The Ballona Wetlands Ecological Reserve Baseline Assessment Program 2009-2010 Final Report

Ballona Wetlands Ecological Reserve, Los Angeles, California
Santa Monica Bay Restoration Commission

Prepared for: California State Coastal Conservancy
California Department of Fish and Game
November 2011

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This report should be cited as follows:

Johnston, K.K., Del Giudice-Tuttle, E., Medel, I.D., Bergquist, S., Cooper, D.S., Dorsey, J., and Anderson, S. 2011. "The Ballona Wetlands Ecological Reserve Baseline Assessment Program: Year One Report." Santa Monica Bay Restoration Commission. *Prepared for the California State Coastal Conservancy, Los Angeles, California.*

Cover Photo Credit:

Karina Johnston; Santa Monica Bay Restoration Commission

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Acknowledgements:
The Ballona Wetlands Baseline Assessment Program was funded by a grant from the California State Coastal Conservancy. We would like to thank the members of the Conservancy who made this project possible and continuously supported it along the way: Mary Small and Sam Schuchat. We would also like to thank the California Department of Fish and Game for providing site access, support, and technical advice, specifically Karen Minor, Rick Mayfield, Terri Stewart, and Dave Lawhead. A special acknowledgement to Sean Bergquist for his strong leadership role and guidance throughout the stages of this project and for being one of the monitoring program's most steadfast supporters.

I am extraordinarily grateful to the numerous people who dedicated and volunteered their time, efforts, and expertise to this project. Thank you to the Technical Advisory Committee of the Santa Monica Bay Restoration Commission for providing technical review in multiple stages of this project, including protocol development and document review. Thank you also to Cooper Ecological Monitoring, Inc., Edith Read and Associates, Southern California Coastal Water Research Project, Southern California Edison, the City of Los Angeles, Los Angeles County, and the Friends of Ballona Wetlands for their assistance and collaboration. We greatly appreciate all of the comments, suggestions, and external peer review from John Dorsey, Dan Cooper, Sean Anderson, Richard Ambrose, Amanda McCarthy, Phil Greer, Edith Read, Jack Goldfarb, Andrew Keller, Eric Zahn, Taylor Parker, Nick Garrity, Hubertus Cox, Ida Meisami-Fard, and Pam Hosking.

We would not have been able to complete the data collection and sampling efforts without the tireless efforts of a full volunteer and student intern monitoring team. Your dedication allowed a phenomenal amount of comprehensive surveying to take place over 12 months. Thank you very much to all who participated.

bay restoration commission
STEWARDS OF SANTA MONICA BAY

CALIFORNIA DEPARTMENT OF FISH&GAME

State of California
Coastal Conservancy

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ABBREVIATION TABLE

µg/kg – micrograms per killigram
µg/L – micrograms per liter
BAP – Ballona Wetlands Ecological Reserve Baseline Assessment Program; Baseline Assessment Program
Bight '08 - Southern California Bight Project 2008
Bay – Santa Monica Bay
BOLD – Ballona Outdoor Learning and Discovery
BWER – Ballona Wetlands Ecological Reserve; Ballona Wetlands
°C – degrees Celsius
Cal-IPC – California Invasive Plant Council
CalEPA – California Environmental Protection Agency
CDFG – California Department of Fish and Game
cm – centimeters
CEQA – California Environmental Quality Act
cfs – cubic feet per second
CNDDB – California Natural Diversity Database
CNPS – California Native Plant Society
CRAM – California Rapid Assessment Program
CSC – California Species of Special Concern
CTR – California Toxics Rule
CWA – Clean Water Act
DDT – dichlorodiphenyl trichloroethane
DO – dissolved oxygen
DPW – Department of Public Works
DTPA – diethylene triamine pentoacetic acid
EAP – Early Action Plan
ECe – Electrical Conductivity
Eco-SSL – Environmental Protection Agency's Ecological Soil Screening Level
EIR – Environmental Impact Report
EPA – Environmental Protection Agency, United States Environmental Protection Agency
ERL – effect range low
ERM – effect range median
FBW – Friends of the Ballona Wetlands
FIB – fecal indicator bacteria
Fish/m^3 – number of fish per cubic meter (density)
FWM – Ballona Freshwater Marsh
GIN – Green Info Network
GIS – geographic information system
GPS – global positioning system
HBC – Hawks Biological Consulting
HDPE – high density polyethylene
ITIS – Integrated Taxonomic Information System
IWRAP – Integrated Wetland Regional Assessment Monitoring Program
KBC – Keane Biological Consulting
LA City – the City of Los Angeles; City of LA
LADPW – Los Angeles Department of Public
LARWQCB – Los Angeles Regional Water Quality Control Board

LAX – Los Angeles International Airport
LISST - *in situ* laser refractometry
LMU – Loyola Marymount University
m – meters
MEC – Managing Environmental Concerns Analytical Systems, now Weston Solutions, Inc.
mg/kg – milligrams per kilogram
mg/L – milligrams per liter
mL – milliliter
MLLW – mean lower low water
MPN – most probable number
MSL – mean sea level
NOAA – National Oceanic and Atmospheric Administration
NO^{-2}, NO_2 – nitrite
NO^{-3}, NO_3 – nitrate
NTU – Nephelometric Turbidity Units
PAH – polycyclic aromatic hydrocarbons
PCB – polychlorinated biphenyl
PO_4 – phosphate
ppb – parts per billion
ppm – parts per million
ppt – parts per thousand
PVC – polyvinyl chloride
PWA – Phillip Williams and Associates
QAQC – Quality Assurance and Quality Control
SAV – submerged aquatic vegetation
SMBRC – Santa Monica Bay Restoration Commission
SMBRF – Santa Monica Bay Restoration Foundation
SRT – self-regulating tide gate
SSAR – Society for the Study of Amphibians and Reptiles
SCC, CCC – California State Coastal Conservancy
SCCWRP – Southern California Coastal Water Research Project
SE – standard error
SONGS – San Onofre Nuclear Generating Station
sp – species
spp – multiple species
SWAMP – Surface Water Ambient Monitoring Program
SWRCB – State Water Resources Control Board
TDS – total dissolved solids
TMDL – Total Maximum Daily Load
TOC – total organic carbon
TSM – total suspended matter
TSS – total suspended solids
US EPA – United States Environmental Protection Agency, Environmental Protection Agency
USACE – United States Army Corps of Engineers
USFWS – United States Fish and Wildlife Service
USGS – United States Geological Survey
WRP – Southern California Wetland Recovery Project
YSI – Yellowsprings Instrument

EXECUTIVE SUMMARY

The mission of the Santa Monica Bay Restoration Commission (SMBRC) is to restore and enhance the Santa Monica Bay (Bay) through actions and partnerships that improve water quality, conserve and rehabilitate natural resources, and protect the Bay's benefits and values. The SMBRC is charged with implementing the Bay Restoration Plan, a stakeholder-developed plan that describes goals, objectives, and milestones to address the environmental problems facing the Bay and the Bay watershed. Scientific monitoring of the Bay's natural resources and restoring coastal wetlands are important parts of the Bay Restoration Plan.

In September 2010, the SMBRC completed the first year of surveys at the Ballona Wetlands Ecological Reserve (BWER). The comprehensive surveys were developed in partnership with the California Department of Fish and Game and the California State Coastal Conservancy to assess the condition of the BWER and inform the state's wetlands restoration planning. The surveys incorporated monitoring and assessment of biological, chemical, and physical components of the BWER ecosystem. Vegetation, seed core, terrestrial invertebrate, soil, and elevation surveys were conducted on permanent transects randomly located throughout all habitat types at the BWER. Additional biological data collected included surveys for small and large mammals, herpetofauna, ichthyofauna, benthic invertebrates, birds, and submerged aquatic vegetation (Table 1). Water quality data collected included dissolved metals, fecal indicator bacteria, nutrients, and additional parameters. This document provides a summary of the data collected during the first year of the Baseline Assessment Program (BAP) survey of the BWER. The second year of the BAP survey will be reported separately.

CHEMICAL ANALYSES

Water quality surveys are a critical component of the BAP. Comprehensive temporal and spatial data on the distributions of metals, nutrients (nitrates, nitrites and orthophosphates), and fecal indicator bacteria (total coliform, *E. coli*, and enterococci) were obtained by several methods. Two 24-hour studies of fecal indicator bacteria and nutrients were conducted in Ballona Creek, within the wetland tidal channels, and in the Fiji Ditch to assess conditions throughout the tidal cycle. Dissolved metals were sampled at eight water stations throughout the BWER on a quarterly basis. Runoff from 12 locations at small drainages and ponding areas during three storms (>1-inch) were also analyzed for metals to determine stormwater contaminant inputs to the BWER. Samples from terrestrial soils were also analyzed for phytoavailable trace metals.

Bacteria levels at most sites consistently exceeded Total Maximum Daily Load (TMDL) levels, sometimes by several orders of magnitude, while nutrient levels were typically below recommended targets. Dissolved copper, lead, and selenium were consistently above dry weather TMDL levels in each quarter and at most stations. Zinc, copper, boron, barium, cadmium, lead, lithium, mercury, selenium, silver, and tin all exceeded acute toxicity levels for seawater during at least one quarterly sampling event[1].

Stormwater exceeded the TMDL wet weather numeric target for copper at seven of the 12 stations. Lead, selenium, and zinc all exceeded the TMDL wet weather numeric target at least once. Aluminum, boron, and cadmium exceeded acute toxicity levels[1] at multiple stations. The water and sediment quality analyses will continue in the second baseline year with reduced sampling frequency.

VEGETATION

A primary goal of the BAP was an intensive cross-habitat vegetation assessment. Vegetation cover surveys were conducted on randomly allocated transects throughout each habitat. Specific methods used depended on habitat type. In addition to vegetation surveys, terrestrial invertebrate, soil, and elevation surveys were conducted on a subset of transects to evaluate ecosystem-level function of the habitat. The objective of the vegetation surveys was to determine average percent cover of species using both transect-level and habitat-level assessments. Several methods were used to assess percent cover and diversity because of the differing conditions across multiple habitats (e.g. plant height and density, species diversity, topography). The tidally influenced lower marsh habitats were surveyed via laser quadrat method. Percent cover was evaluated using size classes to survey the upland dune, scrub, and grassland habitats. Canopy heights were also recorded. Targeted surveys for all species of special concern were conducted throughout the BWER.

Species lists and relative abundances were tallied and analyzed across several variables, including habitat, area, and native or non-native classifications. Preliminary results from the first year of the BAP indicated dominant cover of non-native plant species in the upland habitats and dominant cover of native species within the marsh habitats. The most common non-native species in upland areas included: iceplant (*Carpobrotus edulis*), black mustard (*Brassica nigra*), ripgut chess (*Bromus diandrus*), and crown daisy (*Chrysanthemum coronarium*). The most common native species in the tidal marsh habitats included: common pickleweed (*Salicornia virginica*), alkali weed (*Cressa truxillensis*), and Parish's pickleweed (*Salicornia subterminalis*). Surveys for species of special concern will continue in year two.

VERTEBRATES

The Ballona Wetlands region has suffered a decline in native populations, a reduction in species ranges, and an increase in introduced species throughout the last century (Friesen et al. 1981). Studies spanning the last few decades have shown a decline in native vertebrate populations in the BWER. Up-to-date

[1] Toxicity levels based on EPA Ambient Water Quality Criteria

comprehensive vertebrate surveys are imperative to establish current ranges and species presences at the site. The data collected during the BAP surveys were compared to previous surveys.

Ichthyofauna

Ichthyofauna sampling occurred three times during the first year of baseline assessment: September 2009, April 2010, and July 2010. Sampling methods employed a combination of blocking nets and beach seines, minnow traps, and shrimp trawls. Surveys were conducted in Ballona Creek, the Fiji Ditch, and the tidal channels within Area B of the BWER at six permanent stations: three in the Fiji Ditch, and three in the tidal channels. These stations were a subset of the invertebrate, sediment, and water quality sampling stations. Additionally, five 250m trawls were conducted in Ballona Creek.

The beach seine surveys identified a total of eight native species: topsmelt (*Atherinops affinis*), arrow goby (*Clevelandia ios*), California killifish (*Fundulus parvipinnis*), longjaw mudsucker (*Gillichthys mirabilis*), diamond turbot (*Hypsopsetta guttulata*), Pacific staghorn sculpin (*Leptocottus armatus*), striped mullet (*Mugil cephalus*), and round stingray (*Urobatis halleri*); one non-native species was identified, the western mosquitofish (*Gambusia affinis*). Macroinvertebrates caught in the surveys were also identified. The most common invertebrate captured in the seines was the California horn snail (*Cerithidea californica*).

Herpetofauna

Surveys throughout the BWER have recorded up to ten species of herpetofauna. Several surveys for endangered and special concern herpetofauna species in the last 25 years have found only one endangered species, the California legless lizard (*Anniella pulchra*). The California legless lizard was confirmed in several locations during the first year BAP surveys, including one dune habitat where it had not been found in almost 20 years, according to previous BWER reports.

Surveys during the first baseline year were conducted over three seasons (early fall, spring, and early summer) in four habitat types (seasonal wetland, upland grassland, upland scrub, and dune). To obtain comprehensive information, several sampling methods were utilized throughout the site. Pitfall and driftnet arrays were employed in several of the major habitats including site searches, cover board flipping, and targeted surveys for the California legless lizard within potential habitat areas.

The pitfall traps had a wide variety of success rates, depending on the habitat. The dune habitat had a significantly greater overall capture rate than any of the other habitats (34.62%). Herpetofauna identified during the baseline year included eight species: Great Basin fence lizard (*Sceloporus occidentalis*), western side-blotched lizard (*Uta stansburiana*), San Diego alligator lizard (*Elgaria multicarinata*), California kingsnake (*Lampropeltis getulus*), San Diego gopher snake (*Pituophis* *melanoleucus*), Southern Pacific rattlesnake (*Crotalus viridis*), Baja California treefrog (*Pseudacris regilla*), and the California legless lizard. Amphibian and reptile surveys will continue in year two with the addition of cover board array surveys.

Mammals

Mammals are an important link in functioning wetland and upland ecosystems. Surveys over the past 29 years throughout the Ballona Wetlands have found 16 mammal species (nine native and seven non-native). Three of the species identified from past reports are listed as California species of special concern, although no special status species were identified during the first baseline year. In the 2010 baseline surveys, mammal surveys were conducted using Sherman live traps for small mammals and baited camera stations (Critter Cams) for medium and large mammals.

Eight native species were live captured using Sherman traps, observed visually, or observed using Critter Cams during the first baseline year: California ground squirrel (*Spermophilus beecheyi*), coyote (*Canis latrans*), desert cottontail (*Sylvilagus audubonii*), pocket gopher (*Thomomys bottae*), raccoon (*Procyon lotor psora*), striped skunk (*Mephitis mephitis*), western harvest mouse (*Reithrodontomys megalotis*), and California meadow vole (*Microtus californicus*). Five non-native species were observed or captured: Virginia opossum (*Didelphis virginiana*), house mouse (*Mus musculus*), domestic dog (*Canis familiaris*), domestic cat (*Felis cattus*), and rat (*Rattus sp*).

Avifauna

While birds are one of the most commonly observed groups of animals at the BWER, they are seldom surveyed comprehensively. Site-wide quarterly surveys were performed in October 2009, January, April, and July 2010. Digitized spot-maps display the spatial and temporal distribution of birds on the reserve, as well as their observed relative abundances. During fall and winter of the baseline year, "post-rain" rapid-count censuses were also conducted. Waterbird surveys were conducted on a semi-monthly basis. Between March and June 2010, supplemental visits were made to several of the more productive breeding habitats around the reserve in an effort to fully document nesting occurrences and site usage by nesting species that fell outside the scheduled April and July surveys. Potential nesting areas of special-status species were also visited. Protocol surveys were performed for two special-status species: the Least Bell's Vireo (*Vireo bellii pusillus*) and Belding's Savannah Sparrow (*Passerculus sandwichensis beldingi*). Volunteer waterbird and raptor censuses were conducted monthly and contribute to the professional avian surveys.

A total of 156 species and distinctive subspecies were recorded during the first year of baseline assessment (combining all survey types). A total of 11 special status species were confirmed on site during the quarterly surveys: Belding's savannah sparrow (*Passerculus sandwichensis*), brown pelican

(*Pelecanus occidentalis*), Cooper's hawk (*Accipiter cooperii*), elegant tern (*Thalasseus elegans*), Least Bell's vireo (*Vireo bellii pusillus*), loggerhead shrike (*Lanius ludovicianus*), long-billed curlew (*Numenius americanus*), northern harrier (*Circus cyaneus*), peregrine falcon (*Falco peregrinus*), Vaux's swift (*Chaetura vauxi*), and white-tailed kite (*Elanus leucurus*). The California gnatcatcher (*Polioptila californica*) was seen on site after the completion of the first year baseline surveys.

INVERTEBRATES

The benthic infaunal and epifaunal aquatic invertebrate communities provide essential ecosystem services and support. The presence or absence of certain infaunal taxa within the tidal channels can indicate water quality, identify anthropogenic stressors to the estuary, and gauge the potential to support other trophic levels. Assessments of benthic invertebrate community composition have been conducted in Area B multiple times between 1981 and 2004; data from Areas A and C are limited. For the BAP, infaunal benthic invertebrate sampling was conducted semi-annually in seven locations: two in Area A and five in Area B. Existing protocols were utilized and adapted to the specific needs of the BWER. Presence and relative abundance were calculated for general taxonomic groups at each location. Species-level taxonomic identification will be conducted in year two. Epifaunal benthic invertebrate surveys for California horn snail (*Cerithidea californica*) were conducted using transects on the mudflat habitats.

Flying aerial arthropod biomass surveys were also conducted. The objective was to extrapolate arthropod biomass by weight for each habitat using sticky traps. Results of flying invertebrate data indicate the lowest productivity in the brackish marsh and fairly uniform productivity in the low salt marsh, mid salt marsh, and salt pan habitats. The upland grassland had the highest aerial arthropod productivity and the highest level of variability. Species-level terrestrial surveys will be conducted in year two.

Table 1. Calendar of completed survey events by month for the first year of the BAP at the BWER.

	TARGET	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	FREQUENCY
CHEMICAL	Water Quality - Metals	X			X			X			X			quarterly
	Water Quality - Bacteria	X					X					X	X	dry, wet, and post-wet season
	Water Quality - Nutrients *						X->	<-X->	<-X					annually
	Water Quality - Stormwater - metals		X			X			X					once during wet season
	Water Quality - perm. data sonde	<-X->	<-X->	<-X->	<-X->	<-X->	<-X->	<-X->	<-X->	<-X->	<-X->	<-X->	<-X->	throughout year
	Sediment - Metals	X						X						semi-annually
	Soils - Metals & grain size										X->	<-X->	<-X->	once every 2-5 years
BIOLOGICAL	Vegetation - submerged/algae	X			X			X			X			quarterly
	Vegetation - marsh	<-X->	<-X										X->	bi-annually
	Vegetation - uplands							X->	<-X->	<-X->	<-X->	<-X		bi-annually
	Vegetation - marsh-wide transect	<-X											X->	bi-annually
	Vegetation - biomass													bi-annually
	Seed bank study				X->	<-X->	<-X->	<-X						annually
	Birds - volunteer surveys	X	X	X	X	X	X	X	X	X	X	X	X	monthly
	Birds - professional surveys		X			X			X			X		quarterly (+ post-rain surveys)
	Small Mammals			X							X->	<-X		twice annually (fall & spring)
	Large Mammal *					X->	<-X->	<-X->	<-X->	<-X->	<-X->	<-X->	<-X	throughout spring & summer
	Herpetofauna *			X					X->	<-X->	<-X->	<-X		semi-annually (fall & spring)
	Fish - channels, ditch, and Creek *	X						X				X		semi-annually (fall & spring)
	Invert - flying	<-X->	<-X								X->	<-X->	<-X->	annually (spring/summer)
	Invert - terrestrial	<-X->	<-X								X->	<-X->	<-X->	annually (spring/summer)
	Invert, infauna - benthic	X							X					semi-annually
	Plant Vouchering *					<-X->	<-X->	<-X->	<-X->	<-X->				spring
	Insect Vouchering *					<-X->	<-X->	<-X->	<-X->	<-X->				spring
PHYSICAL	Innundation													semi-annually (spring tides)
	Elevations *										X->	<-X->	<-X->	every 5 years
	Channel Cross-Sections													annually
	Piezometers													annually

** = independent student project*

Figure 1. Map of the BWER with sampling locations identified. The yellow outlines indicate the extent of Areas A, B, and C, but do not indicate the full project site outline. Terrestrial invertebrates, soil quality, and elevation surveys were completed on a subset of the randomly allocated vegetation transects (green). Fish, sediment, and benthic invertebrate surveys were completed at a subset of the water quality stations (blue). Herpetofauna and small mammal surveys are indicated by red markers.

INTRODUCTION
Baseline Assessment Program: 2009-2010 Report

Photo credit: I. Medel

INTRODUCTION

Ballona Wetlands Ecological Reserve, Los Angeles, California
Santa Monica Bay Restoration Commission

Prepared for: California State Coastal Conservancy
November 2011

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INTRODUCTION

“Mankind's failure to use ecological principles to minimize negative impacts of human activities is arguably the most important failure of the twentieth century” (Karr 1987).

The Santa Monica Bay Restoration Commission (SMBRC) is a collaboration of federal, state and local entities whose mission is to restore and enhance the Santa Monica Bay (Bay). Through actions and partnerships The SMBRC protects and improves the health of the 266-square mile Santa Monica Bay and its 400-square mile watershed, located in the second most populous region in the United States.

The SMBRC is a National Estuary Program (NEP) of the United States Environmental Protection Agency (USEPA). The NEP was established by Congress in 1987 to improve the quality of estuaries of national importance, with a focus on habitat restoration and protection as well as water quality. Stakeholders of the SMBRC developed the Bay Restoration Plan (BRP), which includes 14 goals and 67 objectives, for protecting and restoring the Bay. Scientific monitoring of the Bay’s natural resources and restoration of impaired Bay habitats are important goals of the BRP.

In 2009, the SMBRC partnered with the California Department of Fish and Game (CDFG) and the California State Coastal Conservancy (SCC) to assess the ecological condition of the Ballona Wetlands Ecological Reserve (BWER). The Baseline Assessment Program (BAP) was developed to comprehensively survey the biological, chemical, and physical characteristics needed to inform the State’s restoration planning process at the BWER, as well as to develop baseline information and data to assist long-term and regional monitoring programs.

The first annual BAP report presents the data collected during the first year of the BAP and describes methods for each type of survey. Future publications will provide further analyses and interpretations of the data.

Overview and Site History

The Ballona Wetlands 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 2000 acres and included a variety of habitats, dominated by over 1,200 acres of vegetated wetland in 1876 (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. The remaining 600-acre parcel was purchased by the State in 2004 and designated an Ecological Reserve. Wetlands at the site have been reduced to approximately 67 acres of muted intertidal salt marsh and mudflat, with the remaining area largely converted to seasonal wetland or upland habitats. The BWER is now the largest opportunity to restore critical coastal wetlands in the Santa Monica Bay and Los Angeles County.

The Freshwater Marsh is a 24-acre freshwater treatment wetland bordering the BWER, which treats stormwater from neighboring roads and communities. The Freshwater Marsh is monitored (Read and Strecker 2009, Read and Strecker 2010) and maintained separately from the rest of the BWER and is not included in the BAP.

Goals of the Baseline Assessment Program

Previous scientific surveys of the BWER focused largely on individual aspects of the ecosystem or on limited areas. The BAP provides a comprehensive baseline biological assessment designed to determine the biotic integrity of the ecosystem. Biotic integrity can be defined as "the capability of supporting and maintaining a balanced, integrative, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region" (Karr and Dudley 1981).

The BAP is a two-year program. It includes protocol development with scientific review, coordination with regional restoration programs, implementation of the assessment protocols, data analysis and reporting, and external scientific review. The goals of the BAP include:

(1) Provide a measure of pre-restoration baseline conditions at the BWER;
(2) Increase comprehensive knowledge of the health and functioning of the site in an urban environment;
(3) Assess ecological processes, cross-habitat comparisons, species interactions, and potential recovery;
(4) Fill data gaps at the Ballona Wetlands and develop protocols for addressing data gaps at other wetland projects;
(5) Inform adaptive management and long-term restoration plans;
(6) Develop scientific, regional wetland monitoring protocols for southern California;
(7) Inform both a site-specific and regional long-term monitoring program;
(8) Establish an informed, scientifically valid basis for improved watershed management to protect, prevent and reduce pollution to the BWER;
(9) Contribute chemical and ecological data from the BWER to local, regional, and national databases.

Protocol Development

Monitoring protocols were developed in partnership with the Southern California Wetlands Recovery Project (WRP) as a pilot project for site-specific monitoring (EPA Level-III) within the Integrated Wetlands Regional Assessment Monitoring Program (IWRAP) framework. The protocols are applicable to a wide variety of regional and national plans and will facilitate implementation of a regional wetland assessment program. In addition, this project will contribute data from the BWER into regional and national databases, increasing the availability of wetlands information to other programs.

IWRAP was developed by the WRP as a regional assessment tool to evaluate the effectiveness of restoration projects. IWRAP is based on the EPA three-tiered assessment approach that integrates monitoring at varying spatial scales and levels of intensity. The goal of the three-tiered assessment program is to collect integrated information such that the three levels of assessment, implemented at different spatial scales and addressing different questions, also inform and complement each other. By structuring data collection in this manner, site-specific data provide information about specific conditions and are understood in a regional context.

Level-I of the three-tiered approach consists of general acreage inventories of wetlands and associated resources, such as the National Wetlands Inventory. Level-II assessments address resource condition and stressors on a regional scale. The California Rapid Assessment Method (CRAM) developed by the WRP and the Southern California Bight Monitoring Program are Level-II assessments. Level-III assessment is site-specific and addresses detailed management questions about stressors and conditions at the scale of an individual wetland.

The WRP began developing Level-III monitoring protocols with a framework including vegetation, benthic invertebrates, birds, and fish monitoring protocols. The SMBRC expanded on this effort in 2009 to develop a complete set of protocols for application at the BWER. Protocols were adapted from existing monitoring and research in the region. Monitoring programs and plans that were evaluated for the development of this program include: Mugu Lagoon Wetland Restoration Monitoring Program, Carpinteria Salt Marsh Monitoring Program, San Dieguito Lagoon Restoration Monitoring Program, Ormond Beach Salt Marsh Pre-Restoration Monitoring and Assessment Program, Batiquitos Lagoon Long Term Biological Monitoring Program, Malibu Lagoon Restoration Monitoring Program, Tijuana River National Estuarine Research Reserve System-Wide Monitoring Program, San Francisco Bay Area Wetlands Regional Monitoring Program, and Bair Island Restoration Project Monitoring Plan. Protocols were developed with regional wetland scientists and were externally reviewed (Figure i.1). Method development and references are detailed in individual chapters of this report.

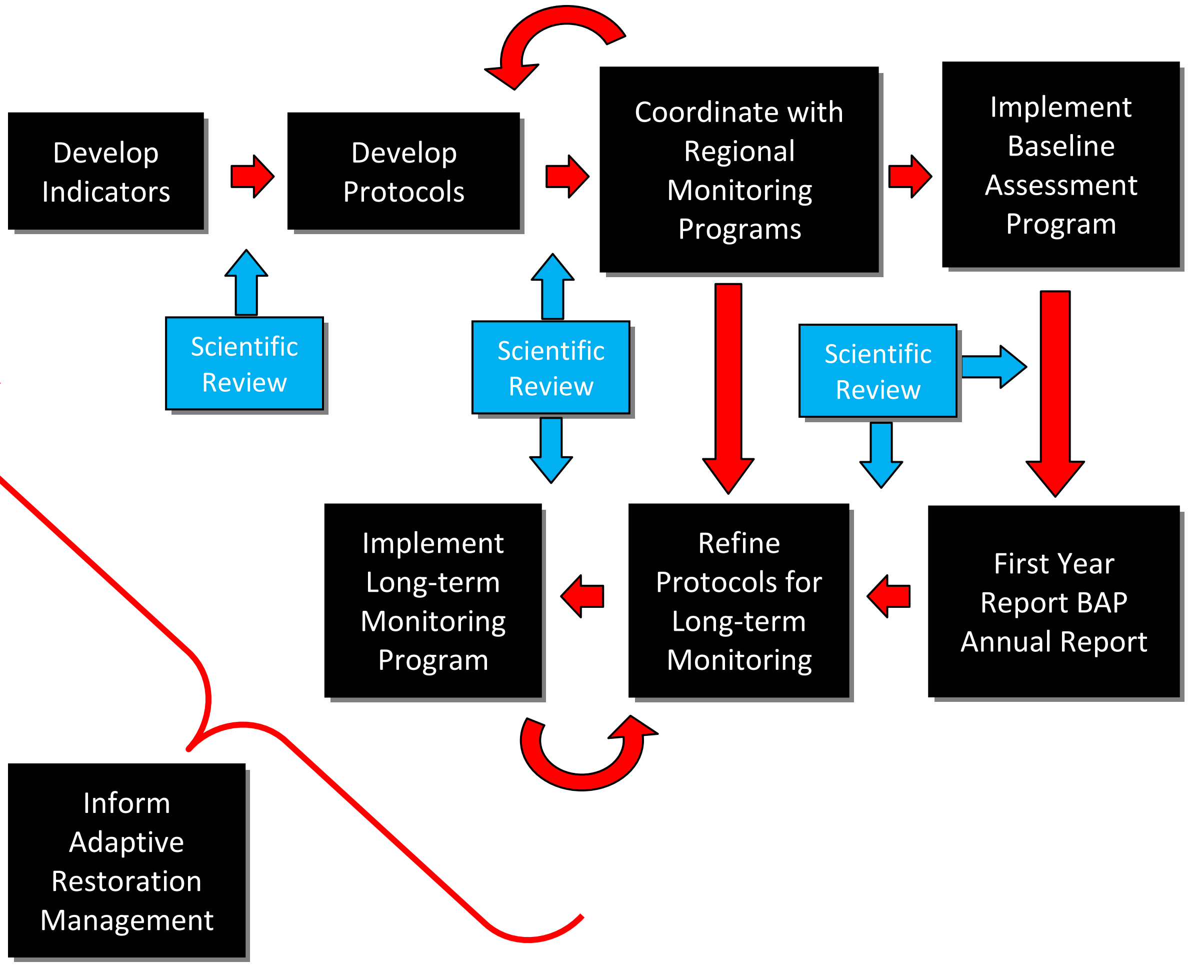

Figure i.1. Development schematic of the BAP and long term monitoring plan.

Scientific Review

Several stages of the BAP underwent external scientific review (Figure i.1). The SMBRC received input from the WRP Science Advisory Panel, SMBRC Technical Advisory Committee, and many research scientists conducting similar studies at other wetlands in southern California. Through this process, the SMBRC proposed protocols for feedback and worked with researchers on detailed protocols. Development of the protocols was an iterative process to achieve the desired goals while working within the unique constraints and conditions of the BWER. Protocols have been adapted in the field when necessary, with direct consultation from experts. Protocol refinement will continue in the second year of the BAP. Additionally, individual chapters of the baseline report underwent external expert review (see list of reviewers).

Report Structure

This report is divided into twelve chapters, one for each of the 11 monitoring components (i.e. water quality, marine sediments, terrestrial soils, vegetation, ichthyofauna, herpetofauna, mammals, avifauna, benthic invertebrates, terrestrial invertebrates, and physical characteristics), and one for the introduction. Each chapter includes the goals of the assessment program for that component of the study, summaries of previous studies of the BWER, detailed methods used in the BAP surveys, and results. Summaries of previous BWER surveys are included as background and for comparison to the BAP surveys. Each chapter also includes a framework for future surveys and an outline of sampling planned for the second baseline year.

Detailed methods are provided for BAP surveys, including locations and parameters targeted. Results are summarized within the text and detailed data are available in the appendices. Interpretations and inferences of the potential relationships of these data will be provided in future publications through in-depth analyses.

SITE DESCRIPTION

The site description for the BWER is modified from the Draft Existing Conditions Report compiled by Phillip Williams and Associates (PWA) in 2006. For additional descriptive details, reference PWA 2006. In previous studies, the BWER has been divided into three areas designated as Areas A, B, and C (Figure i.2). This nomenclature will be continued throughout this report to facilitate comparison to previous reports.

Area A is the approximately 139 acre portion of the BWER that lies north of Ballona Creek, west of Lincoln Boulevard, and south of Fiji Way (Figure i.2). Fill was placed on Area A during the excavations of Ballona Creek and Marina del Rey which resulted in elevations ranging between approximately nine and 17 feet above mean sea level (MSL). Development of Area A is limited to a parking area along the western boundary, a drainage channel (Fiji Ditch) along the northern boundary, and four monitoring well sites maintained by the Gas Company in the western end.

Area B is the approximately 338 acre portion of the BWER that lies south of Ballona Creek and west of Lincoln Boulevard (Figure i.3). Area B extends south to Cabora Drive and contains a utility access road near the base of the Playa Del Rey bluffs. To the west, Area B extends through the dunes to Playa Del Rey. Area B elevations generally range from approximately two to five feet MSL, extending up to 50 feet MSL at the Del Rey bluffs. Culver Boulevard and Jefferson Boulevard are major traffic thoroughfares that traverse Area B. Additionally, the Gas Company maintains an access road that connects its facility in southern Area B to Jefferson Boulevard. Area B contains the largest area of remnant unfilled wetlands with abandoned agricultural lands to the southwest, and the Freshwater Marsh to the northeast. The Gas Company maintains one active oil well in Area B.

Area C is the approximately 66 acre portion of the BWER that is located north of Ballona Creek and east of Lincoln Boulevard (Figure i.2). The 90 Freeway forms the northeastern border of Area C, and Culver Boulevard bisects Area C in an east-west direction. Area C contains fill from the construction of the Ballona Creek flood channel, developments such as Marina del Rey, and the 90 Freeway. Elevations range from approximately 4.5 feet to 25 feet MSL. Area C contains Little League baseball fields.

All three Areas are surrounded by dense urban development.

Figure i.2. Aerial of the BWER and Marina del Rey (photo: SMBRC 2007). Note: the Freshwater Marsh is not included in the BAP surveys.

Personnel Summary Information

Monitoring was conducted by expert regional scientists, staff scientists, volunteer experts, additional in-house staff, contracted employees, and, when appropriate, student interns and volunteers (Figure i.3).

Over 3,000 staff and expert scientist field hours were logged over the course of 215 field days in the first baseline year, not including laboratory and data analyses. Professional participants included: Karina Johnston, Sean Bergquist, Dan Cooper, Dr. Shelley Luce, Dr. John Dorsey, Dr. Sean Anderson, Dr. José Saez, Dr. Guangyu Wang, John Reclosado, Ivan Medel, and Elena Tuttle. Additional scientific reviewers and technical advisory committees participated in the development and review of the program and reporting materials (see document cover pages). 2,384 internship and volunteer hours were completed during the first year.

Figure i.3. Fishing volunteers and staff during a night beach seining event (photo: L. Fimiani, 2010).

For more information and electronic copies of the full report, visit www.ballonarestoration.org.

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Photo credit: K. Johnston

WATER QUALITY

Baseline Assessment Program: 2009-2010 Report

CHAPTER 1:
WATER QUALITY

Ballona Wetlands Ecological Reserve, Los Angeles, California
Santa Monica Bay Restoration Commission

Prepared for: California State Coastal Conservancy
November 2011

Authors: Karina Johnston, John Dorsey, Elena Del Giudice-Tuttle, and Ivan Medel

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WATER QUALITY

INTRODUCTION

Water quality measurements may be used as indicators of both human health concerns and the overall chemical and physical conditions of a site. Reduced wetland water quality suggests poor circulation, lack of tidal flushing, or increased sediment transport in wetlands (Zedler 2001). Water quality can also be negatively affected by upstream inputs to the system (Nichols 1983). Evaluating the water quality in the Ballona Wetlands Ecological Reserve (BWER) by monitoring constituents of concern is vital to understanding the system as a whole. Constituents of concern can be defined as specific chemicals or pollutants that are identified for evaluation in a site assessment process as potential stressors.

Levels of fecal indicator bacteria (FIB) may be indicators of pollution by urban runoff to the system. FIB, including total coliforms, *Escherichia coli*, and enterococci, are often used as substitutes for human pathogens in assessing water quality (Evanson and Ambrose 2006, Dorsey 2006). When these indicator bacteria exist in high enough concentrations within the water column, they can be associated with a number of illnesses. Conducting a variety of surveys for FIB will help determine the influence of external factors such as tide conditions, turbidity, or salinity on the presence of bacteria within the wetlands.

Excess nutrient inputs may increase primary production (eutrophication) and lead to algal blooms which may result in anoxia (Howard-Williams 1985, Nichols 1983, Zedler 2001). Availability of inorganic nitrogen (e.g. NO^{-2}, NO^{-3}, and NH^{+}) often limits primary productivity in wetlands (Zedler 2001); however, excess inputs of nitrogen and phosphorous from freshwater sources are some of the direct causes of estuary eutrophication (EPA 2001, Howard-Williams 1985). The different forms of these nutrients form an important suite of constituents to monitor when tracking wetland condition.

Dissolved metals directly and indirectly affect the health of fish and benthic organisms (Drinkwater and Frank 1994, Hwang et al. 2008); many individual trace metals are toxic to aquatic organisms (e.g. copper, zinc, and lead). Total metals, pollutants, and additional constituents of concern can transfer to a system either through the water column as dissolved constituents, or attached to sediments and particulates through deposition (Sansalone and Buchberger 1997, Lau and Stenstrom 2005, Surbeck et al. 2006, Lau et al. 2009).

The principal goal of the BWER water quality studies was to build on existing research and track overall water quality over time. Specific goals of the BAP included:

1) Determine constituents of concern in the water within the tide channels of Area B, the Fiji Ditch in Area A, and the estuary portion of Ballona Creek;
2) Address data gaps identified by the Existing Conditions Report;
3) Determine FIB and nutrient fluctuations across full tidal cycles within the tide channels, Fiji Ditch, and Ballona Creek.

4) Assess the input of trace metals from stormwater runoff throughout the BWER;
5) Maintain a permanent data sonde for continuous monitoring of general water quality parameters in the east tide channel of Area B;

All values for acute and chronic toxicity are from the National Recommended Water Quality Criteria compiled by the United States Environmental Protection Agency (USEPA) pursuant to Section 304(a) of the Clean Water Act (CWA), henceforth referred to as USEPA 2009.

Existing Conditions Report Summary (Prior to 2005)

The Ballona Wetlands Existing Conditions Report summarizes several reports that analyzed water quality constituents of concern. These reports included some analyses of Ballona Creek and the Ballona Creek Estuary (Estuary); past water quality studies have not been comprehensive or have focused solely on the wetland habitat channels.

The Los Angeles Department of Public Works (LADPW) Integrated Receiving Water Impact Report (Weston Solutions 2005) identified constituents of concern that persistently exceeded water quality objectives in Ballona Creek, including: cyanide, FIB (total coliform, fecal coliform, and enterococci), and metals (copper, lead, and zinc). A table identifying each parameter measured annually at the Ballona Creek station between 1994 and 2005 is available in the Existing Conditions Report (PWA 2006).

The City of Los Angeles also collected data on metals from April 2001 through May 2003 in Ballona Creek for the Ballona Creek Metals Total Maximum Daily Load (TMDL) Report (SWQCB and EPA Region 9, 2005). Studies were also conducted by the State's Surface Water Ambient Monitoring Program (SWAMP) which included four stations in Ballona Creek, and by the Southern California Coastal Water Research Project (SCCWRP) (MPSL and MLML 2005, Stein and Tiefenthaler 2005). Data for each of these reports is summarized in the Existing Conditions Report (PWA 2006).

Interim Research (2005-2010)

In 2007, Weston Solutions prepared the Water Quality Data Gap Investigation Technical Memorandum for the Baseline Assessment Program (BAP) (Pohl 2007). The memo identified data gaps in water quality sampling to date and recommended monitoring strategies to address the gaps. Recommended monitoring strategies included additional sampling at sites in the Fiji Ditch, at potential inlet locations within Marina del Rey, at stormdrain outlets, and in the lower portion of Ballona Creek during varying tide conditions, as well as during storm events. The report also recommends a wet season monitoring program including analyses for total metals, dissolved metals, organic pesticides, synthetic pyrethroids, PAHs, nutrients, hardness, total suspended solids, and total dissolved solids (TDS) (Pohl 2007).

Total Maximum Daily Loads for Ballona Creek

Ongoing water quality monitoring by the State Water Resources Control Board (SWRCB) starting in 1994 prompted the state of California to place Ballona Creek and Estuary on the Clean Waters Act (CWA) 303(d) list of impaired water bodies in 1998 due to the elevated levels of certain metals, organics, bacteria, and toxics. The BWER is directly affected by water quality conditions within Ballona Creek because the Creek is the only source of tidal waters to Area B (via two tide gates).

The Ballona Creek Bacteria TMDL, prepared by the State Water Resources Control Board (SWRCB), is based on four bacteriological density parameters: total coliform, enterococci, fecal coliform, and *Escherichia coli* (Table 1.1).

Table 1.1. Numeric targets for the Ballona Creek bacteria TMDL (modified from SWRCB 2006). Note: asterisk indicates that total coliform density shall not exceed 1,000 / 100 mL, if the ratio of fecal-to-total coliform exceeds 0.1.

Single sample		***Geometric mean***	
Bacteria type	**MPN / 100 mL**	**Bacteria type**	**MPN / 100 mL**
Fecal coliform	400	Fecal coliform	200
Enterococci	104	Enterococci	35
Total coliform*	10,000	Total coliform*	1,000

In 2005, the SWRCB established a TMDL for metals in Ballona Creek and toxics in Ballona Creek and Estuary (LA City 2008). The Ballona Creek metals TMDL set wet- and dry-weather objectives for copper, lead, selenium, and zinc (Table 1.2).

Dry-weather targets apply to days when the maximum daily flow in Ballona Creek is less than 40 cubic feet per second (cfs); wet-weather targets apply to days when the maximum daily flow in Ballona Creek is equal to or greater than 40 cfs. Dry-weather targets are based on the chronic California Toxics Rule (CTR) criteria (EPA 2000); wet-weather targets for copper, lead and zinc are based on the acute CTR criteria. The dry- and wet-weather targets for selenium are independent of hardness and are expressed as total recoverable metals.

Table 1.2. Contaminant listing for the Ballona Creek and Estuary Metals TMDL and numeric targets. Asterisk denotes listing for total recoverable metals.

Water Body	Impaired listing (contaminant)
Segments of Ballona Creek	copper, lead, zinc, total selenium
Sepulveda Canyon Channel	lead
Ballona Creek Estuary (Sediments)	cadmium, lead, zinc, chlordane, DDR, PCBs, and PAHs.

Numeric Targets (dissolved metals µg /L)		
Metals	**Dry Weather**	**Wet Weather**
Copper	23	11
Lead	8.1	49
Selenium*	5	5
Zinc	300	94

To request recent monitoring data and reports regarding the Ballona Creek, Estuary, and Sepulveda Channel TMDLs, contact Los Angeles Regional Water Quality Control Board: (213) 576-6600.

Southern California Bight Project (2008)

The Southern California Bight Project 2008 (Bight 08) assesses, among other things, the impacts of eutrophication, or excessive primary production caused by nutrient enrichment, in southern California estuaries, a data gap identified by the EPA (EPA 2001). Bight 08 assessed the estuary portion of the BWER with a focus on (1) continuous monitoring of water quality parameters known to be sensitive to eutrophication, (2) assessment of primary producer biomass and percent cover and (3) measurement of freshwater nitrogen and phosphorus concentrations and water level. Three transects were included within the main tide channels of Area B, and one permanent data sonde was permanently stationed in the east tide channel approximately 40 meters from the mouth of the channel. Nutrient data were also collected bi-monthly at each of the three transects in the BWER. These data will be publicly available in late 2011 (Bight 08 Eutrophication Sub-committee, unpublished data).

Fecal Indicator Bacteria Studies

Dorsey (2006) measured water quality and FIB densities at five stations in the intertidal channels of the Ballona Wetlands (Figure 1.1). Stations were sampled on a variety of tides ranging from neap to spring tides in February 2003. Densities of total coliforms typically ranged from 10^3–10^4 MPN/100 ml during dry weather, and were as high as 10^6 MPN/100ml during runoff events. Densities of *E. coli* and enterococci generally ranged from 10^1–10^4 MPN/100 ml for *E. coli*, and 10^1–10^5 MPN/100 ml for enterococci; greater densities were associated with runoff events. Densities of FIB were up to three times greater during flood than ebb tide conditions, depending on the tidal range. These results confirmed that more FIB were entering the wetlands on flood tides than leaving during ebbs. Previous surveys suggest a similar pattern (Keddy 2000, Mitsch and Gosselink 2000).

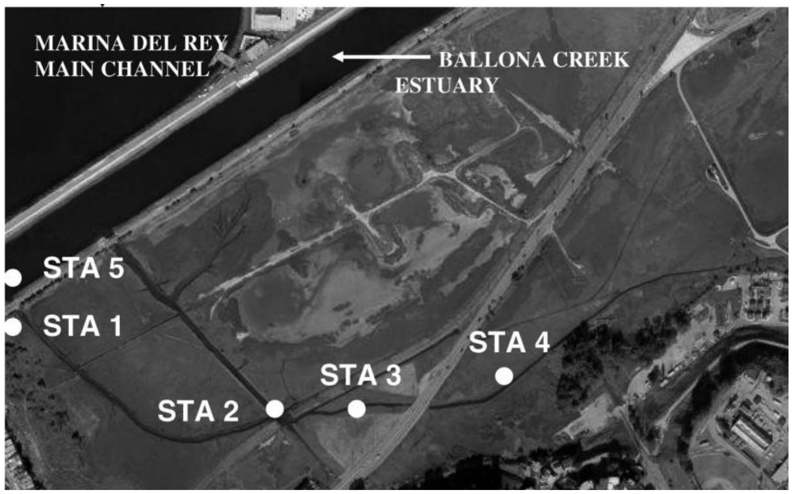

Figure 1.1. Map of Dorsey (2006) monitoring stations (reproduced from Dorsey 2006).

In 2010, Dorsey et al. investigated whether the BWER functions as a FIB sink or source. The study determined FIB loading rates and total FIB loads throughout 24-hour tidal cycles by coupling measurements of FIB densities with water flows in the tidal channels (Figure 1.2). FIB loading rates (MPN/second) were greatest during flood tides as water entered the wetlands, and during spring tides when sediments were resuspended during swifter spring ebb flows. The study concluded that the tidal channels of the BWER acted as both a source and a sink depending on tidal conditions (Dorsey et al. 2010).

Figure 1.2. Location of Dorsey et al. (2010) water quality monitoring stations (reproduced from Dorsey et al. 2010).

SCCWRP Stormwater Data

In 2003, SCCWRP analyzed the relative contributions of various storm drain sources to the total dry-season loading of metals and FIB into Ballona Creek (Stein and Tiefenthaler 2005). They sampled 40 storm drains and 12 Creek sites for flow, total and dissolved metals, and FIB. A relatively small number of storm drains contributed disproportionately to the majority of the dry weather contaminant loading (Stein and Tiefenthaler 2005, Stein and Ackerman 2007).

In 2009, Ackerman and Stein conducted studies to determine the pollutant-particle relationship in runoff and the linkage between suspended particles from the watershed and the bed sediments in Ballona Creek. Four winters were sampled from 2006-2009 using *in situ* laser refractometry (LISST 100x). The initial results of the Ballona Creek stormwater study indicate that larger particles occur during the early portion of the storm and taper off as the storm continues (Ackerman and Stein 2009). The preliminary results from the second study indicate metals are bound to particulates throughout a storm event, but bacteria are not. The third study found considerable variability of total suspended matter (TSM), including both sediment and phytoplankton during the dry season. TSM appeared to be dominated by phytoplankton and associated growth products (i.e. detritus) (Ackerman and Stein 2009).

Topsmelt Die-off Memo

On 3 May 2010, approximately 200-300 visible dead topsmelt (*Atherinops affinis*) and one dead seagull were observed in Ballona Creek near the storm drain outlet on the north levee of Ballona Creek west of the 90 Freeway (Figure 1.3). Several hours after the fish were observed, SMBRC collected water samples and recorded low levels of dissolved oxygen (DO) and salinity during *in situ* water quality measurements at both the Centinela Creek and the storm drain sites (Johnston et al. 2010). Iron, manganese, boron, cadmium, cobalt, lithium and selenium all exceeded USEPA contamination limits for either acute or chronic toxicity levels for aquatic organisms (USEPA 2009). Levels of FIB and phosphates also exceeded recommended limits. The Ballona Creek Storm Drain Water Quality Memorandum (Johnston et al. 2010) presented values for each of the constituents analyzed. At least two additional fish die-offs occurred during the first Baseline year but associated water quality was not sampled.

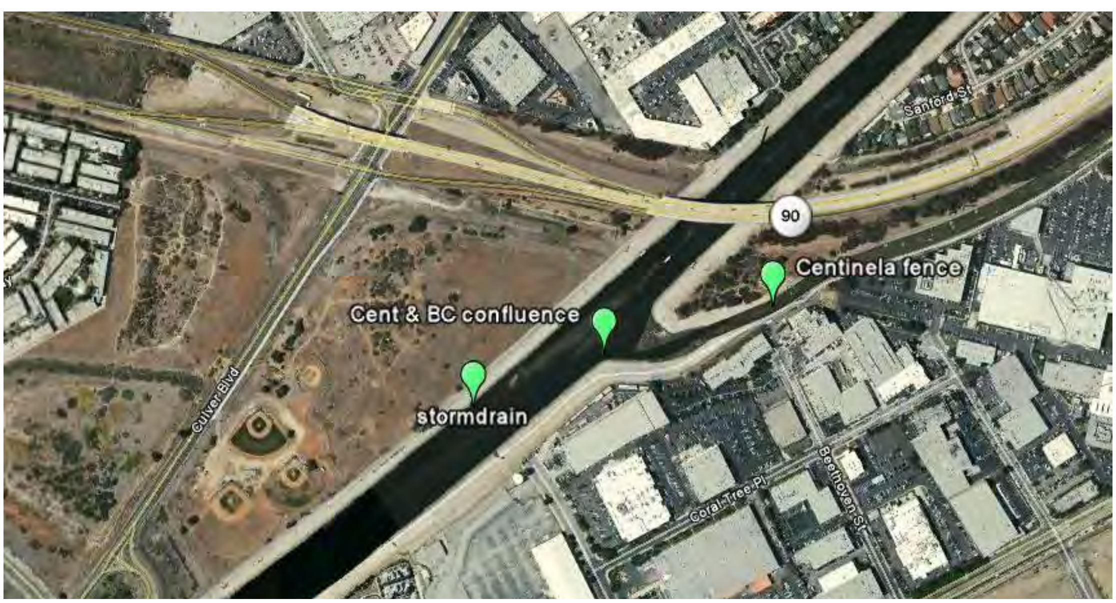

Figure 1.3. Stormdrain sampling stations in Ballona Creek (reproduced from Johnston et al. 2010).

METHODS

Method Comparison and Rationale

To account for monthly and seasonal patterns across habitats within the BWER, water quality surveys were conducted using a variety of standard methods (Zedler 2001). Continuous water quality monitoring via a permanent data logger is important as it can indicate short and long term patterns over tidal cycles, during periods of tide gate closure, or during rain events (Zedler 2001). It provides information about hypoxic conditions and temperature fluctuations, as well as averages of individual parameters over time. To analyze continuous fluctuations over the entire baseline year, a Yellowsprings Instrument Model (YSI) 6600 data sonde was permanently installed in the eastern tide channel of Area B to monitor dissolved oxygen, salinity, pH, temperature, and depth. Dissolved oxygen and salinity often influence the presence and health of marine and estuarine organisms; fish and benthic invertebrates are particularly susceptible to fluctuations (Ambrose and Meffert 1999, Carter 1991, Nordby and Zedler 1991).

Discrete water quality sampling provides useful information for ephemeral phenomena such as runoff pulses or sewage spills, as well as ambient constituent levels at a site. Discrete sampling can also provide data for assessing the variability of FIB, nutrient, and metal constituent levels throughout the BWER across longer temporal scales (e.g. seasonal or annual variability). Multiple samples were taken during each discrete sampling event to account for variability caused by tidal stage, time of day, storm condition, and season (Zedler 2001). Since single sample events may not always represent the conditions of the water across a full tidal cycle, or in different conditions, supplemental 24-hour and stratification surveys were conducted for FIB and nutrients to assess the water quality across a wider range of conditions and tides (Dorsey et al. 2010). These parameters may also supply data to assess impaired tidal flushing (Zedler 2001).

Seven permanent water quality sampling stations were established (Figure 1.4 and Table 1.3). Depending on the sampling parameters, either all stations or a subset of the sampling stations were utilized to monitor the various water quality parameters as well as sediment and biota during the first Baseline year (Table 1.4). Whenever possible, survey sites from previous studies were used to allow comparisons across larger time scales. Stormwater samples were collected opportunistically throughout the wet season and correspond with runoff, not with permanent sampling stations.

Figure 1.4. Map of BAP water quality sampling stations (excluding BW2).

Table 1.3. Latitude and longitude for each sampling station within the BWER.

Station	Latitude	Longitude
BW1	33°58'33.08"N	118°26'26.50"W
BW2	33°58'35.02"N	118°26'22.60"W
BW3	33°58'29.17"N	118°26'00.33"W
BW4	33°57'53.32"N	118°26'52.95"W
BW5	33°57'56.05"N	118°26'47.71"W
BW6	33°57'46.16"N	118°26'45.08"W
BW7	33°57'50.12"N	118°26'59.39"W
BW8	33°57'46.94"N	118°26'33.65"W

Table 1.4. Sampling locations for water quality studies and overlapping sediment and biological studies within the BWER. Note: the table does not include stormwater samples, which were taken opportunistically during rain events.

	# of surveys	Fiji Ditch		Ballona Creek	Area B – Lower Marsh				
		BW1	BW2	BW3	BW4	BW5	BW6	BW7	BW8
Data sonde	Continuous				X				
24 hour studies	2	X		X	X				
Stratification studies	2				X				
Dissolved metals	4	X		X	X	X	X	X	X
Fish	4	X	X		X	X		X	
Sediment	2				X	X	X	X	X
Benthic Invertebrates	4	X	X		X	X	X	X	X

Data Sonde Methods

Site Locations and Times

One permanent data logger (YSI 6600) was installed in the main tidal channel across from the tide gate (BW4; Figure 1.4) to collect data continuously throughout the year. Every three weeks, the data sonde was removed, downloaded, cleaned, fully calibrated, and replaced within 48 hours.

Field Methods

Data collected included depth, temperature, dissolved oxygen, pH, and salinity; parameters were recorded once every 15 minutes. Before being compiled and analyzed, downloaded data were run through a full Quality Assurance and Quality Control (QAQC) process that involved removing readings that were taken prior to deployment, while the data sonde was exposed to air, when battery levels were too low for accurate readings, and when the data sonde was malfunctioning or not calibrated correctly. The data from June and July were corrupted and are not included in the analyses.

Bacteria Sampling Methods

24-hour Surveys

Site Locations and Times

Two 24-hour sampling events were conducted during the Baseline year; the first event was during the dry season (18 September 2009), and the second was at the end of the wet season (17 March 2010). The events were scheduled during spring tides to coincide with the greatest tidal variation. For both events, samples were analyzed for FIB concentration in the form of total coliform, *E. coli*, and enterococci bacteria.

Water quality sampling during the 24-hour surveys was conducted at three locations within the project area in the following order: at the mouth of the Fiji Ditch (BW1), in Ballona Creek at the Lincoln Overpass (BW3), and at the mouth of the east tide channel adjacent to the data sonde (BW4) (Figure 1.4, above).

Field Methods

The 24-hour bacteria sampling events and analyses were conducted using methods similar to those previously developed for FIB sampling (Dorsey 2006, Dorsey et al. 2010). *In situ* water parameters (temperature, dissolved oxygen, pH, and salinity) were measured using a YSI 600 QS sonde extended from the bank into the channel on a 10-foot rod (Figure 1.5). At each station, the sonde was positioned approximately 1 ft beneath the water surface and allowed to equilibrate over a 3-minute period before measurements were taken. Three replicate surface water samples were collected at each station using 125 mL sterile polypropylene bottles attached to the same 10-foot rod as above and extended into the channel in a similar manner. Samples were immediately placed on ice and processed within four hours of collection for FIB and nutrient constituents of concern, as well as turbidity.

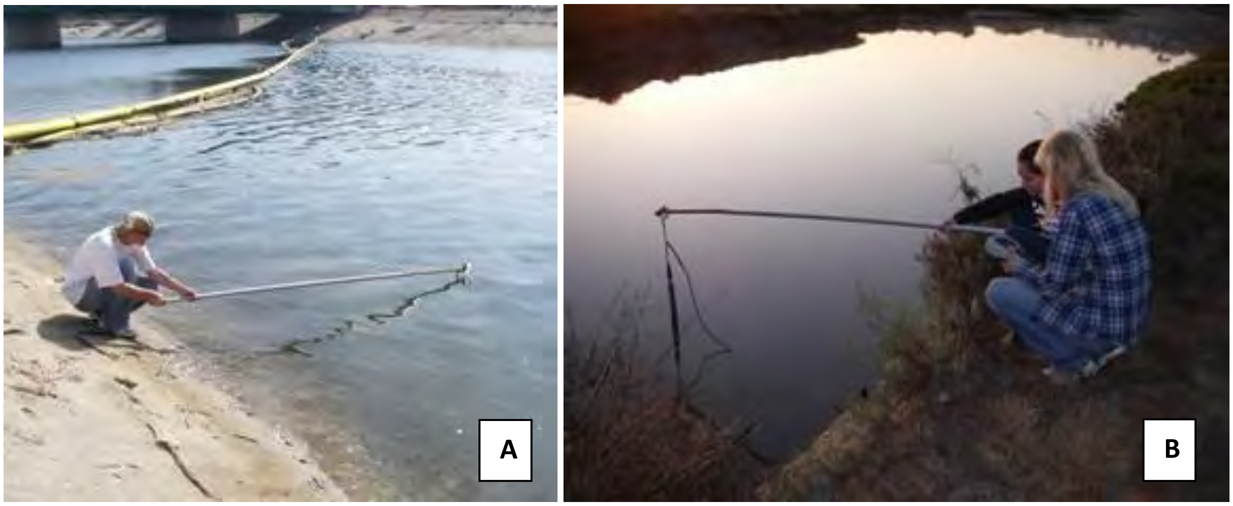

Figure 1.5. Photos depicting: (A) water collection technique, and (B) measurement of *in situ* water parameter data using YSI 600 QS sonde (photos: SMBRC 2010).

Laboratory Methods

Water samples were processed at LMU. Densities of FIB (total coliforms, *E. coli,* enterococci) were measured using Idexx test kits (http://www.idexx.com) based on enzyme substrate test methods (Clescerl et al. 1999: Standard Methods Section 9223 B). For samples collected during dry weather conditions, 10 mL of sample water was added to 90 mL of sterile deionized water mixed with either Enterolert media (for enterococci) or Colilert-18 (for total coliforms and *E. coli*). Each sample was sealed in a Quanti-Tray 2000 97-well tray, then incubated 18-22 hours at 35 °C for total coliforms/*E. coli*, and 24 hours at 41 °C for enterococci (Dorsey 2006, Dorsey et al. 2010). After incubation, reactive wells in the trays were counted and the most probable number (MPN) of bacteria/100 mL was determined for each sample. Turbidity (NTU) was determined using a HACH 2100N turbidimeter in accordance with the procedures described in the user's manual.

Collection bottles were thoroughly cleaned and autoclaved with deionized water before reuse.

Stratification Studies

Site Locations and Times

Stratification studies were conducted on 17 July and 12 August 2010 to measure the stratification of water quality parameters and FIB associated with varying tidal conditions. To determine the effect of the tide gate on the stratification of the water column, the studies were conducted at the permanent data sonde location (BW4) and in Ballona Creek, 100 meters east of the tide gate. The stratified water quality monitoring did not occur within 72 hours of any rain event.

Field Methods

Sampling elevations in the water column were set at 0.05, 0.25, 0.50, and 0.75 meters above the channel bottom. Holes were drilled in a 3 in diameter polyvinyl chloride (PVC) pipe at the selected elevations and half-inch rubber aquarium grade tubing was fed through and glued in place. The free end of the tubing was directed up the PVC pipe (held in place with duct tape and zip ties) and across the channel where the end of each tube was labeled and secured above the ground (Figure 1.6).

Figure 1.6. Stratification sampling set-up (photos: SMBRC 2010).

Four discrete samples were collected at the flood tide, high tide, ebb tide, and low tide points of a full spring tide. At each sampling time, three replicate water samples were taken from each elevation of the water column. Additionally, three replicate surface water samples from BW4 and Ballona Creek were taken during each sampling time. The end of the tube secured to the bank was attached to a peristaltic water pump (American Sigma 900 Max Portable Sampler) which pumped water out of the water column and to the bank (Figure 1.6). The water was then allowed to free-flow for ten seconds to flush the tubes of residual and stagnant water, before being directed into three sterile 125 mL polypropylene sampling bottles. This was repeated for each elevation. Samples from the surface immediately adjacent to the PVC pipe and in Ballona Creek were collected using the same methods as the 24-hour studies.

Immediately following each sampling time, water quality parameters including temperature (°C), salinity (ppt), pH, and dissolved oxygen (mg/L) were taken using a YSI 600 QS. Handheld readings with the YSI were taken at each sampling elevation adjacent to the PVC pipe. One person slowly waded into the water several meters from the PVC pipe and then waited three to five minutes for the water and suspended sediment to settle before taking readings.

Laboratory Methods

After samples were collected, laboratory processing and analyses for FIB were performed using the methods described in the 24-hour water quality sampling above.

Nutrient Sampling Methods

24-hour Studies

The 24-hour nutrient samples were collected in conjunction with the FIB survey during the 0800, 1200, 1600, 2000, and 0400 sampling times during the March 24-hour bacteria study. Samples were collected using the methods described for the 24-hour bacteria studies. All samples were tested for nutrients using a HACH DR2800 spectrophotometer: methods 8048 (phosphates as PO_4), 8192 (nitrogen as NO_3) and 8507 (nitrogen as NO_2) for low ranges (Stephenson 2008).

Stratification Studies

The nutrient stratification samples were collected using the methods and locations described for the stratification bacteria studies above. All samples were tested for nutrients using the methods described for the 24-hour nutrient samples above.

Upper Ballona Creek Studies

Site Locations and Times

Nitrate, nitrite and orthophosphate levels were measured at three locations in the upper Ballona Creek Estuary (Figure 1.7; N4, N5, and N6). Sampling occurred over seven consecutive days from 12 April 2010 to 20 April 2010 at three sites in Ballona Creek: Sawtelle, Slauson and Centinela (sampling did not occur on 14 April). Rain events within two weeks of the beginning of the surveys included: 5, 6, and 12 April 2010 at 0.08, 0.16, and 0.77 inches, respectively (NOAA 2010).

Field Methods

Three field replicate samples were taken per site in sterile 125 mL polypropylene bottles. Samples were put on ice for transportation and were tested within 4 hours of collection. Salinity (ppt), pH, dissolved oxygen (mg/L), and temperature (°C) were also measured at each site using a YSI 600 QS sonde.

Laboratory Methods

Processing methods were the same as those for both the 24-hour nutrient and stratification nutrient processing. Additionally, one-tenth dilutions were used for all sites during wet weather events as well as dry weather days at Slauson due to nutrient values exceeding the maximum for the spectrophotometer low range methods.

Figure 1.7. Survey locations for nutrient input to Ballona Creek (N4, 5, 6) and to the wetlands (N1, 2, 3).

Dissolved Metal Sampling Methods

Quarterly Surveys

Site Locations and Times

Five sampling stations were located in the tidal channels (BW4-8), one site in Ballona Creek south of Lincoln (BW3), and one site in the Fiji Ditch (BW1) (Figure 1.4). Water samples were taken quarterly at all seven sites to test for dissolved metal constituents of concern. Sampling was conducted four times in the Baseline year: 3 September 2009, 16 December 2009, 30 March 2010, and 2 June 2010. Water quality monitoring and sampling did not occur within 72 hours of any rain event.

Field Methods

Water samples were collected using 500mL high-density polyethylene bottles (HDPE) bottles. Before collecting the sample, the bottle was rinsed three times with subsurface water. Precautions were taken to keep the lid close to the top of the bottle to minimize contamination of the bottle with sediment or algae particles. Surface samples were collected, labeled, and stored on ice in a portable cooler until delivery to the lab. A chain of custody form documenting the sample label, date collected, and sample ID accompanied the samples to Wallace Laboratories to test for dissolved metal constituents of concern (Table 1.5). Water was sampled in the wetland sites on an incoming tide over 1.1 meters to capture *in situ* conditions after the tide gate closed. A handheld multi-probe YSI 600 QS was used to measure dissolved oxygen (mg/L), pH, temperature (°C), salinity (ppt), and turbidity.

Laboratory and Analysis Methods

All dissolved metal analyses were conducted by Wallace Laboratories, El Segundo, California using inductively coupled plasma-atomic emission spectrometry in accordance with EPA method 6010B. The resulting data were evaluated using the US Ambient Water Quality Criteria[1] of the USEPA for acute and chronic marine toxicity, and TMDL limits (Table 1.5; USEPA 2009).

Table 1.5. Metal constituents of concern and limits.

	EPA WATER QUALITY CRITERIA[1]		TMDL LIMITS[2]	
	Marine		*for Ballona Creek*	
	acute	**Chronic**	**dry**	**wet**
Phosphorus	----	----	----	----
Potassium	----	----	----	----
Iron	300	50	----	----
Manganese	----	100	----	----
Zinc	90	81	300	94
Copper	4.8	3.1	23	11
Boron	----	1200	----	----
Calcium	----	----	----	----
Magnesium	----	----	----	----
Sodium	----	----	----	----
Sulfur	----	----	----	----
Molybdenum	----	23	----	----
Aluminum	----	----	----	----
Arsenic	69.0	36	----	----
Barium	1000	200	----	----
Cadmium	40	8.8	----	----
Chromium (III)	----	----	----	----
Chromium (IV)	----	----	----	----
Cobalt	----	1.0	----	----
Lead	210	8.1	8.1	49
Lithium	----	----	----	----
Mercury	1.8	0.94	----	----
Nickel	74	8.2	----	----
Selenium	290	71	----	----
Silicon	----	----	----	----
Silver	0.95	----	----	----

	EPA WATER QUALITY CRITERIA[1]		TMDL LIMITS[2]	
Strontium	----	----	----	----
Tin	0.42	0.0074	----	----
Titanium	----	----	----	----
Vanadium	----	50	----	----

[1] USEPA (2009). National Recommended Water Quality Criteria.

[2] SWRCB (2005). Total Maximum Daily Load for Metals in Ballona Creek.

Stormwater Surveys

Site Locations and Times

Samples were collected once at each of 12 locations (Figure 1.7) during one of three storm events throughout the storm season. Sampling locations were tagged using a handheld Garmin GPS unit. All storm events had a total rainfall of greater than one inch. One station (SW11) had high levels of dissolved metals and was therefore sampled twice (i.e. 20 January 2010 and 5 April 2010). Samples SW1 through SW6 were collected on 14 October 2009; Samples SW7 through SW11 were collected on 20 January 2010; Samples SW11 through SW13 were collected on 5 April 2010. SW 2 was not analyzed due to its proximity to another sample already collected. Note that SW12 and 13 were collected on separate sides of the barrier in the Fiji Ditch. Stormwater samples were tested for the same suite of dissolved metals as the quarterly dissolved metals samples (Table 1.5, above).

Field Methods

Water was collected using the methods described for the quarterly dissolved metals surveys.

Figure 1.7. Map of stormwater sampling locations.

Laboratory Methods

Dissolved metals analyses were sent the Wallace Laboratories and processed using the methods described for the quarterly dissolved metals surveys.

RESULTS

Appendix A.1 contains all of the general sampling parameters recorded by the handheld YSI probe including: temperature, salinity, dissolved oxygen, and pH.

The water quality sampling conducted on site during the first Baseline year produced a substantial amount of data. A summary of each set of surveys is included in this report; subsequent in-depth analyses will be incorporated into separate peer-reviewed publications. Overall, water quality sampling showed high levels of bacteria, and that the tidal portion of the BWER functions as a sink, rather than a source of bacteria, since simultaneous sampling showed that bacteria numbers were higher in Ballona Creek than in the tide channels. Nutrients were highest from the samples collected east of the 90

Freeway from Ballona Creek and decreased as the samples were collected closer to the mouth of the Creek.

Dissolved metals from the quarterly sampling within the tidal channels exceeding acute toxicity levels (USEPA 2009) across multiple months included: selenium, boron, zinc, copper, cadmium, lithium, mercury, and tin (Appendix A.2). Dissolved metals from the stormwater surveys that exceeded acute toxicity levels (USEPA 2009) in at least one location included: copper, boron, aluminum, cadmium, chromium, lead, lithium, mercury, selenium, silver, and vanadium (Appendix A.3).

Precipitation influences wet weather sampling and surveys, and flushes toxins and constituents of concern into the stormdrain system. During several months of the Baseline year, the Los Angeles International Airport rain gauge recorded higher than average rainfall (i.e. October, December, January, February, and April; Figure 1.8); however, the total rain fall for the year, 31.6 cm, was similar to the average precipitation from 1944-2010, 31.0 cm.

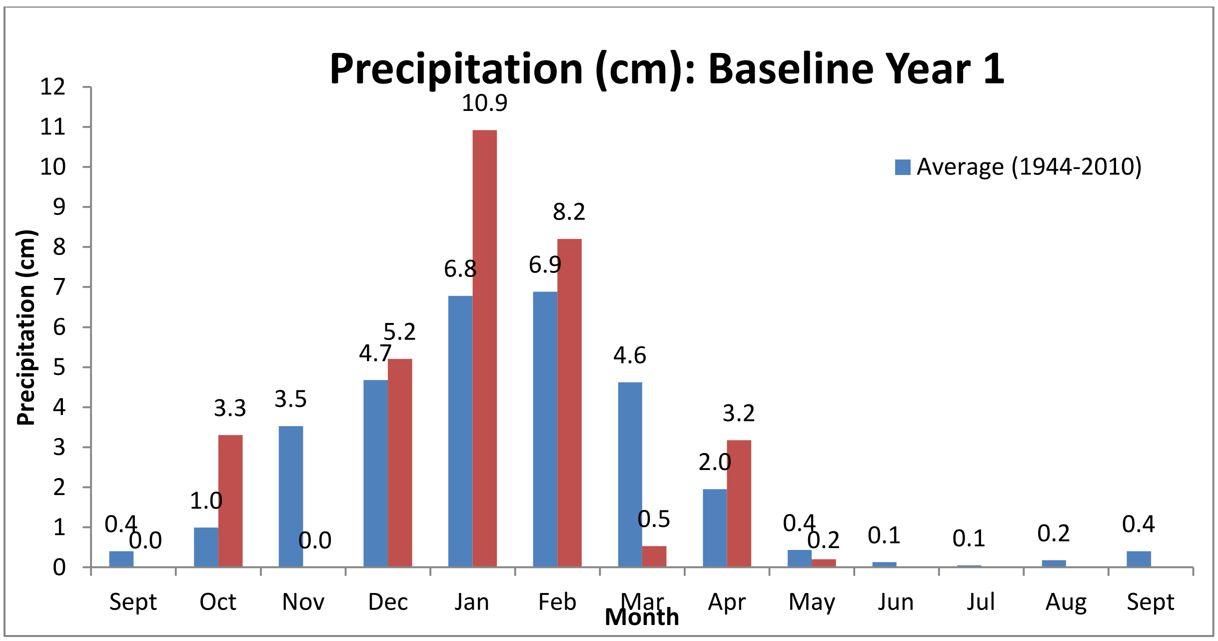

Figure 1.8. Precipitation during the first Baseline Year (September 2009 through September 2010) from the Los Angeles International Airport rain gauge (http://www.wrcc.dri.edu/cgi).

Data Sonde Results

The data obtained using the permanently stationed sonde included readings every 15 minutes over the course of the entire baseline year, before QAQC. Figures 1.9 and 1.10 present examples of the fine-scale level of recorded data by representing two, 24-hour periods during a spring tide event for temperature (Figure 1.9) and salinity (Figure 1.10). Data obtained were also included in separate analyses.

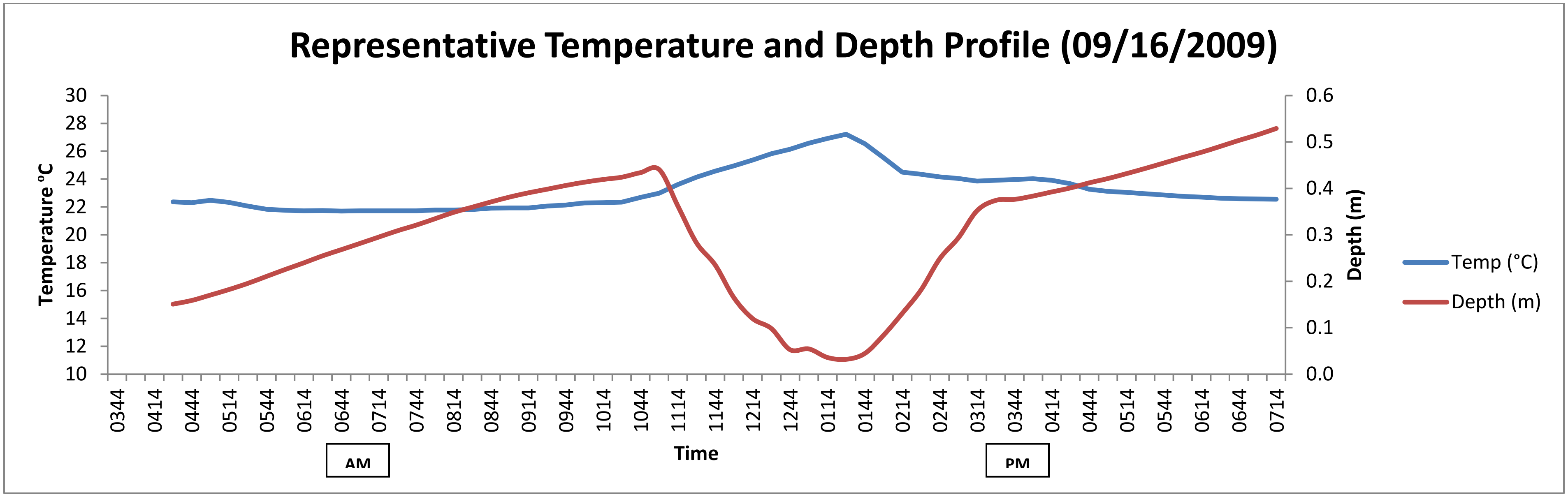

Figure 1.9. Temperature and depth profile using the data sonde (BW4) from 16 September, 2009.

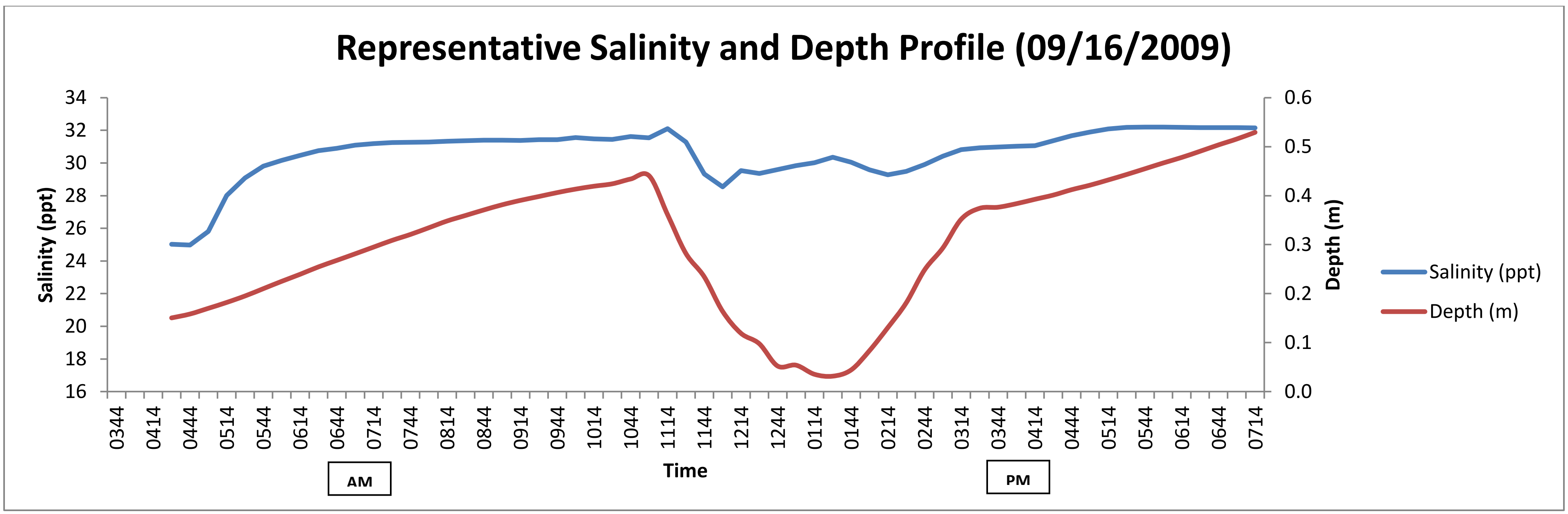

Figure 1.10. Salinity and depth profile using the data sonde (BW4) from 16 September, 2009.

Bacteria Results

24-hour Studies

September 24-hour Study

Figure 1.11 represents the tide height over the course of the sampling period and the average turbidity (± SE) of each station at each time. Note that individual collection times for the samples varied between stations by up to half an hour due to logistical constraints. Overall, turbidity increased during flood tides. The highest turbidity was found in the Ballona Creek sample at high tide.

Figures 1.12-1.14 represent the ditch and wetland FIB sampling data. Bacteria levels often fluctuated by several orders of magnitude throughout the tidal cycle. Only the ditch site was correlated with turbidity (R = 0.77). Ballona Creek samples were found to either exceed the sampling parameters (i.e. >24,200 MPN) or to be several magnitudes higher than both the ditch and wetlands stations (Table 1.6).

Appendix A.1 contains all of the general sampling parameters recorded by the handheld YSI probe including: temperature, salinity, dissolved oxygen, and pH.

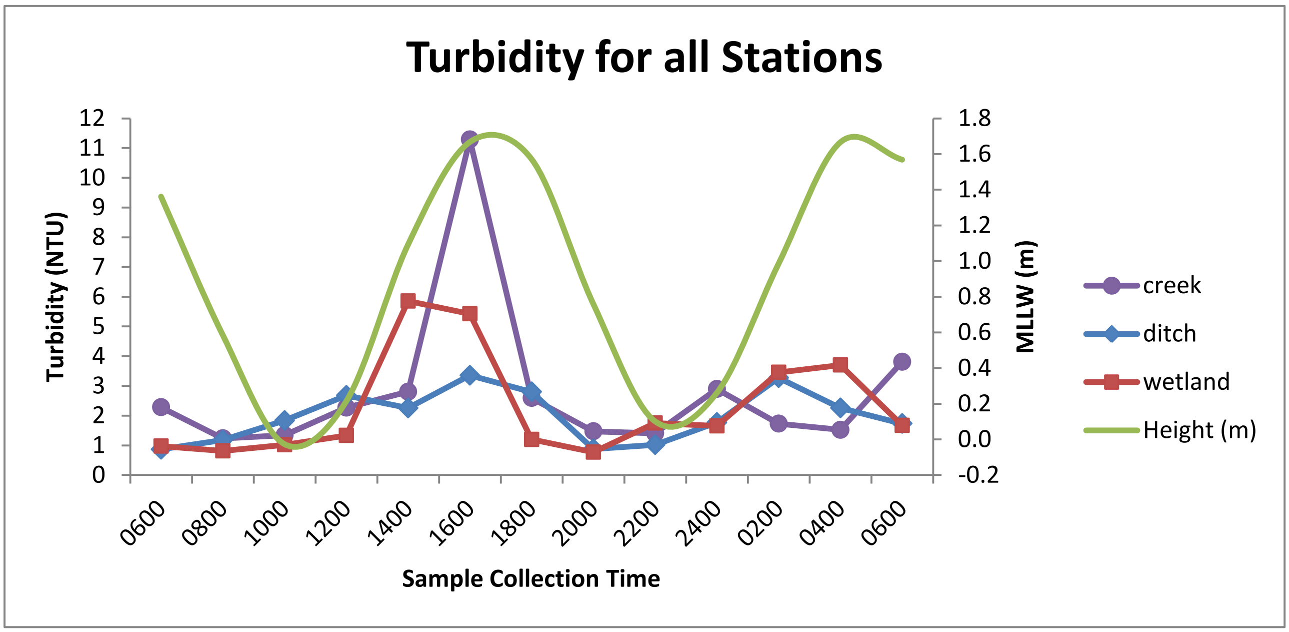

Figure 1.11. Turbidity (NTU) ± standard error at each station over the course of the sampling event and approximate tide height (m).

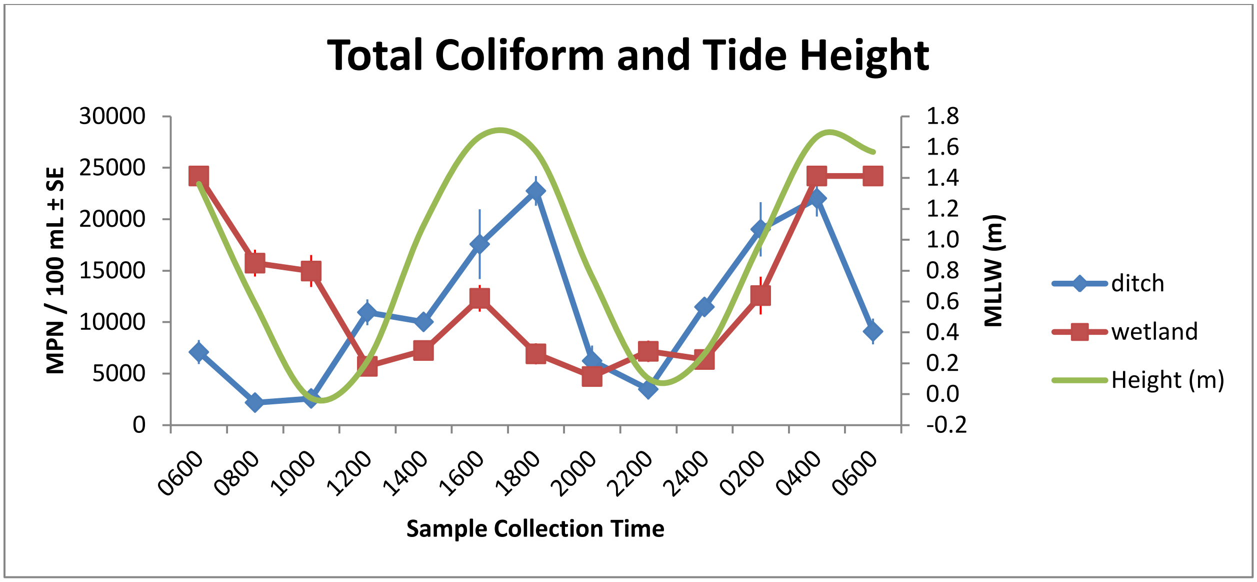

Figure 1.12. Total coliform (MPN / 100 mL) and MLLW throughout the survey at both the ditch and wetland stations.

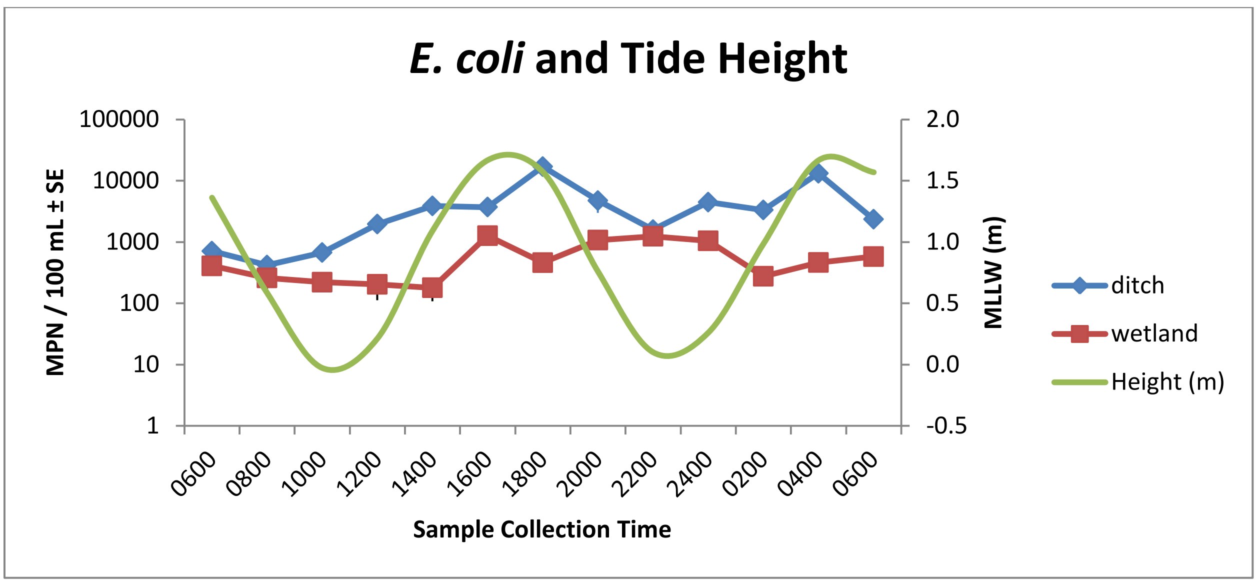

Figure 1.13. *E. coli* (MPN / 100 mL) and MLLW throughout the survey at both the ditch and wetland stations.

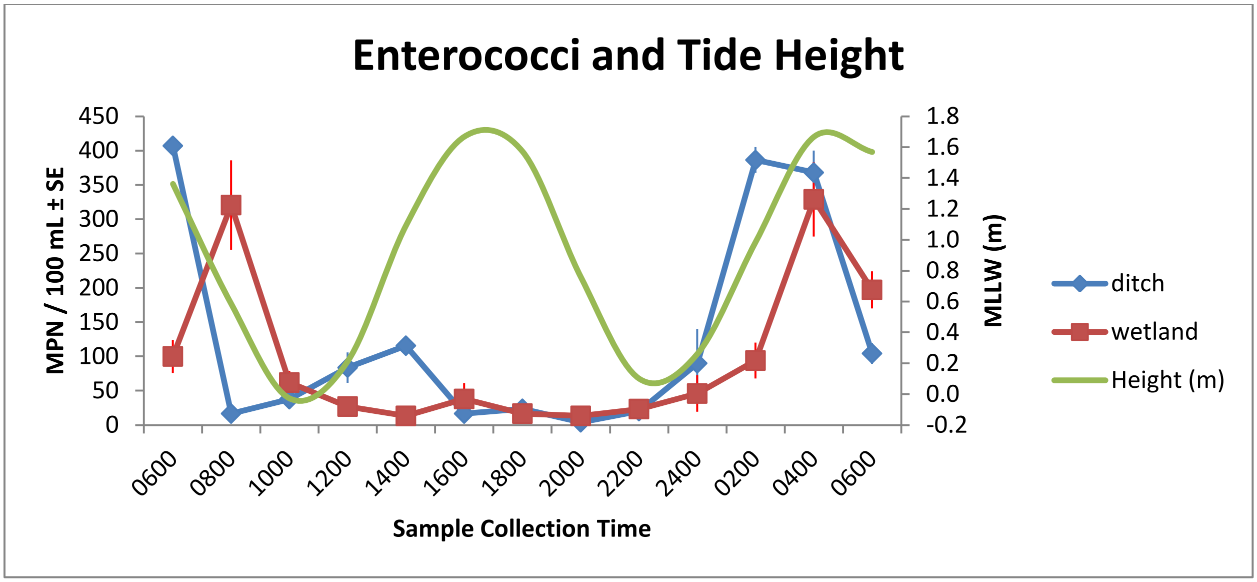

Figure 1.14. Enterococci (MPN / 100 mL) and MLLW throughout the survey at both the ditch and wetland stations.

Table 1.6. Ballona Creek FIB counts for the September survey. 24,200 MPN is the maximum for each test at a 10 mL dilution.

SAMPLE	TIME	TOTAL	*E.COLI* (AVG ± SE)	ENT (AVG ± SE)
1	0600	>24200	497 ± 120	161 ± 30
2	0800	>24200	728 ± 275	1336 ± 489
3	1000	>24200	988 ± 47	289 ± 20
4	1200	>24200	5149 ± 1276	13157 ± 1724
5	1400	>24200	1480 ± 95	3235 ± 651
6	1600	>24200	785 ± 7	249 ± 14
7	1800	>24200	478 ± 73	52 ± 6
8	2000	>24200	5283 ± 269	332 ± 35
9	2200	>24200	4822 ± 396	386 ± 111
10	2400	>24200	2723 ± 180	2329 ± 151
11	0200	>24200	941 ± 429	985 ± 243
12	0400	>24200	1028 ± 51	387 ± 22
13	0600	>24200	510 ± 61	94 ± 27

March 24-hour study

Overall, the March 24-hour study resulted in lower *E. coli* densities than the September 24-hour study. However, both sets of data expressed similar trends of increasing bacteria numbers during the outflow tides. Figure 1.15 represents the tide height over the course of the sampling period and the average turbidity (± standard error) of each station at each time. Note that individual collection times for the samples varied between stations by up to half an hour due to logistical constraints. Turbidity was the highest during ebb, flood, and low tides, while the September surveys found that the flood tides had the highest turbidity. Sediment resuspension was hypothesized to be the cause of the increase in both turbidity and bacteria and was tested during the stratification surveys.

Figures 1.16-1.18 represent the ditch and wetland FIB sampling data. Bacteria levels were highly variable and often fluctuated by several orders of magnitude throughout the tidal cycle. Numbers were highest during outflow and inflow tides and lowest at high tides. Ballona Creek samples either exceeded the sampling parameters (i.e. >24,200 MPN) or were several magnitudes higher than both the ditch and wetlands stations (Table 1.7).

