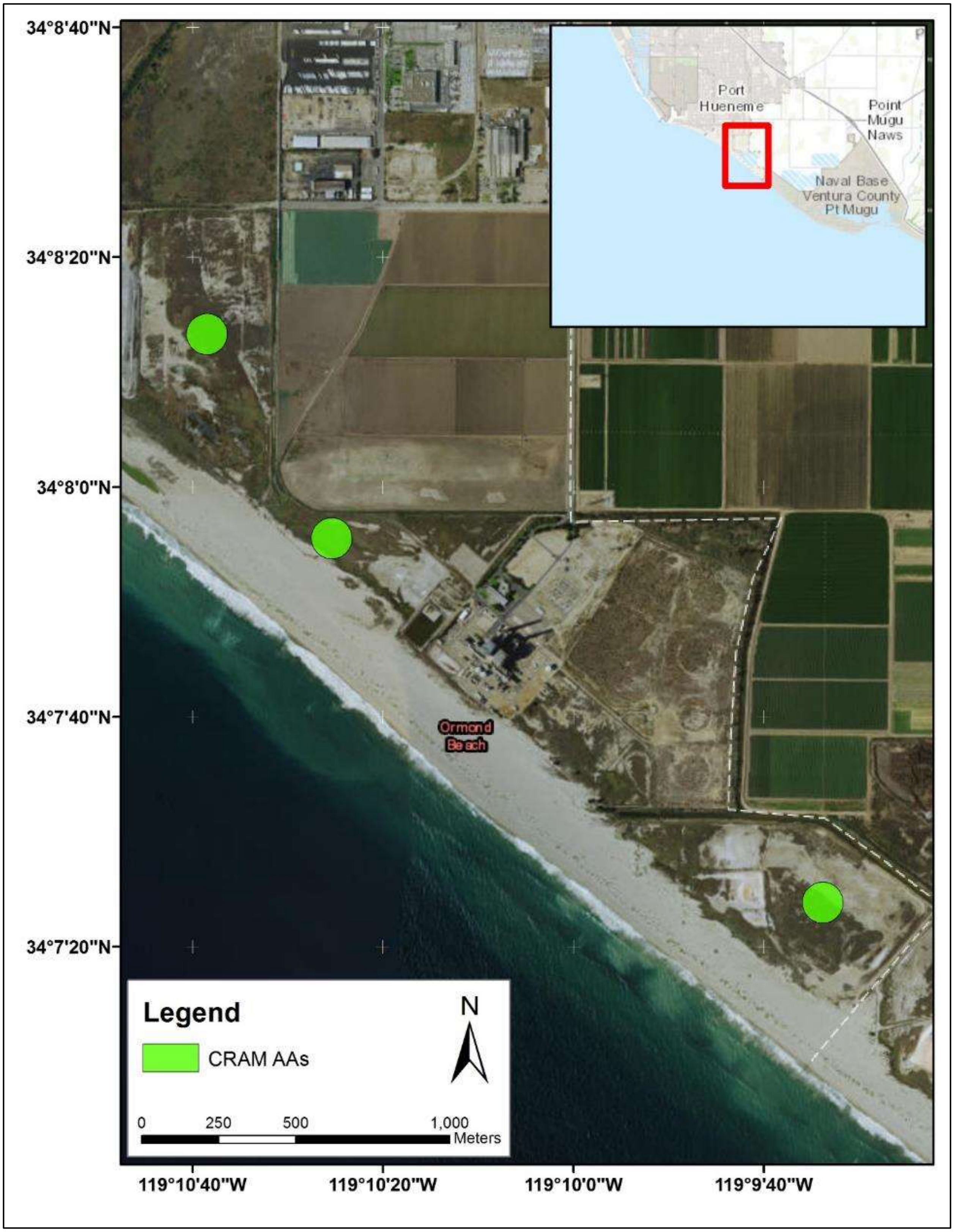

Figure 11. Map of Level 2 surveys at Ormond Beach Wetlands (i.e. CRAM AAs).

Figure 12. Map of Level 2 surveys at Mugu Lagoon (i.e. CRAM AAs).

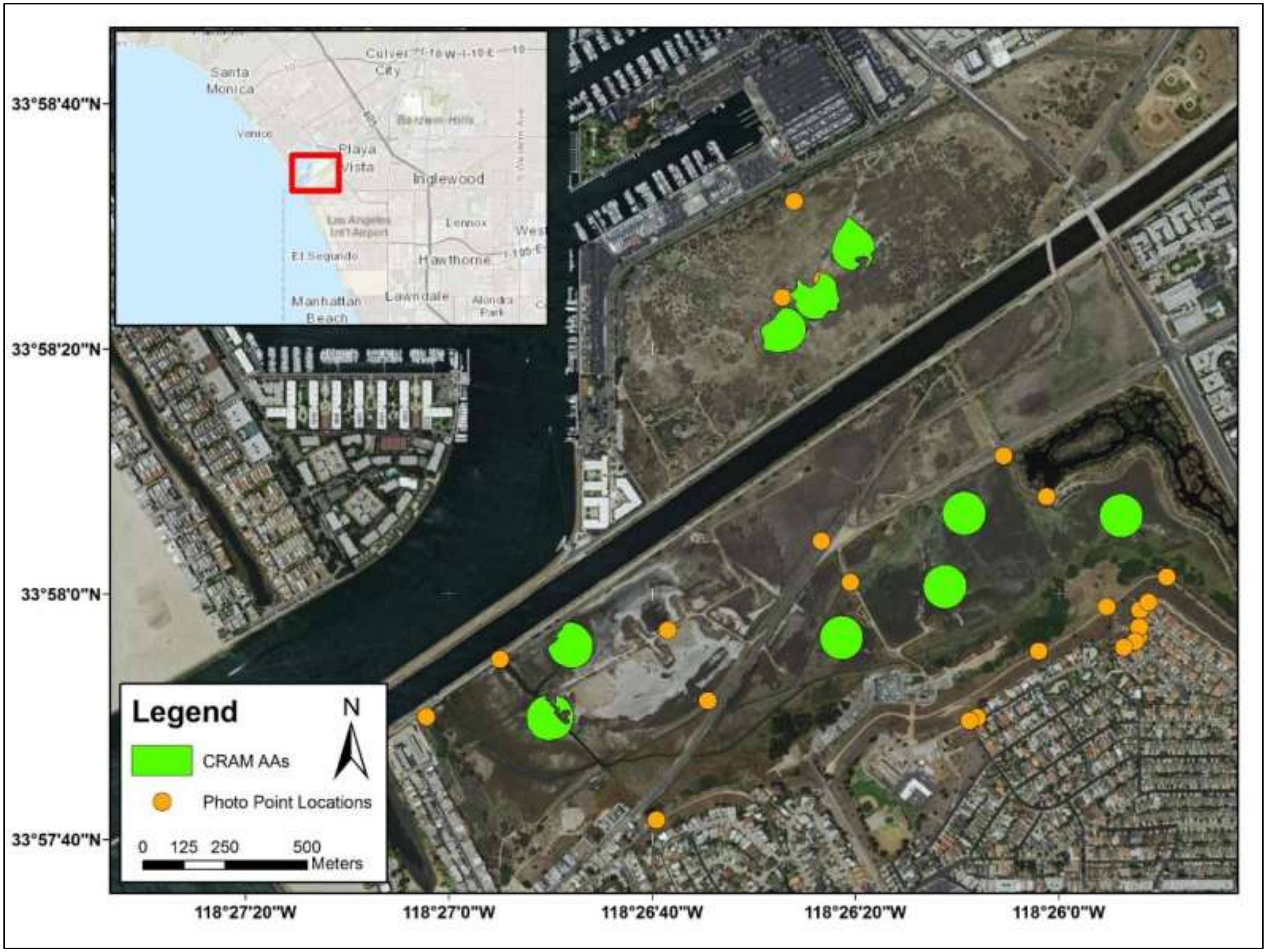

Figure 13. Map of Level 2 surveys at Ballona Wetlands Ecological Reserve (i.e. CRAM AAs and Photo Point locations).

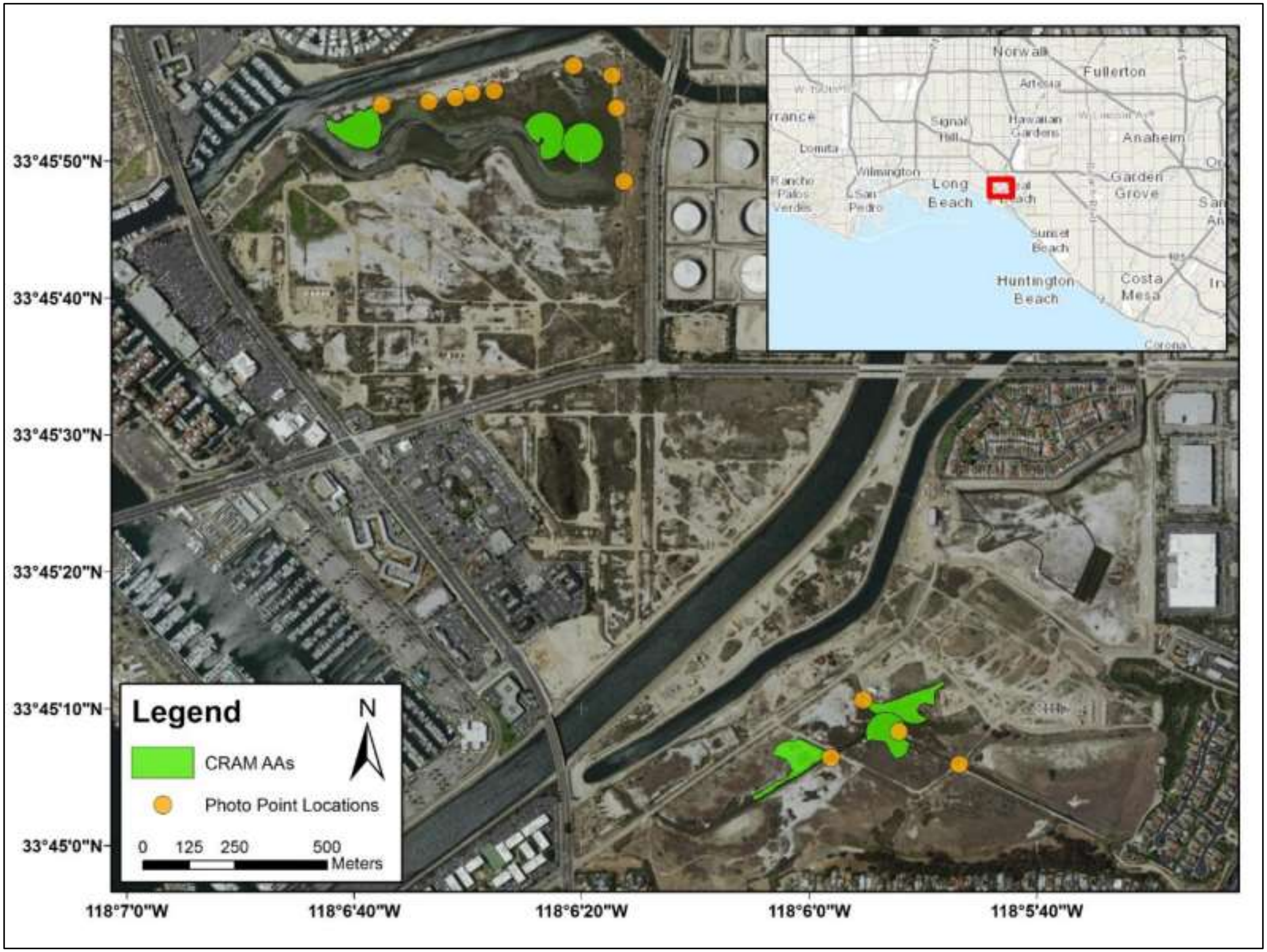

Figure 14. Map of Level 2 surveys at Los Cerritos Wetlands (i.e. CRAM AAs and Photo Point locations).

Due to the slightly subjective nature of some CRAM metric assessments, effort was made to maximize the accuracy of each assessment in accordance with the CRAM methodology. This effort included several strategies: (1) CRAM practitioners attended a training course prior to field implementation; (2) field teams consisted of multiple trained individuals to reduce observer bias; and (3) quality control checks were performed by the Quality Assurance Officer.

Regional Data Results

Final CRAM Score Results

Final score was statistically significantly different by sub area ($F_{11, 23} = 11.88$; $p < 0.001$); Figure 15 displays the categories of significant difference based on averages by sub-area (e.g. category "A", "B", etc.), with Ballona A as the significantly lowest scoring category and Carp-Main in the highest scoring category for overall final score. The data displayed a second tier of high scoring wetlands, including Carp-Ash, Mugu-Central, and LCW-Steamshovel. Similarly, several of the degraded sites fell into a second-lowest tiered category, including Orm-Arnold, Ballona B-E, LCW-Hellman, and Mugu-West Arm. The maximum and minimum final scores for each site displayed a similar pattern, with the individual minimum final score recorded in Ballona A (i.e. 41.0) and the individual maximum final score recorded in Carp-Main (i.e. 89.2) (Table 5).

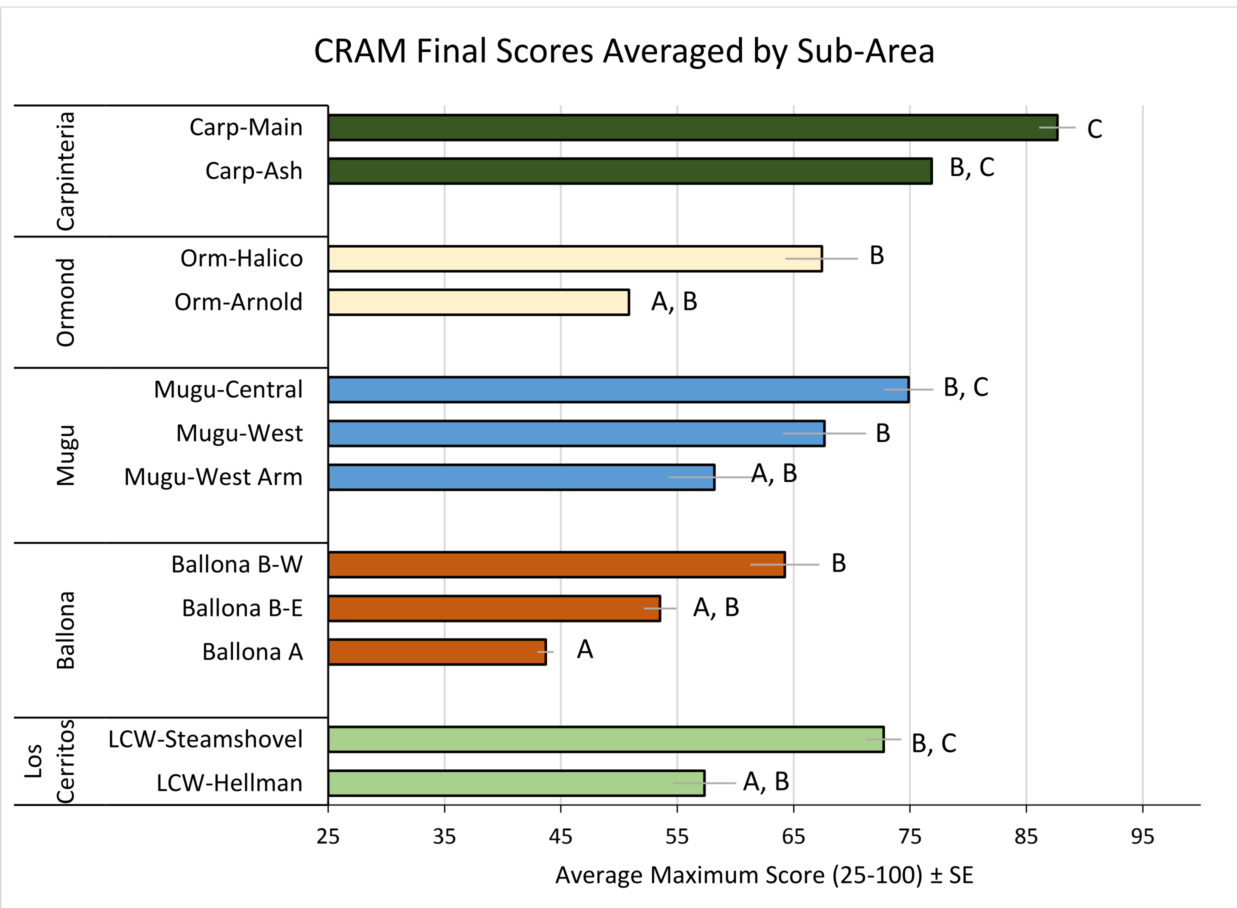

Figure 15. Regional CRAM final scores averaged by sub-area (hydrological sub-units) for each site (± SE).

Table 5. Average, standard error, maximum, and minimum final scores for each wetland sub-area.

Wetland Name	Wetland Sub-Area	Average Final Score	Standard Error	Number of AAs	Minimum Final Score	Maximum Final Score
Carpinteria	Carp-Ash	76.9	0.0	1	76.9	76.9
	Carp-Main	87.7	1.6	2	86.1	89.2
Ormond Beach	Orm-Arnold	50.9	0.0	1	50.9	50.9
	Orm-Halaco	67.4	3.1	2	64.3	70.5
Mugu Lagoon	Mugu-Central	74.9	2.1	9	64.2	82.6
	Mugu-West	67.7	3.6	3	61.1	73.4
	Mugu-West Arm	58.2	4.0	2	54.2	62.2
Ballona	Ballona A	43.7	0.7	6	41.0	45.5
	Ballona B-E	53.5	1.4	6	50.0	59.4
	Ballona B-W	64.2	3.0	6	53.1	69.8
Los Cerritos	LCW-Hellman	57.3	2.7	6	49.0	65.3
	LCW-Steamshovel	72.7	1.5	6	67.0	77.4

Attribute-Level CRAM Results

Results varied by attribute, but displayed some common condition categorizations across all AAs. While all attributes were correlated to the final condition score for each wetland sub-area using a non-parametric Spearman rank correlation (landscape and buffer, r = 0.687; hydrology, r = 0.843; physical structure, r = 0.608; biotic structure, r = 0.638), the highest degree of correlation was seen in the connection between the hydrology attribute and the final condition score.

Mugu-Central and Carp-Main received the highest landscape and buffer condition scores, which was similar to the results and *a priori* classifications assigned by the Level 1 gross landscape analyses (Figure 16, Table 6). Additionally, some of the most urbanized and severely impacted or degraded sites received the lowest scores (i.e. LCW-Hellman, Ballona A, and Orm-Arnold). Mugu-Central, in addition to having several AAs receive the highest condition score possible (i.e. 100), also had the widest range of scores (Table 6), indicating the broadest variation in condition across AAs for the landscape and buffer attribute. Mugu is the largest of all evaluated wetland sites.

The hydrology attribute was fairly consistent across distinct sub-areas of each wetland (Figure 17, Table 7), showing clear groupings by sub-area based on hydrological connectivity confirming the Level 1 characterization of hydrologic sub-areas. Mugu-Central and Carp-Main again had the highest scores, with Ballona A receiving the lowest possible hydrology scores (i.e. 25) across all AAs due to a lack of hydrologic connectivity with estuarine water sources because of levees and fill sediments. Los Cerritos sites consistently had the middle range of scores, for both LCW-Hellman and LCW-Steamshovel, with LCW-Steamshovel displaying a higher minimum and average hydrology score (Table 7).

The physical structure attribute displayed the most variety in results within each sub-area, with much wider ranges exhibited across several of the wetlands (Figure 18, Table 8). For example, LCW-Hellman had a maximum attribute score of 75 for physical structure, and a minimum of 25. Mugu-Central and Ballona B-W also displayed variability within sub-area. The highest average sub-area scores were found in Carp-Main (93.8 ± 6.3) and the lowest in Ballona A and B-E (39.6 ± 2.1).

The biotic structure attribute showed high average values by sub-area for the *a priori* reference locations (Figure 19, Table 9); Carp-Main, and LCW-Steamshovel both had an average score in the mid-eighties, with Mugu-West Arm and Ballona A receiving the lowest average scores (55.6 ± 11.1 and 56.0 ± 2.5, respectively). The Carp-Ash restoration site had the highest average score of 94.4 ± 0, and LCW-Steamshovel had the highest maximum AA score of 97.2. The ranges within each sub-area for the biotic structure attribute were lower than those of the physical structure attribute indicating more consistency within sub-area of each wetland for the vegetation-related metrics when compared to the variety of within-site topographical features and physical structure variability. Larger ranges were seen at the more degraded sites (e.g. Ballona A, Mugu-West Arm).