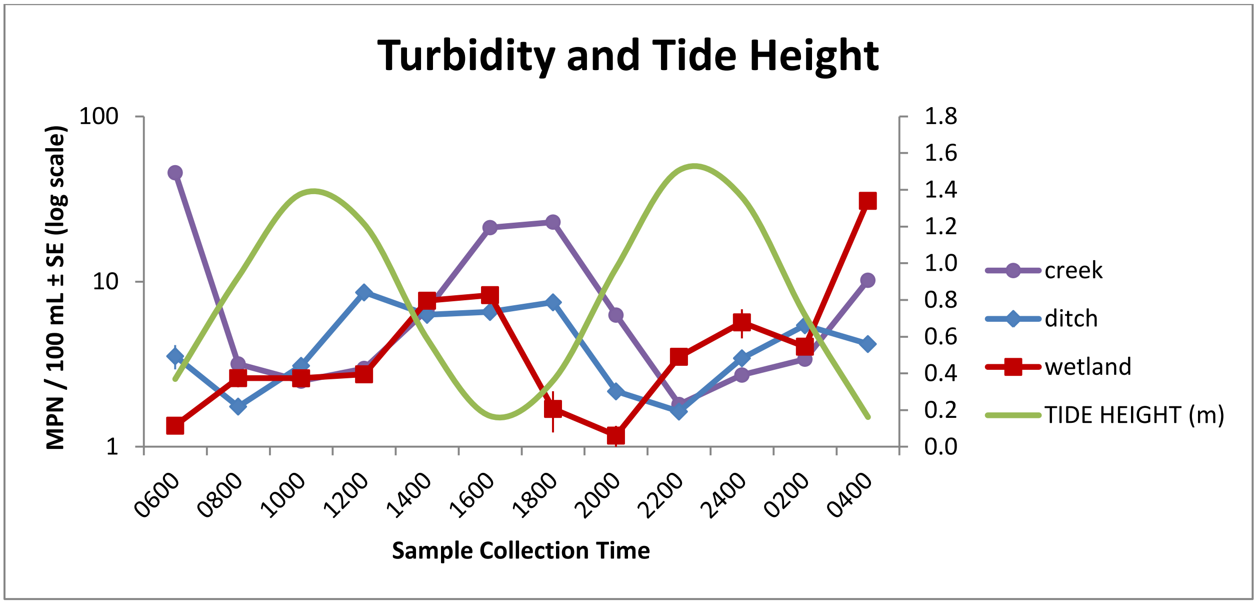

Figure 1.15. Turbidity (NTU) ± standard error at each station over the course of the sampling event and approximate tide height.

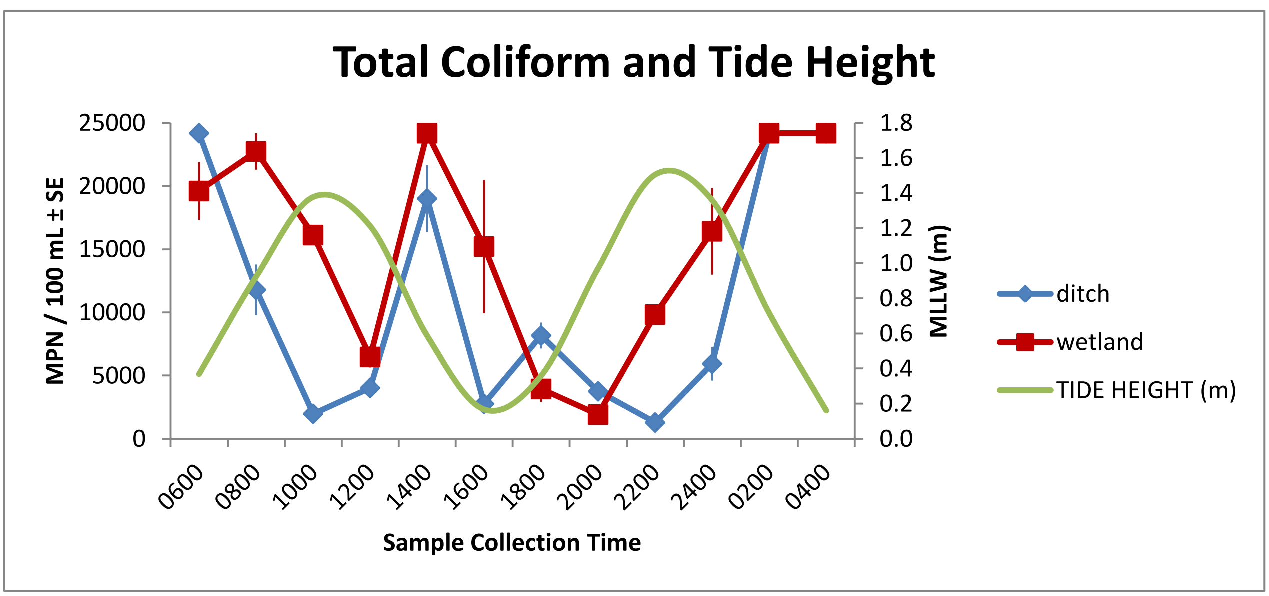

Figure 1.16. Total coliform (MPN / 100 mL) and MLLW throughout the survey at both the ditch and wetland stations.

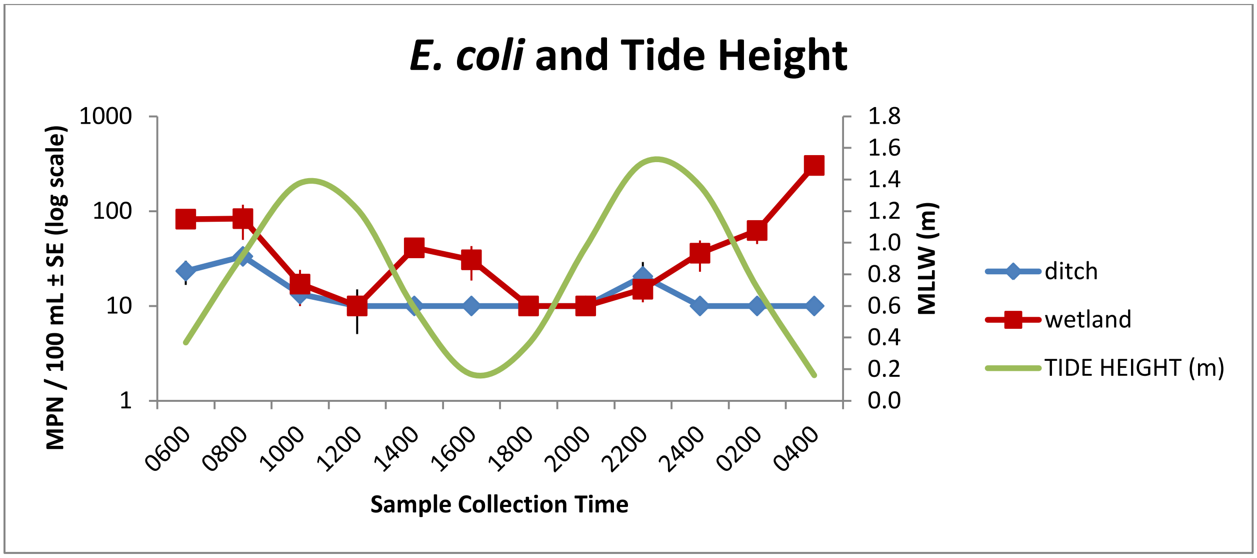

Figure 1.17. *E. coli* (MPN / 100 mL) and MLLW throughout the survey at both the ditch and wetland stations.

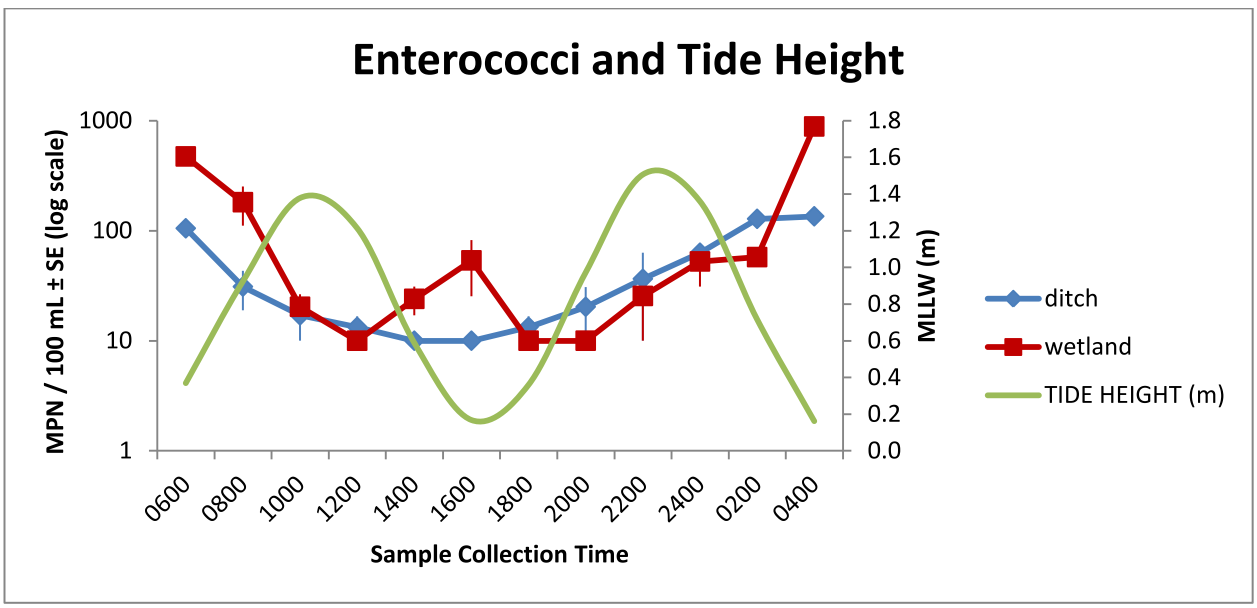

Figure 1.18. Enterococci (MPN / 100 mL) and MLLW throughout the survey at both the ditch and wetland stations.

Table 1.7. Ballona Creek FIB counts for the September survey. 24,200 MPN is the maximum for each test at a 10 mL dilution.

SAMPLE	TIME	TOTAL	*E.COLI* (AVG ± SE)	ENT (AVG ± SE)
1	0600	>24192	523 ± 38	2074 ± 69
2	0800	>24192	231 ± 31	689 ± 173
3	1000	>24192	34 ± 13	162 ± 18
4	1200	>24192	280 ± 40	462 ± 98
5	1400	>24192	199 ± 21	423 ± 60
6	1600	>24192	278 ± 57	732 ± 49
7	1800	>24192	154 ± 6	816 ± 20
8	2000	>24192	52 ± 6	405 ± 27
9	2200	>24192	10 ± 0	240 ± 17
10	2400	>24192	555 ± 116	3564 ± 309
11	0200	>24192	436 ± 56	1254 ± 168
12	0400	>24192	668 ± 19	2610 ± 467

Appendix A.1 contains all of the general sampling parameters recorded by the handheld YSI probe including: temperature, salinity, dissolved oxygen, and pH.

Stratification Studies

Stratification studies were conducted in July and August of the first Baseline year and during March and April of the second Baseline year, to investigate the tidally-influenced movement of bacteria in the wetlands and the relationship to turbidity and resuspension. Detailed analyses and data from the four stratification studies will be presented in the final Baseline Monitoring report.

Figures 1.19 and 1.20 depict the turbidity over depth within the water column from the July (Figure 1.19) and August (Figure 1.20) studies. The colors represent both the time that the samples were collected, and a tide range (i.e. flood, high, ebb, or low). The lowest tides (purple lines on both Figures) have the highest levels of turbidity, due to resuspension of sediment on the outgoing tide. The high tide samples (1400 and 1100) have lower turbidity and were taken after the closure of the tide gate in the wetlands, and after the water column had time without disturbance from flood or ebb tides. Relationships between the different FIB counts within different strata of the water column, and relationships between additional parameters measured (e.g. salinity) will be evaluated in subsequent reports.

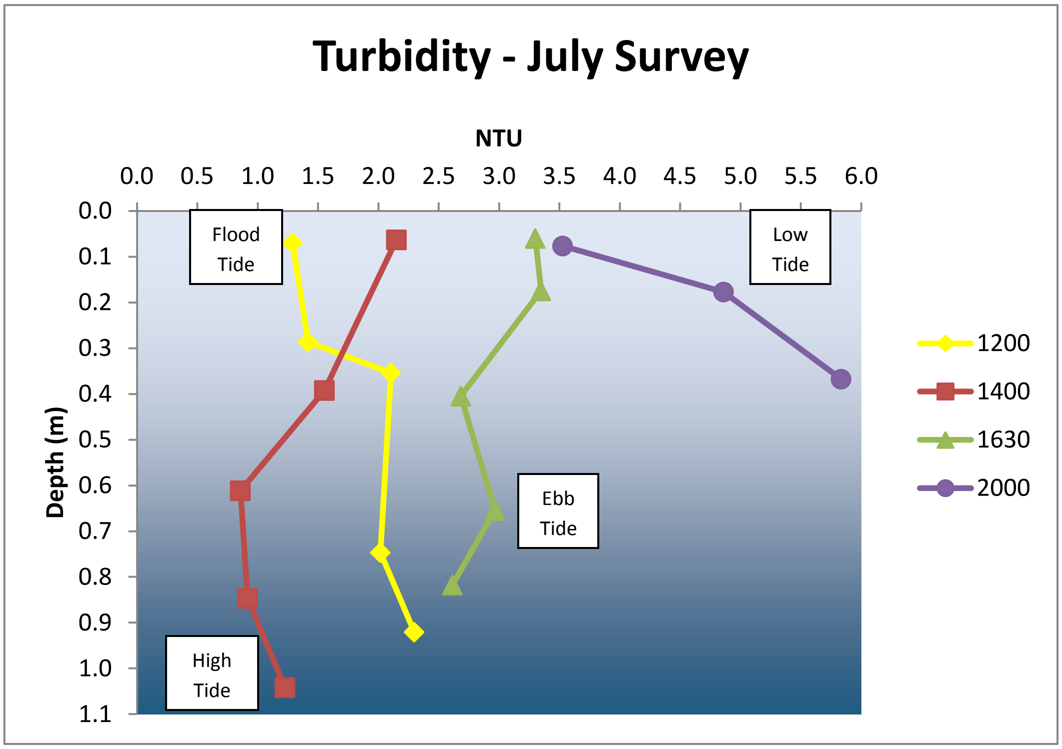

Figure 1.19. Turbidity results from the July stratification survey. Samples were collected at BW4.

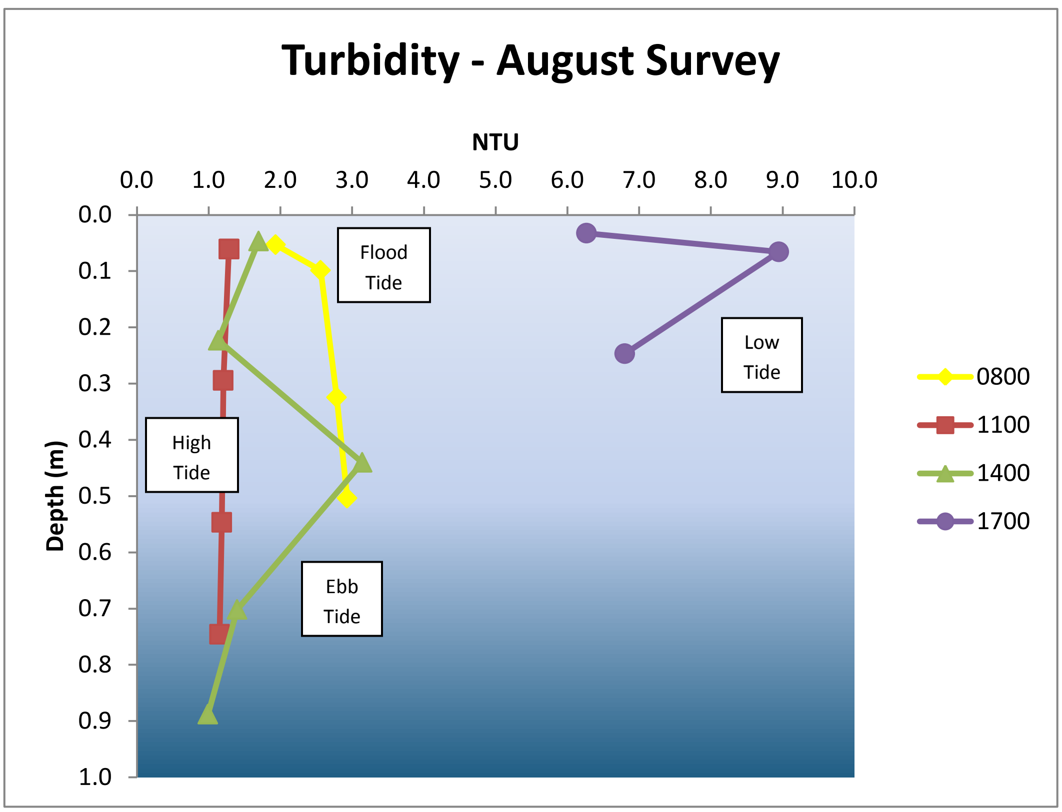

Figure 1.20. Turbidity results from the August stratification survey. Samples were collected at BW4.

Nutrient Results

24-hour Studies

Nitrate (NO_3), nitrite (NO_2), and phosphate (PO_4) were sampled during the March 24-hour survey during every second sample time (Figures 1.21-1.23). Three field replicates were analyzed and averaged for each sample time. As there is no current TMDL for nutrients in Ballona Creek (or consistent estuarine numerical limits), results were not compared to regulatory limits. The closest nutrient TMDL is for Malibu Creek, but it is fresh water based.

In general, nitrate and nitrite remained below 0.1 ppm, but phosphate ranged from 0 to 0.6 ppm. Nitrate, nitrite, and phosphate all increased during outflow tides. The Creek values were usually higher than the ditch and wetland sites, except for several wetland samples in which phosphate concentrations were elevated.

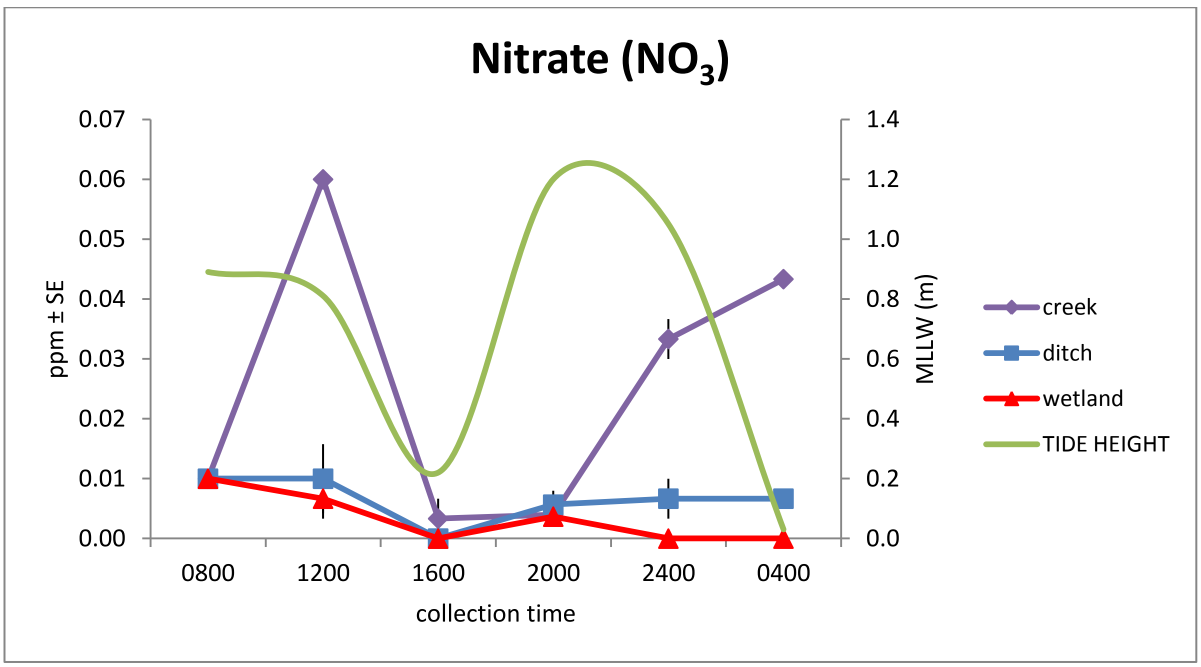

Figure 1.21. Nitrate levels for each sampling station and collection time (± SE) compared with tide height.

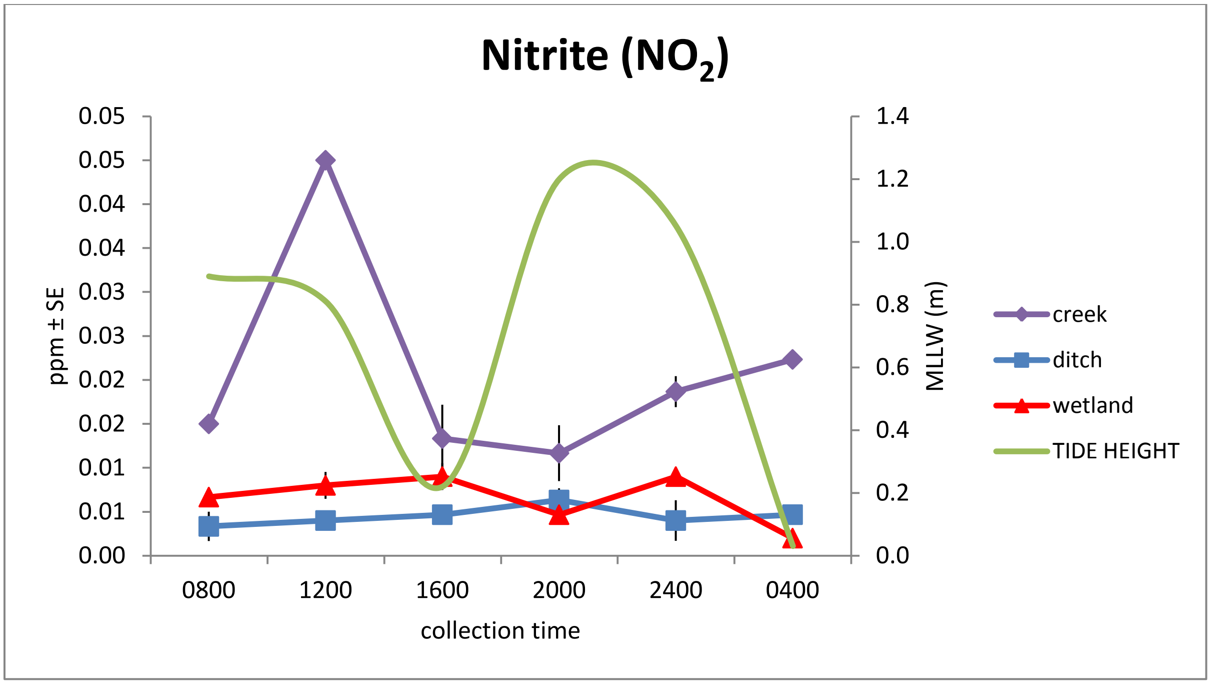

Figure 1.22. Nitrite levels for each sampling station and collection time (± SE) compared with tide height.

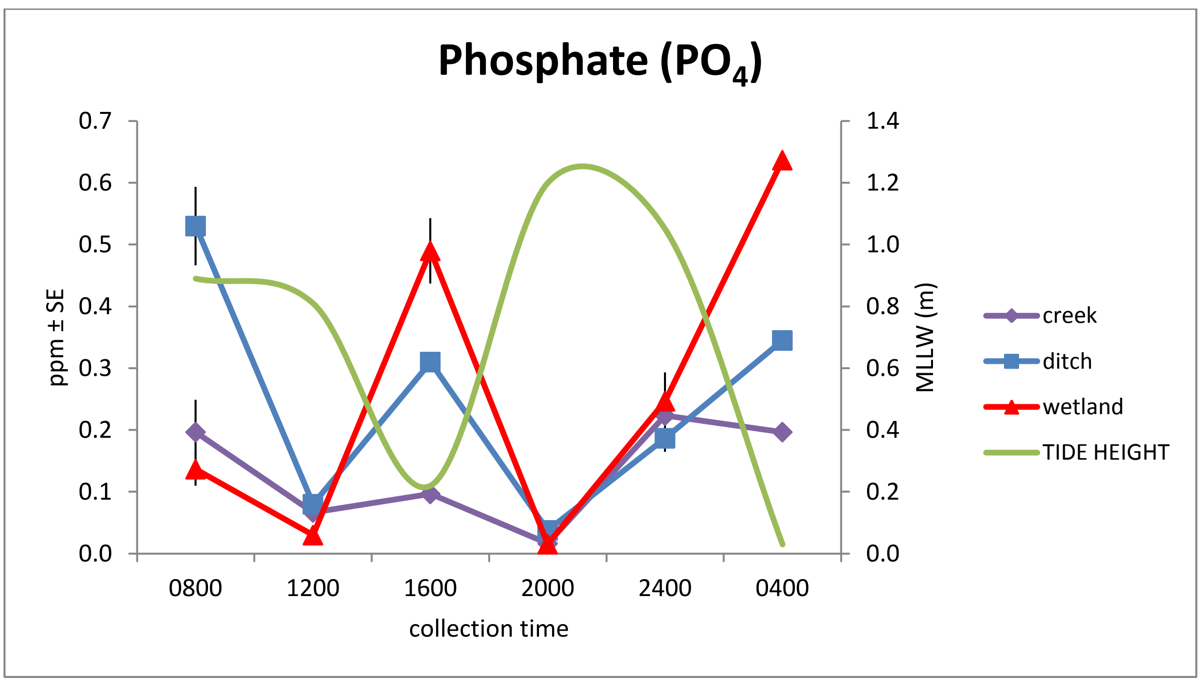

Figure 1.23. Phosphate levels for each sampling station and collection time (± SE) compared with tide height.

Stratification Studies

Average nitrite and nitrate values were low. None of the average nitrate or nitrite values approached 0.1 ppm (Tables 1.8 and 1.9). All of the average phosphate values exceeded the 0.1 ppm. The highest phosphate levels were during the incoming tide (0800) of the August study (Table 1.9).

Table 1.8. Nutrient results from the July stratification study.

TIME	Average NO_3	Average NO_2	Average PO_4
1200	0.0093	0.0063	0.347
1400	0.0083	0.0053	0.922
1630	0.0083	0.0050	0.902
2000	0.0143	0.0100	0.483

Table 1.9. Nutrient results from the August stratification study.

TIME	Average NO_3	Average NO_2	Average PO_4
0800	0.0080	0.0068	1.022
1100	0.0133	0.0078	0.527
1400	0.0083	0.0043	0.450
1700	0.0125	0.0068	0.190

Upper Ballona Creek

The highest nitrate (NO_3) concentrations were at the Ballona Creek sampling station at Slauson. Nitrate levels were above 1.0 ppm at Slauson for 5 consecutive days (Figure 1.25). Nitrite (NO_2) values were all below 1.0 ppm (Figure 1.25). Phosphate (PO_4) levels at all sites exceeded 0.1 ppm in every sample (Figure 1.26). Two spikes in PO_4 levels were observed on the two wet weather days (12 and 20 April).

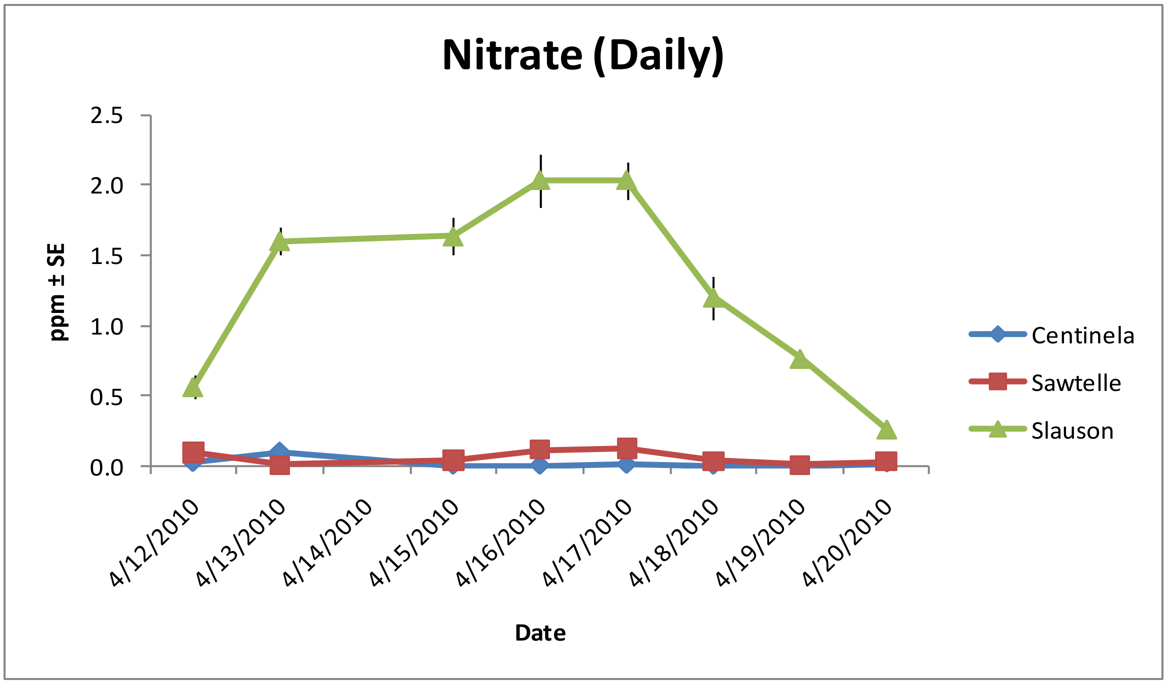

Figure 1.24. Average daily nitrate value for each upper Ballona Creek sampling station (± SE).

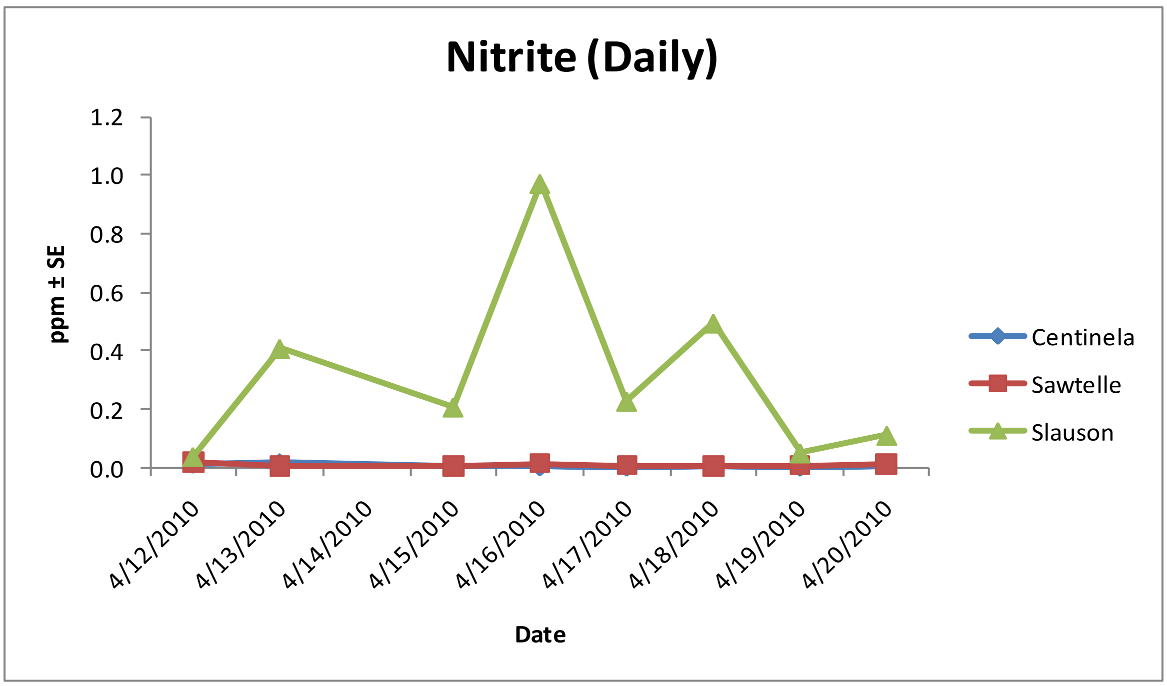

Figure 1.25. Average daily nitrite value for each upper Ballona Creek sampling station (± SE).

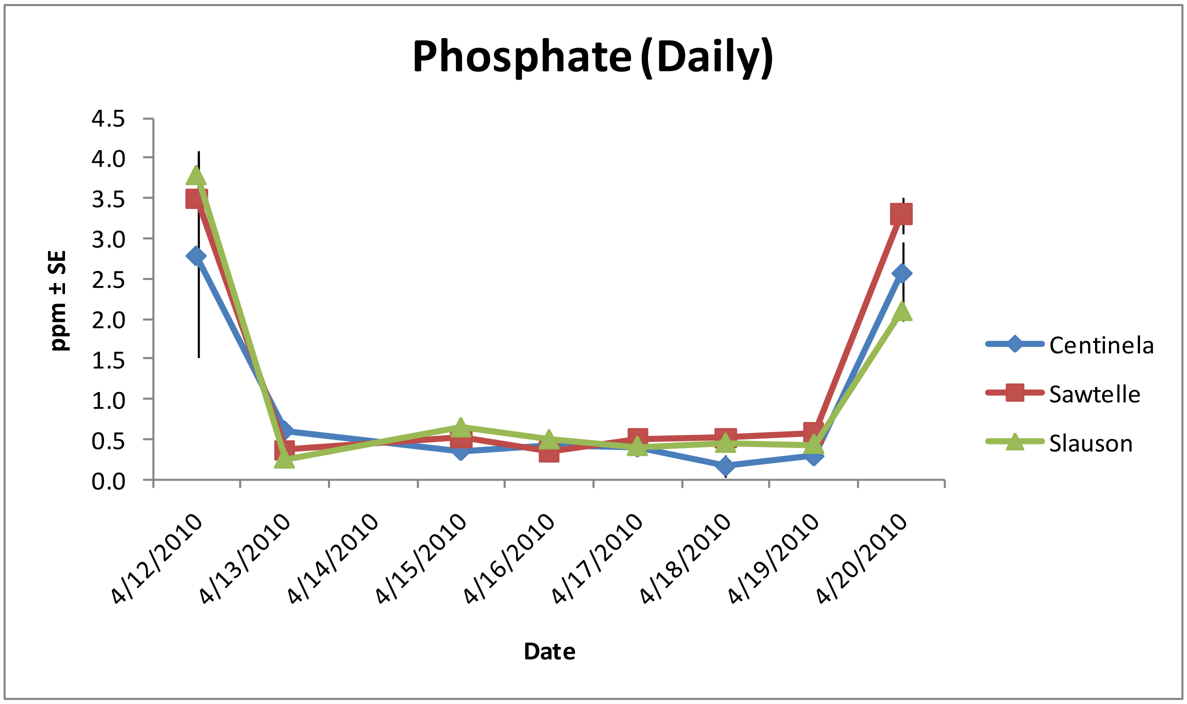

Figure 1.26. Average daily phosphate value for each upper Ballona Creek sampling station (± SE).

Dissolved Metal Results

Quarterly Studies

The dissolved metal values from the quarterly sampling events indicate the ambient conditions within the surface waters of the BWER at the seven stations where samples were collected (i.e. BW1, 3, 4, 5, 6, 7, and 8; Table 1.10). Five stations were within the tide channels, one station in the Fiji Ditch, and one station in Ballona Creek. Results were evaluated using both the TMDL limits from Ballona Creek, and the acute and chronic marine surface water recommended limits by the EPA (Table 1.5; USEPA 2009). Dissolved metals from the quarterly sampling within the tidal channels that exceeded acute toxicity levels (USEPA 2009) across multiple months included: selenium, boron, zinc, copper, cadmium, lithium, mercury, and tin (Table 1.11). Appendix A.2 includes the values for each of the constituents of concern that were surveyed at each station.

Table 1.10. Handheld YSI values for the March and June dissolved metal sampling events. Note: Due to Quality Assurance checks, the data from the September and December YSI readings were not used.

Date	SAMPLE	TEMP (ºC)	SAL (ppt)	DO (%)	DO (mg/L)	pH
3/30/2010	**BW1**	17.73	35.00	0.3	0.05	7.65
3/30/2010	**BW3**	17.88	25.98	10.3	0.86	8.27
3/30/2010	**BW4**	17.18	31.63	19.0	1.53	8.28
3/30/2010	**BW5**	17.51	25.54	17.7	1.45	8.27
3/30/2010	**BW6**	17.57	28.13	19.9	1.60	8.24
3/30/2010	**BW7**	18.01	23.62	24.6	2.03	8.24
3/30/2010	**BW8**	18.08	25.18	27.3	2.17	8.28
6/2/2010	**BW1**	20.48	34.02	73.6	5.62	7.60
6/2/2010	**BW3**	21.63	19.55	143.9	11.38	8.34
6/2/2010	**BW4**	18.76	33.88	120.5	9.21	8.03
6/2/2010	**BW5**	24.50	27.45	130.5	9.37	8.21
6/2/2010	**BW6**	21.59	31.85	122.9	8.99	8.11
6/2/2010	**BW7**	23.36	26.06	138.7	10.15	8.21
6/2/2010	**BW8**	26.23	26.42	156.8	11.05	8.28

Table 1.11. Exceedances of the dissolved metal constituents of concern based on acute toxicity levels for seawater (USEPA 2009). Constituents with USEPA acute toxicity limits are included in the table. Note: S = September 2009, D = December 2009, M = March 2010, J = June 2010.

	BW1	BW3	BW4	BW5	BW6	BW7	BW8	acute max (ppb)
potassium	S D M J	----	D M J	D	D J	S D	----	373000
manganese	----	----	----	----	----	----	----	2300
zinc	M J	J	J	J	J	M J	M J	120
copper	M J	M J	M J	M J	M J	M J	M J	13
boron	S D M J	S D M J	S D M J	S D M J	S D M J	S D M J	S D M J	30
molybdenum	----	----	----	----	----	----	----	16000
aluminum	----	----	----	----	----	----	----	750
arsenic	----	----	----	----	----	----	----	340
barium	S	----	D	S	----	M	----	110
cadmium	S D M J	S M J	S D M J	S D M J	S D M J	S D M J	S D M J	2
chromium	----	----	----	----	----	----	----	16
cobalt	----	----	----	----	----	----	----	1500
lead	----	----	D	----	----	D	M	65
lithium	S D M J	S M J	S D M J	S D M J	S D M J	S D M J	S D M J	260
mercury	S M	S	----	----	----	----	----	1.4
nickel	----	----	----	----	----	----	----	470
selenium	D M J	D M J	S M J	J	D M J	D M J	M J	13
silver	M	M	M	M	----	M	M	1.6
strontium	----	----	----	----	----	----	----	15000
tin	S	D M	S	S	S	----	S M	0.46
titanium	----	----	----	----	----	----	----	2000
vanadium	----	----	----	----	----	----	----	280

Ballona Creek is on the Clean Water Act Section 303(d) list of impaired waterbodies for dissolved copper, dissolved lead, total selenium, and dissolved zinc (SWRCB 2005). Dry weather numeric targets for each constituent are 23, 8.1, 5, and 304 μg/L, respectively. Figures 1.29-1.30 display the values for each of these TMDL constituents during each of the quarter sampling events. Dissolved copper exceeded the TMDL limit at each station in both the March sampling event and the June sampling event (Figure 1.27). Dissolved lead exceeded the TMDL limit during at least one quarter at BW4, BW7, and BW8, all stations within the muted tidal wetlands (Table 1.11, Figure 1.28). Dissolved selenium exceeded the maximum total recoverable limit of 5 μg/L at the majority of the stations during every quarter except for August (Figure 1.29). Dissolved zinc exceeded the TMDL limit in June at both BW1 and BW8 (Fiji Ditch and the station furthest from the tide gate, respectively) (Figure 1.30).

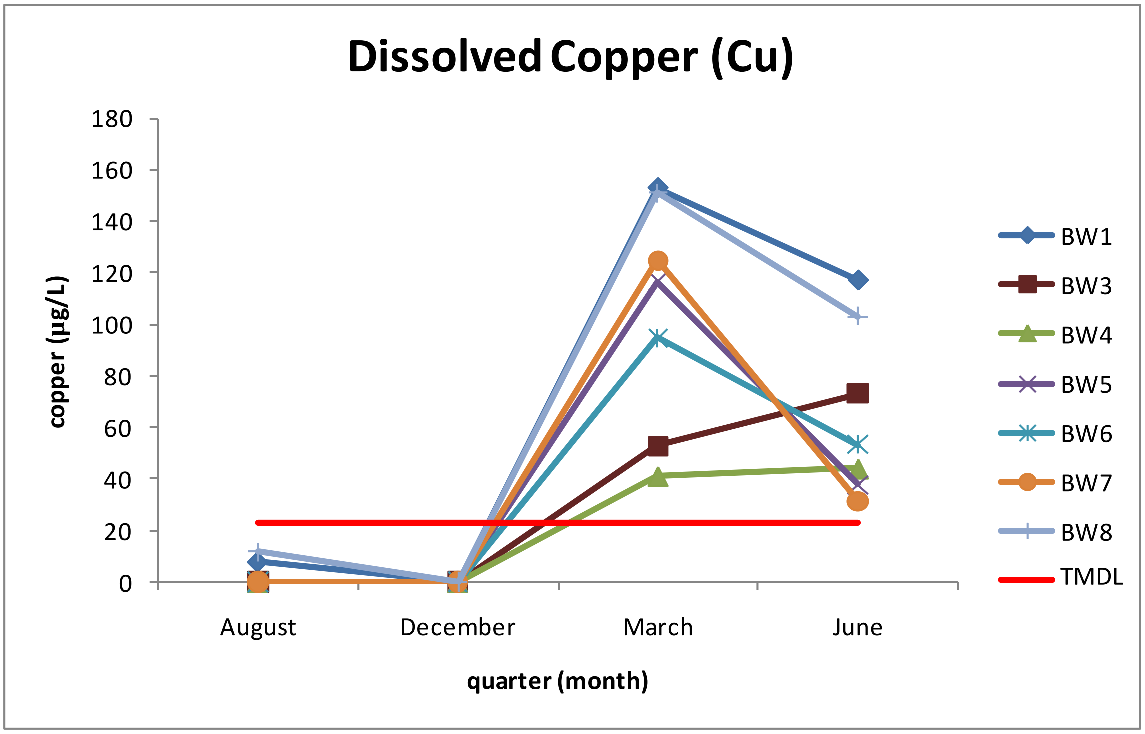

Figure 1.27. Dissolved copper values for each station during each sampling event (quarter). The TMDL limit (23 µg/L) is shown in red.

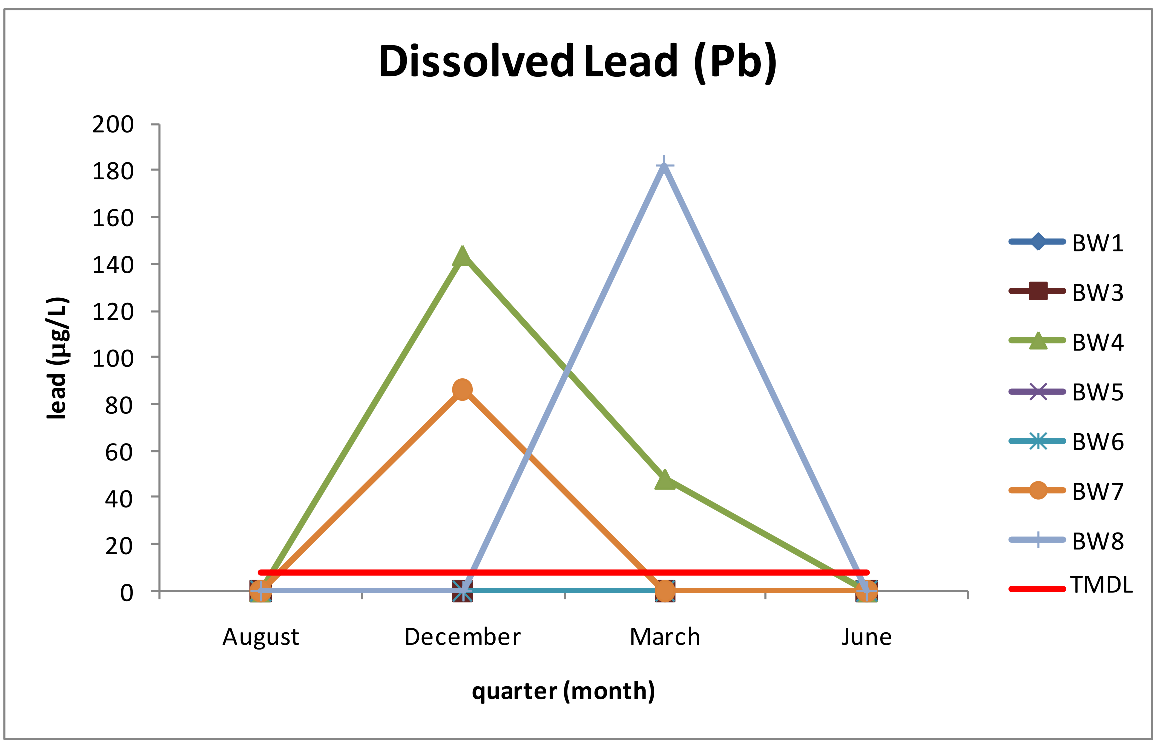

Figure 1.28. Dissolved lead values for each station during each sampling event (quarter). The TMDL limit (8.1 µg/L) is shown in red.

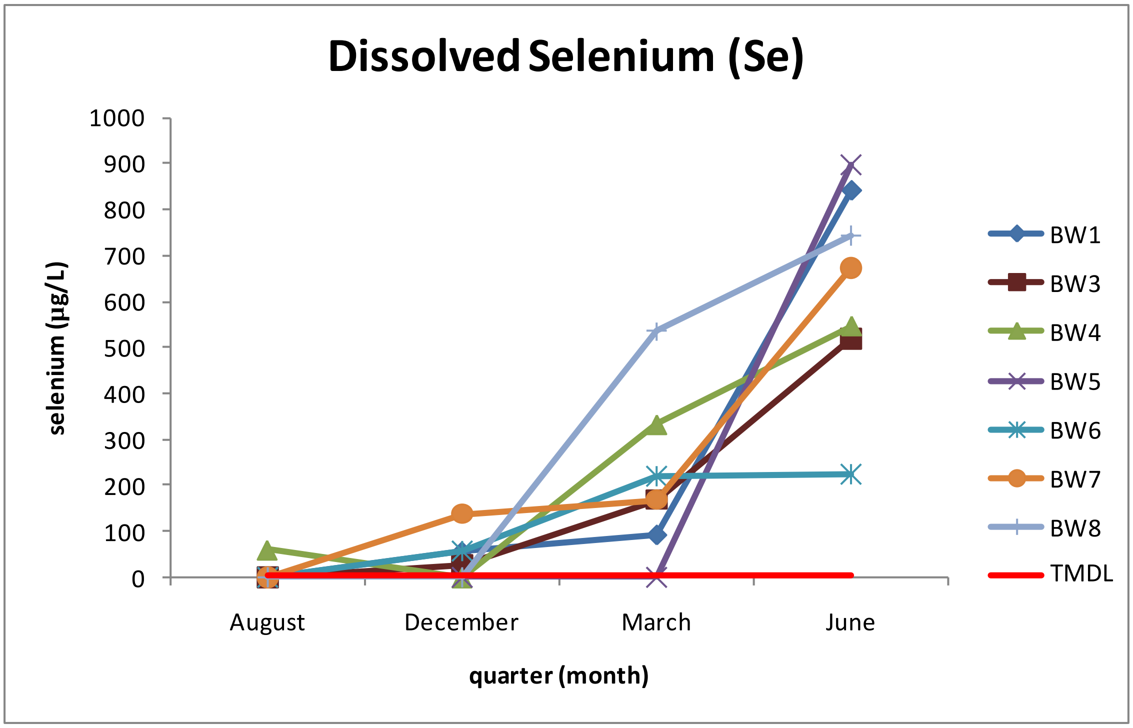

Figure 1.29. Dissolved selenium values for each station during each sampling event (quarter). The TMDL limit (5 µg/L) is shown in red.

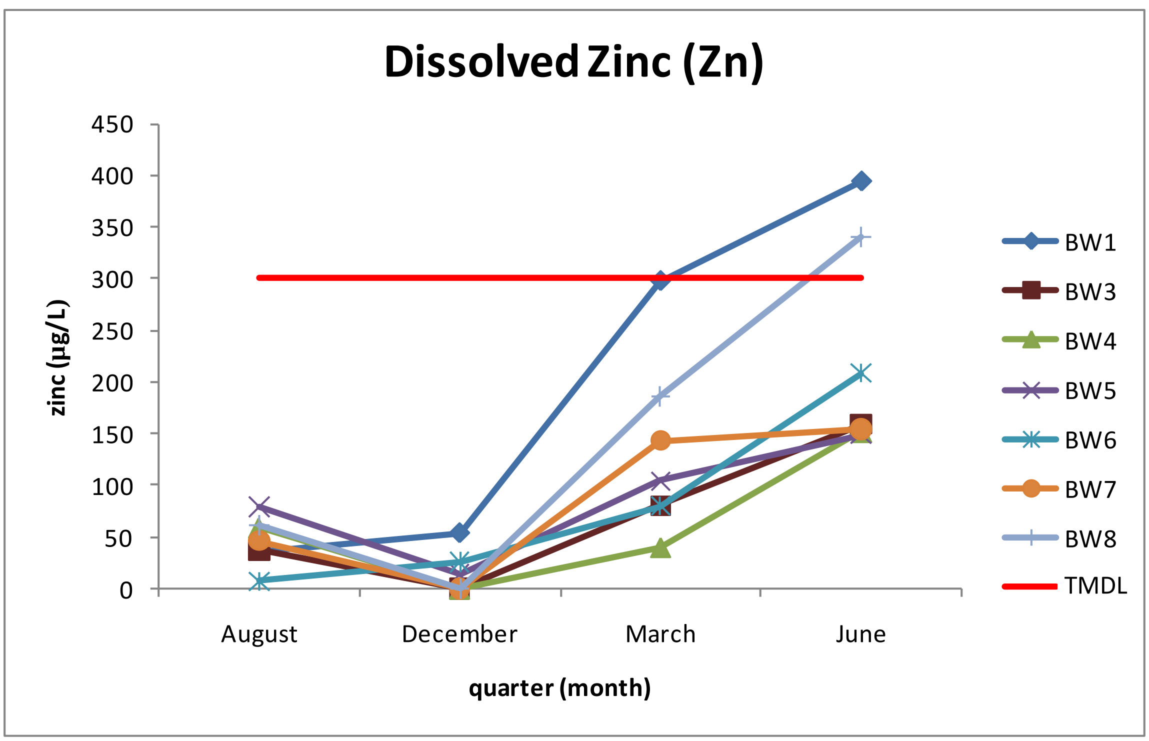

Figure 1.30. Dissolved zinc values for each station during each sampling event (quarter). The TMDL limit (304 µg/L) is shown in red.

Stormwater Dissolved Metal Surveys

Appendix A.3 presents the values for each dissolved metal constituent of concern at all sampling stations.

All four constituents included in the Ballona Creek metal TMDL (copper, lead, selenium, zinc) exceeded the wet weather TMDL limit (11, 49, 5, and 94 μg/L respectively) at one or more stations. Copper also exceeded the acute maximum threshold at seven of the stations (Figure 1.31); lead exceeded the chronic toxicity at two stations (SW4 and 6) and the acute toxicity at one station (SW11); selenium exceeded the chronic toxicity at four stations (SW6, 10, 12 and 13) and the acute at two stations (SW7 and 8). While zinc exceeded the wet weather TMDL limit at station SW5, it did not exceed either the chronic or acute toxicity values at any station.

Several constituents of concern were found to be more than an order of magnitude higher than the acute toxicity levels for fresh water in at least one sample: aluminum (Figure 1.32), boron (Figure 1.33), cadmium, mercury, silver, vanadium (Appendix A.3). Additional constituents found at higher levels than the acute toxicity levels (though not an order of magnitude above) included chromium and lithium.

FUTURE DIRECTIONS

Metals will be sampled semi-annually and timed to capture the highest concentrations of constituents. The permanent data sonde will remain in place, and nutrient and bacteria samples will continue to be processed as needed. Two additional wet weather stratification studies will be conducted in the second Baseline year.

Figure 1.31. Dissolved copper in stormwater samples at all stations. The green dots indicate values below the chronic toxicity value for copper, and the orange and red dots are above the acute maximum toxicity levels (USEPA 2009).

Figure 1.32. Dissolved aluminum in stormwater samples at all stations. The green dots indicate values below the chronic toxicity value for aluminum, and the orange and red dots are above the acute maximum toxicity levels (USEPA 2009).

Figure 1.33. Dissolved boron in stormwater samples at all stations. The green dots indicate values below the chronic toxicity value for boron, and the orange and red dots are above the acute maximum toxicity levels (USEPA 2009).

APPENDIX A.1

Water quality conditions for all sampling events

24 hour Bacteria Sampling							
Date	Location	Time	Temp (ºC)	Salinity (ppt)	DO (%)	DO (mg/L)	pH
9/18/2009	ditch	0610	22.36	33.50	73.1	5.16	7.83
9/18/2009	creek	0624	22.89	12.97	59.4	5.57	8.11
9/18/2009	wetland	0654	22.02	27.50	97.4	7.23	8.25
9/18/2009	ditch	0753	22.89	33.85	111.6	7.81	8.10
9/18/2009	creek	0805	21.93	23.92	103.9	7.94	8.26
9/18/2009	wetland	0827	21.66	27.92	103.9	7.66	8.14
9/18/2009	ditch	1003	23.18	33.99	114.3	8.00	8.03
9/18/2009	creek	1018	22.80	12.92	106.6	7.83	8.15
9/18/2009	wetland	1040	22.95	22.95	118.1	9.10	8.14
9/18/2009	ditch	1154	24.07	34.16	134.6	9.30	8.11
9/18/2009	creek	1208	24.14	29.30	126.2	9.50	8.20
9/18/2009	wetland	1230	23.70	31.29	141.4	10.01	8.15
9/18/2009	ditch	1357	28.45	0.10	225.2	16.10	8.40
9/18/2009	creek	1414	25.17	1.20	193.2	15.91	8.39
9/18/2009	wetland	1436	27.35	13.33	181.6	13.58	8.38
9/18/2009	ditch	1541	31.13	15.50	266.8	17.50	8.60
9/18/2009	creek	1555	27.01	12.50	361.9	27.47	8.96
9/18/2009	wetland	1624	27.66	28.88	196.1	13.07	8.55
9/18/2009	ditch	0556	27.55	34.39	221.5	17.55	8.73
9/18/2009	creek	0612	25.35	19.39	241.4	21.12	8.90
9/18/2009	wetland	0637	23.07	30.85	119.0	8.32	8.30
9/18/2009	ditch	0801	23.74	33.85	114.3	7.83	8.21
9/18/2009	creek	0815	23.75	28.98	124.0	10.23	8.34
9/18/2009	wetland	0840	22.86	30.96	97.2	6.94	8.24
9/18/2009	ditch	1010	23.61	15.20	106.9	8.29	8.21
9/18/2009	creek	2226	23.56	28.69	112.0	8.03	8.32
9/18/2009	wetland	2250	22.61	30.46	124.8	8.96	8.28
9/18/2009	ditch	1158	23.47	33.95	101.2	6.95	8.07
9/19/2009	creek	1211	24.20	12.69	151.8	11.90	8.82
9/19/2009	wetland	1235	22.57	30.15	122.4	8.63	8.24
9/19/2009	ditch	0153	22.88	34.47	69.9	4.74	7.72
9/19/2009	creek	0208	24.26	19.33	117.6	8.69	8.43
9/19/2009	wetland	0230	22.40	31.42	93.8	6.54	8.12
9/19/2009	ditch	0353	22.32	34.36	52.7	3.25	7.52
9/19/2009	creek	0409	23.99	16.17	79.9	5.21	8.22

24 hour Bacteria Sampling							
Date	**Location**	**Time**	**Temp (°C)**	**Salinity (ppt)**	**DO (%)**	**DO (mg/L)**	**pH**
9/19/2009	wetland	0433	22.09	29.70	60.7	4.28	7.95
9/19/2009	ditch	0604	22.30	34.23	----	4.01	7.61
9/19/2009	creek	0624	23.41	24.10	50.8	3.50	8.02
9/19/2009	wetland	0649	22.04	26.73	103.1	7.61	8.25
3/16/2010	ditch	0558	12.55	0.19	36.2	3.49	7.06
3/16/2010	creek	0617	16.37	11.99	71.5	5.17	8.01
3/16/2010	wetland	0638	15.24	25.62	93.8	9.50	8.22
3/16/2010	ditch	0745	15.58	33.77	64.8	5.06	7.81
3/16/2010	creek	0758	14.88	20.25	86.1	7.40	8.25
3/16/2010	wetland	0820	14.76	31.20	101.5	8.41	8.09
3/16/2010	ditch	0957	16.12	34.71	91.6	7.23	7.46
3/16/2010	creek	1011	16.88	27.64	95.8	7.91	7.83
3/16/2010	wetland	1032	15.90	27.86	96.2	8.03	7.78
3/16/2010	ditch	1150	17.48	34.62	138.2	10.77	7.38
3/16/2010	creek	1202	17.80	13.43	132.8	11.63	7.86
3/16/2010	wetland	1221	17.10	28.44	104.2	8.48	7.64
3/16/2010	ditch	1354	22.53	15.00	125.3	10.90	7.51
3/16/2010	creek	1413	19.23	19.11	152.0	12.55	7.83
3/16/2010	wetland	1436	21.04	0.34	116.4	10.50	7.81
3/16/2010	ditch	1552	26.82	0-16*	138.2	11.08	7.86
3/16/2010	creek	1610	21.24	14.20	192.0	15.64	8.52
3/16/2010	wetland	1633	23.64	0-12*	96.6	7.81	8.01
3/16/2010	ditch	1757	22.43	15.60	106.7	8.36	7.98
3/16/2010	creek	1810	20.92	12.58	211.0	17.20	8.91
3/16/2010	wetland	1830	17.19	31.97	122.3	9.80	7.97
3/16/2010	ditch	1945	18.20	34.21	85.2	6.63	7.79
3/16/2010	creek	1955	18.37	23.50	145.7	11.84	8.35
3/16/2010	wetland	2012	15.62	33.91	101.6	8.22	7.95
3/16/2010	ditch	2159	16.77	34.84	93.9	7.47	7.86
3/16/2010	creek	2214	17.48	28.55	131.3	9.81	8.16
3/16/2010	wetland	2233	14.99	32.60	101.9	8.37	7.97
3/16/2010	ditch	2353	16.53	34.55	113.2	8.84	7.79
3/17/2010	creek	2406	18.55	13.40	113.4	10.64	8.79
3/17/2010	wetland	2430	14.89	28.20	88.5	7.60	8.02
3/17/2010	ditch	0156	16.01	15.29	82.4	7.54	7.67
3/17/2010	creek	0213	17.93	20.13	116.9	9.69	8.45
3/17/2010	wetland	0229	15.26	32.46	137.6	10.89	7.89

24 hour Bacteria Sampling							
Date	Location	Time	Temp (ºC)	Salinity (ppt)	DO (%)	DO (mg/L)	pH
3/17/2010	ditch	0352	14.47	33.91	78.6	6.51	7.61
3/17/2010	creek	0402	16.99	12.50	80.5	7.19	8.44
3/17/2010	wetland	0424	14.05	27.74	83.5	7.53	7.84

* readings fluctuated

Stratification Studies						
Date	Time	Pole Depth (m)	Temp (ºC)	Salinity (ppt)	DO (mg/L)	pH
7/17/2010	1140	0.25	21.84	32.08	6.25	8.09
7/17/2010	1140	0.50	22.03	31.97	6.31	8.09
7/17/2010	1140	0.75	22.01	31.98	6.34	8.09
7/17/2010	1140	1.00	22.09	31.93	6.32	8.09
7/17/2010	1215	surface	21.96	30.87	7.79	8.11
7/17/2010	1520	0.05	21.43	34.08	7.24	8.10
7/17/2010	1520	0.25	21.39	34.07	7.16	8.10
7/17/2010	1520	0.50	21.52	21.66	7.73	8.10
7/17/2010	1520	0.75	21.85	34.04	7.11	8.10
7/17/2010	1520	1.00	24.27	32.28	6.87	8.09
7/17/2010	1557	surface	21.23	34.36	7.60	8.15
7/17/2010	1830	0.05	22.97	32.91	7.08	8.14
7/17/2010	1830	0.25	23.04	32.88	7.28	8.15
7/17/2010	1830	0.50	23.50	30.36	7.46	8.15
7/17/2010	1830	0.75	24.99	19.90	7.81	8.19
7/17/2010	1830	1.00	25.07	19.28	8.03	8.21
7/17/2010	1855	surface	24.08	30.21	10.19	8.37
7/17/2010	2150	0.05	24.29	25.65	5.39	8.16
7/17/2010	2150	0.25	24.29	17.92	6.03	8.17
7/17/2010	2150	0.40	23.80	25.41	7.33	8.27
7/17/2010	2200	surface	24.44	21.44	9.82	8.44
8/12/2010	0830	0.05	20.05	26.72	5.67	8.12
8/12/2010	0830	0.25	20.07	26.42	5.85	8.13
8/12/2010	0830	0.50	20.04	26.25	6.03	8.12
8/12/2010	0830	0.62	19.92	26.16	5.97	8.14
8/12/2010	0840	surface	20.10	25.89	6.11	8.25
8/12/2010	1058	0.05	18.69	29.39	7.47	8.13
8/12/2010	1058	0.25	18.67	29.62	7.46	8.13

Stratification Studies						
Date	Time	Pole Depth (m)	Temp (ºC)	Salinity (ppt)	DO (mg/L)	pH
8/12/2010	1058	0.50	18.81	34.09	7.24	8.13
8/12/2010	1058	0.75	19.70	33.81	7.24	8.13
8/12/2010	1058	0.75	19.70	33.81	7.24	8.13
8/12/2010	1108	surface	18.44	34.16	7.46	8.15
8/12/2010	1400	0.05	19.79	31.67	7.75	8.12
8/12/2010	1400	0.25	19.75	31.73	7.71	8.12
8/12/2010	1400	0.50	19.85	21.81	8.23	8.10
8/12/2010	1400	0.75	19.82	22.82	8.20	8.12
8/12/2010	1400	0.95	20.04	23.00	8.20	8.12
8/12/2010	1420	surface	20.33	33.88	7.08	8.10
8/12/2010	1700	0.05	26.49	29.76	10.95	8.37
8/12/2010	1700	0.25	26.48	29.77	10.86	8.36
8/12/2010	1700	0.33	26.46	29.79	10.85	8.36
8/12/2010	1711	surface	22.81	27.59	11.48	8.42

Benthic Invertebrate Sampling							
Date	Location	Time	Temp °C	Salinity (ppt)	DO%	DO (mg/L)	pH
9/17/2009	BW4	1421	27.38	29.74	227.8	15.52	8.39
9/17/2009	BW7	1334	26.77	33.87	168.6	11.22	8.17
10/13/2009	BW1	1142	19.33	33.60	145.1	11.16	8.23
10/13/2009	BW2	1115	18.49	33.70	161.7	12.70	8.14
10/30/2009	BW5	1411	24.65	0.96	269.1	21.95	9.11
10/30/2009	BW6	1433	23.37	29.60	193.8	14.30	8.83
10/30/2009	BW8	1304	18.73	14.02	192.4	16.85	8.58
4/20/2010	BW1	1035	18.27	32.08	125.9	9.65	7.83
4/20/2010	BW2	0901	16.58	13.04	59.7	6.01	7.87
4/20/2010	BW8	0830	19.46	0.15	*71.8- 148.2	7.42	0.13
5/5/2010	BW4	0937	20.97	15.25	7.0	0.02	7.91
5/5/2010	BW5	1127	(water too shallow for accurate readings)				
5/5/2010	BW6	1036	26.58	22.21	14.3	1.04	8.45
5/5/2010	BW7	1210	(water too shallow for accurate readings)				

* Readings had high fluctuations and did not equilibrate

Ichthyofauna Sampling							
Date	Location	Time	>72 hrs from rain	Tide height (m)	Temp (°C)	Salinity (ppt)	pH
9/29/2009	Ditch A	0800	y	1.23	----	----	----
9/29/2009	Ditch A	1830	y	1.45	19.31	----	7.36
9/29/2009	Ditch B	0950	y	0.95	16.77	----	7.41
9/29/2009	Ditch B	1945	y	1.33	19.44	----	7.34
9/29/2009	Ditch C	1135	y	0.71	17.58	----	7.39
9/29/2009	Ditch C	2100	y	1.05	19.23	----	7.28
10/1/2009	Wetland A	0800	y	0.70	----	----	----
10/1/2009	Wetland A	2100	y	0.80	19.23	----	7.28
10/1/2009	Wetland B	1000	y	0.77	16.83	----	7.38
10/1/2009	Wetland B	1850	y	0.72	19.33	----	7.36
10/1/2009	Wetland C	1200	y	0.56	17.84	----	7.39
10/1/2009	Wetland C	2330	y	0.56	18.50	----	7.26
10/7/2009	Ballona Creek	0804	y	1.52	17.17	----	7.23
10/7/2009	Ballona Creek	1849	y	0.14	19.48	----	7.42
4/12/2010	Ditch A	1915	n (<1 in)	1.53	16.39	30.94	8.09
4/12/2010	Ditch B	2210	n (<1 in)	1.20	15.95	31.48	8.00
4/12/2010	Ditch C	2055	n (<1 in)	1.52	16.08	31.82	8.06
4/13/2010	Wetland A	1920	n (<1 in)	0.85	16.01	34.23	7.97
4/13/2010	Wetland B	2150	n (<1 in)	0.98	15.67	34.47	7.97
4/13/2010	Wetland C	2240	n (<1 in)	1.00	15.73	34.28	7.92
4/14/2010	Ditch A	0805	n (<1 in)	1.12	14.98	22.72	8.09
4/14/2010	Ditch B	1000	n (<1 in)	1.13	15.28	27.42	8.04
4/14/2010	Ditch C	0910	n (<1 in)	1.20	15.16	26.63	8.07
4/15/2010	Wetland A	0900	y	0.79	16.12	33.77	8.02
4/15/2010	Wetland B	1034	y	0.86	16.39	34.17	8.05
4/15/2010	Wetland C	1145	y	0.88	16.89	33.89	8.06
6/14/2010	Ditch A*	1900	y	1.12	18.83	32.93	----
6/14/2010	Ditch B*	(not completed due to site access complication)			----	----	----
6/14/2010	Ditch C*	2140	y	1.81	19.28	32.93	----
6/15/2010	Wetland A*	1940	y	0.88	19.49	32.92	----
6/15/2010	Wetland B*	2110	y	0.94	19.79	32.92	----
6/15/2010	Wetland C*	2245	y	1.00	19.96	32.92	----
6/29/2010	Wetland A*	0930	y	0.78	18.34	32.93	----
6/29/2010	Wetland B*	1145	y	0.89	18.59	32.94	----
6/29/2010	Wetland C*	1245	y	0.92	18.98	32.94	----

Ichthyofauna Sampling							
Date	Location	Time	>72 hrs from rain	Tide height (m)	Temp (°C)	Salinity (ppt)	pH
6/30/2010	Ditch A*	1130	y	1.03	18.27	32.89	----
6/30/2010	Ditch B*	0950	y	0.77	16.24	32.88	----
6/30/2010	Ditch C*	1235	y	1.12	18.37	32.89	----

* water conditions taken from SCCOOS at Santa Monica Pier

Tide heights at wetland stations taken from permanent Yellowsprings instrument (YSI) model 6600 taken at main tide gate

Tide heights at ditch stations taken from heights in Ballona creek adjacent to main tide gate

Dissolved Metals Sampling							
Date	Station	Time	Temp (°C)	Salinity (ppt)	DO (%)	DO (mg/L)	pH
3/30/2010	BW1	1104	17.73	35.00	0.3	0.05	7.65
3/30/2010	BW3	1120	17.88	25.98	10.3	0.86	8.27
3/30/2010	BW4	1217	17.18	31.63	19.0	1.53	8.28
3/30/2010	BW5	1140	17.51	25.54	17.7	1.45	8.27
3/30/2010	BW6	1147	17.57	28.13	19.9	1.60	8.24
3/30/2010	BW7	1226	18.01	23.62	24.6	2.03	8.24
3/30/2010	BW8	1200	18.08	25.18	27.3	2.17	8.28
6/2/2010	BW1	1235	20.48	34.02	73.6	5.62	7.60
6/2/2010	BW3	1241	21.63	19.55	143.9	11.38	8.34
6/2/2010	BW4	1421	18.76	33.88	120.5	9.21	8.03
6/2/2010	BW5	1328	24.50	27.45	130.5	9.37	8.21
6/2/2010	BW6	1352	21.59	31.85	122.9	8.99	8.11
6/2/2010	BW7	1429	23.36	26.06	138.7	10.15	8.21
6/2/2010	BW8	1505	26.23	26.42	156.8	11.05	8.28

APPENDIX A.2 **Dissolved metal constituents of concern by quarter and sampling station**

Note: results displayed as parts per billion unless otherwise noted.

	SEPTEMBER 2009						
elements	**BW1**	**BW3**	**BW4**	**BW5**	**BW6**	**BW7**	**BW8**
phosphorus	182.0	0	0	161.2	0	0	0
potassium	444359.9	307563.9	338327.5	317588.9	444359921.7	307563903.9	338327497.9
iron	34.0	36.2	45.7	97.9	34022.9	36160.9	45674.0
manganese	33.5	31.6	25.8	38.6	33516.8	31617.2	25752.5
zinc	36.2	36.7	59.2	79.2	36150.4	36719.0	59161.6
copper	7.9	0	0	0	0	0	0.0
boron	3772	2664	2810	2699	3771786	2663726	2810415
calcium	429790	329541	349092	332409	429790168	329541263	349092156
magnesium	1379436	980961	1065835	991313	1379436307	980960523	1065835071
sodium	8091665	6524335	6815042	6440250	8091664587	6524334867	6815042495
sulfur	918391	642130	689344	637886	918390753	642129956	689344089
molybdenum	258.2	0	0	0	0	0	0
aluminum	0	0	0	0	0	0	0
arsenic	0	0	0	0	0	0	0
barium	130.8	49.9	48.8	144.2	130756.2	49863.4	48787.4
cadmium	74.1	51.2	37.9	52.5	74072.9	51164.2	37873.3
chromium	0	0	0	0	0	0	0
cobalt	79.0	81.0	98.6	80.0	78956.7	81039.1	98642.7
lead	0	0	0	0	0	0	0
lithium	514.4	370.8	410.7	374.0	514432.8	370806.6	410697.7
mercury	352.6	11.1	0	0	0	0	0
nickel	0	0	0	12.0	0	0	0.0
selenium	0	0	60.3	0	0	0	0
silicon	297.6	1450.2	1057.6	1600.5	297597.1	1450186.5	1057577.0
silver	0	0	0	0	0	0	0
strontium	7809.9	5552.5	6051.1	5704.1	7809883.4	5552489.7	6051098.3
tin	28.2	0	36.9	27.8	28173.6	0	36911.4
titanium	0	0	0	0	0.0	0	0
vanadium	0	17.4	1.5	11.4	0	0	0

elements	DECEMBER 2009						
	BW1	BW3	BW4	BW5	BW6	BW7	BW8
phosphorus	43.6	0	0	0	0	0	0.0
potassium	403124.2	161871	375398.6	403204.3	403124179.4	161870806.9	375398599.6
iron	2.1	117.6	38.6	69.0	2136.6	117584.5	38578.3
manganese	24.1	116.2	68.3	76.5	24076.3	116162.2	68318.0
zinc	53.3	0	0	13.4	53297.9	0	0.0
copper	0	0	0	0	0	0	0.0
boron	3134	1356	2946.9	3142.3	3133849.2	1356399.1	2946888.2
calcium	375851	222124	374243.0	385680.6	375850740.2	222123532.5	374242954.9
magnesium	1161538	505223	1094201.3	1136943.9	1161538328.5	505222905.0	1094201271.8
sodium	7254938	3216673	6926704.0	7202443.6	7254938398.4	3216673306.7	6926703955.5
sulfur	952728	411057	890727.2	926130.6	952727575.0	411056943.7	890727219.3
molybdenum	0	40.4	21.3	42.9	0	40440.2	21267.2
aluminum	0	0	0	0	0	0	0
arsenic	14.6	42.1	0	25.6	14617.9	42100.8	0
barium	0	70.7	119.9	39.6	0	70716.8	119870.1
cadmium	47.3	1.7	37.4	50.0	47255.1	1708.9	37422.5
chromium	0	0	0	0	0	0	0
cobalt	56.4	43.3	59.8	63.9	56354.6	43299.0	59796.2
lead	0	0	143.4	0	0	0	0
lithium	397.9	215.0	383.8	394.0	397915.5	214985.2	383801.8
mercury	0	0	0	0	0	0	0
nickel	0	0	0	0	0	0	0
selenium	56.7	26.2	0	0	56651.9	26176.2	0
silicon	109.0	3111.9	1114.9	477.8	108955.4	3111918.6	1114851.0
silver	0	0	0	0	0	0	0
strontium	6924.9	3278.6	6601.3	6866.3	6924922.2	3278580.1	6601267.3
tin	0	16.5	0	0	0	0	0
titanium	0	0	0	0	0	0	0
vanadium	0	0	0	0	0	0	0

elements	MARCH 2010						
	BW1	BW3	BW4	BW5	BW6	BW7	BW8
phosphorus	214.7	266.1	426.4	233.0	214674.2	266117.4	426359.0
potassium	410041.5	303868	377431.6	281937.8	410041533.2	303868167.8	377431579.4
iron	42.7	44.6	71.9	127.6	42669.7	44552.2	71919.3
manganese	40.2	42.5	34.0	37.7	40164.9	42509.5	33988.6
zinc	297.6	80.4	40.3	104.3	297632.1	80372.0	40282.2
copper	152.9	52.8	41.2	116.6	152900.6	52783.4	41169.5
boron	3517	2776	3281.5	2538.6	3517276.6	2775636.9	3281454.1
calcium	392841	322101	373705.1	303615.9	392840793.3	322101364.5	373705072.0
magnesium	1292845	1007238	1206234.5	932237.6	1292845332.1	1007238187.8	1206234534.2
sodium	8353534	6840985	7691666.1	6521931.0	8353533739.5	6840985469.6	7691666067.3
sulfur	999594	766087	926565.4	707538.9	999594080.2	766087013.5	926565379.0
molybdenum	392.9	0	0	0	0	0	0
aluminum	0	0	0	0	0	0	0
arsenic	0	0	34.8	10.3	0.0	0	0
barium	0	48.6	0	6.1	0.0	48569.5	0.0
cadmium	50.3	39.0	53.2	43.8	50332.1	39047.1	53195.2
chromium	0	0	0	0	0	0	0
cobalt	81.7	71.6	109.3	60.6	81745.6	71617.0	109263.5
lead	0	0	48.0	0	0	0	48022.1
lithium	482.5	356.4	443.3	346.6	482451.2	356402.9	443323.1
mercury	140.3	0	0	0	0	0	0
nickel	17.6	0	0	0	0	0	0
selenium	93.2	168.7	332.5	0	93225.8	168712.9	332548.5
silicon	421.5	1067.8	1477.3	1585.2	421463.0	1067785.3	1477322.6
silver	6.8	5.7	6.1	36.9	0	5671.7	6149.4
strontium	7702.3	6101.1	7201.9	5634.2	7702262.1	6101114.5	7201928.3
tin	0	39.0	0	0	0	0	0
titanium	22.3	0	8.2	0.9	22280.0	0	8178.4
vanadium	0	0	0	0	0.0	0	0.0

elements	JUNE 2010						
	BW1	BW3	BW4	BW5	BW6	BW7	BW8
phosphorus	644.0	95.0	153.8	0	0	94975.5	153753.8
potassium	404516	223001	392708.0	345112.7	404515962.8	223000710.8	392707965.5
iron	73.0	30.0	24.7	60.1	72964.6	29970.0	24726.8
manganese	65.0	34.7	29.2	23.0	64950.1	34694.4	29223.6
zinc	394.2	159.1	151.4	149.0	394165.0	159059.6	151390.2
copper	117.1	73.1	44.0	37.7	117109.7	73103.2	44046.1
boron	3695.6	2234	3418.8	3074.5	3695594.5	2234021.1	3418778.4
calcium	396080	267651	384822.7	341864.7	396080126.7	267650662.2	384822656.0
magnesium	1268237	763930	1210036.8	1041712.6	1268236838.4	763930281.2	1210036823.9
sodium	8616436	5866892	8333682.3	7433528.0	8616435704.8	5866892150.0	8333682346.5
sulfur	995165	596185	942402.9	803902.5	995165022.6	596184585.3	942402890.3
molybdenum	0	25.9	51.7	0	0	0	0
aluminum	0	0	0	0	0	0	0
arsenic	206.0	98.7	0	133.7	206003.2	0	0.0
barium	43.2	45.3	36.3	36.9	43183.1	45298.5	36343.9
cadmium	72.9	38.5	63.3	34.7	72926.6	38510.9	63308.0
chromium	0	0	0	0	0	0	0
cobalt	86.9	76.8	73.8	76.8	86888.4	76799.7	73766.5
lead	0	0	0	0	0	0	0
lithium	412.0	278.9	389.0	332.7	412019.3	278896.9	388976.3
mercury	0	0	0	0	0	0	0
nickel	0	0	0	0	0	0	0
selenium	841.3	518.9	546.9	897.5	841280.3	518871.2	546907.7
silicon	702.9	1670.7	720.9	1182.0	702915.9	1670713.1	720890.4
silver	0	0	0	0	0	0	0
strontium	7572.4	4731.1	7402.7	6418.2	7572372.6	4731059.5	7402696.5
tin	0	0	0	0	0	0	0
titanium	0	0	0	0	0	0	0
vanadium	0	0	0	0	0	0	0

APPENDIX A.3

Stormwater dissolved trace metal constituents of concern at all stations. Red = exceedance of acute toxicity levels, pink = exceedance of chronic toxicity levels (USEPA 2009)

elements	SW1	SW3	SW4	SW5	SW6	SW7	SW8	SW9	SW10	SW11a	SW11b	SW12	SW13
phosphorus	60.1	2475.6	230.7	872.7	1247.4	376.9	250.5	0	1036.9	929.4	612.2	330.7	0
potassium	142106	12347	2645	4444	499819	15237	183615	839	8965	3827	9394	9697	10052
iron	0	414	2160	1667	45	1029	0	2026	2672	20510	108	137	169
manganese	11.7	89.4	44.5	61.1	247.5	29.4	66.4	20.0	41.1	206.7	5.7	24.8	18.2
zinc	7.7	25.0	59.0	103.2	15.9	0	95.6	0	0	22.6	14.8	57.8	55.1
copper	5.6	26.0	40.1	45.7	94.4	0	0	0	0	0	60.0	23.4	21.3
boron	313.1	240.8	17.0	50.8	1622.9	170.2	1676.2	1	87.2	76.2	214.4	221.0	97.5
calcium	564241	44173	4348	15841	996250	153608	225653	2234	167925	5720	32694	36353	14062
magnesium	418512	27887	1588	3200	1397199	34248	503279	1388	63761	4981	5280	18900	23167
sodium	4897726	323436	10008	28343	12463485	273290	4318495	4018	332735	12506	48809	168673	190286
sulfur	929884	38985	2292	8334	2191418	137100	385392	657	128453	2425	10762	29783	20157
molybdenum	25.3	0	0	0	0	35.3	30.7	0	0	0	19.0	0	0
aluminum	1	224	2487	1940	1	1	1	623	1002	37880	85	40	181
arsenic	0	10.0	0	0	0	0	55.2	0	0	0	0	0	0
barium	65.7	39.3	20.7	48.6	118.9	43.1	72.6	14.1	52.6	85.6	31.6	32.7	20.7
cadmium	20.8	0	0	0	54.4	1.5	20.2	0	2.8	0	0	0	0
chromium	0	0	6.7	10.0	0	0	10.0	4.8	2.3	33.3	0	0	3.0
cobalt	11.7	7.8	4.4	0	12.0	0	42.5	0	4.3	3.1	3.0	5.9	5.1
lead	0	0	32.3	0	28.1	0	0	0	0	63.5	0	0	0
lithium	377.3	28.0	5.1	16.0	899.2	66.9	204.3	0	70.9	19.0	49.6	41.2	12.2
mercury	23.3	0	0	0	0	0	0	0	0	0	0	0	0
nickel	0	0	0	8.3	0	0	0	0	0	3.6	3.7	0	0
selenium	0	0	0	0	26.5	32.4	172.7	0	43.1	0	0.0	33.0	34.3
silicon	92	865	1881	1985	261	1804	794	2270	3762	23344	1428	1619	507
silver	0	0.0	0	0	30.8	0	0	0	0	0	0	0	0
strontium	5552.7	507.1	46.1	94.5	10387.5	1365.9	3806.9	24.7	1410.2	56.6	213.2	281.0	187.6
tin	0	0	0	0	0	0	0	0	0	0	0	0	0
titanium	0	19.3	141.4	130.4	0.4	62.8	0	159.3	173.6	1174.8	3.3	9.6	12.3
vanadium	1.1	22.4	109.7	92.2	12.8	71.1	0	115.8	158.2	1774.5	7.2	5.0	10.9

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Photo credit: E. Tuttle

CHAPTER 2:
MARINE SEDIMENT

Ballona Wetlands Ecological Reserve, Los Angeles, California
Santa Monica Bay Restoration Commission

Prepared for: California State Coastal Conservancy
November 2011

Author: Karina Johnston

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MARINE SEDIMENT

INTRODUCTION

Urban wetlands can be contaminated by a wide variety of constituents and sources (Comeleo et al. 1996, Bay et al. 2010). Contamination within marine sediments can be an indication of poor water quality (López-Florez et al. 2003). While water quality parameters may change with seasonal and daily fluctuations in inputs, contaminant levels in sediments show less variation and act as indicators of the contamination of an ecological system (Lau and Chu 2000).

Identification and assessment of sediment toxicity levels are essential to understanding wetland systems, as sediment contamination can result in significant impacts to wetland ecological processes (Lau and Chu 2000, Greaney 2005). Impacts can take the form of directly contaminating plants or animals through uptake or ingestion, or by affecting reproductive capabilities, organism function, and bioaccumulation (Thompson and Lowe 2004). Trace metals can also be used as concentration indicators of other pollutants to which they are potentially related (Greaney 2005).

The goals of the sediment surveys for the Baseline Assessment Program (BAP) at the Ballona Wetlands Ecological Reserve (BWER) include:

1) Assessing sediment toxicity within the tidal channels of Area B and the Fiji Ditch,
2) Comparing toxicity levels to previous long-term monitoring programs and projects (e.g. Southern California Bight 2008 surveys), and
3) Comparing bioavailable trace metal constituents in sediments to the levels obtained through acid digestion survey methods within the same survey stations.

Existing Conditions Report Summary (Prior to 2005)

The Existing Conditions Report identified water quality and sediment data gaps in the existing muted tidal marsh in the western portion of Area B and the Fiji Ditch (PWA 2006). At the time of the Report, there were no data available on channel sediments from these sites.

Sediment quality data for the tidal section of Ballona Creek was collected during the 2003 Southern California Bight Regional Monitoring Program (Bight03). The tidal section of Ballona Creek was monitored to estimate the extent and magnitude of ecological change in the Southern California Bight and to determine the mass balance of pollutants that currently reside within the area. Sediments from five stations within the tidal section of Ballona Creek (Figure 2.1) were analyzed for chemistry, toxicity, and benthic macroinvertebrate diversity.

Currently, there are no universally accepted criteria for assessing contaminated sediments (Pohl and Hartman 2006). However, the Effect Range Low (ERL) and Effect Range Median (ERM) values originally

developed by Long and Morgan (1990) and subsequently revised and expanded upon by Long and MacDonald (1992) and Long et al. (1995) were used to evaluate the potential for sediment contamination to cause adverse biological effects (Table 2.1). ERL is defined as the concentration at the lower tenth percentile at which adverse biological effects were observed or predicted, based on results from multiple studies and endpoints. ERM is defined as the median concentration at which adverse biological effects were observed or predicted.
[(http://response.restoration.noaa.gov/faq_topic.php?faq_topic_id=6#erlerm) Ecotox. 1996, 5(4):253].

Results identified stations exceeding trace metal ERL values for copper, lead, and zinc (Table 2.1). Pesticides exceeded ERL values at several stations for both dichlorodiphenyl trichloroethane (DDT) and total detectable chlordane. Table 2.1 also displays the results of the sediment size and total organic carbon (TOC) from the five sampling stations.

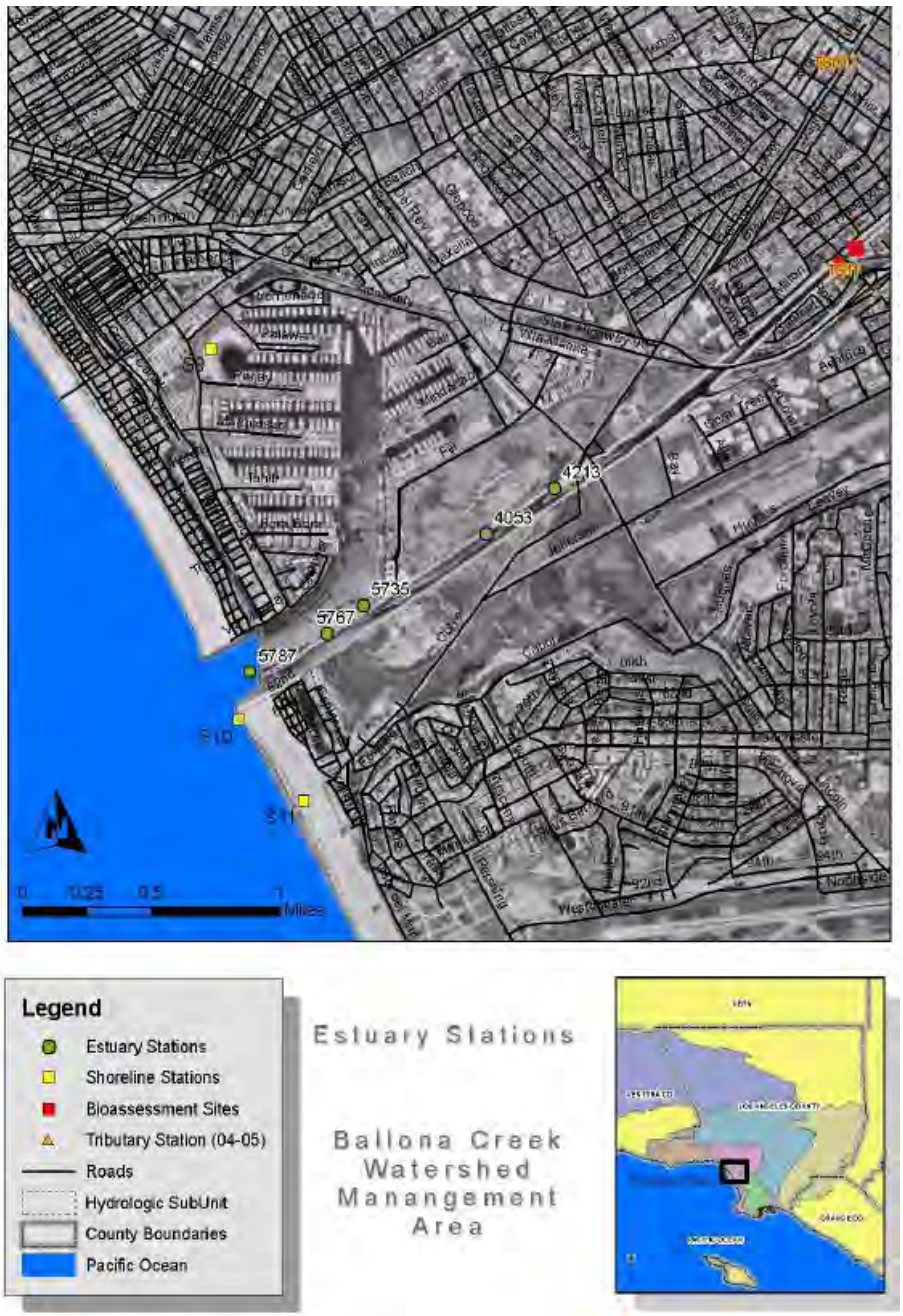

Figure 2.1. Bight03 survey stations within Ballona Creek (reproduced from PWA 2006).

Table 2.1. Analytical summary of results of Bight03 surveys in Ballona Creek (modified from PWA 2006). Note: ERL = Effects Range-Low; ERM = Effects Range-Median; TOC = Total organic carbon; DDT = dichlorodiphenyl trichloroethane; PAHs = polycyclic aromatic hydrocarbons; PCBs = polychlorinated biphenyls.

				STATION ID				
Sediment Size and TOC	**Units**	**ERL**	**ERM**	**4053**	**4213**	**5735**	**5767**	**5787**
Gravel	%	----	----	55.0	55.7	0.2	0.3	0.7
Sand	%	----	----	35.6	42.3	48.5	57.8	79.7
Silt	%	----	----	8.6	1.8	48.8	39.8	19.0
Clay	%	----	----	0.8	0.2	2.5	2.1	0.7
Median size	microns	----	----	2222.9	2187.0	58.3	125.5	710.9
Mean size	microns	----	----	1759.9	2094.0	115.8	133.8	221.7
TOC	%	----	----	4.9	0.5	0.7	1.2	0.4
Metals								
Arsenic	mg/kg	8.2	70.0	4.0	2.4	3.5	7.5	3.0
Cadmium	mg/kg	1.2	9.6	0.8	0.1	0.8	1.0	0.3
Chromium	mg/kg	81.0	370.0	21.9	19.5	21.1	19.3	10.6
Copper	mg/kg	34.0	270.0	36.4	11.5	32.9	33.4	10.6
Lead	mg/kg	46.7	220.0	41.0	12.7	111.0	59.3	35.5
Mercury	mg/kg	0.2	0.7	0.1	0.0	0.1	0.1	0.0
Nickel	mg/kg	20.9	51.6	13.1	9.7	13.3	12.5	7.6
Silver	mg/kg	1.0	3.7	0.9	0.4	0.7	0.9	0.4
Zinc	mg/kg	150.0	410.0	202.0	73.5	186.0	165.0	107.0
Pesticides								
Total detectable DDT	µg/kg	1.6	46.1	17.3	1.4	5.4	9.7	0.0
Total detectable chlordane	µg/kg	0.6	6.0	21.6	1.3	0.0	0.0	0.0
PAHs								
Total detectable PAHs	µg/kg	4022.0	44800.0	1929.0	69.0	182.0	488.0	408.0
PCBs								
Total detectable PCBs	µg/kg	22.7	180.0	0.0	0.0	8.0	0.0	0.0

Interim Research (2005-2010)

Interim research from the BWER includes a technical memo with results of tidal channel sediment sampling completed in 2006, Total Maximum Daily Load (TMDL) monitoring of sediments in Ballona Creek, and a technical report completed by the Southern California Coastal Water Research Project (SCCWRP) in 2010 (Bay et al. 2010).

Tidal Channel Sediment Technical Memo

The Existing Conditions Report identified a lack of assessment of sediment quality in the existing tide channels in Area B (PWA 2006). To address this data gap, Weston Solutions conducted an assessment of these sediments and presented the results in the Ballona Marsh Sediment Sampling Technical Memo (Pohl and Hartman 2006). Sediments from the Ballona Marsh were analyzed for metals, PAHs, pesticides, PCBs, grain size, and toxicity. The sampling stations (BWS-1, 3, 4, 5, 8, 9, 10, and 11) were all within the muted tidal marsh in the western portion of Area B (Figure 2.2).