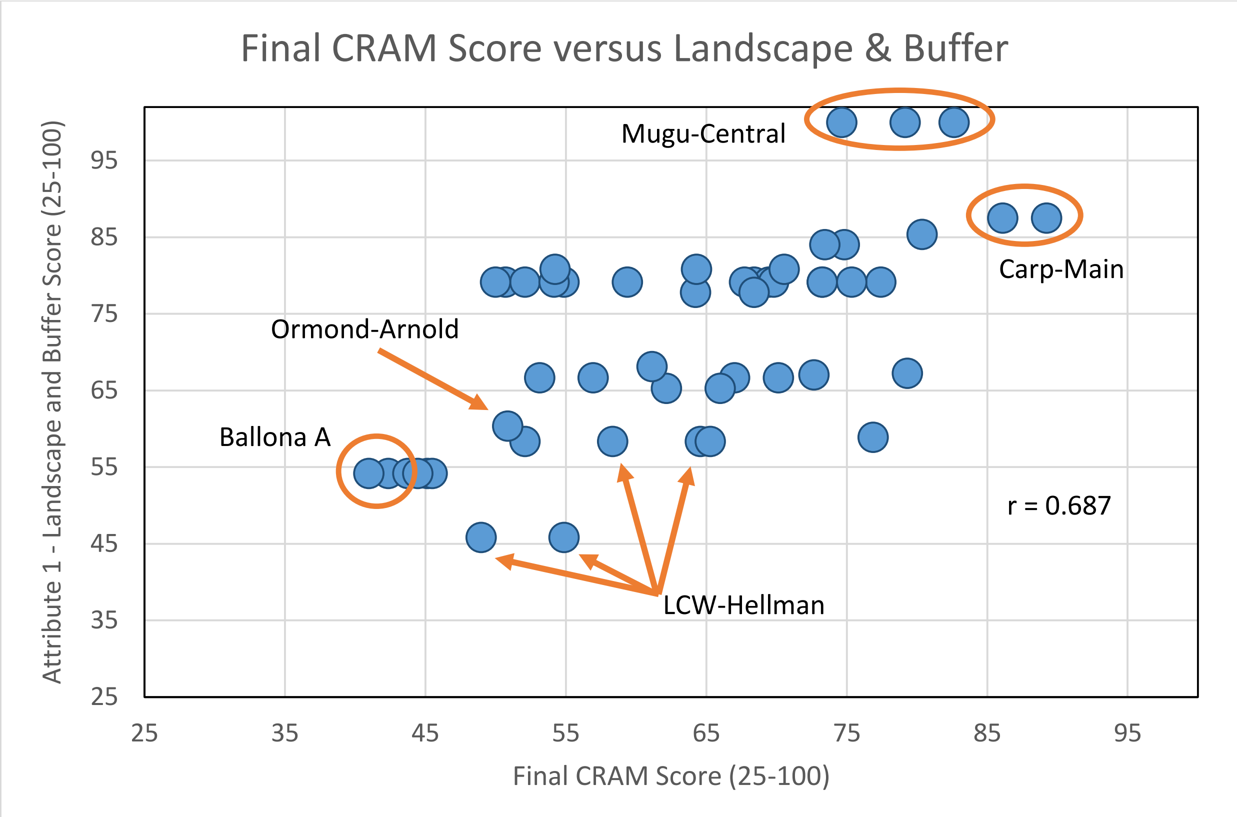

Figure 16. Attribute 1 (Landscape and Buffer) graphed against final CRAM score for each individual AA. Circles and arrows designate specific AAs of a particular wetland.

Table 6. Average, standard error, maximum, and minimum landscape and buffer attribute scores for each wetland sub-area.

Wetland Name	Wetland Sub-Area	Landscape and Buffer Attribute (avg)	Standard Error	Maximum Attribute 1	Minimum Attribute 1
Carpinteria	Carp-Ash	58.9	0.0	58.9	58.9
	Carp-Main	87.5	0.0	87.5	87.5
Ormond Beach	Orm-Arnold	60.4	0.0	60.4	60.4
	Orm-Halaco	80.8	0.0	80.8	80.8
Mugu Lagoon	Mugu-Central	83.0	4.9	100.0	65.3
	Mugu-West	76.6	4.6	84.0	68.1
	Mugu-West Arm	73.0	7.8	80.8	65.3
Ballona	Ballona A	54.2	0.0	54.2	54.2
	Ballona B-E	79.2	0.0	79.2	79.2
	Ballona B-W	75.0	2.6	79.2	66.7
Los Cerritos	LCW-Hellman	54.2	2.6	58.3	45.8
	LCW-Steamshovel	75.0	2.6	79.2	66.7

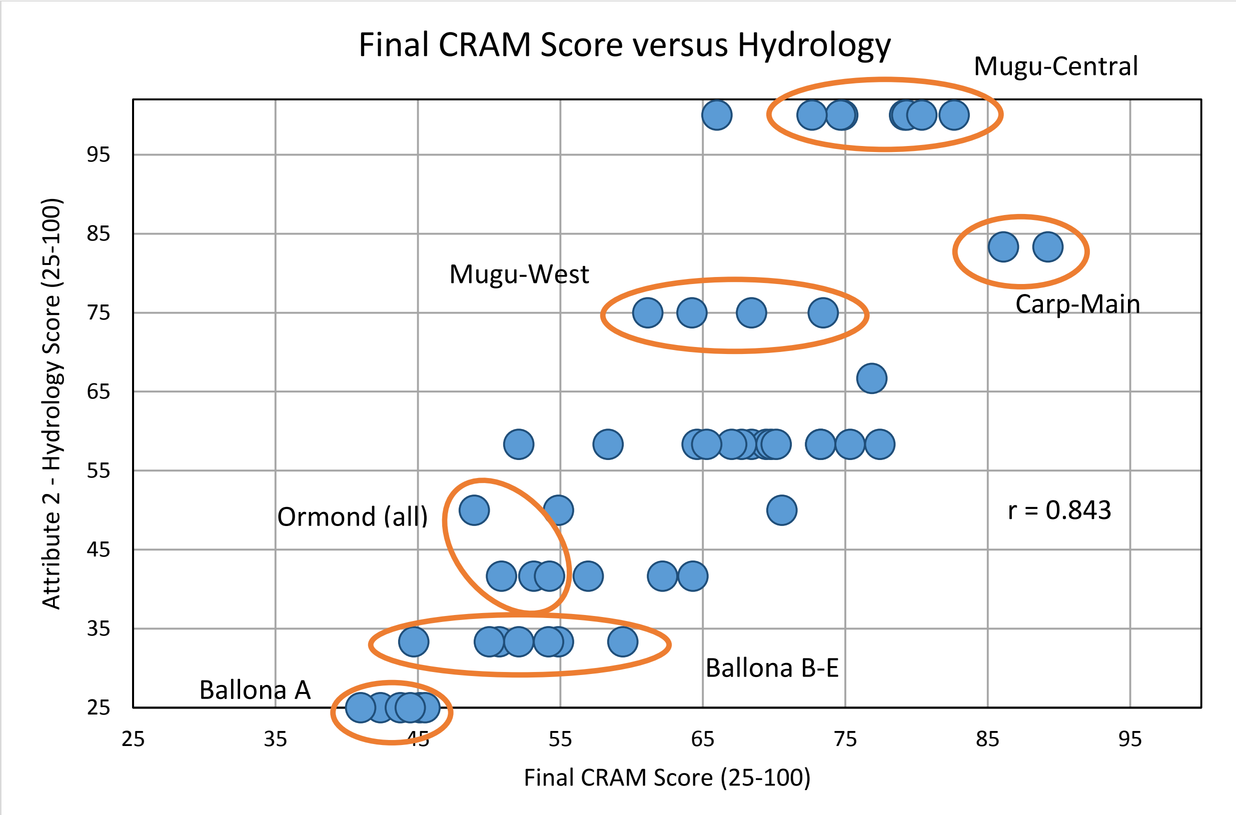

Figure 17. Attribute 2 (Hydrology) graphed against final CRAM score for each individual AA. Circles and arrows designate specific AAs of a particular wetland.

Table 7. Average (± SE), maximum, and minimum hydrology scores for each wetland sub-area.

Wetland Name	Wetland Sub-Area	Hydrology Attribute (avg)	Standard Error	Maximum Attribute 2	Minimum Attribute 2
Carpinteria	Carp-Ash	66.7	0.0	66.7	66.7
	Carp-Main	83.3	0.0	83.3	83.3
Ormond Beach	Orm-Arnold	41.7	0.0	41.7	41.7
	Orm-Halaco	45.8	4.2	50.0	41.7
Mugu Lagoon	Mugu-Central	97.2	2.8	100.0	75.0
	Mugu-West	75.0	0.0	75.0	75.0
	Mugu-West Arm	41.7	0.0	41.7	41.7
Ballona	Ballona A	25.0	0.0	25.0	25.0
	Ballona B-E	33.3	0.0	33.3	33.3
	Ballona B-W	52.8	3.5	58.3	41.7
Los Cerritos	LCW-Hellman	55.6	1.8	58.3	50.0
	LCW-Steamshovel	58.3	0.0	58.3	58.3

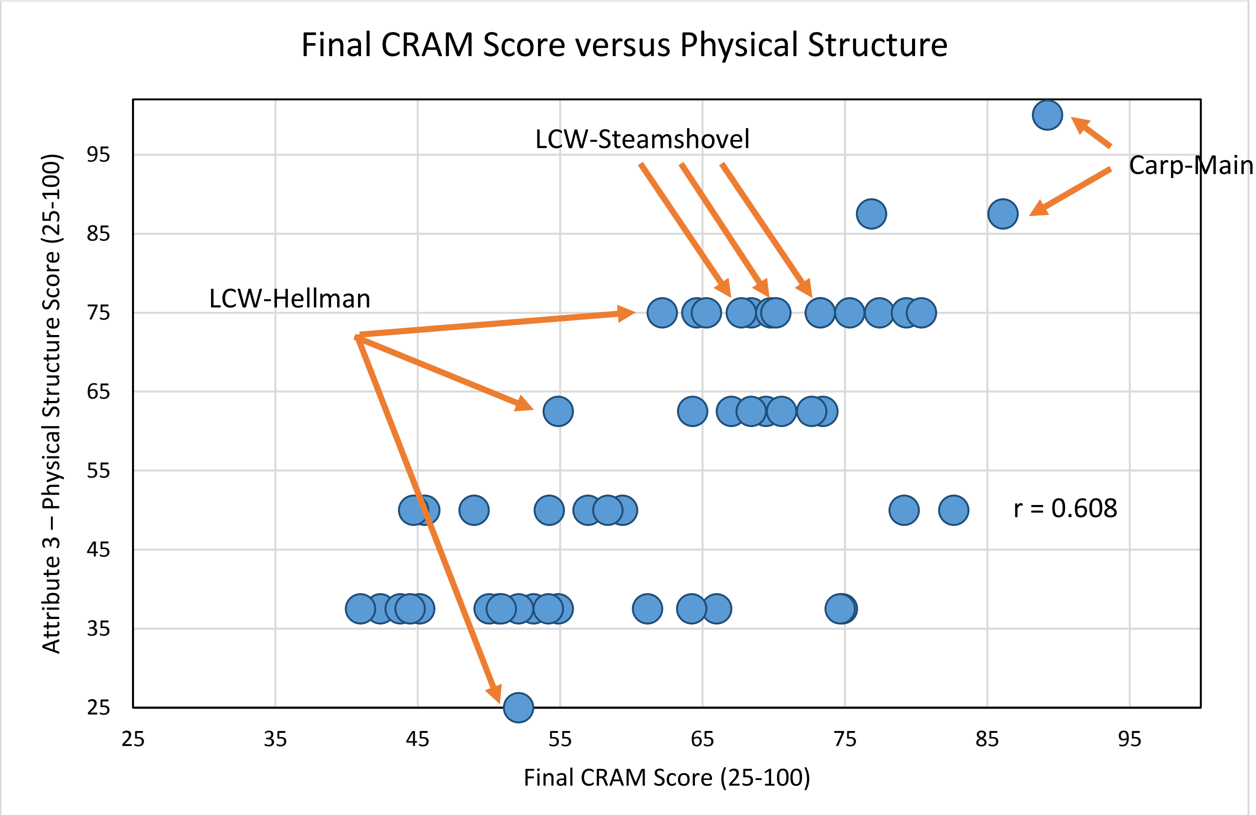

Figure 18. Attribute 3 (Physical Structure) graphed against final CRAM score for each individual AA. Circles and arrows designate specific AAs of a particular wetland.

Table 8. Average (± SE), maximum, and minimum physical structure scores for each wetland sub-area.

Wetland Name	Wetland Sub-Area	Physical Structure Attribute (avg)	Standard Error	Maximum Attribute 3	Minimum Attribute 3
Carpinteria	Carp-Ash	87.5	0.0	87.5	87.5
	Carp-Main	93.8	6.3	100.0	87.5
Ormond Beach	Orm-Arnold	37.5	0.0	37.5	37.5
	Orm-Halaco	62.5	0.0	62.5	62.5
Mugu Lagoon	Mugu-Central	51.4	5.3	75.0	37.5
	Mugu-West	54.2	8.3	62.5	37.5
	Mugu-West Arm	62.5	12.5	75.0	50.0
Ballona	Ballona A	39.6	2.1	50.0	37.5
	Ballona B-E	39.6	2.1	50.0	37.5
	Ballona B-W	62.5	6.5	75.0	37.5
Los Cerritos	LCW-Hellman	56.3	7.7	75.0	25.0
	LCW-Steamshovel	72.9	2.1	75.0	62.5

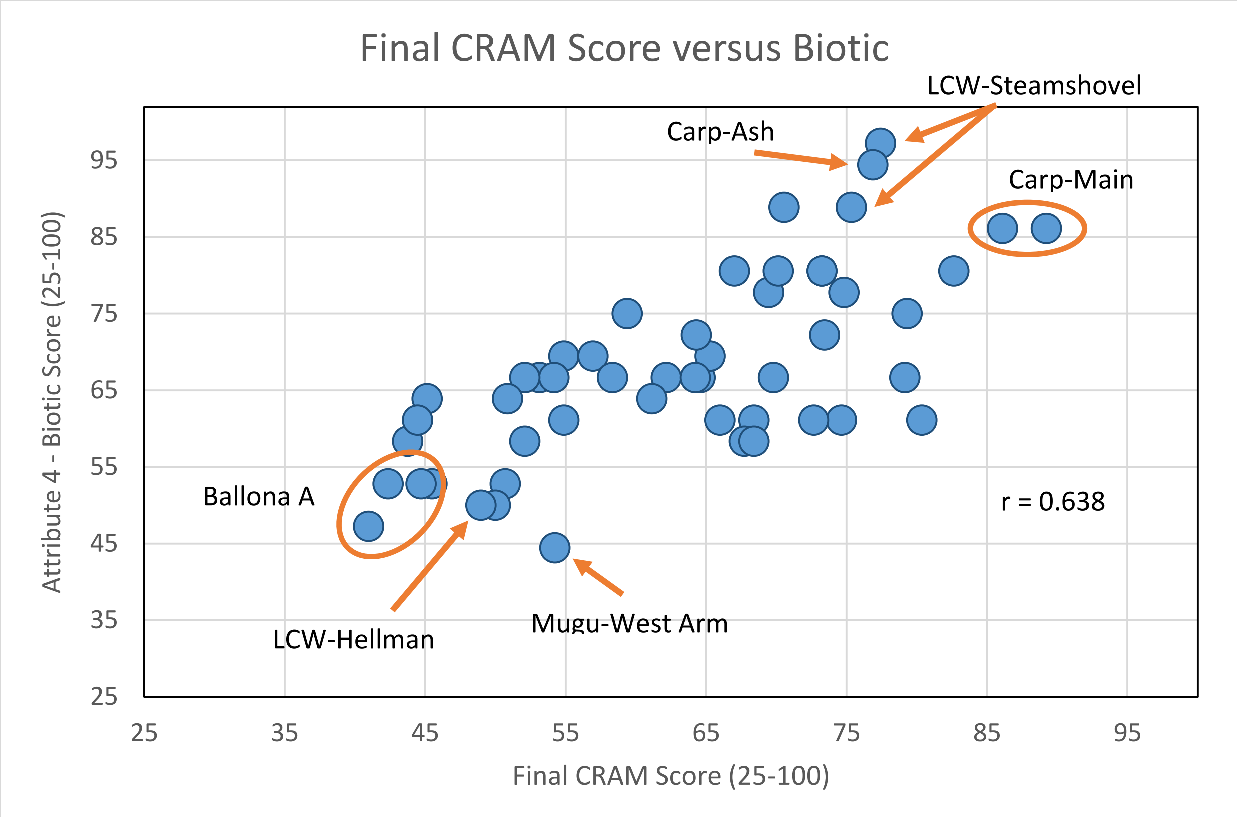

Figure 19. Attribute 4 (Biotic Structure) graphed against final CRAM score for each individual AA. Circles and arrows designate specific AAs of a particular wetland.

Table 9. Average (± SE), maximum, and minimum biotic scores for each wetland sub-area.

Wetland Name	Wetland Sub-Area	Biotic Attribute (avg)	Standard Error	Maximum Attribute 4	Minimum Attribute 4
Carpinteria	Carp-Ash	94.4	0.0	94.4	94.4
	Carp-Main	86.1	0.0	86.1	86.1
Ormond Beach	Orm-Arnold	63.9	0.0	63.9	63.9
	Orm-Halaco	80.6	8.3	88.9	72.2
Mugu Lagoon	Mugu-Central	67.9	2.6	80.6	61.1
	Mugu-West	64.8	4.0	72.2	58.3
	Mugu-West Arm	55.6	11.1	66.7	44.4
Ballona	Ballona A	56.0	2.5	63.9	47.2
	Ballona B-E	62.0	4.0	75.0	50.0
	Ballona B-W	66.7	2.8	77.8	58.3
Los Cerritos	LCW-Hellman	63.4	2.9	69.4	50.0
	LCW-Steamshovel	84.7	2.8	97.2	80.6

LEVEL 2: Photo Point

Introduction

The primary purpose of this sampling was is to visually capture broad changes in the landscape and vegetation communities over seasons or years. This Level 2 rapid method collected georeferenced photos for use in site management (e.g. invasive species tracking), long-term data collection, and visual validation of changes identified by vegetation surveys. Additionally, Photo Point was used to validate Level 1 observations. A set of panorama photographs was taken at permanent locations and bearings to ensure comparable photos.

Methods

Specific Photo Point (PP) methods followed descriptions from the "CA Estuarine Wetland Monitoring Manual" and the PP SOP (Johnston et al. 2015, Appendix B-7.2). Forty-one permanent, photo-monitoring locations (Table 10) were established in Ballona (N = 27) and Los Cerritos (N = 14) to visually document vegetation and large-scale landscape changes over time. Stations were located using GPS and baseline photographs to confirm bearing. The baseline photo point survey was conducted seasonally. Several photographs were lightened to increase visual clarity.

Details on the sampling design and frequency are found in Table 10. Data were not collected from all monitored wetlands because of logistical limitations and a consistent schedule could not be established for the northernmost sites (i.e. Carpinteria, Ormond, and Mugu) as required by this protocol. Because of significant impacts, high variability between wetland habitat types, and ease of scheduling, Ballona and Los Cerritos were chosen to demonstrate this sampling method. At one site, the targeted time was mid- to late summer or during the peak wetland growing season (Los Cerritos), and at the other site, a variety of seasons were targeted to capture seasonal variability (Ballona).

Table 10. List of Photo Point sites by sub-area and number of photos taken in total.

Wetland Name	Wetland Sub-Area	Number of Photo Point Stations	Number of Photos (total)	Season or Date Range
Ballona	Ballona A	3	18	November 2012 to August 2014
	Ballona B-E	17	102	
	Ballona B-W	7	42	
Los Cerritos	LCW-Hellman	5	12	September 2013 and September 2014
	LCW-Steamshovel	9	18	

Regional Data Results

As PP data were not collected at all wetland locations, the individual sites were highly variable, and regional analyses were not possible from qualitative photographic data. Alternatively, data are presented as individual site-specific photographic trends over time for both Ballona and Los Cerritos.

Site-Specific Data

Ballona

Ballona had the most extensive set of PP locations and the largest area covered. Twenty-seven locations including 127 photos were taken four times per year from November 2012 to August 2014. PP locations in the following figures were selected to characterize a subset of the Level 3 intensive sampling areas and are representative of the range of wetland habitats surveyed.

The first set of photos was taken from the western margin of Ballona B-W facing east (Figure 20). Figure 20 shows seasonal variety through the presence and then lack of presence of non-native annual grasses and forbs, with mixed native *Salicornia pacifica* (pickleweed) and non-native *Mesembryanthemum nodiflorum* (slender leaved ice plant) in the middle ground of the photos.

The second set of photos was taken off of Culver Boulevard (Ballona B-E) facing north (Figure 21). A berm with non-native vegetation frames the bottom of the photos, native vegetation is in the center, and the salt pan can be seen in the distance.

The third set of photos was taken near the convergence of the Freshwater Marsh and Ballona B-E south of Jefferson Boulevard (Figure 22). The native vegetation in the foreground is part of the adjacent Freshwater Marsh; the middle ground of the photos are a bare ground overflow basin for the Freshwater Marsh and includes *S. pacifica* mixed with non-native annual grasses.

The fourth and final selected set of photos was taken in the middle of Ballona A facing east, a highly disturbed area with a high proportion of bare ground and non-native vegetation species but still considered delineated wetland habitat by several jurisdictional standards (Figure 23). The pink-red vegetation that can be seen throughout is a non-native iceplant, *M. nodiflorum*.