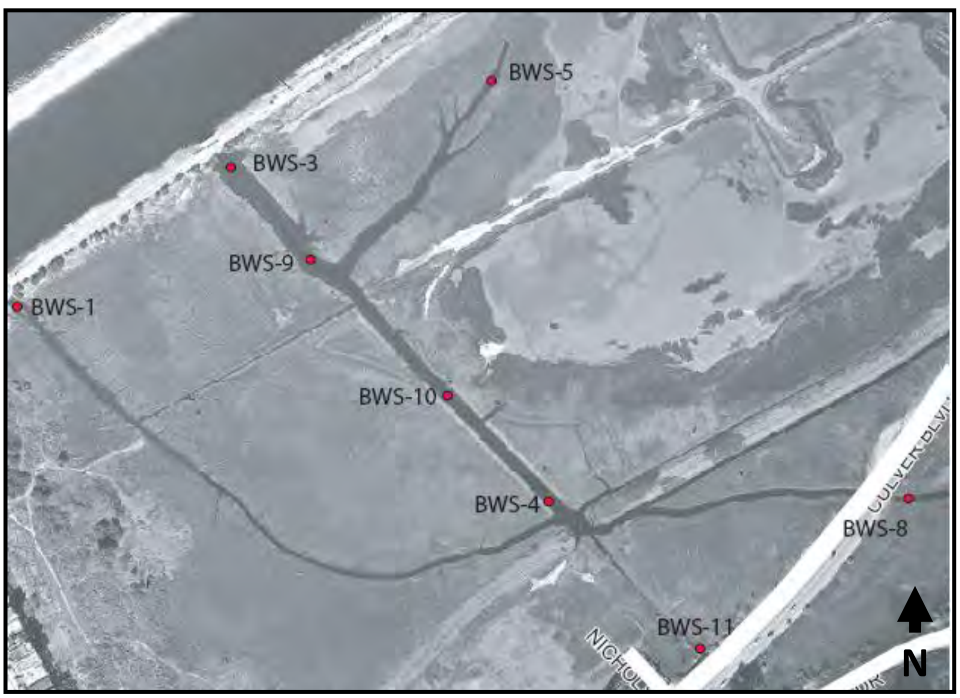

Figure 2.2. Eight sediment sampling stations from the tide channels (reproduced from Pohl and Hartman 2006).

Copper, lead and zinc consistently exceeded ERL levels for many of the sites within the tidal channels of the wetlands as well as Ballona Creek (Table 2.2). An analysis of all metals was not completed during this survey; Table 2.2 lists the constituents analyzed. Pesticides and PCBs exceeded ERL levels at several sites. BWS-11 exceeded ERL levels for all organics except PAHs. The Ballona Marsh Sediment Sampling Technical Memo includes a full analysis of the constituent concentrations (Pohl and Hartman 2006).

Table 2.2. Exceedances from Sediment Technical Memo (Pohl and Hartman 2006). Data are in mg/Kg.

	BALLONA MARSH		
	RANGE	**EXCEEDANCES (ERL)**	**BALLONA CREEK RANGE**
METALS			
Arsenic	3.7 – 14.6	BWS-5, 8, 9, 11	2.37 – 4.01
Cadmium	1.83 – 6.16	ALL SITES	0.13 – 0.96
Chromium	18 – 70.2	----	10.6 – 21.9
Copper	17 – 440	BWS-1, 5, 8, 9, 10, 11	10.6 – 36.4
Lead	20.8 – 248	BWS-5, 8, 9, 11	12.7 – 111
Mercury	0.041 – 0.29	BWS-5, 8, 11	0.03 – 0.11
Nickel	9.2 – 38.5	BWS-5, 8, 10, 11	7.6 – 13.3
Selenium	<0.35 – 1.61	----	N/A
Silver	0.27 – 3.77	BWS-1, 5, 8, 9	0.36 – 0.87
Zinc	54.9 – 1770	BWS-1, 5, 8, 9, 11	73.5 – 202
PAHs (mg/kg)			
Total detectable PAHs	0 – 1.5	----	0.069 – 1.93
Pesticides & PCBs (µg/kg)			
Total detectable DDT	0 – 17.1	BWS-1, 3, 8, 9, 11	0 – 17.3
Total detectable PCBs	0 – 36	BWS-3, 9, 11	0 – 8

Sediment TMDL Monitoring in Ballona Creek

The Ballona Creek Estuary is on the Clean Water Act Section 303(d) list of impaired waterbodies for cadmium, copper, lead, silver, zinc, chlordane, DDT, PCBs and PAHs in sediments. The Los Angeles Regional Water Quality Control Board (LARWQCB) created a Total Maximum Daily Load (TMDL) for the trace metal and organic constituents of concern. Numeric water quality targets (Table 2.3) were based on the ERL guidelines for sediments in Ballona Creek Estuary.

The TMDL was adopted in 2005, and monitoring by the City of Los Angeles will be conducted at six stations within Ballona Creek (Figure 2.3) and summarized in annual reports. The full monitoring plan for these stations is available from City of Los Angeles (2009).

Table 2.3. Numeric target limits for the Ballona Creek Estuary sediment TMDL (LARWQCB 2005).

Metal Numeric Targets (mg/kg)				
Cadmium	Copper	Lead	Silver	Zinc
1.2	34.0	46.7	1.0	150.0
Organic Numeric Targets (µg/kg)				
Chlordane	DDTs	Total PCBs	Total PAHs	
0.5	1.58	22.7	4,022	

Figure 2.3. TMDL sampling stations within Ballona Creek for sediment TMDLs (reproduced from LA City 2009).

Scientists at SCCWRP studied sediment to determine the toxicity and chemistry conditions at six stations within the Ballona Creek Estuary (Bay et al. 2010; Figure 2.4). They found that Ballona Creek Estuary sediments, like those in many other bays and estuaries in highly urbanized watersheds, were contaminated with a wide variety of trace metals and trace organic compounds and often surpassed ERL sediment quality guidelines. They concluded that pyrethroids, and possibly other current use pesticides, were the principal causes of sediment toxicity in Ballona Creek Estuary. Fipronil, a pesticide highly toxic to fish and aquatic invertebrates (Gunasekara et al. 2007), was also detected at levels of possible concern.

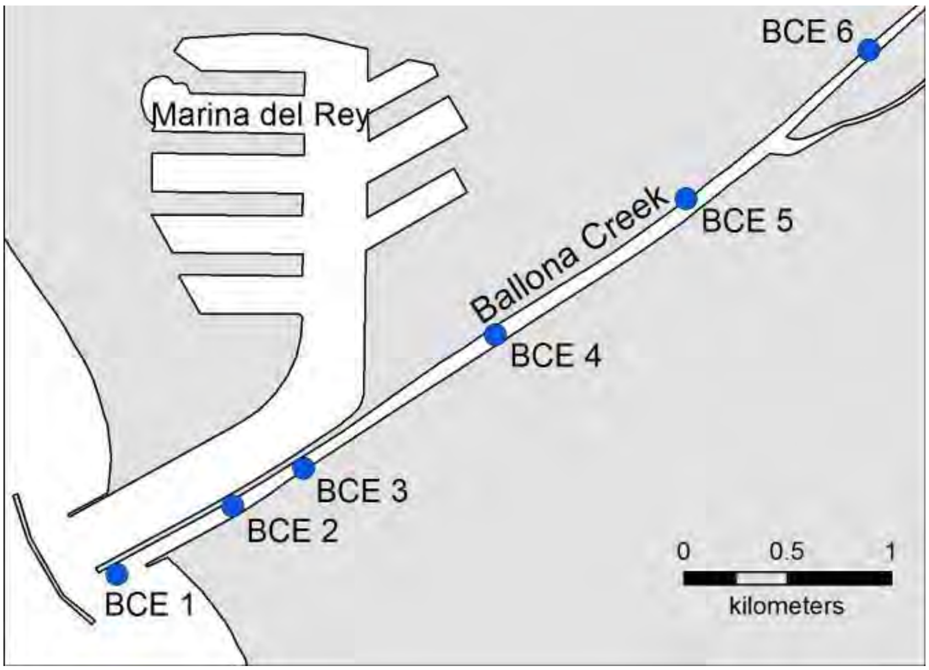

Figure 2.4. Map of sediment sampling stations (reproduced from Bay et al. 2010, SCCWRP).

METHODS

Method Comparison and Rationale

Standard methods have been developed for the collection and analysis of sediment samples in tidal wetlands. The BAP program employed sampling methods similar to those used in previous studies. To ensure consistency and build on previous studies, similar sampling stations were used with some additions. A subset of the stations used in the Sediments memo (Pohl and Hartman 2006) were used, with the addition of sediment sampling stations in the Fiji Ditch and one upper tide channel station. Stations were selected to collect sediment quality data which encompassed the greatest diversity of conditions at the BWER. Sediment sampling stations were also chosen to coincide with water quality and benthic invertebrate sampling locations.

Field Methods

Sediment quality samples were collected at each sampling station twice: once in September 2009, and once in March 2010. Two sampling stations (BW1 and BW2) were located in the Fiji Ditch, and five stations were located in the tidal channels of Area B (BW4-8) (Figure 2.5). BW3 in Ballona Creek, between the Lincoln and Culver Bridges, was the only site excluded from sampling due to inaccessibility.

Figure 2.5. Location of sediment sampling stations within the BWER.

Ten replicate samples were collected and composited for analysis at each sampling station. Sediment samples were obtained from each site by using a 60 mL syringe sampler that had the tip removed. While wearing sterile gloves, the syringe was pushed into the sediment to a depth coinciding with the 10 mL measurement on the syringe (approximately 10 cm below the sediment surface). Ten samples were collected across the width of the channel. All ten samples were composited in a plastic bag by depressing the plunger on the syringe. Approximately 100 mL of sediment were collected and composited at each sampling site. Excess air was removed from the bag; it was then sealed, wrapped by a rubber band, labeled, and placed on ice in a cooler for transport. The syringe was rinsed thoroughly between stations.

Analysis Methods

Sediment samples will be analyzed in two ways: using an extractable ammonium bicarbonate diethylene triamine pentoacetic acid (DTPA) method to assess bioavailability of trace metals within the sediments, and using an acid digestion method to evaluate the soluble, exchangeable, and bulk mineral forms of the metals for comparison.

RESULTS

Results will be available in the annual report for the second year of the BAP.

FUTURE DIRECTIONS

Sampling during the second year will occur semi-annually in March and September to correlate with the sampling from the first Baseline year. This will allow an annual evaluation of maximum contaminant levels. One additional site will be added in the same station as BWS-11 of the Sediment Memo (Pohl and Hartman 2006). This site was found to be the most contaminated, and will be evaluated in year two.

If the funding is available, organic constituents of concern will also be evaluated (e.g. PAHs, PCBs, and pesticide analyses). Coordination and data compilation with the City of Los Angeles for their TMDL monitoring in Ballona Creek Estuary is currently underway.

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Photo credit: E. Tuttle

CHAPTER 3:
TERRESTRIAL SOILS

Ballona Wetlands Ecological Reserve, Los Angeles, California
Santa Monica Bay Restoration Commission

Prepared for: California State Coastal Conservancy
November 2011

Author: Karina Johnston

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TERRESTRIAL SOILS

INTRODUCTION

Human activities pose considerable risk to soil systems (Hooper and Anderson 2009), thereby making it important to understand the influences of anthropogenic activities on the environment and soil toxicity in particular. Terrestrial soil toxicity tests can provide insight into the movement and effects of contaminants and chemicals of concern in an ecosystem and help identify spatial and temporal distributions of soil toxicity (Hooper and Anderson 2009). Assessment criteria and application guidelines for trace elements in terrestrial soils (terrestrial ecotoxicology) is lagging behind that of the aquatic environment, and methods are only sparsely applicable to soil ecosystems (Kabata-Pendia 2004, Peijnenburg et al. 2007).

In general, terrestrial ecotoxicity indices have been assessed in the context of ecosystem function by use of concepts such as 'bioavailability' and 'bioaccessibility', which express whether the concentration of a contaminant would affect organisms within a given ecosystem (Meyer 2002, Peijnenburg and Jager 2003). This is due to the fact that toxic effects on an organism require the availability and uptake of a contaminant by the organism. The bioavailable fraction of a contaminant is defined by Peijnenburg et al. (2007) as: "the fraction of the total amount of a chemical present in a specific environmental compartment that, within a given time span, is either available or can be made available for uptake by (micro)organisms from either the direct surrounding of the organism or by ingestion of food."

Studies that mimic the bioavailable uptake of metals within plants (phytoavailability) demand weak extractants, which reasonably imitate the main processes determining metal availability in these applications (Peijnenburg et al. 2007). Prediction of phytoavailability of trace elements in soil is important for the assessment of environmental quality because soil is the main source of trace elements for plants both as micronutrients and pollutants (Kabata-Pendia 2004).

The Baseline Assessment Program (BAP) conducted the first comprehensive ecologically-based surface terrestrial soil survey across the Ballona Wetlands Ecological Reserve (BWER). The goals of the BAP included:

1) Determining the phytoavailability of constituents of concern within BWER soils,
2) Comparing the phytoavailability of these trace elements across habitat types,
3) Comparing the constituent values to ecological soil criteria for plants, and
4) Providing the first step in an ecological study to compare soil trace metals to plant uptake.

Existing Conditions Report Summary (Prior to 2005)

The Existing Conditions Report did not identify any reports of terrestrial soils surveys at the Ballona Wetlands Ecological Reserve (BWER) (PWA 2006).

Interim Research (2005-2010)

Four studies were completed on terrestrial soil quality in the BWER between the time of the Existing Conditions Report (PWA 2006) and the first year of the Baseline Assessment Program (BAP).

The first survey was conducted by the Santa Monica Bay Restoration Commission (SMBRC) in March 2007, in response to illegal dumping of terrestrial fill soils onto the northeastern portion of Area B. The fill was dumped north of Culver Boulevard, between Culver Boulevard and Jefferson Boulevard. Twenty-five grab samples were collected from throughout the fill and analyzed by a private laboratory, Wallace Laboratories, for trace metal constituents of concern, moisture content, soil texture, nitrates, phosphorous, and sulfates (SMBRC 2007, unpublished data). Data were reported in extractable mg/kg when analyzed using an ammonium bicarbonate diethylene triamine pentoacetic acid (DTPA) method. Data are presented in Appendix B.1.

A set of surveys were completed at the Ballona Outdoor Learning and Discovery (BOLD) project site in the western portion of Area B. The surveys provided a baseline assessment of shallow soils and subsurface hydrology within six feet of ground level in 2007 (Saez 2007). Surveys included: visual soil observations, soil classification, sieve analyses, groundwater levels, estimated groundwater gradient, hydraulic conductivity, moisture content, and selected groundwater quality parameters (Saez 2007). The sampling methods included the collection of soil samples from boreholes and the installation and assessment of monitoring wells.

Saez (2007) concluded that saturated conditions were encountered a few feet below the ground surface immediately above the saturated clay layer. The results indicated predominantly fine and medium sands (either fairly uniform or mixed with silts, small clumps of clay, and few coarser particles) closer to the ground surface, finer soils underneath, with clays at approximately 3-4 feet below ground (Saez 2007). Salinity levels indicated the presence of fresh groundwater near the northeast and southeast property boundaries, which flows into the site and mixes with the higher salinity groundwater within the site. Total nitrogen ranged from 1-53 mg/L (Saez 2007).

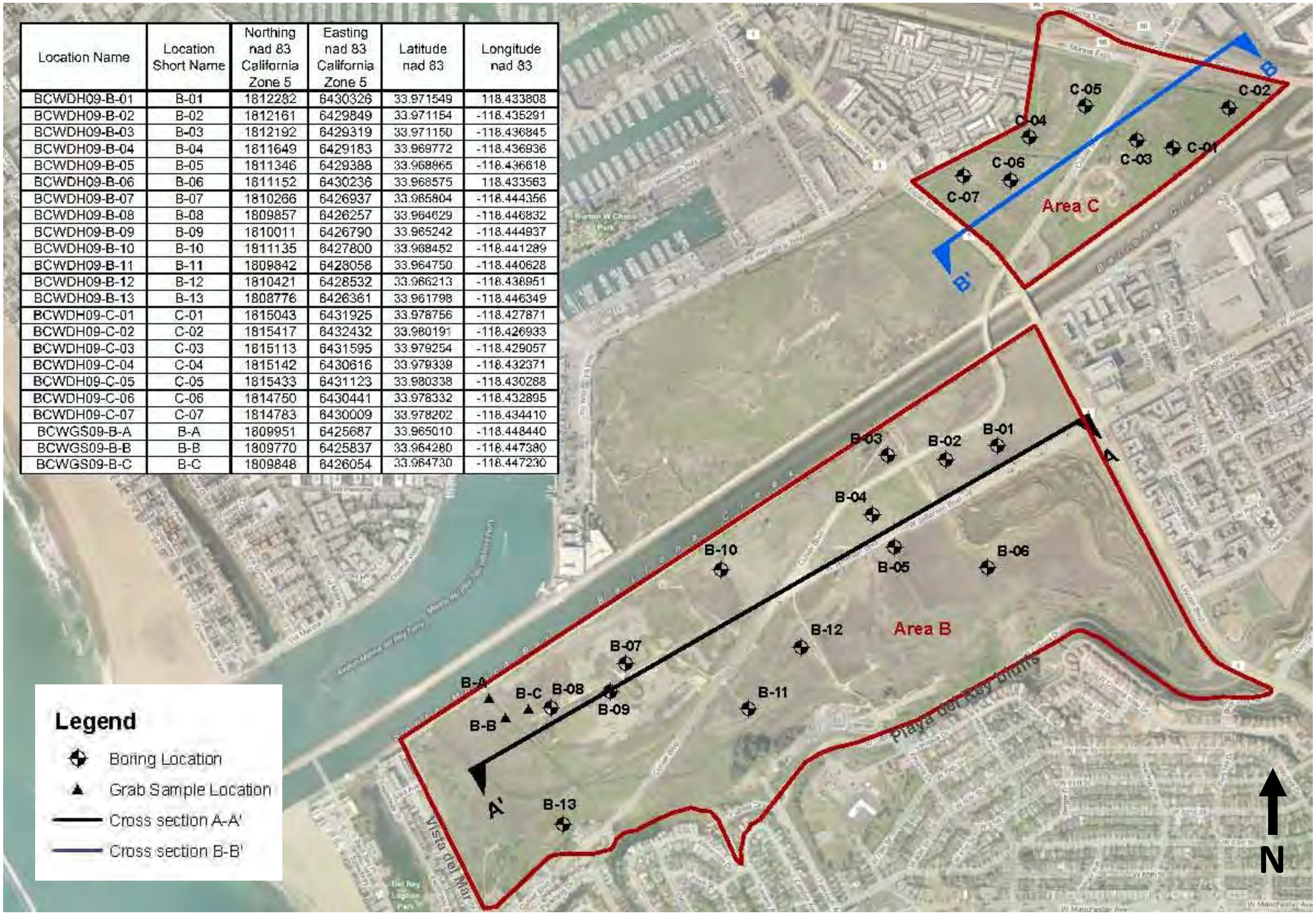
In 2008, Weston Solutions conducted a survey for the Port of Los Angeles to identify the geotechnical, chemical, and physical characteristics of the soil and existing dredged material of Area A. Twenty borings were surveyed throughout Area A and were assessed across two transects (i.e. A-A', B-B'; Figure 3.1). Soil borings were collected and analyzed to a depth of approximately 25 feet at each of the 20 sampling stations using an ATV-mounted direct push rig and a 4-inch diameter solid stem auger drill rig.

Preliminary results indicate the surveyed dredged materials at the site do not vary greatly with depth or location; they also do not vary greatly in grain size or classification (Weston Solutions 2009). The dredged materials are predominantly low plasticity clays, silty clays, and clayey silts. With the exception of one soil sample, none of the samples contained concentrations of polycyclic aromatic hydrocarbons (PAHs), polychlorinated bipheynyls (PCBs), or pesticides above the evaluated soil criteria. Evaluated criteria included hazardous waste criteria (e.g. Total Threshold Limit Concentration and Soluble

Threshold Limit Concentration), human health screening levels, and effects range-low and effects range-medium. Detailed results for organic constituents, soil characteristics, metal concentrations, and cross section evaluations are contained in the full report (Weston Solutions 2009).

Figure 3.1. Deep borehole core sampling locations in Area A (reproduced from Weston Solutions 2009).

In 2008, the U.S. Army Corps of Engineers (USACE) conducted a survey to assess borehole soil cores from Area B and Area C (Figure 3.2; Diaz, Yourman, & Associates 2010). Seven borings were drilled in Area C, and 13 borings were drilled in Area B. Samples were composited by area was and analyzed for grain size distribution, pH, salinity, moisture content, ammonia, total organic carbon (TOC), total petroleum hydrocarbons, sulfides, volatile solids, trace metals, butyltins, phthalates, phenols, PAHs, chlorinated pesticides, and PCBs using U.S. Environmental Protection Agency (EPA) approved strong acid digestion methods. The subsurface soils immediately below the existing grade of Areas B and C consisted mainly of silts, lean clays, and high plastic clays. Detailed results for organic constituents, soil characteristics, metal concentrations, and cross section evaluations are contained in the appendices of the full report (Diaz, Yourman, & Associates 2010).



Location Name	Location Short Name	Northing nad 83 California Zone 5	Easting nad 83 California Zone 5	Latitude nad 83	Longitude nad 83
BCWDH09-B-01	B-01	1812282	6430326	33.971549	118.433808
BCWDH09-B-02	B-02	1812161	6429849	33.971154	-118.435291
BCWDH09-B-03	B-03	1812192	6429319	33.971150	-118.436845
BCWDH09-B-04	B-04	1811649	6429183	33.969772	-118.436936
BCWDH09-B-05	B-05	1811346	6429388	33.968865	-118.436618
BCWDH09-B-06	B-06	1811152	6430236	33.968575	118.433563
BCWDH09-B-07	B-07	1810266	6426937	33.965804	-118.444356
BCWDH09-B-08	B-08	1809857	6426257	33.964629	-118.446832
BCWDH09-B-09	B-09	1810011	6426790	33.965242	-118.444937
BCWDH09-B-10	B-10	1811135	6427800	33.968452	-118.441289
BCWDH09-B-11	B-11	1809842	6428058	33.964750	-118.440628
BCWDH09-B-12	B-12	1810421	6428532	33.966213	-118.438951
BCWDH09-B-13	B-13	1808776	6426361	33.961798	-118.446349
BCWDH09-C-01	C-01	1815043	6431925	33.978756	-118.427871
BCWDH09-C-02	C-02	1815417	6432432	33.980191	-118.426933
BCWDH09-C-03	C-03	1815113	6431595	33.979254	-118.429057
BCWDH09-C-04	C-04	1815142	6430616	33.979339	-118.432371
BCWDH09-C-05	C-05	1815433	6431123	33.980338	-118.430288
BCWDH09-C-06	C-06	1814750	6430441	33.978332	-118.432895
BCWDH09-C-07	C-07	1814783	6430009	33.978202	-118.434410
BCWGS09-B-A	B-A	1809951	6425687	33.965010	-118.448440
BCWGS09-B-B	B-B	1809770	6425837	33.964280	-118.447380
BCWGS09-B-C	B-C	1809848	6426054	33.964730	-118.447230

Figure 3.2. Soil sampling stations in Areas B and C (modified from Diaz, Yourman, & Associates 2010). Red outline indicates the BWER boundary; black and blue lines indicate cross-Area transects.

METHODS

Method Comparison and Rationale

Contaminants may accumulate on soils from sediment dispersed during rain events, aerial deposition, or on high tides in marsh systems. An analysis of surface soils was conducted to determine potential impacts to the health of plant communities and species dependent on these habitats. Studies that mimic the bioavailable uptake of metals within plants (phytoavailability) utilize weak extractants, which reasonably imitate the processes determining metal availability in these applications (Peijnenburg et al. 2007). Soil sampling techniques followed protocols for assessing the phytoavailability of trace contaminants in terrestrial soils (Calabrese and Baldwin 1993, McLaughlin 2001, Meyer 2002, Peijnenburg and Jager 2003, Kabata-Pendia 2004, G. Wallace, pers. comm. 2011).

Site Locations and Times

A stratified random approach was employed for terrestrial soil sampling. Soil samples were collected at five randomly selected vegetation cover survey transects within each of ten habitat types (i.e. brackish marsh, dune, freshwater marsh, upland grassland, upland scrub, low marsh, mid marsh, high marsh, seasonal wetland, and salt pan; Figure 3.3). Transects were randomly allocated within habitat polygons by Green Info Network (GIN) using GIS. One additional transect in the mid marsh habitat was collected and analyzed. Samples were collected between 12 July and 30 September 2010.

Field Methods

Ten soil cores 3 cm in diameter and 10 cm deep were collected and composited from each transect. Soil cores were collected using a plastic syringe 3 cm in diameter with the tip removed and marked at a depth of 10 cm. Soil was collected with a digging trowel, whenever the soil was too compacted to be collected via syringe. Care was taken to maintain the same 10 cm depth using the trowel method. All samples were composited in a sealed plastic bag, labeled with the date and transect number, and taken to the lab within 24 hours of collection.

Figure 3.3. Location of each BAP soil transect and habitat type.

Laboratory Methods

The phytoavailability of trace metal contaminants and minerals was assessed by utilizing a water extraction method with ammonium bicarbonate DTPA. This type of gentle extractant approximates the ability of the roots to assimilate minerals (G. Wallace, pers. comm.).

Laboratory analyses were conducted by a private facility, Wallace Laboratories, of El Segundo, California (Soil and Plant Analysis Laboratory Registry Number CA006, US Department of Agriculture permit number S-56869). All terrestrial soil analyses were based on methods developed in "Methods of Soil Analysis, Part 3-Chemical Methods," Soil Science Society of America, Inc. (Sparks 1996).

Bicarbonate determinations used an end point of bicarbonate titration of 4.5 (G. Wallace, pers. comm.); carbonate determinations used an end point of carbonate titration of pH 8.2. Ammoniacal and nitrate determinations utilized the same methodologies developed in "Methods of Soil Analysis" (Sparks 1996). Elemental determinations (all elements except nitrogen and carbonates) used an inductively coupled argon plasma optical emission spectrophotometer (Sparks 1996).

Soil samples were analyzed for constituents of concern, which included: aluminum, arsenic, barium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, phosphorus, potassium, selenium, silver, sodium, strontium, sulfur, tin, vanadium, and zinc. Additionally, chloride, nitrate, and sulfate were analyzed. Infiltration rate, estimated soil texture, lime, organic matter, and moisture content of the soil were included in the analyses.

Data Analysis Methods

Soil core data were analyzed by individual transect and habitat. Habitat values were averaged across five transects within each habitat (six transects in the mid marsh habitat), and standard error (SE) was used to represent variability.

Soil data were evaluated for each constituent of concern against the U.S. Environmental Protection Agency (EPA) Ecological Soil Screening Level (Eco-SSL) plant values (http://www.epa.gov/ecotox/ecossl/) (Table 3.2). EPA Eco-SSL plant values represent the collaborative effort of a multi-stakeholder workgroup consisting of federal, state, consulting, industry, and academic participants led by the US EPA. The Eco-SSLs are soil screening numbers, and represent risk-based ecological values of concentrations of contaminants in soil that are frequently of ecological concern for plants and animals (EPA 2005). These values can be used to identify those contaminants of potential concern in soils requiring further evaluation in a baseline ecological risk assessment (EPA 2005; Table 3.2).

Table 3.1. Constituents of concern evaluated and associated Eco-SSL plant values (modified from http://response.restoration.noaa.gov/book_shelf/122_NEW-SQuiRTs.pdf).

elements	Eco-SSL (ppb)
aluminum	50,000
arsenic	18,000
barium	500,000
boron	500
cadmium	4,000
calcium	----
chromium	<1,000
cobalt	13,000
copper	70,000
iron	----
lead	50,000
lithium	2,000
magnesium	----
manganese	220,000
mercury	300
molybdenum	2,000
nickel	30,000
phosphorus	----
potassium	----
selenium	520
silver	2,000
sodium	----
strontium	----
sulfur	----
tin	50,000
vanadium	2,000
zinc	50,000

ppb = parts per billion

RESULTS

General Results and Overall Trends

All values for specific constituents and additional parameters across each transect location are available in Appendix B.2.

Table 3.3 includes the recommended Eco-SSL plant values for each constituent, and the number of transects in each habitat that exceeded the Eco-SSL plant value for that constituent. The dune habitat did not exceed plant Eco-SSL limits for any constituents of concern. The upland grassland, mid marsh, and upland scrub habitats exceeded the Eco-SSL plant value for boron. Both the upland grassland and scrub habitats each had one transect with one constituent of concern, above the plant maximum value (i.e. boron); the other habitats had multiple transects. The salt pan habitat had the highest number of transects with constituent of concern plant value exceedances, including boron, selenium, and vanadium (5, 4, and 2, respectively; Table 3.3).

Appendix B.3 contains additional non-constituent soil characteristics data for each transect, including: pH, ECe (electrical conductivity as a measure of soil salinity), calcium, magnesium, sodium, potassium, cation sum, chloride, nitrate as N, phosphorous as P, sulfate as S, anion sum, boron as B, sodium adsorption ratio, relative infiltration rate, estimated soil texture, lime (calcium carbonate), organic matter, moisture content, and half saturation percentage.

Constituents of Concern

Boron, lead, selenium, and vanadium were the four constituents of concern that yielded at least one transect over the Eco-SSL plant value for that constituent. Figures 3.4, 3.5, 3.6, and 3.7 are four maps representing individual transect concentrations of constituents (boron, lead, selenium, and vanadium, respectively) at the BWER. The maps are color coded; green and yellow are below the Eco-SSL plant values; red, maroon, and black are above the Eco-SSL plant values. Different scales are used for each map.

Figures 3.8, 3.9, 3.10, and 3.11 provide graphs of each constituent of concern with at least one transect above the Eco-SSL plant value (boron, lead, selenium, and vanadium, respectively). The dune habitat consistently had the lowest average value for each constituent. The salt pan habitat had the highest average value for both boron and selenium (7734.0 ± 2214.8 ppb and 1606.0 ± 428.0, Figures 3.8 and 3.10, respectively). The freshwater marsh habitat had the highest average value for both lead and vanadium (31897.3 ± 6758.2 and 3763.7 ± 2041.6, Figures 3.9 and 3.11, respectively).

Many of the transects contained values above the Eco-SSL plant value for boron (i.e. 500 ppb) with boron levels especially concentrated in the marsh and salt pan habitats (Figure 3.8). The highest value for boron, 15174 ppb, was on transect 133 in the salt pan. Transect 330 at 55881.4 ppb in the freshwater habitat, exceeded the plant Eco-SSL for lead (i.e. 50000 ppb). High values of selenium (i.e. 520 ppb) were concentrated in the salt pan, although the highest value, 4166.7 ppb, was found on transect 383 in the low marsh habitat. Vanadium was high (i.e. 2000 ppb) in several different portions of Area B, but the highest value, 10176.3 ppb, was found on transect 330 in the freshwater marsh habitat.

Table 3.2. Number of transects for each habitat that exceeded the Eco-SSL plant values for each constituent of concern (EPA 2010).

	Eco-SSL value	Low marsh	Mid marsh	High marsh	Seasonal Wetland	Salt Pan	Freshwater	Brackish	Dune	Grassland	Scrub
Total transects	**----**	**5**	**6**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
aluminum	50000	0	0	0	0	0	0	0	0	0	0
arsenic	18000	0	0	0	0	0	0	0	0	0	0
barium	500000	0	0	0	0	0	0	0	0	0	0
boron	**500**	**5**	**5**	**4**	**3**	**5**	**3**	**5**	0	**1**	**1**
cadmium	4000	0	0	0	0	0	0	0	0	0	0
calcium	----	0	0	0	0	0	0	0	0	0	0
chromium	<1000	0	0	0	0	0	0	0	0	0	0
cobalt	13000	0	0	0	0	0	0	0	0	0	0
copper	70000	0	0	0	0	0	0	0	0	0	0
iron	----	0	0	0	0	0	0	0	0	0	0
lead	50000	0	0	0	0	0	**1**	0	0	0	0
lithium	2000	0	0	0	0	0	0	0	0	0	0
magnesium	----	0	0	0	0	0	0	0	0	0	0
manganese	220000	0	0	0	0	0	0	0	0	0	0
mercury	300	0	0	0	0	0	0	0	0	0	0
molybdenum	2000	0	0	0	0	0	0	0	0	0	0
nickel	30000	0	0	0	0	0	0	0	0	0	0
phosphorus	----	0	0	0	0	0	0	0	0	0	0
potassium	----	0	0	0	0	0	0	0	0	0	0
selenium	**520**	**2**	0	**1**	0	**4**	0	0	0	0	0
silver	2000	0	0	0	0	0	0	0	0	0	0
sodium	----	0	0	0	0	0	0	0	0	0	0
strontium	----	0	0	0	0	0	0	0	0	0	0
sulfur	----	0	0	0	0	0	0	0	0	0	0
tin	50000	0	0	0	0	0	0	0	0	0	0
vanadium	**2000**	**1**	0	0	**2**	**2**	**2**	**1**	0	0	0
zinc	50000	0	0	0	0	0	0	0	0	0	0

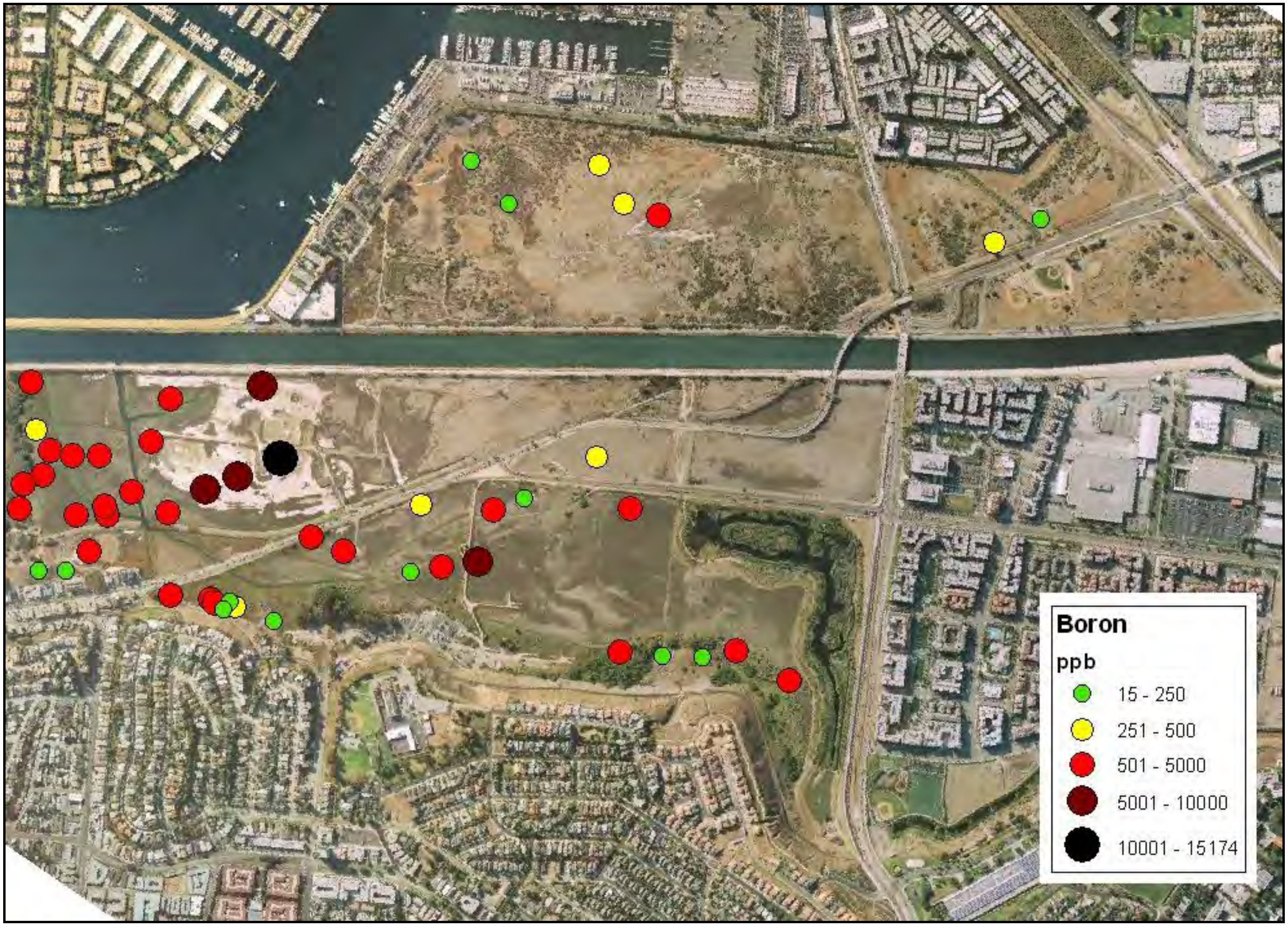


Figure 3.4. Boron (ppb) of each soil transect sampled. Green and yellow are below the Eco-SSL plant value; red, maroon, and black are above the Eco-SSL plant value. Note differing scales in Figures 3.4 – 3.7.

Figure 3.5. Lead (ppb) of each soil transect sampled. Green, yellow, and orange are below the Eco-SSL plant value; red is above the Eco-SSL plant value.

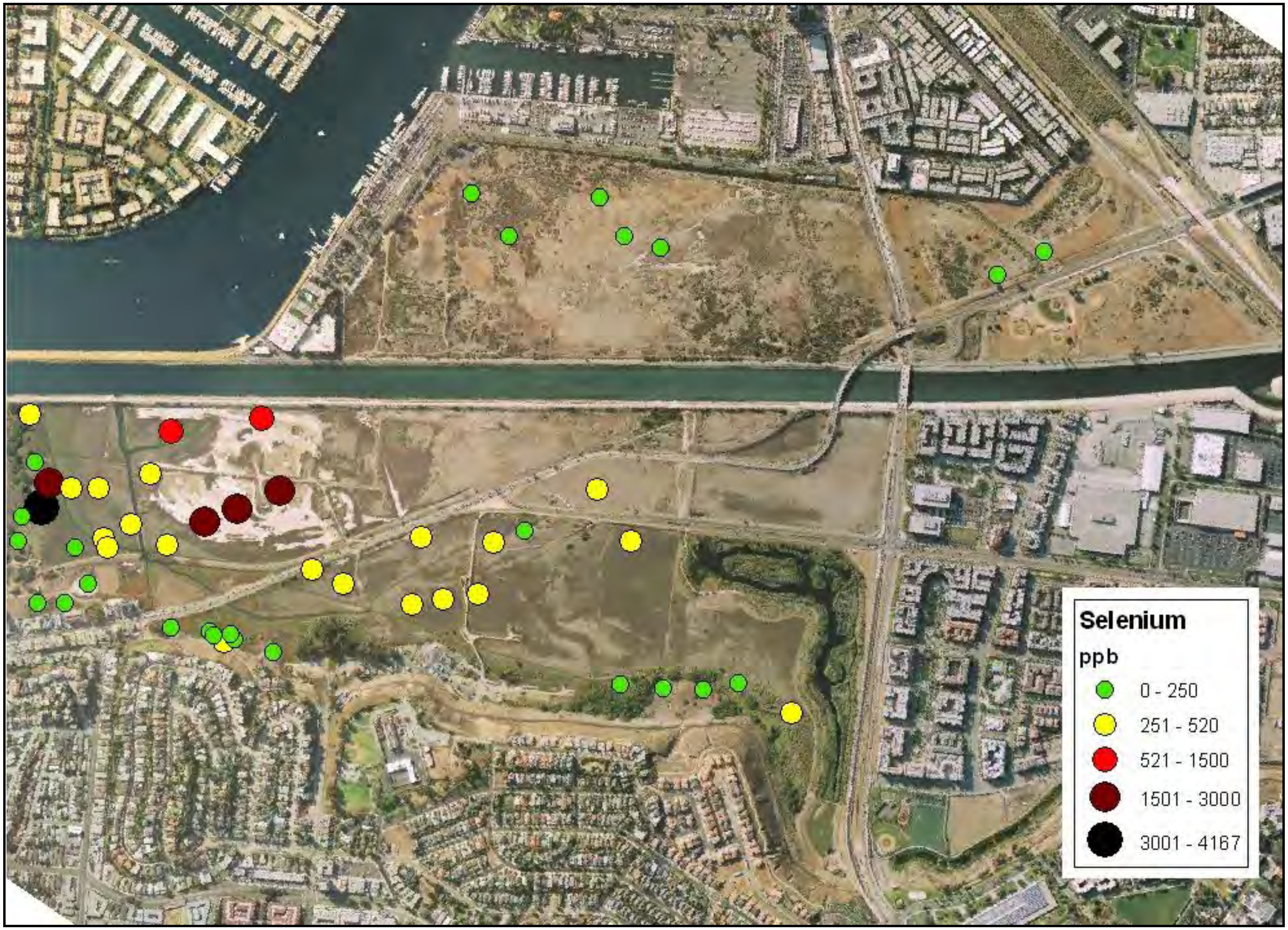


Figure 3.6. Selenium (ppb) of each soil transect sampled. Green and yellow are below the Eco-SSL plant value; red, maroon, and black are above the Eco-SSL plant value.

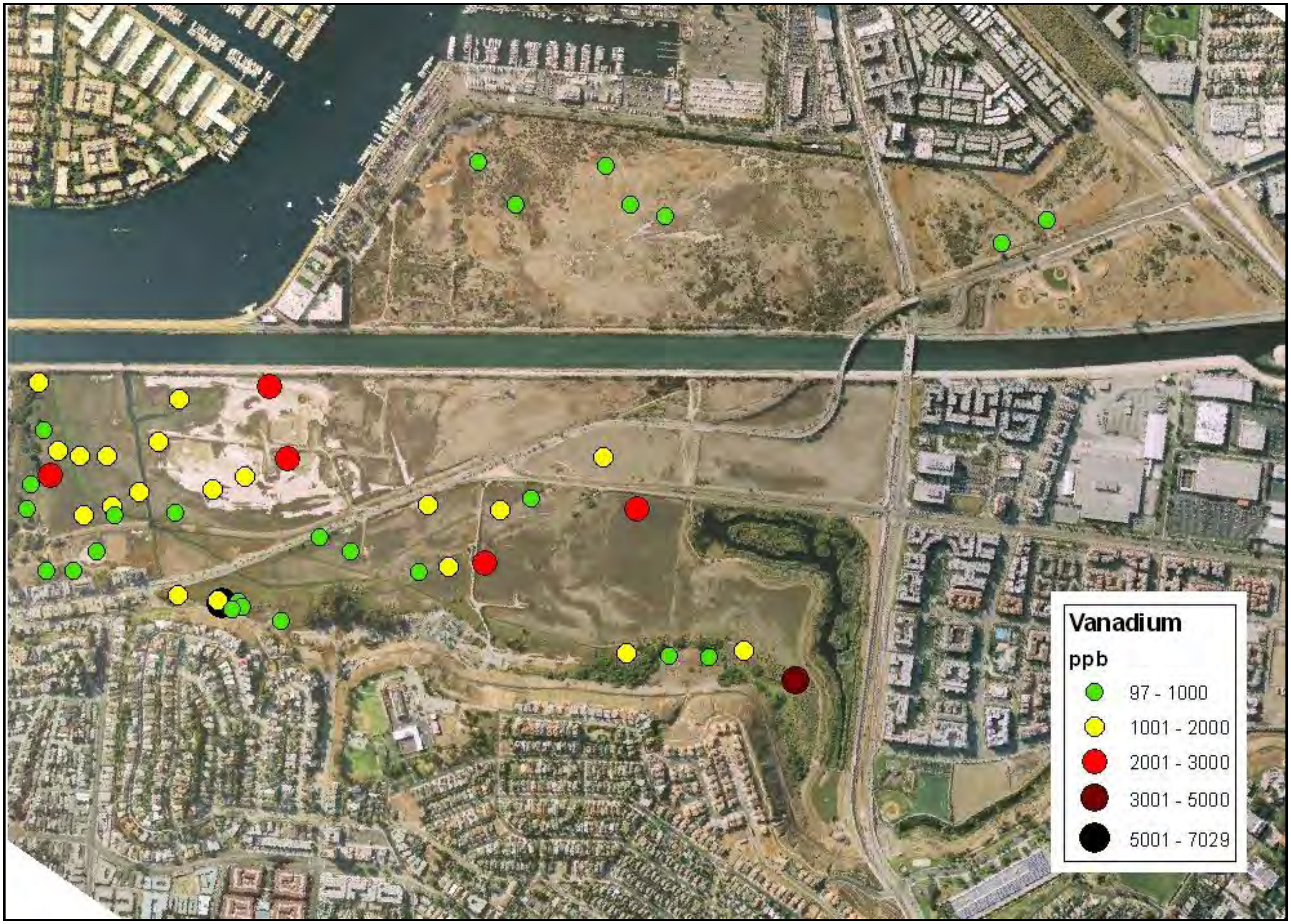


Figure 3.7. Vanadium (ppb) of each soil transect sampled. Green and yellow are below the Eco-SSL plant value; red, maroon, and black are above the Eco-SSL plant value.

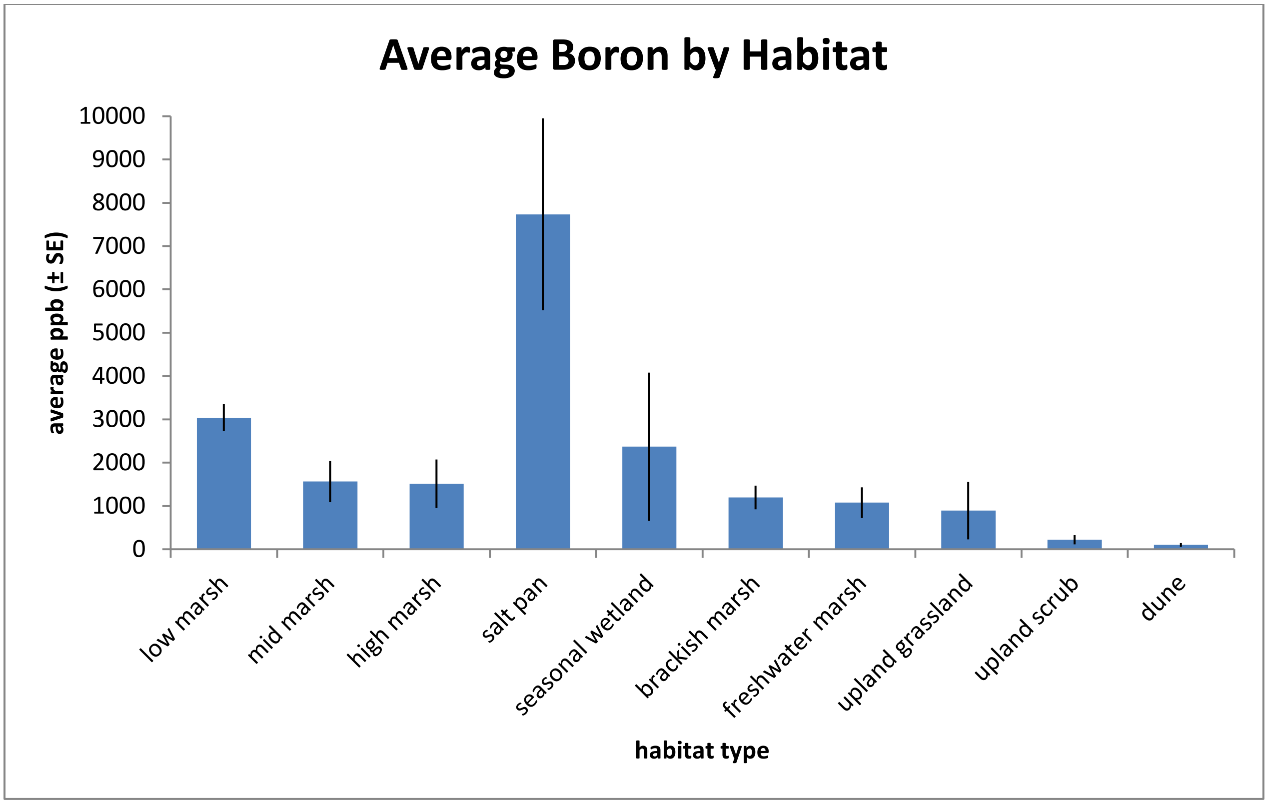


Figure 3.8. Average boron ± SE (ppb) for each habitat. Note: the boron plant Eco-SSL value is 500 ppb.

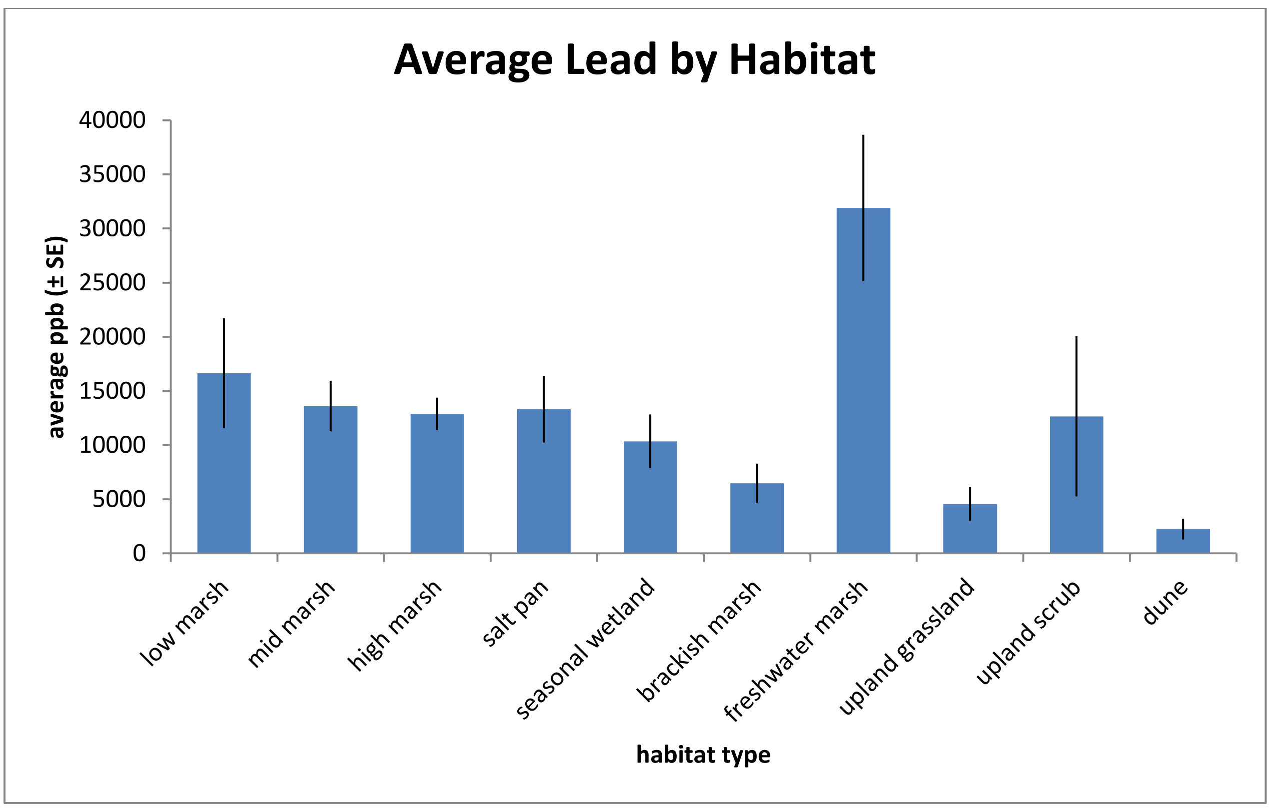


Figure 3.9. Average lead ± SE (ppb) for each habitat. Note: the lead plant Eco-SSL value is 50,000 ppb.

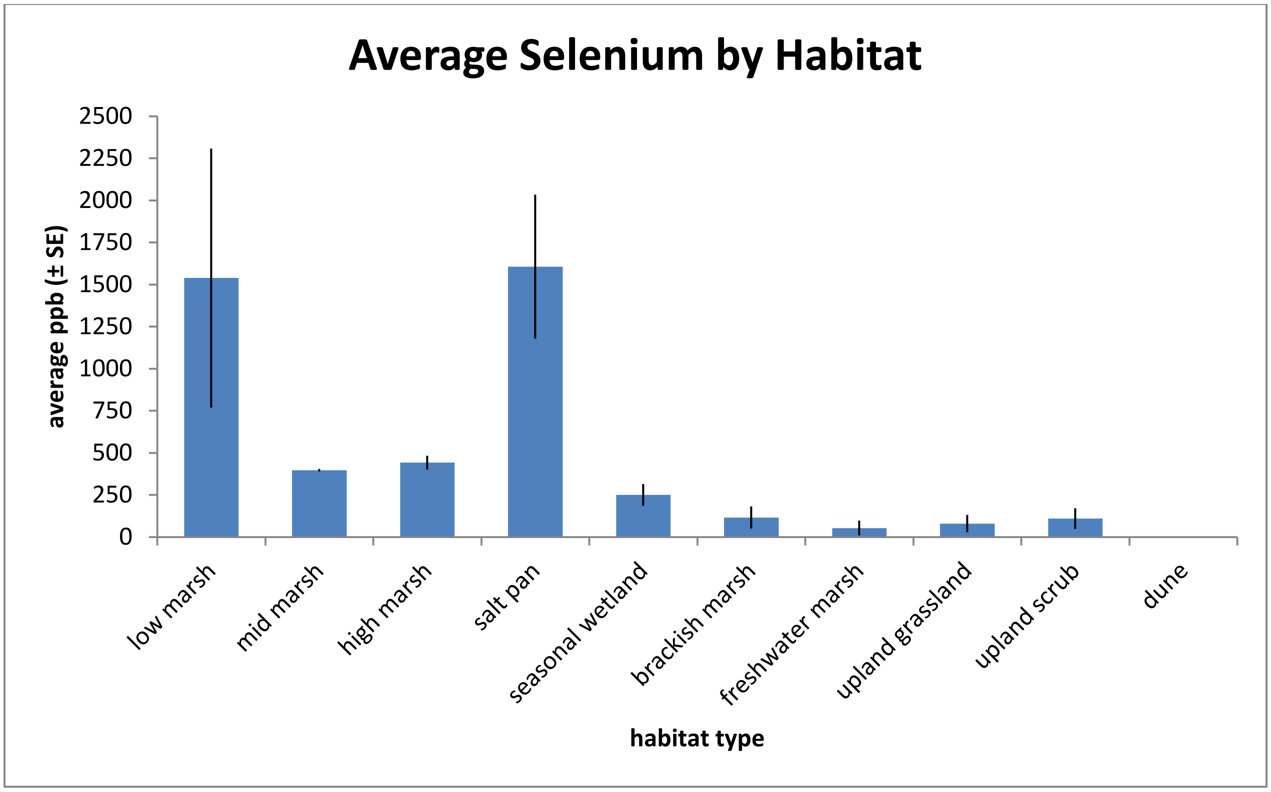


Figure 3.10. Average selenium ± SE (ppb) for each habitat. Note: the selenium plant Eco-SSL value is 520 ppb.

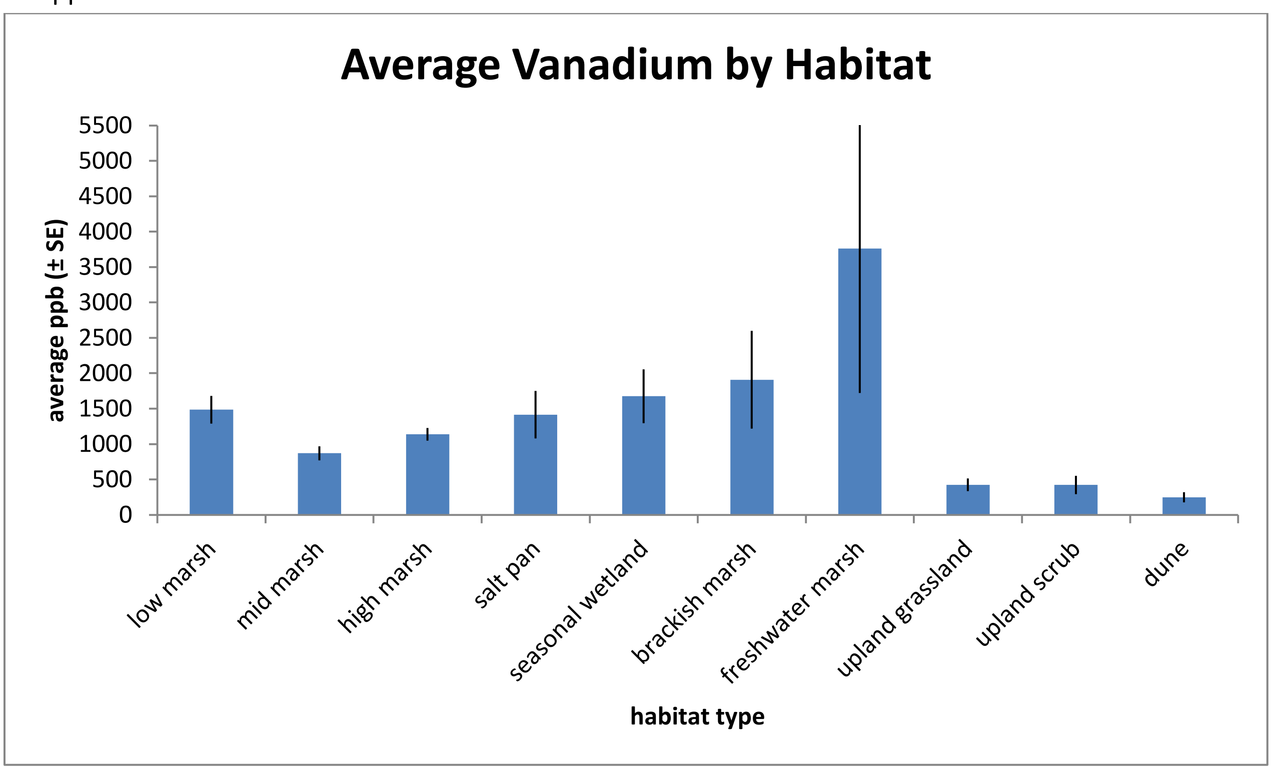


Figure 3.11. Average vanadium ± SE (ppb) for each habitat. Note: the vanadium plant Eco-SSL value is 2,000 ppb.

FUTURE DIRECTIONS

Additional transects will be surveyed in the second Baseline year in areas that had lower sample densities (e.g. Areas A and C). Areas with high levels of metals and contaminants will also be targeted. The sampling methods will remain the same as those from the first Baseline year and will serve as baseline data for future surveys.

Future surveys will also include plant tissue analyses for trace metals along the same transects as the soil surveys. This will allow a comparison of the phytoavailability of metals in the surface soils and the uptake by dominant plant species along the transects.

APPENDIX B.1 – Dumped soil constituent test results (2007)

Note: Values are in extractable mg/kg unless otherwise noted.

Element	1	2	3	4	5	6	7	8	9	10	11	12	13
aluminum	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.835	0.000	0.000	0.000	0.000	0.000
arsenic	0.000	0.217	0.129	0.205	0.236	0.011	0.115	0.318	0.036	0.197	0.116	0.600	0.015
barium	1.687	1.266	1.058	1.325	0.750	4.986	1.080	0.955	0.884	1.410	1.908	1.686	0.268
boron	0.171	0.172	0.299	0.134	0.530	0.104	0.185	0.549	0.199	0.109	0.161	0.246	0.294
cadmium	0.000	0.129	0.054	0.079	0.163	0.000	0.038	0.312	0.020	0.076	0.031	0.143	0.150
calcium	317.099	311.123	336.132	308.255	315.583	352.058	325.282	320.754	250.874	288.655	341.488	370.607	307.311
chloride	16.037	157.918	25.543	217.322	114.205	17.277	39.446	34.040	89.452	221.268	26.989	38.238	1982.962
chromium	0.000	0.013	0.016	0.000	0.020	0.000	0.000	0.038	0.014	0.000	0.013	0.015	0.000
cobalt	0.016	0.086	0.100	0.064	0.084	0.022	0.057	0.059	0.087	0.047	0.053	0.080	0.076
copper	0.307	3.449	2.800	2.054	10.852	0.299	1.581	18.212	1.702	1.900	1.457	21.684	2.075
iron	3.951	12.428	17.672	16.815	50.193	6.886	10.133	77.411	10.275	15.766	7.100	6.297	4.082
lead	0.220	3.292	1.336	0.953	15.180	0.361	0.634	27.976	1.005	0.958	0.875	5.673	0.554
lithium	0.282	0.370	0.331	0.325	0.332	0.311	0.345	0.321	0.302	0.301	0.374	0.346	0.435
magnesium	367.137	599.921	204.646	647.823	225.964	77.798	435.821	133.942	532.721	652.042	589.522	674.255	812.409
manganese	0.225	7.385	5.187	1.372	2.733	0.502	3.344	2.504	6.986	1.134	1.934	4.649	3.944
mercury	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
molybdenum	0.000	0.143	0.081	0.114	0.214	0.012	0.125	0.214	0.090	0.119	0.062	0.215	0.158
nickel	0.000	0.461	0.173	0.181	0.354	0.017	0.108	0.566	0.224	0.151	0.214	1.066	0.350
nitrate	4.764	12.716	16.118	12.248	15.238	1.964	20.052	1.964	13.619	33.035	10.981	5.375	63.248
phosphorus	3.129	11.339	15.781	4.634	9.641	1.911	16.982	9.310	4.133	4.145	6.432	1.624	3.407
potassium	14.828	63.283	65.454	29.980	230.158	23.619	50.185	223.619	40.748	27.594	52.365	56.656	70.319
selenium	0.000	0.146	0.000	0.154	0.000	0.000	0.000	0.000	0.084	0.158	0.000	0.000	0.204
silver	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
sodium	215.160	353.152	118.627	455.654	212.448	24.291	192.885	98.729	544.976	470.424	220.416	269.805	901.085
strontium	3.724	2.218	2.102	2.517	2.035	2.796	2.178	1.912	0.895	2.545	2.712	3.622	1.384
sulfur	13.777	32.202	47.089	145.045	594.883	7.923	45.998	776.027	13.208	128.158	19.866	11.837	323.001
tin	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
vanadium	0.497	0.750	0.569	0.614	0.913	0.194	0.547	0.857	1.079	0.556	0.639	0.682	0.342
zinc	0.216	2.454	1.460	0.970	13.744	0.409	0.831	28.660	1.158	0.900	1.317	15.168	0.562
SAR	4.737	4.395	2.310	5.755	3.074	1.711	2.701	1.650	5.834	5.722	3.027	4.119	4.662
Lime	no	no	yes	no	yes	no	no	no	high	no	no	no	no
Moisture	0.079	0.042	0.020	0.082	0.038	0.034	0.043	0.056	0.046	0.099	0.043	0.055	0.066
pH	8.37	7.8	8.02	8.01	7.82	8.85	7.86	7.58	8.07	8.02	8.11	7.43	6.87
Salinity (ppt)	0.680	1.150	1.140	2.300	3.570	0.550	0.990	2.870	1.200	2.190	0.850	0.670	9.090

Element	14	15	16	17	18	19	20	21	22	23	24	25
aluminum	0.000	0.000	0.870	0.000	0.000	0.233	0.348	0.198	0.235	0.000	0.000	0.385
arsenic	0.121	0.000	0.225	0.629	0.000	0.218	0.474	0.342	0.256	0.133	0.072	0.239
barium	1.381	0.219	0.807	1.740	0.312	0.920	0.509	0.626	0.751	0.308	0.483	0.774
boron	0.123	0.328	0.489	0.258	0.356	0.437	0.908	0.763	0.619	0.156	0.492	0.643
cadmium	0.106	0.113	0.174	0.183	0.147	0.143	0.540	0.368	0.169	0.422	0.211	0.234
calcium	363.281	344.718	332.611	364.932	310.137	327.885	264.381	299.378	311.671	385.156	323.099	308.205
chloride	5.690	605.237	75.464	493.219	2106.541	93.130	88.547	64.167	94.828	1849.394	3238.373	179.685
chromium	0.000	0.000	0.021	0.025	0.014	0.020	0.067	0.047	0.018	0.000	0.019	0.030
cobalt	0.045	0.066	0.047	0.077	0.074	0.031	0.126	0.105	0.035	0.049	0.060	0.069
copper	1.647	1.604	10.931	34.594	3.610	9.076	27.507	23.736	10.623	3.199	1.467	14.250
iron	5.665	4.500	54.590	9.072	6.678	47.453	88.249	66.183	53.183	4.457	9.973	61.308
lead	0.530	0.430	14.009	8.528	0.756	12.278	51.316	50.170	17.002	0.598	0.629	23.773
lithium	0.383	0.484	0.337	0.333	0.444	0.322	0.253	0.275	0.312	0.385	0.340	0.306
magnesium	633.798	709.721	163.177	596.356	675.180	131.202	137.030	153.681	149.746	264.822	491.394	150.022
manganese	0.223	2.205	1.670	4.170	4.325	1.432	5.247	4.038	1.150	2.791	4.145	2.740
mercury	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
molybdenum	0.043	0.160	0.207	0.220	0.219	0.138	0.265	0.279	0.146	0.155	0.211	0.252
nickel	0.173	0.339	0.445	1.014	0.313	0.277	0.923	0.929	0.364	1.256	0.112	0.473
nitrate	4.707	14.816	13.577	17.535	115.433	13.619	33.659	17.426	13.242	18.091	81.962	23.438
phosphorus	10.770	3.126	7.313	2.471	5.620	6.444	11.571	8.564	7.151	8.108	7.470	7.471
potassium	30.904	57.008	237.151	52.740	82.835	172.567	288.823	226.531	214.171	76.087	37.290	213.374
selenium	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.132	0.000
silver	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
sodium	218.820	251.870	151.552	348.641	698.599	133.144	170.864	189.841	208.185	258.727	880.706	162.255
strontium	2.300	1.141	2.044	3.530	1.454	2.178	1.266	1.628	1.975	1.219	1.896	1.724
sulfur	10.201	330.233	555.037	25.478	242.258	398.122	1569.684	1235.379	551.272	84.195	468.665	954.942
tin	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
vanadium	0.616	0.318	0.780	0.594	0.302	0.542	1.076	0.823	0.601	0.425	0.521	0.740
zinc	0.350	0.466	16.665	23.583	3.139	12.148	51.421	41.943	16.830	2.635	0.885	21.817
SAR	2.197	1.787	2.423	4.271	4.025	2.384	2.418	3.166	3.333	2.259	7.711	2.554
lime	no	no	yes	no	no	slight	slight	slight	slight	no	no	yes
moisture	0.087	0.123	0.053	0.048	0.048	0.040	0.038	0.054	0.041	0.073	0.028	0.034
pH	7.73	7.27	7.67	7.17	6.85	7.7	7.62	7.66	7.76	7.45	7.45	7.75
Salinity (ppt)	0.370	3.580	3.120	2.340	9.820	2.990	3.370	3.350	3.740	6.140	16.210	3.410

APPENDIX B.2

Values for all constituents of concern on the terrestrial soil transects

Note: Constituents are recorded as ppb unless otherwise noted.

HABITAT		brackish	brackish	brackish	brackish	brackish	dune	dune	dune	dune	dune
elements	**plant max**	**314**	**316**	**318**	**312**	**319**	**420**	**416**	**425**	**409**	**421**
phosphorus	----	55602.7	59576.8	36017.0	25943.8	48089.2	6650.3	17300.7	26348.7	9133.4	34865.9
potassium	----	236421.6	314900.3	367537.7	68216.3	308542.0	36127.3	43136.7	91835.2	23643.5	125160.6
iron	----	49237.8	22564.9	45979.8	83072.9	83788.1	6702.7	51706.1	30673.4	17438.8	200632.2
manganese	220000.0	11658.0	6763.8	5128.0	16736.0	9012.4	589.3	6580.0	9560.4	10542.8	9892.4
zinc	50000.0	2126.5	3954.6	16882.5	5177.1	13035.9	798.6	9501.2	7246.5	692.9	5816.1
copper	70000.0	2988.2	3408.7	15823.8	1881.2	3509.7	662.5	1697.6	1024.1	425.9	1602.7
boron	500.0	1121.7	1700.5	1931.0	521.1	706.2	26.8	88.2	110.5	20.2	256.5
calcium	----	349333.4	331336.8	338075.5	553265.2	510100.4	428120.3	347817.0	371860.0	285124.2	406997.1
magnesium	----	393002.4	557707.2	1060177.7	101866.6	442061.9	117677.4	66141.9	82060.7	95296.9	187878.2
sodium	----	541429.7	1968989.0	1984946.6	27454.0	799910.1	30711.3	107274.0	25800.1	10914.3	233993.8
sulfur	----	31501.0	1260583.0	771546.1	22515.7	57465.8	5280.7	15125.2	8737.3	5913.9	32372.6
molybdenum	2000.0	58.0	52.8	271.0	12.1	18.6	34.3	73.3	95.0	54.8	0.0
nickel	30000.0	534.6	528.4	2015.5	495.1	1703.1	113.1	277.8	230.0	173.9	757.5
aluminum	50000.0	0.0	0.0	0.0	14903.3	5075.5	407.8	3696.3	2171.9	282.3	16944.2
arsenic	18000.0	145.1	0.0	432.8	0.0	62.6	34.9	0.0	31.0	0.0	41.8
barium	500000.0	958.9	272.7	573.1	236.3	189.1	3454.9	448.2	344.8	2463.6	159.8
cadmium	4000.0	125.2	182.6	581.9	108.2	151.5	0.0	70.1	73.7	25.5	129.0
chromium	<1000	29.3	0.0	33.8	100.3	49.1	0.0	48.7	59.0	26.8	108.7
cobalt	13000.0	57.9	71.4	60.4	101.3	71.0	21.9	104.3	80.3	123.0	78.5
lead	50000.0	3080.7	6155.1	13189.3	3623.4	6371.8	312.7	2432.2	2654.8	308.3	5467.5
lithium	2000.0	112.6	127.3	195.1	192.6	206.8	139.5	115.5	122.3	93.2	147.5
mercury	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
selenium	520.0	240.3	0.0	308.8	0.0	30.7	0.0	0.0	0.0	0.0	0.0
silver	2000.0	0.0	50.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
strontium	----	3392.2	3386.4	4427.6	1499.7	2433.3	3580.6	1116.5	1046.8	2537.4	1556.0
tin	50000.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
vanadium	2000.0	1646.2	1738.1	4552.2	717.6	892.4	97.0	242.1	219.8	166.3	517.9

HABITAT		freshwater	freshwater	freshwater	freshwater	freshwater	grassland	grassland	grassland	grassland	grassland
elements	**plant max**	**324**	**326**	**328**	**330**	**322**	**249**	**171**	**207**	**253**	**268**
phosphorus	----	21748.4	27132.2	34019.1	38449.7	25105.7	17661.3	4617.6	6052.5	16551.1	13794.9
potassium	----	131043.7	145080.1	458644.5	596376.4	369433.3	89161.3	548196.6	174777.0	151436.9	67198.3
iron	----	79978.1	115946.8	26731.5	119700.1	60770.2	6442.1	48189.0	25639.2	24970.6	7496.2
manganese	220000.0	3372.1	56081.1	16089.8	9680.6	19440.0	9718.0	6122.4	4356.5	11817.3	8811.3
zinc	50000.0	16457.5	23637.5	43974.3	32042.6	17471.8	14859.2	808.2	821.3	1277.2	4461.5
copper	70000.0	3508.4	11878.0	3001.2	15194.9	2238.4	2083.2	4485.4	9148.0	6191.5	5215.7
boron	500.0	2046.1	1187.7	328.2	1594.4	221.8	168.5	3543.6	308.5	298.2	143.8
calcium	----	323747.3	499303.3	485142.1	560865.5	490476.0	355871.1	443482.1	334351.1	318171.3	300132.5
magnesium	----	183171.3	410262.1	164881.5	599544.3	134190.6	71471.1	420726.6	73136.8	280558.2	117045.5
sodium	----	271443.1	529490.0	343619.8	835283.4	232017.9	157660.4	2135040.2	25090.9	230102.4	16210.7
sulfur	----	68334.5	94196.5	115760.7	150702.2	70818.1	445816.8	16012746.1	118062.5	43826.9	11878.8
molybdenum	2000.0	12.7	940.9	240.8	122.4	52.1	31.4	173.1	25.5	47.3	13.0
nickel	30000.0	601.3	3660.5	1001.6	3235.0	876.4	157.5	297.2	315.4	478.6	332.9
aluminum	50000.0	3957.5	64.4	1553.4	3459.1	4893.2	0.0	0.0	0.0	0.0	0.0
arsenic	18000.0	259.2	698.3	0.0	527.4	0.0	58.9	88.0	67.5	184.9	232.0
barium	500000.0	419.0	462.1	222.9	625.0	224.8	600.1	132.5	148.9	831.2	793.9
cadmium	4000.0	99.5	471.1	319.6	491.5	195.3	112.0	146.7	50.4	162.4	116.2
chromium	<1000	39.3	102.4	77.2	37.1	114.7	31.2	14.1	20.4	38.1	49.6
cobalt	13000.0	33.3	773.7	117.1	171.3	278.9	88.2	101.8	56.6	124.9	107.5
lead	50000.0	18879.0	36332.3	28101.9	55881.4	20292.0	7880.7	1855.0	1561.8	2746.2	8774.5
lithium	2000.0	137.9	165.6	165.5	279.0	174.5	171.0	499.9	187.3	189.8	157.7
mercury	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
selenium	520.0	0.0	0.0	40.4	226.0	0.0	251.4	146.4	0.0	0.0	0.0
silver	2000.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.4	0.0
strontium	----	2223.4	3529.0	2013.3	4490.4	1032.8	1363.8	9617.0	2261.1	1793.2	1423.6
tin	50000.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
vanadium	2000.0	1027.8	7028.7	266.3	10176.3	319.4	259.2	306.4	314.9	741.5	503.8

HABITAT		high marsh	high marsh	high marsh	high marsh	high marsh	low marsh	low marsh	low marsh	low marsh	low marsh
elements	**plant max**	**51**	**60**	**69**	**77**	**82**	**369**	**378**	**380**	**370**	**383**
phosphorus	----	17671.0	17688.2	18361.7	13133.9	19755.3	9340.2	12856.2	11057.1	18610.5	10946.2
potassium	----	457375.7	808143.6	692221.5	1160652.1	1066941.7	1189366.6	1198448.5	1183093.0	1683992.8	1691592.0
iron	----	7040.7	9937.6	13448.1	4420.6	7201.5	5028.9	7227.8	2551.0	10922.2	6241.3
manganese	220000.0	11525.5	23218.6	18979.5	5247.2	3246.5	502.9	587.3	1939.8	1229.3	1944.0
zinc	50000.0	15940.0	19964.3	18938.9	14276.4	17116.2	9328.1	7042.5	10453.1	21367.6	13358.8
copper	70000.0	10225.0	7996.3	6365.2	5125.2	10043.1	5091.1	4819.8	4415.9	11215.9	6387.0
boron	500.0	373.6	599.6	948.7	2361.4	3277.7	2944.0	2717.8	2317.5	3040.9	4172.6
calcium	----	290144.5	294305.9	247476.1	298553.8	381851.6	266683.8	386911.9	691852.3	946783.9	388204.2
magnesium	----	873499.5	999172.3	1210397.9	1202617.7	1210371.4	1268144.8	1914404.8	1801238.9	2175127.6	1722885.1
sodium	----	1240814.4	3896181.6	7704953.5	7616124.6	7958481.5	9604559.7	13536336.4	11902354.1	10795576.2	8856432.7
sulfur	----	151317.9	194869.6	2340252.5	378251.1	782483.4	388854.9	920203.3	747026.7	583453.3	509719.5
molybdenum	2000.0	107.4	66.9	105.6	97.8	51.8	16.1	0.0	0.0	52.6	0.0
nickel	30000.0	1251.6	1484.9	1248.1	823.2	521.4	350.1	1015.6	678.7	1699.3	1216.4
aluminum	50000.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
arsenic	18000.0	190.4	155.0	160.3	76.9	305.1	159.2	144.1	161.9	556.9	0.0
barium	500000.0	514.7	649.3	92.3	242.0	401.3	300.1	247.5	124.3	283.6	0.0
cadmium	4000.0	594.0	336.9	485.2	187.1	216.7	136.4	179.3	126.2	142.2	186.8
chromium	<1000	16.0	45.3	20.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cobalt	13000.0	140.7	251.3	197.2	122.4	83.1	36.3	49.7	55.3	231.7	157.2
lead	50000.0	17554.2	13660.7	9036.8	10280.4	13870.3	5469.3	25249.2	8879.7	31855.3	11765.2
lithium	2000.0	181.0	257.3	252.1	385.1	434.3	398.9	940.3	728.6	528.2	349.3
mercury	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
selenium	520.0	316.6	467.2	378.0	515.6	530.1	196.4	505.7	403.1	2419.2	4166.7
silver	2000.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	293.0	0.0
strontium	----	2696.2	3401.4	2756.9	3928.7	4859.0	5145.2	10244.3	9581.7	11464.5	4583.0
tin	50000.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
vanadium	2000.0	1163.8	856.4	1237.4	1046.3	1386.6	1269.5	1209.1	1152.4	1588.0	2205.9

HABITAT		mid marsh	mid marsh	mid marsh	mid marsh	mid marsh	mid marsh	salt pan	salt pan	salt pan	salt pan	salt pan
elements	**plant max**	**116**	**83**	**107**	**118**	**129**	**123**	**145**	**133**	**138**	**140**	**156**
phosphorus	----	14447.9	15549.6	13035.4	7938.6	21673.2	20204.0	22006.0	26624.8	12583.3	14395.3	20865.5
potassium	----	978680.7	1117023.7	1347546.4	423908.0	839488.5	995589.5	1986863.0	1536029.0	1005308.8	1403458.1	364323.9
iron	----	10210.8	3825.8	3549.0	13120.6	13317.4	8850.6	1219.7	9932.0	11686.2	10952.9	37268.4
manganese	220000.0	3872.5	3307.3	5872.4	14722.6	2021.3	1206.7	1316.1	1297.5	751.1	436.8	3528.8
zinc	50000.0	31310.6	8725.6	24154.0	15792.4	20381.2	19020.6	5743.6	5102.9	7654.8	14181.0	2346.8
copper	70000.0	10936.6	4000.8	7986.6	4253.3	13427.2	8407.4	5395.1	8046.6	3739.7	7586.6	2248.9
boron	500.0	1173.1	2389.9	3382.1	53.9	1389.0	987.2	9437.8	15174.0	6039.2	6158.4	1860.7
calcium	----	509016.0	319283.4	761171.1	360913.6	559505.8	777656.6	572111.6	301225.6	223376.7	236793.1	329116.9
magnesium	----	1668657.7	1208898.5	1827372.7	906241.0	1074007.5	1312057.3	3761873.9	2368436.3	1625899.3	2126631.0	496716.4
sodium	----	9550726.8	7519876.9	10444602.9	1021052.4	5533782.6	2427643.0	17833002.4	14817769.1	15558276.2	17171275.7	5070764.0
sulfur	----	1127011.8	603084.7	913518.5	457328.5	268956.6	188562.2	2793358.5	1634265.7	7452574.2	8286916.5	520327.1
molybdenum	2000.0	168.2	40.9	80.5	78.2	46.8	65.3	36.1	79.0	0.0	0.0	27.0
nickel	30000.0	2156.2	552.2	790.7	1521.1	625.8	728.9	187.7	256.8	107.2	105.5	198.5
aluminum	50000.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3382.4	0.0	0.0	106.5
arsenic	18000.0	128.8	227.0	217.0	151.4	129.0	142.3	185.1	330.9	122.1	282.2	42.9
barium	500000.0	44.8	278.9	208.8	286.4	244.8	516.7	0.0	324.4	0.0	0.0	384.0
cadmium	4000.0	503.7	180.1	147.6	411.3	229.7	255.6	290.5	248.8	317.1	202.8	57.4
chromium	<1000	0.0	0.0	0.0	19.6	0.0	0.0	0.0	0.0	13.9	0.0	29.5
cobalt	13000.0	298.0	92.6	122.0	131.7	70.3	99.6	310.3	337.6	22.5	24.7	26.1
lead	50000.0	19067.4	7327.5	19702.2	6699.7	12461.1	16316.3	17123.1	14538.2	14447.5	19002.9	1464.7
lithium	2000.0	532.6	383.4	761.1	152.7	280.2	383.6	1002.9	773.4	661.0	599.2	194.7
mercury	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
selenium	520.0	395.8	417.9	373.6	415.6	380.8	397.3	1439.0	1440.9	2584.9	2387.3	178.0
silver	2000.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	171.2	94.8	0.0
strontium	----	6721.2	3923.7	10344.7	2521.4	4215.0	8436.6	8978.3	6723.6	2165.5	8575.5	3544.4
tin	50000.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	82.1	0.0	0.0
vanadium	2000.0	1031.8	1010.4	851.7	394.2	1011.6	916.7	2009.0	2383.6	1004.6	1096.6	584.2

HABITAT		scrub	scrub	scrub	scrub	scrub	seasonal wetland	seasonal wetland	seasonal wetland	seasonal wetland	seasonal wetland
elements	**plant max**	**429**	**435**	**440**	**288**	**300**	**194**	**11**	**29**	**36**	**43**
phosphorus	----	8635.9	26223.2	14056.7	8464.9	11273.4	3852.9	22797.3	16612.4	24811.5	19153.2
potassium	----	44503.7	208305.1	840589.3	110093.7	236228.3	149147.3	665659.2	457080.0	420977.7	194389.9
iron	----	8387.8	17223.1	4981.3	43267.8	15422.2	46458.1	26737.5	12362.6	12668.8	23939.6
manganese	220000.0	2171.0	4886.9	1421.6	5996.3	5210.0	4693.3	14217.4	22075.4	9747.4	13672.3
zinc	50000.0	3608.9	15670.5	21638.4	1406.5	1351.9	582.6	22236.5	15701.9	12398.0	7490.5
copper	70000.0	781.4	3287.4	9500.0	3975.2	8077.1	3021.5	12904.5	10831.2	10535.8	10093.1
boron	500.0	15.2	137.2	624.2	105.4	219.5	451.4	9199.1	815.4	957.0	413.6
calcium	----	614961.8	509279.5	515441.6	388708.1	337272.7	335837.9	360659.9	565400.2	222019.9	204637.8
magnesium	----	92497.6	370251.0	1417212.4	47010.9	107272.8	48908.1	1233969.4	2269630.6	1004349.4	422568.3
sodium	----	25921.3	541850.9	1545492.5	9936.6	9506.5	50608.0	8450972.0	7832676.7	3098810.4	659976.9
sulfur	----	6557.8	58847.5	110139.1	13367.9	14236.6	493587.4	1515312.3	1410138.7	333942.6	282481.0
molybdenum	2000.0	29.3	76.7	54.2	0.0	0.0	35.8	359.1	176.5	180.8	202.3
nickel	30000.0	107.1	628.1	855.7	298.2	369.2	313.2	1539.2	1506.3	961.8	788.3
aluminum	50000.0	1876.5	0.0	0.0	1148.5	0.0	1064.6	0.0	0.0	0.0	0.0
arsenic	18000.0	0.0	217.3	159.9	140.7	91.1	167.0	292.3	204.8	276.2	376.1
barium	500000.0	1519.9	262.2	935.9	218.9	222.3	112.2	219.9	30.0	360.4	440.5
cadmium	4000.0	35.4	289.5	363.4	79.1	76.4	61.2	712.7	665.8	640.4	339.8
chromium	<1000	17.4	21.4	0.0	19.7	33.6	14.9	0.0	0.0	12.7	47.9
cobalt	13000.0	19.7	105.4	78.9	66.0	64.0	38.1	174.8	284.0	90.3	109.2
lead	50000.0	1550.9	17868.0	39519.1	1899.1	2415.8	953.0	14862.3	10494.7	14086.6	11315.3
lithium	2000.0	190.4	168.1	281.6	185.9	170.3	196.9	442.6	391.4	189.9	135.9
mercury	300.0	0.0	0.0	0.0	0.0	0.0	0.0	145.4	0.0	0.0	0.0
selenium	520.0	0.0	156.2	326.4	0.0	64.2	0.0	353.1	351.4	275.6	269.2
silver	2000.0	0.0	0.0	0.0	0.0	30.9	0.0	0.0	0.0	0.0	0.0
strontium	----	2369.8	1840.7	6614.9	2093.0	2067.3	2036.4	4711.3	8321.8	2427.5	1610.3
tin	50000.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
vanadium	2000.0	143.6	360.5	912.7	311.1	382.9	308.9	2440.6	2282.5	1858.4	1485.7

APPENDIX B.3

Values for all additional soil parameters on the terrestrial soil transects

Note: Constituents are recorded as ppm unless otherwise noted.

	brackish	brackish	brackish	brackish	brackish	dune	dune	dune	dune	dune
elements	**314**	**316**	**318**	**312**	**319**	**416**	**425**	**409**	**421**	**420**
pH value	8.23	8.01	7.76	7.26	7.05	6.44	6.39	6.76	6.37	7.39
ECe (milli-mho/cm)	2.84	20.40	6.91	0.51	8.30	2.20	1.12	0.31	2.41	1.64
calcium	30.35	646.15	229.74	85.32	231.61	92.61	69.57	16.76	104.13	66.9
magnesium	24.57	614.18	136.11	17.60	192.93	38.71	27.84	9.19	59.47	31.6
sodium	462.87	3388.01	899.77	20.97	918.71	241.56	78.47	22.94	246.66	161.9
potassium	10.78	73.33	19.18	9.84	105.95	12.82	51.27	2.29	34.60	8.7
chloride	467.92	5066.78	1573.26	11.64	2323.47	527.50	223.15	15.88	593.58	354
nitrate as N	11.48	54.32	14.04	14.23	39.27	4.45	3.02	2.19	9.31	50
phosphorus as P	2.95	2.56	0.77	4.59	1.94	1.55	3.99	1.41	1.95	0.4
sulfate as S	79.75	1364.77	408.43	12.92	72.75	32.28	16.49	12.51	34.95	23.8
boron as B	0.92	1.41	0.66	0.25	0.43	0.23	0.18	0.07	0.41	0.09
SAR	15.14	22.90	11.62	0.54	10.79	5.32	2.01	1.12	4.78	4.1
relative infiltration rate	slow	slow/fair	slow	fair/good	fair/good	fair	fair	slow	fair/good	fair
estimated soil texture	sandy loam	sandy loam	clay	sandy loam	sandy loam	sand	sand	sand	sandy loam	sand
lime (calcium carbonate)	low	low	yes	no	no	no	no	no	no	no
organic matter	low/fair	fair/low	fair/low	fair/good	fair/good	fair	fair	fair/low	fair/good	low/fair
moisture content of soil	0.08	0.08	0.43	0.01	0.12	0.01	0.01	0.01	0.03	7.0%
half saturation percentage	0.19	0.21	0.72	0.20	0.33	0.17	0.18	0.17	0.22	18.2%
hydrophobic	no	yes	no	yes	yes	yes	yes	no	yes	no

		freshwater	freshwater	freshwater	freshwater	freshwater		grassland	grassland	grassland	grassland	grassland	
elements		**324**	**326**	**328**	**330**	**322**		**194**	**207**	**253**	**268**	**249**	
pH value		7.53	7.22	6.86	7.48	5.36		7.42	7.53	7.56	7.66	8.27	
ECe (milli-mho/cm)		2.05	0.93	1.67	1.11	1.60		2.74	1.63	1.61	0.52	0.86	
calcium		44.70	29.25	63.58	30.29	70.28		500.59	265.08	94.97	62.73	63.8	
magnesium		25.90	14.37	24.10	16.35	29.83		41.47	33.12	29.08	13.37	27.7	
sodium		325.05	128.03	239.47	165.41	149.48		88.37	45.45	190.76	21.43	53.6	
potassium		32.69	6.47	102.53	13.70	74.79		46.45	40.98	12.77	4.76	8.6	
chloride		138.92	23.58	42.69	35.17	195.23		134.38	31.19	238.87	18.87	93	
nitrate as N		29.07	2.91	12.37	2.50	3.23		1.68	3.84	3.00	2.39	9	
phosphorus as P		0.91	0.18	10.30	0.95	7.72		0.27	0.64	1.10	0.93	3.2	
sulfate as S		182.53	81.58	207.56	100.12	97.35		504.79	265.15	80.95	21.03	29.5	
boron as B		1.56	0.63	0.38	0.38	0.23		0.54	0.24	0.30	0.09	0.06	
SAR		9.57	4.84	6.49	6.02	3.76		1.02	0.70	4.39	0.64	1.4	
relative infiltration rate		fair/good	slow	fair	slow/fair	fair/good		fair/good	fair	fair/slow	fair/slow	fair	
estimated soil texture		sandy loam	clay	loam	clay	sandy loam		sand	sand	loam	sandy loam	sandy loam	
lime (calcium carbonate)		no	no	no	no	no		yes	yes	yes	yes	slight	
organic matter		fair/low	low/fair	fair/good	fair/low	fair/good		fair/low	fair/low	fair/low	fair/low	fair	
moisture content of soil		0.07	0.63	0.11	0.50	0.08		0.01	0.01	0.03	0.02	1.0%	
half saturation percentage		0.20	0.60	0.33	0.62	0.30		0.23	0.20	0.23	0.17	15.2%	
hydrophobic		yes	no	yes	no	yes		no	no	no	no	yes	

		high marsh	high marsh	high marsh	high marsh	high marsh		low marsh	low marsh	low marsh	low marsh	low marsh	
elements		**51**	**60**	**69**	**77**	**82**		**370**	**383**	**369**	**378**	**380**	
pH value		7.29	7.36	6.88	7.48	7.50		7.19	7.41	7.90	7.55	7.46	
ECe (milli-mho/cm)		10.98	12.97	38.00	20.10	33.80		23.70	15.17	21.50	48.80	35.90	
calcium		327.0	202.9	1,193.5	247.5	395.3		340.78	161.38	342.5	554.5	332.3	
magnesium		340.8	244.0	1,197.1	323.0	744.4		392.06	200.27	298.8	1,227.2	900.6	
sodium		1,552.9	2,276.0	6,107.9	3,407.7	6,077.5		4193.92	2734.42	3,808.0	8,294.3	6,023.6	
potassium		32.8	63.2	166.6	169.7	283.9		203.33	146.11	179.3	374.1	282.4	
chloride		4,063	4,055	14,437	6,498	12,109		7523.07	4601.71	6,386	18,692	13,327	
nitrate as N		32	31	62	32	53		42.08	24.18	44	87	58	
phosphorus as P		0.3	0.0	2.4	1.1	0.0		0.83	1.16	4.1	1.0	1.5	
sulfate as S		240.5	218.3	972.2	351.8	681.0		360.69	241.69	398.5	737.3	573.0	
boron as B		0.14	0.45	1.29	2.09	1.94		1.71	1.11	1.32	1.38	2.06	
SAR		14.3	25.5	29.9	33.6	41.5		36.75	33.95	36.3	45.0	38.9	
relative infiltration rate		fair	fair	slow	slow	slow		very slow	very slow	very slow	very slow	very slow	
estimated soil texture		loam	loam	loam	loam	clay loam		clay	clay	clay	clay	clay	
lime (calcium carbonate)		yes	yes	yes	yes	slight		no	no	yes	yes	yes	
organic matter		low/fair	low/fair	low/fair	low/fair	low/fair		low	low/fair	low	low	low	
moisture content of soil		8.7%	9.6%	18.5%	24.7%	20.0%		0.59	0.45	35.8%	50.5%	38.4%	
half saturation percentage		37.6%	49.0%	45.7%	61.1%	40.8%		0.84	0.93	72.1%	65.6%	70.2%	
hydrophobic		no	no	no	no	yes		no	no	no	no	no	

	mid marsh	mid marsh	mid marsh	mid marsh	mid marsh	mid marsh	salt pan	salt pan	salt pan	salt pan	salt pan
elements	**116**	**83**	**107**	**118**	**129**	**123**	**133**	**138**	**140**	**145**	**156**
pH value	6.76	7.67	7.22	7.06	7.14	7.11	7.53	7.26	7.30	7.44	7.79
ECe (milli-mho/cm)	48.00	21.40	42.00	5.13	8.36	13.05	63.60	100.60	98.40	102.30	55.00
calcium	676.8	189.8	466.3	57.0	59.2	109.2	660.06	712.71	1038.47	958.92	596.1
magnesium	1,266.2	368.4	1,018.0	76.8	84.7	171.0	1383.77	2044.12	3466.78	3190.09	1,343.8
sodium	8,181.0	3,681.3	7,053.9	626.9	1,187.5	1,732.0	13668.56	17687.37	20208.77	20842.19	9,993.0
potassium	306.3	206.0	318.4	26.3	70.2	74.1	400.75	420.07	594.00	702.56	588.7
chloride	18,444	6,807	14,828	1,336	2,374	3,000	23737.87	32554.44	40627.05	40996.77	21,472
nitrate as N	86	32	59	6	17	284	167.62	238.07	313.74	287.68	111
phosphorus as P	0.0	4.3	0.0	0.6	2.3	0.7	1.21	1.88	1.22	2.01	1.6
sulfate as S	939.5	398.5	824.4	70.1	134.7	172.2	1285.38	1755.48	2914.59	2501.46	1,399.4
boron as B	1.47	1.61	1.88	0.27	0.88	1.34	6.76	2.96	3.32	3.82	1.60
SAR	42.8	35.9	41.9	12.7	23.2	24.1	69.38	76.21	67.70	72.76	51.9
relative infiltration rate	fair/good	slow/fair	fair	slow	fair/slow	slow	slow/fair	slow/fair	slow/fair	slow	fair
estimated soil texture	loam	clay loam	loam	clay	clay	clay	clay	clay	clay	clay	sandy loam
lime (calcium carbonate)	no	slight	yes	yes	no	no	yes	yes	yes	low	yes
organic matter	low/fair	low/fair	low/fair	low/fair	low/fair	low/fair	low/fair	low/fair	low/fair	low/fair	low/fair
moisture content of soil	13.8%	27.5%	30.8%	10.5%	16.9%	29.3%	0.23	0.21	0.26	0.20	4.0%
half saturation percentage	50.9%	61.5%	55.8%	47.3%	65.2%	57.9%	0.46	0.26	0.34	0.39	16.8%
hydrophobic	yes	no	no	no	no	no	no	no	no	no	no

		scrub	scrub	scrub	scrub	scrub		seasonal wetland	seasonal wetland	seasonal wetland	seasonal wetland	seasonal wetland	
elements		**288**	**300**	**429**	**435**	**440**		**171**	**11**	**29**	**36**	**43**	
pH value		7.73	7.61	7.33	7.89	7.71		7.52	7.23	6.90	7.57	7.48	
ECe (milli-mho/cm)		0.41	0.69	0.88	6.12	9.25		24.80	31.50	45.10	5.02	12.88	
calcium		55.17	75.65	73.0	255.0	137.8		708.40	969.5	1,417.5	255.0	377.2	
magnesium		7.51	13.78	25.6	145.6	230.5		570.99	626.2	1,723.2	111.4	241.8	
sodium		13.79	19.89	48.4	615.1	1,028.4		3872.66	5,407.1	6,356.0	616.8	2,159.9	
potassium		18.00	31.75	8.5	38.6	81.9		174.77	58.6	46.1	11.3	48.7	
chloride		11.17	6.55	99	1,454	2,307		6997.85	10,043	17,652	1,063	3,722	
nitrate as N		0.71	33.15	61	95	71		38.06	77	78	14	30	
phosphorus as P		0.88	0.94	1.2	1.4	0.8		1.92	1.3	0.9	1.1	0.0	
sulfate as S		12.89	19.34	15.9	84.0	122.1		1278.90	923.5	742.2	363.5	423.8	
boron as B		0.16	0.17	0.11	0.01	0.65		1.83	6.59	0.60	0.31	0.85	
SAR		0.46	0.55	1.2	7.6	12.4		26.25	33.3	26.8	8.1	21.3	
relative infiltration rate		fair/good	fair	fair/good	fair/good	fair		fair/slow	slow/fair	slow/fair	fair/slow	slow/fair	
estimated soil texture		sand	sand	sand	loam	clay		loam	clay loam	clay loam	clay loam	loam	
lime (calcium carbonate)		yes	yes	no	no	no		yes	slight	slight	high	high	
organic matter		fair/low	fair/low	fair	fair	low/fair		low/fair	low/fair	low/fair	low/fair	low/fair	
moisture content of soil		0.01	0.04	4.0%	18.2%	34.7%		0.07	15.3%	14.7%	7.5%	3.5%	
half saturation percentage		0.22	0.21	18.4%	37.2%	49.1%		0.26	51.0%	44.3%	44.2%	27.5%	
hydrophobic		yes	no	yes	no	no		no	yes	yes	no	no	

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Photo credit: E. Tuttle

CHAPTER 4:
VEGETATION

Ballona Wetlands Ecological Reserve, Los Angeles, California
Santa Monica Bay Restoration Commission

Prepared for: California State Coastal Conservancy
November 2011

Author: Karina Johnston

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INTRODUCTION

Long-term monitoring of vegetation is one of the most common methods of evaluating the health and functioning of a wetland system (Zedler 2001). Change in the relative presences of native and non-native plant species may affect the distributions of associated wildlife species. For example, the endangered Belding's savannah sparrow frequently utilizes *Salicornia virginica* (pickleweed) as nesting habitat or other salt marsh related species, including *Distichlis spicata* (saltgrass) and *Salicornia subterminalis* (Parish's pickleweed) (Powell 1993, Zembal and Hoffman 2002, James and Stadtlander 1991; E. Read, pers. comm.). Non-native plant species are present throughout the Ballona Wetlands Ecological Reserve (BWER) (PWA 2006); these non-native species are indicators of past disturbances to the wetland and have potentially reduced the value of the site as habitat for native plants and native wildlife (PWA 2006).