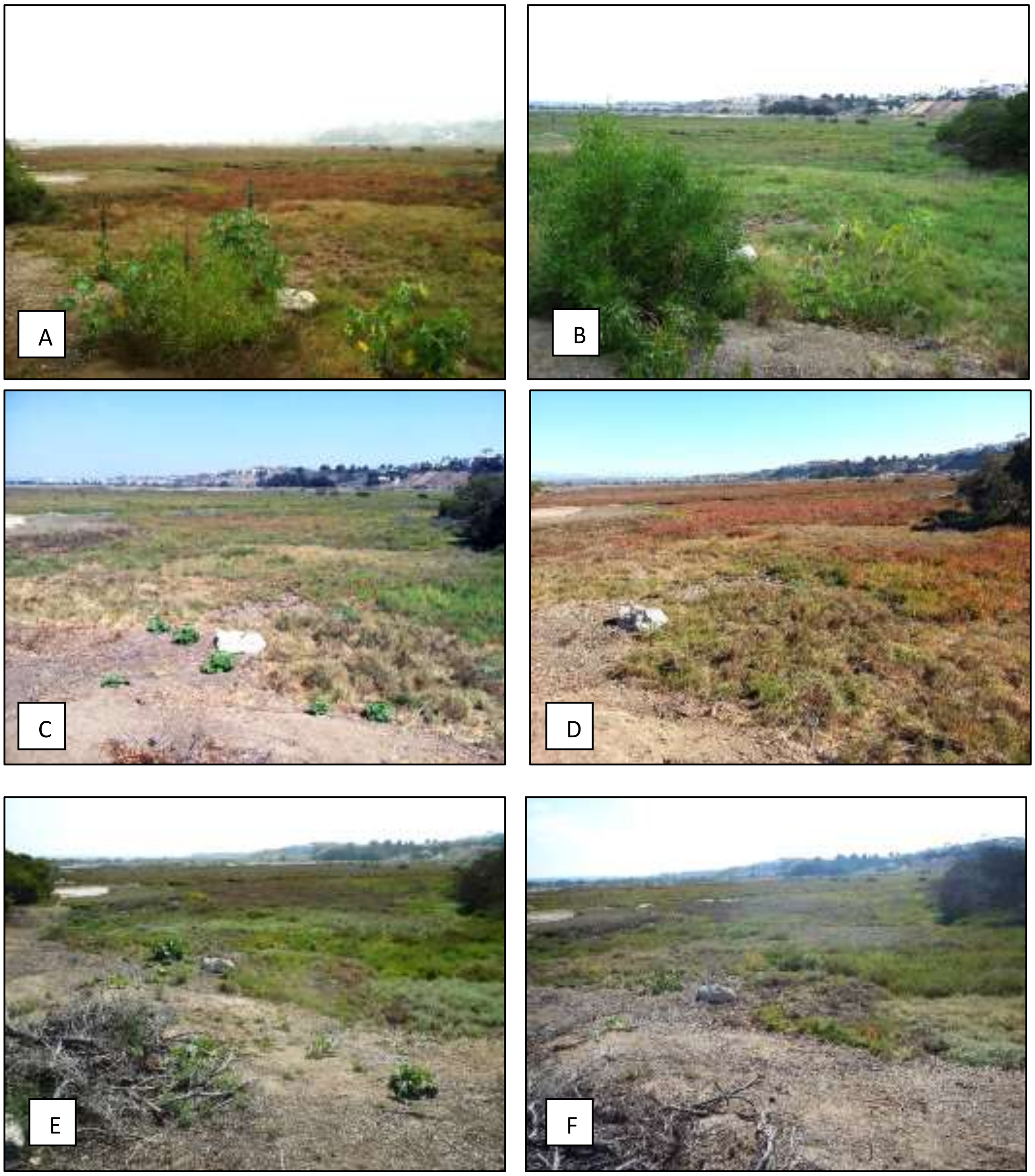

Figure 20. Photo Point P04 Ballona B-W: (A) November 7, 2012; (B) June 5, 2013; (C) August 12, 2013; (D) November 13, 2013; (E) May 9, 2014; and (F) August 21, 2014.

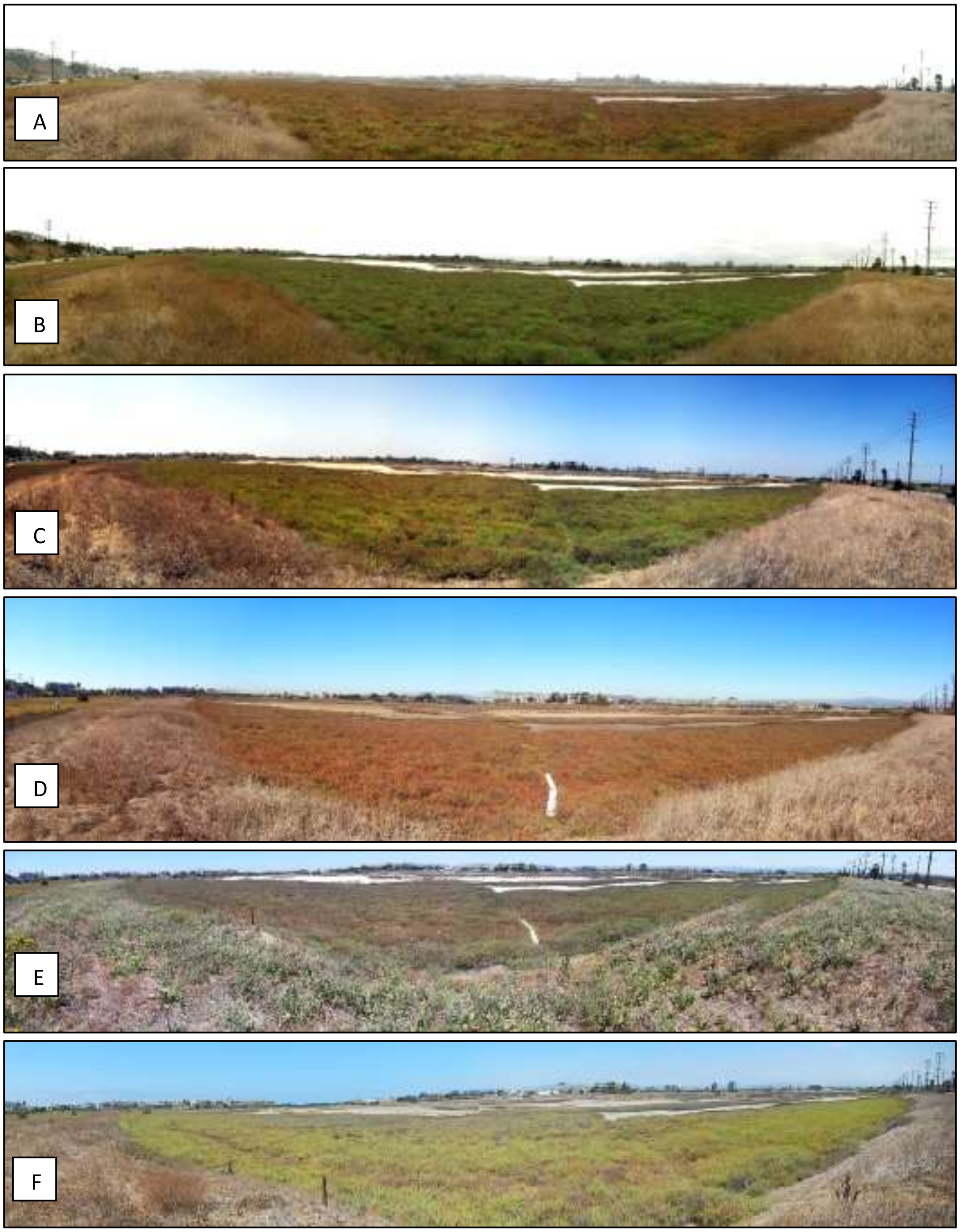

Figure 21. Photo Point P01 Ballona B-E: (A) November 7, 2012; (B) June 4, 2013; (C) August 15, 2013; (D) November 13, 2013; (E) May 6, 2014; and (F) August 21, 2014.

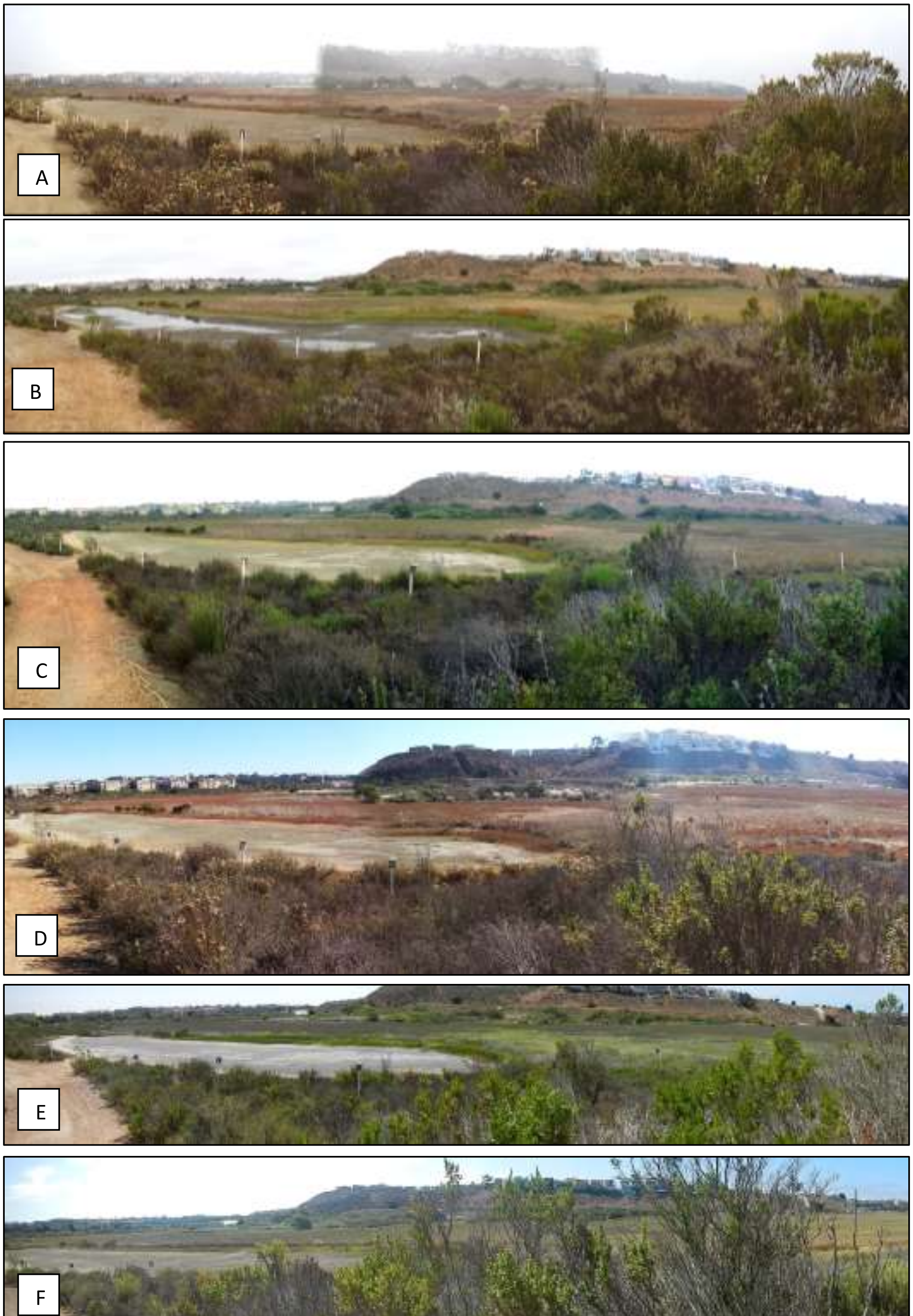

Figure 22. Photo Point PP14 Ballona B-E: (A) November 7, 2012; (B) June 5, 2013; (C) August 15, 2013; (D) November 13, 2013; (E) May 9, 2014; and (F) August 21, 2014.

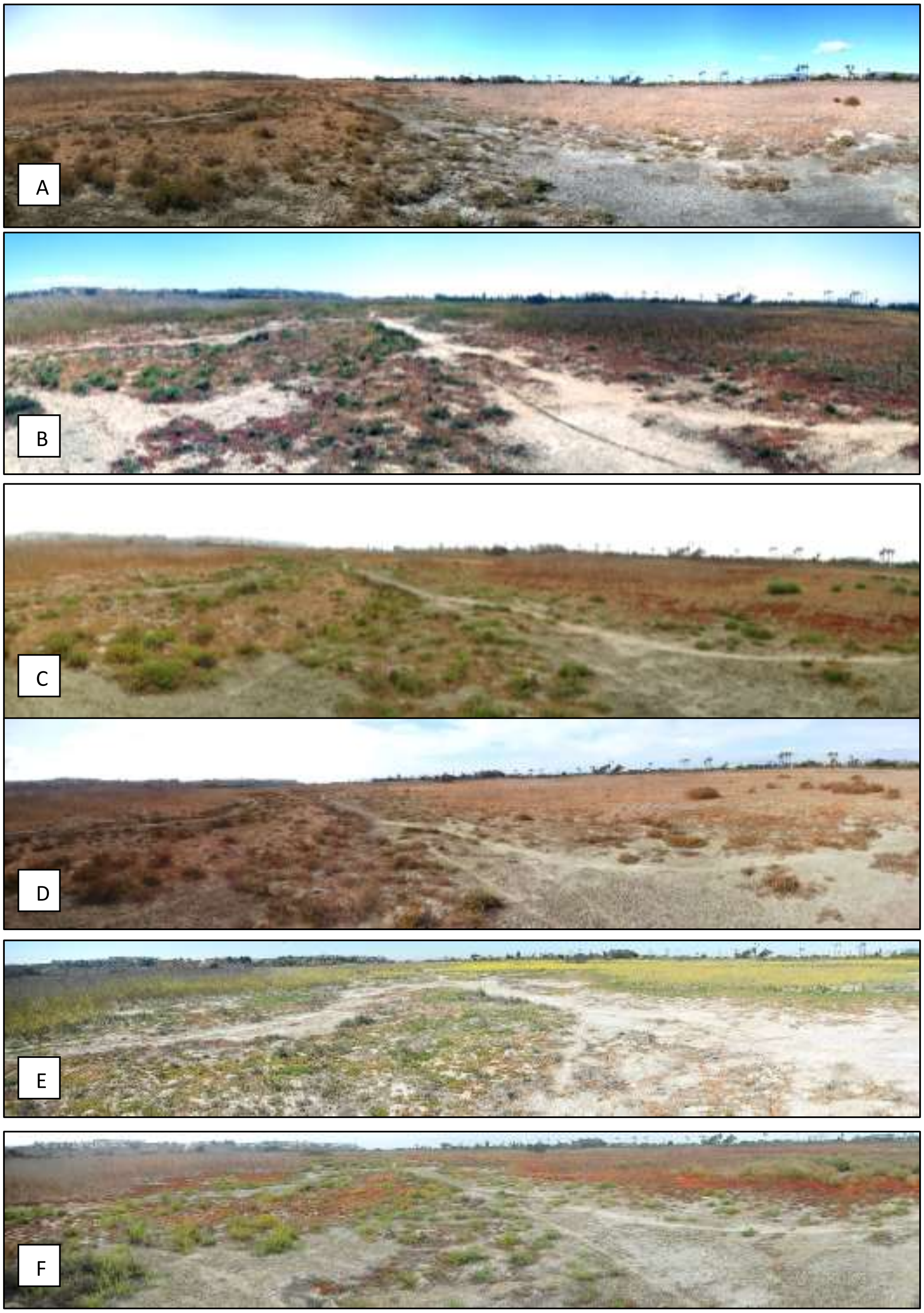

Figure 23. Photo Point PP26 Ballona A: (A) November 9, 2012; (B) May 4, 2013; (C) August 14, 2013; (D) November 19, 2013; (E) May 15, 2014; and (F) August 22, 2014.

Los Cerritos

Fourteen locations were selected at Los Cerritos and georeferenced photos were taken September 2013 and September 2014. PP locations represented in the following figures characterize a subset of the actual sampling area. Figure 24 (A through D) are at two different locations within LCW-Steamshovel. Photos A and B were taken from the northeast corner of LCW-Steamshovel facing southwest. Construction debris and fill frame the edges of this shot. Facing west from the southern portion of LCW-Steamshovel, photos C and D show a tidal channel network. Figure 24 (E and F) are located within LCW-Hellman and were taken on top of an access road above the primary muted tide channel. Figure 24-G is a panorama shot of LCW-Steamshovel from an adjacent access road.

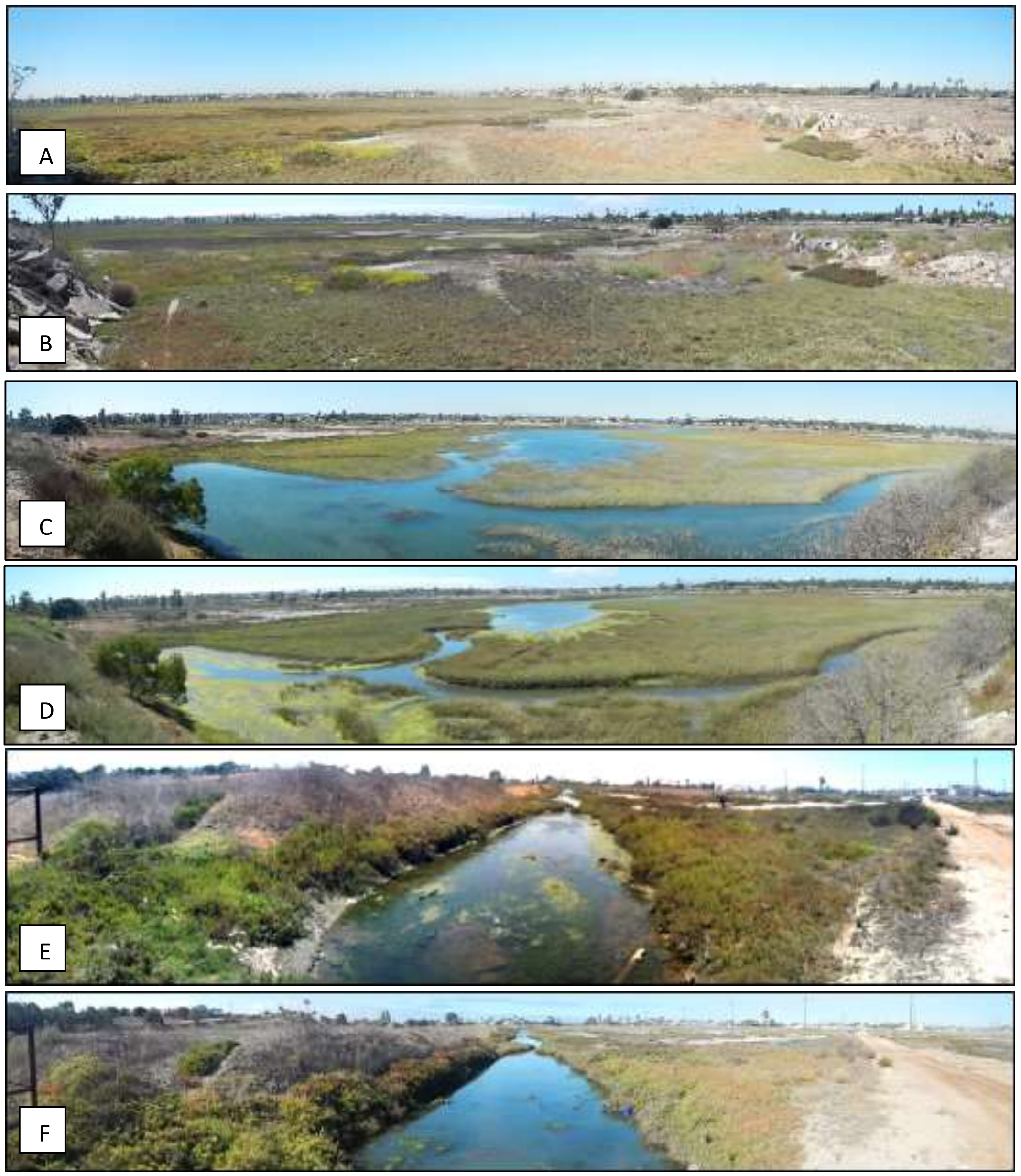

Figure 24. Los Cerritos Wetlands - Steamshovel PP2: (A) September 24, 2013, (B) September 18, 2014; LCW-Steamshovel PP9: (C) September 24, 2013, (D) September 18, 2014; LCW-Hellman PP1: (E) September 24, 2013, and (F) September 18, 2014.

Level 2 Conclusions

As a qualitative assessment, Photo Point documented changes over time and was an effective, low cost complement to the CRAM assessments, especially as a reference point when evaluating the CRAM data at a regional level and to validate the identification of the wetland sub-areas. However, the CRAM data provided much more detailed data for analyses. Both supported the *a priori* allocations of classifications prior to the initiation of the surveys. Additionally, the CRAM analyses supported and confirmed the Level 1 hydrologically distinct sub-area classifications by the distinct groupings of hydrology attribute scores for each wetland sub-area.

Several of the wetland sub-areas were found to be significantly degraded when compared to the reference locations, and clear patterns emerged consistently by sub-area across multiple attributes. Combining the Level 1 and Level 2 data identify clear patterns in watershed-level stressors and CRAM scores. For example, many of the degraded sites had hydrological modifications such as armored levees or concrete culverts (e.g. Ballona, Mugu-West Arm, LCW-Hellman) which reduced their hydrology scores, leading to lower overall final CRAM scores. Three clear reference sites emerged from these analyses: Carp-Main, Mugu-Central, and LCW-Steamshovel.

L2 conclusions will be explored further in the main conclusions section of this report after the Level 3 data and analyses are presented.

Figure 24-G. Panorama photograph of LCW-Steamshovel from an adjacent access road.

LEVEL 3: Introduction

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

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

1) Refine or validate rapid assessment methods based on a characterization of reference condition and specific functions;
2) Diagnose the causes of wetland degradation;
3) Develop design and performance standards for wetland restoration, including compensatory wetland mitigation; and
4) Support the development of water quality standards that are protective of wetlands.

The two primary goals of the Level 3 evaluations in this project were to:

1) Provide site-intensive baseline or supplemental datasets to land managers to inform restoration and management processes; and
2) Evaluate a variety of protocols assessing several key parameters (i.e. water and sediment quality, vegetation, birds, and invertebrates) within a variety of estuarine wetland habitats to contribute to the development of the “California Estuarine Wetland Monitoring Manual” (Johnston et al. 2015).

Habitat Types Evaluated using Level 3 Assessments

As part of project development, protocol testing and implementation was conducted within six habitat types at five coastal, perennial estuarine wetlands in southern California (Figures 26-30). At some wetlands, all habitat types were evaluated, but not all habitat types were present at all wetland locations. Habitat types evaluated (within all or a subset of the wetland locations) included: tidal channel, mud/sand flat, emergent salt marsh, non-tidal salt marsh, salt pan, and “degraded” or fill habitat. Figure 25 displays representative photographs of each habitat type at Ballona. The “degraded” habitats were identified *a priori* based on known impacts, stressors, and Level 1 analyses and then validated using CRAM scores. Figures 26-30 are maps for each wetland site showing the locations of each Level 3 survey completed for this report.

Figure 25. Representative photos of the six habitat types at Ballona: (A) tidal channel, (B) mudflat, (C) emergent salt marsh, (D) non-tidal salt marsh, (E) salt pan, and (F) degraded.

Figure 26. Map of Level 3 surveys at Carpinteria Salt Marsh (i.e. vegetation and invertebrates).

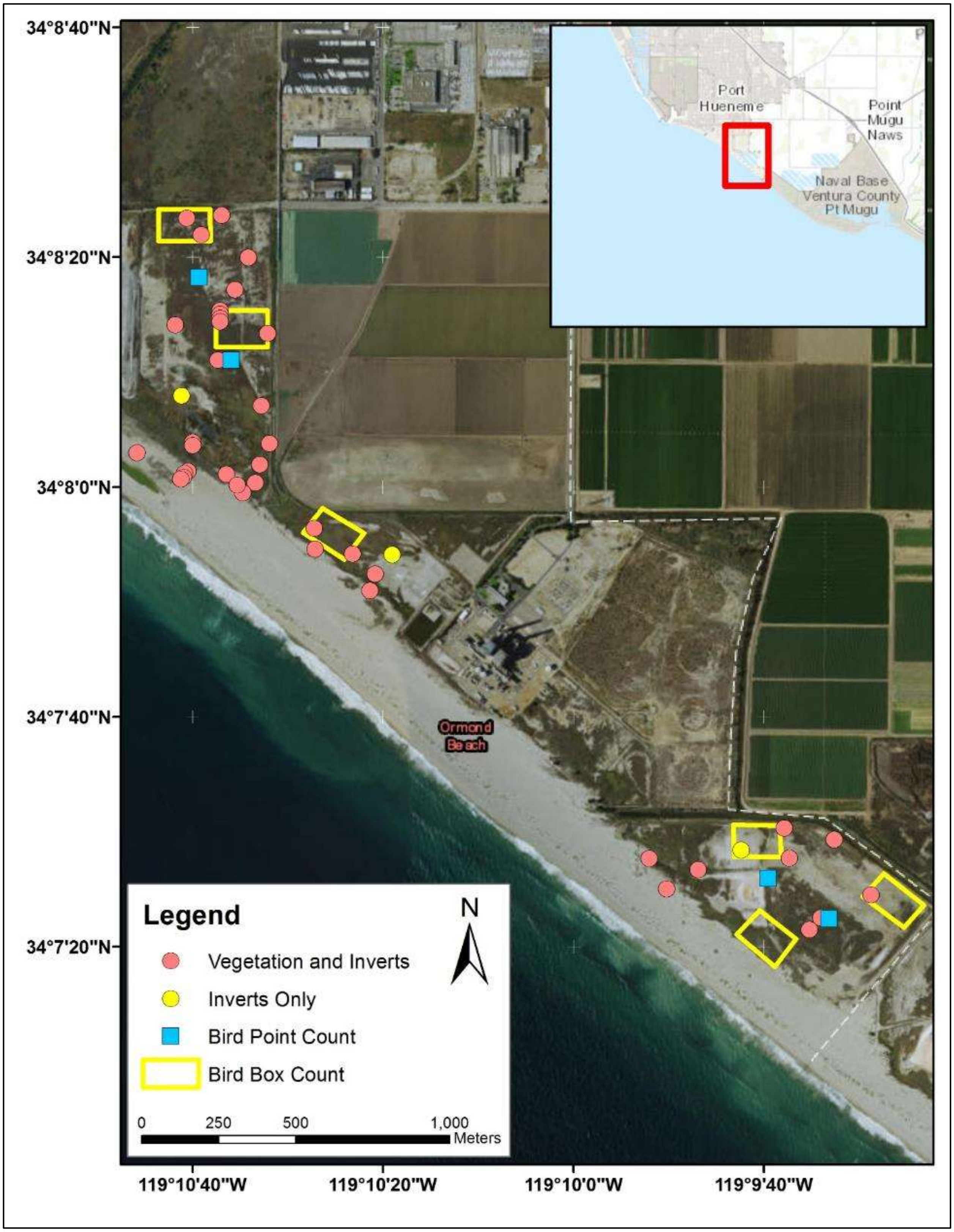

Figure 27. Map of Level 3 surveys at Ormond Beach Wetlands (i.e. vegetation, invertebrates, and birds).

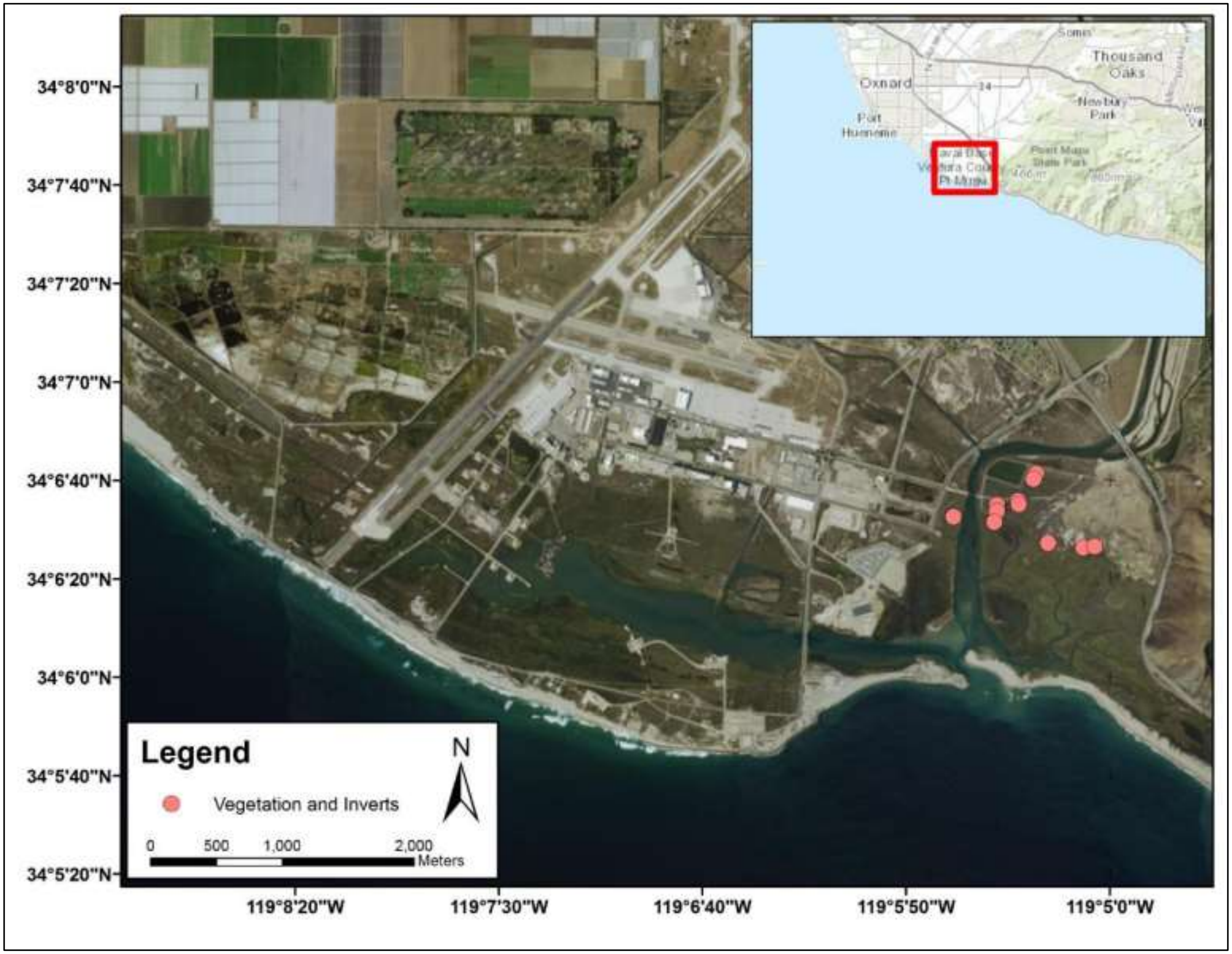

Figure 28. Map of Level 3 surveys at Mugu Lagoon (i.e. vegetation and invertebrates).

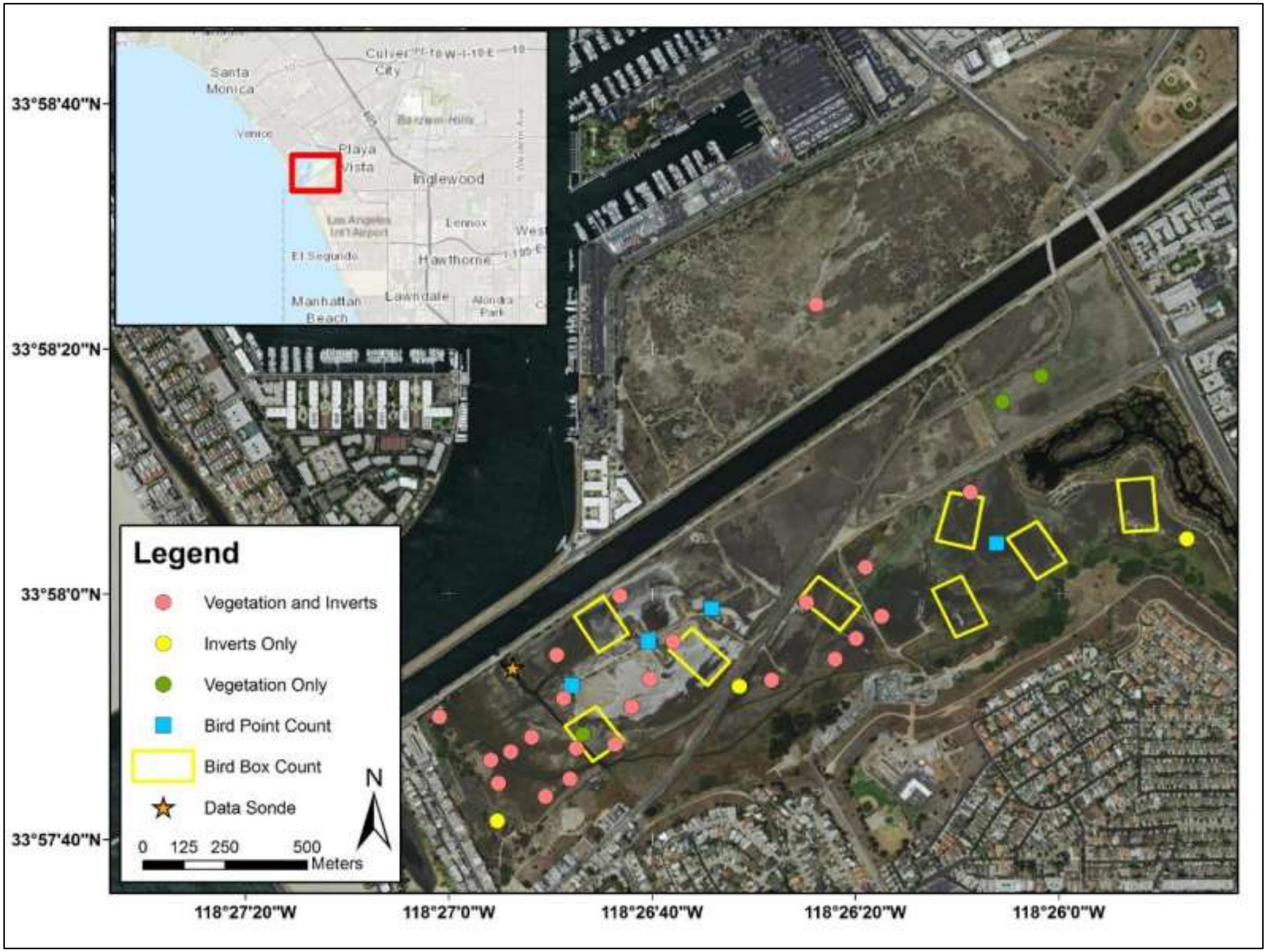

Figure 29. Map of Level 3 surveys at Ballona Wetlands Ecological Reserve (i.e. vegetation, invertebrates, and birds).

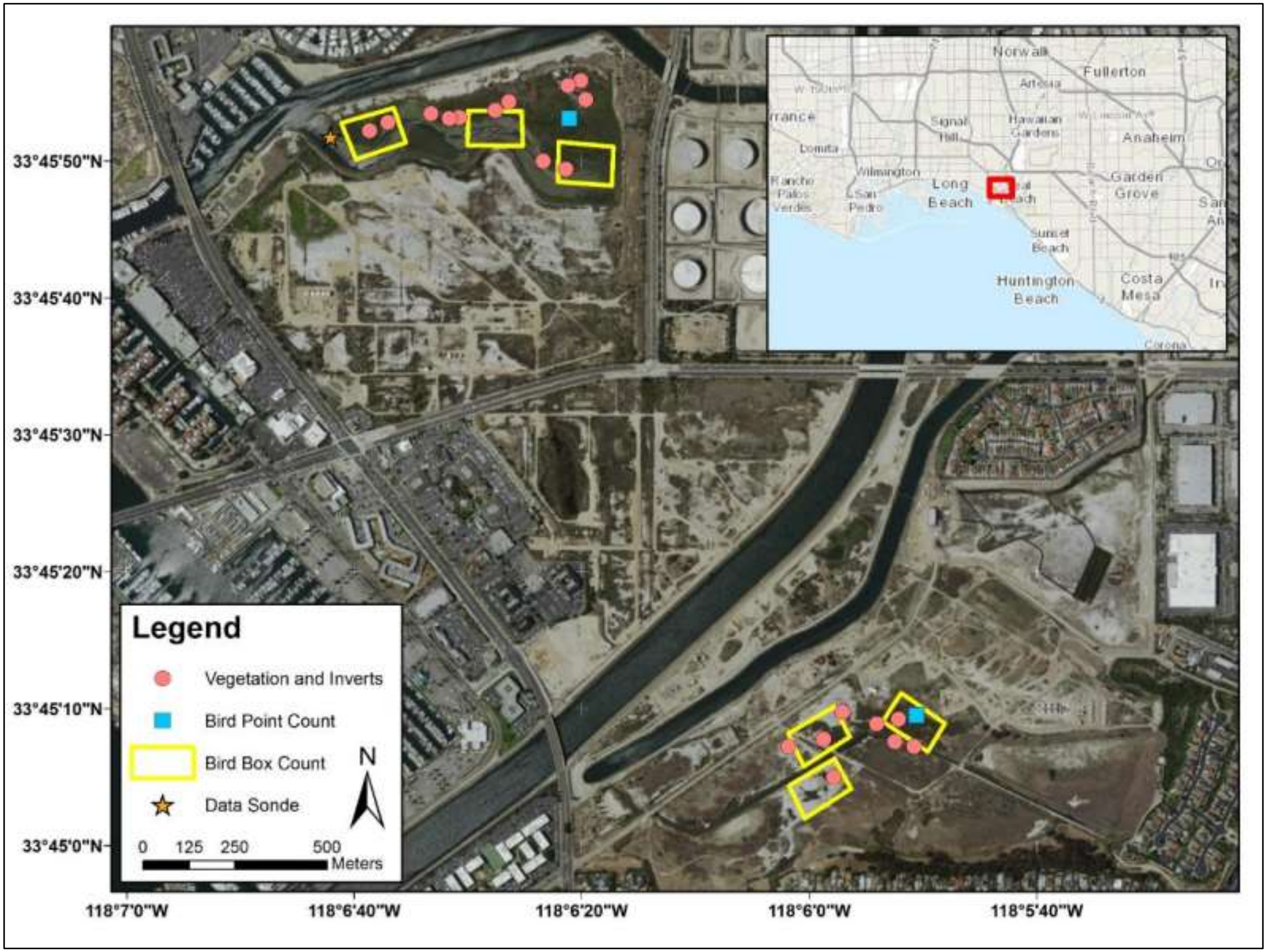

Figure 30. Map of Level 3 surveys at Los Cerritos Wetlands (i.e. vegetation, invertebrates, and birds).

LEVEL 3: Water and Soil Quality

Introduction

The assessment of water and sediment quality can provide supporting information about the physical forces affecting habitat distribution. Prevailing vegetation communities are directly linked to dominant hydrologic regimes, soil salinity, and composition (James-Pirri et al. 2002). Water quality probes are used to measure water parameters in continuous monitoring mode by collecting data at user-defined intervals and storing those data for download at discrete intervals. Water quality multi-probes can be deployed continuously at monitoring stations to characterize parameters over multiple tidal cycles, through freshwater-input events, or over longer periods of time. Water quality sampling objectives may include quantifying specific water parameter (e.g. pH, temperature, salinity, chlorophyll depth) variations over time. Protocols assessing soil composition are aimed at characterizing soil properties such as salinity and texture. Salt composition and distribution within the soil profile affects many biological and chemical parameters including plant response, ion effects, and nutritional imbalances (NSSC 2009). Soil texture and individual phenotypic characteristics of each plant species are also widely understood to influence vegetation growth under various saline soil conditions.

Methods

Specific water and soil quality survey methods followed descriptions from the "CA Estuarine Wetland Monitoring Manual" (Johnston et al. 2015) with specific reference to the individual SOPs for each method (Appendix B – 1.1, 2.1, and 2.2). Data were collected from a subset of the regional wetlands to assess two different forms of hydrological connectivity to southern California wetlands (e.g. fully tidal at LCW-Steamshovel, muted tidal at Ballona).

Permanent Data Sonde

Two permanent data sondes were deployed within tidal channels at both the fully tidal LCW-Steamshovel from February 2014 to March 2015 and the muted main tidal channel within Ballona B-W from October 2010 to August 2014 (Figures 29, 30, and 31). Data were collected for multiple parameters including: temperature, salinity, depth, pH, and dissolved oxygen. This report focuses on describing trends in dissolved oxygen (DO) readings over time, as DO can serve as an indicator of eutrophication and a wetland area's ability to support robust fish and invertebrate populations (McLaughlin et al. 2012). DO data are presented in multiple formats (e.g. averages, graphs, basic summary statistics, and percent of readings above multiple thresholds) to illustrate the variety of approaches available to analyze these types of data.

Figure 31. Photograph of data sonde deployment in the main muted tidal channel at Ballona B-W.

Soil Salinity

In accordance with SOP 2.1, soil salinity samples were collected along a total of 22 transects within Ballona immediately before the first rains of 2012 and 2013 (i.e. September through November). Most parameters within this report are presented by wetland sub-area; however, soil salinity data are analyzed on a habitat-level to allow for groupings of similar vegetation communities and dominant hydrology across the entire site. Seven transects were sampled within tidal wetland habitat areas, twelve within non-tidal salt marsh areas, and seven within the salt pan. Soil salinity within the Hellman sub-wetland were collected from eight salt marsh transects and two transects within salt pan habitat areas. Data results are averaged on a transect level, and again on a habitat level, therefore the resulting data are presented as grand means by habitat type.

Results

Regional Data Results

As water and soil quality data were not collected at all wetland locations, the individual sites were highly variable, and regional analyses were not conducted.

Permanent Data Sonde

Permanent data sonde stations collected data for multiple parameters. However, only DO data are presented as other parameters followed expected and predictable trends (e.g. temperature increases in summer months and decreases in winter months, consistent pH levels, and depth range changes tracking tidal oscillations).

Dissolved oxygen readings displayed high inter-annual variability (within Ballona) and geographic variability between sites. Table 11 presents the percent of readings above specific dissolved oxygen thresholds identified as important biological thresholds by multiple monitoring and restoration projects (McLaughlin et al. 2012, Abramson et al. 2015). More than 95% of all readings were above 1.5 mg/L of dissolved oxygen for all sites across all years ranging from 95.36% - 99.91%. Even at higher dissolved oxygen thresholds, the majority of readings (>70%) at all sites across all years ranged from 71.64% - 88.43%. Additional dissolved oxygen summary statistics by month are presented for Ballona between the period of October 2013 – August 2014, to show data on the average, maximum, and minimum DO readings during those time periods (Table 12). Figure 32 displays the monthly average and standard error for the same location and time period.

Table 11. Percent of readings (%) above DO threshold (mg/L) by site and year.

		Dissolved oxygen threshold (% of readings)			
Site	**Year**	**1 mg/L**	**1.5 mg/L**	**3 mg/L**	**5 mg/L**
Ballona	2010 – 2011	99.98%	99.91%	98.55%	88.43%
	2011 – 2012	97.92%	95.36%	82.84%	71.64%
	2012 – 2013	99.88%	99.65%	96.49%	82.76%
	2013 – 2014	99.67%	99.49%	94.96%	78.10%
Los Cerritos	2014 – 2015	98.24%	96.89%	89.22%	72.73%

Table 12. Basic monthly statistics for DO (mg/L) at Ballona from October 2013 – August 2014.

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

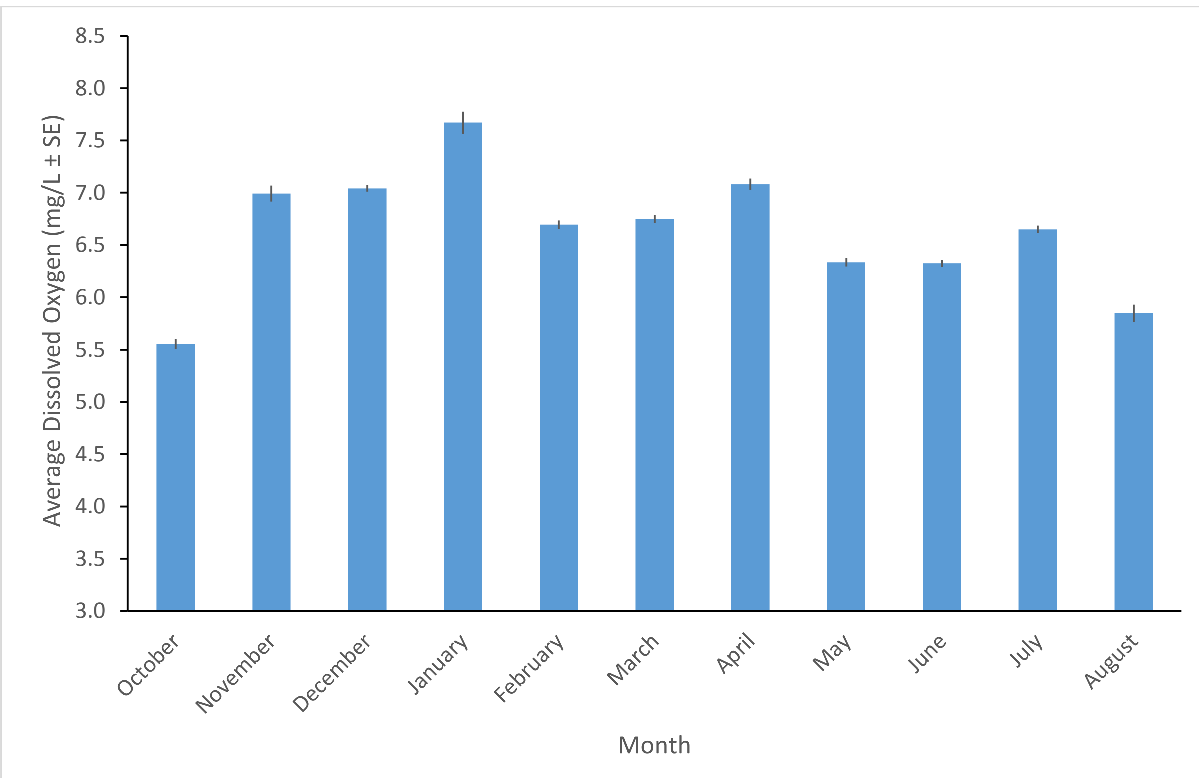

Figure 32. Monthly averages (± standard error) for dissolved oxygen at Ballona from October 2013 – August 2014.