Due to the diverse array of vegetation habitats and communities within the BWER, the Baseline Assessment Program (BAP) vegetation surveys are divided into three distinct types: cover surveys, seed bank surveys, and submerged aquatic vegetation (SAV) and algae surveys. The goals of each survey are listed below. Future analyses will assess data collected as components of a site-wide evaluation of the health and functioning of the BWER.

Cover surveys:
1) Determine areas with high non-native species presence;
2) Summarize the prevalence of native and non-native plant cover in each habitat;
3) Define relative species richness (as number of species) by habitat type;
4) Use percent cover to define dominant species in each habitat.

Seed bank surveys:
1) Summarize the occurrence of native and non-native germinated plant seedlings;
2) Define relative species richness of germinated plant seedlings by habitat type;
3) Determine the potential for future recruitment of plant species within habitat types;
4) Evaluate species propagation at a transect level under ideal conditions.

Algae and submerged aquatic vegetation (SAV) surveys:
1) Continue the long-term monitoring program developed by the Southern California Bight Monitoring Program to assess the algal and SAV cover at the BWER;
2) Compare results to other southern California estuaries.

Taxonomic nomenclature is constantly changing and sometimes in dispute for many plant species. For consistency and accuracy, species are identified using the Jepson Online Interchange California Floristics (Jepson Flora Project; accessed: February 2011), which includes the latest information on the identification and taxonomy of vascular plants. Please note that some of these names may now be out of date (e.g. *Salicornia virginica*).

To avoid confusion, plant species are reported within this section first by their scientific and common names and henceforth by their abbreviated scientific name only. Invasive, exotic, and non-native plant species are henceforth referred to as "non-native" throughout this report.

Existing Conditions Report Summary (Prior to 2005)

The Existing Conditions Report compiled habitat descriptions and a plant species list based on previous reports that focused on the current and former habitats of the BWER (PWA 2006; Appendix C.1). Reports included, but were not limited to: Clark (1979), Gustafson (1981), Zedler (1982), Henrickson (1991), Altschul and Homburg (1992), Read (1995), MEC Analytical Systems (2001), Read (2002), Drennan (2004), and W. Ferren (2007, pers. comm.). In these reports, each habitat was briefly described and several characteristic species of each habitat were listed. Several of these reports contained full floristic evaluations of the BWER (e.g. Henrickson 1991) and found reduced species diversity compared with other southern California wetlands. Several reports (e.g. Read 1995) focused on surveys for sensitive plant species throughout the BWER and did not contain either full floristic evaluations or species percent cover estimates.

Before and since these reports were completed, the habitats of the BWER and the corresponding vegetation alliances (i.e. discrete, identifiable plant communities that are repeated) have undergone extensive anthropogenic modifications and changes. Summaries by PWA (2006) highlight the extensive habitat modifications which have occurred within the BWER, including restricted tidal flushing, changes in freshwater inundation levels, and agricultural impacts (Gustafson 1981, Henrickson 1991, MEC Analytical Systems 2001). For example, Gustafson 1981 describes the flora of the BWER as containing dominant species such as *Carpobrotus edulis* (iceplant), other introduced species, and agricultural impacts and plants throughout much of the eastern portion of Area B. The agricultural land contained species such as *Triticum vulgare* (wheat), *Phaseolus limensis* (lima bean), and *Citrullus lanatus* (watermelon). More recent surveys indicate the cover of agricultural plants that used to dominate portions of Area B has been reduced in recent years (CDFG 2007).

Gustafson (1981) conducted one of the earliest full taxonomic floristic surveys of Areas A and B of the BWER, with the identified plants deposited in the Los Angeles County Natural History Museum. No mapping or transects were completed at this time, but some rough cover estimates were made. Gustafson found a total of 235 plant species, 130 of which were introduced or naturalized, and 105 of which were indigenous to California. Weedy introduced components covered approximately 40% of the area under investigation (Areas A and B). Approximately 15% of the 40% non-native vegetation cover was attributed to *Carpobrotus* spp.

Henrickson (1991) mapped the major vegetation alliances and found the BWER diverse in habitat types and species composition, but subject to invasion of non-native species and human impacts. Henrickson did not quantify the vegetation, but found that Area A was dominated by upland and non-native species (especially *Carpobrotus* spp.), though salt flats and pickleweed were also present. He found Area B contained plant alliances with more natives than non-natives. Area C was dominated by upland plant species and non-natives, but included some small salt flats and pickleweed strands.

Non-native vegetation occurred in most of the BWER habitats, but was especially prevalent in the upland habitat types (PWA 2006, CDFG 2007, Cal-IPC 2010). Problematic perennial species identified in the Existing Conditions Report included *Arundo donax* (giant reed), *Atriplex semibaccata* (Australian saltbush), *Carpobrotus* spp. (ice plant), *Cortaderia* spp. (pampas grass), *Euphorbia terracina* (carnation spurge), *Foeniculum vulgare* (fennel), at least three species of *Acacia* spp. (wattle/acacias), *Malephora crocea* (ice plant), *Myoporum laetum* (myoporum), *Ricinus communis* (castor bean), and *Schinus terebinthifolius* (Brazilian pepper tree). The BWER also has extensive populations of annual non-native species, including: *Bassia hyssopifolia* (five hook bassia), *Brassica* spp. (mustards), *Bromus* spp. (brome grasses), *Centaurea melitensis* (tocalote), *Chrysanthemum coronarium* (garland chrysanthemum), *Lolium* spp. (ryegrass), *Salsola tragus* (Russian thistle), and *Melilotus* spp. (sweet clovers) (Clark 1979, Gustafson 1981, Zedler 1982, Henrickson 1991, PWA 2006, A. McCarthy pers. comm. 2011).

Interim Research (2005-2010)

In 2004, the City of Los Angeles (LA City) conducted a post-construction, biological survey of vegetation for the United States Army Corps of Engineers (USACE) after the installation of two self-regulating tide gates (SRTs) and a one-way flap gate between Ballona Creek and the BWER (LA City 2005). Ten 30 m, permanent vegetation transects were established in the salt marsh in the western portion of Area B. Transects were located adjacent and parallel to the tidal channels at 3, 5, 9, 18, and 30 m distances (two at each distance). The LA City survey team used a 0.25 m^2 (0.5 x 0.5 m) quadrat sampling method spaced every five meters, for a total of six quadrats per transect.

LA City (2005) found nine plant species during their fall 2004 surveys, with most of the transects dominated by *Salicornia virginica* (pickleweed) or *Jaumea carnosa* (fleshy jaumea) (Table 4.1). In addition, the majority of the non-native plant cover was comprised of *A. semibaccata* and *Polypogon monspeliensis* (rabbitfoot grass), with *Bromus madritensis* spp. *rubens* (foxtail chess) occurring in one quadrat.

Table 4.1. Species composition and percent cover for LA City's 2004 surveys (reproduced from LA City 2005). Note: asterisks represent non-native plant species.

	% Cover at Distance from Channel				
Species	**3m**	**5m**	**9m**	**18m**	**30m**
*Atriplex semibaccata**	--	4.2	--	--	--
Atriplex triangularis	--	6.6	4.2	2.5	9.6
*Bromus madritensis spp. rubens**	--	--	--	--	0.4
Cressa truxillensis	5.0	3.8	22.5	3.0	15.8
Distichlis spicata	5.3	--	--	--	--
Jaumea carnosa	55.0	23.8	0.1	0.1	6.3
*Polypogon monspeliensis**	--	--	--	--	17.5
Salicornia subterminalis	--	--	--	--	0.1
Salicornia virginica	19.1	25.8	54.3	58.5	23.9
Total % cover	84.3	64.2	81.1	64.1	73.6
Non-native % cover	--	4.2	--	--	17.9
Percent litter	7.0	23.7	17.7	33.7	24.3
Percent bare ground	10.3	14.8	1.3	2.3	6.3
Percent algal mat	2.8	2.4	--	--	--
Percent trash/refuse	2.6	0.3	--	--	--
Mean canopy height (cm)	44.6	50.6	60.0	58.2	40.7
Maximum canopy height (cm)	66.0	59.0	93.0	77.0	64.0
Salinity (ppt)	9.7	9.7	12.7	12.5	7.8
pH	7.4	7.6	7.7	7.8	7.8

In 2007, the California Department of Fish and Game (CDFG) conducted a site-wide assessment of the major vegetation alliances and habitats to correlate with state-wide data. Plant community type (i.e. alliance-level) surveys were conducted by Todd Keeler-Wolf (CDFG), following the "Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities" (CDFG 2009). These data are presented in Figure 4.1, Figure 4.2 and Appendix C.2. Full floristic surveys were not conducted (CDFG 2007).

The BWER was divided into 16 habitat groups (Table 4.2). The generalized habitat categories were based on characteristics such as structural feature, ecosystem function, and landscape process as well as dominant or characteristic plant species (CDFG 2007), characteristic animal species, and presumed extirpated or rare or endangered species (Ferren et al. 2007). Habitat category descriptions are summarized in Table 4.2.

Also in 2007, a separate set of non-native plant mapping surveys were conducted for four species by J. Casanova of the Los Angeles and San Gabriel Rivers Watershed Council, with assistance from the

California State Coastal Conservancy (Figures 4.3 and 4.4). The four species were *Cortaderia selloana* (pampas grass), *E. terracina*, *Phoenix canariensis* (Canary Island palm), and *Washingtonia robusta* (Washington fan palm). Figure 4.3 identifies the extent of *C. selloana* and *E. terracina* at the BWER; Figure 4.4 identifies the location of each *P. canariensis* and *W. robusta* plant. Figures 4.3 and 4.4 may not represent the current distribution of these species. For example, some of the *C. selloana* have been removed from Area C by the Ballona Wetlands Land Trust and volunteers. *E. terracina,* an introduced species (Riordan et al. 2008), may have spread beyond the distribution in Figure 4.3.

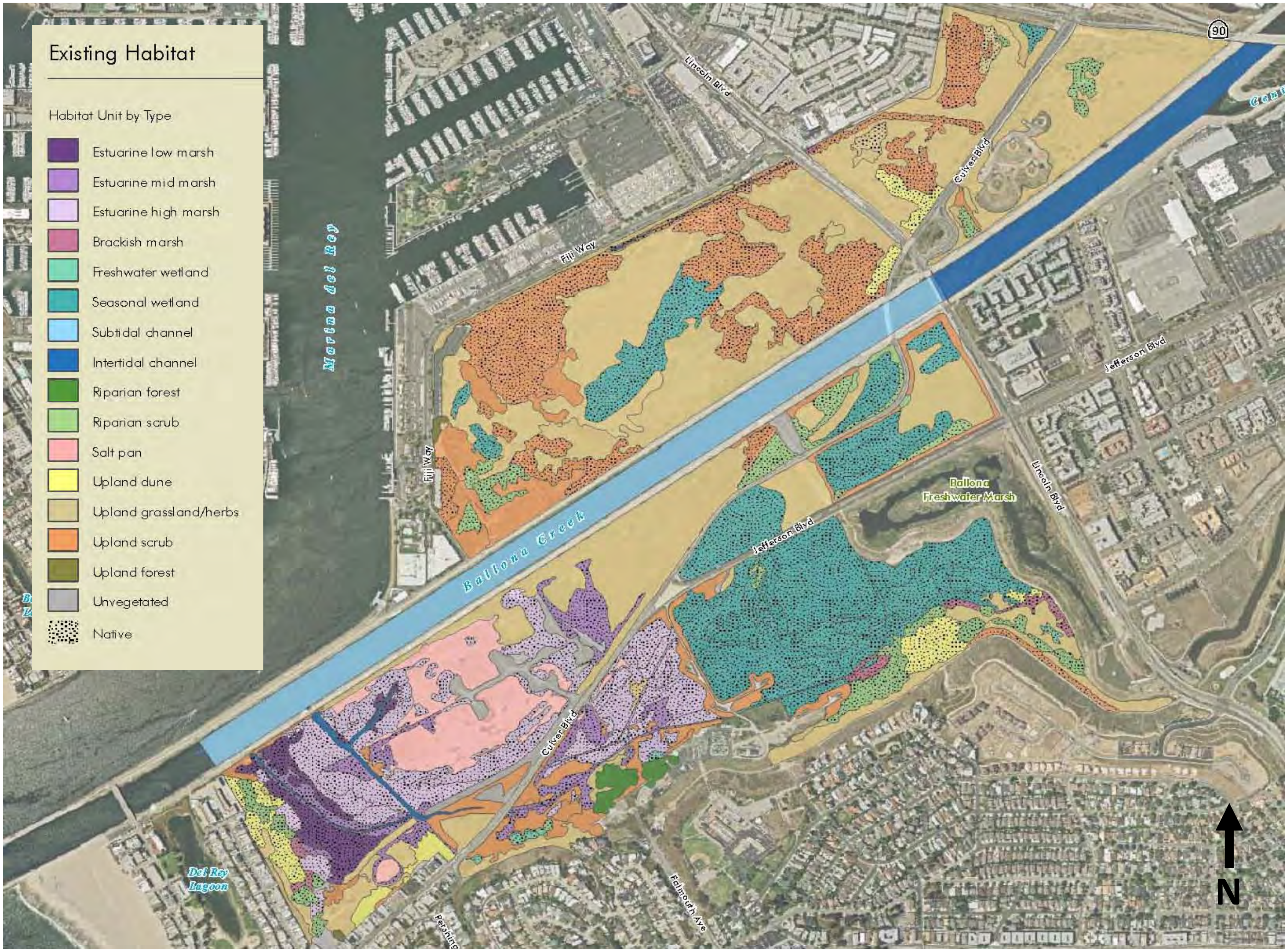

Figure 4.1. Habitat map with dominant nativity from 2006 (reproduced from CDFG 2007).

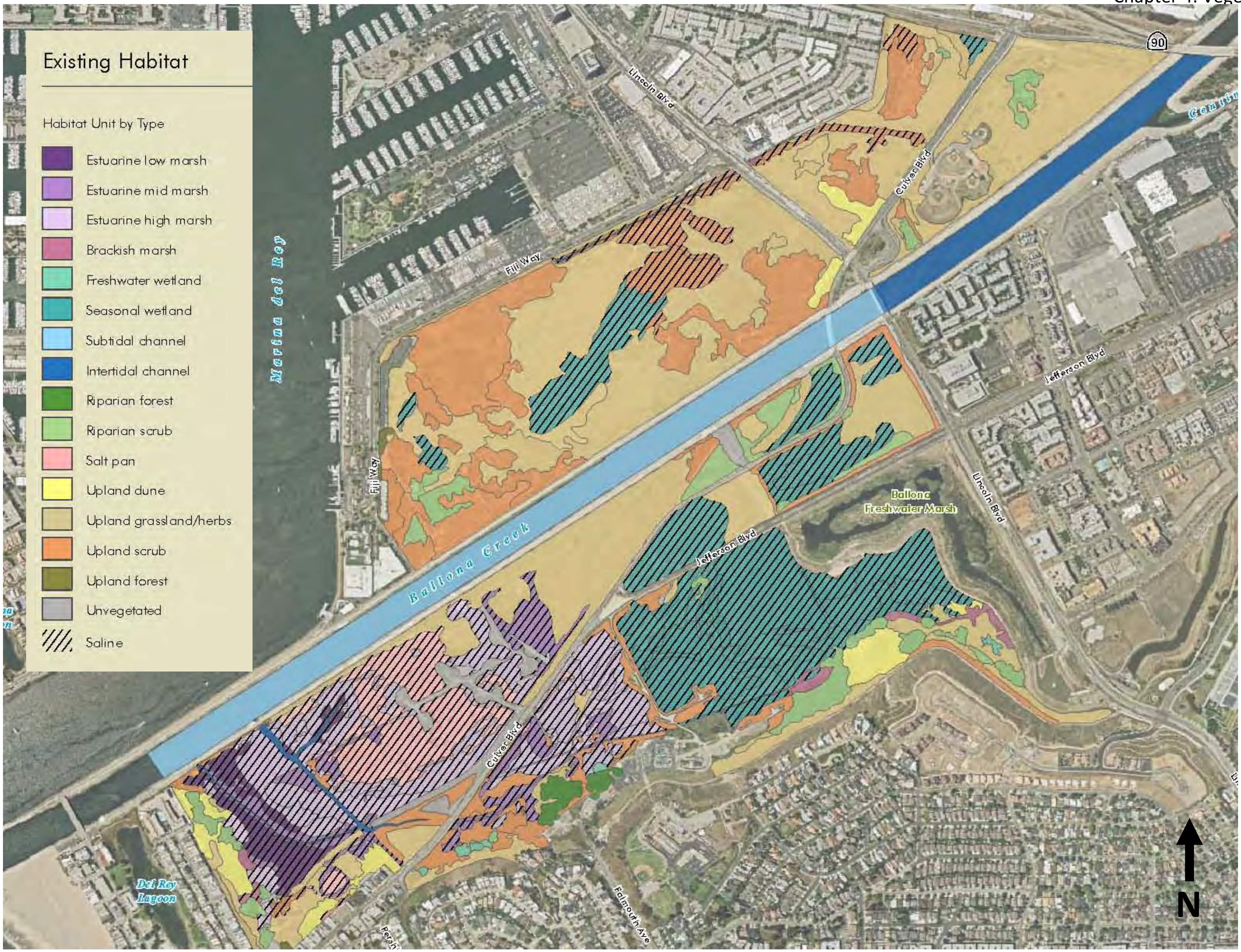

Figure 4.2. Habitat map with salinity from 2006 (reproduced from CDFG 2007).

Table 4.2. Habitat category descriptions (summarized from Ferren et al. 2007).

HABITAT CATEGORY	DESCRIPTION
Low salt marsh	Low salt marsh is regularly and daily inundated by tides and occurs primarily along channel edges and adjacent to mudflats. At higher elevations, the habitat intergrades with mid-marsh species.
Mid salt marsh	Intermediate elevations within the salt marsh are inundated irregularly by tides but at a greater frequency than higher elevations. Plant species that inhabit this elevation are adapted to occasional prolonged inundation.
High salt marsh	High marsh habitats are irregularly to intermittently inundated by tidal water and generally range from saline to hypersaline conditions. Vegetation varies depending on the drainage and density of the soil and salinity.
Seasonal wetlands	Seasonal wetlands (including haline vernal wetlands) are non-tidal wetland and transitional habitats that are flooded to varying degrees by seasonal rainfall and runoff.
Salt pan	Shallow depressions of upper marsh plains with an evaporate zone that is irregularly flooded by tides and that has a salinity of 200 g/L or more in the dry season.
Brackish marsh	Sites where freshwater mixing with saline seawater produces brackish conditions with intermediate salinities. Sites are seasonally variable with dilution during the wet season and concentration of salts during the dry season.
Freshwater wetlands	Freshwater emergent wetlands (including seeps and springs) often occur in saturated, organic rich soils. Habitats are frequently flooded and dependent on a continual source of freshwater.
Upland dune	Dune habitats represent a transition zone between the land and the sea. Vegetation may stabilize loose sand.
Upland grasslands	Habitats are dominated by grasses, herbaceous vegetation, and sub-shrubs.
Upland scrub	Coastal sage scrub can be described as low, soft to woody shrubs and sub-shrubs that occur in a variety of situations, including types that are influenced by salt spray. Low vegetated areas may also support herbaceous species.
Riparian scrub	Willow scrub is characterized by dense broad-leafed, winter deciduous riparian thickets dominated by several willow shrub and tree species.
Upland forest	Forest habitats include woodlands characteristic along slopes, bluffs, and banks adjacent to estuaries. They may also include a number of groves and stands of planted or naturalized non-native trees.
Riparian forest	Riparian forest habitats include isolated stands of trees or tall shrubs that occur at seeps, toe-of-slopes, ponded areas, along streams and rivers, and at other sites with shallow water tables.
Unvegetated	Unvegetated habitats are those of anthropogenic origin (e.g. roads, cement levees, supporting berms, etc).
Open water and subtidal channels	Subtidal habitats include channels, bays, basins, and other features, which at extreme low water do not drain with the outgoing tides. Habitats are either permanently flooded or permanent open water bodies.
Intertidal channels	Intertidal habitats including channels, creeks, basins, banks, benches, and marsh plain that are semi-permanently flooded or exposed. Habitats are subjected to a wide variety of environmental conditions including fluctuations in salinity and depth of tidal inundation.

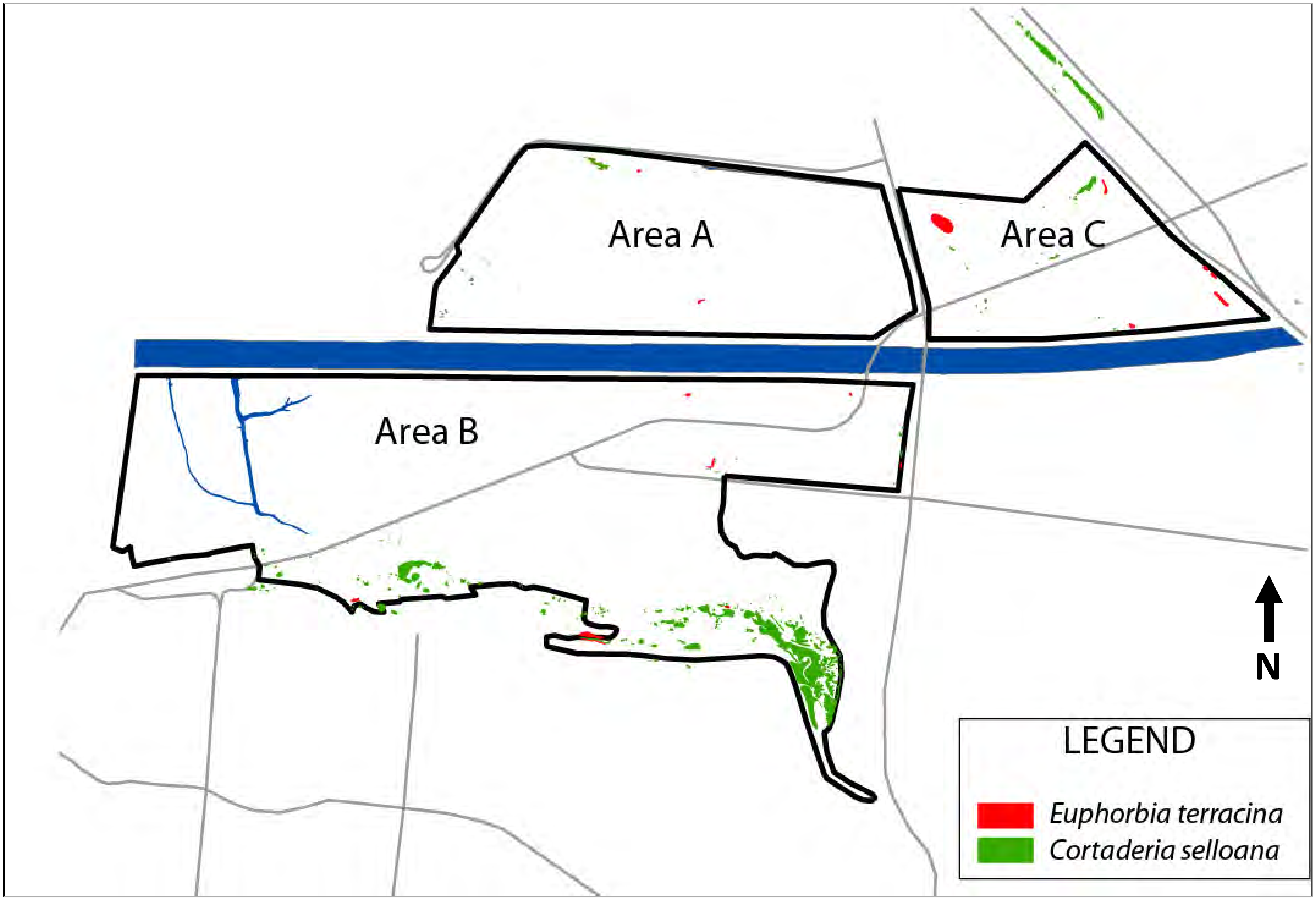

Figure 4.3. Distribution of non-native *C. selloana* and *E. terracina* (modified from J. Casanova 2007).

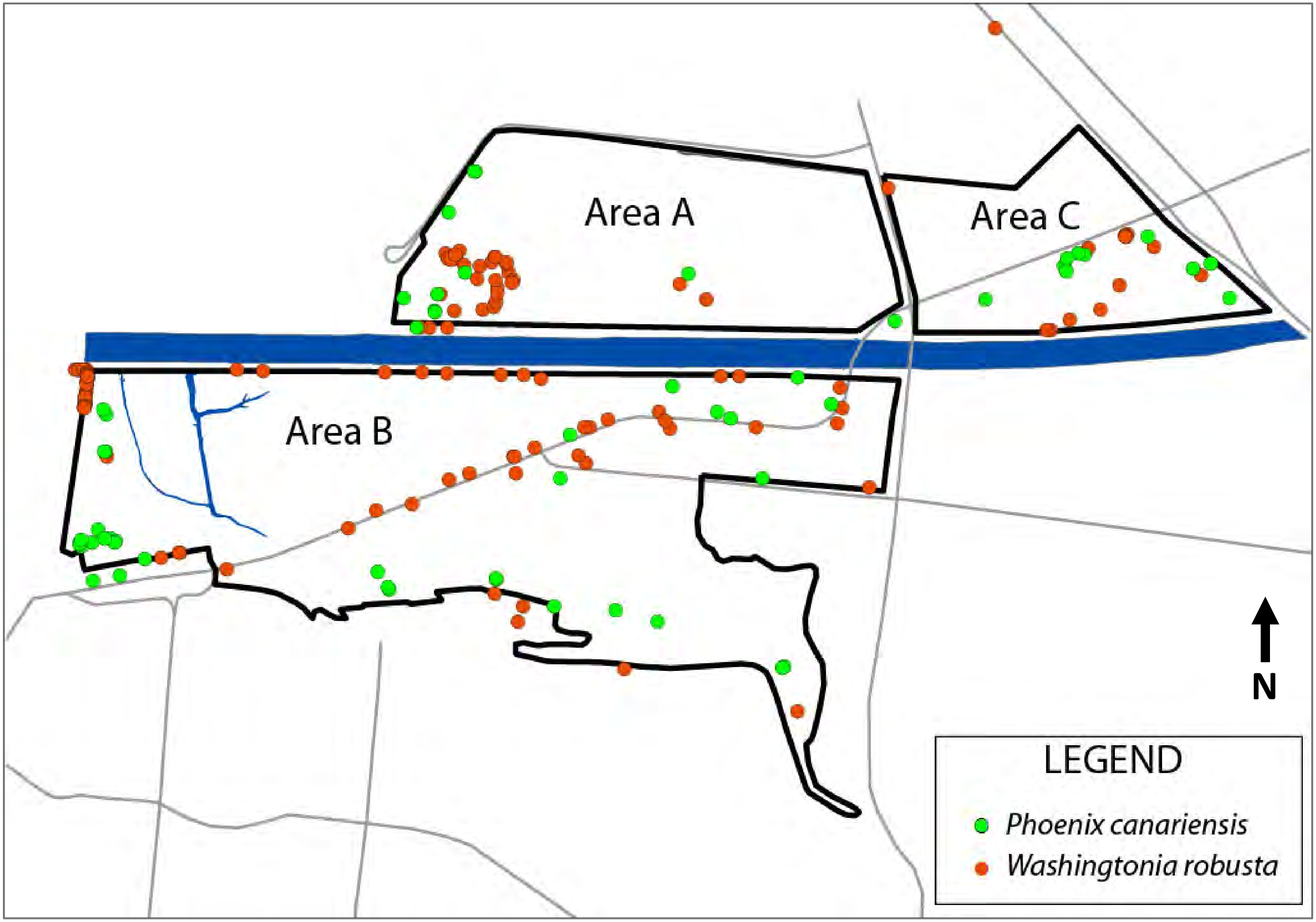

Figure 4.4. Distribution of non-native *P. canariensis* and *W. robusta* (modified from J. Casanova 2007).

Special Status Species

In addition to non-native and native plant species, several special status plant species have the potential to occur in the BWER (Appendix C.3). Surveys for special status plant species throughout the BWER were conducted in July and October of 2010 by WRA, during the period of flowering for each species. This method of data collection documented rare species that may not have been evident in the BAP transect-level vegetation surveys. WRA will complete the 2010-2011 site surveys and a separate special status species report will be produced.

METHODS

Method Comparison and Rationale

Many different approaches have been used to estimate plant species cover, especially for terrestrial vegetation (see review in Murray et al. 2006). The diverse array of habitats within the BWER present different obstacles to assessing vegetation cover and diversity including impenetrable stands of coastal scrub, tall riparian tree canopies, and considerable anthropogenic disturbances. A variety of techniques were employed by the BAP to ensure accurate measurement of habitat characteristics. For a detailed comparison of methods used by the BAP, refer to Appendix C.4.

Visual estimates of percent cover can be rapid, but are subject to bias, depending on the rarity of the species in question (Hatton et al. 1986, Zedler 2001). These biases may be decreased with training and quality control methods (Dethier et al. 1993, Parikh and Gale 1998). Many methods of determining percent cover, including those used by the BAP, involve transects located within each habitat type and a visual estimate of cover within quadrats (Vasey et al. 2002, Shuman and Ambrose 2003, Ambrose et al. 2006, S. Anderson, pers. comm). Site-specific sampling protocols for the BAP were developed in collaboration with Dr. Sean Anderson (California State University, Channel Islands), based on a quadrat method similar to Zedler (2001), but with the addition of laser sight technology to demarcate exact points and reduce observer bias. Protocols were further adapted as necessary based on accessibility, habitat type, and time requirements at each sampling site. For example, at each upland scrub transect, vegetation data were collected using both the line-intercept method and a cover-class quadrat method due to the high level of habitat heterogeneity.

Survey seasons were chosen based on times of peak biomass for each habitat type (e.g. late summer for salt marsh, spring for upland grassland) (Zedler 2001). Access to the salt marsh habitats was prohibited during the Belding's Savannah Sparrow nesting season (i.e. mid-March through the end of June; D. Cooper, pers. comm.) therefore no salt marsh habitats were surveyed at that time.

In addition to vegetation cover estimates, both marsh seed bank data and algae/SAV cover data were collected. Seed bank information may be a better predictor of successful wetland functioning than the presence of adult plants (i.e. plant canopy) alone because the presence of a viable and diverse seed bank indicates recent well-functioning ecological and hydrological dynamics of the site. Soil seed banks also forecast subsequent adult plant species richness under optimal conditions (S. Anderson, pers. comm.) However, it should be noted that this method excludes species that do not rely on seeds to spread. Algae surveys provide important information about primary productivity within a system and given trophic structure. Algae abundance and growth can be useful indicators of eutrophication and tidal flushing (Zedler 2001).

Site Locations and Times

Plant surveys were conducted once during the first Baseline year (2009-2010) during the appropriate season for each habitat type (Table 4.3; Zedler 2001). The general sampling design began by identifying distinct marsh zones or habitat types (low salt marsh, mid salt marsh, upper salt marsh, etc.) within the BWER and randomly allocating transects within each zone (Figure 4.5). Habitat zones were based on preliminary plant community mapping of the BWER (DFG 2007). Transect locations were determined in advance by GreenInfo Network by randomly allocating permanent transect locations within each habitat polygon using Geographic Information System (GIS) data points. A minimum of five transects per habitat were allocated. The number of transects in each habitat was increased if the habitat was greater than 5 acres.

Field Methods

Sampling methods within the BWER were habitat-dependent because of the high variability and diversity between habitats (Table 4.3). The methods used to determine cover for each habitat type were selected based on several determining factors, including: average plant height, cover, and form of the dominant plant species in each habitat (CDFG 2007). Additionally, all plant species within a 10 m radius of each transect were recorded.

For consistency and to reduce trampling along the transects, all quadrats were positioned on the left side of a given transect, (as seen looking from the 0 m marker), with the lower right corner of the quadrat placed directly on the transect at the meter mark corresponding to the random number selected (Ambrose and Diaz 2008).

Table 4.3. BAP vegetation sampling details for habitat types within the BWER.

Habitat	Area	Acres	Transects	Quadrats	Methodology	Survey time
Low marsh	B	8.5	10	70	0.25m²-quadrat sampling along transects & 10m-wide area searches	late summer
Mid-marsh	B	16.4	16	112	0.25m²-quadrat sampling along transects & 10m-wide area searches	late summer
High marsh	B	42.9	15	105	0.25m²-quadrat sampling along transects & 10m-wide area searches	late summer
Seasonal wetland	A, B	74.5	25	175	0.25m²-quadrat sampling along transects & 10m-wide area searches	late summer
Salt pan	B	22.4	4	28	0.25m²-quadrat sampling along transects & 10m-wide area searches	late summer
Freshwater marsh	B	26	5	35	1m-quadrat sampling along transects & 10m-wide area searches	spring
Brackish marsh	B	3.1	5	35	1m-quadrat sampling along transects & 10m-wide area searches	spring
Dune	A, B, C	13	10	70	1m-quadrat sampling along transects & 10m-wide area searches	spring
Upland grassland	A, B, C	176.4	29	203	1m-quadrat sampling along transects & 10m-wide area searches	spring
Upland scrub	A, B, C	92.2	25	175	1m-quadrat sampling along transects & 10m-wide area searches	spring
Unvegetated	B	10.9	----	----	None	----

Figure 4.5. Ma p displaying all transects surveyed across all habitat types.

METHODS – MUTED TIDAL SALT MARSH HABITATS

Field Methods

For all muted tidal salt marsh and additional habitats, where the average vegetation height was less than 1.5 m and was dominated by salt marsh plant species (e.g. *Salicornia* spp.), the laser quadrat method was utilized to demarcate exact points. The method was developed in collaboration with Dr. Sean Anderson (California State University, Channel Islands) and is being utilized at wetlands throughout southern California (S. Anderson, pers. comm.).

The muted tidal salt marsh habitat types surveyed using this method included: low salt marsh, mid salt marsh, high salt marsh, seasonal wetland, and salt pan. Each habitat type contained a minimum of five, 25 m permanent transects with seven randomly allocated quadrats per transect (Table 4.3). The laser quadrat was chosen to reduced observer bias and determine average percent cover. Vegetation data were collected within each of the quadrats and within a 10 m radius of the transect.

Transects were 25 m in length and a minimum of 10 m apart. Transects were not placed within 1 m of the edge of a zone boundary or tidal creek (Ambrose and Diaz 2008). The beginning and end points of each transect were field labeled with thin, UV-resistant PVC piping and a waterproof tag (Figure 4.6), mapped, and permanently identified using GPS.

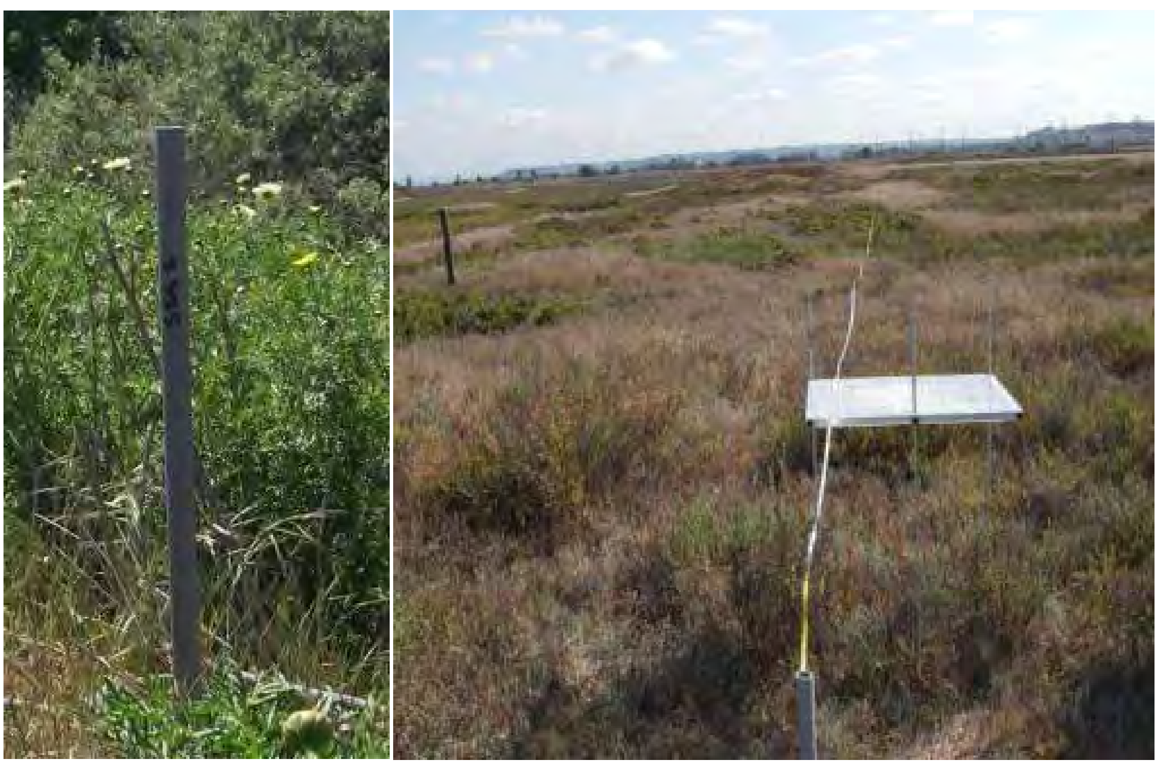

Figure 4.6. Photo of a permanently marked transect (left) and an example transect survey (right) [photos: Santa Monica Bay Restoration Commission (SMBRC) 2009].

Laser Quadrat Survey Method

The laser quadrat method was used to reduced observer bias and determine average percent cover. A portable 0.5 m x 0.5 m (0.25 m^2) Plexiglas™ board, supported by three independently adjustable legs, was positioned parallel to the substrate and leveled at each quadrat starting position along the transect (Shuman and Ambrose 2003, Ambrose et al. 2006, S. Anderson, pers. comm.). Each of the 7 quadrat survey locations was randomly allocated along the meter tape by a random number generator (to a tenth of a meter).

The board design is a modified pin-drop cover board with downward shining laser light taking the place of the rod or pin that would make contact and define any single contact point. A laser pointer was inserted successively into each of the 49 evenly distributed points in a 7 x 7 grid so that the laser beam pointed in a direction perpendicular to the substratum (Figure 4.7). This method is much faster than traditional pin-drop methods, does not disturb the architecture of the canopy (particularly important to surveying vegetation with vertical gramminoid-morphology or with interwoven stems and leaves), and is observer-independent. Plants at the point of laser contact were identified to species according to the Jepson Manual: Higher Plants of California (Hickman 1993) with nomenclature adjusted as needed via the online Jepson Interchange (accessed: February 2011). Species were further recorded as either native or non-native according to the Jepson Manual, and as living or dead. If the laser did not contact plant tissue, the ground type was recorded as bare soil, trash, wrack, or wood. Trash was defined as man-made debris, and wrack was defined as dead organic material. Algae on top of plants was noted, removed to reveal the plant tissue below, and was not included in percent cover estimates (Ambrose and Diaz 2008); *Cuscuta salina* (salt marsh dodder) was recorded in a similar fashion. Percent cover estimates for *C. salina* were calculated separately. Excluding the overlying algal and *C. salina* methodology, cover summed to 100%, and underlying layers were not recorded.

Within each quadrat, three of the 49 points were randomly sampled for canopy height. At each point, the plant height and species identity were recorded. Additionally, the plant height and species identity were recorded for the tallest plant within the 0.5 x 0.5 m quadrat area (to nearest cm) as a measure of maximum canopy height. In this manner, both the average canopy height and maximum canopy height were characterized for each transect.

Laser Quadrat Survey Analysis

Percent cover was analyzed as the proportion of points (out of a total of 49) hitting a particular plant species. Dominant plant species (>10%) and average percent cover of native and non-native species were reported for each habitat type. Plant cover was averaged by transect and then again by habitat type; therefore, habitat type averages are grand means. Variability is represented as standard error.

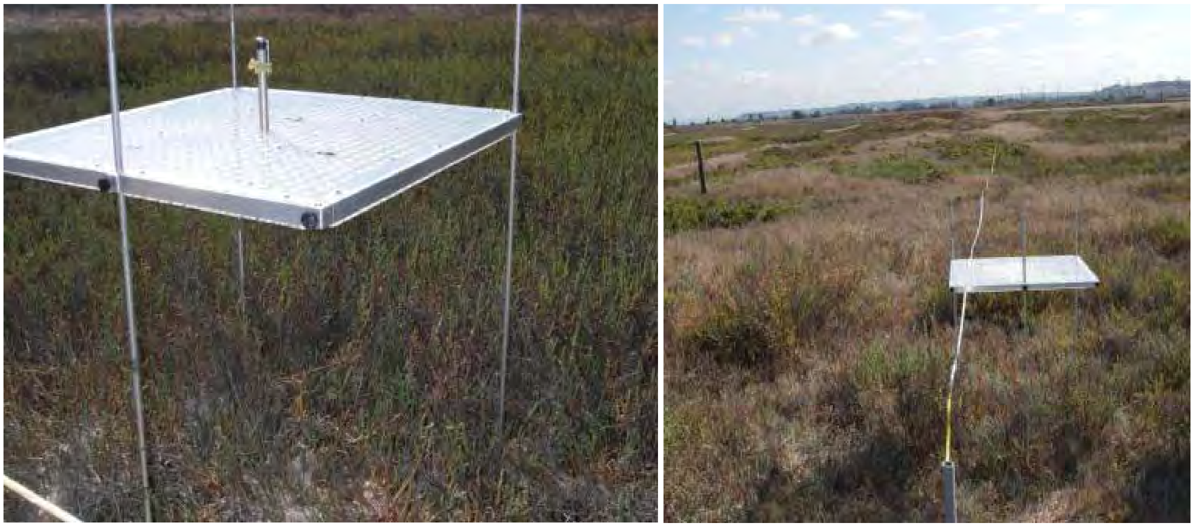

Figure 4.7. Laser quadrat setup along a transect in the salt marsh habitat type (photos: SMBRC 2009).

METHODS – NON-SALT MARSH HABITAT TYPES

Field Methods

Transects within the non-salt marsh habitats were randomly allocated in the same manner as those in the salt marsh habitats. Non-salt marsh habitats included brackish and freshwater marshes, dune habitat, and upland scrub and grasslands (Figure 4.5). Riparian scrub and forest habitats were not surveyed using transects due to inaccessibility.

The GPS coordinates were logged and permanent markers were placed at each end of the 25 m transects for repeat surveys and collection of associated data (invertebrates, soil, etc.). Due to higher variability in the terrain, conditions, and characteristics of the non-salt marsh habitats, adjustments were made to survey methods employed along the transects. Seven quadrats were surveyed on each 25 m transect, similar to the laser quadrat method; however, the quadrat size was increased from 0.25 m^2 to 1 m^2.

A cover-class quadrat sampling method was used for all non-salt marsh transects, and line-intercept surveys were added to the upland scrub surveys. The cover-class quadrat allowed surveys of taller vegetation and a rapid assessment of the plant community including: groundcover, shrub cover, canopy cover, and a list of all plant species within a 10 m radius of the transect.

The cover-class vegetation survey method was based on the Daubenmire (1959) cover-class system using a 7-point scale (Table 4.4). Surveys were conducted using 1 m^2 quadrats subdivided into 16 sub-quadrats to increase the accuracy of cover estimates (Daubenmire 1959). Because canopies of different strata (e.g. grasses, shrubs) may overlap, these cover estimates may total more than 100% (Ambrose and Diaz 2008), unlike the laser-based quadrat cover estimates.

Table 4.4. Cover categories and associated cover class identification numbers used in the BAP surveys (modified from Daubenmire 1959).

Estimated cover category	Cover class
> 0 - 1 %	1
> 1 - 5 %	2
> 5 - 25 %	3
> 25 - 50 %	4
> 50 - 75 %	5
> 75 - 95 %	6
> 95 - 100 %	7

Canopy height was surveyed using a method similar to the salt marsh method. Three intersections of the sub-quadrats were randomly chosen and the plant species identity and height were recorded. The overall tallest plant species and height were also recorded for each quadrat to characterize maximum canopy height.

The 30 upland scrub habitat transects were surveyed using both the cover-class quadrat and the line-intercept methods. Both methods were recorded during the same sampling event. The line-intercept values documented every species observed below the transect tape a minimum of 0.01 m in length. If vegetation occurred below the top of the transect tape, then the first species that came in contact with a hypothetical vertical line straight down from that point on the transect was recorded (Ambrose and Diaz 2008). Each plant was recorded as living or dead.

Analysis Methods

Species data were analyzed using the median of each Daubenmire cover category and averaged to determine percent cover within each transect and habitat. Plant cover was averaged by transect and then again by habitat type; therefore, habitat type averages were grand means. Variability was represented as standard error. Dominant species (represented by average percent cover >10%) were also reported for each habitat type.

Line-intercept data were summed by species and divided by the total length of the transect to determine percent cover for each transect and habitat.

METHODS – MARSH-WIDE TRANSECT

One marsh-wide transect was completed to assess a continuous cross-section of the entire BWER, including transition areas. This transect was approximately 2000 meters long, began in the southwest portion of the marsh, and extended east across Culver Boulevard and the seasonal wetland to the Freshwater Marsh (Figure 4.8). The laser quadrat was placed every 10 m along the transect, and surveys were completed using the same methods as the salt marsh habitats. The marsh-wide transect was not incorporated in analyses for this report, but will help define the baseline conditions and transitions between habitat types. It will be repeated every five years.

Figure 4.8. Map of marsh-wide transect location.

METHODS – SEED BANK SURVEYS

Site Locations and Times

To survey the salt marsh seed bank, soil cores were collected and grown out in a greenhouse and germinated seedlings were identified. Soil cores were collected at ten equally spaced points along 25 m vegetation transects. Three transects were surveyed per habitat, with four additional 100 m transects from several channel banks (Figure 4.9). As most wetlands seeds are positively buoyant, the channel banks represent the current seed bank within the wrack lines and are seed accumulation zones. Soil cores were collected during late fall (November – December 2009), after the first rain of the wet season to capture the seed bank at its peak (S. Anderson, pers. comm.).

Field and Greenhouse Methods

Each soil core was approximately 10 cm deep and 8 cm in diameter. Immediately following collection, each soil core was individually potted in a 4” nursery pot and excess space was filled with steam-sterilized soil. Soil cores were transported to the greenhouse at Loyola Marymount University (LMU) at the end of each field day for incubation. One ‘blank’ core was created as a control for each transect using the same sterilized soil as the transect cores. The ‘blank’ is intended to identify any contamination or seed movement that may occur within the greenhouse. The greenhouse was not temperature controlled, but was completely covered to restrict seed transport into the greenhouse.

Care was taken to ensure the original core orientation and integrity were maintained throughout the collection and incubation process. During collection, the soil plug itself was pushed up and out of the corer to avoid pushing seeds into and/or burying seeds within the soil during transfer (most viable seeds are within the top few millimeters of the soil surface or resting directly upon it; S. Anderson, pers. comm.).

Upon arriving at the greenhouse, cores were initially saturated with water and placed in trays with one inch of freshwater (changed once a week) (Figure 4.10). Subsequently, cores were misted for several minutes once each day with freshwater. Germinated seedlings were counted and identified every 2-3 weeks for 3.5 months.

Figure 4.9. Map of seed bank transect locations. Numbers indicate the four 100 m channel bank transects.

Figure 4.10. Photos of an individual potted core (left) and a collection of cores arranged in a watering tub (right) in the LMU greenhouse.

Analysis methods

Seed bank results were analyzed by identifying each germinated seedling to species. Cores were analyzed by number of germinated seedlings per m² and averaged across each habitat type.

METHODS – ALGAE AND SUBMERGED AQUATIC VEGETATION COVER

Site Locations and Times

Algae and submerged aquatic vegetation (SAV) cover surveys (henceforth, 'algae surveys') were conducted along four 30 m transects deployed parallel to the channel bank with the same elevation contour as the muted tidal channel (Figures 4.11 and 4.12). Surveys were conducted three times during the first Baseline year: March, June, and September 2010. Surveys were conducted at the same times and locations as the *Cerithidea californica* (California horn snail) sampling (Chapter 9: Benthic invertebrates); SAV and algae was identified to species (Abbot and Hollenberg 1976). Surveys began approximately one and a half hours before a low spring tide to obtain the maximum mudflat exposure, and concluded after approximately three hours. Algae surveys were conducted using the same methods and sites as the Southern California Bight '08 eutrophication surveys (Figure 4.11; Bight 2008 Wetlands Sub-Committee 2008), with the addition of one transect in an area of high algal growth during the September surveys (Transect 4).

Field Methods

Quadrats were placed along the transects at ten randomly chosen meter locations determined by a random number generator. Each quadrat was 0.25 m², and included a grid of 49 point intersections in a 7 x 7 array. Percent cover of algae species was assessed by recording the species that fell immediately under each of the 49 intersection points. Intersecting points occurring over bare soil or mud were recorded as bare. The maximum and minimum mat thicknesses were also noted on the datasheet.

In addition to the tidal creeks, areas with extensive and accessible mudflats where algae are known to accumulate were searched and submerged vegetation within the tidal channels was also noted.

Figure 4.11. Map of four algae and SAV transect locations.

Figure 4.12. Photos of deployed transect (left) and an individual quadrat (right).

Analysis Methods

Algae surveys were analyzed by determining percent cover for each quadrat (i.e. number of points for a species / 49 x 100). Quadrats were averaged by transect, and standard error was used to determine variability.

RESULTS

General Results and Overall Trends

All vegetation results are preliminary, part of a long term monitoring program, and should be evaluated as such. Vegetation data will be further assessed in subsequent publications and reports. The data contained herein are compiled from transect-level cover data only and should not be considered a full floristic survey of the BWER. Results are analyzed by habitat types derived from the CDFG plant communities survey conducted in 2007. These habitat types were developed for the distinct conditions at BWER and do not necessarily reflect plant habitat types of other southern California wetlands. For example, the low salt marsh habitat type is generally defined by the presence of *Spartina foliosa* (cordgrass) (Zedler et al. 1999), but this vegetation alliance is absent from the BWER.

Overall, 144 vegetation transects were surveyed including 70 in the salt marsh habitat types and 74 in non-salt marsh habitat types (Table 4.5). The floral compendium in Appendix C.5 includes all plant species surveyed or collected within ten meters of all transects. For the purposes of assessing comparable data within this report, the line-intercept data were not analyzed. Comparisons of the upland scrub habitat methods will be available in future reports or publications (K. Johnston, unpublished data). Appendix C.6 contains photographs of several native species commonly seen within each habitat.

Table 4.5. Total number of transects completed in each habitat.

Salt Marsh Habitats	**# of Transects**		**Non-salt Marsh Habitats**	**# of Transects**
Low salt marsh	10		Brackish marsh	5
Mid salt marsh	16		Freshwater marsh	5
High salt marsh	15		Dune	10
Seasonal wetland (Area A)	10		Upland grassland	29
Seasonal wetland (Area B)	15		Upland scrub	25
Salt pan	4		----	----
TOTAL	**70**		**TOTAL**	**74**

Figure 4.13 displays the average non-native vegetative percent cover across each transect surveyed. All transects in Area C had greater than 10 % non-native vegetative cover; all transects in Area A except for two had greater than 10 % non-native vegetative cover. Conversely, the salt marsh habitats had predominantly native cover. The muted tidal marsh of Area B had a higher percent cover of native plant species than either Area A or C. However, the very southwestern corner of Area B was dominated by *Carpobrotus* spp., and often had a range of non-native plant species cover between 76-100%.

Figure 4.14 displays the average non-native vegetative percent cover data averaged across each habitat polygon area. The black numerals indicate the number of transects averaged across each polygon; note the level of variability of the number of transects between each polygon. These efforts are not intended to present data at the polygon level, but rather by habitat type. This map shows the varying level of average cover across each habitat polygon. There was higher (>10%) non-native plant percent cover in many of the upland habitat type polygons (Areas A and C), and relatively lower (<10%) non-native plant cover in the salt marsh and salt pan habitat types.

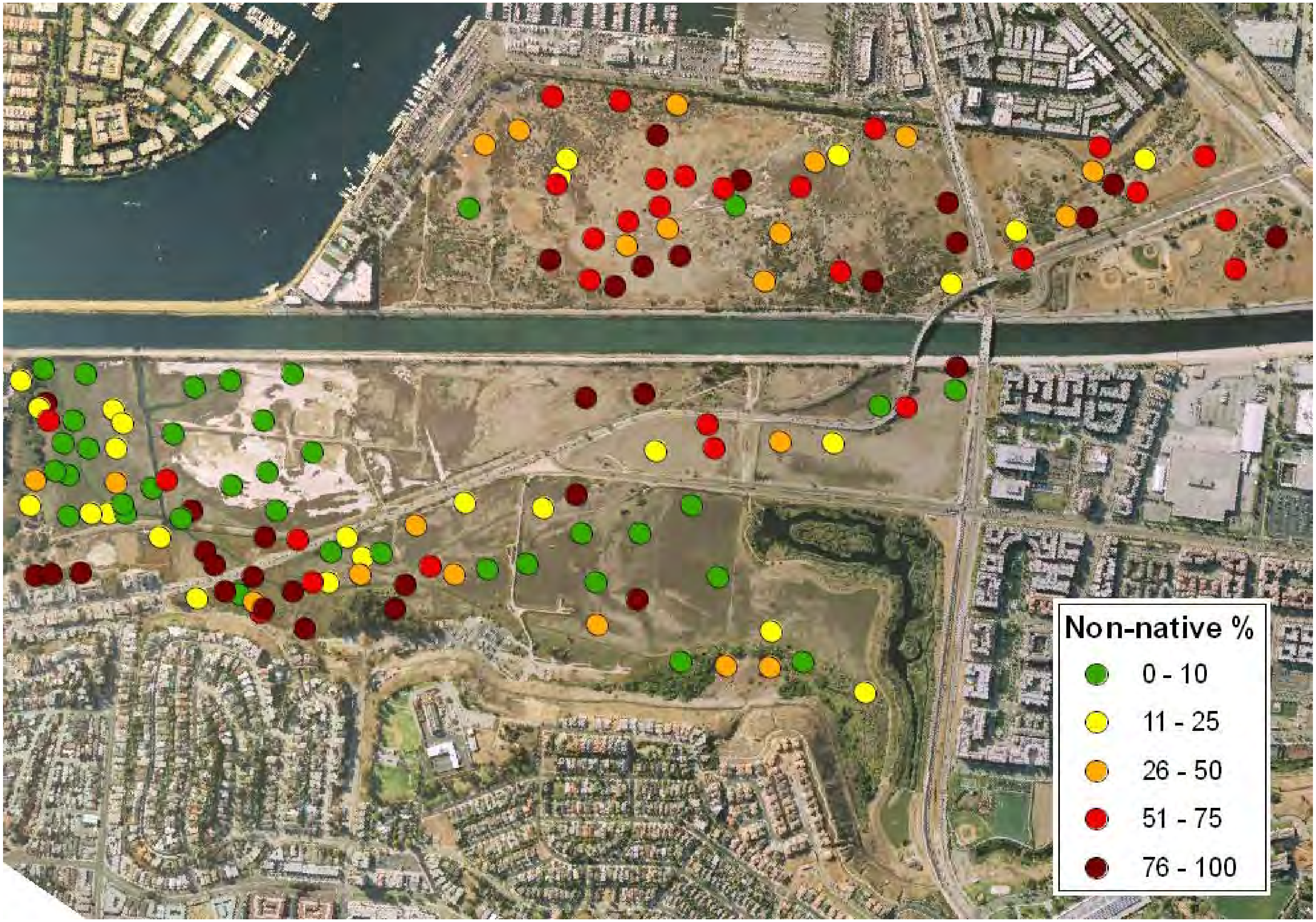

Figure 4.13. Average percent cover of non-native vegetation on each surveyed transect.

Figure 4.14. Cover of non-native vegetation averaged by habitat polygon. Black numbers indicate the number of transects used in the average.

Salt Marsh Habitat Results

The low salt marsh habitat type had the highest average percent cover of native species at 91.0 ± 5.2% (Figure 4.15). The mid and high salt marsh and the seasonal wetlands of Area B all had similar high levels of native cover (60.4 ± 12.9%, 62.3 ± 9.1%, and 60.6 ± 8.5%, respectively). Bare ground was highest in the salt pan habitat types followed by both seasonal wetland habitat types. The seasonal wetland of Area A had the lowest native percent cover at 25.6 ± 7.0% of all the vegetated salt marsh habitat types and the highest non-native cover (45.3 ± 8.5%). Salt pan habitat had low average vegetation cover for both native and non-native species.

In the salt marsh habitats, the highest percent cover for individual plant species often included native species, such as *S. virginica*, *J. carnosa*, and *C. truxillensis* (Figure 4.16 and Table 4.6); non-native grasses were also present in the high marsh and seasonal wetlands.

All salt marsh habitats, except the seasonal wetlands on fill in Area A (two native species), had similar relative species richness, expressed as number of species present (i.e. between five and seven native species) (Figure 4.17). The low marsh habitat also had the highest relative native species richness (seven species) and the lowest relative non-native richness (one species) and cover. Area A seasonal wetland habitats data were analyzed separately from the Area B seasonal wetland habitats because of the difference in plant species composition and elevation.

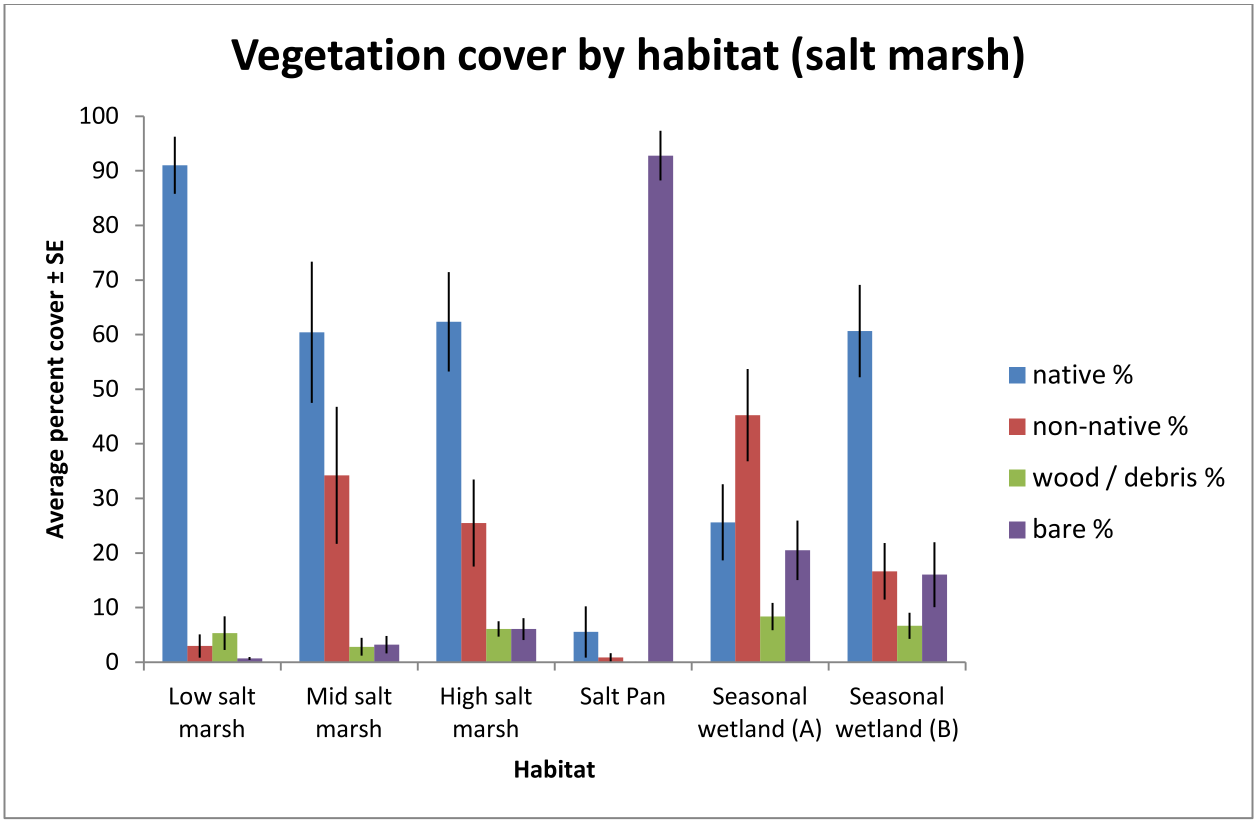

Figure 4.15. Vegetation cover of native versus non-native species averaged for all transect across each salt marsh habitat type.

Figure 4.16. Photo of *S. virginica* (left) and *J. carnosa* (right) (photos: SMBRC 2009).

Table 4.6. Percent cover of dominant species (>10%) for each salt marsh habitat type. Non-native plant species are in red.

Scientific name	Common name	Estuarine high marsh	Estuarine low marsh	Estuarine mid marsh	Seasonal wetland (A)	Seasonal wetland (B)	Salt Pan
Jaumea carnosa	marsh jaumea	-	18.6	17.9	-	-	-
Salicornia virginica	pickleweed	32.2	58.8	33.7	25.4	41.7	-
Cressa truxillensis	alkali weed	13.8	-	-	-	14.6	-
Bromus diandrus	ripgut brome	-	-	15.0	-	-	-
Unknown grass	----	23.1	-	-	39.8	16.5	-
Bare ground	----	-	-	-	-	16.0	92.8

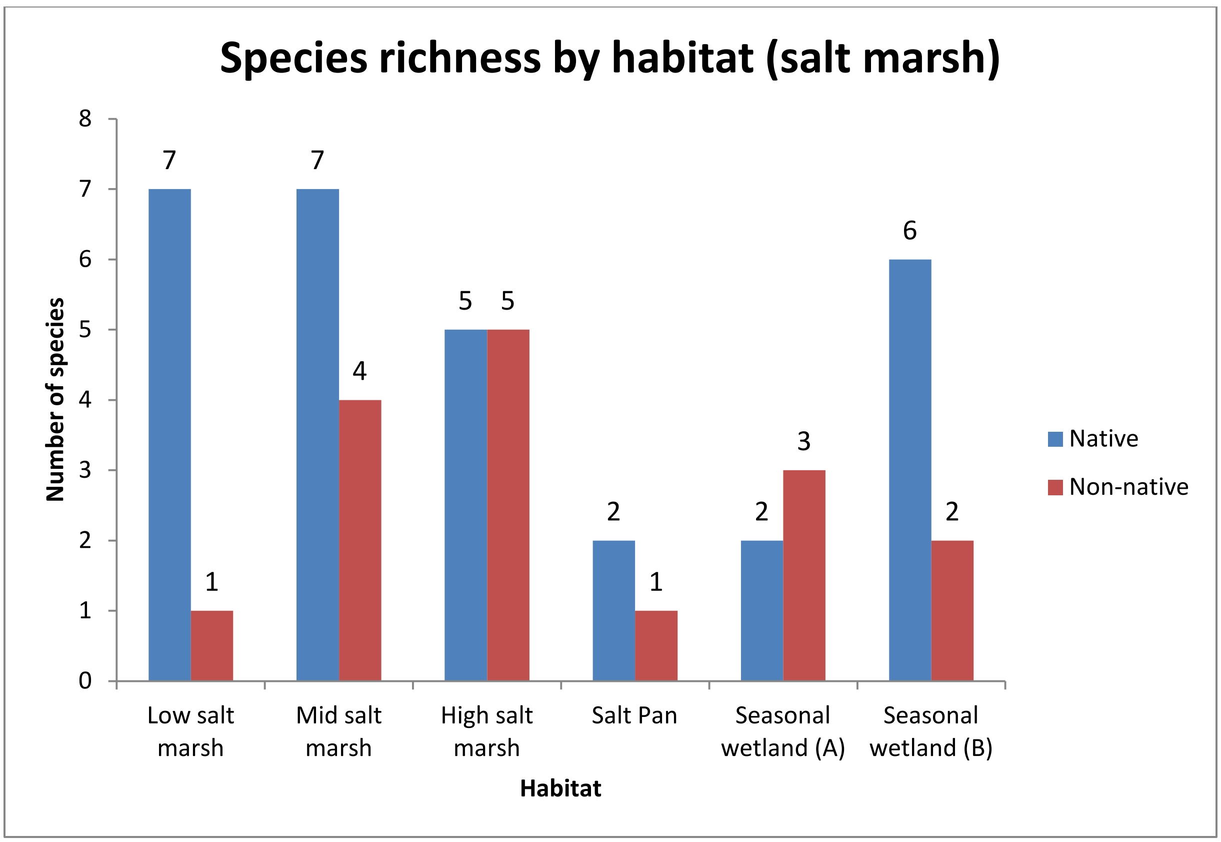

Figure 4.17. Species richness for native and non-native plant species in each of the salt marsh habitats.

Non-Salt Marsh Habitat Results

Non-salt marsh habitats evaluated included brackish and freshwater marshes, dune habitat, and upland scrub and grasslands. The marsh habitats (brackish and freshwater) had a higher average percent cover of native species (76.8 ± 2.3% and 55.0 ± 2.4%, respectively) than non-native species (Figure 4.18); the brackish marsh habitat had the highest average native percent cover. The dune and upland (grassland and scrub) habitats had a higher non-native species average percent cover (45.0 ± 1.1%, 77.1 ± 1.1%, and 58.8 ± 1.1%, respectively) than native (Figure 4.18).

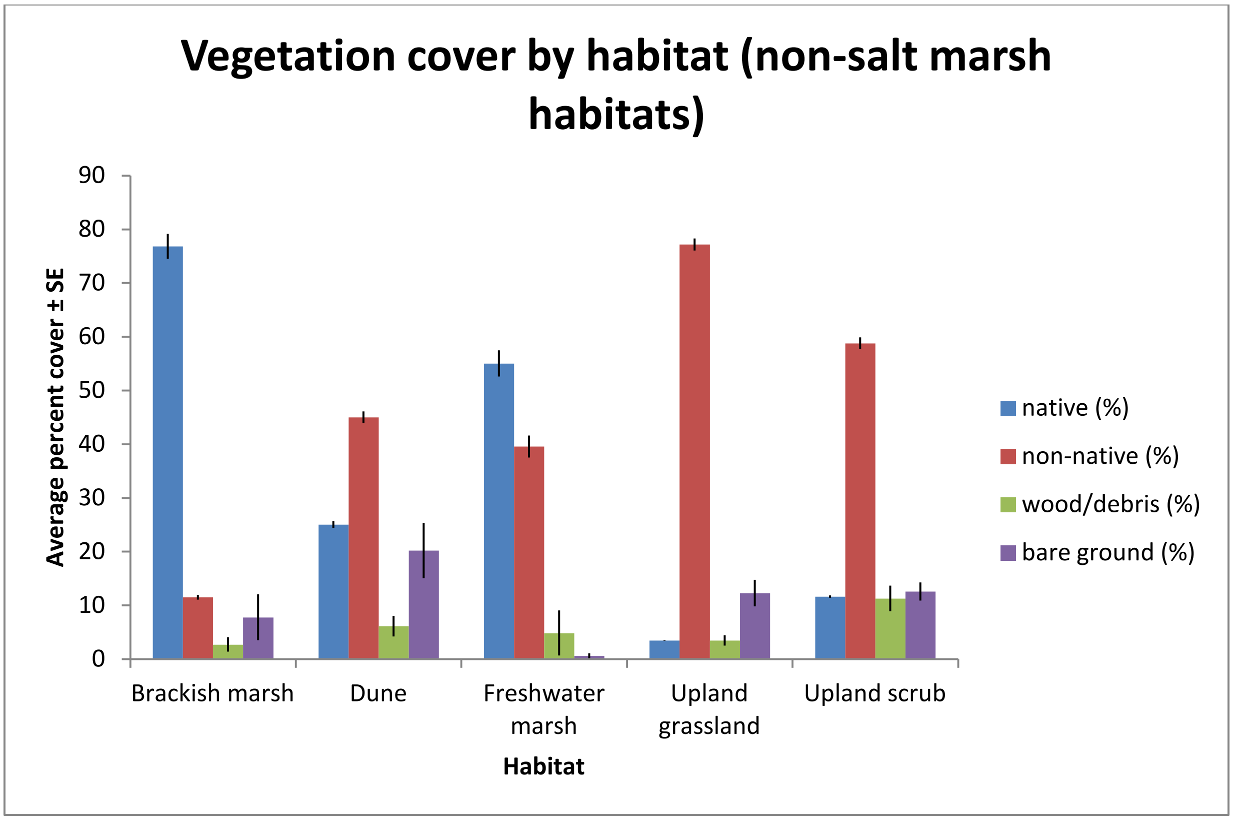

Figure 4.18. Average percent cover of native versus non-native plant species for all transects across each non-salt marsh habitat.

The brackish marsh habitat type was dominated by native *Juncus* spp. and *Scirpus* spp. (Table 4.7). The freshwater marsh habitat of the southwestern portion of Area B was the only other non-salt marsh habitat type sampled that had a higher percentage of native versus non-native plant species and was dominated by the native plant species *Anemopsis californica* (yerba mansa) and *Juncus balticus* (wire rush) (Table 4.7; Figure 4.19). The plant with the highest average percent cover in the freshwater marsh was the non-native *Carpobrotus* spp. (Figure 4.20).

The upland grassland habitat type had the lowest average native plant species percent cover, at 3.5 ± 0.1% and the highest non-native plant species percent cover at 77.1 ± 1.1%. The grassland habitat type had several non-natives that averaged greater than 10% cover: *Bromus diandrus* (ripgut brome), *C. coronarium*, and *Brassica nigra* (black mustard).

Table 4.7. Percent cover of dominant species (>10% cover) for each non-salt marsh habitat. Note: non-native plant species are highlighted in red.

Scientific name	**Common name**	**Upland scrub**	**Upland grassland**	**Freshwater marsh**	**Dune**	**Brackish marsh**
Anemopsis californica	yerba mansa	-	-	26.7	-	-
----	----	13.3	11.2	-	19.7	-
Bromus diandrus	ripgut brome	-	18.7	-	-	-
Brassica nigra	black mustard	16.1	13.9	-	-	-
Carpobrotus spp.	sour-fig (Hottentot-fig)	21.1	-	38.6	22.8	-
Chrysanthemum coronarium	garland daisy	11.7	18.1	-	-	-
Juncus spp.	rush	-	-	15.4	-	32.5
Scirpus spp.	bulrush	-	-	-	-	12.8

Figure 4.19. Native plant species *A. californica* (left) and *Juncus spp.* (right) (photos: SMBRC 2010).


Figure 4.20. Non-native plant *Carpobrotus* sp. (photo: SMBRC 2010).

All the non-salt marsh habitat types, except freshwater marsh, had total relative species richness greater than 20 (Figure 4.21). However, these habitats were sometimes comprised of greater than 50% non-native species (Figure 4.18). Of the non-salt marsh habitats, the brackish and freshwater marsh had a higher number of native than non-native plant species (Figure 4.21). The upland scrub had both the highest native (20) and highest non-native (25) relative plant species richness. The upland grassland showed the greatest disparity between native (10) and non-native (24) relative species richness. Of the non-salt marsh habitat types, freshwater marsh habitat had the lowest native (6) and non-native (5) relative species richness.

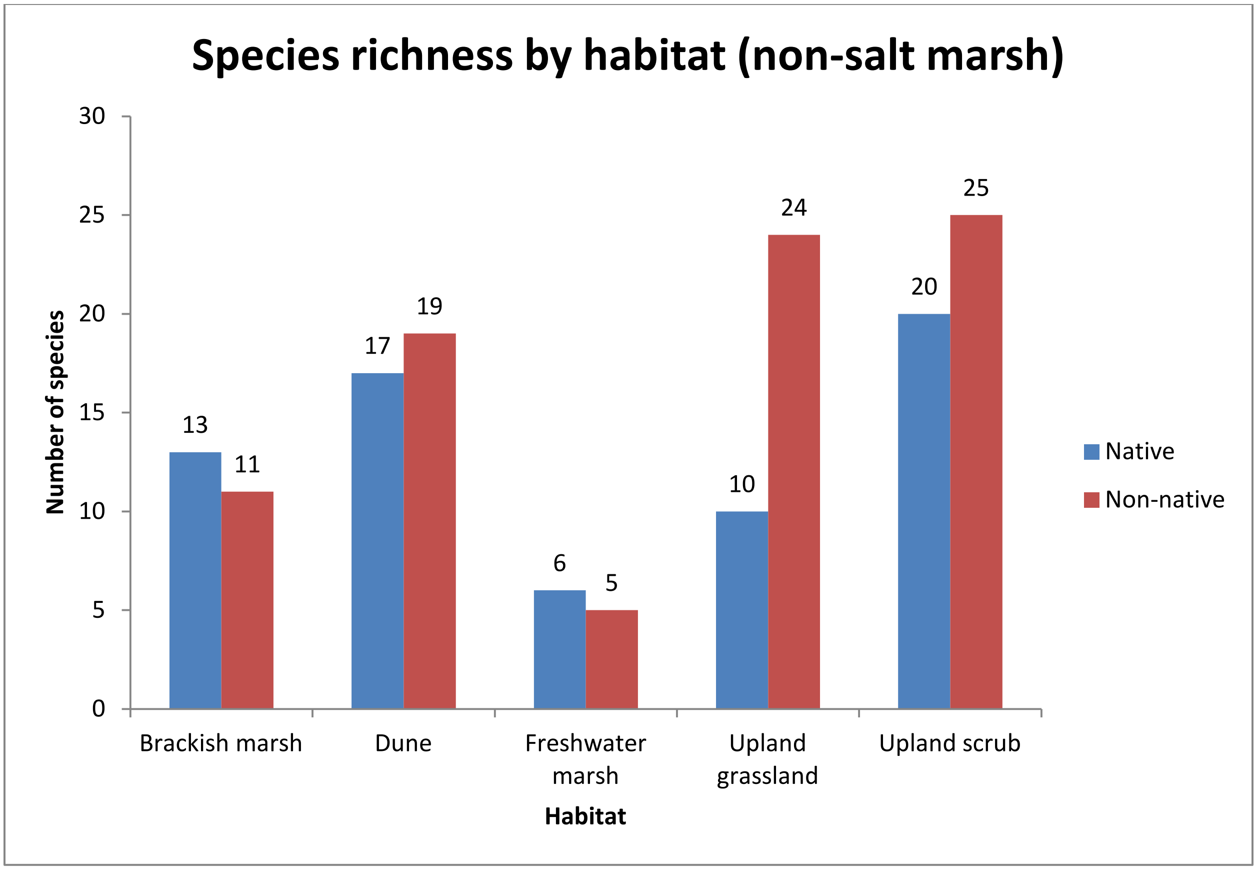

Figure 4.21. Species richness of native and non-native species in each of the non-salt marsh habitats.

Algae Cover Results

Transects were analyzed to determine if there was a seasonal or a transect-level effect. Transects 1 through 3 were surveyed in March, June, and September of 2010. Transect 4 was completed during the September sampling only.

The March surveys had the highest percent cover of *Ulva intestinalis (*algae), followed by June 2010, and September 2010 (Figure 4.22). Transect 1 had the highest percent cover of *U. intestinalis* followed by Transect 3. (Figure 4.23). Transect 4 had the highest percent cover of *U. lactuca* (Figure 4.23). *Ruppia maritima* was also found on Transect 1 and in several other locations within the tidal channels, but not on the other transects.

R. maritima was also observed in the Fiji Ditch during separate fishing events.

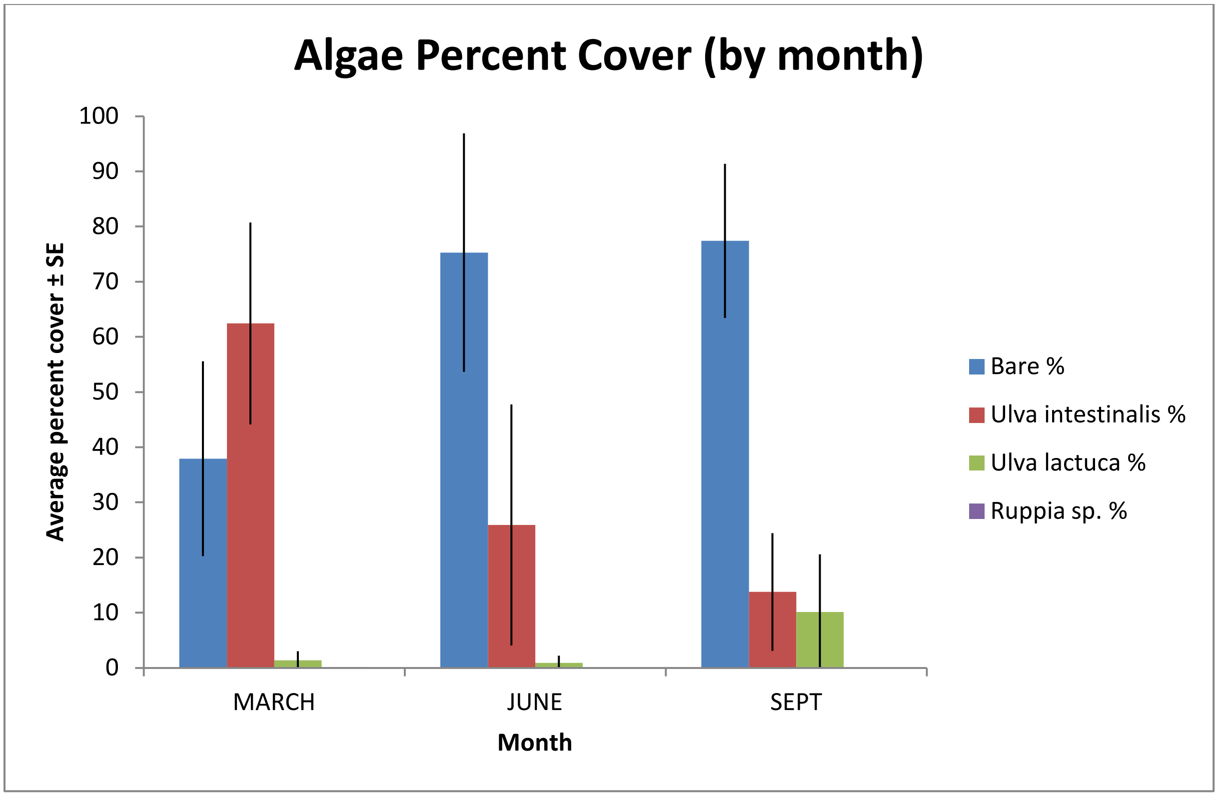

Figure 4.22. Average percent cover of algae/SAV (± SE) by month.

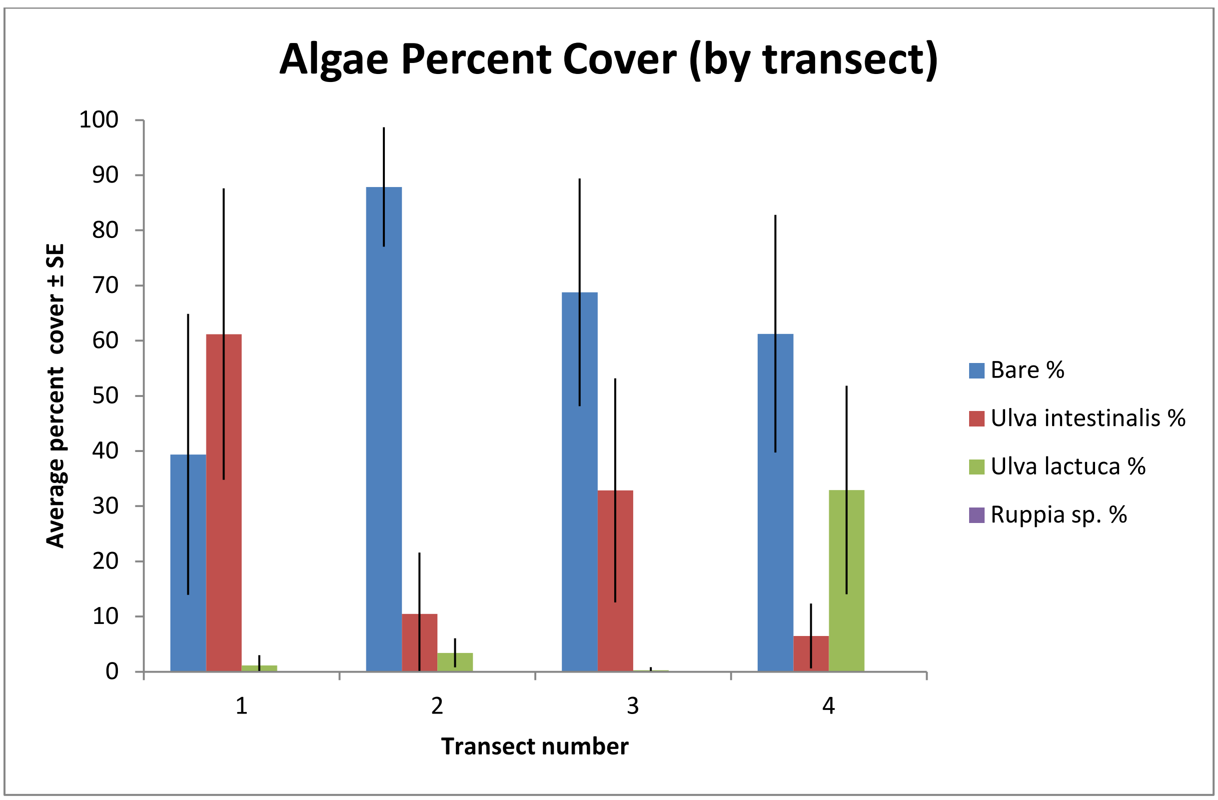

Figure 4.23. Average percent cover of algae/SAV (± SE) by transect.

Seed Bank Survey Results

A total of 190 soil cores were collected from 19 salt marsh transects (i.e. 15 vegetation transects and four channel bank wrack transects). None of the blanks (controls) germinated any seeds. Two categories [i.e. “unk (dead)” and “unk (Asteraceae)”] were created for germinated seedlings that either died before they were identifiable, never flowered, or never grew into adult plants.

Overall, 1,107 seedlings (150 cores) were identified from samples taken from the vegetation transects and 251 seedlings (40 cores) from the samples taken from the channel bank transects. Twenty-six soil cores never germinated any seeds. Seventeen plant species germinated in the soil cores (Table 4.8); eight were native species representing 66.4% of the total number of germinated seedlings on the transects. *S. virginica* and *J. carnosa* together represented 64% of the seedlings on the vegetation transects and 88% of the seedlings on the channel bank transects. Table 4.8 lists all species germinated from both the vegetation transects and the channel bank transects.

The most common species found on the vegetation transects included the native plant species *S. virginica* and *J. carnosa* (Figure 4.24). The most common non-native plant species included: *P. monspeliensis*, *Lolium multiflorum* (Italian ryegrass), *Mesembryanthemum nodiflorum* (slender leaf iceplant), *Bromus hordeaceus* (soft chess), and *Parapholis incurva* (sickle grass) (Figure 4.25; Table 4.8). More than 20 seedlings of each of the aforementioned species germinated.

Table 4.8. All species and total number of germinated seedlings from seed bank transects. Non-native plant species are highlighted in red.

Scientific Name	Common Name	Transect total	Channel bank total
Atriplex triangularis	spear oracle	4	0
Bassia hyssopifolia	bassia	2	0
Bromus diandrus	ripgut brome	14	0
Bromus hordeaceus	soft chess	28	0
Cotula coronopifolia	common brassbuttons	1	0
Cressa truxillensis	alkali weed	5	3
Distichlis spicata	saltgrass	4	3
Heliotropium curassavicum	seaside heliotrope	3	0
Jaumea carnosa	fleshy jaumea	321	67
Juncus bufonius	common toad rush	12	1
Lolium multiflorum	Italian ryegrass	43	2
Melilotus indicus	sour clover	15	5
Mesembryanthemum nodiflorum	slender leaf iceplant	34	0
Parapholis incurva	Sickle grass	33	5
Polypogon monspeliensis	Rabbit foot grass	179	2
Salicornia virginica	pickleweed	384	155
Spergularia sp.	sand-spurrey	2	0
unk (Asteraceae)	aster	21	7
unk (dead)	----	2	1
TOTAL # SEEDLINGS	**----**	**1,107**	**251**
# TRANSECTS	**----**	**15**	**4**
# SEEDLINGS PER TRANSECT	**----**	**73.8**	**62.75**

Figure 4.24. Cores with native *J. carnosa* (top left) and *S. virginica* (top right) seedlings, and cores with seedlings of both species (bottom) (photos: SMBRC 2010).

Figure 4.25. *Melilotus indicus* (sour clover; left) and *P. monspeliensis* (right) seedlings (photos: SMBRC 2010).

The mid marsh habitat type had the highest average number of native germinated seedlings / m² (Figure 4.26); the seasonal wetland habitat types had the lowest average number of native germinated seedlings / m². The high marsh habitat type had the highest number of average non-native germinated seedlings / m².

The channel bank transects had the lowest average number of non-native germinated seedlings / m². Of the individual channel bank transects, Channel-1 had the highest number of seedlings / m², and Channel-4 (the salt pan transect) had the least number of seedlings / m².