Soil Salinity

Soil salinity within Ballona was averaged on a transect level, and again on a habitat level, therefore the resulting data are presented as grand means by habitat type (Figure 33). Soil salinity concentrations within salt pan habitat areas were found to be significantly higher [92.3 ± 5.2 parts per thousand (ppt)] than those within the tidal wetland and non-tidal salt marsh areas, 41.9 ± 4.3 ppt and 35.0 ± 4.8 ppt, respectively.

The salt pan displayed the highest soil salinity concentration of 92.3 ± 5.2 ppt (Figure 33). The second highest soil salinity concentrations were found in tidal wetland habitat areas followed by non-tidal salt marsh habitat areas. This trend was expected as salts within tidal wetland areas are continuously replenished by incoming tidal waters while salt compounds within areas disconnected from tidal inputs (i.e. non-tidal salt marsh) become diluted and are leached through soil strata by the freshwater-dominant hydrology.

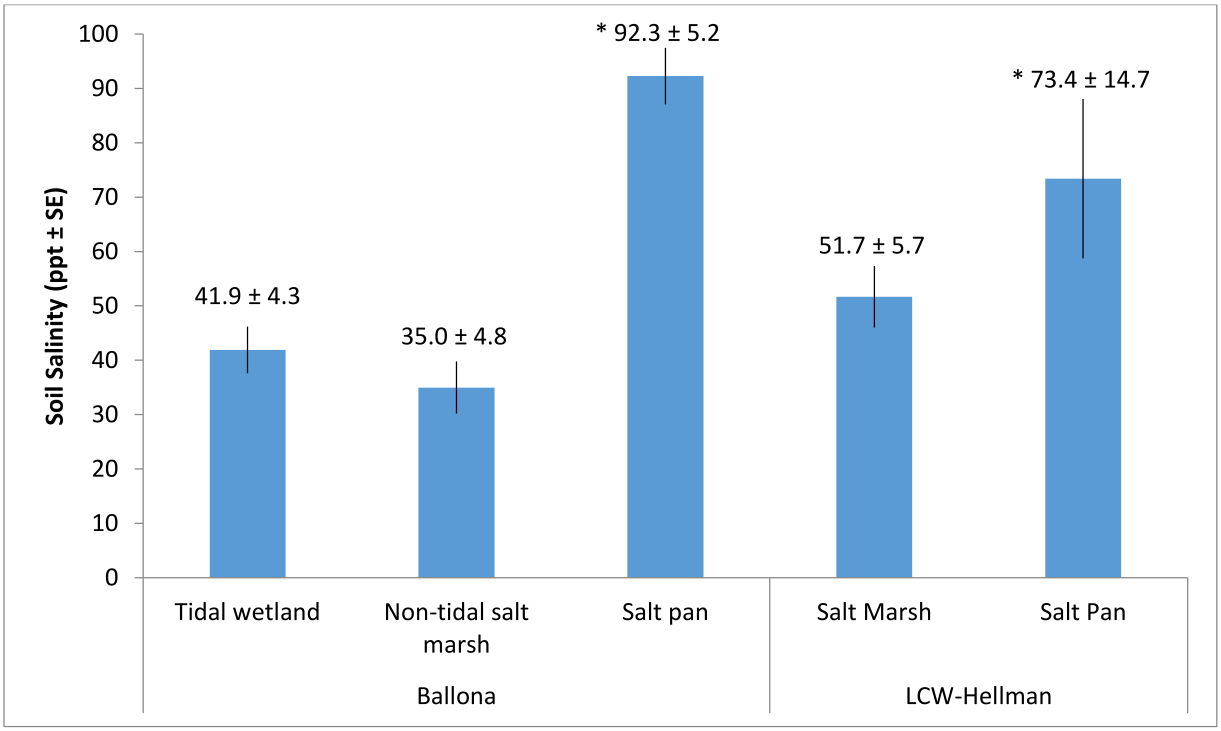

Figure 33. Grand mean of soil salinity concentrations by estuarine habitat type. Asterisks indicate that several readings were above the maximum range (i.e. 100 ppt) of the refractometer.

Conclusions

Dissolved oxygen concentrations were variable across both temporal scales and geographic location; however, an overarching trend within both wetland sites was that extremely low dissolved oxygen levels (i.e. < 1mg/L) occurred less than two percent of the time across all years and locations. This indicates that tidal energies within both the fully tidal LCW-Steamshovel and muted Ballona B-W were sufficient to promote a well-mixed water column, and dissolved oxygen levels were likely capable of supporting robust benthic invertebrate and fish populations.

Soil salinity values followed expected patterns based on dominant hydrology regimes. Areas subject to daily tidal inundation (i.e. Ballona-B tidal wetland and LCW salt marsh) displayed salt concentrations slightly higher than those of marine water (29 – 32 ppt) as soil salts were replenished daily and accumulated in more poorly drained areas as the salt water evaporated. Higher observed soil salinities within the Los Cerritos wetlands are likely attributed to the fact that salt marsh habitats are not specifically delineated by their exposure to daily tidal regimes and some transects may only receive tidal inundation on the highest high tides. Similarly, the highest soil salinity concentrations were observed within the salt pan habitats at both wetland sites as these areas are only exposed to the highest high tides and their extremely low vertical relief promote extended ponding and poor drainage (Figure 34). This allows the evaporation of most of the tidal water which leaves behind and accumulates dissolved salts. As anticipated, the lowest soil salinity concentrations were observed within the non-tidal salt marsh areas as historic salt accumulations are slowly diluted and leached into the soil by the dominant freshwater inputs.

Soil grain size analysis (SOP 2.2) data were not presented due to high degree of variability and inconsistency in the results (e.g. large standard errors within laboratory replicates of the same individual samples). Additionally, due to the significant amount of processing time per sample and the substantial equipment cost (i.e. LISST Particle Analyzer), this protocol was not further explored.

Figure 34. Photograph of the salt pan habitat type at Ballona-B (12-16-2009).

LEVEL 3: Vegetation

Introduction

Vegetation was evaluated using three primary sets of monitoring methods: vegetation cover, seed bank germination studies, and submerged aquatic vegetation / algae cover. Long-term monitoring of vegetation cover is one of the most common methods of evaluating the health and functioning of a wetland system (Zedler 2001); changes in the relative presences of native and non-native plant species may affect the distributions of associated wildlife species. Additionally, increases in vegetation cover and complexity following restoration events are one of the most common indicators of the return many wetland habitat functions.

Information about the seed bank of a wetland is another indicator of wetland functions and may, in some cases, provide supplemental or new information to add to the presence of adult plants (i.e. plant canopy) alone. The presence of a viable and diverse seed bank indicates recent well-functioning ecological and hydrological dynamics of the site (Johnston et al. 2011). Soil seed banks also forecast subsequent adult plant species richness under optimal conditions (S. Anderson, unpublished data). However, it should be noted a limitation of this method is its exclusion of species that do not rely on seed-based propagation processes.

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

Methods

All sampling protocols followed methods described in detail in the "CA Estuarine Wetland Monitoring Manual" (Johnston et al. 2015) and SOP 3.1 (Submerged Aquatic Vegetation and Algae; Figure 35a), SOP 3.2 (Vegetation Cover; Figure 35b), and SOP 3.4 (Seed Bank; Figure 36. Sampling design and frequencies for each wetland sub-area are displayed in Table 13. Note that the number of cover transects may not exactly match those shown in site maps (Figures 26 – 30) as Table 13 lists only transects incorporated into analyses. Some transects may have been sampled during multiple years or removed during the QAQC process due to changes to wetland sub-area classifications or discrepancies in the data. Only vegetated habitats were surveyed using the vegetation cover protocols.

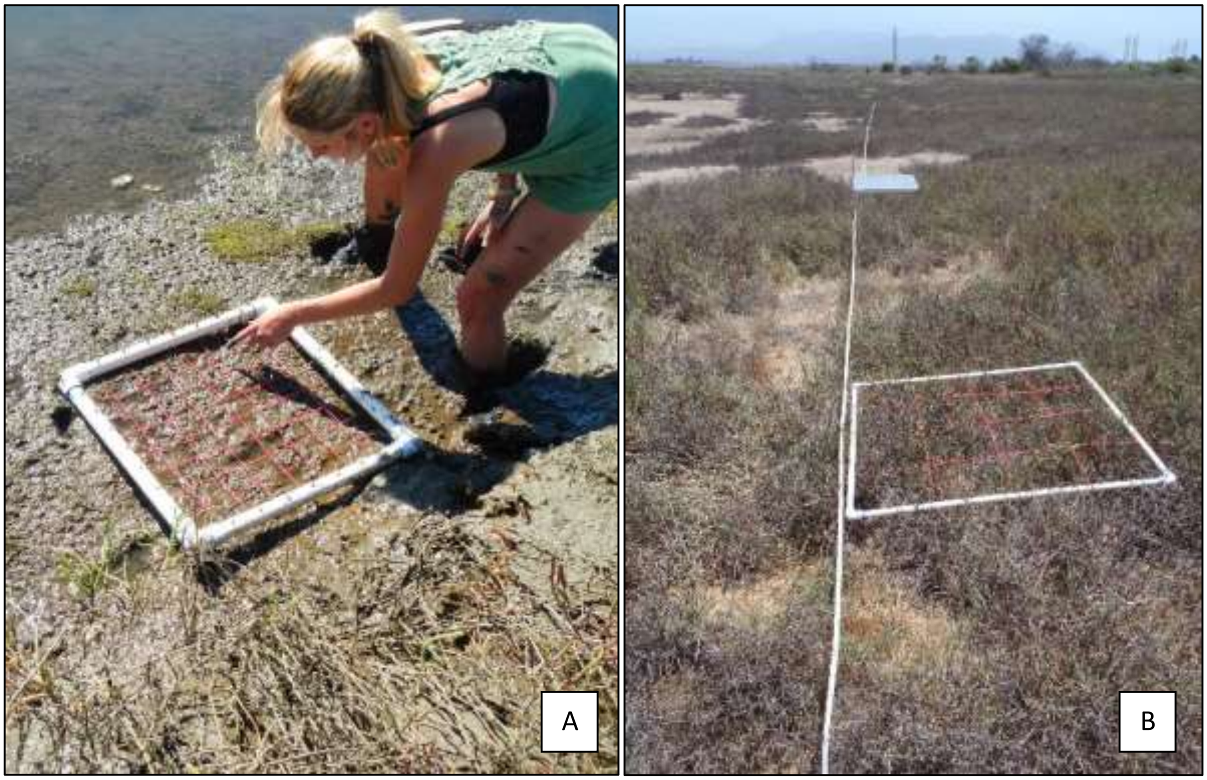

Figure 35. Field photographs of multiple surveys: (A) SAV/algae survey and (B) vegetation cover transect survey at Ballona B-W and Orm-Halaco, respectively.

Figure 36. Photographs in the greenhouse of the Ballona seed bank germination study.

Both vegetation cover data and species richness were analyzed at the transect-level and the wetland sub-area level. Due to the complexity of the data, sub-area level analyses are displayed in this report with additional analyses conducted as part of a draft manuscript (Johnston et al., *in prep*). Multiple one-way ANOVAs were conducted on normalized cover data (log10 transformed) to assess significant differences for *a priori* classification and wetland sub-area.

Most parameters within this report are presented by wetland sub-area; however, seed bank data were analyzed on a habitat-level to allow for groupings of similar vegetation communities and dominant hydrology across the entire wetland. Only Ballona was surveyed using the seed bank protocols due to site and sampling time restrictions and greenhouse seedling grow-out logistics. Germinated seedlings were counted by core over the course of a 3-month period, averaged at a transect-level, and summary statistics are also presented by habitat type (see SOP 3.4: Seed Bank, for more detail).

Table 13. Sampling design summary information for Level 3 vegetation transect surveys.

Wetland Name	Wetland Sub-Area	Season or Date Range	# Cover Transects	Cover Transect Types	Seed Bank Transects	# SAV / Algae Transects
Carpinteria	Carp-Ash	2012, 2014	11	Cover Class	0	0
	Carp-Main	2012, 2014	6	Cover Class	0	0
Ormond Beach	Orm-Arnold	2012, 2014	6	Cover Class	0	0
	Orm-Halaco	2012, 2014	37	Cover Class	0	0
Mugu Lagoon	Mugu-Central	2012, 2014	20	Cover Class	0	0
	Mugu-West	2012, 2014	3	Cover Class	0	0
Ballona	Ballona A	2012, 2014	1	All	Habitat-based	0
	Ballona B-E	2012, 2014	4	All	Habitat-based	0
	Ballona B-W	2012, 2014	19	All	Habitat-based	4
Los Cerritos	LCW-Hellman	2012, 2014	6	All	0	0
	LCW-Steamshovel	2012, 2014	12	All	0	3

Results

Regional Data Results

Vegetation Cover

Primary vegetation cover results reflected accurate groupings of *a priori* categorizations of the individual wetland sites (Figure 37). There was a significantly higher average native vegetation cover at the *a priori* reference wetlands than the degraded wetlands (ANOVA, $F_{2, 345} = 5.647$; $p = 0.004$); similarly, there was significantly higher average non-native vegetation cover at the degraded wetlands than either the reference or restoration sites (ANOVA, $F_{2, 345} = 17.231$; $p < 0.001$). Restoration sites had slightly lower average native vegetation cover and slightly higher average bare ground cover in the vegetated habitats.

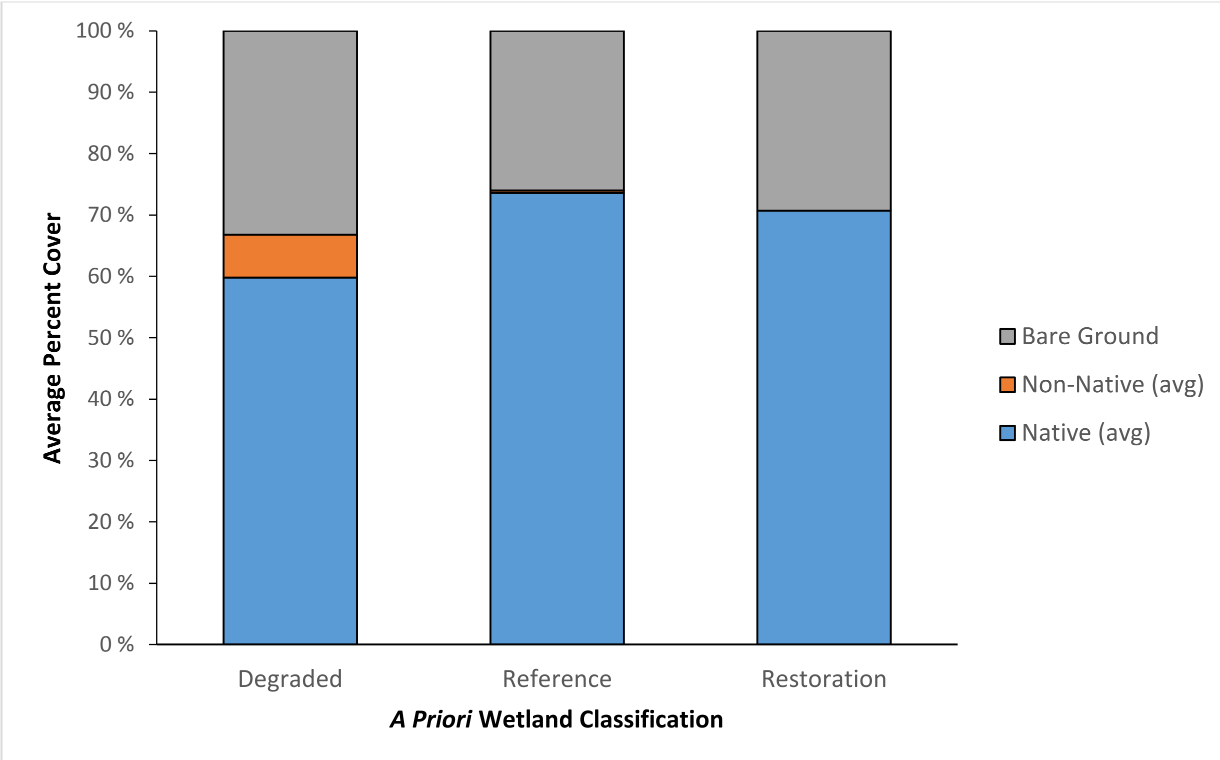

Figure 37. Average percent cover of native and non-native vegetation and bare ground using the *a priori* wetland classification system.

Vegetation data were further analyzed by wetland sub-area (Figure 38). Patterns displayed by wetland sub-area reflected *a priori* classifications and generally revealed similar patterns as the CRAM data final scores. The sites with the most degradation based on Level 1 and 2 assessments (e.g. Ballona, Ormond, and LCW-Hellman) displayed higher percentages of non-native vegetation species invasion and in general, lower overall average native cover. Carp-Ash and Mugu-Central were the sub-areas with the highest average native cover (96% and 87%, respectively).

Several of the wetlands had a high range of within-site (or sub-area) variability (Figure 38). For example, Mugu-West averaged approximately 35% native cover, while Mugu-Central averaged 87% native cover. Similarly, Ballona averages ranged from approximately 31% native cover in Ballona A to 82% in Ballona B-W. The differences in sub-area nativity at Carp, Ormond, and Los Cerritos were smaller.

Vegetation species richness followed similar average patterns by wetland sub-area for both native and non-native species (Figure 39). The highest average native species richness (± standard error) occurred at LCW-Steamshovel (7.4 ± 0.22; Figure 40), and the lowest at Ballona A with only one native species (*S. pacifica*) identified within the sampling area (1.0 ± 0.0). Mugu-West and Ballona B-E also displayed relatively low native species richness by sub-area (1.67 ± 0.33 and 1.37 ± 0.11, respectively). Ballona A and Orm-Arnold displayed the highest average non-native species richness (4.5 ± 0.29 and 2.3 ± 0.84, respectively); Ballona A had almost twice as many average non-native species as the next highest wetland sub-area.

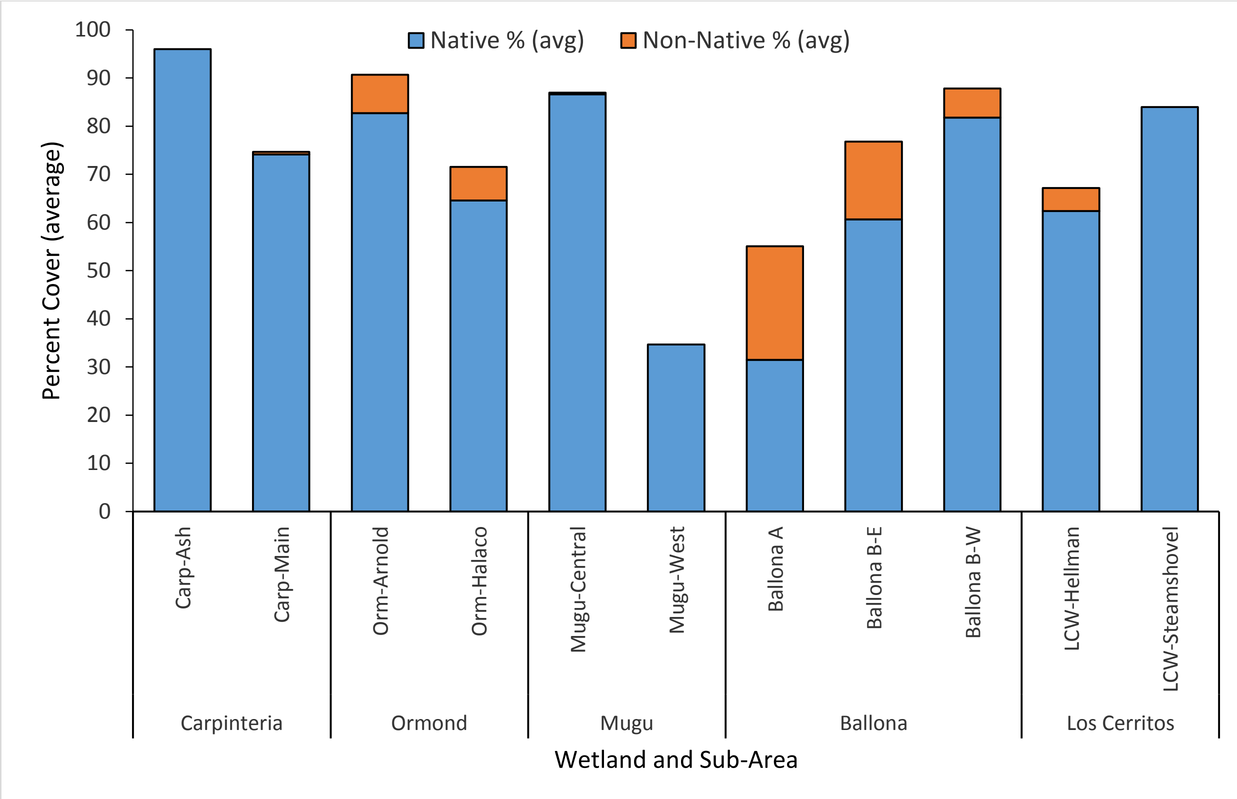

Figure 38. Average percent cover by wetland sub-area for native and non-native vegetation.

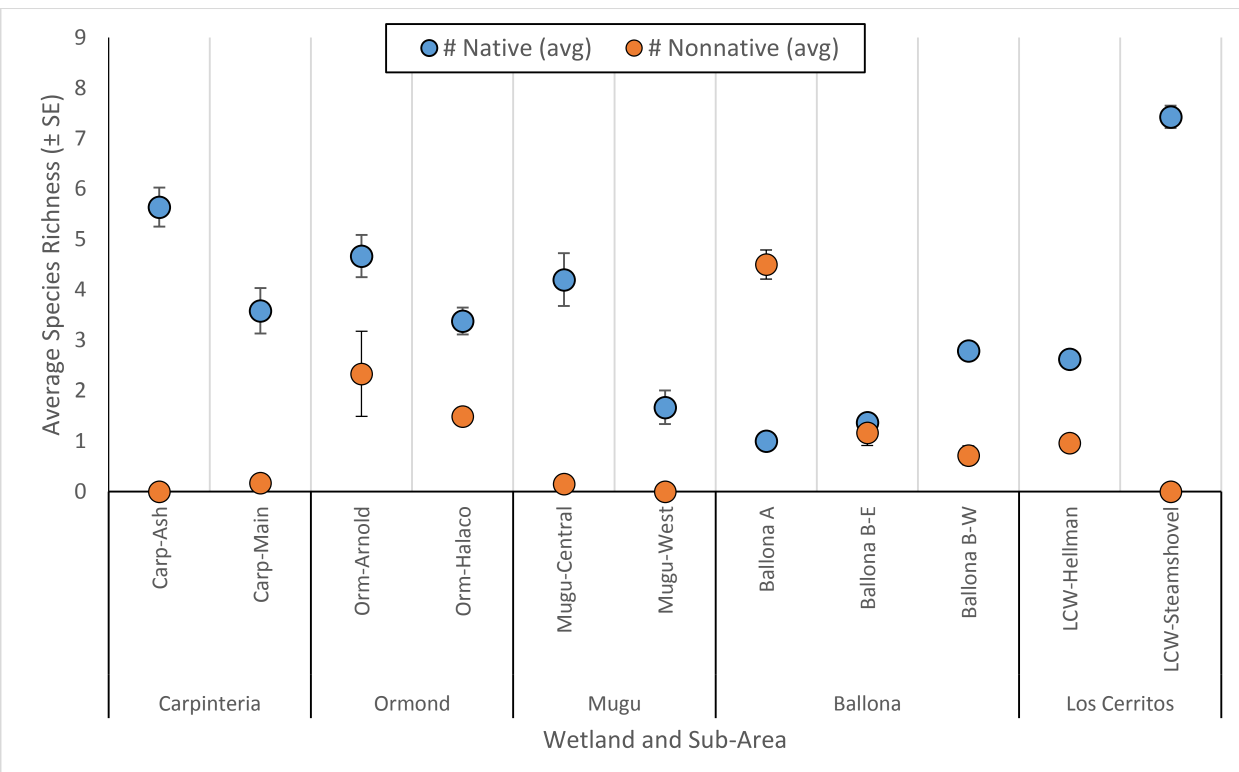

Figure 39. Average species richness (± SE) by wetland sub-area for native and non-native vegetation.

Figure 40. Representative photograph of a highly native species-rich area of LCW-Steamshovel.

To further evaluate the vegetation community patterns at a species-level, Figure 41 displays the average vegetation cover for the three most prevalent native species (by cover) across the regional dataset: *Jaumea carnosa* (marsh jaumea), *S. pacifica*, and *Distichlis spicata* (saltgrass). The site with the highest number of average native species (LCW-Steamshovel) had a lower overall average proportion of cover from the top three natives (approximately 32% in sum) than most of the other sites, with the exception of Ballona A (approximately 31% in sum). The top three native species were fairly evenly distributed within the survey areas at Carp-Ash, and contributed to a fairly high proportion of the overall native cover at that wetland sub-area (approximately 79% cover in sum from the top three species, out of 96%). At two locations, Mugu-West and Ballona A, the cover of *S. pacifica* alone was the sole contributor to the native plant cover out of the top three most prevalent species.

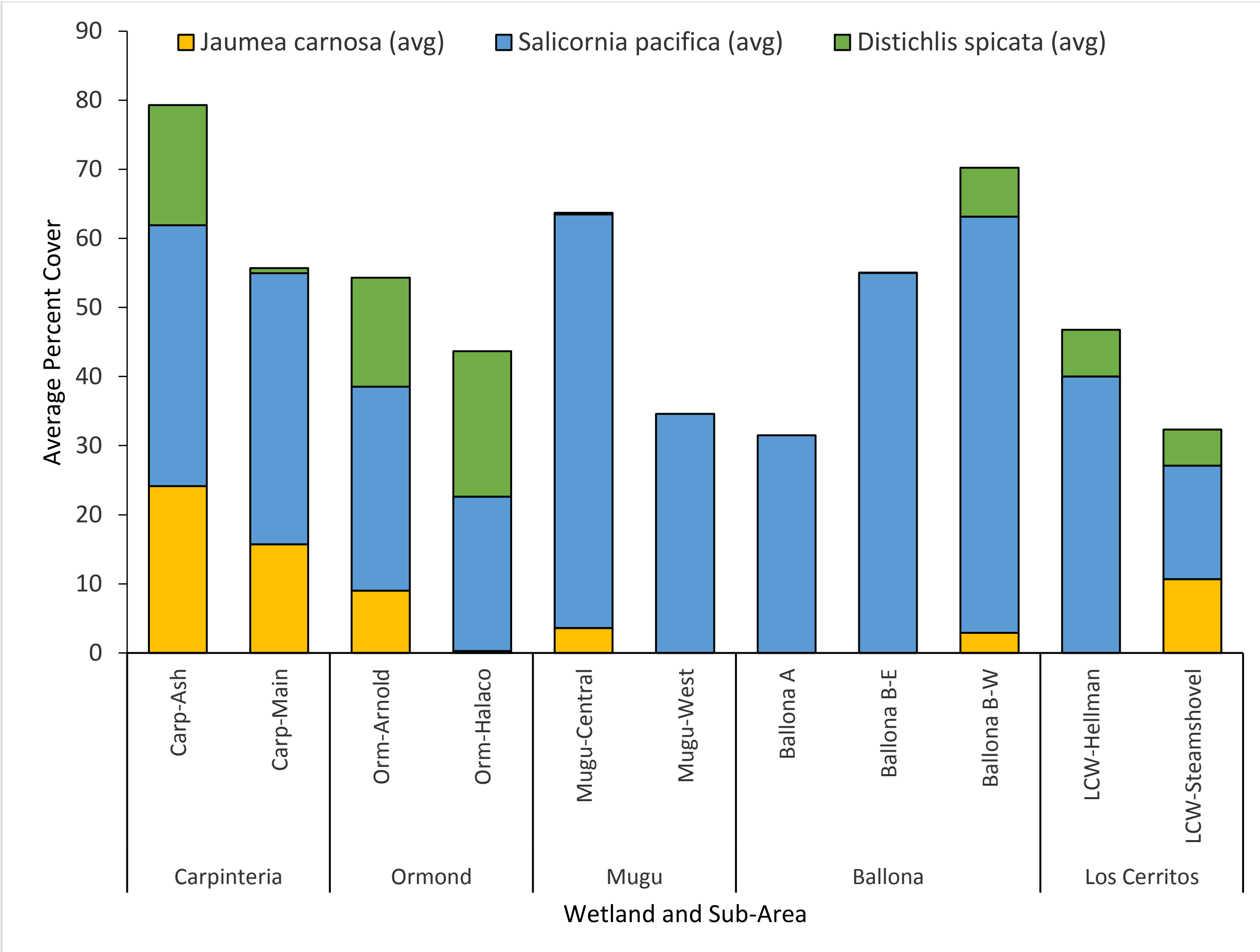

Figure 41. Average percent cover by wetland sub-area for *J. carnosa*, *S. pacifica*, and *D. spicata*.

Algae and Submerged Aquatic Vegetation

The algae community for both sites was primarily unattached or floating algal mats. However, there was a noticeable difference between the specific algae species between the two evaluated project sites (i.e. Ballona and Los Cerritos). Los Cerritos transects were often dominated by *Ulva lactuca* (sea lettuce), with a low range of approximately 1% cover but a high of approximately 99% cover (Figure 42); seven out of the nine transects had 20% or higher *U. lactuca* cover. Conversely, Ballona transects were mostly bare ground with a range of approximately 40-97% bare ground and an average cover of 76.5% bare ground (Figure 42). Most of the algae present at Ballona was found to be *Ulva intestinalis* (sea lettuce, green alga).

Out of both wetland sites, only two transects at Ballona recorded the presence of attached submerged aquatic vegetation (*Ruppia* sp.) at less than 1% cover.

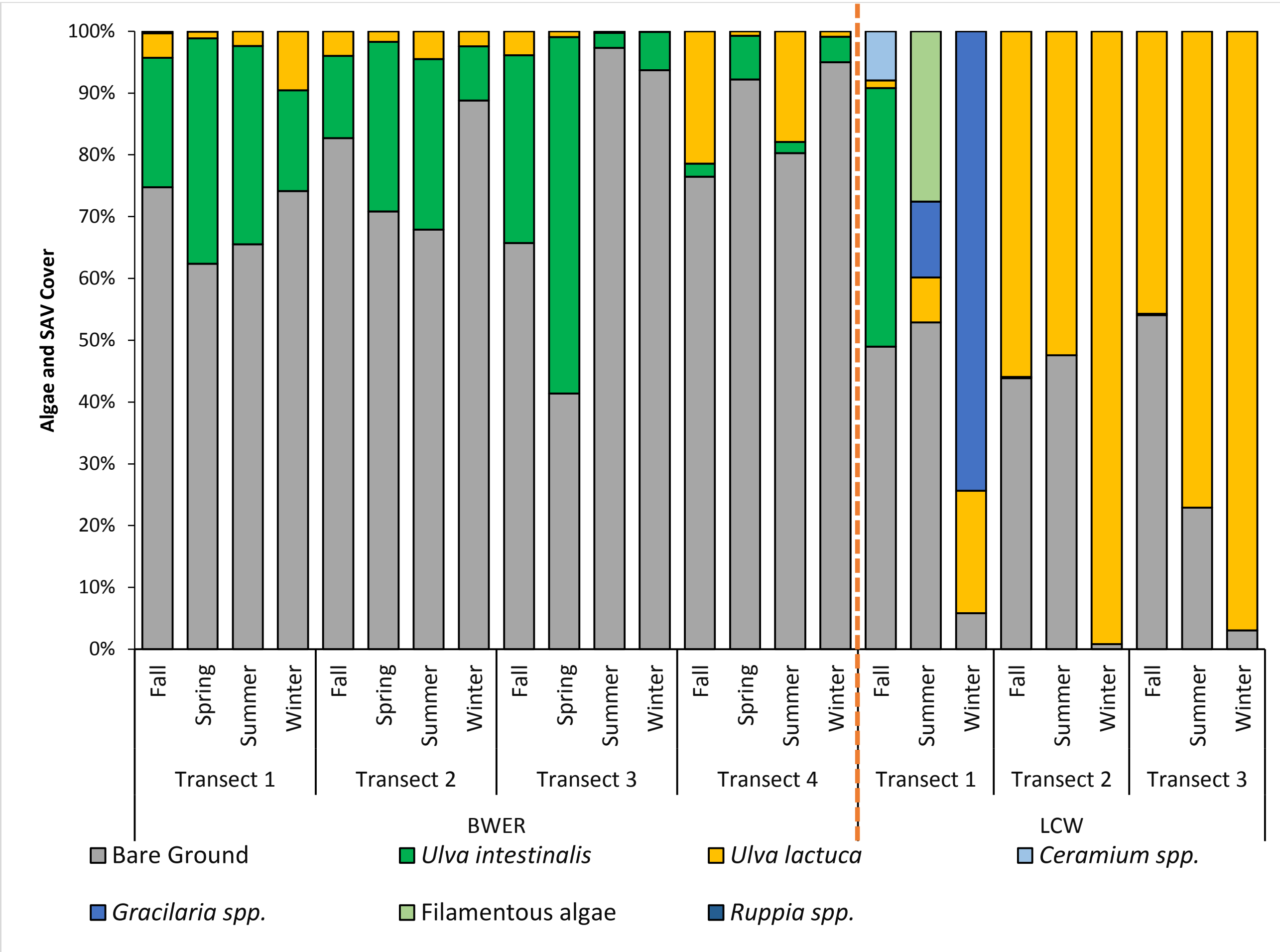

Figure 42. Average percent cover by wetland sub-area for algae and submerged aquatic vegetation by transect and season.

Site-Specific Data

Ballona – Vegetation Cover

A habitat-level analysis was conducted at Ballona to evaluate a higher level of detail of native and non-native vegetation cover. Figure 43 displays the average percent cover of native and non-native vegetation cover as well as bare ground. As a primarily non-vegetated habitat type, the salt pan displayed the highest average cover of bare ground, followed by the ruderal marsh habitats, which were identified as delineated wetlands (WRA 2011) but with reduced or non-existent tidal hydrology and a high proportion of non-native vegetation cover (Medel et al. 2013). The tidal wetland habitat type had the highest average native vegetation cover and the lowest average non-native cover.

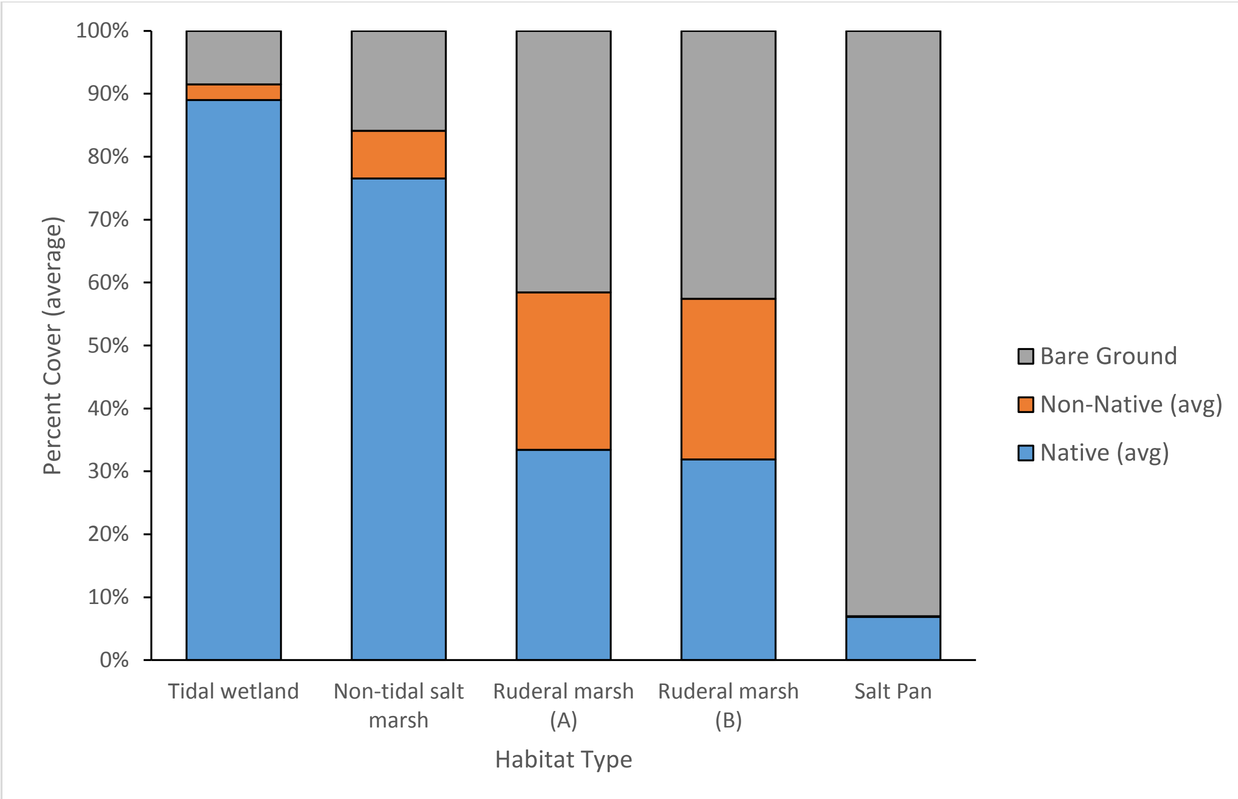

Figure 43. Percent vegetation cover at Ballona for habitat types evaluated.

Germinated Seed Bank

The seed bank of the wetland habitat types surveyed at Ballona was dominated by native seedlings in the tidal habitats and non-native seedlings in the non-tidal and ruderal habitats (Table 14, Figure 44). The salt pan, ruderal marsh, and intertidal habitats had the fewest average germinated seedlings per transect overall.

The tidal wetland habitat type had over four times the average number of native germinated seedlings per transect than the non-tidal salt marsh and over five times the number of native germinated seedlings as the ruderal marsh habitat type. The non-tidal salt marsh had over four times the number of non-native germinated seedlings per transect than the tidal wetland, and the ruderal had almost twice as many on average as the tidal wetland, yet less than half of the non-tidal salt marsh.

Native seedlings were predominantly *S. pacifica* and *J. carnosa*. Non-native seedlings were primarily annual grasses such as *Polypogon monspeliensis* (annual beard grass), which was also the second most common species, overall.

Table 14. Number of native/non-native germinated seedlings by surveyed habitat type. Averages are at the habitat-level per transect and minimum/maximum data are total number of seedlings per core.

	# Native Germinated Seedlings				# Non-native Germinated Seedlings			
Habitat Type	Min	Max	Range	Average Count / Transect	Min	Max	Range	Average Count / Transect
Intertidal	0	11	11	44.00	0	4	4	12.00
Tidal Wetland	0	162	162	101.51	0	42	42	12.75
Non-tidal Salt Marsh	0	52	52	25.61	0	179	179	50.77
Ruderal Marsh	0	62	62	19.71	0	18	18	20.86
Salt Pan	0	2	2	1.00	0	1	1	0.25

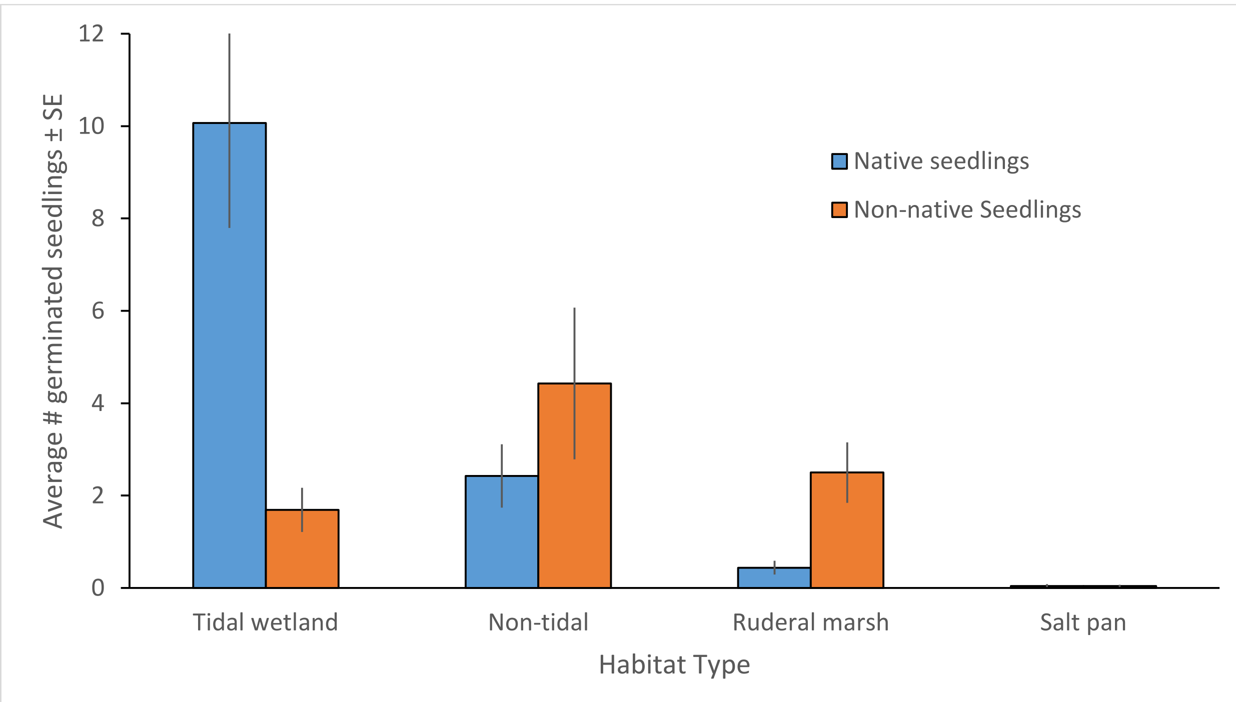

Figure 44. Average germinated seedling density per transect (± SE) for multiple habitat types at Ballona.

Additionally, three transects targeted at the intertidal wrack lines in the tidal wetland habitats were surveyed at the same transect locations across a five-year period (2010-2014). These data display trends over time, with quite a bit of variability between years (Table 15, Figure 45). *S. pacifica* made up the majority of the native germinated seedlings.

When comparing the average number of germinated seedlings per core between the habitat transects and the total count per transect for the wrack line transects (Figure 44 and Figure 45), the overall transect counts for Wrack Line 1 are much higher than the averages across even the tidal wetland transects (which had the highest average number of native germinated seedlings out of all of the habitat types). The highest number of native seedlings was found in Wrack Line 1 in year 4 (373) followed by the same transect in year 3 and year 1 (174 and 158, respectively).