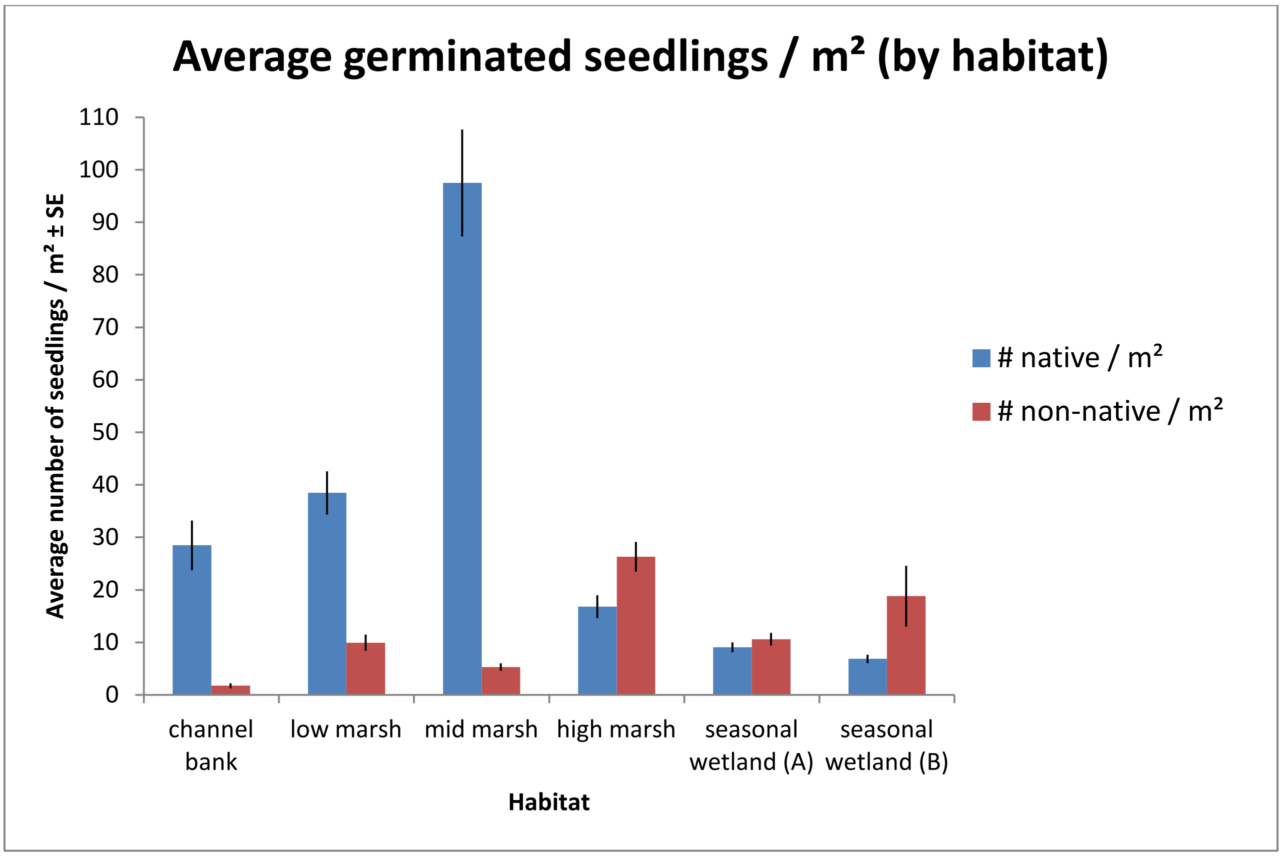

Figure 4.26. Number of germinated seedlings (± SE) averaged across each habitat.

Special Status Species

No special status plant species were observed within 10 m of any vegetation transect. A separate targeted survey program was implemented for all listed plant species of special concern (federal, state, and DFG; Appendix C.3) that may occur within the BWER. The results from special status species plant surveys will be available as separate reports on the BWER website (www.ballonarestoration.org).

FUTURE DIRECTIONS

Cover surveys will continue every two to three years to determine temporal trends. Algal and seed bank surveys will continue annually using the same methods described in this report. Plant tissue and biomass samples will be collected on a subset of the vegetation transects once every five years and three transects will be sampled in each habitat type. Plant tissue will be collected on each of these transects from the three most common plants in the habitat to test for constituents of concern.

Special status plant species surveys will be continued during the second Baseline year.

APPENDIX C.1

Existing conditions plant list (expanded from PWA 2006)

Family	Scientific Name	Common Name	native/ non-native	(1) 1979	(2) 1981	(3) 1991	(4) 1992	(5) 2001	(6) 2002	(7) 2005
Nyctaginaceae	*Abronia umbellata*	common sand verbena	n	x	x	x	x	x	x	
Nyctaginaceae	*Abronia villosa*	villose abronia	n							x
Fabaceae	*Acacia dealbata*	silver wattle mimosa	n-n		x				x	
Fabaceae	*Acacia longifolia*	long-leaved acacia	n-n			x			x	
Fabaceae	*Acacia neriifolia (*)*	mattle	n-n						x	
Fabaceae	*Acacia sp.*	acacia	n-n			x		x	x	x
Fabaceae	*Acmispon americanus*	Spanish clover	n		x	x	x		x	
Fabaceae	*Acmispon glaber*	deerweed	n	x	x	x	x	x	x	x
Fabaceae	*Acmispon strigosus*	strigose lotus	n		x	x	x		x	
Asteraceae	*Acroptilon repens*	Russian knapweed	n-n		x	x			x	
Rosaceae	*Adenostoma fasciculatum*	common chamise	n	x					x	
Agavaceae	*Agave americana*	century plant	n-n			x			x	
Liliaceae	*Agave attenuata (*)*	fox tail agave	n-n						x	
Agavaceae	*Agave sp.*	agave	n-n					x		
Poaceae	*Agrostis semiverticillata*	water beardgrass	n			x			x	
Poaceae	*Agrostis stolonifera*	stoloniferous creeping bentgrass	n-n		x				x	
Fabaceae	*Albizia lophantha*	plume albizia	n-n		x	x			x	
Liliaceae	*Aloe vera (*)*	medicinal aloe	n-n			x			x	
Amaranthaceae	*Amaranthus albus*	tumbleweed amaranthus	n-n		x	x			x	
Amaranthaceae	*Amaranthus californicus*	California amaranthus	n		x		x		x	

Family	Scientific Name	Common Name	native/ non-native	(1) 1979	(2) 1981	(3) 1991	(4) 1992	(5) 2001	(6) 2002	(7) 2005
Amaranthaceae	*Amaranthus deflexus*	low pigweed	n-n		x				x	
Amaranthaceae	*Amaranthus rudis*	waterhemp	n-n			x			x	
Asteraceae	*Ambrosia acanthicarpa*	annual bursage	n		x	x	x		x	
Asteraceae	*Ambrosia chamissonis*	Chamisso's bur-sage	n		x	x	x		x	
Asteraceae	*Ambrosia psilostachya*	western ragweed	n		x	x	x	x	x	x
Lythraceae	*Ammania sp. (*)*	red stem	n						x	
Myrsinaceae	*Anagallis arvensis*	scarlet pimpernel	n-n	x		x		x	x	x
Saururaceae	*Anemopsis californica*	yerba mansa	n		x	x	x		x	
Apiaceae	*Apium graveolens*	garden celery	n-n		x			x	x	x
Aizoaceae	*Aptenia cordifolia*	baby sun rose	n-n		x				x	
Asteraceae	*Artemisia californica*	California sage brush	n	x			x	x	x	x
Asteraceae	*Artemisia douglasiana*	Douglas' mugwort	n	x	x	x	x	x	x	x
Asteraceae	*Artemisia dracunculus*	wild tarragon	n		x	x	x		x	
Poaceae	*Arundo donax*	giant river reed	n-n		x	x		x	x	x
Asteraceae	*Aster subulatus var. ligulatus (**)*	annual water aster	n		x	x	x		x	
Fabaceae	*Astragalus trichopodus*	milk vetch	n			x			x	
Chenopodiaceae	*Atriplex californica*	California saltbush	n			x	x		x	
Chenopodiaceae	*Atriplex lentiformis*	big saltbush	n			x	x		x	
Chenopodiaceae	*Atriplex patula*	spear saltbush	n	x			x			
Chenopodiaceae	*Atriplex rosea*	tumbling oracle	n-n			x			x	
Chenopodiaceae	*Atriplex semibaccata*	Australian saltbush	n-n	x		x	x	x	x	x(t)
Chenopodiaceae	*Atriplex triangularis*	triangle orache	n	x		x	x	x	x	x(t)
Poaceae	*Avena barbata*	slender wild oat	n-n			x		x	x	x(t)
Poaceae	*Avena fatua*	common wild oat	n-n			x		x	x	x
Poaceae	*Avena sp.*	oat	n-n	x						
Asteraceae	*Baccharis pilularis*	common coyote brush	n	x	x	x	x		x	

Family	Scientific Name	Common Name	native/ non-native	(1) 1979	(2) 1981	(3) 1991	(4) 1992	(5) 2001	(6) 2002	(7) 2005
Asteraceae	*Baccharis pilularis var. consanguinea*	coyote brush	n				x			
Asteraceae	*Baccharis salicifolia*	mule fat	n	x		x		x	x	x
Chenopodiaceae	*Bassia hyssopifolia*	five-hooked bassia	n-n		x	x			x	
Fabaceae	*Bauhinia variegata*	orchid tree	n-n			x			x	
Cyperaceae	*Bolboschoenus robustus*	robust bulrush	n	x	x	x	x		x	
Brassicaceae	*Brassica nigra*	black mustard	n-n	x		x			x	x
Brassicaceae	*Brassica rapa*	common yellow mustard	n-n			x			x	
Asteraceae	*Brickellia californica*	California brickellbush	n			x			x	
Poaceae	*Bromus catharticus*	rescue-grass	n-n			x			x	
Poaceae	*Bromus diandrus*	ripgut chess	n-n			x		x	x	x
Poaceae	*Bromus hordeaceus*	soft cheatgrass	n-n			x		x	x	x
Poaceae	*Bromus madritensis ssp. rubens*	foxtail chess	n-n					x	x	x(t)
Poaceae	*Bromus marginatus*	large mountain brome	n				x			
Poaceae	*Bromus sp.*	brome grass	n-n	x						
Brassicaceae	*Cakile maritima*	maritime sea-rocket	n-n			x			x	
Convolvulaceae	*Calystegia macrostegia*	southern California morning glory	n					x		x
Convolvulaceae	*Calystegia macrostegia subsp. cyclostegia*	southern California morning glory	n		x	x	x		x	
Onagraceae	*Camissonia bistorta*	California sun cup	n	x	x	x	x	x	x	x
Onagraceae	*Camissonia cheiranthifolia*	beach evening primrose	n	x	x	x			x	x
Onagraceae	*Camissonia cheiranthifolia ssp. suffruticosa*	beach suncup	n	x			x	x		

Family	Scientific Name	Common Name	native/ non-native	(1) 1979	(2) 1981	(3) 1991	(4) 1992	(5) 2001	(6) 2002	(7) 2005
Onagraceae	*Camissonia lewisii*	Lewis' evening primrose	n			x			x	
Onagraceae	*Camissonia micrantha*	Spencer primrose	n		x	x	x		x	
Onagraceae	*Camissonia sp.*	sun cup	n			x			x	
Cyperaceae	*Carex praegracilis*	clustered field sedge	n		x		x	x	x	x
Aizoaceae	*Carpobrotus chilensis*	sea-fig iceplant	n-n	x				x	x	x
Aizoaceae	*Carpobrotus edulis*	hottentot-fig	n-n	x	x	x		x	x	x
Asteraceae	*Centaurea melitensis*	tocalote	n-n		x	x		x	x	x
Asteraceae	*Centromadia parryi ssp. Australis*	southern tarplant	n						x	
Fabaceae	*Ceratonia siliqua*	St. John's bread	n-n		x	x			x	
Asteraceae	*Chaenactis glabriuscula*	yellow chaenactis	n		x	x	x	x	x	x
Euphorbiaceae	*Chamaesyce albomarginata*	rattlesnake sandmat	n		x		x		x	
Euphorbiaceae	*Chamaesyce maculata*	common spotted spurge	n-n		x	x			x	
Euphorbiaceae	*Chamaesyce polycarpa*	small-seeded spurge	n		x		x		x	
Euphorbiaceae	*Chamaesyce serpens*	serpent euphorbia	n-n		x	x	x		x	
Asteraceae	*Chamomilla suaveolens*	pineapple weed	n-n		x	x			x	
Chenopodiaceae	*Chenopodium berlandieri*	pitseed goosefoot	n			x			x	
Chenopodiaceae	*Chenopodium murale*	nettle-leaved goosefoot	n-n			x			x	
Chenopodiaceae	*Chenopodium sp.*	chenopodium	n	x			x	x	x	x
Asteracea	*Chondrilla juncea*	rush chondrilla	n-n		x					
Asteraceae	*Chrysanthemum sp.*	chrysanth	n-n	x	x	x				
Asteraceae	*Cichorium intybus*	common chickory	n-n		x	x			x	
Apiaceae	*Ciclospermum leptophyllum*	marsh parsley	n-n		x				x	
Asteraceae	*Cirsium vulgare*	bull thistle	n-n		x	x			x	

Family	Scientific Name	Common Name	native/ non-native	(1) 1979	(2) 1981	(3) 1991	(4) 1992	(5) 2001	(6) 2002	(7) 2005
Cucurbitaceae	*Citrullus colocynthis var. lanatus (*)*	watermelon	n-n		x	x			x	
Ranunculaceae	*Clematis ligusticifolia*	western white clematis	n				x			
Apiaceae	*Conium maculatum*	poison hemlock	n-n		x				x	
Convolvulaceae	*Convolvulus arvensis*	field convolvulus	n-n		x	x		x	x	x
Asteraceae	*Conyza bonariensis*	Buenos Aires conyza	n-n		x	x		x	x	x
Asteraceae	*Conyza canadensis*	Canadian horseweed	n		x	x			x	
Asteraceae	*Corethrogyne filaginifolia*	common sandaster	n		x		x		x	
Poaceae	*Cortaderia jubata*	purple pampas grass	n-n							x
Poaceae	*Cortaderia selloana*	silver pampas grass	n-n	x		x			x	
Asteraceae	*Cotula australis*	Australian cotula	n-n						x	
Asteraceae	*Cotula coronopifolia*	common brass buttons	n-n	x	x	x			x	
Asteraceae	*Cotula sp.*	brass-buttons	n-n					x		x
Crassulaceae	*Crassula connata*	sand pygmyweed	n		x	x	x		x	
Crassulaceae	*Crassula ovata*	silver jade plant	n-n		x	x		x	x	x(t)
Convolvulaceae	*Cressa truxillensis*	spreading alkali weed	n	x	x	x	x	x	x	x(t)
Euphorbiaceae	*Croton californicus*	California croton	n		x	x	x	x	x	x
Boraginaceae	*Cryptantha intermedia*	clearwater cryptantha	n			x	x		x	
Cucurbitaceae	*Cucurbita foetidissima*	foetid gourd	n		x	x	x		x	
Cupressaceae	*Cupressus arizonica ssp. arizonica (**)*	Arizona cypress	n-n			x			x	
Convolvulaceae	*Cuscuta californica*	California Dodder	n		x	x	x	x	x	x
Convolvulaceae	*Cuscuta campestris (**)*	field dodder	n		x		x		x	
Convolvulaceae	*Cuscuta indecora*	large-seeded dodder	n			x			x	
Convolvulaceae	*Cuscuta sp.*	dodder	n			x			x	

Family	Scientific Name	Common Name	native/ non-native	(1) 1979	(2) 1981	(3) 1991	(4) 1992	(5) 2001	(6) 2002	(7) 2005
Poaceae	*Cynodon dactylon*	creeping-cynodon	n-n			x		x	x	x
Cyperaceae	*Cyperus eragrostis*	eragrostoid cyperus	n		x	x	x		x	
Cyperaceae	*Cyperus esculentus*	chufa flat-sedge	n		x	x			x	
Cyperaceae	*Cyperus involucratus*	umbrella papyrus	n-n		x	x			x	
Solanaceae	*Datura wrightii*	Wright's datura	n		x	x	x	x	x	x
Asteraceae	*Deinandra fasciculata*	fascicled tarplant	n		x		x		x	
Asteraceae	*Deinandra paniculata*	San Diego tarplant	n			x			x	
Aizoaceae	*Delosperma litorale*	seaside delosperma	n-n		x				x	
Convolvulaceae	*Dichondra occidentalis*	western dichondra	n			x			x	
Poaceae	*Digitaria sp.*	digitaria	n-n			x			x	
Poaceae	*Distichlis spicata*	spiked saltgrass	n	x		x	x	x	x	x(t)
Chenopodiaceae	*Dysphania ambrosioides*	American wormseed	n-n			x			x	
Chenopodiaceae	*Dysphania botrys*	Jerusalem-oak goosefoot	n-n			x			x	
Chenopodiaceae	*Dysphania pumilio*	clammy goosefoot	n-n						x	
Poaceae	*Echinochloa crus-galli*	common barnyard-grass	n-n			x			x	
Poaceae	*Ehrharta erecta*	upright veldtgrass	n-n			x			x	
Cyperaceae	*Eleocharis macrostachya*	longstem spike-rush	n		x	x	x		x	
Cyperaceae	*Eleocharis montevidensis*	Montevideo spike-rush	n		x		x		x	
Asteraceae	*Encelia californica*	California encelia	n					x		x
Onagraceae	*Epilobium ciliatum*	ciliate willow-herb	n			x			x	
Asteraceae	*Ericameria ericoides*	Californian goldenbush	n		x		x		x	
Asteraceae	*Ericameria pinifolia*	pine goldenbush	n			x			x	
Polygonaceae	*Eriogonum fasciculatum*	California wild buckwheat	n			x	x	x	x	x

Family	Scientific Name	Common Name	native/ non-native	(1) 1979	(2) 1981	(3) 1991	(4) 1992	(5) 2001	(6) 2002	(7) 2005
Polygonaceae	*Eriogonum gracile*	slender woolly eriogonum	n				x			
Polygonaceae	*Eriogonum parvifolium*	seacliff wild buckwheat	n			x	x	x	x	x
Geraniaceae	*Erodium botrys*	long-beaked filaree	n-n		x	x		x	x	x(t)
Geraniaceae	*Erodium cicutarium*	red-stemmed filaree	n-n	x	x	x			x	
Brassicaceae	*Erysimum insulare ssp. suffrutescens (*)*	island wallflower	n	x		x			x	
Brassicaceae	*Erysimum suffrutescens*	suffrutescent wallflower	n	x			x			
Papaveraceae	*Eschscholzia californica*	California poppy	n			x		x	x	x
Myrtaceae	*Eucalyptus camaldulensis*	red gum	n-n		x	x			x	
Myrtaceae	*Eucalyptus globulus*	blue gum	n-n			x			x	
Myrtaceae	*Eucalyptus sp*	eucalyptus	n-n	x						
Myrtaceae	*Eucalyptus tereticornis*	forest red gum	n-n		x				x	
Myrtaceae	*Eucalyptus viminalis*	manna gum	n-n		x				x	
Euphorbiaceae	*Euphorbia esula (**)*	leafy spurge	n-n			x			x	
Euphorbiaceae	*Euphorbia peplus*	pretty spurge	n-n		x	x			x	
Asteraceae	*Euryops pectinatus (*)*	Euryops daisy	n-n			x			x	
Asteraceae	*Euthamia occidentalis*	western goldenrod	n		x	x	x			
Poaceae	*Festuca arundinacea*	reed fescue	n-n			x			x	
Moraceae	*Ficus carica*	common fig	n-n			x			x	
Asteraceae	*Filago sp.*	filago				x			x	
Apiaceae	*Foeniculum vulgare*	common fennel	n-n	x	x	x		x	x	x
Frankeniaceae	*Frankenia salina*	alkali frankenia	n	x	x	x	x	x	x	x(t)
Oleaceae	*Fraxinus velutina*	velvet arizona ash	n		x		x		x	
Rubiaceae	*Galium angustifolium*	narrow-leaved bedstraw	n		x		x		x	

Family	Scientific Name	Common Name	native/ non-native	(1) 1979	(2) 1981	(3) 1991	(4) 1992	(5) 2001	(6) 2002	(7) 2005
Asteraceae	*Gazania linearis*	hardy gazania	n-n			x			x	
Asteraceae	*Gazania scaposa (*)*	African daisy	n-n		x				x	
Asteraceae	*Glebionis coronaria*	garland chrysanthemum	n-n					x	x	x(t)
Asteraceae	*Gnaphalium californicum*	California cudweed	n			x	x	x	x	x
Asteraceae	*Gnaphalium ramosissimum*	pink cudweed	n		x		x		x	
Asteraceae	*Gnaphalium sp.*	cudweed	n	x					x	
Asteraceae	*Gnaphalium stramineum*	Chilean cudweed	n		x	x			x	
Asteraceae	*Grindelia camporum (*)*	Great Valley grindelia	n		x	x	x		x	
Brassicaceae	*Guillenia lasiophylla*	California mustard	n				x	x		x
Araliaceae	*Hedera canariensis*	Canary ivy	n-n			x			x	
Asteraceae	*Hedypnois cretica*	Crete hedypnois	n-n		x				x	
Asteraceae	*Helianthus annuus*	common annual sunflower	n		x	x	x		x	
Boraginaceae	*Heliotropium curassavicum*	salt heliotrope	n			x	x	x	x	x
Asteraceae	*Helminthotheca echioides*	bristly ox-tongue	n-n	x	x	x				
Rosaceae	*Heteromeles arbutifolia*	toyon	n			x			x	
Asteraceae	*Heterotheca grandiflora*	telegraph weed	n		x	x	x	x	x	x
Asteraceae	*Heterotheca villosa*	villous golden-aste	n			x			x	
Brassicaceae	*Hirschfeldia incana*	field mustard	n-n			x			x	
Fabaceae	*Hoffmannseggia glauca*	waxy hoffmannseggia	n			x			x	
Poaceae	*Hordeum murinum ssp. leporinum*	mouse barley	n			x			x	
Poaceae	*Hordeum sp.*	barley	n-n	x						
Asteraceae	*Hypochaeris glabra*	smooth cat's-ear	n-n			x	x	x	x	x
Iridaceae	*Iris pseudacorus*	pale-yellow iris	n-n							

Family	Scientific Name	Common Name	native/ non-native	(1) 1979	(2) 1981	(3) 1991	(4) 1992	(5) 2001	(6) 2002	(7) 2005
Asteraceae	*Jaumea carnosa*	fleshy Juamea	n		x	x	x		x	x(t)
Juglandaceae	*Juglans regia*	English walnut	n-n			x			x	
Juncaceae	*Juncus balticus*	Baltic rush	n			x	x		x	
Juncaceae	*Juncus bufonius*	common toad-rush	n			x	x	x	x	x
Juncaceae	*Juncus bufonius var. occidentalis*	common toad-rush	n			x			x	
Juncaceae	*Juncus mexicanus*	Mexican rush	n			x			x	
Juncaceae	*Juncus sp.*	rush wire-grass	n	x						
Asteraceae	*Lactuca eucra (*)*		n-n			x			x	
Asteraceae	*Lactuca serriola*	prickly lettuce	n-n		x	x	x	x	x	x
Asteraceae	*Lactuca virosa*	wild lettuce	n-n			x	x	x	x	x
Asteraceae	*Laennecia coulteri*	Coulter's horseweed	n		x				x	
Poaceae	*Lamarckia aurea*	goldentop	n-n			x			x	
Verbenaceae	*Lantana camara*	orange-flowered lantana	n-n			x			x	
Brassicaceae	*Lepidium latifolium*	broad-leaved peppergrass	n-n			x			x	
Brassicaceae	*Lepidium virginicum var. pubescens*	tall peppergrass	n			x	x		x	
Poaceae	*Leptochloa uninervia*	Mexican sprangle top	n			x	x		x	
Poaceae	*Leymus condensatus*	giant rye grass	n			x			x	
Hamamelidaceae	*Liquidambar styraciflua*	sweet gum	n-n			x			x	
Brassicaceae	*Lobularia maritima*	sweet alyssum	n-n	x		x			x	
Poaceae	*Lolium multiflorum*	Italian ryegrass	n-n			x		x	x	x
Poaceae	*Lolium perenne*	perennial ryegrass	n-n			x		x	x	x
Myrtaceae	*Luma apiculata*	temu	n-n			x			x	
Fabaceae	*Lupinus bicolor*	bicolored lupine	n		x	x	x		x	
Fabaceae	*Lupinus chamissonis*	coastal bush lupine	n	x	x	x	x	x	x	x
Fabaceae	*Lupinus excubitus hallii*	grape soda lupine	n		x		x		x	

Family	Scientific Name	Common Name	native/ non-native	(1) 1979	(2) 1981	(3) 1991	(4) 1992	(5) 2001	(6) 2002	(7) 2005
Fabaceae	*Lupinus longifolius*	longleaf bush lupine	n			x			x	
Fabaceae	*Lupinus succulentus*	arroyo lupine	n		x	x	x		x	
Fabaceae	*Lupinus truncatus*	truncate-leaved lupine	n		x		x		x	
Solanaceae	*Lycium californicum*	California boxthorn	n							x
Solanaceae	*Lycium ferocissimum*	African boxthorn	n-n		x	x			x	
Solanaceae	*Lycopersicon esculentum*	common tomato	n-n		x				x	
Lythraceae	*Lythrum hyssopifolia*	hyssop loosestrife	n-n		x	x			x	
Malvaceae	*Malacothamnus fasciculatus*	chaparral bush-mallow	n		x		x		x	
Asteraceae	*Malacothrix saxatilis*	cliff aster	n		x	x	x		x	
Aizoaceae	*Malephora crocea*	red-flowered iceplant	n-n		x	x			x	
Anacardiaceae	*Malosma laurina*	laurel sumac	n	x	x	x	x		x	x
Malvaceae	*Malva nicaeensis*	bull mallow	n-n		x	x			x	
Malvaceae	*Malva parviflora*	cheeseweed mallow	n-n		x	x		x	x	x
Malvaceae	*Malvella leprosa*	alkali mallow	n		x	x	x		x	
Lamiaceae	*Marrubium vulgare*	horehound	n-n	x	x	x			x	
Fabaceae	*Medicago polymorpha*	California burclover	n-n	x	x	x		x	x	x
Poaceae	*Melica imperfecta*	imperfect melic	n			x	x		x	
Fabaceae	*Melilotus albus*	white sweetclover	n-n		x	x			x	
Fabaceae	*Melilotus indicus*	sourclover	n-n	x	x	x		x	x	x(t)
Fabaceae	*Melilotus limensis (*)*		n-n		x					
Aizoaceae	*Mesembryanthemum crystallinum*	crystalline iceplant	n-n			x		x	x	x(t)
Aizoaceae	*Mesembryanthemum nodiflorum*	slender leaf iceplant	n-n	x	x	x			x	
Poaceae	*Monanthochloe littoralis*	shoregrass	n			x			x	

Family	Scientific Name	Common Name	native/ non-native	(1) 1979	(2) 1981	(3) 1991	(4) 1992	(5) 2001	(6) 2002	(7) 2005
Moraceae	*Morus albus*	white mulberry	n-n			x			x	
Myoporaceae	*Myoporum laetum*	myoporum	n-n	x	x	x		x	x	x
Amaryllidaceae	*Narcissus tazetta*	paper white narcissus	n-n		x				x	
Poaceae	*Nassella cernua*	nodding needlegrass	n			x			x	
Apocynaceae	*Nerium oleander*	oleander	n-n			x			x	
Solanaceae	*Nicotiana glauca*	tree tobacco	n-n	x	x	x		x	x	x
Onagraceae	*Oenothera elata ssp. hirsutissima*	hairy evening primrose	n				x			
Onagraceae	*Oenothera elata ssp. hookeri*	Hooter's evening primrose	n		x	x			x	
Oleaceae	*Olea europaea*	olive	n-n			x			x	
Cactaceae	*Opuntia ficus-indica*	mission cactus	n-n			x			x	
Cactaceae	*Opuntia littoralis*	coastal prickly pear	n			x			x	
Asteraceae	*Osteospermum fruticosum*	African daisy	n-n		x				x	
Oxalidaceae	*Oxalis pes-caprae*	Bermuda buttercup	n-n	x	x	x			x	
Poaceae	*Parapholis incurva*	sickle grass	n-n	x				x	x	x(t)
Poaceae	*Paspalum dilatatum*	Dallis grass	n-n			x			x	
Geraniaceae	*Pelargonium zonale*	garden geranium	n-n			x			x	
Polygonaceae	*Persicaria lapathifolia*	willow weed	n			x	x	x	x	x
Solanaceae	*Petunia parviflora*	wild Petunia	n			x			x	
Boraginaceae	*Phacelia ramosissima*	branching Phacelia	n		x	x				x
Boraginaceae	*Phacelia ramosissima var. austrolitoralis*	branching Phacelia	n				x		x	
Poaceae	*Phalaris paradoxa*	hood Canary grass	n-n							
Fabaceae	*Phaseolus limensis (*)*	marge lima bean	n-n						x	
Arecaceae	*Phoenix canariensis*	Canary island date palm	n-n		x	x		x	x	x

Family	Scientific Name	Common Name	native/ non-native	(1) 1979	(2) 1981	(3) 1991	(4) 1992	(5) 2001	(6) 2002	(7) 2005
Arecaceae	*Phoenix dactylifera*	date palm	n-n			x		x	x	x
Poaceae	*Piptatherum miliaceum*	smilo grass	n-n			x			x	
Plantaginaceae	*Plantago lanceolata*	English plantain	n-n		x	x		x	x	x
Plantaginaceae	*Plantago major*	common plantain	n-n		x	x		x	x	x
Poaceae	*Poa annua*	annual bluegrass	n-n			x			x	
Podocarpaceae	*Podocarpus macrophylla (*)*	yew podocarpus	n-n			x			x	
Caryophyllaceae	*Polycarpon tetraphyllum*	four-leaved allseed	n-n			x			x	
Polygonaceae	*Polygonum aviculare ss. depressum*	common knotweed	n-n			x		x	x	x
Poaceae	*Polypogon monspeliensis*	rabbit's foot grass	n-n			x		x	x	x(t)
Salicaceae	*Populus fremontii*	Fremont cottonwood	n	x	x	x	x	x	x	x
Rosaceae	*Prunus persica*	peach	n-n			x			x	
Rosaceae	*Prunus sp.*	apricot	n-n			x			x	
Asteraceae	*Pseudognaphalium beneolens*	fragrant everlasting cudweed	n		x	x	x		x	
Asteraceae	*Pseudognaphalium bicolor (Bioletti) (*)*	twocolor cudweed	n		x	x	x	x	x	x
Asteraceae	*Pseudognaphalium microcephalum*	small-headed white everlasting	n		x		x		x	
Rosaceae	*Pyracantha sp.*	firethorn	n-n			x			x	
Fagaceae	*Quercus agrifolia*	coast live oak	n			x			x	
Fagaceae	*Quercus virginiana (*)*	mybrid live oak	n-n						x	
Brassicaceae	*Raphanus sativus*	wild radish	n-n	x		x	x	x	x	x
Anacardiaceae	*Rhus integrifolia*	lemonade berry	n		x		x		x	x
Anacardiaceae	*Rhus ovata*	sugar bush	n	x				x	x	x
Grossulariaceae	*Ribes malvaceum*	chaparral currant	n	x	x		x		x	
Euphorbiaceae	*Ricinus communis*	castor bean	n-n	x	x	x		x	x	x

Family	Scientific Name	Common Name	native/ non-native	(1) 1979	(2) 1981	(3) 1991	(4) 1992	(5) 2001	(6) 2002	(7) 2005
Rosaceae	*Rosa californica*	California rose	n			x			x	
Polygonaceae	*Rumex crispus*	curly dock	n-n	x		x		x	x	x
Polygonaceae	*Rumex fueginus*	golden dock	n				x			
Polygonaceae	*Rumex salicifolius*	willow dock	n			x	x	x	x	x
Ruppiaceae	*Ruppia maritima*	ditch grass	n		x		x		x	
Alismataceae	*Sagittaria montevidensis ssp. calycina*	Montevideo arrowhead	n		x		x		x	
Chenopodiaceae	*Salicornia subterminalis*	Parish's pickleweed	n	x		x	x	x	x	x(t)
Chenopodiaceae	*Salicornia virginica*	common pickleweed	n	x		x	x	x	x	x(t)
Salicaceae	*Salix exigua*	narrow-leaved willow	n			x			x	
Salicaceae	*Salix gooddingii*	black willow	n						x	
Salicaceae	*Salix laevigata*	red willow	n	x	x	x	x	x	x	x
Salicaceae	*Salix lasiolepis*	arroyo willow	n		x	x	x	x	x	x
Chenopodiaceae	*Salsola tragus*	Russian thistle	n-n			x	x	x	x	x(t)
Adoxaceae	*Sambucus nigra ssp. canadensis (**)*	blue elderberry	n-n			x			x	
Anacardiaceae	*Schinus molle*	Peruvian pepper tree	n-n		x	x			x	
Anacardiaceae	*Schinus terebinthifolius*	Brazilian pepper tree	n-n			x		x	x	x
Poaceae	*Schismus barbatus*	Mediterranean grass	n-n			x			x	
Cyperaceae	*Schoenoplectus americanus*	Olney bulrush	n		x	x	x		x	
Cyperaceae	*Schoenoplectus californicus*	California bulrush	n		x	x	x		x	
Asteraceae	*Senecio vulgaris*	common groundsel	n-n		x				x	
Aizoaceae	*Sesuvium verrucosum*	western sea-purslane	n	x			x		x	
Poaceae	*Setaria gracilis*	bristlegrass	n			x			x	
Caryophyllaceae	*Silene gallica*	small-flowered catchfly	n-n							

Family	Scientific Name	Common Name	native/ non-native	(1) 1979	(2) 1981	(3) 1991	(4) 1992	(5) 2001	(6) 2002	(7) 2005
Asteraceae	*Silybum marianum*	milk thistle	n-n		x	x			x	
Brassicaceae	*Sisymbrium altissimum*	tumble-mustard	n-n			x			x	
Brassicaceae	*Sisymbrium irio*	London rocket	n-n			x			x	
Solanaceae	*Solanum americanum*	small-flowered nightshade	n			x			x	
Solanaceae	*Solanum douglasii*	Douglas's Nightshade	n		x	x	x	x	x	x
Solanaceae	*Solanum nigrum*	black nightshade	n-n		x	x			x	
Solanaceae	*Solanum sarrachoides (**)*	hairy nightshade	n-n		x				x	
Solanaceae	*Solanum xanti*	chaparral nightshade	n	x		x			x	
Asteraceae	*Solidago velutina ssp. californica*	California goldenrod	n			x			x	
Asteraceae	*Sonchus asper ssp. asper*	prickly sow thistle	n-n		x	x	x	x	x	x(t)
Asteraceae	*Sonchus oleraceus*	common sow thistle	n-n	x	x	x			x	
Poaceae	*Sorghum halepense*	Johnson's grass	n-n			x			x	
Poaceae	*Sorghum nutans (*)*	Indian grass	n-n			x			x	
Fabaceae	*Spartium junceum*	Spanish broom	n-n			x			x	
Caryophyllaceae	*Spergularia bocconi*	Boccone's sandspurrey	n-n			x	x	x	x	
Caryophyllaceae	*Spergularia macrotheca*	salt marsh sand spurry	n	x			x			
Caryophyllaceae	*Spergularia marina*	hairy sand spurry	n	x		x	x		x	
Caryophyllaceae	*Spergularia villosa*	sand spurrey	n-n			x			x	
Poaceae	*Stenotaphrum secundatum*	St. Augustine grass	n-n			x			x	
Asteraceae	*Stephanomeria exigua*	small wire lettuce	n		x		x		x	
Asteraceae	*Stephanomeria sp.*	milk aster	n					x		x
Asteraceae	*Stephanomeria virgata*	tall stephanomeria	n		x	x	x		x	
Chenopodiaceae	*Suaeda calceoliformis*	horned sea blite	n		x		x		x	

Family	Scientific Name	Common Name	native/ non-native	(1) 1979	(2) 1981	(3) 1991	(4) 1992	(5) 2001	(6) 2002	(7) 2005
Chenopodiaceae	*Suaeda sp.*	sea-blite	n	x				x	x	x
Chenopodiaceae	*Suaeda taxifolia*	woolly sea-blite	n			x			x	
Asteraceae	*Taraxacum officinale*	dandelion	n-n			x			x	
Aizoaceae	*Tetragonia tetragonoiodes*	New Zealand spinach	n-n		x	x				
Zygophyllaceae	*Tribulus terrestris*	puncture vine	n-n						x	
Tropaeolaceae	*Tropaeolum majus*	garden nasturtium	n					x		x
Typhaceae	*Typha domingensis*	southern Cattail	n				x		x	
Typhaceae	*Typha latifolia*	broad-leaved Cattail	n				x		x	x
Typhaceae	*Typha sp.*	cattail	n						x	
Ulmaceae	*Ulmus parvifolia*	Chinese elm	n-n						x	
Ulmaceae	*Ulmus sp.*	elm	n-n						x	
Urticaceae	*Urtica dioica ssp. holosericea*	hoary nettle	n				x		x	
Urticaceae	*Urtica urens*	dwarf nettle	n-n						x	
Scrophulariaceae	*Verbascum virgatum*	wand mullein	n-n						x	
Verbenaceae	*Verbena lasiostachys*	common Verbena	n				x		x	
Poaceae	*Vulpia myuros var. myuros*	rat-tailed fescue	n-n					x	x	
Poaceae	*Vulpia myuros*	rat-tailed fescue	n-n							x
Poaceae	*Vulpia myuros var. hirsuta*	rat-tailed fescue	n-n				x	x	x	
Arecaceae	*Washingtonia robusta*	slender fan palm	n-n						x	x
Arecaceae	*Washingtonia sp.*	fan palm	n-n						x	
Asteraceae	*Xanthium sp.*	cocklebur		x					x	
Asteraceae	*Xanthium spinosum*	spiny cocklebur	n						x	
Asteraceae	*Xanthium strumarium*	rough cocklebur	n				x	x	x	x
Liliaceae	*Yucca gloriosa (*)*	Spanish dagger	n-n						x	

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Note:
(*) = unpublished, invalidly published, illegitimate, or rejected name for taxon native to CA **OR** not found on Jepson interchange
(**) = taxonomic or nomenclatural synonym for taxon not occurring in CA (erroneous reports, misapplication of names, misidentifications, other exclusions

APPENDIX C.2

Plant Community Alliances and Habitat Types within the Ballona Wetlands Ecological Reserve based on California Department of Fish and Game surveys completed in 2007

Area	Habitat	Plant Community	Acres
A	Riparian scrub	*Baccharis salicifolia* alliance	3.23
A	Seasonal wetland	*Salicornia virginica* - annual grass	10.92
A	Upland dune	*Lotus scoparius* alliance	1.03
A	Upland forest	*Eucalyptus* spp.	0.57
A	Upland grassland/herbs	*Bromus diandrus* - mixed herb association	6.56
A	Upland grassland/herbs	*Centaurea diluta*	0.68
A	Upland grassland/herbs	*Chrysanthemum coronarium*	18.24
A	Upland grassland/herbs	Exotic landscaping	2.18
A	Upland grassland/herbs	Ruderal herbaceous (tall)	36.30
A	Upland scrub	*Atriplex lentiformis* alliance	10.91
A	Upland scrub	*Baccharis pilularis - Artemisia californica* association	1.38
A	Upland scrub	*Baccharis pilularis* / annual grass - herb association	4.32
A	Upland scrub	*Baccharis pilularis* alliance	16.10
A	Upland scrub	*Carpobrotus edulis - Baccharis pilularis - Chrysanthemum coronarium*	7.10
A	Upland scrub	*Carpobrotus edulis* association	6.04
A	Upland scrub	*Malosma laurina*	11.63
B	Brackish marsh	*Leymus triticoides* alliance	0.37
B	Brackish marsh	Schoenoplectus (*S. californicus, S. americanus, S. maritimus)*	1.95
B	Brackish marsh	*Schoenoplectus americanus* alliance	0.69
B	Estuarine high marsh	*Cressa truxillensis*	11.64
B	Estuarine high marsh	*Distichlis spicata* alliance	3.51
B	Estuarine high marsh	*Frankenia salina*	1.38
B	Estuarine high marsh	*Frankenia salina - Distichlis spicata* association	0.74
B	Estuarine high marsh	*Malva leprosa*	1.01
B	Estuarine high marsh	*Salicornia subterminalis* alliance	0.20
B	Estuarine high marsh	*Salicornia virginica - Salicornia subterminalis* association	12.74
B	Estuarine high marsh	*Salicornia virginica* alliance	11.70
B	Estuarine low marsh	*Jaumea carnosa*	0.80
B	Estuarine low marsh	*Salicornia virginica* alliance	7.72
B	Estuarine mid marsh	*Distichlis spicata - Salicornia virginica - Jaumea carnosa* association	3.17
B	Estuarine mid marsh	*Salicornia virginica* - annual grass	0.73

Area	Habitat	Plant Community	Acres
B	Estuarine mid marsh	*Salicornia virginica - Distichlis spicata* association	7.40
B	Estuarine mid marsh	*Salicornia virginica - Salicornia subterminalis* association	1.17
B	Estuarine mid marsh	*Salicornia virginica* alliance	3.95
B	Freshwater wetland	*Anemopsis californica* alliance	0.36
B	Freshwater wetland	*Euthamia occidentalis*	0.14
B	Freshwater wetland	*Juncus balticus - Juncus mexicanus* alliance	0.12
B	Freshwater wetland	*Typha* spp. alliance	0.45
B	Intertidal channel	Open water	2.23
B	Riparian forest	*Eucalyptus* spp.	2.90
B	Riparian scrub	*Arundo donax* alliance	0.69
B	Riparian scrub	*Baccharis salicifolia* alliance	5.44
B	Riparian scrub	*Clematis ligusticifolia*	0.26
B	Riparian scrub	*Salix exigua* alliance	0.14
B	Riparian scrub	*Salix lasiolepis* alliance	8.77
B	Salt pan	Unvegetated (salt scald)	22.37
B	Seasonal wetland	*Cressa truxillensis*	19.48
B	Seasonal wetland	*Distichlis spicata* alliance	0.35
B	Seasonal wetland	*Malva leprosa*	7.99
B	Seasonal wetland	*Salicornia virginica* - annual grass	3.56
B	Seasonal wetland	*Salicornia virginica* alliance	41.16
B	Unvegetated	Developed unpaved	0.38
B	Unvegetated	Unvegetated (cleared)	8.62
B	Unvegetated	Unvegetated (no vegetation this year)	0.82
B	Unvegetated	Unvegetated (unspecified)	1.11
B	Upland dune	*Carpobrotus edulis* association	2.33
B	Upland dune	*Lotus scoparius - Croton californicus*	4.04
B	Upland dune	*Lupinus chamissonis*	3.54
B	Upland forest	*Eucalyptus* spp.	0.15
B	Upland grassland/herbs	*Ambrosia psilostachya* alliance	0.12
B	Upland grassland/herbs	*Brassica nigra*	29.25
B	Upland grassland/herbs	*Bromus diandrus* - mixed herb association	5.45
B	Upland grassland/herbs	California annual grassland alliance	1.20
B	Upland grassland/herbs	*Cortaderia selloana* association	4.80
B	Upland grassland/herbs	*Euphorbia terracina*	0.24
B	Upland grassland/herbs	Exotic landscaping	0.76
B	Upland	*Lolium multiflorum* alliance	7.94

Area	Habitat	Plant Community	Acres
	grassland/herbs		
B	Upland grassland/herbs	Ruderal herbaceous	10.77
B	Upland grassland/herbs	Ruderal herbaceous (tall)	2.19
B	Upland scrub	*Acacia* spp.	1.77
B	Upland scrub	*Artemisia californica* association	1.49
B	Upland scrub	*Atriplex semibaccata*	1.11
B	Upland scrub	*Baccharis pilularis* / annual grass - herb association	1.00
B	Upland scrub	*Carpobrotus edulis* association	14.37
B	Upland scrub	Exotic woody - mixed herb	3.69
B	Upland scrub	*Lotus scoparius* alliance	0.10
B	Upland scrub	*Myoporum laetum*	1.27
C	Brackish marsh	Schoenoplectus (*S. californicus, S. americanus, S. maritimus)*	0.11
C	Riparian scrub	*Baccharis salicifolia* alliance	2.30
C	Seasonal wetland	*Frankenia salina*	0.59
C	Upland dune	*Lotus scoparius - Croton californicus*	2.06
C	Upland grassland/herbs	*Bromus diandrus* - mixed herb association	7.95
C	Upland grassland/herbs	California annual grassland alliance	26.57
C	Upland grassland/herbs	*Centaurea diluta*	0.19
C	Upland grassland/herbs	*Chrysanthemum coronarium*	1.13
C	Upland grassland/herbs	*Euphorbia terracina*	1.39
C	Upland grassland/herbs	*Heterotheca grandiflora*	1.81
C	Upland grassland/herbs	Ruderal herbaceous (tall)	10.65
C	Upland scrub	*Atriplex lentiformis* alliance	2.95
C	Upland scrub	*Baccharis pilularis - Artemisia californica* association	3.94
C	Upland scrub	*Baccharis pilularis* alliance	2.65
C	Upland scrub	*Carpobrotus edulis* association	0.37

APPENDIX C.3

Special status plant species that ***may*** occur, or are known to occur in habitats similar to those found in the Ballona Wetlands Ecological Reserve. Note: List compiled from the U.S. Fish and Wildlife Service (USFWS) Species Lists (September 2010), California Native Plant Society (CNPS) Electronic Inventory (September 2010) and California Natural Diversity Database (CNDDB) (September 2010) searches of the Venice, Redondo Beach, Beverly Hills, and Topanga USGS 7.5 minute quadrangles. Appendix reproduced from WRA 2011.

SPECIES	STATUS*	HABITAT REQUIREMENTS	POTENTIAL TO OCCUR IN PROJECT AREA	RESULTS AND RECOMMENDATIONS
Red sand verbena *Abronia maritima*	List 4	Coastal dunes. Elevation range: 0 – 325 feet. Blooms: February – November.	**Moderate Potential.** The Reserve contains restored coastal dune habitat that may support this species.	**Not Observed.** Focused rare plant survey in October did not observe this species in the Reserve.
Aphanisma *Aphanisma blitoides*	List 1B	Coastal bluff scrub, coastal dunes, coastal scrub. Typically located on bluffs and slopes near the ocean on sandy or clay soils. Elevation range: 1 – 990 feet. Blooms: March – June.	**Unlikely.** Although the Reserve contains restored coastal dune and coastal scrub habitat, this species is known primarily from the Channel Islands and drier, steeper bluff sites not present in the Reserve.	No further actions are recommended for this species.
Marsh sandwort *Arenaria paludicola*	FE, SE, List 1B	Marshes and swamps. Typically located in dense mats of emergent marsh vegetation. Elevation range: 485 – 3965 feet. Blooms: May – August.	**Unlikely.** Although the Reserve contains coastal salt marsh habitat, this species is closely associated with freshwater wetland habitat.	No further actions are recommended for this species.
Braunton's milk-vetch *Astragalus brauntonii*	FE, List 1B	Closed-cone coniferous forest, chaparral, coastal scrub, valley and foothill grassland. Often in recent burns or disturbed areas on gravelly clay soils overlying granite or limestone. Elevation range: 10 – 2075 feet. Blooms: January – August.	**Unlikely.** Although the Reserve contains coastal scrub habitat, this species is known from more inland sites.	No further actions are recommended for this species.
Ventura milk-vetch *Astragalus pycnostachyus* var. *lanosissimus*	FE, SE, List 1B	Coastal salt marsh, coastal dune, coastal scrub. Typically located within reach of high tide protected by barrier beaches and near seeps on sandy bluffs. Elevation range: 1 – 115 feet. Blooms: June – October.	**Moderate Potential.** The Reserve contains coastal salt marsh, restored coastal dune, and coastal scrub habitat that may support this species. Nearest known occurrence is less than 1.5 miles to the north.	**Not Observed.** Focused rare plant surveys in July and October did not observe this species in the Reserve.
Coastal dunes milk-vetch *Astragalus tener* var. *titi*	FE, SE, List 1B	Coastal bluff scrub, coastal dunes. Located on moist, sandy depressions of bluffs and dunes along or near the ocean. Elevation range: 1 – 165 feet. Blooms: March – May.	**Moderate Potential.** The Reserve contains restored coastal dune habitat that may support this species.	**Not Observed.** Focused rare plant surveys in April did not observe this species in the Reserve.
South Coast saltscale *Atriplex pacifica*	List 1B	Coastal scrub, coastal bluff scrub, playas, chenopod scrub. Located on alkali soils. Elevation range: 0 – 460 feet. Blooms: March – October.	**Moderate Potential.** The Reserve contains coastal scrub habitat that may support this species.	**Not Observed.** Focused rare plant surveys in April, July, and October did not observe this species in the Reserve.

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SPECIES	STATUS*	HABITAT REQUIREMENTS	POTENTIAL TO OCCUR IN PROJECT AREA	RESULTS AND RECOMMENDATIONS
Parish's brittlescale *Atriplex parishii*	List 1B	Alkali meadows, vernal pools, chenopod scrub, playas. Typically located on alkali flats with finely textured soils. Elevation range: 80 – 6160 feet. Blooms: June – October.	**Moderate Potential.** The Reserve contains playa-like and alkali meadow habitat that may support this species.	**Not Observed.** Focused rare plant surveys in July and October did not observe this species in the Reserve.
Davidson's saltscale *Atriplex serenana* var. *davidsonii*	List 1B	Coastal bluff scrub, coastal scrub. Located on alkaline soils. Elevation range: 30 – 650 feet. Blooms: April – October.	**Moderate Potential.** The Reserve contains coastal scrub habitat underlain by alkaline substrate that may support this species.	**Not Observed.** Focused rare plant survey in October did not observe this species in the Reserve.
Brewer's red maids *Calandrinia breweri*	List 4	Chaparral, coastal scrub. Located on sandy or loamy soils, often in disturbed areas. Elevation range: 30 – 3695 feet. Blooms: March – June.	**Unlikely.** Although the Reserve contains coastal scrub habitat, this species is known from more inland sites at higher elevations.	No further actions are recommended for this species.
Seaside red maids *Calandrinia maritima*	List 4	Coastal bluff scrub, coastal scrub, valley and foothill grassland. Elevation range: 15 – 975 feet. Blooms: sometimes February, March – June, sometimes August.	**Unlikely.** Although the Reserve contains coastal scrub habitat, this species is known from the Channel Islands.	No further actions are recommended for this species.
Plummer's mariposa-lily *Calochortus plummerae*	List 1B	Coastal scrub, chaparral, valley and foothill grassland, cismontane woodland, lower montane coniferous forest. Located on rocky and sandy sites derived from granitic or alluvial material; often occurs following fires. Elevation range: 320 – 5510 feet. Blooms: May – July.	**Unlikely.** Although the Reserve contains coastal scrub habitat, this species is known from sites with higher elevation and further inland.	No further actions are recommended for this species.
Santa Barbara morning-glory *Calystegia sepium* ssp. *binghamiae*	List 1A	Coastal marshes. Elevation range: 0 – 65 feet. Blooms: April – May.	**Moderate Potential.** The Reserve contains coastal salt marsh habitat that may support this species.	**Not Observed.** Focused rare plant survey in April did not observe this species in the Reserve.
Lewis' evening-primrose *Camissoniopsis lewisii* [*Camissonia lewisii*]	List 3	Coastal bluff scrub, cismontane woodland, coastal dunes, coastal scrub, valley and foothill grassland. Elevation range: 0 – 975 feet. Blooms: March – May, sometimes June.	**High Potential.** The Reserve contains restored coastal dune and coastal scrub habitat that may support this species. Known occurrence from previous studies suggest this species is present in the Reserve.	**Present.** Focused rare plant survey in April located this species in Areas A and C1.
Southern tarplant *Centromadia parryi* ssp. *australis*	List 1B	Marshes and swamps margins, valley and foothill grassland. Often located on disturbed sites near the coast on alkali soils. Elevation range: 0 – 1385 feet. Blooms: May – November.	**High Potential.** The Reserve contains coastal salt marsh habitat that may support this species. Known occurrence from previous studies suggest this species is present in the Reserve.	**Not Observed.** Focused rare plant survey in July did not observe this species in the Reserve.

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SPECIES	STATUS*	HABITAT REQUIREMENTS	POTENTIAL TO OCCUR IN PROJECT AREA	RESULTS AND RECOMMENDATIONS
Orcutt's pincushion *Chaenactis glabriuscula* var. *orcuttiana*	List 1B	Coastal bluff scrub, coastal dunes. Located on sandy soils. Elevation range: 10 – 330 feet. Blooms: January – August.	**High Potential.** The Reserve contains restored coastal dune habitat that may support this species. Known occurrence from previous studies suggest this species is present in the Reserve.	**Present.** Focused rare plant survey in April located this species in Area B1.
Coastal goosefoot *Chenopodium littoreum*	List 1B	Coastal dunes. Located on sandy soils. Elevation range: 30 – 95 feet. Blooms: April – August.	**Moderate Potential**. The Reserve contains coastal dune habitat that may support this species.	**Not Observed.** Focused rare plant survey in April did not observe this species in the Reserve.
San Fernando Valley spineflower *Chorizanthe parryi* var. *fernandina*	FC, SE, List 1B	Coastal scrub. Located on sandy soils. Elevation range: 490 – 4000 feet. Blooms: April – July.	**Moderate Potential.** The Reserve contains coastal scrub habitat that may support this species. Known occurrence from Ballona Harbor less than 1 mile to the north.	**Not Observed.** Focused rare plant survey in July did not observe this species in the Reserve.
Small-flowered morning-glory *Convolvulus simulans*	List 4	Chaparral, coastal scrub, valley and foothill grassland. Located in openings on clay soils and serpentine seeps. Elevation range: 95 – 2275 feet. Blooms: March – July.	**Unlikely.** Although the Reserve contains coastal scrub habitat, this species is known from sites with higher elevation and further inland.	No further actions are recommended for this species.
Salt marsh bird's-beak *Cordylanthus maritimus* ssp. *maritimus*	FE, SE, List 1B	Coastal salt marsh, coastal dunes. Located on the higher zones of salt marshes. Elevation range: 0 – 100 feet. Blooms: May – October.	**Moderate Potential.** The Reserve contains coastal salt marsh habitat that may support this species.	**Not Observed.** Focused rare plant surveys in July and October did not observe this species in the Reserve.
Paniculate tarplant *Deinandra paniculata*	List 4	Coastal scrub, valley and foothill grassland, vernal pools. Typically located on vernally mesic sites. Elevation range: 80 – 3055 feet. Blooms: April – November.	**Moderate Potential.** The Reserve contains coastal scrub habitat that may support this species.	**Not Observed.** Focused rare plant surveys in July and October did not observe this species in the Reserve.
Western pony's-foot *Dichondra occidentalis*	List 4	Chaparral, cismontane woodland, valley and foothill grassland, coastal scrub. Elevation range: 160 – 1625 feet. Blooms: sometimes January, March – July.	**High Potential.** The Reserve contains coastal scrub habitat that may support this species. Reported occurrences from previous studies suggest this species is present in the Reserve (Existing Conditions citing Hendrickson 1991 EIR).	**Not Observed.** Focused rare plant surveys in April and July did not observe this species in the Reserve.

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SPECIES	STATUS*	HABITAT REQUIREMENTS	POTENTIAL TO OCCUR IN PROJECT AREA	RESULTS AND RECOMMENDATIONS
Beach spectaclepod *Dithyrea maritima*	ST, List 1B	Coastal dunes, coastal scrub. Located at sea shores on sand dunes and sandy places near the shore. Elevation range: 10 – 165 feet. Blooms: March – May.	**Moderate Potential.** The Reserve contains restored coastal dune and coastal scrub habitat that may support this species. Additionally, the nearest known occurrence is from "vicinity of Ballona Marshes" (CNDDB 2010).	**Not Observed.** Focused rare plant survey in April did not observe this species in the Reserve.
Santa Monica dudleya *Dudleya cymosa* ssp. *ovatifolia*	FT, List 1B	Chaparral, coastal scrub. Located in canyons on sedimentary conglomerates on primarily north-facing slopes. Elevation range: 485 – 5430 feet. Blooms: March – June.	**Unlikely.** Although the Reserve contains coastal scrub habitat, this species is known from sites with higher elevation and further inland.	No further actions are recommended for this species.
Many-stemmed dudleya *Dudleya multicaulis*	List 1B	Chaparral, coastal scrub, valley and foothill grassland. Located on clay soils. Elevation range: 45 – 2560 feet. Blooms: April – July.	**Moderate Potential.** The Reserve contains coastal scrub habitat that may support this species.	**Not Observed.** Focused rare plant survey in July did not observe this species in the Reserve.
Island green dudleya *Dudleya virens* ssp. *insularis*	List 1B	Coastal bluff scrub, coastal scrub. Located on rocky sites. Elevation range: 15 – 975 feet. Blooms: April – June.	**Unlikely.** Although the Reserve contains coastal scrub habitat, this species typically is known from rocky, bluff sites in coastal scrub.	No further actions are recommended for this species.
Suffrutescent wallflower *Erysimum insulare* ssp. *suffrutescens*	List 4	Coastal bluff scrub, coastal scrub, valley and foothill grassland. Elevation range: 0 – 490 feet. Blooms: January – July.	**High Potential.** The Reserve contains coastal scrub habitat that may support this species. Known occurrence from previous studies suggest this species is present in the Reserve.	**Present.** Focused rare plant survey in July and April observed this species in the Area B1.
Los Angeles sunflower *Helianthus nuttallii* ssp. *parishii*	List 1A	Coastal salt and freshwater marshes and swamps. Elevation range: 30 – 5445 feet. Blooms: August – October.	**Moderate Potential.** The Reserve contains coastal salt marsh habitat that may support this species.	**Not Observed.** Focused rare plant survey in October did not observe this species in the Reserve.
Vernal barley *Hordeum intercedens*	List 3	Coastal dunes, coastal scrub, valley and foothill grassland, vernal pools. Located on saline flats and depressions. Elevation range: 15 – 3240 feet. Blooms: March – June.	**Moderate Potential.** The Reserve contains coastal scrub and restored coastal dune habitat that may support this species.	**Not Observed.** Focused rare plant survey in April did not observe this species in the Reserve.
Mesa horkelia *Horkelia cuneata* ssp. *puberula*	List 1B	Chaparral, cismontane woodland, coastal scrub. Elevation range: 225 – 2625 feet. Blooms: February – July, sometimes September.	**Unlikely.** Although the Reserve contains coastal scrub habitat, this species is known from sites with higher elevation and further inland.	No further actions are recommended for this species.

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SPECIES	STATUS*	HABITAT REQUIREMENTS	POTENTIAL TO OCCUR IN PROJECT AREA	RESULTS AND RECOMMENDATIONS
Southwestern spiny rush *Juncus acutus* ssp. *leopoldii*	List 4	Coastal dunes, meadows and seeps, coastal salt marshes. Located on mesic, alkali sites. Elevation range: 10 – 2925 feet. Blooms: May – June.	**Moderate Potential.** The Reserve contains coastal salt marsh and restored coastal dune habitat that may support this species.	**Not Observed.** Focused rare plant survey in April did not observe this species in the Reserve.
Coulter's goldfields *Lasthenia glabrata* ssp. *coulteri*	List 1B	Coastal salt marshes, playas, valley and foothill grassland, vernal pools. Typically located on alkaline soils in playas, sinks, and grasslands. Elevation range: 1 – 3955 feet. Blooms: February – June.	**High Potential.** The Reserve contains coastal salt marsh habitat that may support this species. Although last observed in 1934, the nearest known occurrence of this species is known from "Ballona Marshes".	**Not Observed.** Focused rare plant survey in April did not observe this species in the Reserve.
California spineflower *Mucronea californica*	List 4	Chaparral, cismontane woodland, coastal dunes, coastal scrub, valley and foothill grassland. Located on sandy soils. Elevation range: 0 – 4550 feet. Blooms: March – July, sometimes August.	**Moderate Potential.** The Reserve contains restored coastal dune and coastal scrub habitat underlain by sandy substrate that may support this species.	**Not Observed.** Focused rare plant surveys in April and July did not observe this species in the Reserve.
Mud nama *Nama stenocarpum*	List 2	Marshes and swamps. Located on lake shores, streams banks, and intermittently wet areas. Elevation range: 15 – 1620 feet. Blooms: January – July.	**Moderate Potential.** The Reserve contains freshwater marsh margins that may support this species. Additionally, the nearest known occurrence of this species is from less than four miles to the north.	**Not Observed.** Focused rare plant survey in July did not observe this species in the Reserve.
Gambel's watercress *Nasturtium gambellii*	FE, ST, List 1B	Brackish and freshwater marshes and swamps. Located on lake and stream margins at or immediately above the water line. Elevation range: 15 – 1075 feet. Blooms: April – October.	**Unlikely.** Although the Reserve contains coastal salt marsh habitat, this species is known from freshwater and brackish marshes with lower salinity.	No further actions are recommended for this species.
Moran's nosegay *Navarretia fossalis*	FT, List 1B	Vernal pools, chenopod scrub, marshes and swamps, playas. Located on hardpan soils in swales, depressions, and pools. Elevation range: 95 – 4225 feet. April – June.	**Unlikely.** Although the Reserve contains marsh habitat, this species is known from more inland sites with lesser salinity and higher elevation.	No further actions are recommended for this species.
Prostrate vernal pool navarretia *Navarretia prostrata*	List 1B	Coastal scrub, valley and foothill grassland, vernal pools. Elevation range: 45 – 2270 feet. Blooms: April – July.	**Unlikely.** Although the Reserve contains coastal scrub, this species is requires freshwater vernal pool habitat not present in the Reserve.	No further actions are recommended for this species.
Coast woolly-heads *Nemacaulis denudata* var. *denudata*	List 1B	Coastal dunes. Elevation range: 0 – 325 feet. Blooms: April – September.	**Unlikely.** Although the Reserve contains restored dune habitat, this species is known only from south of Rancho Palos Verdes.	No further actions are recommended for this species.

APPENDIX C.3

SPECIES	STATUS*	HABITAT REQUIREMENTS	POTENTIAL TO OCCUR IN PROJECT AREA	RESULTS AND RECOMMENDATIONS
California Orcutt grass *Orcuttia californica*	FE, SE, List 1B	Vernal pools. Elevation range: 45 – 2145 feet. Blooms: April – August.	**No Potential.** The Reserve does not contain vernal pool habitat.	No further actions are recommended for this species.
Lyon's Pentachaeta *Pentachaeta lyonii*	FE, SE, List 1B	Chaparral, valley and foothill grassland. Located on the edge of openings at the ecotone between chaparral and grassland. Elevation range: 95 – 2050 feet. Blooms: March – August.	**No Potential.** The Reserve does not contain chaparral or intact grassland habitat.	No further actions are recommended for this species.
South Coast branching phacelia *Phacelia ramosissima* var. *austrolitoralis*	List 4	Chaparral, coastal dunes, coastal scrub, coastal salt marshes. Located on sandy, often rocky soils. Elevation range: 20 – 975 feet. Blooms: March – August.	**High Potential.** The Reserve contains restored coastal dune, coastal scrub, and coastal salt marsh habitat that may support this species. Additionally, the nearest documented occurrence is from within the Reserve.	Focused rare plant surveys in July, October, and April located this species; however, recent taxonomic descriptions do not recognize varieties (Jepson 2011).
Brand's star phacelia *Phacelia stellaris*	FC, List 1B	Coastal scrub, coastal dunes. Located in open areas. Elevation range: 1 – 1300 feet. Blooms: March – June.	**Moderate Potential.** The Reserve contains coastal scrub and coastal dune habitat that may support this species. Additionally, the nearest known occurrence of this species from less than one mile to the south.	**Not Observed.** Focused rare plant survey in April did not observe this species in the Reserve.
Ballona cinquefoil *Potentilla multijuga*	List 1A	Brackish meadows and seeps. Elevation range: 0 – 10 feet. Blooms: June – August.	**Moderate Potential.** The Reserve contains brackish grassland sites. The Reserve is the type locality of this species; however, it is presumed extinct.	**Not Observed.** Focused rare plant survey in July did not observe this species in the Reserve.
White rabbit-tobacco *Pseudognaphalium leucocephalum*	List 2	Riparian woodland, cismontane woodland, coastal scrub, chaparral. Elevation range: 0 – 6825 feet. Blooms: sometimes July, August – November, sometimes December.	**Unlikely.** Although the Reserve contains coastal scrub habitat, this species is known primarily from sites further inland.	No further actions are recommended for this species.
Salt Spring checkerbloom *Sidalcea neomexicana*	List 2	Alkali playas, brackish marshes, chaparral, coastal scrub, lower montane coniferous forest, Mojavean Desert scrub. Located on alkali springs and marshes. Elevation range: 45 – 4960 feet. Blooms: March – June.	**Moderate Potential.** The Reserve contains brackish marsh and coastal scrub habitat that may support this species.	**Not Observed.** Focused rare plant surveys in April did not observe this species in the Reserve.

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SPECIES	STATUS*	HABITAT REQUIREMENTS	POTENTIAL TO OCCUR IN PROJECT AREA	RESULTS AND RECOMMENDATIONS
Estuary seablite *Suaeda esteroa*	List 1B	Coastal salt marshes. Located on clay, silt, and sand substrates. Elevation range: 0 – 15 feet. Blooms: May – October.	**High Potential.** The Reserve contains coastal salt marsh habitat. Reported occurrences from previous studies suggest this species is present in the Reserve (Existing Conditions citing Hendrickson 1991 EIR).	**Not Observed.** Focused rare plant surveys in July and October did not observe this species in the Reserve.
Woolly seablite *Suaeda taxifolia*	List 4	Coastal bluff scrub, coastal dunes, margins of coastal salt marshes. Elevation range: 0 – 165 feet. Blooms: January – December.	**High Potential.** The Reserve contains coastal salt marsh and coastal dune habitat. Known occurrences from previous studies suggest this species is present in the Reserve.	**Present.** Focused rare plant surveys in April, July, and October located this species in Area B1.
San Bernardino aster *Symphyotrichum defoliatum*	List 1B	Meadows and seeps, marshes and swamps, coastal scrub, cismontane woodland, lower montane coniferous forest, grassland. Located in mesic grassland near ditches, streams, and springs. Elevation range: 5 – 6630 feet. Blooms: July – November.	**Unlikely.** Although the Reserve contains coastal scrub habitat, this species is known from sites further inland.	No further actions are recommended for this species.
Greata's aster *Symphyotrichum greatae*	List 1B	Chaparral, cismontane woodland. Located in mesic canyons. Elevation range: 975 – 6535 feet. Blooms: June – October.	**No Potential.** The Reserve does not contain chaparral or woodland habitat to support this species.	No further actions are recommended for this species.

APPENDIX C.3

*** Key to status codes:**

FE	Federal Endangered
FT	Federal Threatened
FC	Federal Candidate
FD	Federal De-listed
BCC	USFWS Birds of Conservation Concern
SE	State Endangered
SD	State Delisted
ST	State Threatened
SR	State Rare
SSC	CDFG Species of Special Concern
CFP	CDFG Fully Protected Animal
WBWG	Western Bat Working Group High or Medium Priority species
List 1A	CNPS List 1A: Plants presumed extinct in California
List 1B	CNPS List 1B: Plants rare, threatened or endangered in California and elsewhere
List 2	CNPS List 2: Plants rare, threatened, or endangered in California, but more common elsewhere
List 3	CNPS List 3: Plants about which CNPS needs more information (a review list) *[not special status]*
List 4	CNPS List 4: Plants of limited distribution (a watch list) *[not special status]*

Species Evaluations:
No Potential. Habitat on and adjacent to the site is clearly unsuitable for the species requirements (cover, substrate, elevation, hydrology, plant community, site history, disturbance regime).
Unlikely. Few of the habitat components meeting the species requirements are present, and/or the majority of habitat on and adjacent to the site is unsuitable or of very poor quality. The species is not likely to be found on the site.
Moderate Potential. Some of the habitat components meeting the species requirements are present, and/or only some of the habitat on or adjacent to the site is unsuitable. The species has a moderate probability of being found on the site.
High Potential. All of the habitat components meeting the species requirements are present and/or most of the habitat on or adjacent to the site is highly suitable. The species has a high probability of being found on the site.
Present. Species was observed on the site or has been recorded (i.e. CNDDB, other reports) on the site recently.

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APPENDIX C.4

Method comparison and rationale for Baseline Assessment Program vegetation surveys

Long-term monitoring of vegetation composition is one of the most common methods of evaluation of the health and functioning of a wetland system (Zedler 2001). Change in the relative presences of native and non-native plant species can be indicative of the distribution of associated wildlife species. For example, the endangered Belding's savannah sparrow frequently utilizes the native *Salicornia virginica* (pickleweed) for nesting habitat or other salt marsh related species, including *Distichlis spicata* (saltgrass) and *Salicornia subterminalis* (Parish's pickleweed) (Powell 1993, Zembal and Hoffman 2002, James and Stadtlander 1991, E. Read pers. comm.).

Vegetation Cover Comparison

Many different approaches have been used to estimate plant species cover, especially for terrestrial vegetation (see review in Murray et al. 2006). The majority of current methods for determining vegetation percent cover involve transects allocated within habitat types and some measure of visual estimation of cover within quadrats (Shuman and Ambrose 2003, Ambrose et al. 2006, S. Anderson, pers. comm); although, more general visual percent cover estimates are occasionally used as well (Gustafson 1981, Henrickson 1991). Repeat sampling of permanently marked transects allows for identification of spatial and temporal trends in species composition with less effort compared to randomly placed transect sampling and greater precision than broad scale cover estimates.

Visual estimates of percent cover can be quite rapid, but are subject to bias, including over- or under-estimating, depending on the rarity of the species in question (Floyd and Anderson 1987, Zedler 2001). These biases can often be decreased with training and quality control methods (Dethier et al. 1993, Parikh and Gale 1998). Using broad ranges of percent cover when making a visual estimate can also reduce the amount of personal error and bias in percent cover estimates while still obtaining relatively accurate data on the vegetation habitat as a whole (Daubenmire 1959). To aid in visual estimation of vegetation cover, the sample frame can be divided into quarter sections using string with an additional outline in one corner separating 5% of the plot area, so that 5, 25, 50, 75, and 95 percent of the plot area are easily recognizable for reference (Figure C.3.1, Daubenmire 1959). Zedler (2001) used similar cover classes when sampling the Tijuana Estuary.

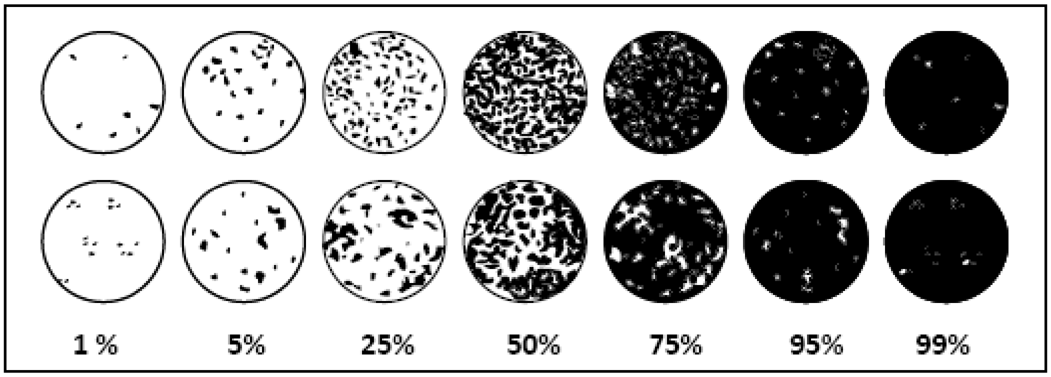

Figure C.3.1. Reference diagram for percent cover estimates (reproduced from Ambrose 2008).

The specific methods for the Baseline Assessment Program (BAP) were developed in collaboration with Dr. Sean Anderson (California State University, Channel Islands), using a quadrat method similar to Zedler (2001), but with the addition of a laser sight technology in the salt marsh habitats to demarcate exact points and reduce observer bias. Both line-intercept and cover class quadrats were used in the upland habitats.

Specific protocols were adapted to be site-specific based on accessibility, habitat type, and time requirements of each survey method. For example, at each upland scrub transect, vegetation data was collected using both the line-intercept method and a cover-class quadrat method due to the high level of habitat heterogeneity. The line-intercept method was chosen because it can be conducted rapidly across a highly variable three-dimensional habitat structure, but can underestimate diversity. The cover-class method was chosen to allow comparison with the other habitat types. A combination of both protocols allows a higher level of species richness to be surveyed.

Sampling time was chosen based on times of peak biomass for each habitat type (e.g. late summer for salt marsh, spring for upland grassland) (Zedler 2001). Access to the salt marsh habitats was prohibited during the Belding's Savannah Sparrow nesting season (i.e. April through the end of June). Sampling was not conducted in salt marsh habitats at that time.

Marsh Seed Bank Rationale

Seed bank information was used in conjunction with percent cover of vegetation to determine the nature of the existing plant community and the potential for future recruitment of plant species into the area. The recruitment and subsequent survival of plants to adulthood may be a better predictor of successful wetland functioning than the presence of adult life history stages (i.e. plant canopy) alone (S. Anderson, *in prep*). However, it should be noted that this method will exclude species that do not rely on seeds for spread (e.g. *Arundo donax*) or whose seeds are not readily incorporated into the seed bank.

Germinated seedlings were used as a proxy for viable seed bank composition and density. In addition to conducting seed bank surveys on a subset of the vegetation transects, an additional four, 100 m seed bank transects were surveyed from several channel banks to obtain an indicator for the maximum seed bank density from the wrack line (S. Anderson, *pers. comm.*). This method has been used recently by Anderson as a standardized surveying effort to compare wetlands across the region. These wrackline seedbank compositions typically represent the maximum seed density and diversity of the marsh and allow for cross-system comparisons.

Algae and Submerged Aquatic Vegetation Cover

Algae cover is an important factor which indicates primary productivity within a system and within the trophic structure; algal abundance and growth are also useful indicators of eutrophication and tidal flushing (Zedler 2001). Algae cover surveys were conducted using the same methods developed by the Southern California Bight '08 eutrophication surveys to obtain comparable data across a larger spatial and temporal scale. These data will be analyzed in the future as part of a long-term monitoring program and in coordination with simultaneously collected data throughout other southern California estuaries as part of our collaborative Bight '08 effort (currently expected to be completed in late 2011).

APPENDIX C.5

Plant species identified within 10 meters of the 170 permanent vegetation transects at the Ballona Wetlands Ecological Reserve

Family	Scientific Name	Common Name	Estuarine Marsh			Seasonal Wetland		Other Marsh		Upland		
			Low	Mid	High	(A)	(B)	Brackish	Freshwater	Dune	Grassland	Scrub
Aizoaceae	*Carpobrotus edulis*	hottentot-fig		X	X			X	X	X	X	X
Aizoaceae	*Mesembryanthemum crystallinum*	crystalline iceplant				X						
Aizoaceae	*Mesembryanthemum nodiflorum*	slenderleaf iceplant			X						X	X
Anacardiaceae	*Schinus terebinthifolius*	Brazilian pepper tree						X		X	X	
Apiaceae	*Foeniculum vulgare*	common fennel						X				
Arecaceae	----	palm tree								X		
Asteraceae	*Ambrosia chamissonis*	ragweed								X		
Asteraceae	*Ambrosia psilostachya*	western ragweed						X		X		
Asteraceae	*Artemisia californica*	California sage brush							X		X	X
Asteraceae	*Baccharis pilularis*	coyote brush				X				X	X	X
Asteraceae	*Baccharis salicifolia*	mule fat				X			X	X		X
Asteraceae	*Centaurea melitensis*	tocalote									X	X
Asteraceae	*Chrysanthemum coronarium*	crown daisy								X	X	X
Asteraceae	*Conyza canadensis*	horseweed						X		X	X	X
Asteraceae	*Ericameria ericoides*	California goldenbush								X		
Asteraceae	*Euthamia occidentalis*	western goldenrod							X			
Asteraceae	*Gnaphalium canescens ssp. beneolens*	everlasting cudweed								X		X
Asteraceae	*Gnaphalium palustre*	western marsh cudweed										X
Asteraceae	*Heterotheca grandiflora*	telegraph weed						X		X	X	X

Family	Scientific Name	Common Name	Estuarine Marsh			Seasonal Wetland		Other Marsh		Upland		
			Low	Mid	High	(A)	(B)	Brackish	Freshwater	Dune	Grassland	Scrub
Asteraceae	*Jaumea carnosa*	fleshy jaumea	X	X	X						X	X
Asteraceae	*Lactuca serriola*	common prickly lettuce									X	X
Asteraceae	*Sonchus arvensis*	field sowthistle						X	X	X	X	
Asteraceae	*Sonchus oleraceus*	common sow thistle						X		X	X	X
Boraginaceae	*Heliotropium curassavicum*	salt heliotrope						X	X			
Brassicaceae	*Brassica nigra*	common black mustard			X	X	X			X	X	X
Brassicaceae	*Raphanus sativus*	wild radish						X	X	X	X	X
Chenopodiaceae	*Atriplex lentiformis*	saltbrush				X						X
Chenopodiaceae	*Atriplex semibaccata*	Australian saltbush		X	X						X	
Chenopodiaceae	*Atriplex triangularis*	spear oracle		X			X	X				X
Chenopodiaceae	*Bassia hyssopifolia*	five-hook bassia		X								X
Chenopodiaceae	*Salicornia subterminalis*	Parish's pickleweed	X	X	X							
Chenopodiaceae	*Salicornia virginica*	salt marsh pickleweed	X	X	X	X	X	X		X	X	X
Convolvulaceae	*Cressa truxillensis*	spreading alkali weed	X	X	X		X			X	X	X
Cuscutaceae	*Cuscuta salina*	Salt marsh dodder		X								
Cyperaceae	*Scirpus* sp.	bulrush					X	X	X			
Euphorbiaceae	*Croton californicus*	California croton								X		
Euphorbiaceae	*Euphorbia terracina*	terracina spurge							X	X	X	X
Euphorbiaceae	*Ricinus communis*	castor bean							X	X		X
Fabaceae	*Lotus scoparius*	common deerweed								X		X

Family	Scientific Name	Common Name	Estuarine Marsh			Seasonal Wetland		Other Marsh		Upland		
			Low	Mid	High	(A)	(B)	Brackish	Freshwater	Dune	Grassland	Scrub
Fabaceae	*Lotus* sp.	lotus						X		X		X
Fabaceae	*Lupinus chamissonis*	fragrant dune lupine									X	
Fabaceae	*Medicago lupulina*	black medicago									X	
Fabaceae	*Medicago polymorpha*	toothed burclover									X	
Fabaceae	*Melilotus indicus*	sourclover						X		X	X	X
Frankeniaceae	*Frankenia salina*	alkali heath	X	X	X				X		X	X
Geraniaceae	*Erodium cicutarium*	storksbill								X	X	
Hydrophyllaceae	*Phacelia ramosissima*	branching phacelia								X		
Juncaceae	*Juncus* sp.	rush wire grass			X			X	X			
Lamiaceae	*Marrubium vulgare*	horehound										X
Malvaceae	*Malva parviflora*	cheeseweed mallow									X	
Malvaceae	*Malvella leprosa*	alkali mallow					X	X		X		X
Myoporaceae	*Myoporum laetum*	lollypop tree	X	X	X	X					X	
Myrtaceae	*Eucalyptus* sp.	gum tree							X			
Onagraceae	*Camissonia cheiranthifolia*	beach evening primrose								X		
Onagraceae	*Camissonia* sp.	sun cup								X	X	X
Poaceae	*Avena fatua*	wild oat									X	X
Poaceae	*Arundo donax*	giant cane							X	X		
Poaceae	*Bromus diandrus*	ripgut chess		X	X	X				X	X	X
Poaceae	*Bromus hordaecheus*	brome grass									X	
Poaceae	*Bromus madritensis ssp. rubens*	foxtail chess									X	X
Poaceae	*Cortaderia selloana*	pampas grass		X			X	X	X	X	X	X
Poaceae	*Distichlis spicata*	saltgrass	X	X	X		X	X	X	X	X	X
Poaceae	*Hordeum depressum*	dwarf barley									X	

Family	Scientific Name	Common Name	Estuarine Marsh			Seasonal Wetland		Other Marsh		Upland		
			Low	Mid	High	(A)	(B)	Brackish	Freshwater	Dune	Grassland	Scrub
Poaceae	*Hordeum murinum ssp. leporinum*	wild barley									X	
Poaceae	*Lolium multiflorum*	Italian rye-grass				X					X	
Poaceae	*Parapholis incurva*	sicklegrass						X		X		
Poaceae	*Polypogon monspeliensis*	rabbit's foot grass						X		X		X
Polygonaceae	*Eriogonum sp.*	buckwheat								X	X	
Polygonaceae	*Rumex crispus*	curly dock									X	
Primulaceae	*Anagallis arvensis*	scarlet pimpernel								X		
Salicaceae	*Salix lasiolepis*	arroyo willow			X				X			
Saururaceae	*Anemopsis californica*	yerba mansa							X			
Solanaceae	*Nicotiana glauca*	tree tobacco									X	

APPENDIX C.6

Photos of common plant species at the Ballona Wetlands Ecological Reserve

<table>
<tr><th colspan="2">NATIVE</th></tr>
<tr><td>
Anemopsis californica, yerba mansa</td><td>
Baccharis pilularis, coyote brush</td></tr>
<tr><td>
Baccharis salicifolia, mule fat</td><td>
Camissonia sp., sun cup</td></tr>
<tr><td>
Cressa truxillensis, spreading alkali weed</td><td>
Croton californicus, California croton</td></tr>
<tr><td>
Cuscuta salina, salt marsh dodder</td><td>
Distichlis spicata, salt grass</td></tr>
</table>

APPENDIX C.6

NATIVE	
 *Euthamia occidentalis,* western goldenrod	 *Frankenia salina,* alkali sea-heath
 *Gnaphalium sp.*, gnaphalium	 *Heliotropium curassavicum,* salt heliotrope
 *Hordeum depressum,* dwarf barley	 *Jaumea carnosa,* marsh jaumea
 *Lotus scoparius,* common deerweed	 *Lupinus chamissonis,* dune lupine

APPENDIX C.6

NATIVE	
 *Malosma laurina,* laurel sumac	 *Malva leprosa,* alkali mallow
 *Salicornia subterminalis,* Parish's pickleweed	 *Salicornia virginica,* salt marsh pickleweed

NONNATIVE	
 *Anagallis arvensis,* scarlet pimpernel	 *Avena sp.,* oat
 *Brassica nigra,* black mustard	 *Carpobrotus sp.,* iceplant

APPENDIX C.6

<table>
<tr><th colspan="2">NONNATIVE</th></tr>
<tr><td>
Chrysanthemum coronarium, crown daisy</td><td>
Cortaderia selloana, pampas grass</td></tr>
<tr><td>
Erodium sp., filaree</td><td>
Euphorbia terracina, terracina spurge</td></tr>
<tr><td>
Melilotus indicus, annual yellow sweetclover</td><td>
Mesembryanthemum crystallinum, crystalline iceplant</td></tr>
<tr><td>
Mesembryanthemum nodiflorum, slenderleaf</td><td>
Nicotiana glauca, yellow tree-tobacco</td></tr>
</table>

APPENDIX C.6

NONNATIVE	
 *Parapholis incurve,* curved sickle grass	 *Polipogon monspeliensis,* rabbit's foot grass
 *Rumex crispus,* curly dock	 *Schinus terebinthifolius,* Brazilian pepper tree

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Photo credit: S. Woodard

CHAPTER 5:
ICHTHYOFAUNA

Ballona Wetlands Ecological Reserve, Los Angeles, California
Santa Monica Bay Restoration Commission

Prepared for: California State Coastal Conservancy
November 2011

Author: Karina Johnston

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ICHTHYOFAUNA

INTRODUCTION

Defining the fish assemblage of a wetland can be difficult, due to the highly mobile nature of the fauna, although they are often the first organisms to rapidly colonize restored habitats (Zedler 2001). Surveys at various spatial and temporal scales have identified wetland ichthyofauna throughout southern California wetlands using an assortment of methods (Allen 1982, Yoshiyama et al. 1986, Zedler et al. 1992, Desmond et al. 2000, Zedler 2001). Employing a combination of survey methods to obtain data on fish abundances is often the most effective survey plan and minimizes error (Reed et al. 2002, Steele et al. 2006a, Steele et al. 2006b, Ambrose 2008, Merkel and Associates 2009b).

The goals of the Baseline Assessment Program (BAP) for the Ballona Wetlands Ecological Reserve (BWER) ichthyofauna surveys included:

1) Assessing the distributions and relative abundances of fish species within the BWER tidal channels, Fiji Ditch, and Ballona Creek;
2) Assessing species richness within the same sites;
3) Comparing the results to previous BWER surveys; and
4) Developing a baseline for long-term monitoring.

All ichthyofauna nomenclature follows descriptions from “The Ecology of Marine Fishes: California and Adjacent Waters”, Allen, L.G., D.J. Pondella II, and M.H. Horn (2006). University of California Press, Berkeley, California.

Existing Conditions Report Summary (Prior to 2005)

Historically, before the channelization of Ballona Creek (1930s), the Los Angeles River occasionally flooded the Ballona Wetland region (1800s), which provided greater diversity of microhabitats and resulted in higher ichthyofaunal diversity than current conditions. This flooding may have brought species that inhabited the Los Angeles River to the Ballona watershed, or were in the wetland habitats, including several special status species that have not been recorded in surveys over the past 25 years (PWA 2006).

Swift and Franz (1981) reported the first detailed surveys of fish species within the Ballona area for the “Biota of the Ballona Region” (Schreiber 1981). This was the first study of an upper marsh fish community in southern California and serves as a reference to past conditions and diversity (PWA 2006).

In 1991 and 1996, several surveys of the Ballona Wetlands, Ballona Creek, and the adjacent Marina del Rey were completed (Allen 1991, Boland and Zedler 1991, Stolz 1991, and Haglund et al. 1996). Table 5.1 details species identified in the open water areas of Marina del Rey and Ballona Creek, and Table 5.2

details species found within the tidal channels of the BWER. The species found on all the 1991 surveys are grouped together and designated as '1991' in both tables. Table 5.2 incorporates surveys done by MEC Analytical Systems for the City of Los Angeles in 2001 and 2004. The 2005 and 2009 data in Tables 5.1 and 5.2 are from reports compiled by LA City (2005) and Merkel & Associates (2009a), and were conducted after the completion of the Existing Conditions Report (PWA 2006). See the *Interim Research* section for a summary of these reports.

A total of 46 native species and three non-native species were found in the combined Marina del Rey and Ballona Creek surveys over the past 20 years. Fourteen native and three non-native species have been found in the surveys conducted within the tidal channels of the BWER over the past 25 years. Distinguishing between native and non-native species is important, as non-native species have been known to negatively affect native species through predation or competition (Meffe 1985, Ross 1991, Lydeard and Belk 1993, Mills et al. 2004, Caiola and de Sostoa 2005). California Vector Control first introduced western mosquito fish (*Gambusia affinis*) to California in 1922 to reduce mosquito breeding populations. Los Angeles County West Vector Control still uses the non-native fish as the main biological control agent for mosquito breeding sources (LA West Vector website 2010; http://www.lawestvector.org/). The other two non-native species found were the sailfin molly (*Poecilia latipinna*) and yellowfin goby (*Acanthogobius flavimanus*) (PWA 2006, Workman and Merz 2007).

The Existing Conditions Report identifies the Fiji Ditch in Area A as a data gap because there are no reports of scientific surveys of the Fiji Ditch prior to 2006 (PWA 2006). Anecdotal reports identified the presence of unidentified fish and round stingrays (*Urobatis halleri*) (S. Bergquist, *pers. comm.* 2006).

Table 5.1. Fish species identified from Marina del Rey and Ballona Creek (PWA 2006). Note: asterisk denotes non-native species; 1991 and 1996 survey results are reproduced from PWA (2006). Species marked with an 'X' were present during surveys.

COMMON NAME	SCIENTIFIC NAME	1991	1996	2005	2009
Arrow goby	*Clevelandia ios*	X	X	X	
Barred sand bass	*Paralabrax nebulifer*	X	X		
Bat ray	*Myliobatis californica*	X	X		
Bay pipefish	*Syngnathus leptorhynchus*				X
Black croaker	*Cheilotrema saturnum*				X
California barracuda	*Sphyraena argentea*	X	X		
California clingfish	*Gobiesox rhessodon*	X			
California corbina	*Menticirrhus undulatus*		X		
California halibut	*Paralichthys californicus*	X	X	X	X
California killifish	*Fundulus parvipinnis*			X	
California needlefish	*Strongylura exilis*	X	X		
California tonguefish	*Symphurus atricauda*	X	X		
Cheekspot goby	*Ilypnus gilberti*	X	X		
CIQ goby (unknown)	*Clevlandia/Ilypnus/Quietula complex*				X
Diamond turbot	*Hypsopsetta guttulata*	X	X		X
Fantail sole	*Xystreurys liolepis*		X		X
Giant kelpfish	*Heterostichus rostratus*	X			
Hornyhead turbot	*Pleuronichthys verticalis*	X			X
Jacksmelt	*Atherinopsis californiensis*		X		
Kelp bass	*Paralabrax clanthratus*	X			
Longjaw mudsucker	*Gillichthys mirabilis*	X	X	X	
Mussel blenny	*Hypsoblennius jenkinsi*	X	X		
Northern anchovy	*Engraulis mordax*	X	X		
Opaleye	*Girella nigricans*		X		
Pacific sardine	*Sardinops sagax*	X	X		
Pacific staghorn sculpin	*Leptocottus armatus*	X			X
Queenfish	*Seriphus politus*	X	X		X
Round stingray	*Urobatis halleri*	X			X
Sailfin molly *	*Poecilia latipinna*			X	
Salema	*Xenistius californiensis*	X	X		X
Sargo	*Anisotremus davidsoni*		X		X
Shadow goby	*Quietula y-cauda*		X		
Shiner perch	*Cymatogaster aggregata*	X	X		X
Shovelnose guitarfish	*Rhinobatis productus*				X
Specklefin midshipman	*Porichthys myriaster*		X		
Spotted kelpfish	*Gibbonsia elegans*	X	X		
Spotted sand bass	*Paralabrax maculatofasciatus*		X		
Spotted turbot	*Pleuronichthys ritteri*	X	X		
Striped kelpfish	*Gibbonsia metzi*				X
Striped mullet	*Mugil cephalus*				X
Topsmelt	*Atherinops affinis*	X	X	X	X
Western mosquitofish *	*Gambusia affinis*			X	
White croaker	*Genyonemus lineatus*	X	X		
White seabass	*Atractoscion nobilis*	X	X		
White seaperch	*Phanerodon furcatus*		X		
Yellowfin croaker	*Umbrina roncador*		X		X
Yellowfin goby *	*Acanthogobius flavimanus*	X			
Zebra perch	*Hermosilla azurea*		X		

Table 5.2. Fish species in the tide channels of the BWER (PWA 2006). Note: asterisk denotes non-native species; 1981, 1991, 1996, 2001, and 2004 survey results are reproduced from PWA (2006). Species marked with an 'X' were present during surveys.

COMMON NAME	SCIENTIFIC NAME	1981	1991	1996	2001	2004	2005	2009
Arrow goby	*Clevelandia ios*	X	X	X	X		X	X
Black perch	*Embiotoca jacksoni*	X						
California halibut	*Paralichthys californicus*	X						
California killifish	*Fundulus parvipinnis*	X	X	X	X	X	X	X
Cheekspot goby	*Ilypnus gilberti*	X		X	X			X
CIQ goby	*Clevlandia/Ilypnus/Quietula complex*							X
Diamond turbot	*Hypsopsetta guttulata*	X				X		
Longjaw mudsucker	*Gillichthys mirabilis*	X	X	X	X		X	X
Western mosquitofish *	*Gambusia affinis*	X	X	X	X	X	X	X
Pacific staghorn sculpin	*Leptocottus armatus*	X	X	X	X			
Queenfish	*Seriphus politus*	X						
Sailfin molly *	*Poecilia latipinna*	X	X	X		X	X	
Shadow goby	*Quietula y-cauda*	X		X				
Shiner perch	*Cymatogaster aggregate*	X						
Striped mullet	*Mugil cephalus*	X	X					X
Topsmelt	*Atherinops affinis*	X	X	X	X		X	X
Yellowfin goby *	*Acanthogobius flavimanus*	X	X					

Interim Research (2005-2010)

In September 2005, the City of Los Angeles surveyed fish and macroinvertebrates in the BWER at eight stations within the tide channels (Figure 5.1) and compared their results to surveys conducted in 2001, 2003, and 2004 (LA City 2005). They found six species; the most abundant was the non-native western mosquitofish (2,719 individuals). California killifish (*Fundulus parvipinnis*) was the second most abundant (721 individuals), and the combination of the two species represented 91% of the total catch. The other species collected, in order of decreasing abundance, were topsmelt (*Atherinops affinis*), longjaw mudsucker (*Gillichthys mirabilis*), arrow goby (*Clevelandia ios*), and sailfin molly. The sailfin molly is also a non-native species (Black 1980), and was found in the upper channel stations only (e.g. BWF4, 6, 7, and 8 in Figure 5.1). Overall, fish diversity was slightly lower than previous survey years, and fish abundance roughly reflected the survey abundances of 2003, but not 2004 (LA City 2005).

Incidental catch of macroinvertebrates in the beach seines was also recorded during the 2005 surveys. Two nudibranchs (*Navanax inermis*), two barred grass shrimp (*Palaemon ritteri*), and one shore crab (*Pachygrapsus crassipes*) were collected during the seine surveys.

Figure 5.1. City of Los Angeles fish survey stations in 2005 (LA City 2005).

Merkel & Associates (2009a) conducted a study of the fish species in the lower Ballona Creek area for the US Army Corps of Engineers Feasibility Report. They included surveys in Ballona Creek, the tide channels of Area B, and the first reported surveys from within the Fiji Ditch (Figure 5.2). They conducted daytime surveys in August, nighttime surveys in October, and both day and night surveys in early December.

Seventeen fish species were captured in Ballona Creek, seven species in the BWER tide channels, and five species in the Fiji Ditch (Tables 5.1 and 5.2). The most abundant species collected in the tide channels was topsmelt, followed by longjaw mudsuckers, CIQ gobies (*Clevlandia/Ilypnus/Quietula complex*), and killifish. CIQ gobies represent either an arrow goby or a cheekspot goby (*Ilypnus gilberti*), but were unidentifiable in the field. Two species captured in the wetlands, but not in the Fiji Ditch, were longjaw mudsucker and striped mullet (*Mugil cephalus*). The two most common species observed in the Fiji Ditch were killifish and western mosquitofish.

Yellowfin croaker (*Umbrina roncador*), California halibut (*Paralichthys californicus*), and queenfish (*Seriphus politus*) were the most abundant species in Ballona Creek during the nighttime surveys (57, 26, and 25 individuals, respectively). Five individuals were captured in the daytime surveys in Ballona Creek from all species. Merkel & Associates found that there were higher numbers and diversity of fish caught, overall, during the nighttime surveys.

Figure 5.2. Merkel and Associates (2009a) fish survey stations (reproduced from Merkel & Associates 2009a).

Merkel & Associates (2009a) collected the highest numbers of invertebrates from Ballona Creek in the late summer surveys, in order of decreasing relative abundance: Pacific calico scallop (*Argopecten ventricosus*), Navanax nudibranch (*Navanax inermis*), Asian mussel (*Musculista senhousia*), Gould's bubble snail (*Bulla gouldiana*), Cancer crab (*Cancer* sp.), green shore crab (*Hemigrapsus oregonensis*), and kelp crab (*Pugettia producta*). One individual of each of the following invertebrates was also captured in the trawls: clam (*Chione sp*.), Pacific batwing seaslug (*Gastropteron pacificum*), Mediterranean mussel (*Mytilus galloprovincialis*), and tuberculate pear crab (*Pyromaia tuberculata*).

No invertebrates were captured at the Fiji Ditch (Merkel & Associates, 2009a), although California horn snail (*Cerithidea californica*) was observed. Invertebrates captured in the tide channel sites include: green shore crab, California horn snail, Mediterranean mussel, clam, Pacific calico scallop, common slipper limpet (*Crepidula fornicate*), eggcockle (*Laevicardium sp.*), and Asian mussel.

METHODS

Method Comparison and Rationale

Surveys at various spatial and temporal scales have identified wetland ichthyofauna throughout southern California wetlands using an assortment of methods (Swift et al. 1993). Employing a combination of survey methods to obtain data on fish abundance is often the most effective survey plan and minimizes error (Reed et al. 2002, Steele et al. 2006a, Steele et al. 2006b, Ambrose 2008, Merkel & Associates 2009b). The BAP reviewed previous survey strategies and tested several methods to determine the most appropriate methods (Appendix D.1).

An issue addressed in the evaluation of the survey methods for the BWER was the reduced area and number of tidal channels at the BWER, as compared to other marsh habitats that have been surveyed, such as Carpinteria Salt Marsh and Mugu Lagoon (Saiki 1997, Reed et al. 2002, Ambrose et al. 2006). Since there is less channel area, fewer replicates were used with an increased effort per replicate to decrease the impact to the marsh (Steele et al. 2006b). Stations were chosen to replicate previous reports, except for the upper tidal channels. Upper tidal channels often resulted in low numbers of species, and a primary goal of the BAP was to evaluate the highest possible diversity.

Variability can be reduced by repeating stations and sites over multiple seasons and years. Zedler (2001) recommended June and September as the most important months for measuring ichthyofaunal diversity. To address temporal changes throughout the year, the BAP sampled during September, April, and June.

BAP methods were based both on field tests and recommendations and results from similar surveys. Both the times and tides of each survey period (CCC 2006, Ambrose 2008, Merkel & Associates 2009a) influenced survey results, as well as the most effective survey method (Zedler et al. 1992, Steele et al. 2006). Because several studies found higher fish diversity, density, and biomass during nocturnal surveys than diurnal in the BWER and other marsh systems (Hoffman 2006, Merkel 2007, Merkel & Associates 2009a), the BAP conducted surveys both diurnally and nocturnally to assess the highest level of diversity and relative abundance possible.

Site Locations and Times

Surveys were conducted three times during the Baseline Year: September 2009, April 2010, and June 2010. Tables 5.3, 5.4, and 5.5 provide the dates and times of each fish survey event. When possible, survey events occurred at least 72 hours after the last storm or rainfall event that produced more than 0.5 inches of rain. Surveys were conducted at three sites: Ballona Creek, Fiji Ditch, and the tidally influenced channels of the western portion of Area B. Three permanent survey stations were positioned in the Fiji Ditch, and three in the tidal channels (Figure 5.3). These stations were also a subset of the invertebrate, sediment, and water quality sampling stations. Five survey stations were positioned within Ballona Creek, using 250-meter trawling transects along the length of the Creek (Figure 5.3).

During the September surveys, three methods (i.e. beach seines, minnow traps, and shrimp/otter trawls) were employed at various stations (Tables 5.3, 5.4, and 5.5). After the first round of surveys in September 2009, it was determined that minnow traps were not an effective method to evaluate a high species richness, as they only caught California killifish and longjaw mudsuckers, which were adequately represented using the beach seine method. Beach seines were found to be effective for benthic and demersal fish as well as pelagic fish.

For each event, fish were surveyed during an incoming, semidiurnal spring tide once during the day and once again at night to provide a comparison of diurnal versus nocturnal fish activity and abundance. Fishing was conducted with a minimum of 12 hours between survey times at each station.

Table 5.3. Beach seine deployment dates for each fishing event at each survey station.

STATION	DATE	START TIME	END TIME	DATE	START TIME	END TIME	DATE	START TIME	END TIME
DITCH_A	9/29/2009	0800	0945	6/30/2010	1130	1220	4/14/2010	0805	0905
DITCH_B	9/29/2009	0950	1130	6/30/2010	0950	1110	4/14/2010	1000	1100
DITCH_C	9/29/2009	1135	1200	6/30/2010	1235	1310	4/14/2010	0910	0945
DITCH_A	9/29/2009	1824	1928	6/14/2010	1945	2040	4/12/2010	1915	2030
DITCH_B	9/29/2009	1945	2049	6/14/2010	2050	2130	4/12/2010	2210	2315
DITCH_C	9/29/2009	2100	2157	6/14/2010	2140	2210	4/12/2010	2055	2200
WETLAND_A	10/1/2009	0800	0859	6/15/2010	1940	2100	4/15/2010	0900	1020
WETLAND_B	10/1/2009	1005	1120	6/15/2010	2115	2220	4/15/2010	1034	1130
WETLAND_C	10/1/2009	1201	1352	6/15/2010	2245	2330	4/15/2010	1145	1235
WETLAND_A	10/1/2009	2100	2240	6/29/2010	1020	1130	4/13/2010	1920	2010
WETLAND_B	10/1/2009	1850	2035	6/29/2010	1145	1230	4/13/2010	2150	2221
WETLAND_C	10/1/2009	2330	2430	6/29/2010	1245	1320	4/13/2010	2240	2320

Table 5.4. Ballona Creek deployment dates for individual shrimp/otter trawls.

STATION	DATE	START TIME	END TIME
BC_A	10/7/2009	0804	0806
BC_B	10/7/2009	0811	0815
BC_C	10/7/2009	0884	0827
BC_D	10/7/2009	0831	0835
BC_E	10/7/2009	0843	0849
BC_A	10/7/2009	1849	1851
BC_B	10/7/2009	1900	1904
BC_C	10/7/2009	1910	1916
BC_D	10/7/2009	1919	1924
BC_E	10/7/2009	1931	1937

Table 5.5. Minnow trap deployment dates for each survey station.

STATION	DATE	START TIME	END TIME
Ditch A	10/21/2009	0805	1625
Ditch B	10/21/2009	0755	1500
Ditch C	10/21/2009	0740	1635
Wetland A	10/22/2009	0830	1652
Wetland B	10/22/2009	0841	1445
Wetland C	10/22/2009	0855	1603
Wetland D	10/22/2009	0918	1636
BC1	10/26/2009	0938	1610
BC2	10/26/2009	1003	1622
BC3	10/26/2009	1015	1621

Figure 5.3. Fish survey stations; red lines indicate individual stations. Note: stations are not drawn to scale.

Field Methods

During all survey methods, fish were transferred immediately from the nets, cages, or trawl cod end into buckets filled with seawater to be measured and identified to species using fish field guides (Miller and

Lea 1972, Allen et al. 2006). All surveys were live catch and release. If there were fewer than 30 individuals of a species, all fish standard lengths were measured to the nearest millimeter (Merkel and Woodfield 2007, City of Los Angeles 2005). If more than 30 individuals of a given species were collected in a given seine, only the first 30 randomly selected individuals of each species were measured. The remaining individuals were identified to species and counted only. Fish that were too small to accurately identify in the field were labeled as juveniles (approximately ≤ 10 mm). Fish were returned at their capture station immediately after processing.

Macroinvertebrates collected in the nets, cages, and trawls were photographed, identified, and counted but not measured. Due to the spatial variability of these species and the non-targeted method by which they were captured, the data were collected to augment species lists and determine presence and relative abundance, rather than to provide quantitative population data. Additional conditions, including start time, duration of survey, cloud cover, and precipitation at each station, were recorded. Trash was also recorded as present or absent at each station and during each shrimp/otter trawl or beach seine.

Tidal Channels and Fiji Ditch

Multiple survey methods were employed within the tidal channels and Fiji Ditch of the BWER during September 2009 to ensure that all species were represented and to obtain accurate densities for each species of fish. Fishing methods included minnow traps and beach seines with blocking nets.

For each beach seine station, two blocking nets were positioned perpendicular to the bank and extended across the full expanse of the tidal channel. The blocking nets were deployed first, perpendicular to the shore and across the whole channel to prevent fish from escaping the survey area (Nordby and Zedler 1991, Steele et al. 2006b, WRP 2006). These nets were of the same mesh dimensions as the beach seines (1.8 m depth and 3.2 mm mesh delta style knotless nylon netting), though they were longer (25 m) to enable coverage of the width of the widest channel sampled (i.e. Wetland A; Figure 5.4). Both blocking nets were deployed simultaneously in a steady movement across the channel. It was imperative that blocking nets be taken out at the same time, with the lead line remaining in constant contact with the bottom substrate, to reduce the potential for fish to escape. After the blocking nets were deployed across the channel, it was verified by touch that the lead line was resting directly on the bottom substrate and that the float line was above the water level.

Five replicate beach seines occurred at each station between the blocking nets. The beach seine was 6 m long by 1.8 m deep, with 3.2 mm mesh delta style knotless nylon netting. Since seine length does not significantly affect the estimates of species richness (Steele et al. 2006b), a standard seine length of 6 m was used to ease handling.

The first beach seine was extended to the blocking nets with a parallel orientation to the channel edge and then pulled across the channel. Care was taken to keep the lead line in contact with the bottom of the channel (LA City 2005). The seine was hauled out on the far shore (lead line first), where fish were immediately placed into large buckets of water (Figure 5.5). Topsmelt were pulled out of the net first, as they were more susceptible to asphyxiation than the other species (Skinner et al. 1962), including the longjaw mudsucker, which can respire aerially (Todd and Ebeling 1966). Once the net was thoroughly searched multiple times, each fish was identified, measured, weighed, and placed in an adjacent bucket. The beach seining was repeated five times. After the last seine, the blocking nets were pulled to shore by bringing the ends together and then having one net drawn inside the other (Figure 5.6). The nets were pulled up on shore one at a time, and the fish were identified in the same manner as the beach seines. Fish from both blocking nets were combined and counted as a final haul. All fish and invertebrates were returned to the area of collection when identification and measuring were complete.

Figure 5.4. Blocking nets fully deployed at station Wetland A (photo: SMBRC 2010).

Figure 5.5. Fish collection at station Wetland A (photo: SMBRC 2010).

Figure 5.6. Blocking nets being retrieved at station Wetland B (photo: SMBRC 2010).

In addition to the beach seines, minnow traps (Gee Minnow Traps, 9" x 17.5" with a mesh size of 1/4") were deployed at three evenly spaced points at each station. One additional minnow trap station was added at the Boy Scout Platform (station: Wetland D), at the confluence of the channels, to assess fish diversity at an additional station. Traps were baited with standardized amounts (1 cup) of dry dog food (Kibbles and Bits™) and deployed at each station just before tidal inundation (Figure 5.7). They were recovered on the outgoing tide before exposure to the elements for an approximate deployment time of 6-8 hours. Exact times were recorded for each station. Each fish was identified, measured for standard length, and transferred to an adjacent bucket of seawater using the same methods as the beach seines.

Figure 5.7. Minnow trap deployed at station: Ditch B (photo: SMBRC 2010).

Ballona Creek Surveys

Fish surveys within Ballona Creek in September 2009 employed both shrimp/otter trawls and minnow traps. The shrimp/otter trawl was deployed from a small skiff (4 m) traveling between 1.5 and 2 knots along a 250 m transect (Figure 5.8). Methods similar to those developed for Ballona Creek in 2009 were used to maintain consistency between survey years. The shrimp/otter trawl was used in the BAP to collect both small and large fish which inhabit Ballona Creek, including demersal and mid-water species. The trawl had an 8 ft mouth; the body was made with 1 3/8" mesh and the bag was made with 1 1/4" mesh netting. The trawl boards were 16" x 9" with 75 ft tow lines. All fish were identified, measured for standard length, and released using the same methods as the beach seines. Five replicate trawls were completed, from the entrance of the Creek at the Pacific Avenue Bridge to approximately the Culver Boulevard Bridge, or the furthest inland station negotiable by boat at high tide (Figure 5.3). Transect start and end points were navigated using recorded GPS coordinates along with the additional assistance of visual notations of nearby shore features.

Minnow trap surveys occurred at four stations along the southern Ballona Creek levee in September of the Baseline Year, using the same methods as minnow traps deployed in the tide channels and the Fiji Ditch. Upon completion, it was determined that the survey effort was too high for the resultant low fish and macroinvertebrate species richness. All fish and invertebrates were subsequently returned to their collection stations.

Figure 5.8. Shrimp/otter trawl deployment in Ballona Creek (photo: M. Kearney 2010).

Laboratory and Analysis Methods

No laboratory methods or analyses were conducted for these survey events. All fish were caught and immediately released on site after identification and measurement.

RESULTS

General Results and Overall Trends

The results section is organized by survey method; the beach seine data are presented first, followed by the shrimp/otter trawl data and the minnow trap data. Separate sections present the incidental macroinvertebrate catch and describe special status species. Appendix A.1 includes a summary of water quality and weather data collected during the first Baseline year.

Twelve species of fish were caught in the Baseline surveys (Table 5.6). In the wetland and ditch sites, 2,618 fish were caught using the beach seine method, 286 fish were caught in the minnow traps, and 10 fish were caught in the trawls of Ballona Creek.

No fish were captured at station Wetland C during the June surveys. Sampling was incomplete at station Ditch B during the June survey due to inaccessibility.

During the first surveys, locating the identifying characteristics of both arrow gobies (*Clevelandia ios*) and cheekspot gobies (*Ilypnus gilberti*) in the field proved too time consuming, especially for the smaller sized individuals. While the first survey confirmed that almost all of the gobies were arrow gobies (>95%), cheekspot gobies may have been present. Therefore, both species will henceforth be referred to as 'arrow goby'.

Trash was recorded at every station during both the beach seines and shrimp/otter trawls. Trash was found in every trawl in Ballona Creek and was often dominated by plastics.

Table 5.6. Species found in all first year BAP surveys. Note: asterisk denotes non-native species. Species marked with an 'X' were present during surveys.

COMMON NAME	SPECIES	CODE	Fiji Ditch	Tide Channels	Ballona Creek
Arrow goby	*Clevelandia ios or Ilypnus gilberti*	CLIO	X	X	X
Bat ray	*Myliobatis californica*	MYCA			X
California halibut	*Paralichthys californicus*	PACA			X
California killifish	*Fundulus parvipinnis*	FUPA	X	X	X
Diamond turbot	*Hypsopsetta guttulata*	HYGU		X	
Longjaw mudsucker	*Gillichthys mirabilis*	GIMI	X	X	
Pacific staghorn sculpin	*Leptocottus armatus*	LEAR	X	X	
Round stingray	*Urobatis halleri*	URHA	X		
Specklefin midshipman	*Porichthys myriaster*	PONO			X
Striped mullet	*Mugil cephalus*	MUCE	X		X
Topsmelt	*Atherinops affinis*	ATAF	X	X	
Western mosquitofish *	*Gambusia affinis*	GAAF	X		

Beach Seine Data: Fish Counts

The most common fish caught using the beach seine method was the arrow goby, with 824 individuals across all sites (Figure 5.9). These data show the beach seine method was reflective of demersal fish populations in the BWER. Therefore, enclosure traps were not used. Killifish and topsmelt were the next highest species in terms of relative abundances, with 701 and 669, respectively. The highest number of fish caught at any station was at Wetland A, with 1,133 fish (Figure 5.10). The fewest fish were caught at station Wetland C at the west outflow tide gate, with 62 individuals (Figure 5.10). Daytime survey catch numbers ranged from 307 fish in April to 591 fish in June. Fish counts for the night surveys were similar throughout each season with a low of 437 fish in April and a high of 449 fish in June.

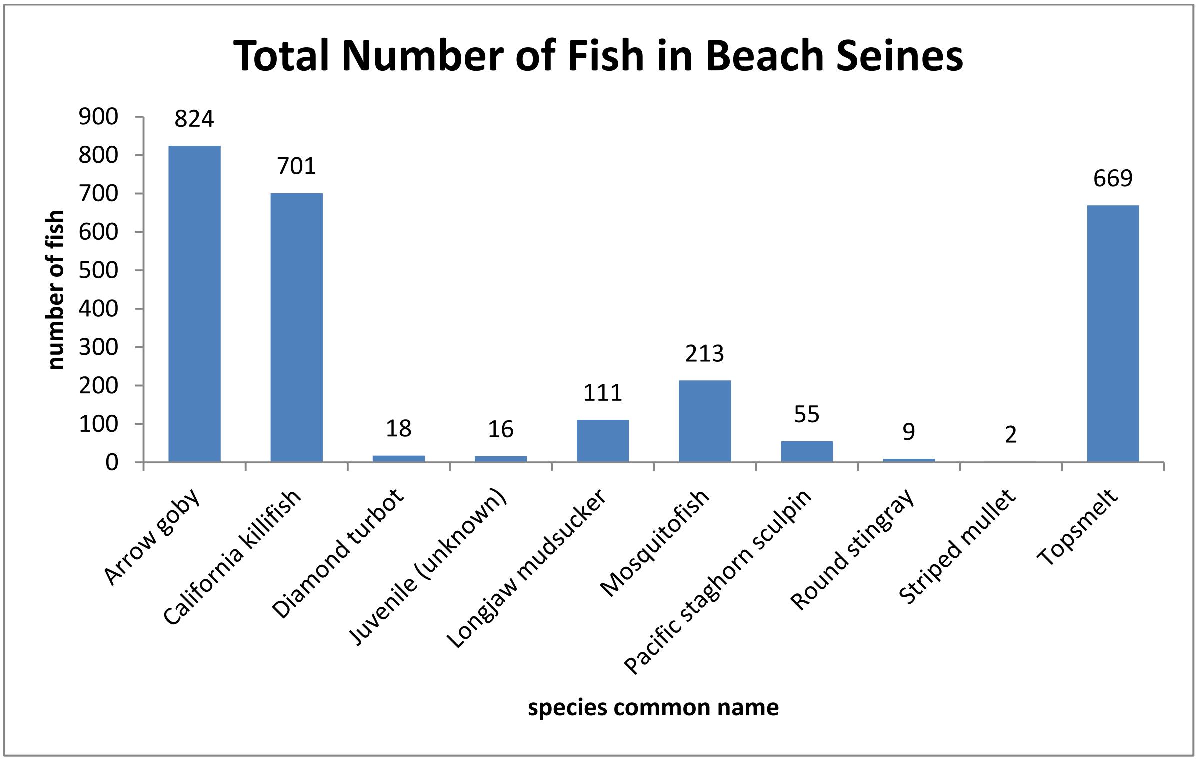

Figure 5.9. Total counts of each species of fish caught in the beach seine surveys across all stations throughout the first Baseline year. Note: Juvenile (unknown) represents juvenile fish that were too small to accurately identify in the field.

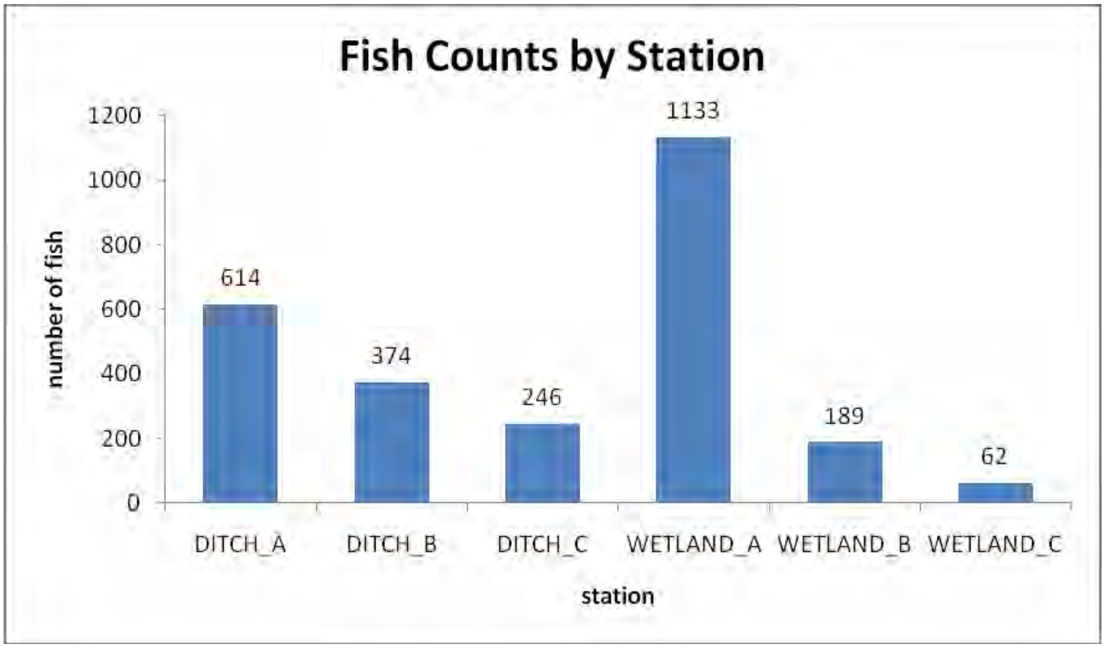

Figure 5.10. Total fish counts for each station across all beach seine surveys.

Wetland A consistently had the highest total number of fish per sampling event, and Wetland C consistently had the lowest (Figure 5.11). During the April surveys, pregnant killifish were caught both in the day and night surveys and spawning occurred during the Fiji Ditch night surveys. The higher overall numbers of fish caught in June at Ditch A, Wetland A, and Wetland B reflect higher numbers of juvenile fish, which is similar to previous studies (Zedler 2001).

Table 5.7 illustrates that Ditch C had the highest density of fish caught (91.1 fish/m^3). This was more than two and a half times greater than the next highest density stations (Ditch B and Ditch A respectively). Wetland C had the lowest fish density (2.6 fish/m^3; Table 5.7) and the lowest fish counts. The highest density of an individual species was the arrow goby (4.98 fish/m^3), and the lowest was the striped mullet (0.01 fish/m^3). Topsmelt and killifish were also found in high densities at many of the stations, with overall densities of 4.04 and 4.23 fish/m^3, respectively.

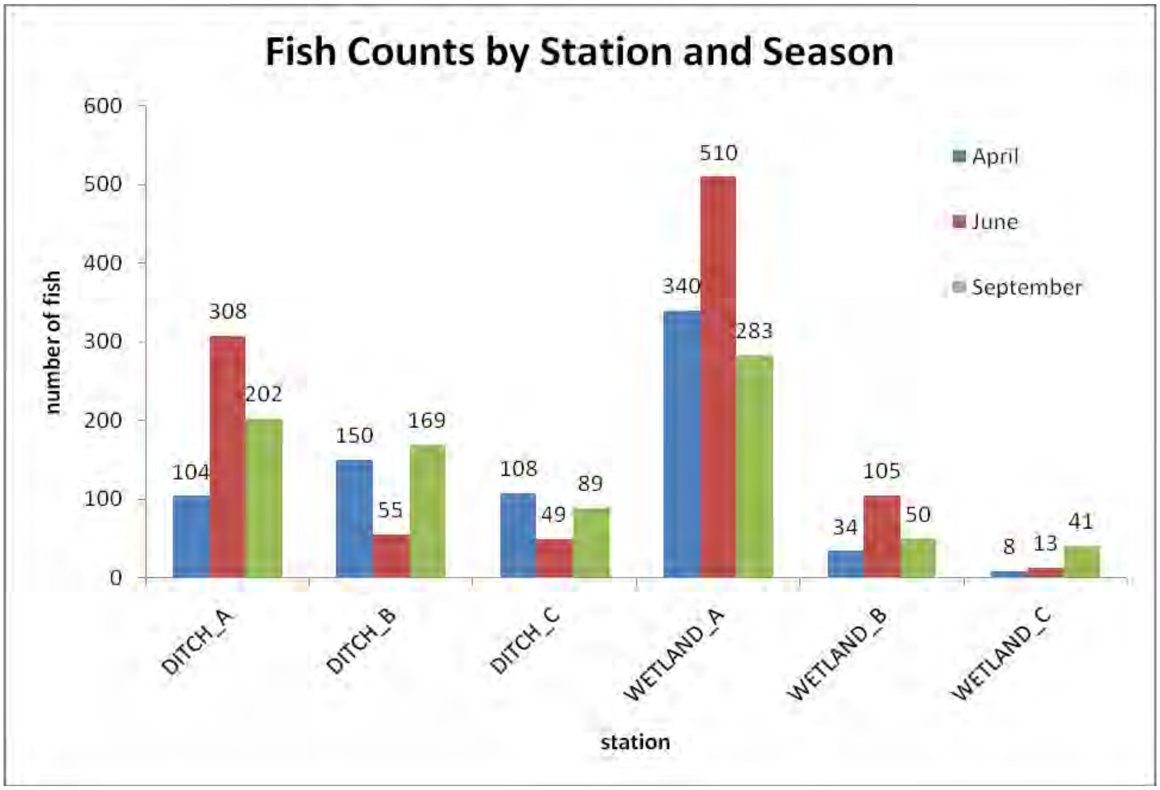

Figure 5.11. Total fish counts for all surveys summarized by station and season.

Table 5.7. Fish density (fish/m³) at each site by species. Note: Juvenile (unknown) represents juvenile fish that were too small to accurately identify in the field.

STATION	DITCH_A	DITCH_B	DITCH_C	WETLAND_A	WETLAND_B	WETLAND_C	Total
Dimensions	*6x6x.6*	*3.5x6x.5*	*1.5x6x.3*	*16x6x.9*	*5x6x.8*	*5x6x.8*	
Volume (m^3)	18.0	10.5	2.7	86.4	24.0	24.0	**165.6**
Arrow goby	0.0	2.2	3.3	8.5	1.8	0.6	**5.0**
California killifish	18.9	21.0	27.0	0.6	0.2	0.5	**4.2**
Diamond turbot	0.0	0.0	0.0	0.2	0.0	0.0	**0.1**
Juvenile (unknown)	0.0	0.7	3.3	0.0	0.0	0.0	**0.1**
Longjaw mudsucker	0.9	0.8	0.4	0.5	1.0	0.8	**0.7**
Pacific staghorn sculpin	0.9	0.6	0.0	0.4	0.0	0.0	**0.3**
Round stingray	0.2	0.5	0.0	0.0	0.0	0.0	**0.1**
Striped mullet	0.0	0.2	0.0	0.0	0.0	0.0	**0.0**
Topsmelt	12.4	4.1	5.2	3.0	4.9	0.6	**4.0**
Western mosquitofish	0.8	5.6	51.9	0.0	0.0	0.0	**1.3**
TOTAL	**34.1**	**35.6**	**91.1**	**13.1**	**7.9**	**2.6**	**15.8**

Table 5.8 shows fish species counts for each station and time (i.e. day or night). The daytime and nighttime counts for each fish species are combined across all months. Relative abundances are represented as percent catch at the Ditch and Wetland stations.

Killifish represented the highest overall proportion of the catch in the Ditch stations at 51.4%, followed by topsmelt at 22.7%, and western mosquitofish at 17.3% (Table 5.8). Arrow gobies represented the highest overall proportion of the catch in the Wetland stations at 57.2%, followed by topsmelt at 28.1%, and longjaw mudsuckers at 6.1%.

Catch in the Fiji Ditch was dominated by killifish at the western stations nearest the tidal connection to Marina del Rey (Ditch A and B), but was dominated by western mosquitofish at Ditch C which is more shallow, narrow and further from the mouth. The principal species in the tide channel sites included both arrow gobies and topsmelt, reflecting a slightly different species composition than that of the Fiji Ditch sites. Killifish were present at each station.

Numbers of benthic fish species were relatively higher at the Wetland stations than at the Ditch stations (i.e. longjaw mudsuckers, arrow gobies, diamond turbot (*Hypsopsetta guttulata*), and Pacific staghorn sculpin (*Leptocottus armatus*) (Table 5.8). The exception was the round stingray, which was found exclusively at the Fiji Ditch stations. The round stingray was also caught exclusively at night during the September and June surveys, although round rays were visually confirmed during the day surveys during both months. This is likely due to the visible nature of the beach seines in the daytime and the evasive capabilities of the stingrays.

No western mosquitofish were found in the tide channel Wetland stations, even though they have been found in historical surveys farther up the tide channels in the shallower habitats (PWA 2006). Western mosquitofish were found at all three Fiji Ditch stations and were the only non-native species captured using the beach seine method. The non-native sailfin molly and yellowfin goby have been historically reported at the tide channel stations; they were not found during the BAP surveys. All fish species found during the BAP are representative of southern California marshes (Miller and Lea 1972, Moyle et al. 1995, Allen et al. 2006).

Table 5.8. Number of individual fish for each species by station.

STATION	TIME	Arrow goby	California killifish	Diamond turbot	Juvenile (unknown)	Longjaw mudsucker	Pacific staghorn sculpin	Round stingray	Striped mullet	Topsmelt	Western mosquitofish	TOTAL
DITCH_A	**day**	0	159	0	0	8	1	0	0	194	1	363
	night	0	181	0	0	9	15	4	0	29	13	251
DITCH_B	**day**	9	156	0	7	4	2	0	1	18	55	252
	night	14	65	0	0	4	4	5	1	25	4	122
DITCH_C	**day**	3	3	0	9	0	0	0	0	0	61	76
	night	6	70	0	0	1	0	0	0	14	79	170
DITCH TOTAL		**32**	**634**	**0**	**16**	**26**	**22**	**9**	**2**	**280**	**213**	**1234**
% OF CATCH		**2.6%**	**51.4%**	**0.0%**	**1.3%**	**2.1%**	**1.8%**	**0.7%**	**0.2%**	**22.7%**	**17.3%**	**100%**
WETLAND_ A	**day**	339	2	11	0	8	19	0	0	117	0	496
	night	395	48	7	0	34	14	0	0	139	0	637
WETLAND_ B	**day**	32	2	0	0	13	0	0	0	39	0	86
	night	11	2	0	0	11	0	0	0	79	0	103
WETLAND_ C	**day**	8	4	0	0	1	0	0	0	6	0	19
	night	7	9	0	0	18	0	0	0	9	0	43
WETLAND TOTAL		**792**	**67**	**18**	**0**	**85**	**33**	**0**	**0**	**389**	**0**	**1384**
% OF CATCH		**57.2%**	**4.8%**	**1.3%**	**0.0%**	**6.1%**	**2.4%**	**0.0%**	**0.0%**	**28.1%**	**0.0%**	**100%**

Beach Seine Data: Standard Lengths

Standard length data were collected from each fish (up to 30 fish per species) for each repetitive haul by the beach seines and in the blocking nets (Figure 5.12). The largest fish caught were round stingrays (Figure 5.13), in the Fiji Ditch, ranging from 30 to 38 cm in length. The stingrays were excluded from the following graphs, as it was much larger than all other species.

The next largest average standard length of any fish species caught in the seines was the longjaw mudsuckers at night (97.0 ± 2.7 mm) (Figure 5.14). The smallest average standard length were the unidentified juveniles at 10.5 ± 0.5 mm and 15.1 ± 0.3 mm, the juvenile diamond turbots at 18.5 ± 1.6 mm, and the western mosquitofish at 20.3 ± 0.3 mm and 22.1 ± 0.3 mm (Figure 5.14). For all species except diamond turbot and arrow gobies, longer standard lengths were recorded during night surveys compared to day surveys.

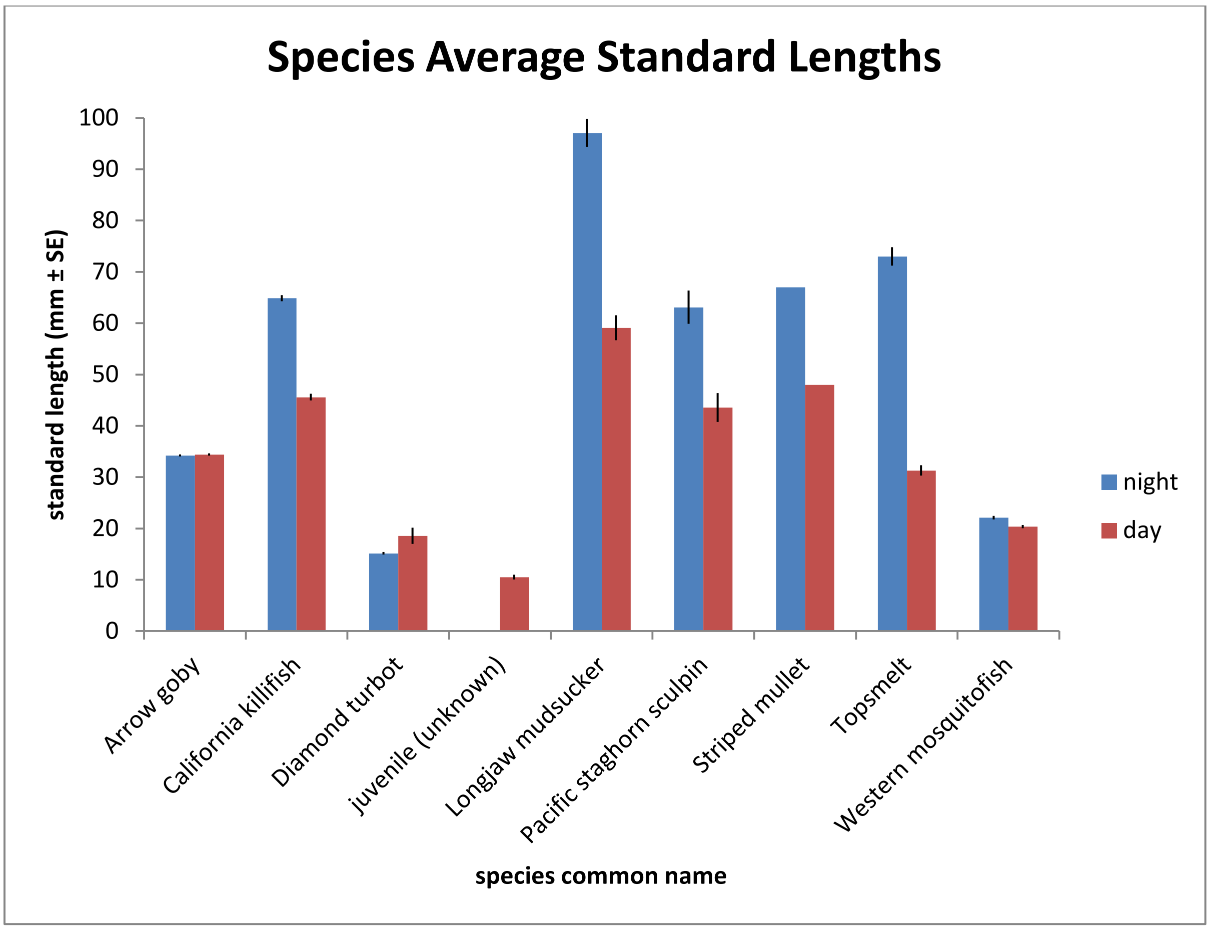

Figure 5.12. Species standard length by time of survey (mm ± standard error) based on averages across all beach seine stations.

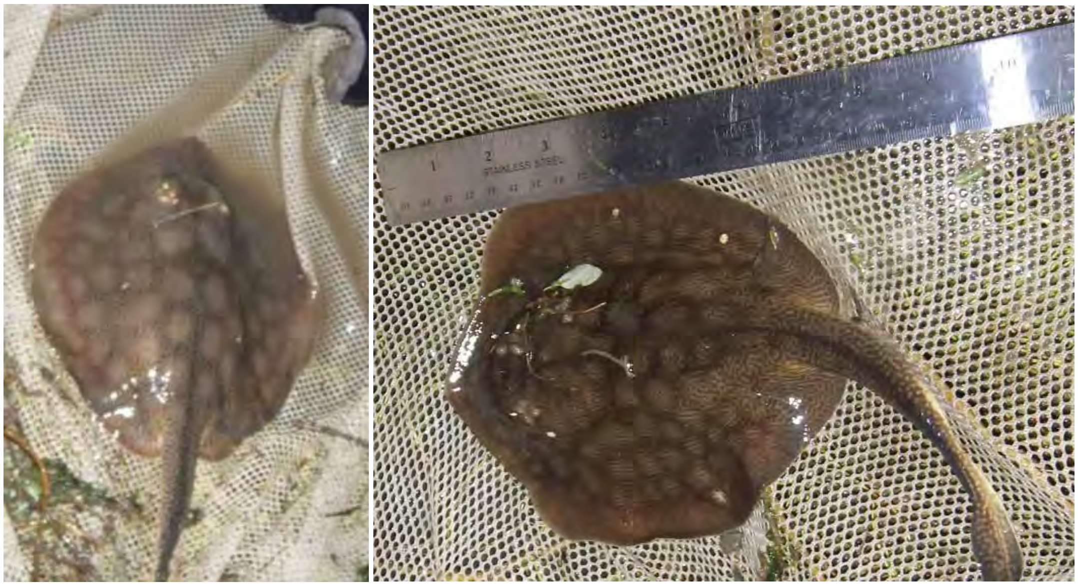

Figure 5.13. Round stingray from the Fiji Ditch (photos: SMBRC 2009).

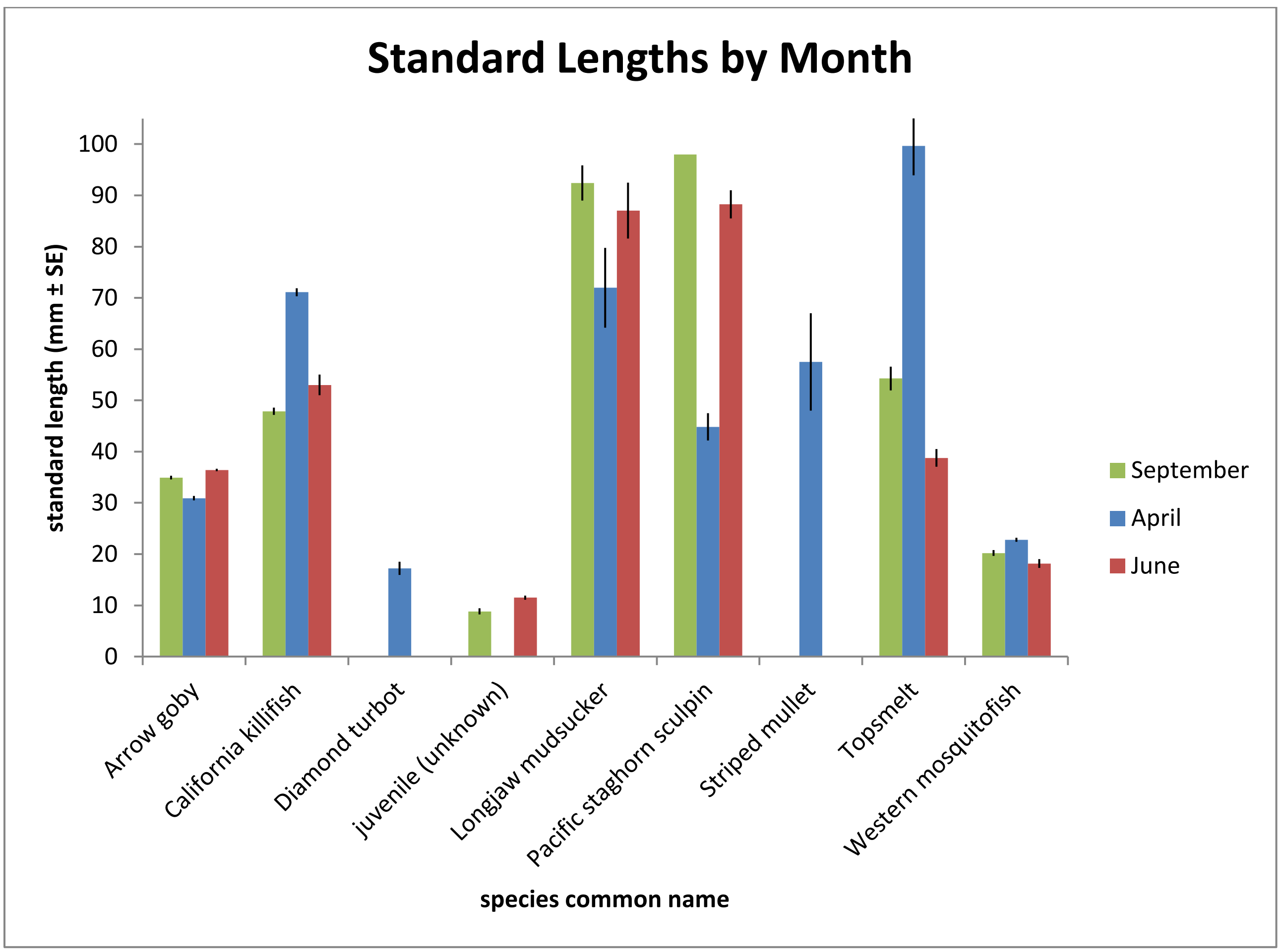

Figure 5.14. Species standard length by month (mm ± standard error) based on averages over all beach seine stations.

The size frequency distributions for the three most common fish (i.e. killifish, topsmelt, and arrow gobies) are presented in Figure 5.15. The topsmelt display a bimodal distribution pattern, with the bulk of the number of individual fish falling into a smaller size category and the second mode representing the larger adult population at 115 – 165 mm. Killifish and arrow gobies showed normal distribution patterns (Figure 5.15). The mean length and range for each species caught in the beach seines are presented in Figure 5.16.

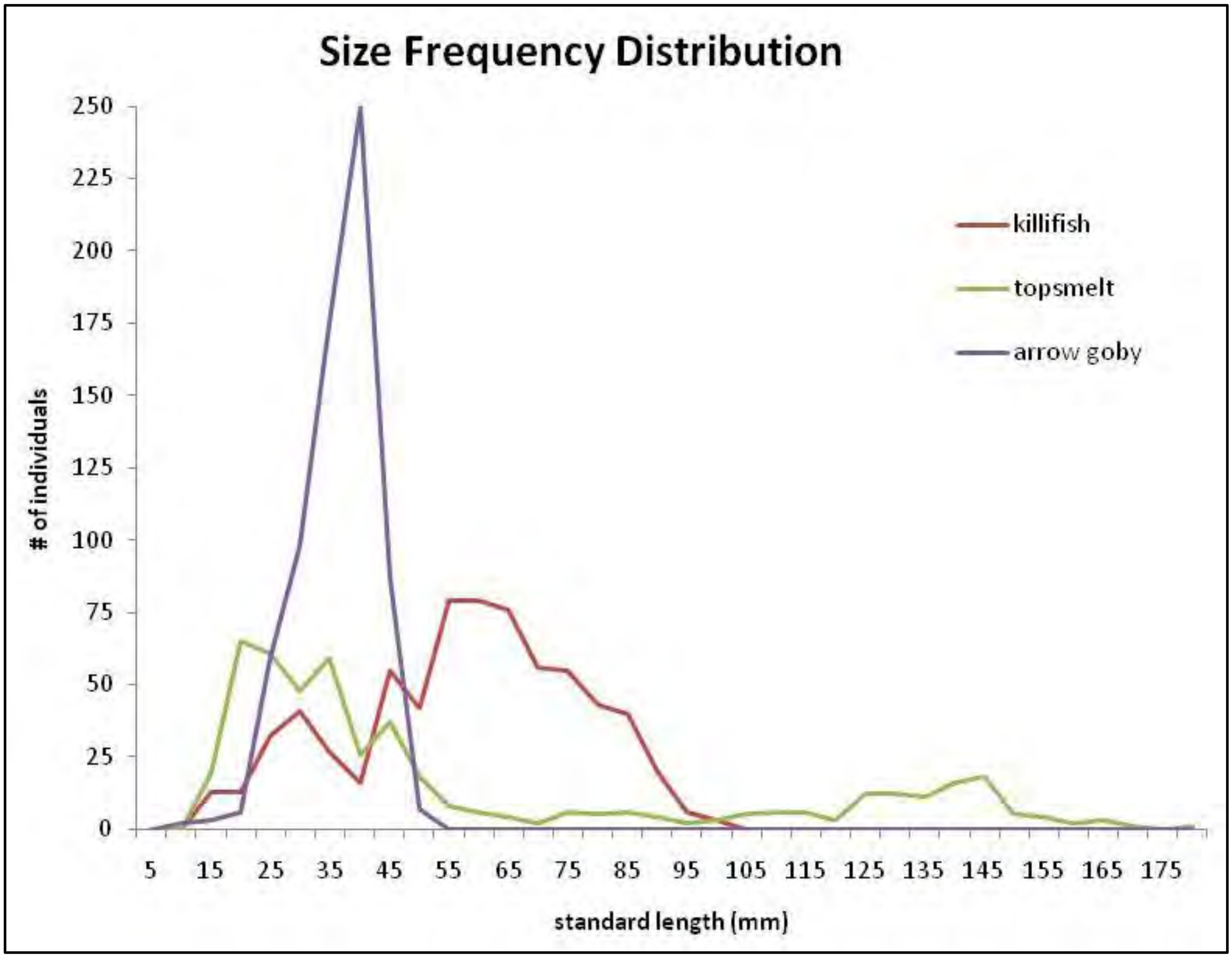

Figure 5.15. Size frequency distribution for killifish, topsmelt, and arrow gobies.

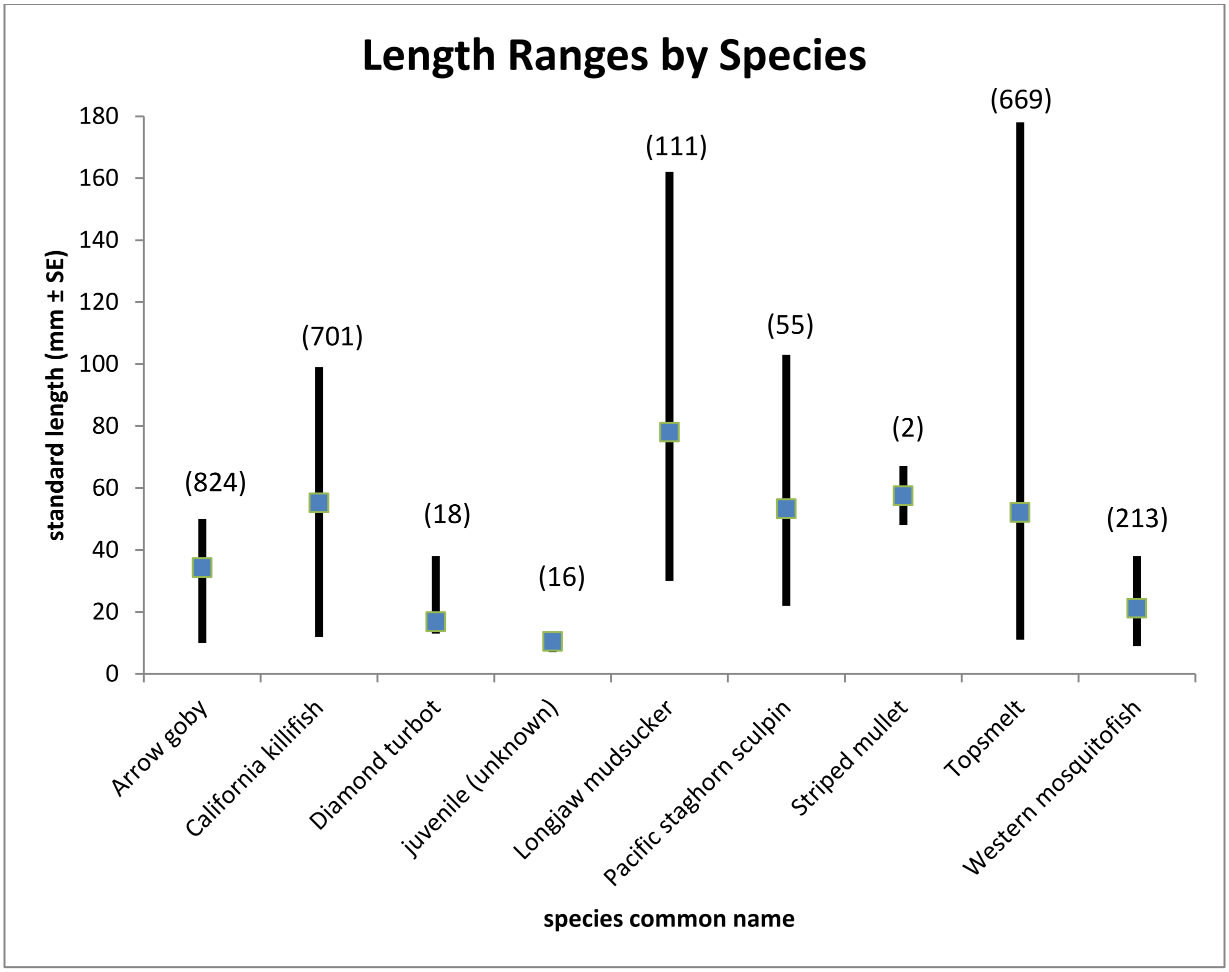

Figure 5.16. Minimum, maximum, and mean lengths of each species caught in the beach seines. Note: the blue box indicates the average overall mean standard length, the vertical line indicates the minimum and maximum lengths. The number in parenthesis indicates the number of individual fish included in the length analyses.

Minnow Trap Data

A total of 286 fish of three different species were caught in 30 minnow traps at 10 stations (three traps per station). Totals for the three fish species captured were three topsmelt, 264 killifish, and 19 longjaw mudsuckers (Table 5.9). The majority of each catch was killifish (Figures 5.17 and 5.18). Minnow trap data do not represent all species present at any given station because they target specific species and size fish. The beach seine method found a higher species richness (number of species) at each station. The minnow trap data reflect relative abundances of each species when compared to the other minnow trap stations with equal deployment, and should not be taken as overall species abundances for each station.

The data in Table 5.9 show the number of fish of each species caught at each station. The highest abundances were at the two upper Fiji Ditch stations (i.e. Ditch B and C). No fish were caught in any of the traps at the BC1, BC2 or Wetland A stations. No macroinvertebrates were caught in the minnow traps. One topsmelt was caught at station Wetland D. No juvenile fish were caught; the larger mesh size of the minnow traps relative to the beach seines likely allowed the juveniles to escape the minnow traps.

Table 5.9. Minnow trap data from each station for each species found.

STATION	topsmelt	killifish	mudsuckers	TOTAL # OF FISH
BC_1	0	0	0	0
BC_2	0	0	0	0
BC_3	0	26	0	26
BALLONA CREEK TOTAL	**0**	**26**	**0**	**26**
Ditch_A	1	37	5	43
Ditch_B	1	65	9	75
Ditch_C	0	103	0	103
FIJI DITCH TOTAL	**2**	**205**	**14**	**221**
Wetland_A	0	0	0	0
Wetland_B	0	33	1	34
Wetland_C	0	0	4	4
Wetland_D	1	0	0	1
TIDE CHANNEL TOTAL	**1**	**33**	**5**	**39**

Figure 5.17. Deployed minnow trap (BC_1, left) and catch of killifish (right) (photos: SMBRC 2009).

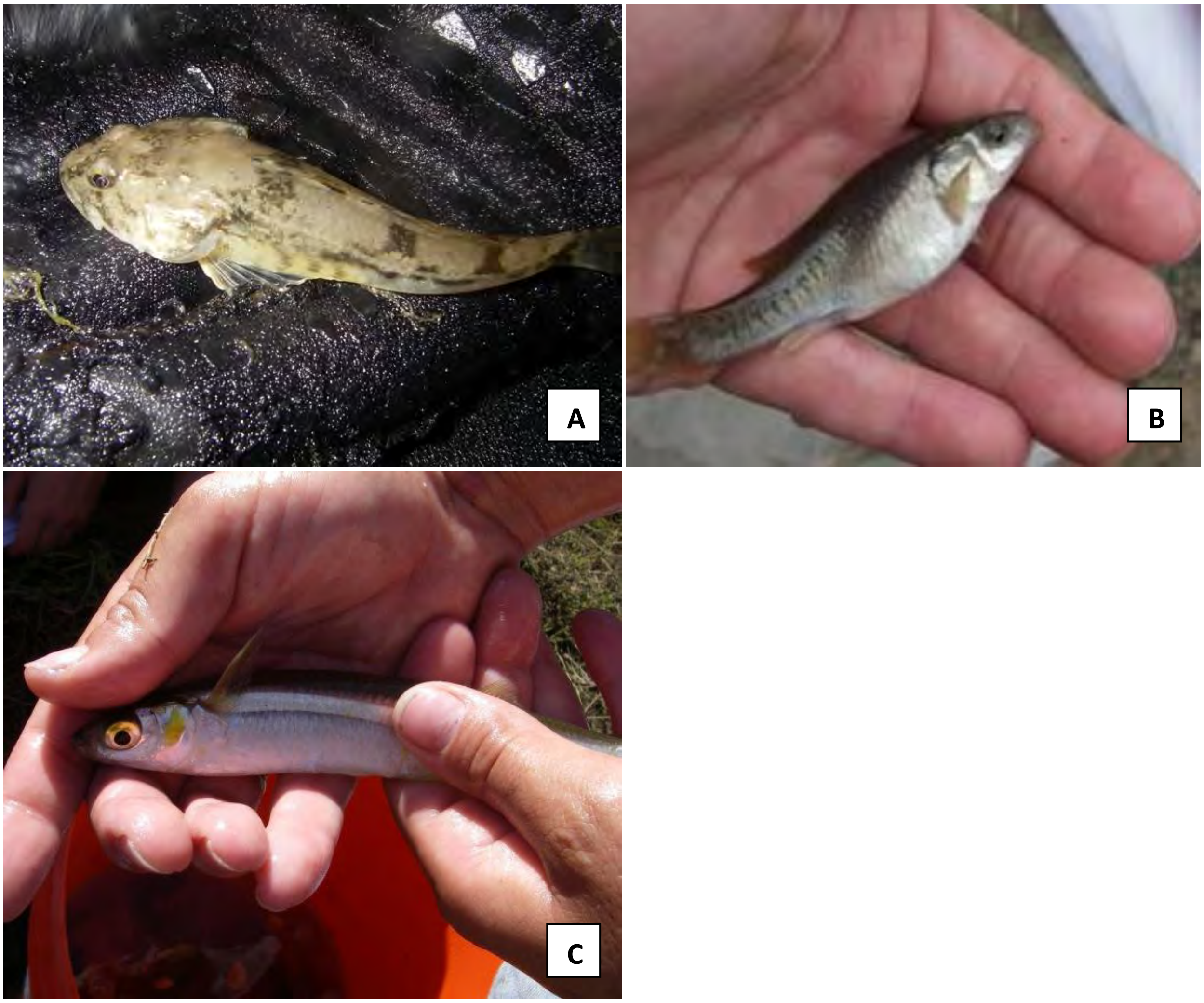

Figure 5.18. Pacific staghorn sculpin (A), California killifish (B), and topsmelt (C) from the Wetland stations (photos: SMBRC 2010).

Shrimp Trawl Data

A total of 10 fish were found in the shrimp/otter trawls in Ballona Creek (Table 5.10). The only fish collected during the daytime surveys during all five hauls was one California halibut at 203 mm (Figure 5.19). Two California halibut at 130 and 195 mm; four arrow gobies at 32, 35, 33, and 30 mm; and three speckled midshipmen (*Porichthys myriaster*) larvae at 26, 22, and 23 mm were collected during the night surveys. No fish were caught at station BC-C. Two other species were confirmed in Ballona Creek: killifish were found in the minnow traps (Table 5.9), and a large school (≥ 50 fish) of striped mullet were visually identified in Ballona Creek next to the eastern tide gate on 12 August 2010. An incidental catch of a small bat ray (*Myliobatis californica*) occurred when one of the trawls pulled up a fishing pole. When the fishing pole was pulled in, the bat ray was still attached, alive, and had pulled the fishing pole into the Creek. The bat ray was photographed and released back into Ballona Creek.

Table 5.10. Individual fish identified in the Ballona Creek shrimp/otter trawls. Note: SL denotes standard length in millimeters.

STATION	TIME	COMMON NAME	SCIENTIFIC NAME	SL (mm)
BC-B	day	California halibut	*Paralichthys californicus*	203
BC-A	night	California halibut	*Paralichthys californicus*	130
BC-B	night	arrow goby	*Clevelandia ios*	35
BC-D	night	arrow goby	*Clevelandia ios*	35
BC-D	night	arrow goby	*Clevelandia ios*	33
BC-D	night	arrow goby	*Clevelandia ios*	30
BC-D	night	speckled midshipmen	*Porichthys myriaster*	26
BC-D	night	speckled midshipmen	*Porichthys myriaster*	22
BC-D	night	speckled midshipmen	*Porichthys myriaster*	23
BC-E	night	California halibut	*Paralichthys californicus*	195

Figure 5.19. California halibut from Ballona Creek (photo: SMBRC 2009).

Incidental Macroinvertebrate Catch

The most common invertebrate caught incidentally in the beach seines was the California horn snail (*Cerithidea californica*), with several dozen caught in each haul at some stations. They were captured in beach seines at each Ditch and Wetland station (Table 5.11), but not in the Ballona Creek shrimp/otter trawls (Table 5.12). Another common invertebrate identified at multiple stations was the barred grass shrimp, previously seen in the 2005 City of LA surveys. An unknown Nereidae polychaete caught at the Wetland C and Ditch B stations was also observed at the other Wetland stations, but not collected in the seines. Navanax nudibranchs (*Navanax inermis*) and Gould's bubble snails (*Bulla gouldiana*) were commonly caught in the Ballona Creek trawls (Figure 5.20). Table 5.12 shows the species caught in the day and night trawls.

Table 5.11. Macroinvertebrates caught in the beach seines at each station. Note: species marked with an 'X' were present during surveys; asterisks indicate non-native species.

Common Name	**Scientific Name**	**Ditch_A**	**Ditch_B**	**Ditch_C**	**Wetland_A**	**Wetland_B**	**Wetland_C**
Asian mussel *	*Musculista senhousia*				X		
Barred grass shrimp	*Palaemon ritteri*	X		X			X
California horn snail	*Cerithidea californica*	X	X	X	X	X	X
Clam (unknown)	*Chione sp.*				X		X
Egg sac	----				X		
Gould's bubble snail	*Bulla gouldiana*		X				
Mussel (unknown)	*Mytilus sp.*				X		
Navanax nudibranch	*Navanax inermis*		X		X		
Pacific calico scallop	*Argopecten ventricosus*				X		
Polychaete (unknown)	*Nereis sp.*		X				X
Striped shore crab	*Pachygrapsus crassipes*				X		X
Trash	----	X	X	X	X	X	X

Table 5.12. Macroinvertebrates caught in the September Ballona Creek shrimp/otter trawls. Note: species marked with an 'X' were present during surveys; asterisks indicate non-native species.

Common Name	**Scientific Name**	**DAY**	**NIGHT**
Asian mussel *	*Musculista senhousia*	X	X
Clam (unknown)	*Chione sp.*	X	X
Decorator crab	*Loxorhynchus crispatus*	X	
Gould's bubble snail	*Bulla gouldiana*		X
Kelp crab	*Pugettia producta*	X	
Mussel (unknown)	*Mytilus sp.*	X	X
Navanax nudibranch	*Navanax inermis*	X	X
Nudibranch (unknown)	----		X
Pacific calico scallop	*Argopecten ventricosus*	X	X
Pacific razor clam	*Siliqua patula*		X
Sand dollar	*Dendraster excentricus*	X	
Trash	----	X	X

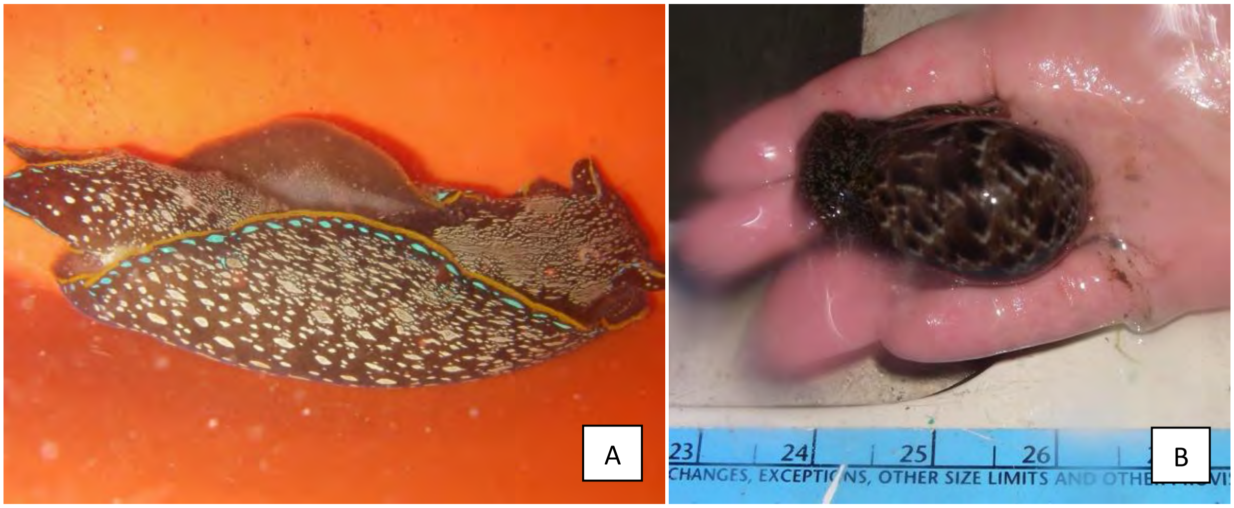

Figure 5.20. Common macroinvertebrates from Ballona Creek: (A) Navanax nudibranch and (B) Gould's bubble snail (photos: SMBRC 2009).

Special Status Species

No special status fish species were found during the first year BAP surveys. Appendix D.2 includes special status fish species with the potential to inhabit the BWER.

Prior to year one of the BAP, Steve Williams (Resource Conservation District of the Santa Monica Mountains) photographed two steelhead trout upstream of the BWER in Ballona Creek. The individuals were confirmed via photograph on 12 March 2008, underneath the Overland Avenue overpass in Culver City approximately four kilometers upstream from the 90 Freeway overpass (Figure 5.21).

Figure 5.21. Photo of steelhead trout in Ballona Creek (photo: S. Williams 2008).

FUTURE DIRECTIONS

During the second year of BAP surveys, the beach seine surveys will continue at the same sites and with similar frequency, effort, and timing. Minnow traps did not provide any new information, but required a high level of effort; therefore they will not be repeated in the second year of BAP surveys. Shrimp/otter trawl surveys will be repeated, with five transects and a minimum of three sampling events in the Creek in the second year of BAP surveys.

APPENDIX D.1

Ichthyofauna sampling methods comparison and review

Method Comparison and Rationale

Surveys at various spatial and temporal scales have identified wetland ichthyofauna throughout southern California wetlands using an assortment of methods. Employing a combination of survey methods to obtain data on fish abundance is often the most effective survey plan and minimizes error (Reed et al. 2002, Steele et al. 2006a, Steele et al. 2006b, Ambrose 2008, Merkel & Associates 2009b). The BAP reviewed previous survey strategies and tested several methods to determine the most appropriate methods. Evaluated survey methods included shrimp/otter trawls, purse seines, beach seines (active survey method evaluation) and enclosure traps and minnow traps (passive survey method evaluation).

Active Evaluation

The beach seine is pulled through the water column and is typically used in conjunction with blocking nets (Nordby and Zedler 1991). The blocking nets are deployed first, perpendicular to the shore and across the whole channel to prevent fish from escaping the survey area (Nordby and Zedler 1991, Steele et al. 2006b, WRP 2006). Fish abundance is generally expressed in terms of density, or the number of fish caught per area, and biomass, or the average fish weight per area.

Shrimp/otter trawls are utilized in a similar manner, but without blocking nets. Both trawls and purse seines are used most frequently in areas incorporating open water, as they are both deployed from a boat or skiff. There is often a tradeoff between effectiveness of the survey type for different species and the impact level on the environment (Table 5.3; Reed et al. 2002, Ambrose 2008, CCC 2006). In addition, the impact to the tidal channels increases as the number of survey stations increases. Table 5.3 describes the effectiveness of each type of survey gear in relation to common marsh species of southern California. Purse seines were not evaluated for the BWER because the overall water depth was too shallow.

Passive Evaluation

Minnow traps are baited and left out for a known period of time. Fish abundance is expressed as "catch per unit effort" (the amount of time the trap is deployed in the field). Enclosure traps also determine fish abundance, but within a specific, predefined area and are more often used for benthic fish as they do not cover enough area to accurately sample many species in the water column (Steele et al. 2006a, Ambrose et al. 2006; Table 5.3).

Table 5.3. Survey design effectiveness by species and impact (adapted from Reed et al. 2002).

FISH	**Minnow trap**	**Enclosure**	**Beach seine**	**Otter/Shrimp trawl**
Killifish	1	1	**2**	**2**
Topsmelt	0	0	**2**	1
Mullet	0	0	1	1
Mudsuckers	**2**	**2**	**2**	**2**
Gobies	0	**2**	1	**2**
Crabs / Macroinverts	**2**	**2**	1	0
IMPACT	**Low**	**Moderate**	**High**	**Moderate**

NOTE: **2** = highly effective; 1 = moderately effective; 0 = not effective

An additional issue addressed in the evaluation of the survey methods for the BWER was the reduced area and number of tidal channels at the BWER, as compared to other marsh habitats that have been surveyed, such as Carpinteria Salt Marsh and Mugu Lagoon (Reed et al. 2002, Ambrose et al. 2006). Since there is less channel area, fewer replicates were used with an increased effort per replicate to decrease the BAPs impact on the marsh (Steele et al. 2006b). Stations were chosen to replicate previous reports, except for the upper tidal channels. Upper tidal channels often resulted in low numbers of species, and a primary goal of the BAP was to evaluate the highest possible diversity.

Variability can be reduced by repeating stations and sites over multiple seasons and years. Zedler (2001) recommended June and September as the most important months for measuring ichthyofaunal diversity. A spring survey event should be added, if funds are available, to increase temporal repetition as well as to provide additional spawning information (CCC 2006). To address temporal changes throughout the year, the BAP sampled during September, April, and June.

BAP methods were based both on field tests and recommendations and results from similar surveys. Both the times and tides of each survey period (CCC 2006, Ambrose 2008, Merkel & Associates 2009a) influenced survey results, as well as the most effective survey method (Zedler et al. 1992, Steele et al. 2006). For example, blocking nets often reduce survey bias, but when used alone, they underestimate fish densities and diversity (Steele et al. 2006b). Therefore, a combination of blocking nets and repetitive beach seines in each station was used in this study. Because several studies found higher fish diversity, density, and biomass during nocturnal surveys than diurnal in the BWER and other marsh systems (Hoffman 2006, Merkel 2007, Merkel & Associates 2009a), the BAP conducted surveys both diurnally and nocturnally to assess the highest level of diversity and relative abundance possible.

APPENDIX D.2

Special status ichthyofauna species with the potential to inhabit the Ballona Wetlands Ecological Reserve

Common Name	**Scientific Name**	**Status**
Arroyo chub	*Gila orcutti*	California Species of Special Concern
Santa Ana speckled dace	*Rhinichthys osculus*	California Species of Special Concern
Santa Ana sucker	*Castostomus santaanae*	Federally threatened
Steelhead trout	*Oncorynchus mykiss*	Federally threatened
Tidewater goby	*Eucyclogobius newberri*	Federally endangered
Unarmored threespine stickleback	*Gasterosteus aculeatus williamsoni*	Federally endangered

Note: All ichthyofauna nomenclature was cited from “The Ecology of Marine Fishes: California and Adjacent Waters”, Allen, L.G., D.J. Pondella II, and M.H. Horn (2006). University of California Press, Berkeley, California.

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Photo credit: J. Goldfarb

CHAPTER 6:
HERPETOFAUNA

Ballona Wetlands Ecological Reserve, Los Angeles, California
Santa Monica Bay Restoration Commission

Prepared for: California State Coastal Conservancy
November 2011

Author: Karina Johnston

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HERPETOFAUNA

INTRODUCTION

Herpetofauna (i.e. amphibians and reptiles) are considered an integral but undervalued part of natural ecosystems (Gibbons et al. 2000, Meyers and Pike 2006). Gibbons et al. (2000) reflects that declines of herpetofauna species diversity and population size can be attributed in part to causes including: anthropogenic factors, habitat loss, presence of invasive and introduced species, pollution, and disease. Site-specific lists of species presence are important in the development of baseline information for a site, especially when directing conservation or management efforts (Tuberville et al. 2005); this information can also provide indicators of the health of a site.

The goal of the herpetofauna surveys for the Baseline Assessment Program (BAP) was to determine reptile species presence by habitat type throughout the Ballona Wetlands Ecological Reserve (BWER) and to contribute baseline information for future abundance and long-term monitoring surveys.

All herpetofauna scientific names in this report are cited using the *Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, With Comments Regarding Confidence in Our Understanding, Sixth Edition* by the Committee on Standard English and Scientific Names, Brian I. Crother, Chair, January 2008 (Society for the Study of Amphibians and Reptiles Herpetological Circular No. 37), henceforth referred to as SSAR 2008.

Existing Conditions Report Summary (Prior to 2005)

Past surveys in Areas A and B of the BWER have recorded nine species on site (Table 6.1). Hayes and Guyer (1981) found what they believed to be a small portion of the potential past diversity on site, due to anthropogenic habitat alteration and the encroachment of invasive vegetation (Shreiber 1981). Several species have been commonly observed on site, including: Great Basin fence lizards (*Sceloporus occidentalis longipes*), western side-blotched lizards (*Uta stansburiana elegans*), San Diego alligator lizards (*Elgaria multicarinata webbii*), California kingsnakes (*Lampropeltis getula californiae*), and San Diego gopher snakes (*Pituophis catenifer annectens*) (Hayes and Guyer 1981, Frank Hovore and Associates 1991, Impact Sciences, Inc. 1996, SSAR 2008). Table 6.1 summarizes the results of the scientific surveys conducted for herpetofauna over the past 25 years that were included in the Existing Conditions Report (PWA 2006).

Three amphibian species have been documented on site: Baja California treefrogs (*Pseudacris hypochondriaca hypochondriaca*), California toads (*Bufo boreas halophilus*), and the garden slender salamander (*Batrachoseps major major*). Their numbers have declined from the early 1980s to the early 1990s, potentially due to drought conditions in 1991 (Hayes and Guyer 1981, Frank Hovore and Associates 1991).

Several general census studies and targeted special status species surveys have been conducted over the past 25 years (Hayes and Guyer 1981, Impact Sciences, Inc. 1996, Psomas and Associates 2001). The only special status species found on site in the past 25 years was the California legless lizard (*Anniella pulchra*), which is a California Species of Special Concern that was found in the dune restoration area in the western portion of Area B (Hayes and Guyer 1981, Frank Hovore and Associates 1991).

The herpetofauna of Area C in the BWER has not been documented in past reports and was identified as a data gap for the BAP surveys (Hayes and Guyer 1981, Frank Hovore and Associates 1991).

Table 6.1. Herpetofauna species list (modified from PWA 2006 using nomenclature from SSAR 2008). Note: Threatened, endangered, and species of special concern that have been specifically surveyed for on site are listed first. Only those species with an 'X' were present during surveys.

COMMON NAME	**SCIENTIFIC NAME**	**STATUS**	**1981**	**1991**	**1996**
Arroyo toad	*Bufo californicus*	Federally Endangered / CA Species of Special Concern			
California legless lizard	*Anniella pulchra*	CA Species of Special Concern	X	X	
California red-legged frog	*Rana draytonii*	Federal Threatened / CA Species of Special Concern			
Coast horned lizard	*Phrynosoma blainvillei*	CA Species of Special Concern			
South coast garter snake	*Thamnophis sirtalis ssp.*	CA Species of Special Concern			
Southwestern pond turtle	*Actinemys marmorata pallida*	CA Species of Special Concern			
Two-striped garter snake	*Thamnophis hammondi*	CA Species of Special Concern			
Western spadefoot toad	*Spea hammondii*	CA Species of Special Concern			
Baja California treefrog	*Pseudacris hypochondriaca hypochondriaca*	Native species	X		X
California kingsnake	*Lampropeltis getula californiae*	Native species	X	X	X
California toad	*Bufo boreas halophilus*	Native species	X		X
Garden slender salamander	*Batrachoseps major major*	Native species	X	X	
Great Basin fence lizard	*Sceloporus occidentalis longipes*	Native species	X	X	X
San Diego alligator lizard	*Elgaria multicarinata webbii*	Native species	X	X	X
San Diego gopher snake	*Pituophis catenifer annectens*	Native species	X	X	X
Western side-blotched lizard	*Uta stansburiana elegans*	Native species	X	X	X

Interim Research (2005-2010)

Two reports have been compiled concerning herpetofauna in the western portion of Area B in the intervening period between the Existing Conditions Report and the BAP: the Ballona Outdoor Learning and Discovery (BOLD) Report (Sustaita et al. 2007) and a report on the herpetofauna and mammal surveys conducted for the Early Action Plan (EAP) (Johnston et al. 2009).

The BOLD Report (Sustaita et al. 2007) summarized findings from two herpetofauna surveys conducted on the BOLD project site over 180 trapping nights in the southwestern portion of Area B near the Gordon's lot entranceway (Figure 6.1). The surveys were conducted in spring and late summer of 2005 (Sustaita et al. 2007). Herpetofauna were classed as either common or uncommon. Two species of common lizard were caught in the study area: Great Basin fence lizard and western side-blotched lizard. No species of special concern were found using pitfall traps in the study area, despite trap placement in areas where the California legless lizard was likely to occur; however, two California legless lizards were observed in sandy soil underneath logs (Sustaita et al. 2007). The only other reptile species observed during the study was the San Diego alligator lizard; although a San Diego gopher snake was photographed on the site the day before the surveys. San Diego Alligator lizards were observed near the education trailer and in the surrounding pickleweed (*Salicornia virginica*). Additionally, Baja California treefrogs were heard vocalizing during the May survey period, but were not confirmed visually.

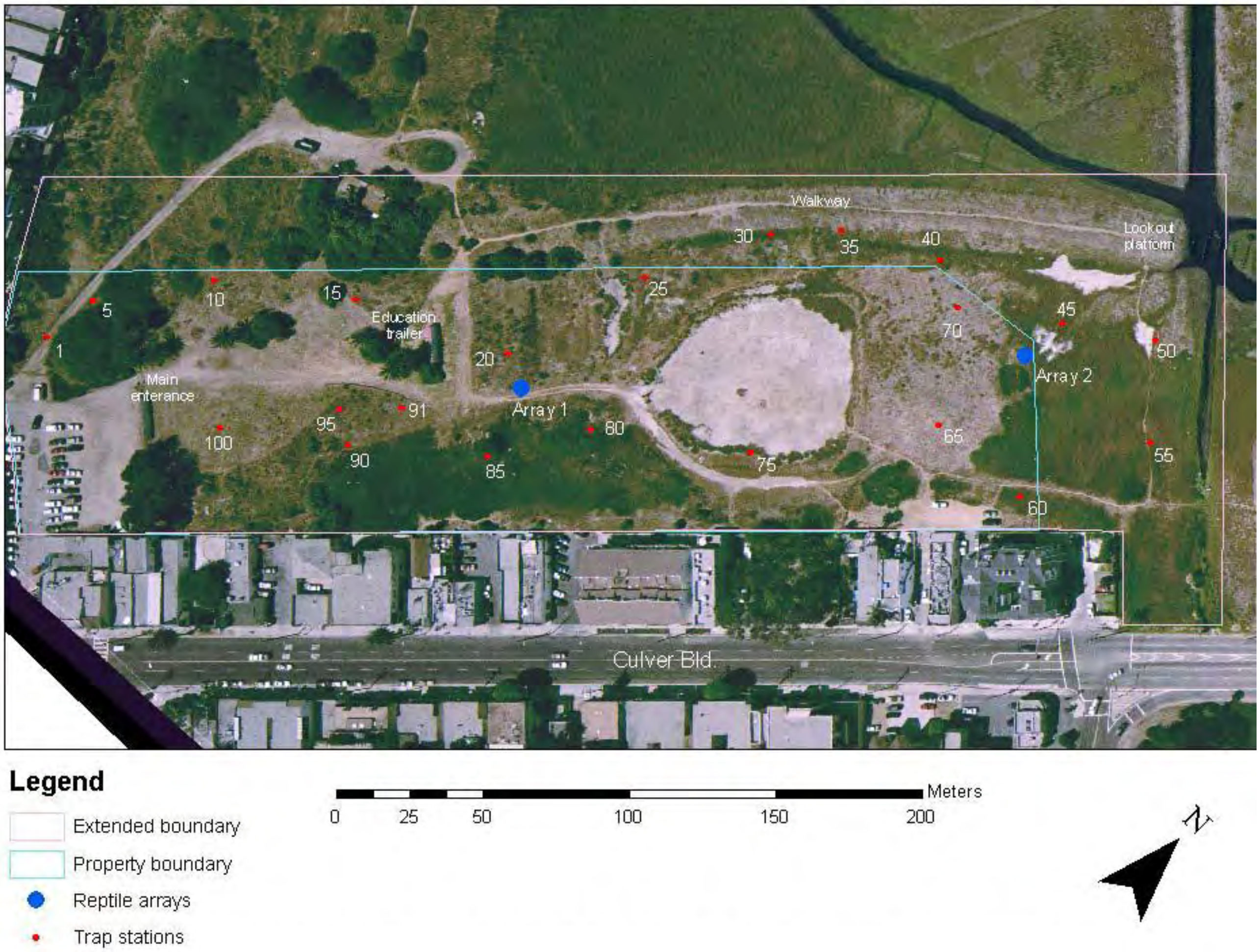

Figure 6.1. Map of BOLD site boundaries and survey locations (reproduced from Sustaita et al. 2007).

Johnston et al. (2009) conducted a survey for herpetofauna in the portion of Area B located directly adjacent to Gordon's lot within the area designated the EAP (Figure 6.2). Surveys conducted during June 2009 utilized pitfall trap and driftnet arrays as well as comprehensive area searches. The two pitfall and driftnet arrays are represented by blue polygons in Figure 6.2. Three lizards were caught in two arrays over 88 trap nights: two western side-blotched lizards and one San Diego alligator lizard. Additional site searches of the area were conducted, revealing one San Diego gopher snake and three Great Basin fence lizards.

Figure 6.2. Survey locations for herpetofauna and mammal surveys within EAP project site (reproduced from Johnston et al. 2009). Note: pitfall and driftnet arrays are in blue; green lines indicate mammal transects.

METHODS

Method Comparison and Rationale

Generally, a combination of survey methods is recommended to achieve the highest possible species richness (number of species) and to increase the probability of detecting the most types of herpetofauna (Mengak and Guynn 1987, Ryan et al. 2002, Fisher et al. 2008, Tuberville et al. 2005, Thompson and Thompson 2007).

Pitfall traps in combination with driftnet arrays is one of the most common survey methods for herpetofauna because it effectively determines species richness and can potentially detect rare or secretive species (Crosswhite et al. 1999, Russel et al. 2002, Tuberville et al. 2005); although it can be time intensive and may produce irregular results. Crosswhite et al. (1999) found the pitfall and driftnet combination an effective survey method for frogs, toads, salamanders, lizards, and small snakes, although they were unable to use the method on large snakes. Funnel traps were required to catch the large squamates (Crosswhite et al. 1999). Capture success for Crosswhite et al. (1999) was highly variable and appeared to be correlated with temperature and precipitation.

Ryan et al. (2002) surveyed for herpetofauna in a variety of habitats, including: bottomland wetlands, upland wetlands, clearcut forests, pine plantations, and mixed pine-hardwood forests. Their results suggested that driftnet fences were superior to other methods in capturing individuals and species and that they were the preferred method for evaluating poorly represented species.

Recent literature is in agreement that a combination of methods is the most effective in evaluating species presence across multiple habitats and to inform long term monitoring programs. The BAP employed a combination of driftnet fences, pitfall traps, and site searches for herpetofauna in the first Baseline year.

Site Locations and Times

Herpetofauna surveys were conducted in three habitat types: seasonal wetland, upland grassland, and upland scrub (Figure 6.3). Surveys were conducted during three seasons (early fall, spring, and early summer) of the Baseline year (September 2009 – September 2010). Early fall surveys occurred from 2 November to 12 November 2010; spring surveys occurred from 30 March to 12 April 2010; early summer surveys occurred from 24 June to 5 July 2010.

Pitfall traps and driftnet fence arrays were used in several of the major habitat types, determined by the California Department of Fish and Game (CDFG) plant community surveys (CDFG 2007; see Vegetation chapter for more details). Herpetofauna surveys occurred for ten consecutive days and nights, when possible. Spring surveys were cut short at Arrays B1 and B2 due to groundwater flooding. Surveys were conducted during the same months and approximate locations as the small mammal surveys, but not within one week of a previous small mammal trap deployment. Additionally, site-wide searches involving board and cover flipping, and targeted surveys for the California legless lizard, were conducted.

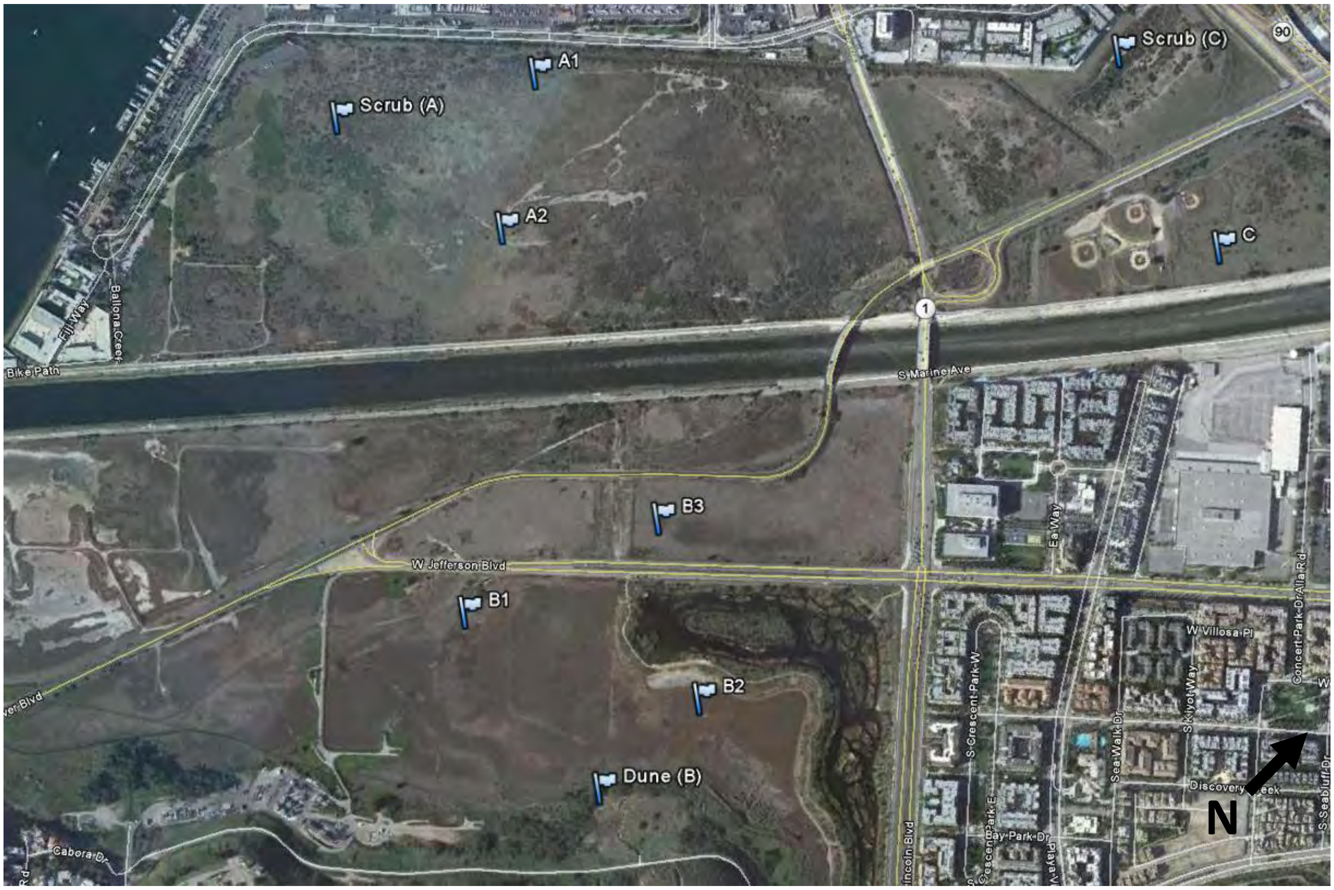

Figure 6.3. Herpetofauna survey stations during the first Baseline year.

Field Methods

Three arrays were located in each of two habitat types: seasonal wetlands and uplands. Arrays were placed in areas with little to no vegetation (Tuberville et al. 2005). Arrays consisted of nylon mesh net transects held in place by wooden dowels or stakes. Three primary transects (9 m) were placed in each of the appropriate habitats. The primary transect was intersected perpendicularly on either side by two sets of smaller (3 m long) transects evenly spaced every 3 m (Figures 6.4 and 6.5). At the corner of each intersection, one plastic bucket with smooth side walls was buried until the edge was flush with the ground. The bucket was subsequently covered by a piece of plywood propped open several inches. Buckets were checked once daily in the early afternoon to minimize exposure time for captured individuals. Captured individuals were identified using the *Field Guide to Western Reptiles and Amphibians* (Stebbins 2003), recorded, weighed, measured, marked, photographed, and subsequently released back into the area of capture. The lizards were marked by painting their right hind toes with red nail polish.

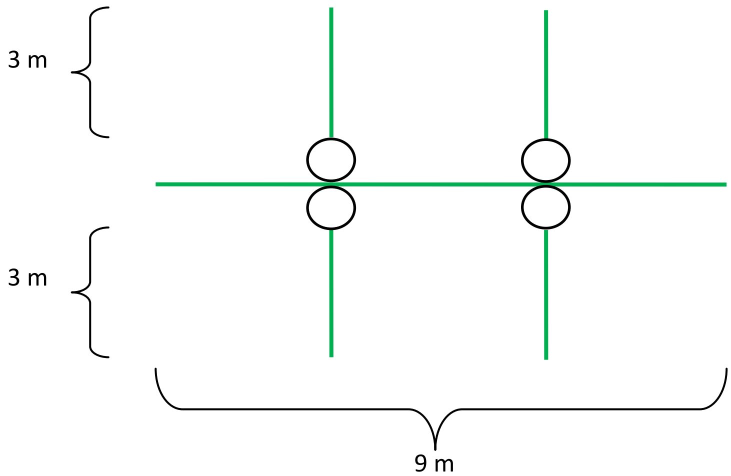

Figure 6.4. Drift net conceptual design. Not drawn to scale.

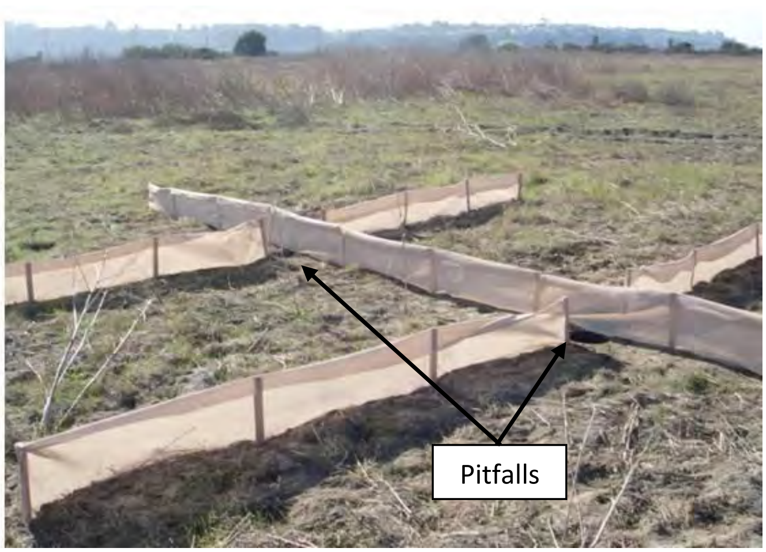

Figure 6.5. Photos of full drift net array (photos: Santa Monica Bay Restoration Commission (SMBRC) 2010).