Table 15. Number of native and non-native germinated seedlings by transect, by year. Totals are at the transect-level and minimum/maximum data are total number of seedlings per core.

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

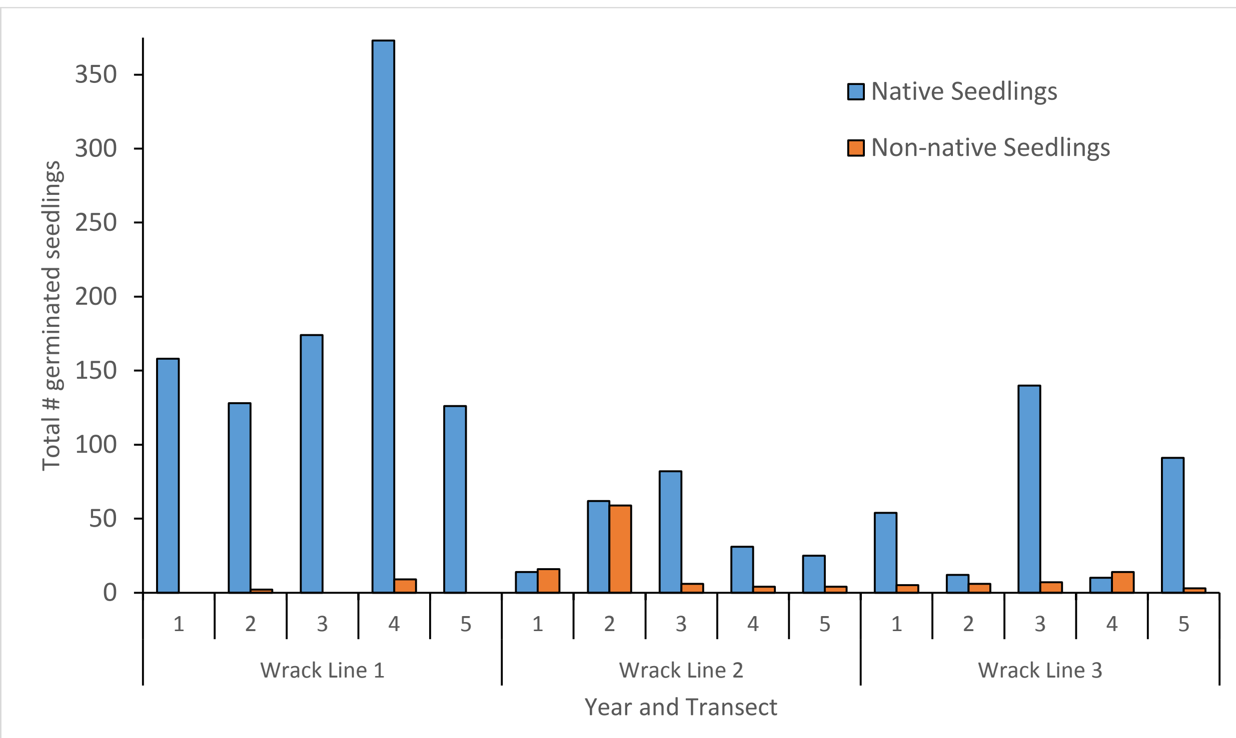

Figure 45. Total germinated seedling density transect for wrack line transects at Ballona. Note: Year 1-5 corresponds to surveys between 2010-2014.

Conclusions

Overall, the vegetation cover data reflected expected patterns of nativity based on the *a priori* classification system. The reference sites had higher overall cover, and a greater proportion of that was native species. The sites with the most impacts, stressors, and degradation over time based on Level 1 and 2 assessments displayed the highest percentages of invasion of non-native vegetation through both the cover assessments and the species richness assessments. The reference sites generally had higher native species richness, especially LCW-Steamshovel. The exception to that was Orm-Arnold, which had a greater number of native species on average than either Carp-Main or Mugu-Central.

As expected, the site with the highest number of average native species (LCW-Steamshovel) had a lower overall average proportion of cover from the top three natives than most of the other sites. At two locations, Mugu-West and Ballona A, the cover of *S. pacifica* alone was the sole contributor to the native plant cover out of the top three most prevalent species. Based on the nativity assessments, the overall condition of these two sub-areas is lower relative to the other sites, and, in the case of Ballona A, there is an increase in the presence of invasion of non-native species.

Site-Specific Conclusions: Ballona

The tidal wetland habitat type had the highest average native vegetation cover and the lowest average non-native cover. Additionally, the seed bank of transects surveyed in the tidal wetland habitat type was predominantly native, with approximately five times as many native germinated seedlings on average than non-native. The hypothesis that the wrack line seed bank transects had the highest proportion of natives and higher germination rates was supported by the Ballona data.

Additional comparisons to Level 2 CRAM data will be made in the final conclusions section of this report.

LEVEL 3: Bird Abundance

Introduction

The presence and distribution of avifauna within an ecosystem is often used as an index of habitat quality because of their diet and vulnerability to environmental conditions (Conway 2008). Bird communities are in constant flux; therefore, regular, repeated surveys help maintain a clear picture of bird communities on a site. Bird surveys completed for this project included a comparison of two survey methods, box count and point count, across three wetlands and six hydrologically distinct sub-units of those wetlands. Species lists and richness tables and graphs were created to analyze the data.

Methods

Bird surveys were conducted in accordance with the box count and point count methodologies described in detail in the "CA Estuarine Wetland Monitoring Manual" (Johnston et al. 2015) and using SOP 5.1 (i.e. bird abundance and activity) at Ormond, Ballona, and Los Cerritos in September 2014 (Fall), January 2015 (Winter), and April 2015 (Spring). These three sites were selected to provide pre-restoration data to the individual land managers and to include several wetland habitat types across a range of condition scores. Table 16 outlines the number of surveys conducted within each hydrologic sub-unit by survey type. Surveys were conducted during the morning and evening for each survey type during each sampling season, with several exceptions due to poor survey conditions (Table 16).

Table 16. Quantity of surveys conducted by hydrologic sub-unit by survey type.

Site	Hydrologic Unit	Boxes	Total # of Box Count Surveys	Points	Total # of Point Count Surveys
Ballona	Ballona B-E	4	23	1	6
	Ballona B-W	4	22	3	18
Ormond	Orm-Arnold	3	18	2	12
	Orm-Halaco	3	18	2	12
Los Cerritos	LCW-Hellman	3	18	1	6
	LCW-Steamshovel	3	18	1	6

Results

Regional Data Results

A total of 3,944 birds were identified comprising 94 species across three wetlands and two survey types. While there were few overall trends by site across both survey types, LCW-Steamshovel had the highest number of birds observed per hectare for the box count surveys (27.48 birds/ha; Table 17) and Ballona B-W had the highest for the point-count surveys (98.49 birds/ha; Table 18). Orm-Halaco and Ballona B-E had the lowest number of birds per hectare (3.93 and 4.99, respectively) (Table 17). The trends for species richness observed per hectare were similar, with the highest number of species per hectare seen at LCW-Steamshovel on the point-count surveys (5.08 species/ha; Table 20) and the lowest seen on the box count surveys at Ballona B-E (0.46 species/ha; Table 19).

Point count surveyed generally identified a higher proportional number of birds per hectare than the box count surveys (range of 0.76 to 8.32 times more) (Tables 17 and 18), and of the surveys conducted, point count surveys also captured a higher proportion of number of species per hectare than box plot (range of 1.93 to 5.47 times more) (Tables 19 and 20).

Table 17. Bird abundances by site, sub-area, and per hectare for the box count survey method.

Site	Sub-area	Total Birds	# Surveys	Total ha	# Birds / ha
Ormond	Orm-Arnold	387	18	27.00	14.33
	Orm-Halaco	106	18	27.00	3.93
Ballona	Ballona B-E	172	23	34.50	4.99
	Ballona B-W	823	22	33.00	24.94
Los Cerritos	LCW-Hellman	177	18	27.00	6.56
	LCW-Steamshovel	742	18	27.00	27.48

Table 18. Bird abundances by site, sub-area, and per hectare for the point-count survey method.

Site	Sub-area	Total Birds	# Surveys	Total ha	# Birds / ha
Ormond	Orm-Arnold	255	12	7.88	32.36
	Orm-Halaco	120	12	3.94	30.46
Ballona	Ballona B-E	45	6	11.82	3.81
	Ballona B-W	776	18	7.88	98.49
Los Cerritos	LCW-Hellman	215	6	3.94	54.57
	LCW-Steamshovel	126	6	3.94	31.98

Table 19. Bird species richness by site, sub-area, and per hectare for the box count survey method.

Site	Sub-area	Total # Species	# Surveys	Total ha	# Species / ha
Ormond	Orm-Arnold	35	18	27.00	1.30
	Orm-Halaco	24	18	27.00	0.89
Ballona	Ballona B-E	16	23	34.50	0.46
	Ballona B-W	42	22	33.00	1.27
Los Cerritos	LCW-Hellman	28	18	27.00	1.04
	LCW-Steamshovel	35	18	27.00	1.30

Table 20. Bird species richness by site, sub-area, and per hectare for the point-count survey method.

Site	Sub-area	Total # Species	# Surveys	Total ha	# Species / ha
Ormond	Orm-Arnold	31	12	7.88	3.93
	Orm-Halaco	24	12	7.88	3.05
Ballona	Ballona B-E	10	6	3.94	2.54
	Ballona B-W	29	18	11.82	2.45
Los Cerritos	LCW-Hellman	17	6	3.94	4.32
	LCW-Steamshovel	20	6	3.94	5.08

The number of species identified within each site across both survey types are presented in Figure 46. While the number of identified species for each site is similar for each season, demonstrable seasonal variation was identified, with winter surveys capturing the highest quantity of bird species with a range across all three sites of 40 – 42 species. The next highest quantities of bird species was found in Spring (27 – 34 species) and the lowest number of identified bird species in during fall surveys (17 – 22 species).

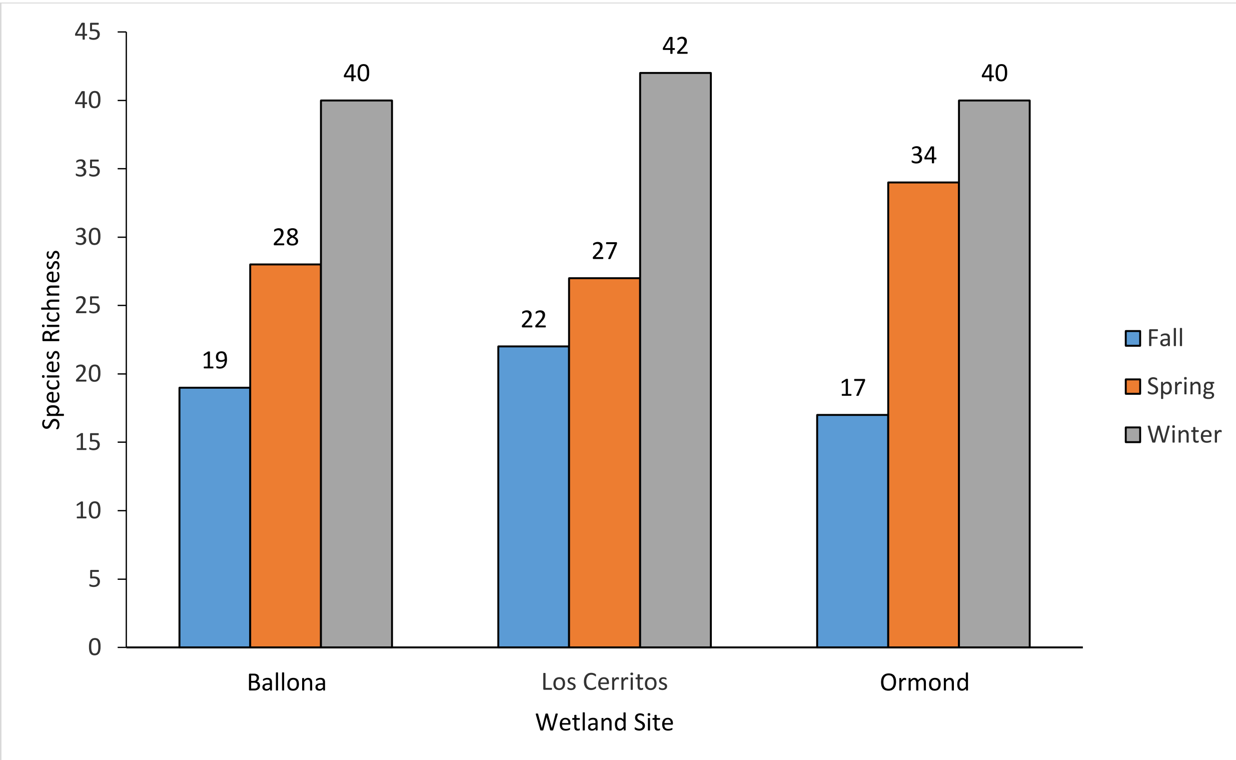

Figure 46. Number of bird species identified for both survey types by season and site.

Table 21 list all species identified by site and season for both survey types combined (i.e. box count and point count). Two species were identified during all surveys during all sites and seasons, the least sandpiper (*Calidris minutilla*) and the California Special Status Belding's savannah sparrow (*Passerculus sandwichensis beldingi*). The common yellowthroat (*Geothlypis trichas*) and willet (*Tringa semipalmata*) were also identified in all surveys except one.

Table 21. Bird species identified by site and season for both survey types combined.

	Ormond			Ballona			Los Cerritos		
Bird Common Name	Fall	Spring	Winter	Fall	Spring	Winter	Fall	Spring	Winter
Allen's Hummingbird		X						X	
American Avocet		X	X						X
American Coot			X			X			
American Crow					X				
American Kestrel	X		X	X		X	X		X
American Pipit			X			X			
American White Pelican									X
American Wigeon			X			X			X
Anna's Hummingbird		X				X			
Baird's Sandpiper					X				
Barn Swallow		X		X	X	X	X	X	
Belding's Savannah Sparrow	X	X	X	X	X	X	X	X	X
Belted Kingfisher				X		X			X
Black Phoebe			X			X	X	X	X
Black-bellied Plover		X	X	X		X	X		X
Black-necked Stilt		X	X						
Bufflehead			X			X			X
California Gull	X								
Canada Goose - feral						X			
Caspian Tern					X		X		
Cassin's Kingbird						X		X	X
Cinnamon Teal		X		X					X
Clark's Grebe									X
Cliff Swallow		X		X	X			X	
Common Goldeneye			X						
Common Raven									X
Common Yellowthroat	X	X	X	X	X	X	X	X	
Cooper's Hawk						X	X		
Double-crested Cormorant					X				X
Dunlin			X		X	X		X	
Eared Grebe			X					X	X
European Starling		X						X	
Forster's Tern								X	X
Gadwall			X						
Great Blue Heron				X		X	X	X	X
Great Egret				X			X		X
Greater Yellowlegs			X					X	X

Great-tailed Grackle		X							
Green-winged Teal		X				X			X
Heermann's Gull							X		
Horned Lark		X							
House Finch		X		X	X			X	
House Wren				X	X	X	X	X	
Killdeer			X	X	X	X	X	X	X
Lazuli Bunting					X				
Least Sandpiper	X	X	X	X	X	X	X	X	X
Least/Western Sandpiper							X		
Lesser Goldfinch								X	
Lesser Scaup									X
Lesser Yellowlegs			X						
Lincoln's Sparrow			X			X			
Loggerhead Shrike	X		X		X				
Long-billed Curlew					X				
Long-billed Dowitcher		X	X		X	X	X		
Mallard		X	X		X	X			
Marbled Godwit			X			X	X		X
Marsh Wren		X	X			X			X
Mourning Dove					X		X		X
N/A									
Northern Harrier		X	X			X			X
Northern Mockingbird		X						X	
Northern Pintail									X
Northern Rough-winged Swallow		X					X		
Northern Shoveler			X			X			
Pied-billed Grebe									X
Red-breasted Merganser									X
Red-necked Phalarope	X								
Red-tailed Hawk			X	X				X	
Red-winged Blackbird		X							
Ring-billed Gull							X		
Ruddy Duck			X						
Savannah Sparrow	X			X	X	X		X	X
Say's Phoebe						X			X
Semipalmated Plover	X		X	X	X	X		X	
Semipalmated Sandpiper	X								
Snowy Egret		X	X		X	X			X

Snowy Plover		X							
Song Sparrow	X	X		X	X	X			
Sora		X	X						X
Tree Swallow		X	X		X				X
Turkey Vulture	X	X					X	X	X
Western Grebe									X
Western Gull	X	X							
Western Kingbird								X	
Western Meadowlark			X		X	X			X
Western Sandpiper	X	X	X		X	X		X	X
Whimbrel		X			X	X		X	
White-crowned Sparrow						X			X
White-faced Ibis		X	X						
White-tailed Kite	X		X						
Willet		X	X	X	X	X	X	X	X
Wilson's Phalarope	X								
Wilson's Snipe			X			X			
Yellow-headed Blackbird	X								
Yellow-rumped Warbler			X			X			X
TOTAL SPECIES RICHNESS	**17**	**34**	**40**	**19**	**28**	**40**	**22**	**27**	**42**

Conclusions

Except for the spring surveys, Los Cerritos had a slightly higher overall bird species richness by season, as well as the highest overall species richness per hectare and abundance (LCW-Steamshovel). However, the number of species identified within each wetland site was relatively similar across all seasons. Data indicate high variability in species presence within each wetland site and may be partially attributed to the presence and distribution of adjacent habitats. For example, the highest quantity of grassland and miscellaneous landbird species was found within Ballona, which is the only wetland site with sizeable grassland and upland habitat types adjacent to wetland areas. Additionally, the highest quantity of shorebird species were identified within Ormond, which constitutes the only wetland site immediately adjacent to natural or semi-natural beach and coastal strand habitat types.

Increased species richness within winter surveys indicate that all wetland sites are being utilized by a variety of bird species as an over wintering migratory stopover location. This is not surprising as the surveyed wetland systems constitute some of the largest estuarine wetland habitat areas within Los Angeles and Ventura counties. The function of these sites as a winter stopover are becoming increasingly important as wetland resources continue to decline within the region.

LEVEL 3: Terrestrial Invertebrates

Introduction

Terrestrial invertebrates are an important component of wetland and adjacent habitat food webs and can be seen as indicators of the overall health of a system (Zedler 2001). Invertebrate-related ecosystem function has traditionally been measured by enumerating and identifying insects to the species level to calculate compositional biodiversity. In practice, such approaches are exceedingly costly, require extensive periods of sample interrogation, and therefore have resulting processing times on the order of many months to years for monitoring efforts with robust/frequent sampling plans.

Logistically, simpler and more rapid measures that more directly describe functions or rates of arthropod productivity may be better indicators of ecosystem health (Anderson 2009, Johnston et al. 2011, 2012). The high diversity of coastal arthropods, a lack of complete baseline inventories, and the growing dearth of qualified invertebrate taxonomists also make traditional high-resolution taxonomically-focused terrestrial invertebrate assessments in this habitat expensive and difficult. As a result, analyses for this report focused on biomass of aerial arthropods as a proxy for productivity and order richness for invertebrates in pitfall traps by wetland and sub-area.

Methods

Specific terrestrial invertebrate (i.e. pitfall and aerial traps) sampling methods followed descriptions from the "CA Estuarine Wetland Monitoring Manual" (Johnston et al. 2015) and the individual SOP for terrestrial invertebrate monitoring (Appendix B – 6.2). Details on the sampling design and frequency are found in Table 22. Data were collected from a subset of the regional wetlands to assess a range of habitat types and hydrological connectivity (e.g. fully tidal at LCW-Steamshovel, muted tidal at the Ballona B-W). Data are presented as biomass per meter squared for aerial traps (Figure 47) and are presented at the order level for pitfall traps by wetland and sub-area.

Table 22. Sampling design and frequency of aerial and pitfall traps.

Wetland Name	Sub-Area	Season or Date Range	# Aerial Trap Transects	# Pitfall Trap Transects
Carpinteria	Carp-Ash	Fall 2013	7	0
Ormond	Orm-Arnold	Fall 2013 and Fall 2014	3	7
	Orm-Halaco	Fall 2013 and Fall 2014	21	7
Mugu	Mugu-Central	Fall 2013 and Fall 2015	7	0
Ballona	Ballona B-E	Fall 2013	4	4
	Ballona B-W	Fall 2013	17	21
Los Cerritos	LCW-Hellman	Fall 2013	6	6
	LCW-Steamshovel	Fall 2013	12	7

Figure 47. Photograph of deployed aerial arthropod sticky trap with tomato cage removed.

Results

Regional Data Results

Aerial Traps

Biomass data collected from aerial trap data are presented in Figure 48 as grams per square meter for each hydrologic sub-unit. The highest biomass was found at Orm-Arnold (6.64 ± 0.2 grams / m²) followed by LCW-Steamshovel (5.98 ± 1.7 grams / m²). The lowest biomass values were both within salt pan habitat areas of Los Cerritos and Mugu Lagoon with biomass values of 0.51 ± 0.04 and 0.79 ± 0.4 grams / m², respectively.

Overall, wetland-sub areas within Ormond demonstrated the largest range in biomass values from an average maximum of 6.64 ± 0.2 grams / m² at Arnold to 0.79 ± 0.4 grams / m² within salt pan areas.