Intensive site searching was undertaken twice within each survey period to detect species that may have been missed by the drift net arrays (e.g. turtles, salamanders, and semi-aquatic reptiles and amphibians). Individuals were taxonomically identified and counted, and size-class was estimated when possible. Holes, crevices, logs, rocks, and overhangs were thoroughly searched, and ancillary observations of herpetofauna were recorded during other surveys. All snakes seen during the Baseline year were visually identified, photographed, and had their GPS location marked.

California Legless Lizard Survey Methods

The California legless lizard, a California Species of Special Concern, has been recently confirmed on site in the dune restoration area in the western corner of Area B (K. Rose, pers. comm. 2009). Therefore, the BAP incorporated targeted surveys for this species in each habitat type classified as dune throughout the

BWER and in adjacent areas with suitable leaf litter (CDFG 2007). Three such habitat types exist at the BWER: the dune restoration site in Area B (8.6 acres), the dune wash area in Area B below the Cabora Road bluffs (3.60 acres), and a small area of disturbed dune habitat in Area C, located near the Culver Boulevard and Lincoln Boulevard interchange (2.06 acres). Survey methods followed protocols developed by Linda Kuhnz, specific to the California legless lizard (Kuhnz 2000, and Kuhnz et al. 2005). Non-invasive protocols were chosen to minimize site disruption and to obtain presence information for each habitat area. California legless lizard survey protocols were cleared by the CDFG to be congruent with their survey preferences for the BWER (D. Lawhead, CDFG, pers. comm. 2010).

Each dune habitat type was surveyed at least once during late summer. The dune restoration site in Area B was surveyed twice during August (19 August and 24 August 2010); the dune wash in Area B was surveyed once on 21 September 2010; the disturbed dune habitat of Area C was surveyed once on 29 September 2010. Small hand tools were used to flip the top layer of leaf litter and sand in the preferred habitats (Kuhnz 2000, and Kuhnz et al. 2005). Substrate was returned to its original location and orientation upon completion of the search. To minimize disturbance, standards were established that the discovery of one legless lizard in a location was sufficient to determine presence for that area. The dune restoration area was surveyed twice due to the extensive size of the habitat (8.6 acres compared to 3.60 and 2.06 acres of dune habitat in other locations).

Laboratory and Analyses Methods

No laboratory methods were used in the herpetofauna surveys. For the analyses, species presence was reported, along with capture rate (i.e. number of individuals / total number of trapping nights x 100) by habitat.

RESULTS

General Results and Overall Trends

In the 2010 Baseline surveys, eight herpetofauna species were captured or observed on site (Table 6.2, Figure 6.6). An additional three species were reported during the first Baseline year in the adjacent Ballona Freshwater Marsh (FWM) (E. Read, pers. comm. 2009). Table 6.2 includes all species present during the Baseline year as well as the special status species that have the potential to occur [SSAR 2008, California Natural Diversity Database (CNDDB) 2010]. A total of 71 lizards were caught in the pitfall traps and driftnet arrays over the course of the Baseline year: 49 Great Basin fence lizards, 19 western side-blotched lizards, and three San Diego alligator lizards. In addition to the herpetofauna, there were several instances of incidental mammal capture in the pitfall traps: two Botta's pocket gophers (*Thomomys bottae*) and one western harvest mouse (*Reithrodontomys megalotis*). All individuals were released into the vegetation surrounding the pitfall array of capture.

As a result of the BAP surveys, three additional species present at the BWER were added to the herpetofauna species list in the Existing Conditions Report (PWA 2006): southern Pacific rattlesnake (*Crotalus oreganus helleri*), red-eared slider (*Trachemys scripta elegans*), and American bullfrog (*Rana catesbeiana*). Both the red-eared slider and American bullfrog are non-native species and were identified in the FWM (Edith Read, pers. comm. 2009).

Table 6.2. Herpetofauna species identified during the first Baseline year. Note: '2010' indicates species found during the BAP surveys; 'FWM' indicates species seen at the Ballona Freshwater Marsh adjacent to the site (E. Read, pers. comm. 2009). Species marked with an 'X' were present during surveys.

COMMON NAME	**SCIENTIFIC NAME**	**STATUS**	**2010**	**FWM**
American bullfrog	*Rana catesbeiana*	Non-native species (introduced)		X
Baja California treefrog	*Pseudacris hypochondriaca hypochondriaca*	Native species	**X**	X
California kingsnake	*Lampropeltis getula californiae*	Native species	**X**	X
California legless lizard	*Anniella pulchra*	California Species of Special Concern	**X**	
California toad	*Bufo boreas halophilus*	Native species		X
Great Basin fence lizard	*Sceloporus occidentalis longipes*	Native species	**X**	X
Red-eared slider	*Trachemys scripta elegans*	Non-native species (introduced)		X
San Diego alligator lizard	*Elgaria multicarinata webbii*	Native species	**X**	
San Diego gopher snake	*Pituophis catenifer annectens*	Native species	**X**	X
Southern Pacific rattlesnake	*Crotalus oreganus helleri*	Native species	**X**	
Western side-blotched lizard	*Uta stansburiana elegans*	Native species	**X**	

Figure 6.6. Photos of common herpetofauna observed during the BAP: (A) Great Basin fence lizard, (B) western side-blotched lizard, (C) San Diego alligator lizard, (D) San Diego gopher snake, and (E) California kingsnake (photos: SMBRC 2010).

Walking Survey Results

Walking surveys resulted in sightings of several species of snake over the course of the Baseline year. Abundance surveys were not conducted for snakes, but visual confirmations of individuals were recorded. Locations of the six California kingsnakes, five San Diego gopher snakes, and three southern Pacific rattlesnakes (Figure 6.6) identified throughout the year of surveys are shown in Figure 6.7. In addition to being captured during the pitfall trapping, Great Basin fence lizards and western side-blotched lizards (Figure 6.6) were visually identified throughout the site in all three Areas (A, B, and C).

Southern Pacific rattlesnakes were seen on three occasions during the first year of the BAP (Figure 6.7). Two sightings were confirmed by photographs received by the monitoring team on 24 April and 20 July 2010. The third sighting was of a juvenile rattlesnake that was warming on the rocks adjacent to the southern Ballona Creek levee next to the eastern (main) tide gate. This rattlesnake was anecdotally reported to the monitoring team by three different local residents walking along the levee, but photographic evidence was not available. The red-eared slider and bullfrog that were found in the FWM system were not surveyed for on the rest of the site due to lack of preferred habitat (E. Read, pers. comm. 2009). Both species are non-native and have been introduced to the southern California region (Stebbins 2003).

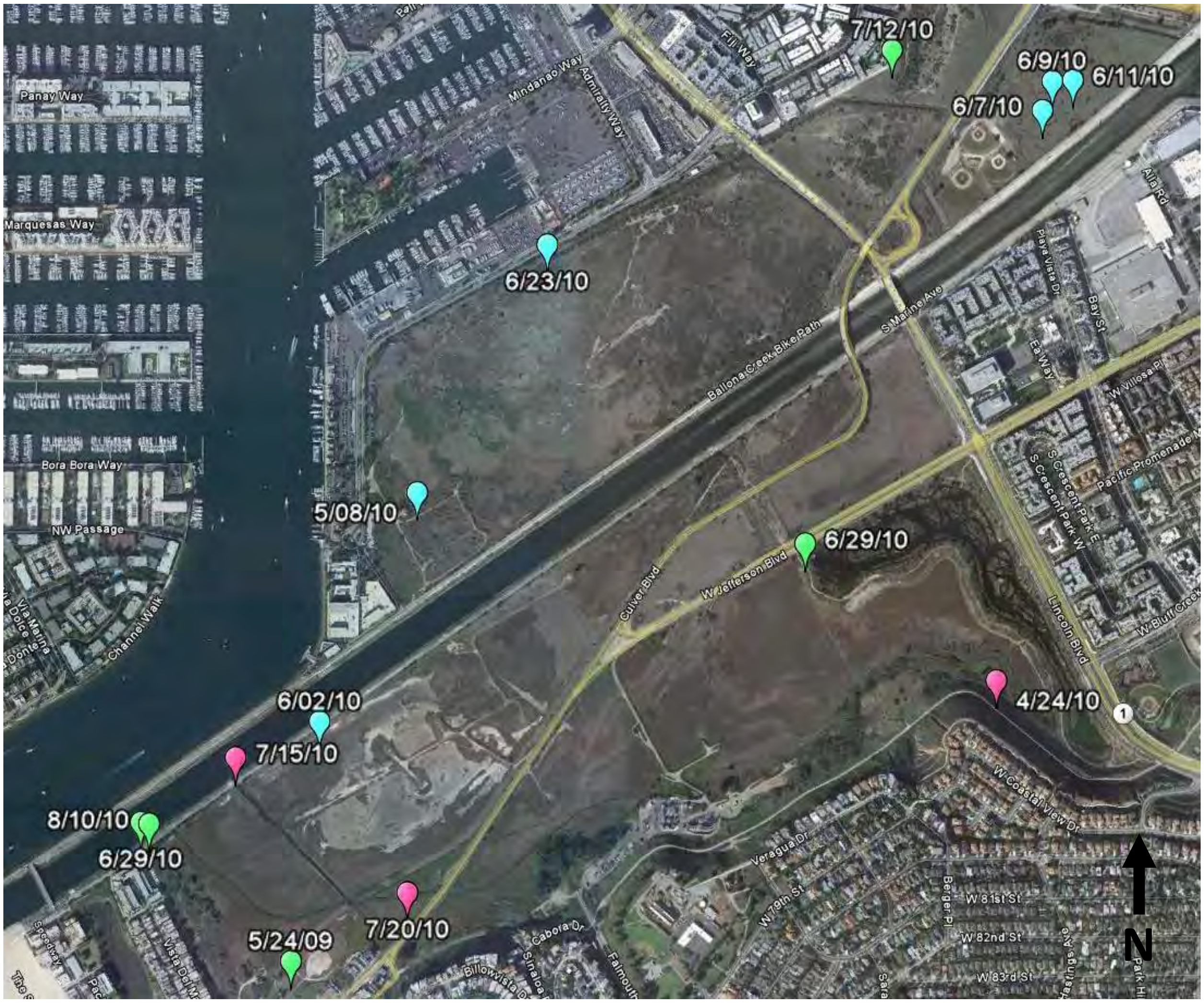

Figure 6.7. Map of snake sightings confirmed by photograph in the BWER and date of sighting. Pink markers indicate southern Pacific rattlesnakes, light blue markers indicate California kingsnakes, and green markers indicate San Diego gopher snakes.

The garden slender salamander (*Batrachoseps major major*) was found in previous surveys (Hayes and Guyer 1981, Frank Hovore and Associates 1991) but was not recorded during the first Baseline year. Targeted surveys for this species will continue during the second Baseline year during the appropriate season (i.e. October through May) and habitat (i.e. damp soils).

Drift Net and Pitfall Trap Results

Success rates of pitfall trap and driftnet array protocols generally vary widely based on survey area, habitat, and season (Crosswhite et al. 1999). The BAP found, during the first Baseline year, drift net and pitfall trap surveys had a much higher capture rate of lizards at 34.6% in summer 2010 than in fall 2009 or spring 2010, at 2.3% and 7.0% respectively (Tables 6.3, 6.4, and 6.5).

The dune survey had a higher total capture rate, at 69.2%, than any of the other surveys (Table 6.5). The dune survey catch was dominated by Great Basin fence lizards, but also had the highest diversity of any array and included all three of the most common lizards on site (Great Basin fence, western side-blotched, and San Diego alligator). Great Basin fence lizards were the most common captured and observed lizard and appeared to be ubiquitous throughout the BWER. Overall trap success was greater for Great Basin fence lizards during the spring survey, for both the upland habitats, at 8.3%, and the seasonal wetland habitats at 3.1%. One San Diego alligator lizard was caught in each season: fall 2009 and spring and summer 2010.

Fall Results

During the fall 2009 survey, five lizards were captured over 216 trap nights for an overall capture rate of 2.3% (Table 6.3). Great Basin fence lizards were caught more often than San Diego alligator lizards. One lizard was caught in the seasonal wetland surveys (B2). Several individual arrays had a zero capture rate (A2, B1, and B3), and no lizards were recaptured during the fall surveys. A San Diego alligator lizard was caught in the grassland array in Area C, south of Culver Boulevard.

Table 6.3. Fall 2009 herpetofauna survey results for lizards including numbers of individuals and capture rates.

HABITAT	COMMON NAME	SCIENTIFIC NAME	# INDIV	TRAP NIGHTS	CAPTURE RATE (%)		# RE-CAPTURE	RECAPTURE RATE (%)
Upland grassland (A1)	Great Basin fence	*Sceloporus occidentalis longipes*	3	36	8.3		0	0.0
Upland grassland (A2)	(none)	----	0	36	0.0		0	0.0
Upland grassland (C)	San Diego alligator	*Elgaria multicarinata webbii*	1	36	2.8		0	0.0
GRASSLAND TOTAL	----	----	4	108	3.7		0	0.0
Seasonal wetland (B1)	(none)	----	0	36	0.0		0	0.0
Seasonal wetland (B2)	Great Basin fence	*Sceloporus occidentalis longipes*	1	36	2.8		0	0.0
Seasonal wetland (B3)	(none)	----	0	36	0.0		0	0.0
SEASONAL WETLAND TOTAL	----	----	1	108	0.9		0	0.0
GRAND TOTAL	----	----	5	216	2.3		0	0.0

Spring Results

During the spring 2010 survey, a total of 12 lizards were caught over 172 total trap nights for an overall capture rate of 7.0% (Table 6.4). The lower number of trap nights was due to the flooding of traps and subsequent removal of those arrays (B1 and B2). The grassland habitat had a capture rate almost double that of the seasonal wetland habitat, at 8.3% and 4.7% respectively. The highest capture rate was seen in array A1 at 22.2%, which was composed of all Great Basin fence lizards. Two Great Basin fence lizards were recaptures from array A1 in the grasslands. The San Diego alligator lizard was found in the seasonal wetland array (B1) to the east of the Ballona Freshwater Marsh and west of the Gas Company Road.

Table 6.4. Spring 2010 herpetofauna survey results for lizards including numbers of individuals and capture rates.

HABITAT	COMMON NAME	SCIENTIFIC NAME	# INDIV	TRAP NIGHTS	CAPTURE RATE (%)	# RE-CAPTURE	RECAPTURE RATE (%)
Upland grassland (A1)	Great Basin fence	*Sceloporus occidentalis longipes*	8	36	22.2	2	5.6
Upland grassland (A2)	Great Basin fence	*Sceloporus occidentalis longipes*	1	36	2.8	0	0.0
Upland grassland (C)	(none)	----	0	36	0.0	0	0.0
GRASSLAND TOTAL	----	----	9	108	8.3	0	0.0
Seasonal wetland (B1)	Great Basin fence	*Sceloporus occidentalis longipes*	1	16	6.3	0	0.0
Seasonal wetland (B1)	San Diego alligator	*Elgaria multicarinata webbii*	1	16	6.3	0	0.0
Seasonal wetland (B2)	Great Basin fence	*Sceloporus occidentalis longipes*	1	16	6.3	0	0.0
Seasonal wetland (B3)	(none)	----	0	32	0.0	0	0.0
SEASONAL WETLAND TOTAL	----	----	3	64	4.7	0	0.0
GRAND TOTAL	----	----	12	172	7.0	2	1.2

Summer Results

During the summer 2010 survey, 54 lizards were caught over 156 total trap nights for a capture rate of 34.6% (Table 6.5). The summer catch rate was almost five times that of the spring survey and was more than an order of magnitude higher than the capture rate of the fall survey. Trap success during the summer survey was greatest in the dune habitat array, at 69.2%. The summer survey resulted in the most recaptures: six Great Basin fence lizards and three western side-blotched lizards in total.

Table 6.5. Summer 2010 herpetofauna survey results for lizards including numbers of individuals and capture rates.

	SCIENTIFIC NAME	# INDIV	TRAP NIGHTS	CAPTURE RATE (%)	# RE-CAPTURE	RECAPTURE RATE (%)
Dune (B) - TOTAL	----	36	52	69.2	8	15.4
Great Basin fence	*Sceloporus occidentalis longipes*	16	52	30.8	5	9.6
Western side-blotched	*Uta stansburiana elegans*	19	52	36.5	3	5.8
San Diego alligator	*Elgaria multicarinata*	1	52	1.9	0	0.0
Scrub (A) - TOTAL	----	12	52	23.1	1	1.9
Great Basin fence	*Sceloporus occidentalis longipes*	12	52	23.1	1	1.9
Scrub (C) - TOTAL	----	6	52	11.5	0	0.0
Great Basin fence	*Sceloporus occidentalis longipes*	6	52	11.5	0	0.0
GRAND TOTAL	----	**54**	**156**	**34.6**	**18**	**11.5**

Freshwater Marsh Species

Species seen at the FWM throughout the Baseline year were recorded by the Director of the marsh, Dr. Edith Read. Systematic surveys for herpetofauna were not conducted in the FWM during the Baseline year, but ancillary observations were made during other surveys (E. Read, pers. comm. 2010). Ancillary observations in the FWM included several species: California toad, Baja California treefrog, California kingsnake, San Diego gopher snake, red-eared slider, American bullfrog, and Great Basin fence lizard.

The California toad was most readily observed in association with rodent burrows, especially around trees, and emerged when these burrows flooded with rain or irrigation water (E. Read, pers. comm. 2010). Baja California treefrogs mostly congregated in artificial habitat such as irrigation valve boxes.

Special Status Species

The only threatened, endangered or California Species of Special Concern reported at the BWER is the California legless lizard (Hayes and Guyer 1981, Frank Hovore and Associates 1991, Impact Sciences, Inc. 1996, K. Rose, pers. comm. 2009). The BAP included targeted surveys for the California legless lizard. Appendix E.1 contains special status herpetofauna species with the potential to inhabit the BWER.

California Legless Lizard Results

A California Species of Special Concern, the California legless lizard, was found in targeted surveys. Two California legless lizards were found in the restored dune habitat in the western portion of Area B (Figures 6.8 and 6.9). Biologists following approved legless lizard search protocols (D. Lawhead, CDFG, pers.comm. 2010) searched a total of 12 hours in the appropriate habitat. Both were found in leaf litter below *Salix* sp. Surrounding vegetation searched included: *Lupinus chamissonis, Phacelia rhamissonia, Eriogonum parvifolium,* and *Ambrosia chamissonis*. Nearby *Carpobrotus edulis*, detritus, and wood piles were also searched.

For the first time in 19 years of scientifically documented surveys in the BWER, a California legless lizard was found in the dune wash habitat of Area B beneath Cabora Road. Biologists following the legless lizard search protocols (D. Lawhead, CDFG, pers. comm. 2010) searched a total of five hours in the appropriate habitat (Figure 6.9). Surrounding vegetation searched included: *Lotus* sp., *Salix* sp., *Avena fatua, Croton californicus*, *Gnaphalium canescens*, *Heterotheca grandiflora*, and *Carpobrotus edulis* detritus. Once the lizard's presence was confirmed, searching was concluded.

No California legless lizards were found in the dune habitats of Area C. The vegetation of Area C searched included: *Artemesia californica, Croton californicus, Malosma laurina,* and *Lotus scoparius*, as well as other less common species.

One lizard escaped before it could be measured, but the other two measured 24 cm in length, 1.15 cm maximum width and 22 cm in length, 1.05 cm maximum width, respectively (Figure 6.9). Videos were taken of the California legless lizard found in the restored dune habitat and photographs were taken of individual lizards found and the surrounding habitat. All lizards were found underneath 4-5 cm of leaf litter and an additional 3-4 cm of sand.

Several dozen California legless lizard tracks were found in the hard packed sand in the immediate vicinity of the capture of the second California legless lizard found in the western restored dune habitat. The tracks were visible in the top layer of sandy soil over a packed dirt road (Figure 6.10). Searching in other areas of similar habitat and soil composition yielded no results.

Figure 6.8. Map of habitat surveyed for California legless lizards: (A) restoration habitat area in western Area B, (B) dune wash habitat in southern Area B, (C) dune habitat in Area C (east of Lincoln Boulevard).

Figure 6.9. Photos of captured California legless lizards and their surrounding vegetation: (A) western restored dune area, and (B) dune wash beneath Cabora Road (photos: SMBRC 2010).

Figure 6.10. Photos of California legless lizard tracks (photos: SMBRC 2010).

Kelly Rose, the Programs Director for the Friends of the Ballona Wetlands (FBW), reports that California legless lizards were not seen by FBW staff during all restoration events during the first Baseline year, although they usually encounter 8-10 individuals per year (K. Rose, pers comm. 2009). The California legless lizards are most often seen during rubble raking and rarely in ice plant detritus. Since encountering the California legless lizard, the FBW have restricted their areas of activity to avoid impacting legless lizard habitat.

FUTURE DIRECTIONS

To address the lack of snakes and amphibians encountered in the driftnet and pitfall surveys, coverboard array surveys will be conducted in the second Baseline year, with the assistance of herpetologists Jack Goldfarb and Andrew Keller. The coverboard arrays will be placed in suitable habitats in all three Areas (A, B, and C) of the BWER. Preliminary results indicate that the coverboard arrays are a more successful method for surveying herpetofauna diversity in the BWER.

The coverboard arrays will be placed in October 2010 and checked routinely during the appropriate sampling season for all species. Spring and summer pitfall trapping will continue, but fall surveys will not be repeated due to the low abundance of captured lizards. Additional pitfall traps will be placed in targeted habitats. Preliminary data show the presence of most species found during the first Baseline year as well as more numerous instances of snakes and two instances of the garden slender salamander in Area B.

APPENDIX E.1

Special status herpetofauna species with the potential to inhabit Ballona Wetlands Ecological Reserve

COMMON NAME	SCIENTIFIC NAME	STATUS
Arroyo toad	*Bufo californicus*	Federally Endangered / California Species of Special Concern
California legless lizard	*Anniella pulchra*	California Species of Special Concern
California red-legged frog	*Rana draytonii*	Federally Threatened / California Species of Special Concern
South coast garter snake	*Thamnophis sirtalis ssp.*	California Species of Special Concern
Coast horned lizard	*Phrynosoma blainvillei*	California Species of Special Concern
Southwestern pond turtle	*Actinemys marmorata pallida*	California Species of Special Concern
Two-striped garter snake	*Thamnophis hammondi*	California Species of Special Concern
Western spadefoot toad	*Spea hammondii*	California Species of Special Concern

NOTE: All herpetofauna scientific names are cited using the *Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, With Comments Regarding Confidence in Our Understanding, Sixth Edition* by the Committee on Standard English and Scientific Names, Brian I. Crother, Chair, January 2008 (Society for the Study of Amphibians and Reptiles Herpetological Circular No. 37).

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Photo credit: J. Reclosado

CHAPTER 7:
MAMMALS

Ballona Wetlands Ecological Reserve, Los Angeles, California
Santa Monica Bay Restoration Commission

Prepared for: California State Coastal Conservancy
November 2011

Author: Karina Johnston

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MAMMALS

INTRODUCTION

Mammals are an important link to functioning wetland and upland ecosystems within a complex food web (Mayfield et al. 2000). They can indicate change in overall vertebrate populations within a system, thereby serving as indicators of the overall health of the system (Manley et al. 2004). The Ballona Wetlands region has experienced a decline in the size of native species' populations, a reduction in several native species' ranges, and an increase in the types and population sizes of introduced species throughout the last century (Friesen et al. 1981).

The principle goal of the Baseline Assessment Program (BAP) mammal surveys was to identify the presence of mammal species inhabiting or utilizing the Ballona Wetlands Ecological Reserve (BWER). The BAP was comprehensive across the entire site, unlike previous studies which targeted particular Areas or species. Several methods were used to identify groups of mammals varying in lifestyle and distribution.

All mammal nomenclature follows current citations from the Smithsonian Museum of Natural History, North American Mammals (searched January 2011; http://www.mnh.si.edu/mna/main.cfm).

Existing Conditions Report Summary (Prior to 2005)

Surveys throughout the BWER in the past 29 years have yielded a comprehensive inventory of 16 mammal species, three of which are designated California Species of Special Concern (Table 7.1), i.e. Southern California saltmarsh shrew (*Sorex ornatus salicornicus*), San Diego black-tailed jackrabbit (*Lepus californicus bennetti*), and South Coast marsh vole (*Microtus californicus stephensi*) (Williams 1986).

Previous BWER surveys used a variety of mammal sampling methods, including: Sherman live traps, pitfall traps, scent station monitoring, track station monitoring, and observational site searches (Friesen et al. 1981, Frank Hovore and Associates 1991, Impact Science, Inc. 1996, Erickson 2000, Psomas and Associates 2001). The 2001 surveys were conducted within Area B, and are not representative of the entire site (Psomas and Associates 2001).

The introduction of non-native herbivores and carnivores has had documented negative effects on ecosystems (Andersson and Erlinge 1977, Sinclair et al. 1990, Mayfield et al. 2000). An example of this at the BWER was the presence of the non-native red fox (*Vulpes vulpes*), which was deemed a threat to the small mammal populations on site (Frank Hovore and Associates 1991, R. Mayfield, pers. comm.). Seven mammal species identified in past surveys have been classified as non-native to the Ballona region, including: red fox, black rat (*Rattus rattus*), domestic cat (*Felis cattus*), domestic dog (*Canis* *familiaris*), house mouse (*Mus musculus*), Norway rat (*Rattus norvegicus*), and Virginia opossum (*Didelphis virginiana*) (Table 7.1).

Bat surveys were conducted by Friesen et al. (1981) and Impact Sciences (1996). No evidence of bats was found in either study, though eight species of bat have been identified through voucher specimens as historically inhabiting the area (Natural History Museum of Los Angeles County; PWA 2006). The previous surveys utilized hand-held bat detectors, traplines, Sherman live traps, Museum Special traps, and extensive observations and site searching for indirect evidence (e.g. guano, staining, and other indicators).

Interim Research (2005-2010)

Two mammal surveys were conducted in the western portion of Area B between the development of the Existing Conditions Report (PWA 2006) and the initiation of the BAP: the Ballona Outdoor Learning and Discovery (BOLD) Report (Sustaita et al. 2007) and a report on the herpetofauna and mammal surveys conducted for the Early Action Plan (EAP) (Johnston et al. 2009).

Two mammal surveys were conducted on the BOLD project site in the southwestern portion of Area B near the Culver Gateway during 400 trapping nights; one in spring and one in late summer of 2005 (Sustaita et al. 2007, Figure 7.1). During the first survey period, May 2005, 43 individuals of four species were captured, including 26 non-native house mice, two non-native Virginia opossums, two Botta's pocket gophers (*Thomomys bottae*), and 13 western harvest mice (*Reithrodontomys megalotis*). Six individuals of three additional species were observed, including one non-native domestic cat, two California ground squirrels (*Spermophilus beecheyi*), and three desert cottontails (*Sylvilagus audubonii*), along with signs (i.e. prints or scat) of one or more raccoons (*Procyon lotor*). During the second survey period, August 2005, 135 individuals of three species were caught, including 79 house mice, two California ground squirrels, and 54 western harvest mice. One desert cottontail was observed but not captured. No special status species were caught or observed in the study area (Sustaita et al. 2007).

Table 7.1. Mammal species list (modified from PWA 2006). Note: Threatened, endangered, and Species of Special Concern that were targeted during surveys are listed first. Species marked with an 'X' were present during surveys.

COMMON NAME	SCIENTIFIC NAME	STATUS	1981	1991	1996	2000	2001
Southern California saltmarsh shrew	*Sorex ornatus salicornicus*	California Species of Special Concern	X	X			
San Diego black-tailed jackrabbit	*Lepus californicus bennetti*	California Species of Special Concern	X				
South Coast marsh vole	*Microtus californicus stephensi*	California Species of Special Concern	X	X	X		X
California leaf-nosed bat	*Macrotus californicus californicus*	California Species of Special Concern					
Long-eared myotis bat	*Myotis evotis*	California Species of Special Concern					
Pacific pocket mouse	*Perognathus longimembris pacificus*	Federally Endangered					
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	California Species of Special Concern					
Pallid bat	*Antrozous pallidus pacificus*	California Species of Special Concern					
Western mastiff bat	*Eumops perotis californicus*	California Species of Special Concern					
Yuma myotis bat	*Myotis yumanensis*	California Species of Special Concern					
Black rat	*Rattus rattus*	Non-native			X	X	
Botta's pocket gopher	*Thomomys bottae*	Native			X		X
California ground squirrel	*Spermophilus beecheyi*	Native				X	X
Desert cottontail	*Sylvilagus audubonii*	Native			X		
Domestic cat	*Felis cattus*	Non-native			X		
Domestic dog	*Canis familiaris*	Non-native	X		X		
House mouse	*Mus musculus*	Non-native	X	X	X	X	X
Norway rat	*Rattus norvegicus*	Non-native	X		X		
Raccoon	*Procyon lotor*	Native	X	X			
Red fox	*Vulpes vulpes*	Non-native		X	X		
Striped skunk	*Mephitis mephitis*	Native			X		
Virginia opossum	*Didelphis virginiana*	Non-native	X	X	X		
Western harvest mouse	*Reithrodontomys megalotis*	Native		X	X	X	X

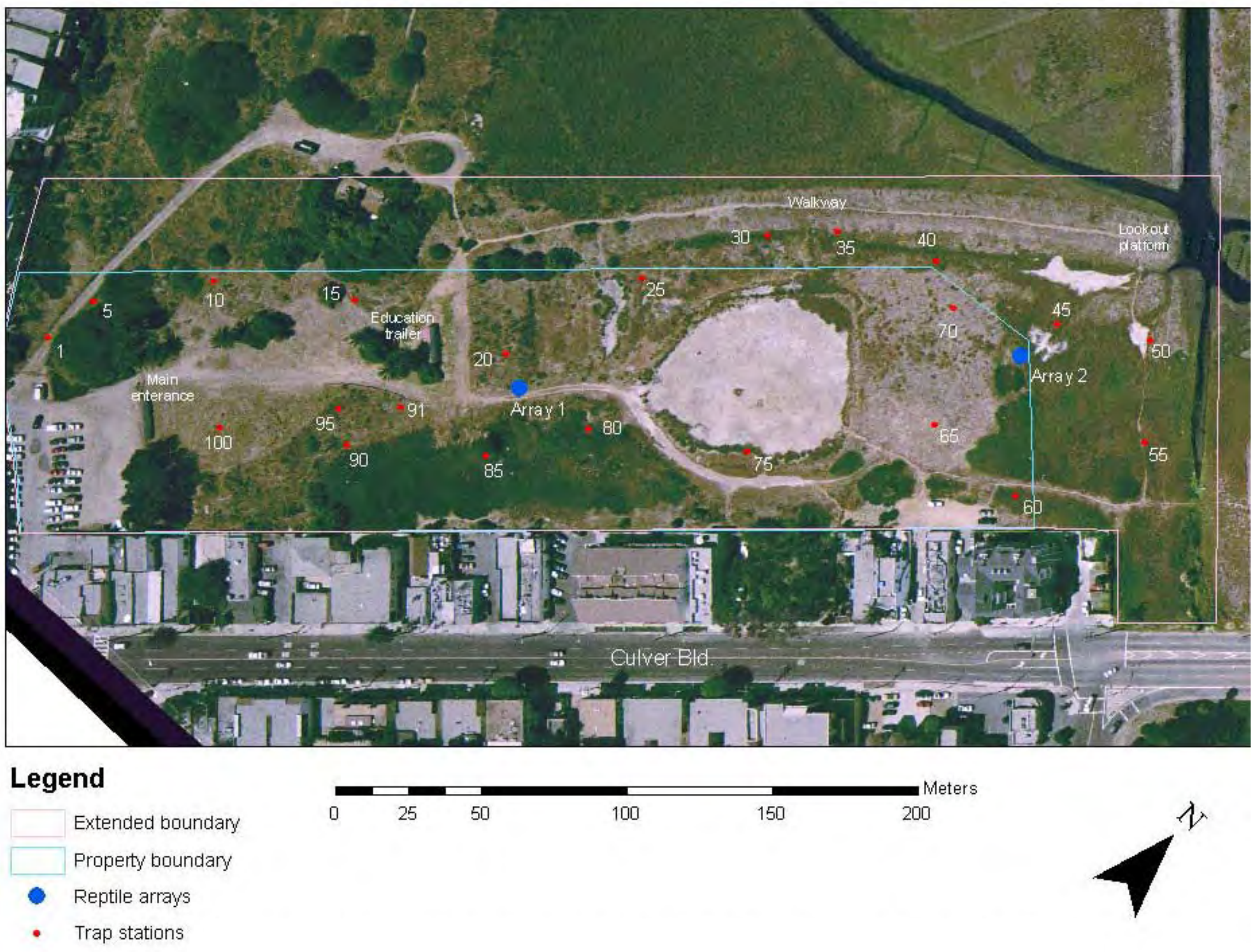

Figure 7.1. Map displaying BOLD site boundaries and survey locations (reproduced from Dorsey and Bergquist 2007).

Johnston et al. (2009) surveyed for mammals in the southwestern portion of Area B directly adjacent to the Culver Gateway, within the Early Action Plan (EAP) designated area (Figure 7.2). Sampling was conducted over three nights from June 1 – June 4, 2009. Nine individuals of two species were captured: eight western harvest mice and one juvenile California ground squirrel. Additional site searches of the area revealed: two Botta's pocket gophers, 6-10 California ground squirrels, two domestic cats, one desert cottontail, and one western gray squirrel (*Sciurus griseus*). The ground squirrel number is approximate because it is possible that some of the individuals were counted more than once due to movement in and out of their burrows. Additional indirect evidence (i.e. paw prints) confirmed the presence of raccoons as well as other species previously recorded.

Figure 7.2. Survey locations for herpetofauna and mammal sampling within the EAP project area (reproduced from Johnston et al. 2009).

METHODS

Method Comparison and Rationale

Various methods for sampling mammal populations include: live traps, pitfall traps, scent station monitoring, track station monitoring, transect censuses, observational site searches, and indirect evidence. Since assessments of mammal populations occur on different temporal and spatial scales and through a wide variety of environmental conditions, different survey methods are utilized (Silveira et al. 2003). Using multiple types of traps and sampling methods may avoid biases for trap selectivity (Sealander and James 1958).

Small live traps are commonly used for small mammal sampling (Sealander and James 1958, Nichols and Pollock 1983, Slade et al. 1993, Whittaker et al. 1998, Cypher 2001). Their effectiveness can vary based on the species captured and the size of the trap (Mengak and Guynn 1987, Mills et al. 1995). An example is the Sherman live trap, commonly used for sampling mice, rats, shrews, and other small rodents (Slade et al. 1993).

Camera stations may be more appropriate for surveying larger mammals in a range of environmental conditions (Kucera and Barrett 1993, Silveira et al. 2003, Bonaker 2008). Large mammals, from foxes to bears and bobcats, have been sampled using this method (Moruzzi et al. 2002, Heilbrun et al. 2003, Trolle and Kery 2005, Larrucea et al. 2007a, Larrucea et al. 2007b, Sarmento et al. 2009). Appropriately positioned cameras (i.e. along game trails) can be a cost-effective way to sample large mammals for an extended period of time.

Since a combination of methods is the most effective way to sample a wide variety of species (Sealander and James 1958), the BAP incorporated several methods, including: camera stations, Sherman live traps, pitfall traps, and observations. Small mammal trapping was conducted with Sherman live traps to determine species presence in several habitat types (i.e. high salt marsh, seasonal wetland, upland grassland, and upland scrub). Motion camera stations recorded medium and large mammal presence throughout the BWER. Incidental observations and recordings of indirect evidence were used to corroborate the data.

Site Locations and Times

Sherman Live Traps

The BAP surveyed small mammals throughout the BWER using baited Sherman live traps deployed in both array and transect forms (Table 7.2 and 7.3; Figure 7.3). Sampling was conducted during fall 2009 and early summer 2010 of the Baseline year. During the fall sampling event, arrays were placed throughout the site. During the summer, targeted transects were located throughout the upland scrub habitats.

Table 7.2. Sampling station deployment dates, total trap nights, and GPS coordinates during fall sampling.

FALL	Start date	End date	# of nights	# of traps	Trap nights	Latitude	Longitude
High Marsh 1	11/9/2009	11/13/2009	4	49	196	33.964875°	-118.448612°
High Marsh 2	11/9/2009	11/13/2009	4	49	196	33.963919°	-118.447993°
High Marsh 3	11/9/2009	11/13/2009	4	49	196	33.965603°	-118.439653°
Grassland 1	11/16/2009	11/20/2009	4	49	98	33.975494°	-118.440594°
Grassland 2	11/16/2009	11/20/2009	4	49	98	33.973136°	-118.439804°
Grassland 3	11/16/2009	11/20/2009	4	49	196	33.978070°	-118.428571°
Seasonal Wetland 1	11/30/2009	12/4/2009	4	49	168	33.968004°	-118.436712°
Seasonal Wetland 2	11/30/2009	12/4/2009	4	49	168	33.968683°	-118.432327°
Seasonal Wetland 3	11/30/2009	12/4/2009	4	49	196	33.970653°	-118.434581°

Table 7.3. Sampling station deployment dates, total trap nights, and GPS coordinates during summer sampling.

Summer	Start date	End date	# of Nights	# of traps	Trap nights	Latitude	Longitude
Scrub 1a	6/7/2010	6/11/2010	4	10	40	33.975033°	-118.440997°
Scrub 1b	6/7/2010	6/11/2010	4	10	40	33.975064°	-118.441066°
Scrub 2a	6/7/2010	6/11/2010	4	10	40	33.973716°	-118.441932°
Scrub 2b	6/7/2010	6/11/2010	4	10	40	33.973770°	-118.441849°
Scrub 3a	6/7/2010	6/11/2010	4	10	40	33.979190°	-118.432237°
Scrub 3b	6/7/2010	6/11/2010	4	10	40	33.979285°	-118.432195°

Figure 7.3. Map of mammal survey locations within the BWER. Note: Green boxes indicate mammal arrays; red lines indicate 100 m transects.

Critter Cam Stations

Medium and large mammal sampling was conducted using baited Scout Guard camera stations. A total of 12 'Critter Cam' stations were spread throughout the site between February and September 2010 (Table 7.4, Figure 7.4). Five Critter Cam stations were in Area A, five were in Area B, and two were in Area C (Table 7.4).

Table 7.4. Critter Cam stations, deployment dates, and duration of deployment.

Camera Name	Area	Type	Latitude	Longitude	Deployment Date	Pull Date	Duration (days)
A-2	A	camera	33.9731	-118.4400	2/10/2010	4/15/2010	64
A-2	A	video	33.9731	-118.4400	7/22/2010	8/23/2010	32
A-3	A	camera	33.9733	-118.4396	2/23/2010	3/11/2010	16
A-Middle	A	camera	33.9734	-118.4416	2/22/2010	3/22/2010	28
A-West	A	camera	33.9729	-118.4431	3/13/2010	4/1/2010	19
A-East	A	camera	33.9756	-118.4374	3/28/2010	4/22/2010	25
A-East	A	video	33.9756	-118.4374	4/22/2010	4/29/2010	7
B-Dune	B	camera	33.9664	-118.4330	7/22/2010	9/7/2010	47
B-Hole	B	camera	33.9638	-118.4508	6/2/2010	7/8/2010	36
B-Hole	B	video	33.9638	-118.4508	6/15/2010	6/22/2010	7
B-Channel	B	camera	33.9648	-118.4490	7/22/2010	8/10/2010	19
B-FBW	B	camera	33.9632	-118.4497	6/22/2010	7/8/2010	16
B-FBW	B	video	33.9632	-118.4497	6/2/2010	6/22/2010	20
B-Riparian	B	camera	33.9669	-118.4335	8/23/2010	9/7/2010	15
B-Riparian	B	video	33.9669	-118.4335	8/3/2010	8/23/2010	20
C-Ballfields	C	camera	33.9794	-118.4282	4/1/2010	4/22/2010	21
C-Ballfields	C	video	33.9794	-118.4282	4/22/2010	4/29/2010	7
C-Residential	C	camera	33.9787	-118.4316	4/1/2010	4/22/2010	21
C-Residential	C	video	33.9787	-118.4316	4/22/2010	4/29/2010	7

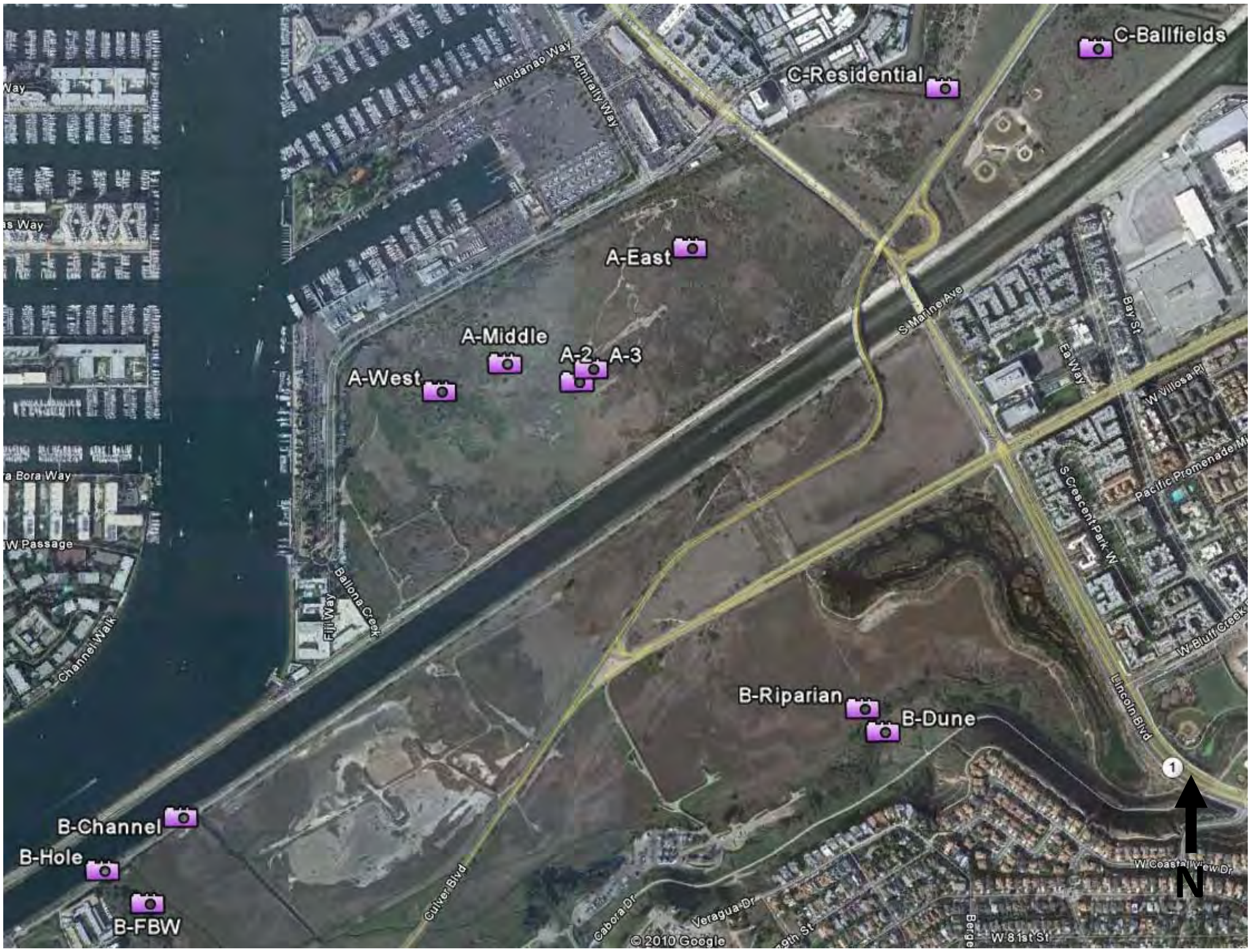

Figure 7.4. Map of Critter Cam locations throughout the BWER for the first Baseline year.

Field Methods

Sherman Live Traps

Live trapping using Sherman traps was conducted semi-annually for four consecutive nights at each location. Sherman traps were 12" x 3.75" x 3.5" in size, made of folding aluminum, and labeled with a unique trap number (Figure 7.5). Sampling was conducted in spring and fall and took place within each major habitat comprising more than 40 acres (e.g. high marsh, seasonal wetland, upland grassland, and upland scrub). Three arrays of Sherman live traps were deployed in three of the four habitats (i.e. high salt marsh, seasonal wetland, and upland grassland) for a total of nine arrays, to determine density and abundance data for small mammals. Because the fourth habitat, upland scrub, was too densely vegetated to deploy a full array, it was sampled using 100 m transects.

Each array was 70 m x 70 m and consisted of one trap deployed every 10 m (i.e. one trap per 100 m^2), which totaled 49 traps per array. Traps were baited with a combination of oats, peanut butter, and vanilla extract, and contained a cotton pad so the captured mammal could retain warmth overnight. Traps were left open from dusk until after dawn. After dawn each morning, the traps were checked for mammals, which were transferred into buckets or large plastic bags where they were then identified, weighed, tagged using a colored permanent marker at the base of the tail, and released. Mammals were identified using common field guides (Jameson and Peeters 2004). The empty traps remained closed and locked during the day. This process was repeated each evening/morning for the four successive deployed nights.

Figure 7.5. Photo of the deployed Sherman live trap with label (photo: SMBRC 2010).

Critter Cam Stations

Large mammals were surveyed using motion sensitive, outdoor Scout Guard cameras. These 'Critter Cam' stations consisted of a camera attached to a 2" x 4" stake driven into the ground. The camera was locked to two cinderblocks to deter tampering (Figure 7.6). Each Critter Cam station was baited once a week with the same bait balls that were used in the Sherman live traps. Critter Cam stations were left out a minimum of two weeks at each location, when conditions allowed (Table 7.4). Critter Cam stations were removed during significant storm events (>1 inch of rain) or if evidence of tampering was present (i.e. disturbance, removal of locks or memory card). The resulting photograph and video data were combined to assess species diversity, but not abundance.

Figure 7.6. Deployed Critter Cam stations (photos: SMBRC 2010).

Analysis Methods

Data analysis determined the presence of each species observed or captured in the Baseline year. The Sherman trap data were also analyzed for capture rates (i.e. number of individuals divided by the total number of trap nights). Data analysis did not include mark-recapture abundance information, since too few individuals were caught (Nichols and Pollock 1983).

RESULTS

General Results and Overall Trends

In the first Baseline year, 15 species were captured or observed on site, including one California Species of Special Concern, the South Coast marsh vole (Table 7.5, Figure 7.7). Table 7.5 includes those mammal species present at the BWER during the Baseline year.   House mice were captured during preliminary surveys several weeks before the Baseline year began but not during the Baseline surveys, and are denoted with a double asterisk in the table. Five of the 15 species recorded during the Baseline year are classified as non-native to the Ballona region, including: domestic cat, domestic dog, rat, and Virginia opossum. Domesticated off-leash dogs ranged in size from small dachshunds to larger dogs such as Rottweilers and Labradors. Occurrences of off-leash dogs were observed in Areas A, B, and C.

The South Coast marsh vole was identified as present in Area B. The vole was identified in the field to species (*Microtus californicus*), and understood to be the subspecies (*Microtus californicus stephensi*). Confidence in the vole identification as the subspecies was high due to the habitat, historical presence, type locality, and voucher specimens of the subspecies housed in the Natural History Museum of Los Angeles. However, full taxonomic identification of the subspecies in the field is virtually impossible without sacrifice and conducting skull measurements (Jim Dines, Natural History Museum of Los Angeles; pers. comm., 2011). As the collections were catch and release, skull measurements were not possible.

Incidental mammal catches in the pitfall traps used for herpetofauna surveys in Area A in June 2010 included two Botta's pocket gophers and one western harvest mouse. All individuals were released into the vegetation surrounding the pitfall array where they were captured. Incidental mammal catch also occurred in the terrestrial invertebrate pitfall traps, including three western harvest mice.

Table 7.5. Species found during the first BAP year (2009-2010 column). Note: double asterisk denotes species captured during surveys several weeks before the Baseline year began, but not during the Baseline surveys. CSC = California Species of Special Concern.

COMMON NAME	**SCIENTIFIC NAME**	**STATUS**	**2009-2010**
Botta's pocket gopher	*Thomomys bottae*	Native	X
California ground squirrel	*Spermophilus beecheyi*	Native	X
Coyote	*Canis latrans*	Native	X
Desert cottontail	*Sylvilagus audubonii*	Native	X
Domestic cat	*Felis cattus*	Non-native	X
Domestic dog	*Canis familiaris*	Non-native	X
House mouse	*Mus musculus*	Non-native	**
Human	*Homo sapien*	Native	X
Raccoon	*Procyon lotor*	Native	X
Rat (unknown species)	*Rattus* sp.	Non-native	X
South Coast marsh vole	*Microtus californicus stephensi*	Native, CSC	X
Striped skunk	*Mephitis mephitis*	Native	X
Virginia opossum	*Didelphis virginiana*	Non-native	X
Eastern fox squirrel	*Sciurus niger*	Non-native	X
Western harvest mouse	*Reithrodontomys megalotis*	Native	X


A


A


A


B


B


C


C


D
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D
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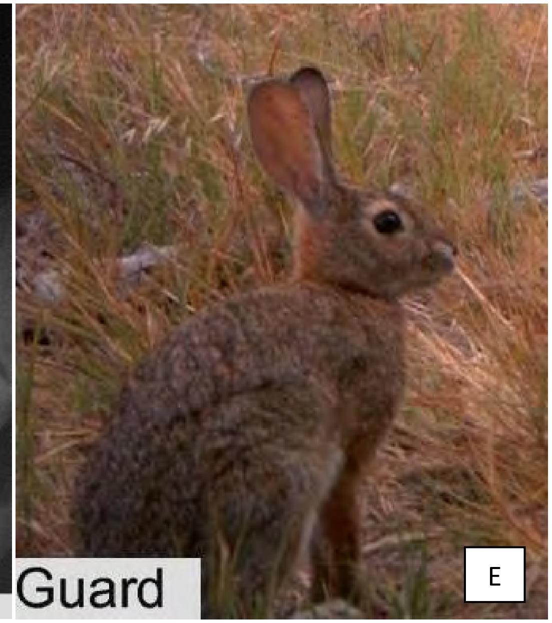
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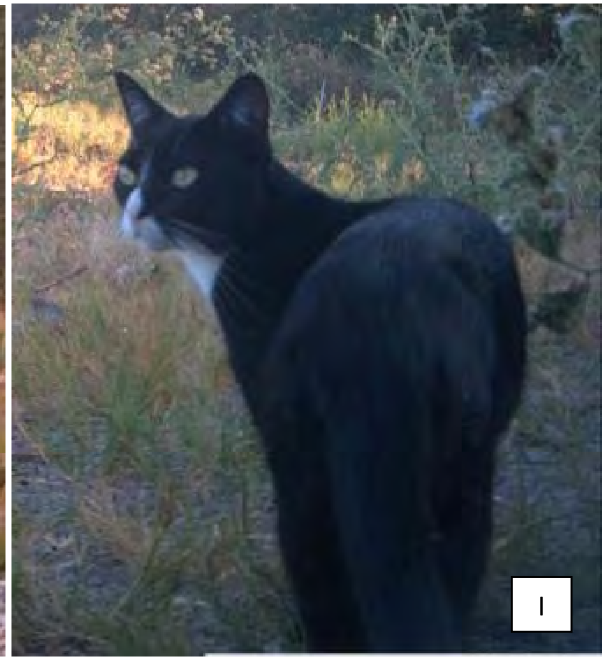
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Figure 7.7. Photos of each mammal species recorded during the first Baseline year: (a) South Coast marsh vole, (b) Botta's pocket gopher, (c) western harvest mouse (d) coyote, (e) desert cottontail, (f) raccoon, (g) Virginia opossum, (h) rat, (i) domestic cat, (j) domestic dog, (k) striped skunk, (l) California ground squirrel, and (m) eastern fox squirrel (photos: SMBRC 2010).

Sherman Live Traps

During the first Baseline year, 16 small mammals were caught in the Sherman live traps: 12 western harvest mice and four South Coast marsh voles (*Microtus californicus stephensi*) (Table 7.6). All mammals were captured during the fall; none were captured in the summer targeted transect surveys of the upland scrub areas.

The overall fall capture rate was highest in the seasonal wetland habitat (1.69%), followed by the high marsh habitat (0.85%) (Table 7.6). The lowest capture rate was in the upland habitat (0.51%). The lower number of trap nights in the grassland habitat was due to the disturbance of two of the arrays by coyotes. The coyotes pulled apart and damaged several dozen traps to reach the bait (Figure 7.8) so that two of the arrays had to be removed several nights early; therefore, there are fewer trapping nights for the upland habitat.

All captured small mammals were weighed and released next to the trap. Figure 7.9 shows the average weight ± standard error. The largest small mammal captured in the Sherman traps was the California meadow vole (47.4 ± 4.84 grams) followed by the western harvest mouse (11.4 ± 0.91 grams). House mice were recorded on site two months prior to the first Baseline year, but were not found in the BAP. This may be because house mice commonly inhabit areas with a high level of disturbance and human activity (e.g. roads, trails, etc) (Kaufman and Kaufman 1990, King et al. 1996). The traps were placed away from areas commonly disturbed by human activity to prevent tampering and theft.

Table 7.6. Results for fall BAP surveys of small mammals using Sherman live traps. Note: the number of captured individuals of each species is in parenthesis.

HABITAT	ARRAY	TRAP NIGHTS	# OF CAPTURES	CAPTURE RATE	SPECIES
High Marsh (HM)	1	196	3	1.53%	marsh vole (1), harvest mouse (2)
High Marsh (HM)	2	196	0	0.00%	----
High Marsh (HM)	3	196	2	1.02%	marsh vole (2)
TOTAL (HM)	**ALL**	**588**	**5**	**0.85%**	
Seasonal Wetland (SW)	1	168	1	0.60%	marsh vole (1)
Seasonal Wetland (SW)	2	168	7	4.17%	harvest mouse (7)
Seasonal Wetland (SW)	3	196	1	0.51%	harvest mouse (1)
TOTAL (SW)	**ALL**	**532**	**9**	**1.69%**	
Upland grassland (U)	1	98	0	0.00%	----
Upland grassland (U)	2	98	0	0.00%	----
Upland grassland (U)	3	196	2	1.02%	harvest mouse (2)
TOTAL (U)	**ALL**	**392**	**2**	**0.51%**	
GRAND TOTAL	**ALL**	**1,512**	**16**	**1.06%**	

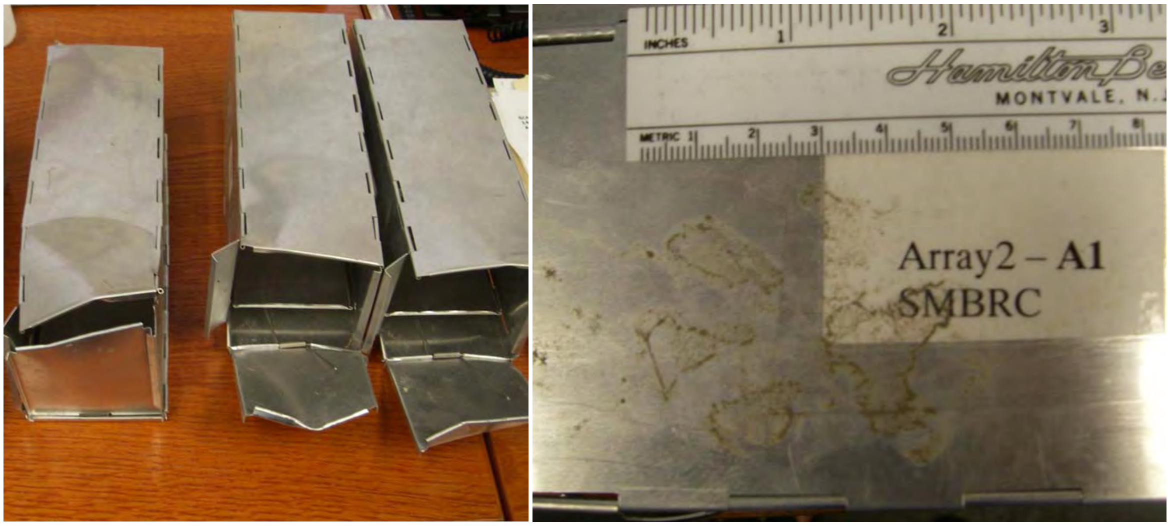

Figure 7.8. Photo of traps destroyed by coyote (left) and paw print on one trap (right) (Photos: SMBRC 2009).

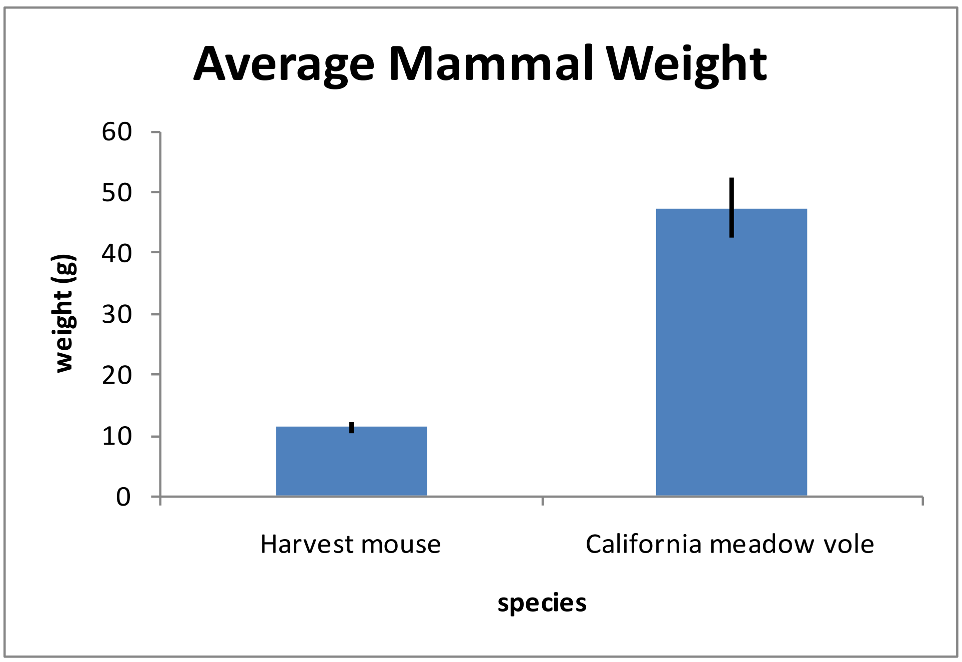

Figure 7.9. Average mammal weight (g ± SE) for both species captured in the Sherman live traps.

Critter Cam Stations

Twelve Critter Cam stations recorded 16 species throughout the BWER (Table 7.7). Ten species were mammals and six species were birds. Four species of mammals were recorded in Area A, nine in Area B, and four in Area C. The cottontail was observed most frequently and was recorded at all stations across all Areas. Several mammal species were seen exclusively within Area B: raccoon, California ground squirrel, striped skunk, Virginia opossum, and domestic cats (Table 7.7); rats were seen exclusively in Area C.

This is the first report to confirm the presence of coyotes on the BWER in over 30 years, signifying the return of a top predator to the site. On several occasions, groups of three or four coyotes were recorded by the Critter Cams in Area A.

Neither native nor non-native foxes were identified in the BAP surveys.

Additional mammal presence was evaluated using indirect evidence, i.e. scat, paw prints, and vocalizations. Indirect evidence of coyotes, cottontails, and humans were recorded throughout the BWER (Figure 7.10). During a nocturnal fishing event in June 2010, recordings were made of two distinct coyote groups barking to each other across Ballona Creek, likely in response to an ambulance siren. Indirect raccoon evidence was photographed and recorded in the salt marsh habitat of Area B.

One incidental sighting of a harbor seal (*Phoca virulina*) was recorded in Ballona Creek near the western tide gate in September 2009.

Table 7.7. List of all species recorded by the Critter Cams in each Area of the BWER. Note: asterisk denotes non-native species. Species marked with an 'X' were present during surveys.

		Area A					Area B					Area C	
Common Name	**Scientific Name**	**A-Middle**	**A-2**	**A-3**	**A-West**	**A-East**	**B-Dune**	**B-Hole**	**B-Channel**	**B-FBW**	**B-Riparian**	**C-Ballfields**	**C-Residential**
California ground squirrel	*Spermophilus beecheyi*						X	X		X			
Cottontail	*Sylvilagus audubonnii*		X	X	X	X	X	X	X	X	X	X	X
Coyote	*Canis latrans*		X	X	X		X		X				
Raccoon	*Procyon lotor*						X	X		X			
Rat *	*Rattus* sp.											X	
Striped skunk	*Mephitis mephitis*						X						
Virginia opossum *	*Didelphis virginiana*						X	X		X	X	X	
American crow	*Corvus brachyrhynchos*					X		X	X				
Mourning dove	*Zenaida macroura*						X						
Egret	*Ardea* sp.	X	X	X									
Great blue heron	*Ardea herodias*	X											
Northern harrier	*Circus cyaneus*		X										
Sparrow	*Passerculus sandwichensis (spp.)*		X									X	
Domestic cat *	*Felis cattus*						X	X		X	X		
Domestic dog *	*Canis familiaris*		X			X		X		X			
Human	*Homo sapien*		X	X		X	X	X		X		X	

Figure 7.10. Photo of (a) coyote prints, (b) cottontail prints, (c) human prints next to a bike track, (d) unidentified scat, and (e) raccoon prints (photos: SMBRC 2010).

Special Status Species

A California Species of Special Concern, the South Coast marsh vole, was identified as present in the small mammal live traps in Area B (Figure 7.7, Table 7.6). This subspecies was also found in previous surveys in Areas A and B (Friesen et al. 1981, Hovore 1991, Impact Sciences, Inc. 1996, Psomas and Associates 2001). Past surveys have captured the vole most often in marsh habitats containing saltgrass (*Distichlis spicata*). Although it was not identified in Area A during the first year of Baseline surveys, areas that may contain suitable habitat will continue to be surveyed during the next Baseline year.

The southern California saltmarsh shrew was found in previous surveys in Area B (Friesen et al. 1981, Frank Hovore and Associates 1991), but not in subsequent surveys or reports. Areas that may contain suitable habitat for the California saltmarsh shrew will continue to be surveyed during the next Baseline year.

The San Diego black-tailed jackrabbit was found in a previous survey in Areas A and B (Friesen et al. 1981), but was not observed during the first BAP year. Surveys will continue during the next Baseline year.

No special status mammal species have been documented within Area C (PWA 2006). Appendix F.1 contains a full list of the special status mammal species with the potential to inhabit the BWER.

FUTURE DIRECTIONS

The second Baseline year will deploy additional targeted transects within smaller habitats throughout the site. Transects will also be positioned close to the herpetofauna coverboard array surveys. Large mammal surveys will continue using the Critter Cam stations throughout non-winter months (i.e. April through October 2011).

Bats are known to forage on site (PWA 2006), but will not be surveyed as part of the Baseline Assessment Program. If funding becomes available, bat surveys may be included at a later time.

APPENDIX F.1

Special status mammal species with the potential to inhabit Ballona Wetlands Ecological Reserve

COMMON NAME	SCIENTIFIC NAME	STATUS
Southern California saltmarsh shrew	*Sorex ornatus salicornicus*	California Species of Special Concern
San Diego black-tailed jackrabbit	*Lepus californicus bennetti*	California Species of Special Concern
South Coast marsh vole *	*Microtus californicus stephensi*	California Species of Special Concern
California leaf-nosed bat	*Macrotus californicus californicus*	California Species of Special Concern
Long-eared myotis bat	*Myotis evotis*	California Species of Special Concern
Pacific pocket mouse	*Perognathus longimembris pacificus*	Federally Endangered
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	California Species of Special Concern
Pallid bat	*Antrozous pallidus pacificus*	California Species of Special Concern
Western mastiff bat	*Eumops perotis californicus*	California Species of Special Concern
Yuma myotis bat	*Myotis yumanensis*	California Species of Special Concern

Note: All mammal nomenclature follows current citations from the Smithsonian Museum of Natural History, North American Mammals (searched January 2011; http://www.mnh.si.edu/mna/main.cfm). Asterisk indicates species found during the first Baseline year.

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Photo credit: S. Woodard

CHAPTER 8:
AVIFAUNA

Ballona Wetlands Ecological Reserve, Los Angeles, California
Santa Monica Bay Restoration Commission

Prepared for: California State Coastal Conservancy
November 2011

Authors: Dan Cooper, Ivan Medel, and Karina Johnston

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AVIFAUNA

INTRODUCTION

The presence and distribution of avifauna within an ecosystem is often used as an index of habitat quality due to their diet and vulnerability to environmental conditions (Conway 2008). Specific bird species' presences have also been used as a measure of success of wetland restoration efforts (Cooper 2006a, 2008). Bird communities are in constant flux. Turnover, especially at isolated sites, can be high from decade to decade with new species colonizing and rare species becoming extirpated (Cooper 2006a). Regular, repeated surveys help maintain a clear picture of bird communities on a site. North American salt marsh bird species have been under sampled by existing broad-scale monitoring programs (Conway and Droege 2006).

The Baseline Assessment Program (BAP) provides the first comprehensive assessment of the avifauna of the Ballona Wetlands Ecological Reserve (BWER), using original research, since 1992. The BAP builds on previous assessments from 1981 and 1943. The goals of the avifauna surveys of the BWER were to:

1) Develop georeferenced maps of species distributions during several seasons;
2) Collect data on waterbirds along Ballona Creek, an identified data gap; and
3) Supplement historical avifauna records with current site-wide baseline surveys.

All bird nomenclature follows current citations from the American Ornithologists' Union's check-list of North American birds (7th Edition, 1998).

Existing Conditions Report Summary (Prior to 2005)

The avifauna of the Ballona Wetlands system has been well-documented, owing to a recent effort to uncover historical bird records and describe the area's land use history in relation to the extirpation and colonization of bird species (summarized in Cooper 2008). Numerous reports in early southern California ornithological literature (Grinnell 1898, Willet 1912, Willet 1933, Grinnell and Miller 1944) focus on the avifauna of the Ballona Wetlands and the "Venice Marshes", which historically covered wetlands to the north of the present-day BWER (now Marina del Rey). Comprehensive annotated checklists of the birds of Ballona Wetlands, produced at regular intervals (von Bloeker 1943, Dock and Schreiber 1981, Corey 1992, Cooper 2006b), provide a record of bird occurrences dating back over 100 years.

Despite the strong historical record, direct comparisons of today's bird community with that of previous eras is made difficult by the lack of systematic scientific data. For example, tables of species' occurrence by month or season in the public record are sporadic and the vast majority of those data are contained in unpublished notes of observers, which have only recently been explored and synthesized (Cooper

2006a, 2006b). The first known published data tables of sightings that reflected regular surveys by observers, over set periods of time, are from Dock and Schreiber (1981), who performed weekly walking transects of Areas A and B from February 1979 to June 1981. Corey (1992) conducted bi-monthly surveys of open space, from April 1990 to April 1991, both east and west of Lincoln Boulevard, including lands now occupied by Playa Vista. Neither of these two studies included Ballona Creek as an important waterbird site. Only Corey (1992) appears to have investigated the nesting status of bird species, other than anecdotal observations by a few other authors. No study developed distribution maps of species and individual bird locations.

Interim Research (2005-2010)

The Ballona Outdoor Learning & Discovery (BOLD) Report (2007) included avian surveys in the southwestern corner of Area B during the spring and winter of 2005 and 2006 (Cooper 2007). During the spring surveys (April and May 2005), eleven visits were made and all nesting behavior of birds was noted. During these visits, 67 species were recorded. Winter raptor surveys were also conducted between December 2005 and January 2006, which consisted of five visits and yielded observations of 37 bird species. Additionally, several sensitive species were identified in the main salt pan to the northeast of the BOLD site, including the White-tailed Kite (*Elanus leucurus),* Burrowing Owl (*Athene cunicularia*)*,* Loggerhead Shrike (*Lanius ludovicianus*), and Elegant Terns (*Thalasseus elegans*).

Cooper (2006b) described the historic presence of bird species within the Ballona region using anecdotal field notes and historical observations. His data suggest 38 species have been extirpated from the region in at least one role (e.g. breeding, nesting), and 11 other species were reestablished in the region between the early 1900s and 2005. The list of reestablished species includes the Ruddy Duck (*Oxyura jamaicensis*), Least Bittern (*Ixobrychus exilis),* American Coot (*Fulica americana*) and Black-necked Stilt (*Himantopus mexicanus*).

Special Status Species (from Report Summary & Interim Research)

Relatively little is known about the avifauna of the site between the 1930s (von Bloeker 1943) and the late 1970s (Dock and Schreiber 1981) except for sporadic observations and museum collection specimens. Awareness of sensitive and declining birds at Ballona expanded greatly through the 1980s and 1990s, as more species were included in state and federal lists of protected species, and increased enforcement of environmental laws encouraged developers to conduct professional, thorough surveys before starting construction. Multiple directed surveys conducted after 1990 (e.g. KBC 1996, PWA 2006) attempt to document earlier local records of species such as the Burrowing Owl (California Species of Special Concern) and California Gnatcatcher (*Polioptila californica*; Federally Threatened).

Surveys targeting abundance, distribution, and breeding territories of the California endangered Belding's Savannah Sparrow (*Passerculus sandwichensis beldingi*) were conducted between the time of the Existing Conditions Report and the BAP. Each survey (KBC 2005, 2006, 2007, 2008, and 2009) utilized the same monitoring methods: five individual 3-4 hour walking surveys within the southwestern marsh habitats of Area B. Surveys were conducted to the north and south of Culver Boulevard in the spring and summer of each year. Table 8.1 provides a comparative summary of the findings across all surveys.

Table 8.1. Comparative summary of each Belding's Savannah Sparrow survey (2005 – 2009) (modified from KBC 2009).

Survey Year	# of territories (spring survey)	# of family groups (summer survey)
2005	11	2
2006	12	No summer survey
2007	12	6
2008	13	12
2009	22	13

METHODS

Method Comparison and Rationale

Utilizing a single method may not accurately depict the variety of species and their roles within bird communities. For example, due to the habitat variability and site size, a large number of point-count stations would be required to represent the BWER for most species (Conway and Droege 2006, Nadeau et al. 2008), so point-count stations were utilized solely in the volunteer surveys to observe raptors. Raptors fly at much higher altitudes than other birds and can be seen from far distances. Volunteer surveys were conducted in groups of two over multiple days and seasons, as described in Conway (2008).

Aural surveys using playback methods are useful for identifying concealed birds, but are time- and equipment-intensive, and are most useful for a few cryptic species assessed individually (Conway and Gibbs 2005). Alternatively, the BAP utilized passive visual and aural surveys which are useful for more species over broader areas.

The BAP employed several survey methods to allow comparisons with other studies and to account for temporal variability. The BAP included four scientific avifauna survey methods: reserve-wide surveys, waterbird surveys, post-rain surveys and breeding bird surveys. The BAP additionally incorporated two types of volunteer-based monitoring for a subset of raptor and waterbird species. Additional special-status bird surveys were conducted as part of the California Environmental Quality Act process.

Reserve-wide Survey Methods

Site Locations and Times

Reserve-wide surveys were conducted as extensive area-searches (excepting Ballona Creek) four times during the first Baseline year to capture a seasonal snapshot of avian activities and distribution across the terrestrial habitats of the BWER. These surveys were conducted over multiple days once every quarter (i.e. October 2009, January, April, and July 2010), to represent fall, winter, spring and summer periods. Surveys were conducted between 0600 and 1130, when the birds were most vocal and easily detected. Existing paths were followed during each survey to ensure consistency across quarters. Surveys were not conducted in fog, rain, or high winds, which are known to decrease bird counts (Ralph et al. 1995, Conway 2008). Additional surveys were conducted in areas experiencing high avian activity (e.g. Ballona Creek) or brief periods of high productivity (e.g. salt pan after rain events).

Field Methods

A spot-mapping survey method was employed in the field, wherein the ornithologist walked the entire survey area and marked locations of all birds on an aerial photo. Approximate searching times for each Area were as follows: 2.5 hours in Area A, 2 hours in Area C, and 6 hours in Area B.

Species and breeding dispositions (e.g. paired, singing, mating, and other behavior) of all birds encountered were noted. Observations were terminated for the day if adverse weather conditions arose (e.g. wind, heat, cold). Surveys avoided double counting, with individuals suspected of being the same noted as such on the data sheets. With a few exceptions (e.g. a flock of gulls flying high overhead), birds in flight were recorded with their direction of flight noted by arrows. In cases such as a large flock of foraging swallows, a rough outline was drawn around the position of the flock, noting the approximate species make-up and number of individuals. Completed spot-maps were then digitized.

Waterbird Survey Methods

Site Locations and Times

Waterbird surveys included bi-monthly counts of waterfowl, shorebirds and other species along the Ballona Creek channel. Sampling occurred twice daily during a two-day period and consisted of two consecutive visits (morning and late afternoon) to capture both high and low tides on the creek. The surveyed area included the Ballona Creek channel, from Centinela Avenue downstream to the Pacific Avenue Bridge at the mouth of Ballona Creek (Figure 8.1); however, only the area downstream of the 90 Freeway was included in the analyses.

Figure 8.1. Map of waterbird survey path along Ballona Creek (orange line).

Field Methods

Walking surveys were conducted along the north levee of the Ballona Creek channel, and all individuals of observed species were recorded. The survey from Centinela Avenue to Pacific Avenue took approximately two hours, and only birds observed between the levee tops were noted. Birds in flight were not recorded. Double-counting of birds was avoided by walking at a brisk pace and counting in one direction only. Over-counting may have occurred for a few groups of highly mobile species. Special notations were made when a new species was observed on the return walk.

Birds using the large, often dry salt pan of Area B were recorded during the December and February waterbird surveys when the site held water.

Post-rain Survey Methods

Site Locations and Times

Post-rain surveys of the salt pan were conducted during the fall and winter of 2009 and early 2010 because previous reports suggested that the flooded salt pan supports large numbers of waterbirds (Cooper 2005). Post-rain surveys used a rapid-count census during *ad hoc* visits to the large salt pan in Area B following rain events large enough to flood the salt pan (Figure 8.2). In 2009, these surveys were conducted twice on October 14, and once each on December 8, 9, 15, and 16. In 2010, a survey was conducted on February 7.

Figure 8.2. Post-rain survey area (orange circle).

Field Methods

Observational surveys consisted of counts made through a spotting scope while standing on a raised point along the bluffs immediately south of the salt pan. When conditions allowed, counts were made by walking west along one of the utility roads on the east side of the salt pan.

Breeding Bird Survey Methods

Breeding bird surveys were supplemental visits to habitat areas likely to harbor nesting birds, especially cryptic species, in an effort to document individuals that might have been missed during other surveys.

Between March and June 2010, supplemental visits were made to several breeding habitats around the BWER in an effort to document nesting instances and site usage by nesting species. These surveys were intended to supplement reserve-wide surveys conducted in April and July and to ensure accurate counts of rare nesting events by cryptic and/or retiring nesting species [e.g. Northern Harrier (*Circus cyaneus),* herons/egrets (Family: Ardeidae), and Western Meadowlark (*Sturnella neglecta)*]. Similar to the reserve-wide surveys, these visits were made during the morning hours, when bird activity was likely to be highest. The results from these surveys and breeding observations made during other surveys are presented in Appendix G.1. Breeding status was summarized according to the categories in Table 8.2.

Table 8.2. Breeding status categories.

CATEGORY	**DESCRIPTION**
Category 1a	Nesting confirmed (active nest or presence of dependent young incapable of sustained flight/movement) at the BWER/lower Ballona Creek
Category 1b	Breeding activity observed during survey, but actual nesting was adjacent to BWER/lower Ballona Creek (e.g. Ballona Freshwater Marsh).
Category 2	Potential breeding activity observed at BWER/lower Ballona Creek during survey; e.g., paired and/or territorial birds during breeding season in suitable habitat, or family groups (including young capable of flight) appearing mid-season.
Category 3	Sporadic occurrence of adult birds during breeding season, but with no direct evidence of breeding on or adjacent to site. This category is reserved for species known to breed in region, and not for over-summering, obviously non-breeding individuals (including certain waterfowl, shorebirds) that might linger or pass through during spring/summer.

Volunteer Survey Methods

Site Locations and Times

Starting in October 2009, volunteers performed two types of surveys at the BWER and adjacent Ballona Creek (Figure 8.3). A twice-daily census of 12 waterbird species on Ballona Creek [i.e. Lesser Scaup (*Aythya affinis*), Green-winged Teal (*Anas crecca*), Great Blue Heron (*Ardea herodias*), Great Egret (*Ardea alba*), Snowy Egret (*Egretta thula*), Willet (*Catoptrophorus semipalmatus*), Marbled Godwit (*Limosa fedoa*), Whimbrel (*Numenius phaeopus*), Black-bellied Plover (*Pluvialis squatarola*), Least Tern (*Sternula antillarum*), Elegant Tern, and Caspian Tern (*Hydroprogne caspia*)] was performed during the high and low tides on the first Saturday of every month. In addition, stationary raptor surveys were conducted between 1000 and 1200 hours at four stations (Figure 8.3) for eight raptor species [Red-tailed Hawk (*Buteo jamaicensis*), Cooper's Hawk (*Accipiter cooperii*), Northern Harrier, Osprey (*Pandion haliaetus*), White-tailed Kite, American Kestrel (*Falco sparverius*), Peregrine Falcon (*Falco peregrinus*), and Loggerhead Shrike] on the fourth Saturday of every month. Raptors were counted every 15 minutes.

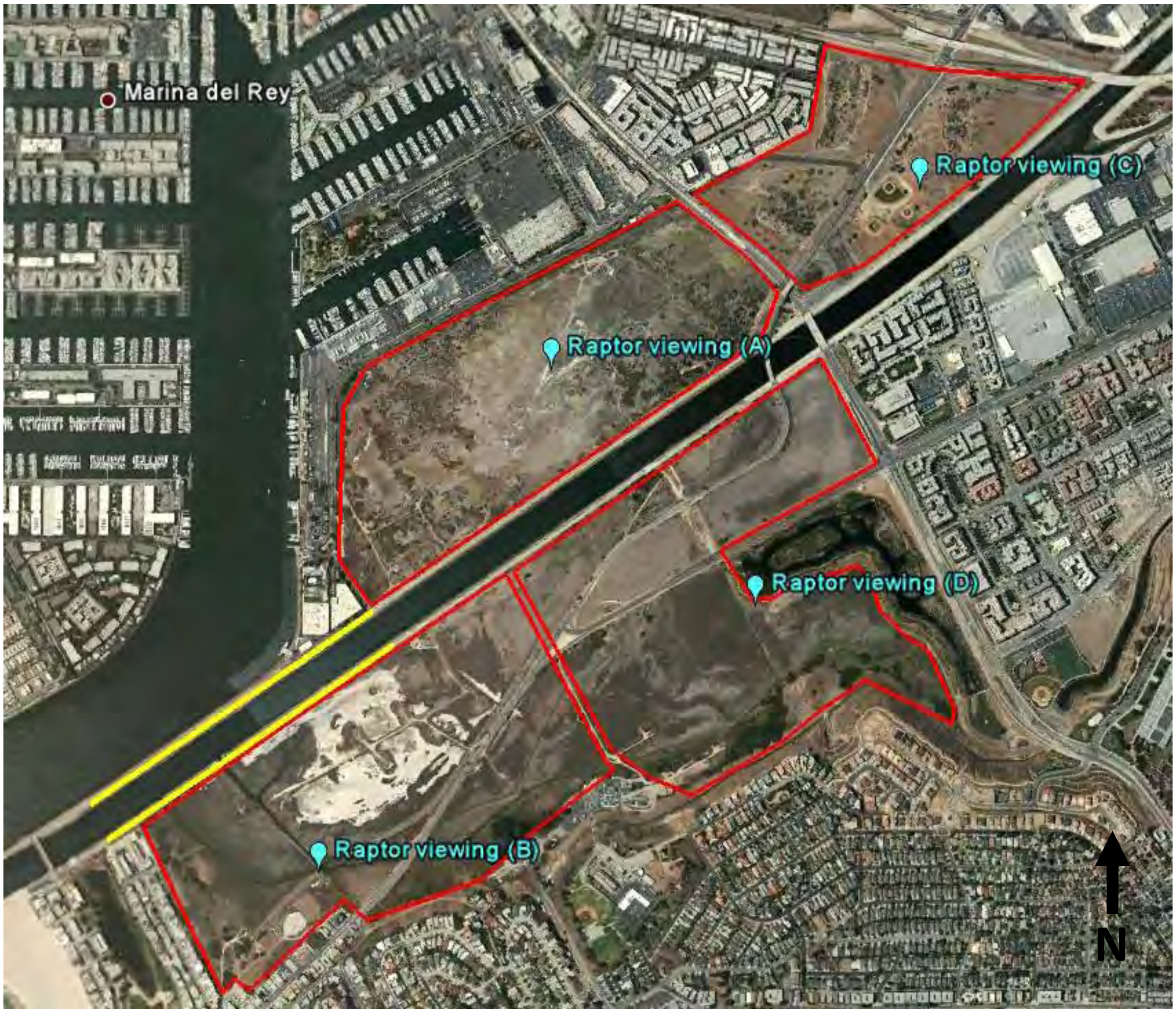

Figure 8.3. Volunteer survey locations. Yellow lines indicate waterbird walking paths; red outlines indicate the area surveyed for raptors.

Field Methods

Students and local volunteers were trained to conduct stationary counts to assess the use of BWER by raptors. They were also trained to assess the waterbird usage of lower Ballona Creek during monthly walking surveys. While the results of the volunteer surveys are not reported in detail here, the data confirm and supplement the overall analyses. Volunteer data strengthened the findings of observations of the raptor community throughout the Baseline year and of the timing and magnitude of shorebird migration along Ballona Creek.

Laboratory Methods / Analysis Methods

All birds were observed and documented on site. No laboratory methods or analyses were conducted for these sampling events. The reserve-wide surveys generated maps of the specific location of each sighting of individual birds. Unlike past surveys, which simply offer data tables of counts, these maps permit the display of both the spatial and temporal distribution of birds and their relative abundance throughout the entire BWER.

RESULTS

During the BAP, 154 species and distinctive subspecies[1] (hereafter simply "species") were recorded (all survey types included). The reserve-wide surveys identified 105 species during week-long evaluations in October 2009, January, April, and July 2010. The bi-monthly waterbird surveys identified 78 species along lower Ballona Creek from October 2009 to August 2010. Incidental observations (D. Cooper, *pers. comm*.), including breeding bird surveys and protocol surveys for the Least Bell's Vireo and the Belding's Savannah Sparrow, added several additional species not found on either the reserve-wide or waterbird surveys. A table of all bird species detected during the BAP (October 2009 - September 2010) and the survey on which they were observed is provided in Appendix G.1.

The avifauna of the BWER was highly seasonal with few bird species present year-round. However, 26 bird species were found on all four quarters of the reserve-wide surveys, and nine species were found on all waterbird survey visits. Some bird species were present on all reserve-wide and all waterbird surveys [e.g. Great Blue Heron (*Ardea herodias*); Figure 8.4].

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

Figure 8.4. Great Blue Herons in the Area B salt marsh (photo: S. Woodard 2010).

Reserve-wide Survey Results

The highest bird species richness (72 species) was found during the April reserve-wide survey. Many wintering birds were still present, transients were moving through, and summer birds were arriving for the nesting season. July, which falls between migration periods and prior to the influx of wintering birds, saw the lowest number of total species (49). October and January surveys saw intermediate counts, showing 68 and 61 species, respectively, and included somewhat different species compositions (transients were present in October and absent in January).

While the reserve-wide bird species reflect low level, year-round bird diversity on the BWER, several known resident species were not found using the combined survey methods, especially the rarer taxa. Not all 'resident' bird species breed locally or even remain at the BWER year-round. For example, the Semipalmated Plover (*Charadrius semipalmatus*), which breeds near the Arctic Circle, was detected in every quarter during the reserve-wide surveys. The Semipalmated Plovers seen on the April surveys were north-bound migrants, and those in the same location (the Area B salt pan) in July appeared to be the first south-bound fall migrants, having already completed the journey to the far north and returned to southern California for the winter.

Reserve-wide survey maps clarified the relative abundance and distribution of each bird species. For example, Figure 8.5 presents the difference between the breeding (April) and post-breeding (July) distribution of the Common Yellowthroat (*Geothlypis trichas*), one of the most abundant resident species on the BWER. Note the reduction in range of birds from the northeastern parcels of Area C and the far western portion of Area B, following the nesting season.

The surveys clarified actual ranges of several sensitive and/or high-interest bird species at the BWER, such as the Western Meadowlark, which has recently been on the decline in the Los Angeles area (Unitt 2004). The Western Meadowlark was identified in short-grass vegetation and drier portions of the salt marsh. Figure 8.6 depicts year-round distribution of the Western Meadowlark at the BWER. All but one of the records were from October 2009 through April 2010.

Distribution maps depicting urban-adapted species at the BWER indicate which parts of the BWER they are using. Figure 8.7 shows the distribution of three notable urban-adapted species across all quarters: the European Starling (*Sturnus vulgaris*), Northern Mockingbird (*Mimus polyglottos*) and House Sparrow (*Passer domesticus*) (Garrett and Dunn 1981). Note the concentration of birds along the north side of Area A (adjacent to urbanized Marina del Rey), the far western portion of Area B (adjacent to Playa Del Rey), roadways, and site boundaries.

Figure 8.5. Distribution of the Common Yellowthroat at the BWER during the April breeding survey (green) and July post-breeding survey (pink). Note: Pin numbers indicate individual numbers of birds.

Figure 8.6. Distribution of the Western Meadowlark (*Sturnella neglecta*). Pink pins denote October 2009 birds; dark red pins denote January 2010 birds; green pins denote April 2010 birds; yellow pins denote July 2010 birds. Note: Pin numbers indicate individual numbers of birds with stars denoting >10 individuals.

Figure 8.7. Distribution of European Starling (dark red), Northern Mockingbird (pink), and House Sparrow (green), in all seasons. Note: Pin numbers indicate individual numbers of birds with stars denoting >10 individuals.

Waterbird Survey Results

Seventy-eight species[2] were recorded along the Ballona Creek channel during six, two-day waterbird surveys from fall 2009 through summer 2010 (i.e. October, December, February, April, June, and August). August 2010 saw the highest numbers of individual birds (maximum: 2,656 individuals of all species combined), with February (2,080 individuals) ranking second highest. December 2009 saw the highest species richness (53 species), whereas June 2010 saw the lowest usage of Ballona Creek (382 individuals, 29 species). The three most numerous species averaged across the BWER during all seasons were three species of shorebirds: Willet, Black-bellied Plover, and Least Sandpiper (*Calidris minutilla*). Both Willet and Black-bellied Plover were also the species with the highest recorded single-day totals along the creek (895 individual Willets in August 2010 and 600 Plovers in February 2010). California Gull (*Larus californicus*, 463 in February 2010) and Whimbrel (455 in August 2010) were found in high numbers, with less month to month regularity.

Although not a focus of the waterbird survey, breeding behavior was noted in a handful of species along Ballona Creek. The Gadwall (*Anas strepera*), Mallard (*Anas platyrhynchos*), and Barn Swallows (*Hirundo rustica*) were all seen with newly-hatched young. The Killdeer (*Charadrius vociferus*) was recorded as possibly paired and occupying potential nesting habitat through the breeding season in an area of the south levee that was restricted from public access (Figure 8.8). Individuals were vocal during both spring and summer seasons. A juvenile Pied-billed Grebe (*Podilymbus podiceps*) was observed in August 2010 along Ballona Creek, and Northern Rough-winged Swallows (*Stelgidopteryx serripennis*) were present in increasing numbers through the breeding season, and were known to nest in the area (Cooper 2006b). The Black Phoebe (*Sayornis nigricans*) was seen at a potential nesting site upstream of the 90 Freeway (outside the study area), and Ruddy Ducks also lingered upstream during spring and summer.

The lowest portion of Ballona Creek supported the widest diversity of waterbirds when assessed by species richness (number of species). A few species showed a clear preference for the upstream reaches, censused concurrently but not included in the BAP. These species included Gadwall, Mallard, Ruddy Duck, American Coot, Black-necked Stilt (*Himantopus mexicanus*), Greater Yellowlegs (*Tringa melanoleuca*), Long-billed Dowitcher (*Limnodromus scolopaceus*) and Northern Rough-winged Swallow. Most of the species that preferred the upstream reaches tended to occur most often in freshwater settings. In the case of the black-necked stilt, preference tended toward shallow, often alkaline ponds, including the nearby Ballona Freshwater Marsh (D. Cooper, *unpublished data*).

[2] One species, the Cinnamon Teal (*Anas cyanoptera*), was recorded using the tidal channels/salt pan of Area B and/or the upstream portion of Ballona Creek and otherwise unrecorded during the waterbird surveys. The birds were in the tidal channels in Area B on 14 December 2009 (1) and upstream of the Marina Freeway on 18 February (1) and 24 June 2010 (2).

Figure 8.8. Juvenile killdeer on south levee (photo: D. Cooper 2010).

Post-rain Survey Results

The seven post-rain surveys of the Area B salt pan (October 2009 – February 2010) broadly confirmed patterns found during both the reserve-wide surveys and the waterbird surveys. Notable findings include the documentation of up to 1,500 Bonaparte's Gulls (*Larus philadelphia*), along with approximately 150 other unidentified gulls. These birds were roosting on the salt pan in February 2010 during a strong onshore wind, a phenomenon that had been noted previously (D. Cooper, *unpublished data*). Caspian Terns, Elegant Terns, and Black-bellied Plovers were commonly identified (Figure 8.9). Additionally, during the October 2009 post-rain survey, approximately 100 Western Meadowlarks were observed descending for an apparent night roost in mats of pickleweed (*Salicornia* spp.) just west of the main salt pan.

Figure 8.9. Caspian and Elegant Terns in the salt pan of Area B (photo: D. Cooper 2010).

Breeding Bird Survey Results

Using a generalized categorization strategy developed for the adjacent Ballona Freshwater Marsh, 59 bird species were found to use the BWER (and to a lesser extent, the adjacent Ballona Creek) for some aspect of their breeding activity during 2010 (Appendix G.1; Table 8.2). Of these bird species, 21 were confirmed as having nested on the BWER itself (e.g. Mallards, Great Horned Owl; Figure 8.10). Twenty species, such as the Black-necked Stilt, had likely built a nest located near, but not on the BWER. Ten bird species, such as the American Kestrel, were suspected of nesting on or near the reserve. As many as eight additional species could have bred elsewhere in the west Los Angeles/South Bay region and used the BWER. For example, bird species such as the White-throated Swift (*Aeronautes saxatalis*) forage well away from their nests, and the Caspian Tern accompany their young to post-breeding areas.

Statements that include definitive breeding species numbers remain problematic, since each bird species may use the BWER in a different way during its breeding period. In addition, the total number of species varies from year to year as part of natural turnover in the system, or because of anthropogenic effects such as habitat modification in the region.

Figure 8.10. Great Horned Owl juvenile in Area B (photo: D. Cooper 2010).

Special-status Species Results

The actual number of special-status bird species using a given area is difficult to ascertain as most bird species are afforded special-status only when engaged in a particular activity such as breeding. Appendix G.2 contains a list of all special-status bird species present during surveys in the first Baseline year. Approximately two-thirds of all the bird species recorded at the BWER during the BAP were present in a non-breeding capacity. Two separate special-status species surveys were conducted concurrently to the BAP and directed at assessing the nesting status of the Belding's Savannah Sparrow (State Endangered) and the Least Bell's Vireo (*Vireo bellii pusillus*; Federal and State Endangered) known to be nesting at the BWER (Cooper 2010a, 2010b).