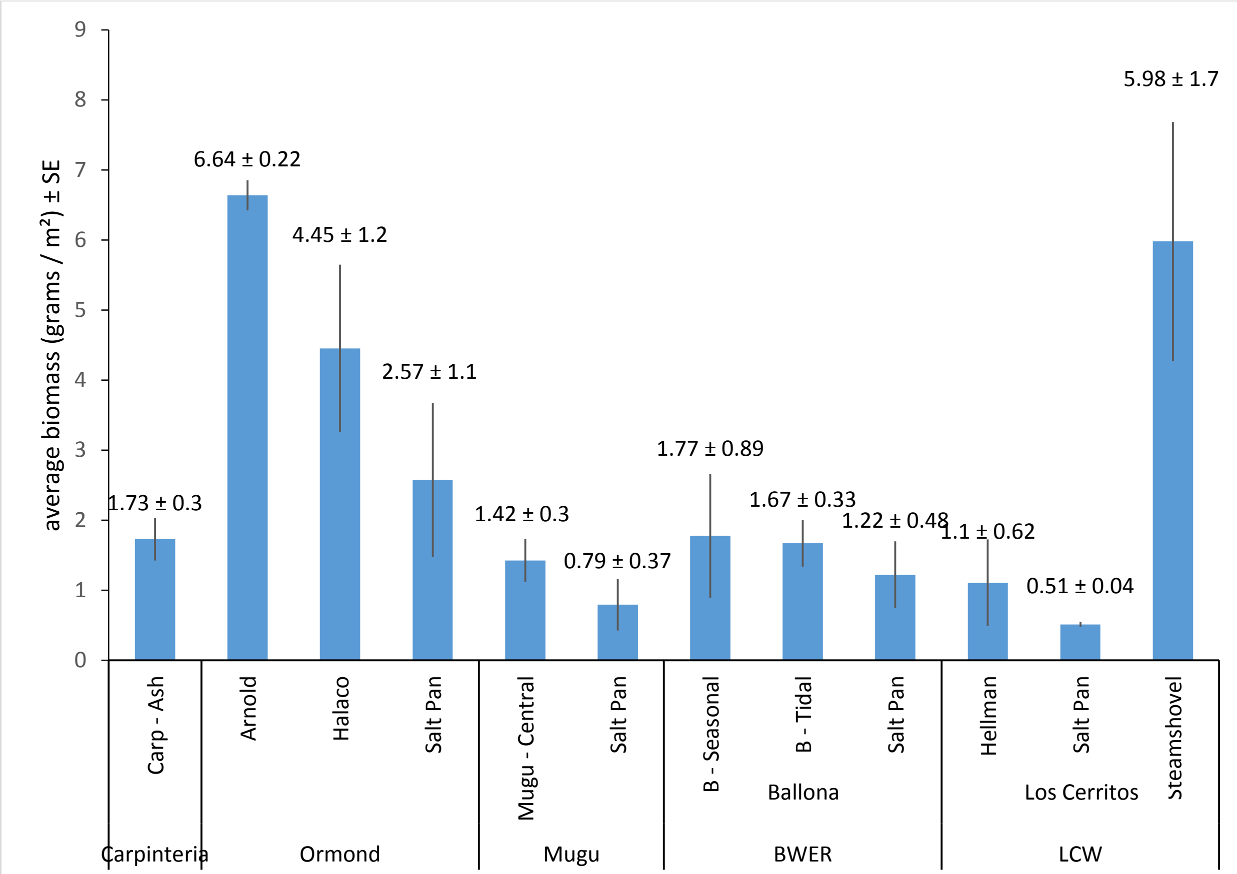

Figure 48. Average aerial invertebrate biomass in grams / m² displayed by wetland sub-area.

Table 23 displays the average number of invertebrates in each size class per transect per wetland sub-area. However, in some instances several transects had an extra sticky trap for error assessments. These extra traps are not accounted for in the averages, so the numbers may not be exactly representative of the transect-level average. The highest frequency of captured aerial invertebrates by size class was found in the smallest category (i.e. 0.5 mm or smaller). The smallest average number of captured aerial invertebrates was found in the largest size class bins (i.e. 5-10 mm and > 10 mm) for all wetland sub-areas.

Table 23. Aerial invertebrate data displayed as average number of invertebrates by size class for each wetland and sub-area.

Wetland	Sub-Area	0.5 mm	< 2 mm	2-5 mm	5-10 mm	> 10 mm	# of Transects
Carpinteria	Carp-Ash	42.14	70.71	4.08	1.40	0.04	7
Ormond	Orm-Arnold	61.00	21.10	6.77	5.57	0.87	3
	Orm-Halaco	66.05	27.75	11.32	3.69	0.39	21
Mugu	Mugu-Central	14.71	21.08	8.33	1.22	0.07	7
Ballona	Ballona B-E	150.25	14.00	12.17	1.21	0.13	4
	Ballona B-W	96.65	29.60	5.74	1.40	0.11	17
Los Cerritos	LCW-Hellman	236.00	8.97	7.97	0.28	0.11	6
	LCW-Steamshovel	121.42	73.22	99.78	0.74	0.04	12

Pitfall Traps

Table 24 displays all invertebrate orders identified within each surveyed wetland sub-area. A total of 24 invertebrate orders were identified within the surveyed wetland sites (i.e. Ballona, Los Cerritos, and Ormond). Six orders of taxa were identified ubiquitously within all the wetland sub-areas, including: Araneae, Coleoptera, Diptera, Hemiptera, Hymenoptera, and Isopoda.

The highest quantity of taxa were identified within the B-tidal wetland sub-area of Ballona (21 total orders); however, at least three times as many transects were surveyed within B-tidal than all other sub-areas. The remaining sub-areas with relatively comparable numbers of surveyed transects found the highest number of invertebrate orders identified at LCW-Hellman. By wetland site, the lowest identified orders were found within both Ormond sub-areas which displayed the lowest taxa counts (i.e. Arnold = 8 orders, Halaco = 10 orders). Numbers of transects were not accounted for in the analyses; instead, presence by order is represented by Table 24, below. Figures 49 and 50 are representative photos of two pitfall invertebrate orders.

Table 24. Invertebrate orders identified by wetland sub-area.

Order	Ormond		Ballona		Los Cerritos	
	Orm-Arnold	Orm-Halaco	Ballona B-E	Ballona B-W	LCW-Hellman	LCW-Steamshovel
Amphipoda				X	X	X
Araneae	X	X	X	X	X	X
Arcanae		X				
Blattodea				X	X	
Coleoptera	X	X	X	X	X	X
Decapoda						X
Dermaptera	X		X	X	X	
Diptera	X	X	X	X	X	X
Embiidina			X	X		
Entomobryomorpha				X		
Hemiptera	X	X	X	X	X	X
Homoptera		X				
Hymenoptera	X	X	X	X	X	X
Isopoda	X	X	X	X	X	X
Lepidoptera	X	X	X	X	X	
Microcoryphia			X	X	X	X
Oribatida				X		
Orthoptera		X		X	X	
Pseudoscorpionida				X		X
Psocodea			X	X	X	
Squamata			X	X		
Thysanoptera				X		
Trombidiformes			X	X	X	
Zygentoma			X	X	X	
Total Number of Orders	**8**	**10**	**14**	**21**	**15**	**10**

Figure 49. Photo of order Coleoptera invertebrate from Ballona as dorsal view.

Figure 50. Photo of order Blattodea invertebrate from Ballona as lateral view.

Conclusions

A varied sampling strategy was implemented within each wetland sub-area which made direct comparisons fairly difficult. However, the aerial invertebrate biomass data do not seem to express any clear trends based on site impacts or degradation. The data also do not appear to follow the patterns expressed by the vegetation and CRAM data (e.g. higher cover and scores at the healthier wetland locations).

As the largest number of pitfall transects were conducted within Ballona B-W, it was expected that wetland sub-area would capture the highest taxa (order) richness. This finding supports the idea that terrestrial invertebrate populations may have small distribution ranges even within similar habitat areas, and they may require extensive sampling grids to capture cryptic or low abundance taxa. A comprehensive regional wetland invertebrate inventory has never been conducted and little research has been performed on invertebrate taxa distributions. Three orders (i.e. Arcanae, Decopoda, Homoptera) were only captured within a single sub-area and may be less common or not appropriately captured by a pitfall collection methodology. Decopoda was likely captured at LCW-Steamshovel because the pitfalls experienced periodic flooding during high tides. The orders listed in Table 24 may constitute the beginnings of a framework for order-level data expected within regional wetlands.

Conclusions and Wetland Condition Assessments

Regional wetland goals from alliances such as the Southern California Wetlands Recovery Project (WRP) include prioritizing wetland restoration efforts and overseeing post-restoration maintenance through adaptive monitoring and management (WRP 2001). Managing and restoring these systems requires a regional perspective that can inform holistic decision making (Stein et al. 2014, Anderson 2013). While individual Level 3 protocols provide high resolution datasets for discreet parameters, it is imperative to integrate a multi-level (i.e. Level 1, 2, and 3) monitoring strategy to address broader scale questions regarding overall wetland health or ecological function across a range of ecological indicators. Level 1 and 2 analyses begin to provide a context for urbanization impacts, and Level 3 data support the condition assessments and provide in-depth parameter-specific functional baselines.

There were two primary objectives of this project. The first was to increase knowledge of the health and functioning of regional estuarine wetlands while informing adaptive management opportunities and long-term restoration plans for several degraded wetland systems (e.g. Ballona Wetlands Ecological Reserve, Ormond Beach Wetlands, Los Cerritos Wetlands complex). To address the first goal, this report examines Level 3 data results in combination with Level 2 CRAM results to provide a broad characterization about the health of each of the wetlands evaluated and the health of wetlands in the north-central sub-region of the Southern California Bight. The second goal was to field-test a series of Level 3, site-intensive, protocols to help guide the framework for a standardized method approach through the development of a "California Estuarine Wetland Monitoring Manual" (see companion document, Johnston et al. 2015). Individual protocols were implemented to collect quantitative biological data. To address the second goal, a Level 3 protocol evaluation was conducted and a brief summary is included in the conclusions, below; however, detailed protocols, descriptions, and comparative analyses may be found in the Monitoring Manual companion document to this report (Johnston et al. 2015) or http://www.santamonicabay.org/learn/reports/.

Based on the goals of this project, the data results presented are preliminary and are being analyzed in greater detail as part of an ongoing Level 3 monitoring program for the USEPA. The sampling design of this project focused on five large coastal estuarine systems as a starting point, and intentionally included a range of possible conditions of wetland habitat types, including highly degraded sites. The conclusions below are interpretations based on the specific systems included as part of this project and may not reflect conditions of the entire Southern California Bight. Additionally, Level 3 analyses and conclusions in this report specifically targeted delineated wetland habitats and did not extend to adjacent habitat types. Thus, the larger context for the health of each system as a whole may not have been captured.

Data collected as part of this project were provided to individual land managers and scientists conducting research at individual wetlands to aid in restoration planning efforts. Using the summary findings and data from this report as a baseline, additional project-specific data collection and analyses should be conducted for each degraded area prior to restoration planning efforts focusing on the goals of the individual restoration project. Methods used should generate data that are compatible with potential post-restoration evaluations and success criteria, and resulting adaptive management.

Condition of Surveyed Wetlands in Southern California

Southern California's coastal estuarine wetlands provide a broad suite of ecological, hydrological, and biogeochemical functions (Stein et al. 2014). Yet, southern California has more flood control dams, debris basins, and miles of concrete-encased stream channels than any other region in the nation (WRP 2001). The region has lost approximately 75% of its coastal estuarine wetlands, with Los Angeles and Orange Counties suffering a disproportionately high percentage of loss (Stein et al. 2014). Much of the loss can be attributed to type conversion of wetland areas into upland or subtidal habitat types. Level 1 analyses for the five wetland sites included in this project confirmed many of the impacts, identified historic type conversions, and categorized stressors including habitat fragmentation, hydrological disconnection, fill deposition, and overall degradation. The wetland loss indicates both an overall loss of biodiversity and corresponding functionality loss over time (Stein et al. 2014). Although coastal wetlands in southern California have been subjected to severe loss and impacts over time, this project is the first step towards constructing a regional framework (with a focus on the north-central portion of the Southern California Bight) to evaluate the current health of individual sites at a more intensive level.

As there are no wetlands in southern California devoid of impacts, no single system will likely present the full suite of potential ecological functions. This was initially confirmed by proxy from a lack of final CRAM scores exceeding 89.2 at any wetland sub-area evaluated. In fact, only two site sub-areas (Carp-Main and Mugu-Central) had individual CRAM AA scores over 80. Several of the wetland sub-areas were found to be significantly degraded when compared to the *a priori* reference locations, and patterns emerged consistently by sub-area across multiple attributes. Combining the Level 1 and Level 2 data also identified clear patterns in watershed-level stressors and CRAM scores. For example, substantial hydrological modifications were present at many of the degraded sites such as armored levees or concrete culverts (e.g. Ballona A and B-E, Mugu-West Arm, LCW-Hellman). The modifications reduced their hydrology CRAM scores and impacted biotic structure conditions, leading to lower overall final CRAM scores. Three higher condition sub-areas of the wetland sites emerged from these analyses: Carp-Main, Mugu-Central, and to some extent, LCW-Steamshovel. Each of the three sub-areas were characterized by the presence of continued hydrological connectivity, specifically, tidal influence.

To some degree, hydrology (based on Level 1 and Level 2 assessments) seemed to be the best predictor of variability in overall wetland condition (final CRAM score). In addition to having the highest correlation value, it can be an important driving mechanism for the other attributes (except for landscape and buffer condition). Tidal inundation supports robust estuarine wetland vegetation populations adapted to daily fluctuations in water level and salinity regimes and helps develop heterogeneous niche habitat structures. Thus, the sites with the most significant alteration of the natural hydrology (e.g. Ballona and Ormond) also had comparatively lower CRAM final scores. These findings are supported by similar studies in other systems (e.g. Anderson 2013).

Level 3 and Level 2 (CRAM) Comparisons

Overall, the Level 3 vegetation data reflected the highest degree of corroboration of the Level 1 assessments and Level 2 CRAM results by wetland sub-area. The sites with the most impacts, stressors, and degradation over time, based on Level 1 and 2 assessments, displayed the highest percentages of invasion of non-native vegetation through both the cover assessments and species richness assessments. The higher condition sites, as identified by CRAM, generally had higher native species richness, especially LCW-Steamshovel. Additionally, when evaluated at a site-specific level (i.e. Ballona), the areas with the highest vegetation cover of native species were also those that had higher hydrology condition scores, thus supporting the need for tidal connectivity to reach a higher condition level for estuarine habitats.

Clear patterns of interpretation of the bird and invertebrate data were not immediately apparent. Both sets of data require more significant levels of data analysis by ornithologists and entomologists, respectively, to understand the complexity of patterning in the data (e.g. guilds, functional groups, etc.). It is also likely that birds and invertebrates require both a larger heterogeneous set of evaluated sites (both sets of data were only collected at a subset of the project sites) and additional adjacent habitat evaluations, etc., to clearly identify trends and assess the data at a functional level.

Site-Specific Wetland Condition Assessments

While the *a priori* classifications are important to separate sub-areas into potential categories for detailed statistical analyses, they are still overgeneralized for site-specific wetland condition assessments. Thus, Table 25, in lieu of including the *a priori* categorization, includes a brief description of overall condition for each sub-area based on the *post hoc* assessments of the data results, based primarily on CRAM and vegetation assessments. These descriptions are derived from data comparisons presented in this report, and are not necessarily reflective of their scale or range relative to other California systems or a broader evaluation, except in the context of the standardized CRAM scores.

Ballona A was consistently the lowest scoring sub-area; however, it is also the sub-area that retains the fewest characterizations of an estuarine wetland, and most of it only meets wetland delineation criteria for some regulatory agency standards (e.g. Coastal Commission, but not Army Corps). It had the highest degree of invasion of non-native vegetation, lowest CRAM scores, and poor hydrology. Mugu-West Arm displayed similar data results, for the assessments conducted. The grouping of the next tier up in condition scores based on the metrics analyzed included: LCW-Hellman, Ballona B-E, and Orm-Halaco. All three sub-areas had similar vegetation results and experience limited hydrological connectivity. Carp-Main and Mugu-Central both consistently exhibited trends on the higher end of the evaluation range for most individual metrics, including vegetation cover, CRAM scores, and reduced of presence of non-native species. Table 25 describes results from each sub-area in more detail.

Although specific functions were not assessed for this report other than those loosely covered by the Level 3 protocols (e.g. invertebrate biomass as a food subsidy) and those functions for which CRAM serves as a proxy (e.g. structural patch richness and physical structure as a proxy for wildlife use of the site), Table 25 assumes high overall condition scores translate to higher and more diverse functions provided by that individual wetland sub-area.

Table 25. Classification of sub-area condition based on *post-hoc* data evaluations.

Wetland	Sub-Area	*Post-hoc* Assessment
Carpinteria	Carp-Ash	This restoration sub-area had some of the highest biotic attribute scores, while not receiving the upper echelon of hydrology or landscape scores, thus making it a slight outlier. The CRAM final and physical structure scores were the second highest, overall, and it had the highest cover of native vegetation, no non-native vegetation species, and second largest number of native vegetation species.
	Carp-Main	While still part of the smallest wetland system included in this project (i.e. Carpinteria), this was one sub-area that clearly retains and/or provides many of the higher level functions of a wetland based on most CRAM metrics, final score, and vegetation data. It could be used in future assessments as a reference site or for the upper range of regional condition assessments for many metrics.
Ormond	Orm-Arnold	This sub-area presented conflicting results. It received the lowest overall physical structure attribute score, low hydrology and landscape scores, and the second lowest final CRAM score (second to Ballona A). However, it had a fairly high overall cover and species richness of native vegetation species. More site-specific surveys should be conducted to inform restoration processes.
	Orm-Halaco	This sub-area also experienced lower hydrology scores, while falling generally into the middle range of the overall CRAM assessments and significantly below Carp-Main. It was similar to LCW-Hellman and Ballona B-E in native vegetation cover.
Mugu	Mugu-Central	This sub-area may also be appropriate to use as a reference location in future assessments as it often represented the upper range of condition scores (similarly to Carp-Main). Specifically, it received the highest hydrology and landscape attribute scores and had a high overall cover of native vegetation, although it was predominantly *S. pacifica*.
	Mugu-West	Portions of this sub-area have undergone restoration, although the bulk of the area still experiences hydrological restrictions. However, it still fell on the higher CRAM hydrology score range with slightly lower scores than Carp-Main.
	Mugu-West Arm	While not evaluated for most assessment metrics (e.g. Level 3 methods), this area is the most hydrologically restricted out of the three sub-areas evaluated for this project and retained some of the lowest CRAM scores.

Wetland	Sub-Area	*Post-hoc* Assessment
Ballona	Ballona A	This sub-area consistently fell at the lower end of the spectrum of all analyses, likely because it is no longer functioning as estuarine wetland habitat. It received the lowest CRAM scores, lowest native vegetation results, and highest degree of invasion from non-native vegetation. Conversion back to wetland habitat from degraded fill spoils could dramatically increase the functional lift of this habitat type as a wetland.
	Ballona B-E	Receiving slightly better scores in most CRAM assessments than Ballona A, this sub-area also had higher overall native vegetation cover, although it was predominantly a monoculture of *S. pacifica*. It also fell below the middle range of CRAM scores for hydrologically-similar sites (e.g. LCW-Hellman) with a higher average percentage of non-native vegetation cover.
	Ballona B-W	To some extent, this area could be classified as a restoration area, given the increase in the tidal prism since the 1990's. Of the Ballona sub-areas, it consistently was on the higher end of the condition score ranges. However, when compared to the rest of the project sites, this sub-area had low native vegetation species richness, high non-native vegetation cover, and similar final CRAM scores as Orm-Halaco.
Los Cerritos	LCW-Hellman	This sub-area was mostly in the same range as Ballona B-E, with similar final CRAM scores, overall native vegetation cover and number of non-native vegetation species. This may be attributed to both areas experiencing tidal muting through multiple culverts and tide gates. However, LCW-Hellman had a higher number of native vegetation species than Ballona B-E or Mugu-West and a similar number of native species as Ballona B-W.
	LCW-Steamshovel	This sub-area may be considered at a local level to be a reference site. It received overall CRAM final scores similar to Mugu-Central, and consistently high scores for many of the individual CRAM assessment metrics and attributes. It also had the highest average native species richness, far surpassing even the second-ranked site (Carp-Ash) and almost no invasion of non-native species.

These analyses provide a starting point for additional site-specific evaluations to inform restoration planning efforts (especially at several sub-areas at Ballona, Ormond, and Los Cerritos) and to inform current land management practices. For example, increasing the tidal prism at several of the wetland sites not completely hydrologically restricted (e.g. LCW-Hellman) could provide an increase in the overall health of the area.

Protocol Evaluations

While site-specific goals should be the principal consideration to inform protocol selection and sampling design, this project also evaluated the protocols included in this report and others as part of supplementary monitoring programs. The companion document to this report, the "CA Estuarine Wetland Monitoring Manual" (Johnston et al. 2015), provides a suite of protocol recommendations based on analyses conducted as part of this project, including weighing multiple factors influencing protocol implementation and choice, including: resource requirements, quality and importance of data outputs, and site disturbance. Specifically, the analyses included in this report and other data analyses were used to supplement the Level 3 survey and data quality assessments and evaluations for each of the Standard Operating Procedures in the Manual (Johnston et al. 2015, Appendices B-1.1 through B 7.2). Through evaluation of multiple protocols for each of the main parameter categories, the report and Manual provide the basis for a monitoring "toolkit" which should be supplemented by additional protocols and/or additional parameters on a site- or project-specific basis. Detailed protocols, descriptions, and comparative analyses can be found in the Monitoring Manual (Johnston et al. 2015), including many of the specific methods for the data collection included in this report.

Next Steps

Further analyses should be conducted on the range of habitat types at each wetland site and the possibility that there is a connection between the diversity of habitats and several of the indicators evaluated in this report (e.g. invertebrates, birds). Additional statistical evaluations should be conducted to further strengthen the conclusions, especially correlating individual CRAM score metric results with some of the vegetation assessments and nativity of each sub-area. Anomalies, especially the sub-areas classified as 'degraded' that did not express the same patterns as the other degraded sites, should be explored further and subsequently reevaluated. Site-specific functions should be assessed for each site individually before the development and implementation of a full restoration.

The next step for the Level 3 program development will crosswalk pre-existing monitoring program datasets to assess their comparability given slight differences in protocol implementation, sampling frequencies, or constraints. Cross-program data transfer and the opportunity to synthesize the datasets in an online database management system should be further explored. This project did not translate the data into performance targets, whether at a site-specific or regional level. To achieve this, additional datasets will be collected, combined, and evaluated in further investigations.

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