Protocol surveys covered all areas of the BWER for the Belding's Savannah Sparrow, and the northern base of the Playa del Rey bluffs within Area B was surveyed for the Least Bell's Vireo during several days from April to July, 2010. Protocol surveys were performed following accepted guidelines developed by the appropriate regulatory agencies (e.g. Fish and Wildlife 2001, and California Department of Fish and Game 2006). Results from these surveys are briefly summarized in this report with full species reports available as part of the BWER Environmental Impact Report (Cooper 2010a, 2010b).

Belding's Savannah Sparrows were recorded during the July surveys (birds in October, January, and April could have been of migratory Savannah Sparrow species, and not the resident *P. s. beldingi*). This species was largely confined to pickleweed (*Salicornia* spp.) dominated areas in the western portion of Area B. Most individuals were found north of Culver Boulevard (Figures 8.11 and 8.12). The Belding's Savannah Sparrow was also recorded along Ballona Creek during the December 2009 and April 2010 surveys.

The Marsh Wren (*Cistothorus palustris*), a California Species of Special Concern, was fairly common on both the October 2009 and January 2010 reserve-wide surveys, with a single record from the April 2010 survey (Figure 8.13). Marsh Wren were found almost exclusively in Area B (various habitats), with three sightings in Area A and one in Area C. No singing birds were detected.

Figure 8.11. Distribution of the Belding's Savannah Sparrow in July 2010 with singing birds (green), juveniles (dark red), adults (pink), and concentrations of >10 birds (blue stars).

Figure 8.12. Photo of Belding's Savannah Sparrow on 12 May 2010 (photo: D. Cooper).

Figure 8.13. Observations of the Marsh Wren (*Cistothorus palustrus*) on reserve-wide surveys at the BWER, 2009-10 (all but one from October or January visits).

Four additional special-status species including the Double-crested Cormorant (*Phalacrocorax auritus*), White-tailed Kite (Figure 8.14), Cooper's Hawk, and California Least Tern, bred nearby and visited the BWER for foraging during the study. Anecdotally, a Light-footed Clapper Rail (*Rallus longirostrus levipes*) was observed just prior to the Baseline Year (2008), but was likely a transient, as there is little to no Clapper Rail breeding habitat within the BWER (Cooper, *in press*).

Following completion of the BAP, during October 2010, observations were also made of the Federally Threatened California gnatcatcher (Federally Threatened).

Figure 8.14. White-tailed Kite on 19 October 2009 (photo: Dan Cooper, 2009).

FUTURE DIRECTIONS

In the second year, the BAP will continue to incorporate reserve-wide walking surveys on a semi-annual basis to target the breeding and winter seasons. The waterbird surveys aimed at documenting the bird usage of Ballona Creek will continue, and shift from bi-monthly to quarterly. Protocol-level, light-footed clapper rail surveys using playbacks are scheduled to be performed in conjunction with the California Environmental Quality Act (CEQA) process during the second year of the BAP. Other, targeted special status species surveys will continue as part of the CEQA process with specific, target species to be determined.

APPENDIX G.1

Bird species presence for all survey types during the first Baseline Assessment Program year

			Quarterly Surveys				Waterbird Surveys						Post-rain Surveys	Other surveys/ misc. observations
Species		Breeding code	Oct	Jan	Apr	Jul	Oct	Dec	Feb	Apr	Jun	Aug	All	All
Allen's Hummingbird	*Selasphorus sasin*	2	X	X	X	X								X
American Coot	*Fulica americana*	1b					X	X	X	X				
American Crow	*Corvus brachyrhynchos*	1a	X	X	X	X	X	X						X
American Goldfinch	*Carduelis tristis*	1b		X	X	X								X
American Kestrel	*Falco sparverius*	2	X	X	X	X								X
American Pipit	*Anthus rubescens*		X	X	X			X	X					
American Robin	*Turdus migratorius*				X									
American Wigeon	*Anas americana*						X	X	X	X				
Anna's Hummingbird	*Calypte anna*	1a	X	X	X	X								X
Ash-throated Flycatcher	*Myiarchus cinerascens*				X	X								X
Barn Owl	*Tyto alba*		X											
Barn Swallow	*Hirundo rustica*	1a	X		X	X				X	X	X		X
Belding's Savannah Sparrow	*Passerculus sandwichensis beldingi*	1a	X	X	X	X		X		X				
Bell's Vireo	*Vireo bellii*	1a				X								X
Belted Kingfisher	*Ceryle alcyon*		X		X									
Black Oystercatcher	*Haematopus bachmani*						X	X						

Species		Breeding code	Quarterly Surveys				Waterbird Surveys						Post-rain Surveys	Other surveys/ misc. observations
			Oct	Jan	Apr	Jul	Oct	Dec	Feb	Apr	Jun	Aug	All	All
Black Phoebe	*Sayornis nigricans*	1a	X	X	X	X	X	X	X	X	X	X		X
Black Turnstone	*Arenaria melanocephala*						X			X				
Black-bellied Plover	*Pluvialis squatarola*		X	X		X	X	X		X		X	X	X
Black-crowned Night-Heron	*Nycticorax nycticorax*	1b								X	X	X		
Black-headed Grosbeak	*Pheucticus melanocephalus*				X									
Black-necked Stilt	*Himantopus mexicanus*	1b					X	X	X	X		X		
Black-throated Gray Warbler	*Dendroica nigrescens*		X											
Blue Grosbeak	*Passerina caerulea*													X
Blue-gray Gnatcatcher	*Polioptila caerulea*		X	X	X									
Blue-winged Teal	*Anas discors*									X				
Bobolink	*Dolichonyx oryzivorus*		X											
Bonaparte's Gull	*Larus philadelphia*							X	X	X			X	
Brandt's Cormorant	*Phalacrocorax penicillatus*								X					
Brewer's Blackbird	*Euphagus cyanocephalus*		X											
Brown Pelican	*Pelecanus occidentalis*						X	X	X	X	X	X		X
Brown-headed Cowbird	*Molothrus ater*	2	X		X	X								X
Bufflehead	*Bucephala albeola*			X				X	X					

			Quarterly Surveys				Waterbird Surveys						Post-rain Surveys	Other surveys/ misc. observations
Species		**Breeding code**	**Oct**	**Jan**	**Apr**	**Jul**	**Oct**	**Dec**	**Feb**	**Apr**	**Jun**	**Aug**	**All**	**All**
Bullock's Oriole	*Icterus bullocki*	1a			X									X
Bushtit	*Psaltriparus minimus*	1a	X	X	X	X								X
California Gull	*Larus californicus*						X	X	X	X	X	X	X	
California Thrasher	*Toxostoma redivivum*		X	X										
California Towhee	*Pipilo crissalis*	1a	X		X	X								X
Canada Goose	*Branta canadensis*	1b				X								
Caspian Tern	*Hydroprogne caspia*	3				X				X	X	X		X
Cassin's Kingbird	*Tyrannus vociferans*	2	X	X	X	X								X
Cattle Egret	*Bubulcus ibis*									X				
Cinnamon Teal	*Anas cyanoptera*	1b												X
Cliff Swallow	*Petrochelidon pyrrhonota*				X	X								X
Common Poorwill	*Phalaenoptilus nuttallii*		X											
Common Raven	*Corvus corax*	1a	X		X	X					X			
Common Yellowthroat	*Geothlypis trichas*	1a	X	X	X	X		X			X	X		X
Cooper's Hawk	*Accipiter cooperii*	1b	X	X	X	X		X				X		X
Costa's Hummingbird	*Calypte costae*					X								
Double-crested Cormorant	*Phalacrocorax auritus*	1b					X	X	X	X	X	X		

Species		Breeding code	Quarterly Surveys				Waterbird Surveys						Post-rain Surveys	Other surveys/ misc. observations
			Oct	Jan	Apr	Jul	Oct	Dec	Feb	Apr	Jun	Aug	All	All
Downy Woodpecker	*Picoides pubescens*	3												X
Dunlin	*Calidris alpina*		X	X				X					X	
Dusky Flycatcher	*Empidonax oberholseri*													X
Eared Grebe	*Podiceps nigricollis*						X	X	X	X		X		
Elegant Tern	*Thalasseus elegans*	3			X	X						X		
European Starling	*Sturnus vulgaris*	1b	X	X	X	X		X		X	X			X
Gadwall	*Anas strepera*	2		X	X		X	X	X	X	X			X
Glaucous-winged Gull	*Larus glaucescens*						X				X			
Golden-crowned Sparrow	*Zonotrichia atricapilla*		X	X										
Grasshopper Sparrow	*Ammodramus savannarum*		X											
Great Blue Heron	*Ardea herodias*	1b	X	X	X	X	X	X	X	X	X	X		
Great Egret	*Ardea alba*	1b	X	X	X	X	X	X	X			X		
Great Horned Owl	*Bubo virginianus*	1a												X
Greater Yellowlegs	*Tringa melanoleuca*								X					
Great-tailed Grackle	*Quiscalus mexicanus*	3		X										
Green Heron	*Butorides virescens*	1b			X									X
Green-winged Teal	*Anas crecca*		X	X			X	X	X					

			Quarterly Surveys				Waterbird Surveys						Post-rain Surveys	Other surveys/ misc. observations
Species		Breeding code	Oct	Jan	Apr	Jul	Oct	Dec	Feb	Apr	Jun	Aug	All	All
Hammond's Flycatcher	*Empidonax hammondi*													X
Heermann's Gull	*Larus heermanni*						X	X	X		X	X		
Hermit Thrush	*Catharus guttatus*		X	X	X									
Herring Gull	*Larus argentatus*						X	X						
Hooded Oriole	*Icterus cucullatus*	2			X	X								X
House Finch	*Carpodacus mexicanus*	1a	X	X	X	X		X			X			X
House Sparrow	*Passer domesticus*	1a	X	X	X	X					X	X		
House Wren	*Troglodytes aedon*	3	X	X		X								X
Killdeer	*Charadrius vociferus*	1a	X	X	X	X	X			X	X	X	X	
Lawrence's Goldfinch	*Carduelis lawrencei*													
Lazuli Bunting	*Passerina amoena*				X									X
Least Sandpiper	*Calidris minutilla*		X	X	X		X	X	X	X		X	X	
Least Tern	*Sternula antillarum*	1b				X					X			X
Lesser Goldfinch	*Carduelis psaltria*	1a	X	X	X	X				X				X
Lesser Scaup	*Aythya affinis*							X	X					
Lincoln's Sparrow	*Melospiza lincolnii*		X	X										
Loggerhead Shrike	*Lanius ludovicianus*		X	X										

Species		Breeding code	Quarterly Surveys				Waterbird Surveys						Post-rain Surveys	Other surveys/ misc. observations
			Oct	Jan	Apr	Jul	Oct	Dec	Feb	Apr	Jun	Aug	All	All
Long-billed Curlew	*Numenius americanus*													X
Long-billed Dowitcher	*Limnodromus scolopaceus*			X		X	X	X	X	X			X	
Mallard	*Anas platyrhynchos*	1a	X	X	X		X	X	X	X	X	X		X
Marbled Godwit	*Limosa fedoa*			X			X	X	X	X		X		
Marsh Wren	*Cistothorus palustris*			X	X									
Merlin	*Falco columbarius*		X	X	X									
Mew Gull	*Larus canus*							X						
Mourning Dove	*Zenaida macroura*	1a	X	X	X	X					X			X
Northern Flicker	*Colaptes auratus*		X	X										
Northern Harrier	*Circus cyaneus*			X	X			X						
Northern Mockingbird	*Mimus polyglottos*	1a	X	X	X	X								X
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	2			X	X			X	X	X			X
Northern Shoveler	*Anas clypeata*						X	X						
Orange Bishop	*Euplectes franciscanus*	2	X		X									X
Orange-crowned Warbler	*Vermivora celata*	2	X	X	X									X
Osprey	*Pandion haliaetus*													
Pacific-slope Flycatcher	*Empidonax difficilis*				X									X

Species		Breeding code	Quarterly Surveys				Waterbird Surveys						Post-rain Surveys	Other surveys/ misc. observations
			Oct	Jan	Apr	Jul	Oct	Dec	Feb	Apr	Jun	Aug	All	All
Peregrine Falcon	*Falco peregrinus*		X	X	X	X			X					
Pied-billed Grebe	*Podilymbus podiceps*	1b					X	X	X			X		
Red-breasted Merganser	*Mergus serrator*							X	X					
Red-shouldered Hawk	*Buteo lineatus*													X
Red-tailed Hawk	*Buteo jamaicensis*	1a	X	X	X	X								X
Red-throated Loon	*Gavia stellata*							X						
Red-winged Blackbird	*Agelaius phoeniceus*	2		X	X	X								
Ring-billed Gull	*Larus delawarensis*						X	X	X	X		X		
Rock Pigeon	*Columba livia*	1b		X	X	X			X		X	X		
Royal Tern	*Thalasseus maximus*						X						X	
Ruby-crowned Kinglet	*Regulus calendula*			X										
Ruddy Duck	*Oxyura jamaicensis*	1b						X	X	X				
Ruddy Turnstone	*Arenaria interpres*						X	X	X	X				
Sanderling	*Calidris alba*								X					
Savannah Sparrow (ssp.)	*Passerculus sandwichensis*		X	X	X	X	X	X		X				
Say's Phoebe	*Sayornis saya*	1b	X	X	X		X							
Semipalmated Plover	*Charadrius semipalmatus*		X	X	X	X	X	X		X		X	X	

			Quarterly Surveys				Waterbird Surveys						Post-rain Surveys	Other surveys/ misc. observations
Species		**Breeding code**	**Oct**	**Jan**	**Apr**	**Jul**	**Oct**	**Dec**	**Feb**	**Apr**	**Jun**	**Aug**	**All**	**All**
Sharp-shinned Hawk	*Accipiter striatus*		X		X									
Snowy Egret	*Egretta thula*	1b			X	X	X	X	X	X	X	X		
Song Sparrow	*Melospiza melodia*	1a	X	X	X	X		X			X	X		X
Sora	*Porzana carolina*				X									
Spotted Sandpiper	*Actitis macularius*		X				X	X	X	X		X		
Spotted Towhee	*Pipilo maculatus*			X										
Surf Scoter	*Melanitta perspicillata*							X	X		X	X		
Surfbird	*Aphriza virgata*								X	X				
Swainson's Thrush	*Catharus ustulatus*													X
Thayer's Gull	*Larus thayeri*							X						
Townsend's Warbler	*Dendroica townsendi*				X									
Tree Swallow	*Tachycineta bicolor*	1a	X		X	X			X		X			
Vaux's Swift	*Chaetura vauxi*		X											
Vermilion Flycatcher	*Pyrocephalus rubinus*		X											
Vesper Sparrow	*Pooecetes gramineus*				X									
Violet-green Swallow	*Tachycineta thalassina*		X											
Wandering Tattler	*Heteroscelus incanus*									X				

			Quarterly Surveys				Waterbird Surveys						Post-rain Surveys	Other surveys/ misc. observations
Species		Breeding code	Oct	Jan	Apr	Jul	Oct	Dec	Feb	Apr	Jun	Aug	All	All
Western Grebe	*Aechmophorus occidentalis*						X	X	X			X		
Western Gull	*Larus occidentalis*						X	X	X	X	X	X		
Western Kingbird	*Tyrannus verticalis*				X									
Western Meadowlark	*Sturnella neglecta*	3	X	X	X	X								
Western Sandpiper	*Calidris mauri*		X	X	X	X	X	X		X		X	X	
Western Wood-Pewee	*Contopus sordidulus*													X
Whimbrel	*Numenius phaeopus*				X		X	X	X	X	X	X		
White-crowned Sparrow	*Zonotrichia leucophrys*		X	X	X			X						
White-faced Ibis	*Plegadis chihi*													X
White-tailed Kite	*Elanus leucurus*	1b	X	X	X									
White-throated Swift	*Aeronautes saxatalis*	3			X									
Willet	*Catoptrophorus semipalmatus*			X			X	X	X	X	X	X	X	
Willow Flycatcher	*Empidonax traillii*													X
Wilson's Snipe	*Gallinago delicata*		X	X										
Wilson's Warbler	*Wilsonia pusilla*		X		X									
Wrentit	*Chamaea fasciata*			X	X									
Yellow Warbler	*Dendroica petechia*		X			X								

			Quarterly Surveys				Waterbird Surveys						Post-rain Surveys	Other surveys/ misc. observations
Species		**Breeding code**	**Oct**	**Jan**	**Apr**	**Jul**	**Oct**	**Dec**	**Feb**	**Apr**	**Jun**	**Aug**	**All**	**All**
Yellow-breasted Chat	*Icteria virens*													X
Yellow-rumped (A) Warbler	*Dendroica coronata*		X	X	X		X	X						
Yellow-rumped (M) Warbler	*Dendroica coronata*		X		X									
Total # of spp.	----	----	**68**	**61**	**72**	**49**	**40**	**53**	**41**	**41**	**29**	**34**	**11**	**49**

CATEGORY	DESCRIPTION
Category 1a	Nesting confirmed (active nest or presence of dependent young incapable of sustained flight/movement) at the BWER/lower Ballona Creek
Category 1b	Breeding activity observed during survey, but actual nesting was adjacent to BWER/lower Ballona Creek, such as at Ballona Freshwater Marsh.
Category 2	Potential breeding activity observed at BWER/lower Ballona Creek during survey; e.g., paired and/or territorial birds during breeding season in suitable habitat, or family groups (including young capable of flight) appearing mid-season.
Category 3	Sporadic occurrence of adult birds during breeding season, but with no direct evidence of breeding on or adjacent to site. This category is reserved for species known to breed in region, and not for over-summering, obviously non-breeding individuals (including certain waterfowl, shorebirds) that might linger or pass through during spring/summer.

NOTE: All bird nomenclature follows current citations from the American Ornithologists' Union's check-list of North American birds (7^{th} Edition, 1998).

APPENDIX G.2

Special status bird species with the potential to inhabit the Ballona Wetlands Ecological Reserve

Common Name	Scientific Name	Status	2010
Belding's Savannah Sparrow	*Passerculus sandwichensis beldingi*	SE	X
Black Oystercatcher	*Haematopus bachmani*	BCC (if nesting)	X
Burrowing Owl	*Athene cunicularia*	CSC	
Brown Pelican	*Pelecanus occidentalis*	FE (if nesting)	X
California Gull	*Larus californicus*	WL (if nesting)	X
Least Tern	*Sternula antillarum*	FE/SE (if nesting)	X
Caspian Tern	*Hydroprogne caspia*	BCC/LAC (if nesting)	X
Cooper's Hawk	*Accipiter cooperii*	WL (if nesting)	X
Double-crested Cormorant	*Phalacrocorax auritus*	WL (if nesting)	X
Elegant Tern	*Thalasseus elegans*	WL/BCC/LAC (if nesting)	X
Grasshopper Sparrow	*Ammodramus savannarum*	CSC (if nesting)	X
Least Bell's Vireo	*Vireo bellii pusillus*	FE/SE (if nesting)	
Loggerhead Shrike	*Lanius ludovicianus*	CSC (if nesting); LAC (if wintering)	X
Long-billed Curlew	*Numenius americanus*	CSC (if nesting); LAC (if wintering)	X
Marsh Wren	*Cistothorus palustris*	CSC	X
Merlin	*Falco columbarius*	WL	X
Northern Harrier	*Circus cyaneus*	CSC (if nesting)	X
Osprey	*Pandion haliaetus*	WL (if nesting)	
Peregrine Falcon	*Falco peregrinus*	SE (if nesting)	X
Sharp-shinned Hawk	*Accipiter striatus*	WL (if nesting)	X
Short-eared Owl	*Asio flammeus*	CSC (if nesting)	
Swainson's Thrush	*Catharus ustulatus*	LAC (if nesting)	X
Vaux's Swift	*Chaetura vauxi*	CSC (if nesting)	X
Vermilion Flycatcher	*Pyrocephalus rubinus*	CSC (if nesting)	X
Vesper Sparrow	*Pooecetes gramineus*	LAC	X
Western Meadowlark	*Sturnella neglecta*	LAC	X
White-faced Ibis	*Plegadis chihi*	WL (if nesting)	X
White-tailed Kite	*Elanus leucurus*	FP (if nesting)	X
Willow Flycatcher	*Empidonax traillii*	SE (if nesting)	
Yellow Warbler	*Dendroica petechia*	CSC (if nesting)	X
Yellow-breasted Chat	*Icteria virens*	CSC (if nesting)	X

	Abbreviation	Status
Federal	FE/FT	Federally Endangered/Federally Threatened
	BCC	Bird Species of Conservation Concern
State	FP	California Fully Protected
	SE/ ST	State Endangered/ State Threatened
	WL	California WatchList (formerly a Species of Special Concern; limited protection)
	CSC	California Bird Species of Special Concern
Local	LAC	Los Angeles County Bird Species of Special Concern

NOTE: 2010 column indicates presence during the first year BAP surveys.

NOTE: All bird nomenclature follows current citations from the American Ornithologists' Union's check-list of North American birds (7th Edition, 1998).

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Photo credit: E. Tuttle

CHAPTER 9:
BENTHIC INVERTEBRATES

Ballona Wetlands Ecological Reserve, Los Angeles, California
Santa Monica Bay Restoration Commission

Prepared for: California State Coastal Conservancy
November 2011

Authors: Elena Del Giudice-Tuttle, Karina Johnston, and Ivan Medel

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BENTHIC INFAUNA AND EPIFAUNA

INTRODUCTION

Benthic invertebrate taxa are useful as ecological indicators; they provide a reflection of the state of the environment, especially at the transition from water to land and can indicate local biodiversity (Hilty and Merenlender 2000). Long-term changes are often assessed by looking at the invertebrate community at a higher taxonomic level or by evaluating the community as a whole (Hodkinson and Jackson 2005). The presence or absence of certain infauna (i.e. burrows into and lives in bottom sediments) or epifauna (i.e. lives on the surface of bottom sediments) within tidal channels can serve as indicators of water quality, anthropogenic stressors to the estuary, and the potential to support other trophic levels (WRP 2006); these benthic communities provide essential ecosystem services and support (Shreiber 1981).

The goals of the benthic invertebrate surveys for the Baseline Assessment Program (BAP) included:

1) Determining invertebrate density, diversity, and distribution within the intertidal channels of the Ballona Wetlands Ecological Reserve (BWER);
2) Determining the approximate densities of *Cerithidea californica* within the tidal channels of Area B in concordance with Southern California Bight 2008 sampling protocols (Bight 2008);
3) Determining species richness at each survey station.

The first year of the BAP did not identify benthic invertebrates to species; these protocols will be added during the second Baseline year. Species names reproduced from previous BWER reports are cited using current ITIS nomenclature. As invertebrate common names are highly variable or not established for each species, only the scientific names are presented for the purposes of this report.

Existing Conditions Report Summary (Prior to 2005)

Many benthic invertebrates are sessile, so water quality parameters, such as temperature and salinity, are important determinants of the invertebrate taxa that colonize a habitat (Zedler 2001). For these reasons, censuses of distribution and abundance have been conducted before and after hydrological modifications within the BWER to assess the impacts of these projects. Specifically, surveys were conducted before and after the replacement of flap gates (Chambers 1996, 1999) and after the installation of the east channel (main) tide gate (LACity 2005).

Assessments of benthic invertebrate community composition have been mostly conducted in Area B. Data from Area A is limited, and due to lack of tidal influence, Area C has never been sampled for benthic invertebrates.

Reish (1980) conducted what is considered by some to be a definitive study of the benthic invertebrates of the BWER (Chambers 1996). From previous reports evaluated by Reish (Bakus 1975, Metz 1978, Clark

1979), a combined total of 15 taxa were found (Figure 9.1). From the four seasons (August and November 1979 and April and June 1980) during which Reish (1980) sampled, 63 taxa were identified. The number of taxa found at each station increased as distance from the mouth of the tide channel decreased. The lowest number of taxa was recorded in April 1980. The highest number of taxa was found in June 1980. Reish (1980) found that Area B was dominated by a few species typical of southern California coastal wetlands. *Streblospio benedicti* was the most abundant species and was present at all stations. *Capitella capitata, Polydora nuchalis*, and unidentified oligochaetes were the next most abundant species.

Ramirez (1981) conducted monthly sampling of marine mollusks in the BWER between August 1980 and May 1981 and identified 19 mollusk taxa. The highest species richness (14 species) was recorded at Station 4 (Figure 9.1). Ramirez recorded the presence of *Macoma nasuta, Protothaca staminea, Assiminea californica,* and *Melampus olivaceus* at all stations.

In April, July, and October of 1990, the Pacific Estuarine Research Laboratory of San Diego State University surveyed six stations (Boland and Zedler 1991) (Figure 9.1). A total of 11 taxa were identified. Boland and Zedler (1991) also found that species richness was lowest at the stations furthest from the tide gates. 1990 was noted as a year with below average rainfall (Reish 1980).

Figure 9.1. Benthic infauna sampling stations from previous BWER reports (Reish 1980, Ramirez 1981, Boland and Zedler 1991, Chambers 1996, 1999, WRA 2004, MEC 2005). Yellow bars represent the flap gate (A) and tide gate locations (B), respectively. Chambers A is in the Fiji Ditch of Area A. Note: Station labels do not correspond to labels used by original reports.

Carter (1991) conducted quarterly surveys of non-insect invertebrates in Areas A, B, C, and D that focused on epifauna. The study's aim was to define species composition and relative distribution over the course of one year. The study found a total of 30 taxa, with the most common including: *M. nasuta, Tagelus subteres, Bulla gouldiana, Uca crenulata, Pachygrapsus crassipes,* and *C. capitata. C. capitata* are known to invade disturbed habitats and are indicators of pollution, when found occurring in large populations in an ecosystem that is otherwise species poor (Grassle and Grassle 1974). *C. californica* was the most abundant species found in the saline channels.

The Chambers Group sampled seven sites in Ballona Creek, Marina del Rey, and Areas A and B in 1996 and 1999 to compile a census of the benthic invertebrate communities of the BWER (Figure 9.1). A total of 23 taxa were identified. Annelids, arthropods, and mollusks were the predominant organismal groups. Oligochaetes were the most numerous taxa found at all stations, except Chambers A and Chambers 2 (Figure 9.2). Densities of benthic invertebrates varied from 6,089 individuals /m^2 at Chambers A to 95,550 individuals/ m^2 at Chambers 3 (Figure 9.2). The highest densities of benthic invertebrates were recorded at the Area B stations closest to the tide gates. They concluded that the BWER had a benthic community dominated by taxa characteristic of southern California coastal wetlands, but that the species diversity was lower than that of larger, less disturbed wetlands (Chambers 1996).

In 1998, the Chambers Group returned to sample the same eight stations in Areas A and B to assess benthic invertebrate communities after the replacement of the easternmost tidal flap gates (Figure 9.1). They found that densities of benthic invertebrates were lower at all stations, while distribution trends remained generally the same. Densities of oligochaetes were also reduced (Chambers 1999).

Figure 9.2 provides a summary of the density (total number of individuals / m^2) of all organisms combined for each station of each report.

Figure 9.2. Densities (number of benthic infauna individuals / m^2) from previous reports (Reish 1980, Chambers 1996 and 1999, Dorsey 2007). A and B represent the flap gate and tide gate locations, respectively. Chambers A is in the Fiji Ditch of Area A. Note: Station labels do not correspond to labels used by original reports.

The United States Army Corps of Engineers (USACE) installed a self-regulating tide gate, in March 2003 (Figure 9.1).   MEC conducted benthic invertebrate surveys in Area B in 2001, 2003, and 2005 (LA City 2005).

In 2003, a survey was conducted for benthic infauna in the tide channels of Area B before and after the installation of the USACE self-regulating tide gates to assess the benthic invertebrate population (WRA 2004). The trend observed at all stations was an overall increase in the number of benthic invertebrates as distance from the tide gate increased. Additionally, WRA (2004) found that all stations had an increased number of benthic invertebrates in the September (before) sampling than in the February (after) sampling, with the exception of amphipods.

Although dominant species were not consistent between reports, the most common species found included: *S. benedicti, C. californica, C. capitata, M. nasuta, Acteocina inculta,* and unidentified oligochaetes. Annelids, mollusks, and arthropods were the most represented taxa.

According to past reports compiled and summarized by Phillip Williams and Associates (PWA 2006), no special status benthic invertebrate species have been known to inhabit the BWER in recent years (Glen Lukos Associates 2000, Psomas 2001, Psomas and Lockhart 2001).   Targeted surveys specific to *Tryonia imitator* were conducted in 1991 and 1995 by Carter and in 1999 by Chambers. No *T. imitator* individuals were found (Chambers 1999).

Interim Research (2005-2010)

In 2005, benthic invertebrate surveys were conducted at two stations in the tidal channels of Area B as part of the Ballona Outdoor Learning and Discovery (BOLD) Report (Dorsey 2007) (Figure 9.3). Samples were collected at both stations during April and August 2005. Three replicates were collected at each station using a hand held Birge Ekman spring-loaded box corer, producing samples with an area of 0.024 m^2. The most abundant macrofauna was *C. californica*, with 311 individuals / m^2, followed by the sea anemone (*Diadumene sp*.) with 1.3 individuals / m^2 (Figure 9.2). Sixteen taxa of infauna were identified. The most abundant taxa were: *Monocorophium insidiosum, A. inculta, C. capitata, P. nucalis,* and *S. benedicti*. Species abundance was higher in the April samples (17,429 individuals / m^2 and 4,388 individuals / m^2) than in the August samples (4,054 individuals / m^2 and 2,946 individuals / m^2).

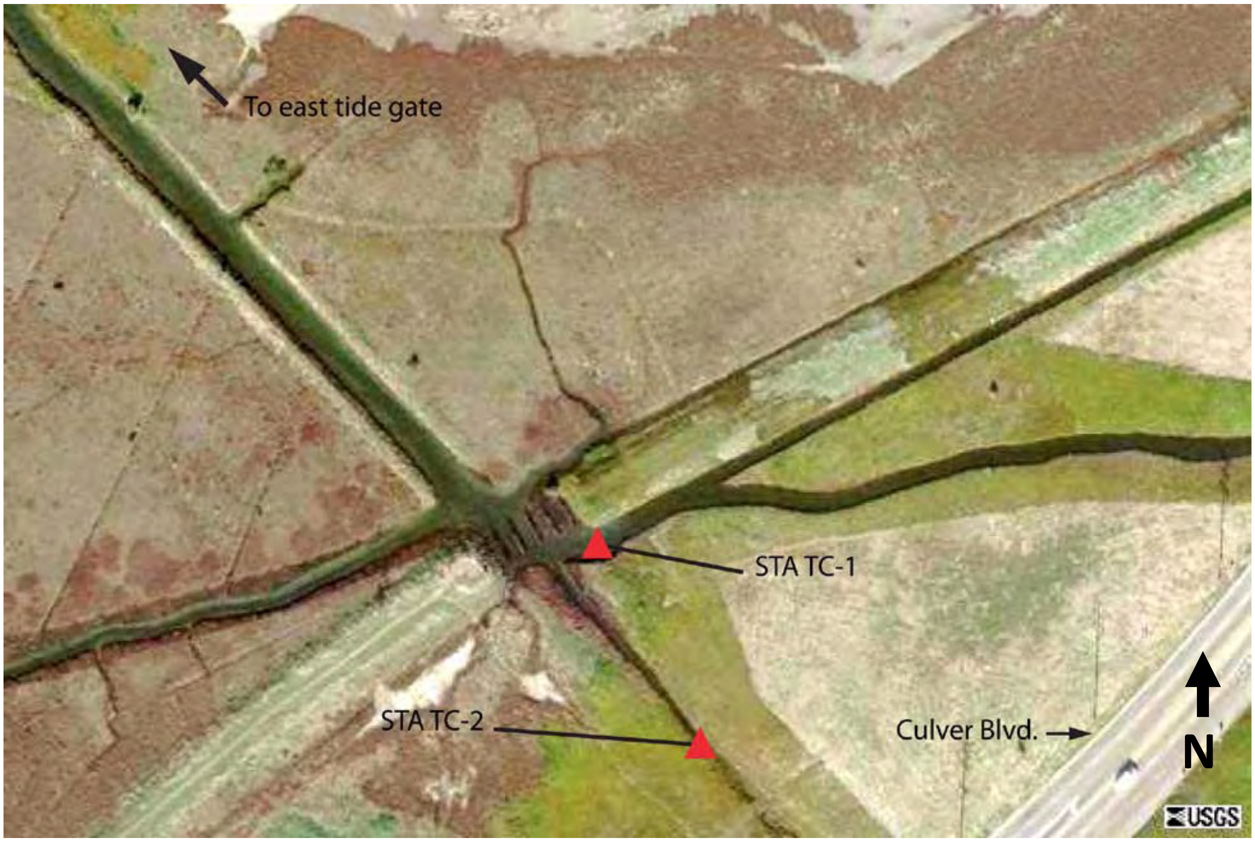

Figure 9.3. BOLD Report tidal channel sampling stations, TC-1 and TC-2 (reproduced from Dorsey 2007).

Overall, Reish (1980), Boland and Zedler (1991), Carter (1991), Chambers (1996 and 1999), MEC (2005), and Dorsey (2007) found increased abundance of invertebrates at stations closer to the tide gates. WRA (2004) found the opposite, with the resulting trend of increased abundance as distance from the tide gates increased.

METHODS

Method Comparison and Rationale

The BAP utilized handheld corers to allow easier transportation of samples and to minimize the impact of monitoring activities. The use of handheld corers is a widely accepted means of sample collection and has been used extensively in past surveys of the BWER [Reish 1980, Ramirez 1981, Boland and Zedler 1991, Carter 1991, Chambers 1996, 1999, MEC 2001, 2003, 2005, WRA 2004, Bight Program 2008]. Other wetland monitoring programs have also utilized similar sampling equipment (San Francisco Estuary Institute Wetland Regional Monitoring Program; Environmental Protection Agency (EPA) Environmental Monitoring and Assessment Program on the West Coast; Coastal Commission San Onofre Nuclear Generating Station (SONGS) Monitoring, and Mugu Lagoon Wetland Monitoring). BAP protocols were adapted from those used in the Mugu Lagoon Final Report (UCLA 2006) and the Coastal Commission SONGS Monitoring.

Reduced sample volumes minimized the impact on the wetland ecosystem. Page et al. (2006) found compositing several small cores a viable method to save time and effort in processing benthic samples.

Sieves are often used to separate sediments from invertebrate samples in the field or lab. Smaller sieves (500 µm) at shallower depths (5-10 cm depth) target surface-dwelling infauna in the smaller samples (Zedler 2001, Dorsey 2007) and larger sieves (5 mm) at deeper depths (30-40 cm) target deeper dwelling infauna, such as mollusks (Reish 1980, Ramirez 1981). All previous studies used formalin to initially preserve the samples, and all samples were subsequently stored in ethanol (Reish 1980, Ramirez 1981, Boland and Zedler 1991, Carter 1991, Chambers 1996 and 1999, MEC 2001, 2003, 2005, WRA 2004, Bight 2008).

BAP survey stations were based on previous studies to facilitate between-survey comparisons (Figure 9.1). Page et al. (2006) found spatial autocorrelation up to 30 m in some southern California wetlands; to assess samples independently, the BAP benthic invertebrate sampling stations were all spaced more than 30 m apart.

A semi-annual sampling schedule was chosen to obtain one sample after the wet season (April/May) and one sample at the end of the dry season (September/October). To collect the highest levels of species diversity, Zedler (2001) recommends not sampling during wet weather. BAP samples were collected several months apart to allow for seasonal comparisons (Reish 1980, Ramirez 1981, Onuf 1987, Carter 1991, Boland and Zedler 1991, Chambers 1996, 1999, WRA 2004, MEC 2005, Dorsey 2007), and at low tides due to the exposure of substrate and ease of access (Ramirez 1981, Boland and Zedler 1991, WRA 2004).

Although some previous studies identified specimens to the lowest identifiable taxon, the results from the BAP were analyzed and discussed using general taxonomic groups (Boland and Zedler 1991, WRA 2004) and quantitative indices, such as total individuals / m^2 (Reish 1980, Ramirez 1981, Onuf 1987, Boland and Zedler 1991, Carter 1991, Chambers 1996, 1999, WRA 2004, MEC 2005, Dorsey 2007). This enabled the BAP to allocate resources more efficiently in the first year of monitoring and to analyze the benthic invertebrate samples using these general and time saving parameters.

METHODS – INFAUNA

Site Locations and Times

For the BAP, infaunal benthic invertebrate sampling was conducted semi-annually (fall and spring) during 2009-2010 at seven stations: two in Area A (BW1 and BW2) and five in Area B (BW4, BW5, BW6, BW7, and BW8) (Figure 9.4). Station BW3, in Ballona Creek, was not sampled for benthic invertebrates.

Sampling was conducted in the fall on 17 September, 13 October, and 30 October. At each sampling event, each of the seven stations was surveyed once. Henceforth, in the results, these samples will be referred to collectively as the October sampling. Sampling was conducted in the spring season on 20 April and 5 May and will henceforth be referred to collectively as the April sampling.

The sampling on 17 September 2009 was preceded by dry conditions and no precipitation (Figure 9.5). Between 13 October 2009 (after the surveys) and 15 October 2009 the Los Angeles International Airport (LAX) received 3.30 cm of precipitation. The remaining sampling stations were surveyed at the end of October to allow more than one week without precipitation. The remainder of October received no precipitation. Between December 2009 and the end of March 2010, LAX received 24.86 cm of precipitation (Figure 9.5); between 1 April 2010 and the 20 April 2010 sampling, LAX received 2.56 cm of precipitation; between 20 April 2010 and the 5 May 2010 sampling LAX received 0.61 cm of precipitation. Precipitation events did not occur within one week of any survey dates. During the first year of the BAP, the total rainfall for the months of October, January, and April exceeded the average monthly rainfall for those months at the Los Angeles International Airport rain gauge (Figure 9.5).

Figure 9.4. BAP benthic invertebrate sampling stations. Yellow bars represent the flap gate (A) and tide gate (B) locations, respectively. BW1 and BW2 are in the Fiji Ditch of Area A.

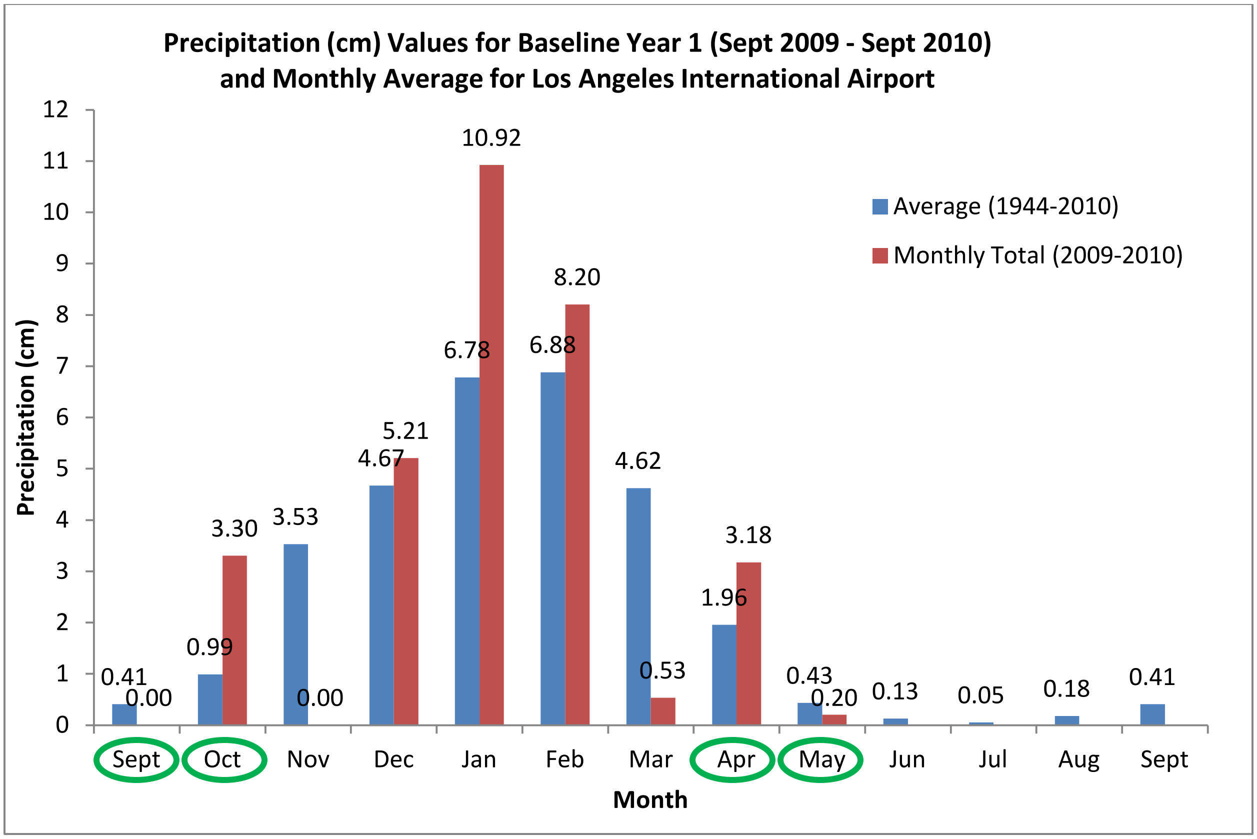

Figure 9.5. Total monthly precipitation (cm) from the first year of the BAP, and the monthly average precipitation (cm) for the Los Angeles International Airport (LAX). Months during which sampling occurred are circled in green (http://www.wrcc.dri.edu/cgi : accessed Feb 2011).

Samples were collected at low tide when sediment was partially exposed. A total of seven sampling stations were chosen, five based on previous benthic and ichthyofauna surveys at the BWER (BW2, 4, 5, 6 and 7) and two additional stations (BW1 and 8) located in the same places as BAP water quality and sediment monitoring stations (Figure 9.4). Each station consisted of a cross-section transect of the tidal channels. Large and small core samples were taken from the left, right, and thalweg of the channel facing the outflow (Figure 9.6). The thalweg was defined as the lowest portion of the channel, and did not necessarily fall directly in the middle of the channel.

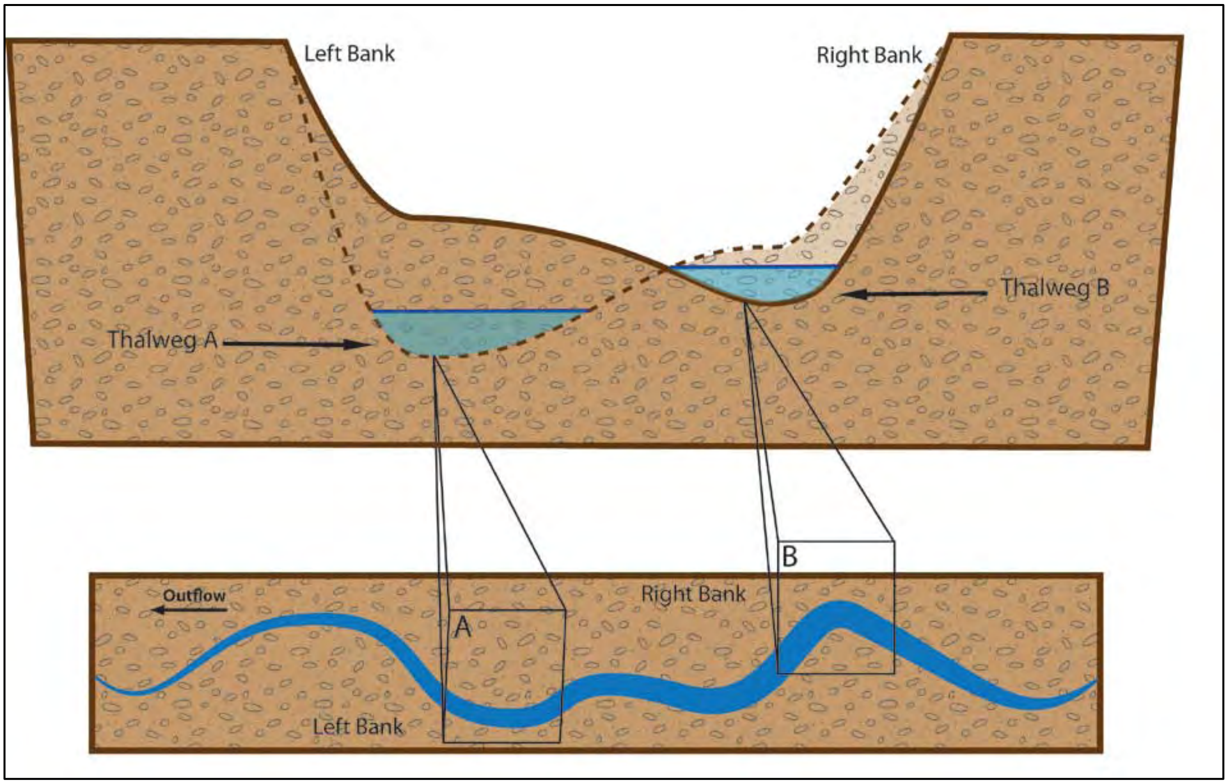

Figure 9.6. Depiction of cross-section transect of a tidal channel. The figure is not directly representative of a particular benthic survey station. Note: the thalweg is the deepest portion of the channel and not the midpoint.

Field Methods

Readings for water temperature, salinity, dissolved oxygen (% and mg/L), and pH were taken with a handheld YSI 650 QS at each station before entering the water. The water at stations BW5 and BW7 was too shallow (i.e. < 5 cm) for accurate water quality readings using the handheld YSI.

Deep dwelling infauna (e.g. bivalves and shrimp) were collected using a handheld, 10 cm diameter corer pushed into the sediment to a depth of 30 cm. One core was taken at the left, right, and thalweg of the channel (facing the outflow) (Figure 9.7). Each core covered an area of 0.007854 m^2.

Smaller invertebrate infauna (e.g. polychaetes and amphipods) were collected using a 6 cm diameter corer pushed into the sediment to a depth of 5 cm. Three small cores were collected and composited from the left, right, and thalweg of the channel (Figure 9.7). Each set of composited cores covered an area of 0.00848 m^2.

The samples underwent initial wet-sieving field processing in a bucket filled with creek water, to separate infauna from sediment. Small cores were processed using a 0.5 mm mesh sieve, and large cores were processed using a 2.5 mm mesh sieve. Everything remaining in the sieve was placed in labeled, sealed plastic zip-top bags and transported back to the lab for subsequent rinsing in a controlled environment.

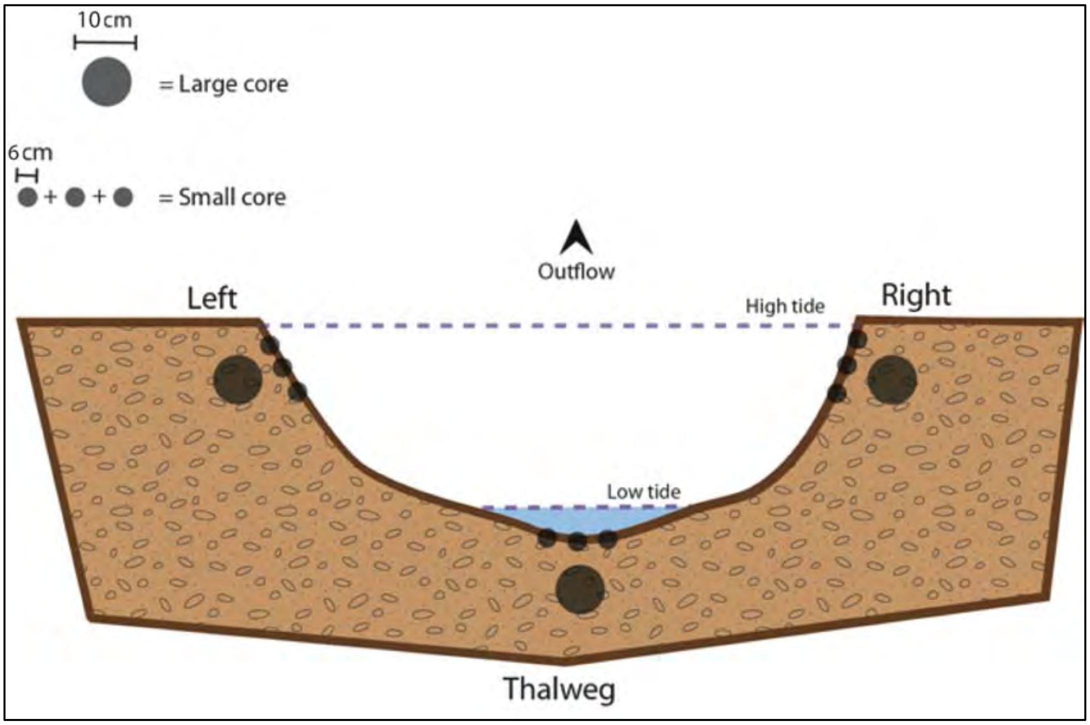

Figure 9.7. Diagram of benthic infaunal core sizes and locations. Note: figure not drawn to scale.

Laboratory and Analysis Methods

In the laboratory at Loyola Marymount University (LMU), samples underwent a final rinse through the appropriate sized sieve (i.e. 0.5 mm or 2.5 mm). The remaining material on the screen of the sieve (organisms, large sediment, and debris) was carefully transferred using forceps into labeled, screw top glass jars. The sieves were rinsed and scrubbed after each sample was processed to avoid cross contamination.

The jars were filled with sample material to 50-70% capacity, leaving at least 30% uncovered space for further processing. If more than one jar was needed for the entire sample, the split number (e.g. 1 of 2, 2 of 2, etc.) was labeled. Each label included the station ID, sample location within the channel (i.e. left, right, thalweg), date, and the split number (as applicable). Jars were initially preserved with a 10% formalin freshwater solution. No fewer than 48 hours after fixation, the formalin was decanted and properly disposed of, and the samples were rinsed in tap water. Samples were then transferred to containers and filled with a 95% ethyl alcohol (ethanol) solution, to a level that completely immersed the sample. Samples were stored in the ethanol solution until sorting and analysis.

To facilitate sorting, samples were placed in white plastic plates and divided into small sorting trays using an illuminator, dissecting scope, spatula, and forceps. Benthic invertebrates were sorted into the following categories: bivalves (subdivided into ridged and smooth clams, razor clams, and mussels), *C. californica*, other gastropods, worms, and amphipods (Figure 9.8; WRA 2004). All shelled organisms were recorded as dead or alive, determined by whether or not the bivalves still contained muscle tissue. Each gastropod was checked for an intact operculum. All unknown invertebrates were placed in vials and labeled for later taxonomic identification. Examples of each taxon were preserved as voucher specimens. The presence of wood was noted, as was the presence and grain size of the remaining rocky substrate. If present, algae and sea grass were collected and placed in small aluminum pie tins. Tins were then placed in a dehydrator for 24 hours, weighed, and the value was recorded to determine dry algal weight per sample. Presence and relative abundance of general taxonomic groups was calculated for each location.

Figure 9.8. Large core benthic invertebrate sample sorted in the lab showing bivalves (A) (D), *C. californica* (C), and other gastropods (B) (photo: SMBRC 2010).

The resulting data were analyzed to determine the density of benthic infauna, which was recorded as the number of individuals per meter squared for each station. Data were combined for each portion of the creek sampled (i.e. left, right, and thalweg), and analyzed separately for both large and small cores. Each station sampled a total area of 0.023562 m^2 for the large cores and 0.02544 m^2 for the small cores.

METHODS – EPIFAUNA

Site Locations and Times

C. californica were quantified along three transects (i.e. Transects 1-3) in June and four transects in September 2010 within the eastern and western muted tidal channels of Area B (Figure 9.9). Transect 4 was added to the September surveys within a small connector channel (Figure 9.9, orange line).

C. californica were surveyed 6 inches from the vegetation line on the channel bottom at five randomly allocated locations along a 30 m transect, using a 0.25 m^2 polyvinyl chloride (PVC) quadrat (Figure 9.10). *C. californica* were surveyed along the same transects and in conjunction with submerged aquatic vegetation and algae.

Figure 9.9. *C. californica* sampling transects. Transects 1-3 are represented as blue lines, and Transect 4, represented as an orange line, was added during the second survey period.

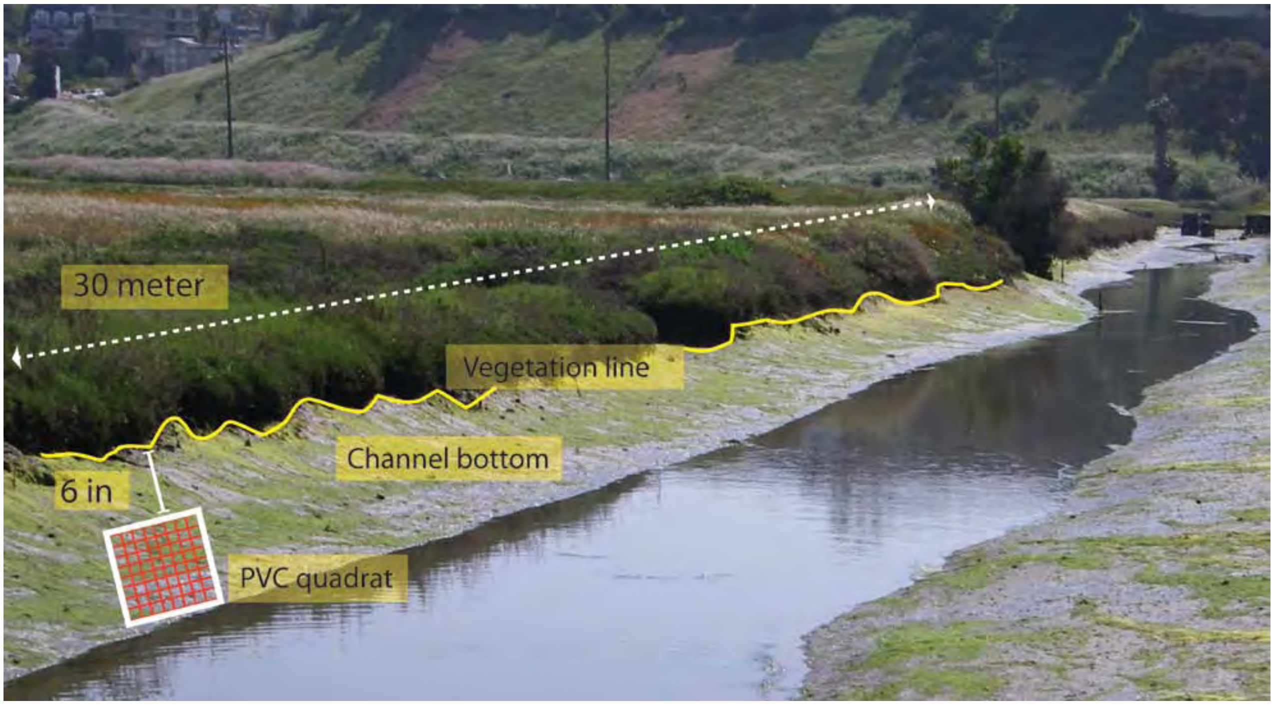

Figure 9.10. Diagram of *C. californica* transect showing placement of quadrat 6 inches from vegetation line (photo: SMBRC 2009). Note: diagram is not drawn to scale.

Field Methods

All live individuals were counted at each of five randomly placed quadrats along a given transect (Figure 9.10). Live individuals were defined as being a color other than white, and having an intact shell. In cases with very high snail populations, defined as over 100 individuals (Figure 9.11), or where snails were highly mobile, *C. californica* were quantified by counting the individuals in the lower left quarter of the quadrat and multiplying by four to obtain the number of *C. californica* for the whole quadrat.

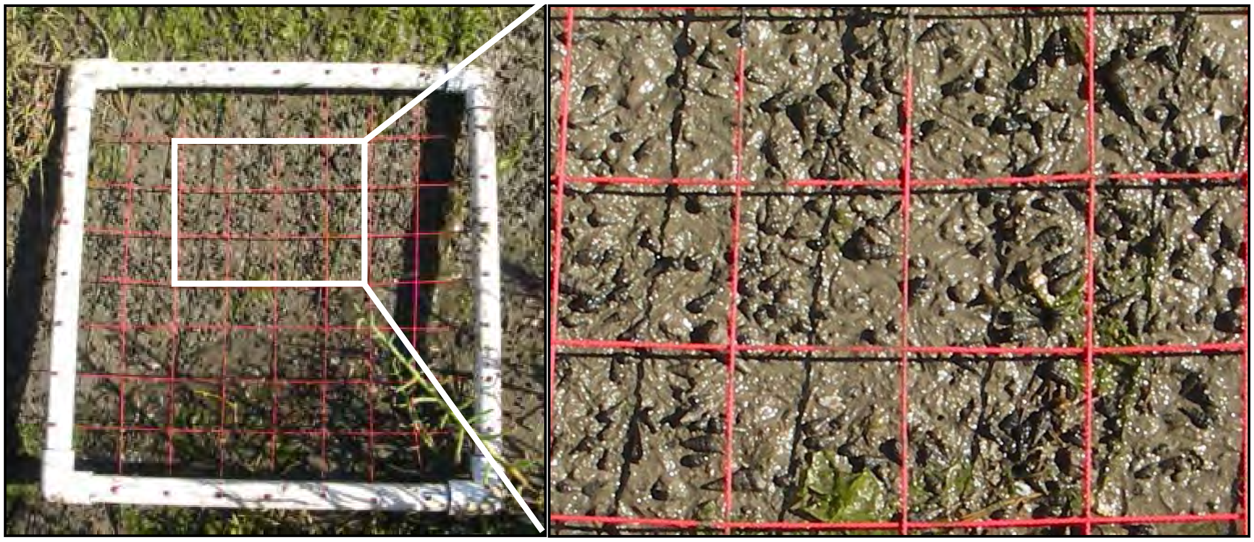

Figure 9.11. High density (>100 individuals) quadrat along *C. californica* transect (photos: SMBRC 2010).

Laboratory and Analysis Methods

All snails were counted on site. No laboratory methods were conducted for these sampling events. Analyses were completed by determining the average number of *C. californica* / m^2 (± standard error) along each transect and comparing densities between transects and survey months.

RESULTS

Infauna Results

Average densities, as individuals / m^2, were calculated for each station by month and core size (Table 9.1). The BAP found, similar to WRA (2004), invertebrate density, when averaged for all cores and all organisms combined, increased with increased distance from the tide gates. The exception was station BW7, which had low overall abundances during both sampling periods. BW8, which was the furthest station from the tide gate in Area B (Figure 9.4), had the highest average number of individuals / m^2 in both October 2009 (55,640 individuals / m^2) and April 2010 (74,223 individuals / m^2) when averaged for all cores (Table 9.1); whereas, Boland and Zedler (1991) recorded densities of zero in the southern wetland channels of Area B.

Reish (1980) found the highest density of invertebrates, 229,406 individuals / m^2, at Station 4 in June (Figure 9.2). At the BAP survey station BW6 (Figure 9.4; a station located near Reish Station 4), an average of 22,914 individuals / m^2 in April 2010 and 39,186 individuals / m^2 in October 2009 were found. The lowest average density was recorded during the October 2009 sampling at BW1, located in Area A, at 2,968 individuals / m^2 when averaged for all cores combined.

All groups that conducted surveys in more than one season or month noted seasonal variations in composition and abundance (Reish 1980, Carter 1991, Boland and Zedler 1991, Chambers 1996 and 1999, WRA 2004); this was also true through the first year of the BAP (Table 9.1). Boland and Zedler (1991) found twice the abundance of invertebrates in April as they found in October.

For the BAP, stations BW1 and BW2 in Area A (Figure 9.4) had approximately three times more invertebrates in April 2010 than in October 2009 (Table 9.1). Invertebrate abundance at stations BW4 and BW7 had similar numbers of individuals in October and April. Stations BW5 and BW6 had higher invertebrate abundance during October 2009 than in April 2010.

Table 9.1. Densities (number of individuals / m^2) of benthic invertebrates at each sampling station. Table displays the average density for all large cores, small cores, and the average density for all cores.

Station ID	OCTOBER		
	Large Core	**Small Core**	**AVERAGE**
BW1	3735	2201	2968
BW2	3268	9355	6312
BW4	20245	4363	12304
BW5	26271	15134	20702
BW6	54197	24175	39186
BW7	6621	5149	5885
BW8	33529	77752	55640
Station ID	**APRIL**		
	Large Core	**Small Core**	**AVERAGE**
BW1	6324	22091	14207
BW2	11884	26926	19405
BW4	5475	18907	12191
BW5	11968	21777	16873
BW6	34547	11281	22914
BW7	2292	9159	5725
BW8	37518	110928	74223

The group of organisms that consistently had the highest proportion of the samples at each station was gastropods (Figure 9.12), dominated by *C. californica*, when all samples for each station were combined. The *C. californica* density included both live and dead individuals. The groups that were the next highest proportion of the samples were mollusks and gammarids (Figure 9.12). BW4, the station closest to the tide gate in the main channel, had the highest proportion of mollusks compared to the other stations.

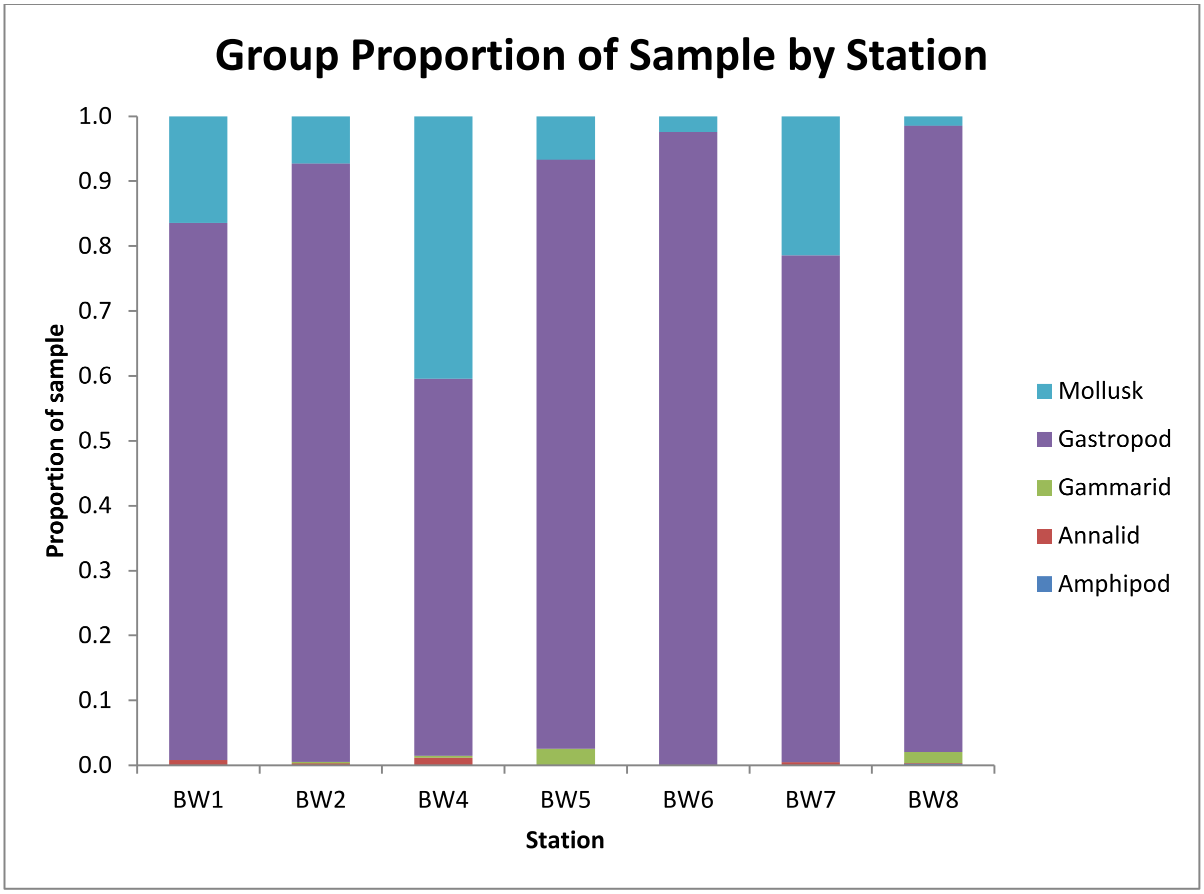

Figure 9.12. Proportion of each group of organisms at each station. Data were combined for both months and both core sizes.

Large Core Results

BW6 had the highest average density of organisms for the large core samples in October (54,197 individuals / m^2). BW8 was the station with the highest density of all organisms combined for the large core samples in April (37,518 individuals / m^2), followed by BW6 (34,547 individuals / m^2) (Table 9.1).

Amphipods were present in the large core samples only in April; they were found at stations BW2, 4, 5, and 8 (Figure 9.13; Table 9.2). The large cores were mostly dominated by *C. californica* and to a lesser extent, clams and other bivalves (Figure 9.13; Table 9.2). The *C. californica* density included both live and dead individuals.

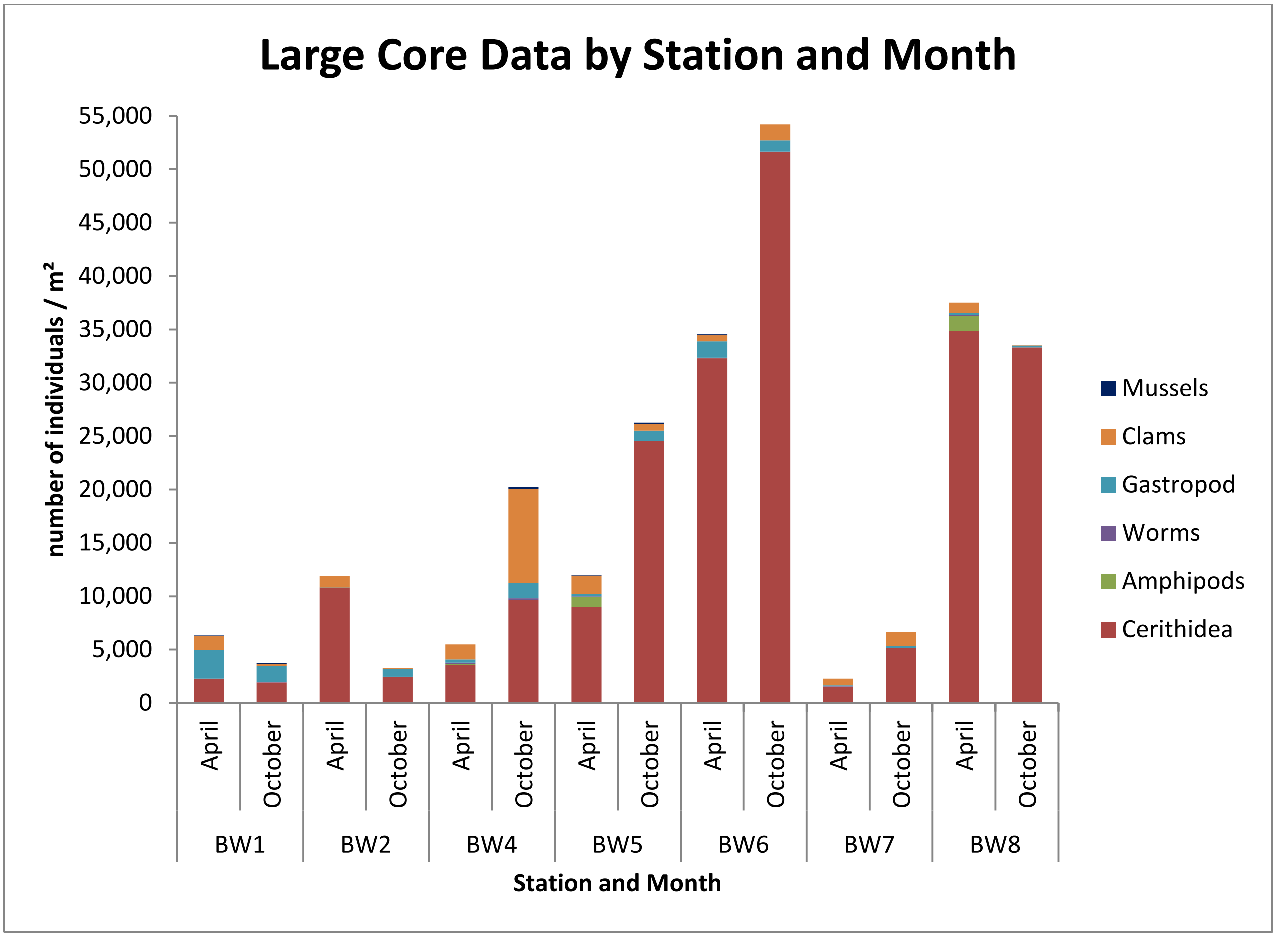

Figure 9.13. Average density of organisms by month and station for large cores.

Table 9.2. Average density of organisms by month and station for large cores.

	Month	All Organisms	Cerithidea	Amphipods	Worms	Gastropod	Clams	Mussels
BW1	**April**	6324	2292	0	0	2674	1316	42
	October	3735	1910	0	85	1443	212	85
BW2	**April**	11884	10823	42	0	0	1019	0
	October	3268	2419	0	42	722	85	0
BW4	**April**	5475	3565	85	127	297	1401	0
	October	20244	9634	0	170	1443	8828	170
BW5	**April**	11968	8998	934	42	212	1740	42
	October	26271	24531	0	0	976	637	127
BW6	**April**	34547	32298	0	42	1528	594	85
	October	54197	51609	0	42	1061	1485	0
BW7	**April**	2292	1528	0	42	85	637	0
	October	6621	5135	0	0	212	1273	0
BW8	**April**	37518	34844	1401	85	212	976	0
	October	33529	33316	0	0	170	42	0

Small Core Results

BW8 had the highest average density of organisms for the small core samples in both October (77,752 individuals / m²) and April (110,928 individuals / m²) (Table 9.1). BW6 was the only station where the total density of all organisms combined was smaller in April than October (Figure 9.14).

Amphipods were higher in April than October at stations BW2, 4, 5, 7, and 8, and dominated the small core samples at BW4 in both October and April (Figure 9.14; Table 9.3). The worm and mussel groups generally had lower overall densities at most of the stations (Figure 9.14; Table 9.3).

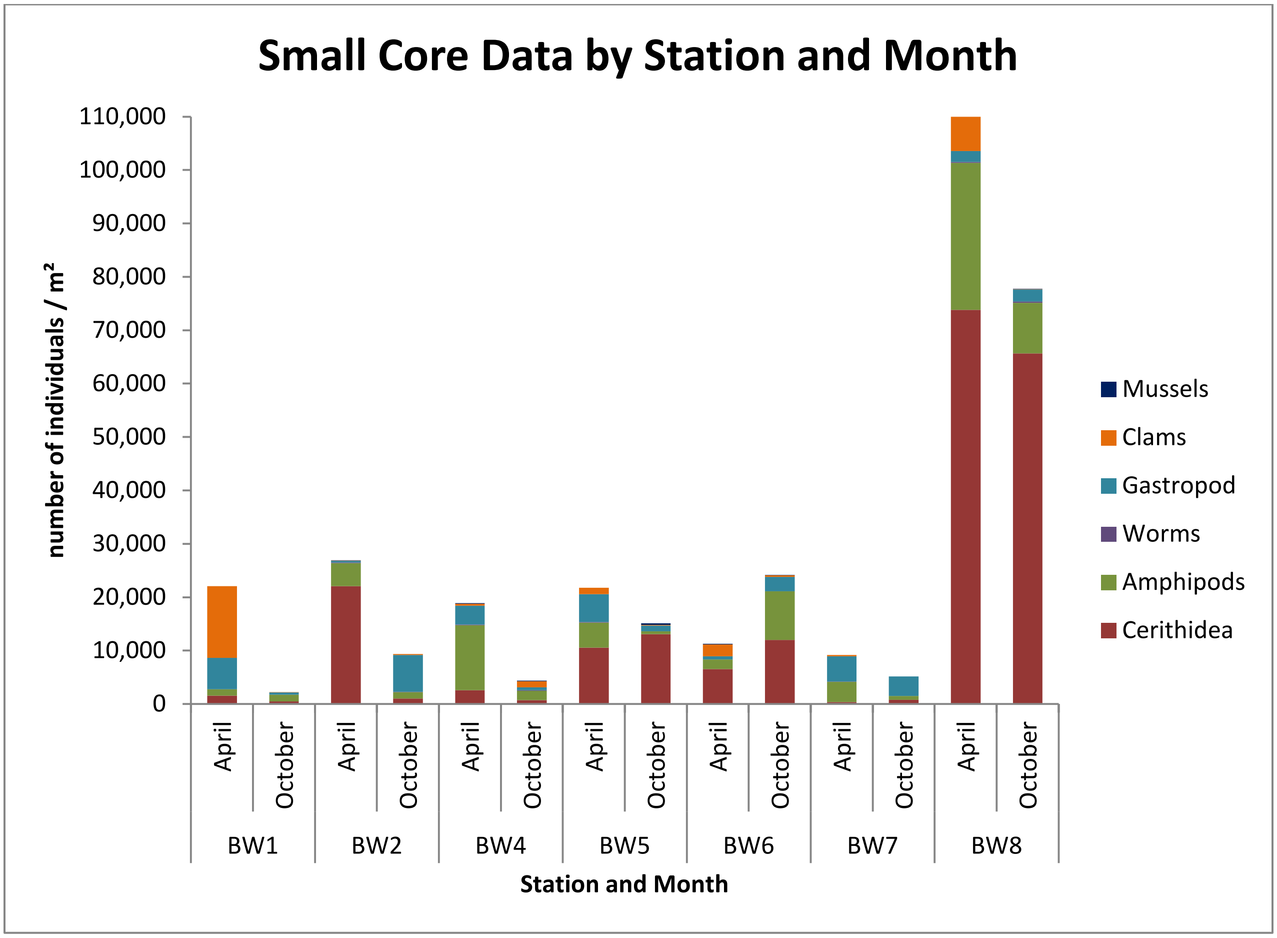

Figure 9.14. Average density of organisms by month and station for small cores.

Table 9.3. Average density of organisms by month and station for small cores.

	Month	All Organisms	Cerithidea	Amphipods	Worms	Gastropod	Clams	Mussels
BW1	**April**	22091	1572	1179	0	5896	13443	0
	October	2201	511	1258	0	393	39	0
BW2	**April**	26926	22052	4363	118	275	79	39
	October	9355	1022	1179	79	6918	157	0
BW4	**April**	18907	2594	12186	79	3538	393	118
	October	4363	708	1769	118	511	1179	79
BW5	**April**	21777	10535	4678	118	5228	1219	0
	October	15134	13090	550	0	1061	118	314
BW6	**April**	11281	6564	1769	0	590	2241	118
	October	24175	11989	9119	0	2673	314	79
BW7	**April**	9159	393	3774	39	4756	197	0
	October	5149	786	708	0	3656	0	0
BW8	**April**	110928	73821	27516	197	2044	7351	0
	October	77752	65684	9434	236	2319	39	39

Epifauna Results

Transect 3 had the highest average number of *C. californica* (77.3 individuals / m^2) in June (Table 9.4). Transect 1 had the highest average number of *C. californica* (102.4 individuals / m^2) during the September sampling period (Table 9.4). Transect 4 was added to the protocols in September 2010 and was only sampled once; therefore, Transect 4 is not included in Figure 9.15. The average number of *C. californica* were similar across all transects in June 2010. In September, only Transect 1 had a higher value than that of June. Both Transects 2 and 3 had lower numbers of *C. californica* in September.

Table 9.4. Average number of *C. californica* ± SE (standard error) for all transects, separated by sampling period. Note: transect 4 was only sampled in September 2010.

	Average # / m²	Standard Error
Transect 1	71.2	6.22
Transect 2	68.0	7.84
Transect 3	77.6	9.28
June (All)	72.3	4.22
Transect 1	102.4	11.54
Transect 2	43.2	3.89
Transect 3	9.6	0.93
Transect 4	722.4	38.87
September (All)	219.4	19.19
Grand Mean	156.34	11.43

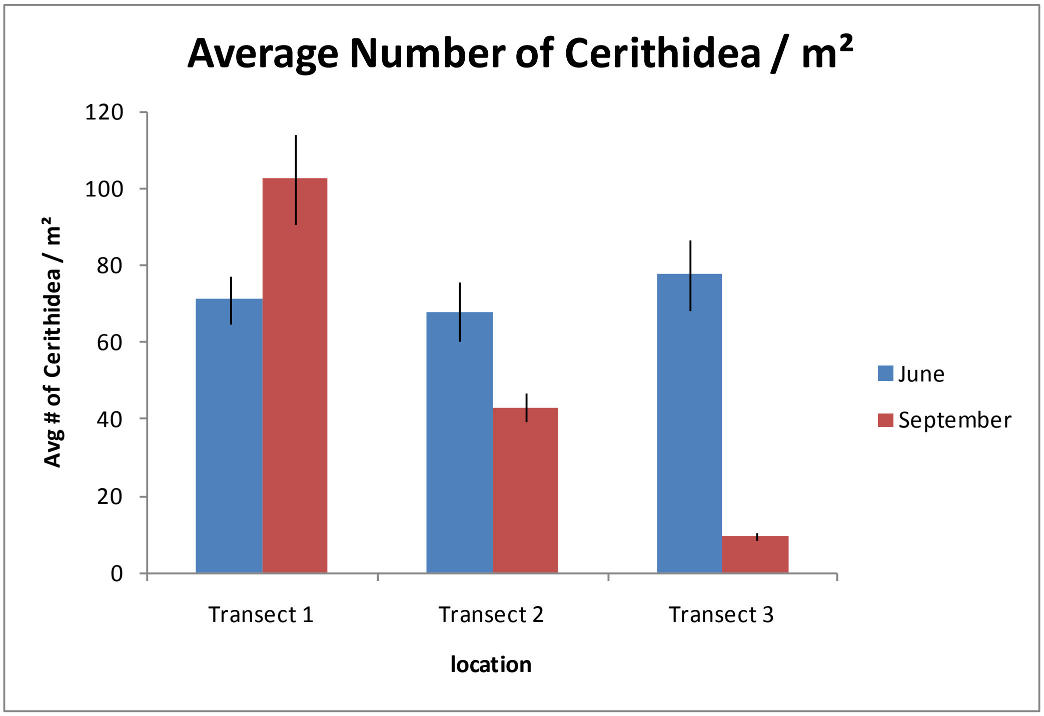

Figure 9.15. Average number of *C. californica* per meter squared ± standard error. Note: Transect 4 data from September are not included on this graph; data are available in Table 9.4.

Special Status Species

Targeted surveys for *Tryonia imitator* were not conducted during the first year of the BAP. No species of special concern were observed visually at the sampling stations nor were they found in any of the samples.

FUTURE DIRECTIONS

Benthic invertebrate surveys will continue using the same spatial and temporal sampling pattern in the second Baseline year (2010-2011). However, the second year of benthic invertebrates will be identified to the lowest taxonomic category possible to achieve BAP goals. This will enable comparison of the species richness to previous reports which included species level taxonomic identifications.

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Photo credit: S. Woodard

TERRESTRAIL INVERTEBRATES

Baseline Assessment Program: 2009-2010 Report

CHAPTER 10:
TERRESTRIAL INVERTEBRATES

Ballona Wetlands Ecological Reserve, Los Angeles, California
Santa Monica Bay Restoration Commission

Prepared for: California State Coastal Conservancy
November 2011

Authors: Elena Del Giudice-Tuttle, Karina Johnston, and Ivan Medel

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TERRESTRIAL INVERTEBRATES

INTRODUCTION

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

The objective of the Baseline Assessment Program (BAP) invertebrate assessment of the Ballona Wetlands Ecological Reserve (BWER) for the first Baseline year (2009-2010) was to extrapolate aerial arthropod productivity (as biomass) using length-fresh weight regressions for each habitat.

Taxonomic nomenclature and conservation status for species in this report are from the Integrated Taxonomic Information System (ITIS; http://www.itis.gov/, searched January 2011).

Existing Conditions Report Summary (Prior to 2005)

Both Nagano et al. (1981) and Mattoni (1991) note the dearth of taxonomic knowledge and the diminishing pool of expert entomologists, both factors being obstacles to the study of coastal southern California insects. Nagano et al. (1981) and Mattoni (1991) both agree that there has not been a complete survey of the overall insect fauna of a pristine coastal locality in southern California. For example, past data on ant species found at the BWER are limited, even though ants represent a keystone species. Mattoni (1991) found the non-native Argentine ant (*Linepithema humile*) to be dominant at all survey sites and the most common insect found in pitfall traps; only three ant species were documented from the 1990 surveys.

Nagano et al. (1981), Mattoni (1991), Boland and Zedler (1991), and Hawks Biological Consulting (HBC) (1996) used various collection methods in insect surveys at the BWER and attempted to identify terrestrial invertebrates to species (Table 10.1).

Table 10.1. Previous terrestrial invertebrate surveys and reports (reproduced from PWA 2006).

Year	**Author**	**Geographic Extent**	**Description**
1981	Nagano et al.	Areas A and B	Baseline report on insects and related terrestrial arthropods for *The Biota of the Ballona Region* report
1991	Boland and Zedler	Area B	Fish and invertebrate research sponsored by the National Audubon Society
1991	Mattoni	Area B	Terrestrial arthropod survey for Playa Vista Environmental Impact Report (EIR)
1996	Hawks Biological Consulting	Areas A, B, C and D	Sensitive insect survey for Impact Sciences
2000	Psomas	Area B	Survey of El Segundo blue butterfly for Psomas and USFWS

Nagano et al. (1981) conducted the most comprehensive terrestrial invertebrate survey of the BWER to date. The goal of the survey was to collect and catalogue the terrestrial invertebrates of the BWER. The survey methods included nets, traps, soil sifting and berlese funnels. The greatest arthropod diversity was in the sand dunes of Area B. The brackish and freshwater marshes were extensively sampled, but less diverse. The coastal sage and bluff habitats were not sampled.

Mattoni (1991) conducted surveys in Area B, tracing a continuous survey transect through all the habitat types present; all "butterflies, dayflying moths, dragonflies, beeflies, robber flies, other large flies and obvious bee and wasp species" were recorded. In addition, pitfall traps and targeted surveys (for certain tiger beetles and several flies) were used. Species distribution was found to be highly non-random.

Boland and Zedler (1991) conducted terrestrial invertebrate surveys from March through November 1990 as part of a broad ecology study sponsored by the National Audubon Society. The terrestrial invertebrates were sampled using pan traps. Five habitats were surveyed for terrestrial invertebrates: western salt marshes, central salt marshes, eastern salt marshes, salt pans, and old agricultural fields (Figure 10.1). The contents of the traps were identified to family. Large invertebrates were sampled using circular quadrats, and large animals (primarily snails) were counted (Boland and Zedler 1991). Pitfall traps were found to be dominated by amphipods, spiders, and insects (Collembola, Diptera, Homoptera, and Hymenoptera), with higher numbers of invertebrates found in the wet pickleweed (*Salicornia spp.*) sites than in the dry pickleweed sites. The non-native milk snail (*Otala lacteal*) was common throughout the study area, reaching a peak density of approximately one individual / m^2 (Boland and Zedler 1991).

Hawks Biological Consulting (HBC) (1996) conducted special interest insect species and habitat surveys in Areas A, B, C, and D, though they focused their efforts in the dune habitat of Area B (20 pitfall traps). Additional field survey techniques included: walks (collection and observation), beating sheets, sweep nets, and an aspirator. Sixteen insect orders were collected from Areas A, B, and C. HBC also found three unlisted species of interest: the western mudflat tiger beetle (*Cicindela trifasciata sigmoidea*), two undescribed species of Jerusalem cricket (*Stenopelmatus new species*), and one undescribed species of sand roach (*Arenivage new species*) (HBC 1996).

Sapphos Environmental Inc. (2000) assessed habitats for the El Segundo blue butterfly (*Euphilotes battoides allyni*) in October and November 2000 by walking belt-transects to identify areas that could support native coastal dune vegetation. No suitable habitat for the El Segundo blue butterfly was identified in Areas A, C, and D while a portion of Area B [identified as suitable habitat by the United States Fish and Wildlife Service (USFWS 1998 and 2008)] was confirmed as suitable by Sapphos Environmental Inc. Environmental Inc. (2000).

Figure 10.1. Survey sites from previous reports: Boland and Zedler 1991 (blue), Mattoni 1991 (green), and HBC 1996 (pink).

Existing Conditions Report Summary – Special Status Species

Appendix H.1 contains a full list of the special status species with the potential to inhabit the BWER.

Four butterflies are considered special status species with the potential to inhabit the BWER (Appendix H.1): monarch butterfly (*Danaus plexippus*), wandering skipper (*Panoquina errans*), El Segundo blue butterfly (*Euphilotes battoides allyni*), and Quino checkspot butterfly (*Euphilotes editha quino*).

Two of the four special status butterflies have been documented at the BWER: the monarch butterfly (Mattoni 1991) and the wandering skipper (Nagano et al. 1981, Mattoni 1991, HBC 1996, Sapphos Environmental Inc. 2000, Psomas and Lockhart 2001).

Belkin's dune tabanid fly (*Brennania belkini*) is a sand obligate species, which has not been found in the Ballona Wetlands region since the 1980s (Mattoni 1991). Dorothy's El Segundo dune weevil (*Trigonoscuta dorothea dorothea*) was found in Area B in 1995 and more recently in the dune system immediately west of Area B (HBC 1996, Psomas and Lockhart 2001). Lange's El Segundo dune weevil (*Onychobaris langei*) is a sand obligate species that was found in the BWER by Nagano et al. (1981), Mattoni (1991), and Psomas and Lockhart (2001).

The globose dune beetle (*Coelus globosus*) is also a sand obligate species that was observed in the dunes in Area B by HBC (1995) and by Psomas and Lockhart (2001). The last sighting of the sandy beach tiger beetle (*Cicindela hirticollis gravid*) was reportedly in 1906 (Mattoni 1991).

In addition to the nine species listed above, two Federally Endangered fairy shrimp, the San Diego fairy shrimp (*Branchinecta sandiegonensis*) and the Riverside fairy shrimp (*Streptocephalus woottoni*), have been surveyed in the BWER by Glenn Lukos Associates (2000) and Psomas (2001). No ponds in Areas A, B, or C were determined to be capable of supporting either type of fairy shrimp and both were determined to be absent from the BWER (Psomas 2001, Psomas and Lockhart 2001, PWA 2006).

Interim Research (2005-2010)

Walking surveys were conducted in the Ballona Outdoor Learning and Discovery (BOLD) southwestern portion of Area B to assess habitat suitability for special status species (Arnold 2007). The survey concluded that the wandering skipper and mudflat tiger beetle have the greatest likelihood of using the BOLD project area. A single adult wandering skipper was observed at the BOLD site, along with small cabbage white butterfly larva (*Pieris rapae*), buckeye butterfly (*Junonia coenia*), Argentine ant, honey bee (*Apis mellifera*), and an unidentified species of ground-nesting bee. The cabbage white butterfly, Argentine ant, and honey bee are non-native species.

Recent walking surveys for butterflies conducted by the Friends of Ballona Wetlands (FBW) found 13 species in 2008, seven species in 2009, and 18 species in 2010 in the salt marsh in the western portion of Area B in July of each year (FBW 2010, unpublished data; Table 10.2); four additional species were found in habitats adjacent to the salt marsh. The FBW recorded the presence of one of the special status butterflies, the wandering skipper. The non-native small cabbage white butterfly was the most commonly seen species in 2008 and 2009 in the brackish marsh.

Table 10.2. Butterfly counts from the salt marsh habitats of Area B (FBW 2010, unpublished data). Note: X* denotes counts from a non-salt marsh habitat type (specified within table).

Common Name	**Species Name**	**2008**	**2009**	**2010**
Acmon blue	*Plebejus acmon*	X	X	X
Anise swallowtail	*Papilio zelicaon*			X
Blue sp. (unknown)	----			X
Small cabbage white	*Pieris rapae*	X	X	X
Checkered white	*Pontia protodice*	X	X	X
Cloudless sulphur	*Phoebis sennae*	X		
Common buckeye	*Junonia coenia*	X		X
Eufala skipper	*Lerodea eufala*	X	X	X
Fiery skipper	*Hylephila phyleus*	X		X
Gray hairstreak	*Strymon melinus*	X		X
Gulf fritillary	*Agraulis vanillae*			X* (freshwater)
Marine blue	*Leptotes marina*	X	X	X
Mourning cloak	*Nymphalis antiopa*			X* (riparian)
Orange sulphur	*Colias eurytheme*	X		
Queen	*Danaus gilippus*	X		
Sachem skipper	*Atalopedes campestris*			X
Sandhill skipper	*Polites sabuleti*			X
Skipper (unknown)	----		X	X
Umber skipper	*Poanes melane*	X		X
Wandering skipper	*Panoquina errans*			X
West Coast lady	*Vanessa annabella*			X
Western pygmy-blue	*Brephidium exilis*	X	X	X
Western tiger swallowtail	*Papilio rutulus*			X* (riparian, Cabora Road, freshwater)
White checkered skipper	*Pyrgus albescens*			X* (freshwater)
White sp. (unknown)	----			X
Red = Non-Native Blue = Special Status Species				

METHODS

Method Comparison and Rationale

The high diversity of coastal arthropods and lack of qualified invertebrate taxonomists make traditional terrestrial invertebrate assessments in this habitat expensive and difficult.

Therefore the BAP used innovative metrics aimed at describing function or rates of productivity to assess the health of the marsh system based on terrestrial invertebrate communities. Non-taxonomic metrics developed by Anderson (2009) and focused on invertebrate roles in the ecosystem are rapid, useful across multiple habitats, and when focused on arthropod productivity by size class, indicative of food availability for various feeding guilds (e.g. spiders, birds, etc).

Site Locations and Times

Aerial arthropod sampling was conducted in September and October 2009. To analyze aerial arthropod biomass, 35 transects were surveyed, including five randomly chosen vegetation transects within each of seven habitat types: brackish marsh, low salt marsh, mid salt marsh, high salt marsh, salt pan, seasonal wetland, and upland dune (Figure 10.2). Flying insects were not sampled within two weeks of vegetation or other transect monitoring. Three traps were deployed equidistant along 30 m transects, which extended 2.5 meters past the start and end of the 25 m vegetation transects (Figure 10.3). Each trap was labeled with the individual transect number, date deployed, and replicate (1, 2, or 3) along the transect (Figure 10.4).

Field Methods

Insect traps were tanglefoot-covered, sticky yellow plastic sheets (Bioquip catalog #2873) that were placed on wire holders (Bioquip catalog #2874) and suspended over the vegetation or soil surface (Figure 10.4). Traps were supplied in 6 x 12 inch sheets, which were cut in half to produce 6 x 6 inch sheets (or 14 cm x 15 cm) with an area of 0.021 m^2. The sticky-sheets were then placed so the lower edge of the sheet was approximately 2-5 cm above the soil surface or upper edge of the vegetation canopy (Figure 10.4). In cases of short or sparse vegetation, the insect trap was set a minimum of 10 cm above the ground to avoid potential inundation or entanglement with blowing plant stems (Anderson 2009).

Traps were left out for four days (deployment times of 3-6 days produce statistically indistinguishable results when standardized for days of deployment; Anderson 2009). Upon collection, the traps were wrapped with clear plastic and returned to the lab for processing. This prevented additional items from getting stuck on the trap surface and allowed traps to be stacked without sticking to one another.

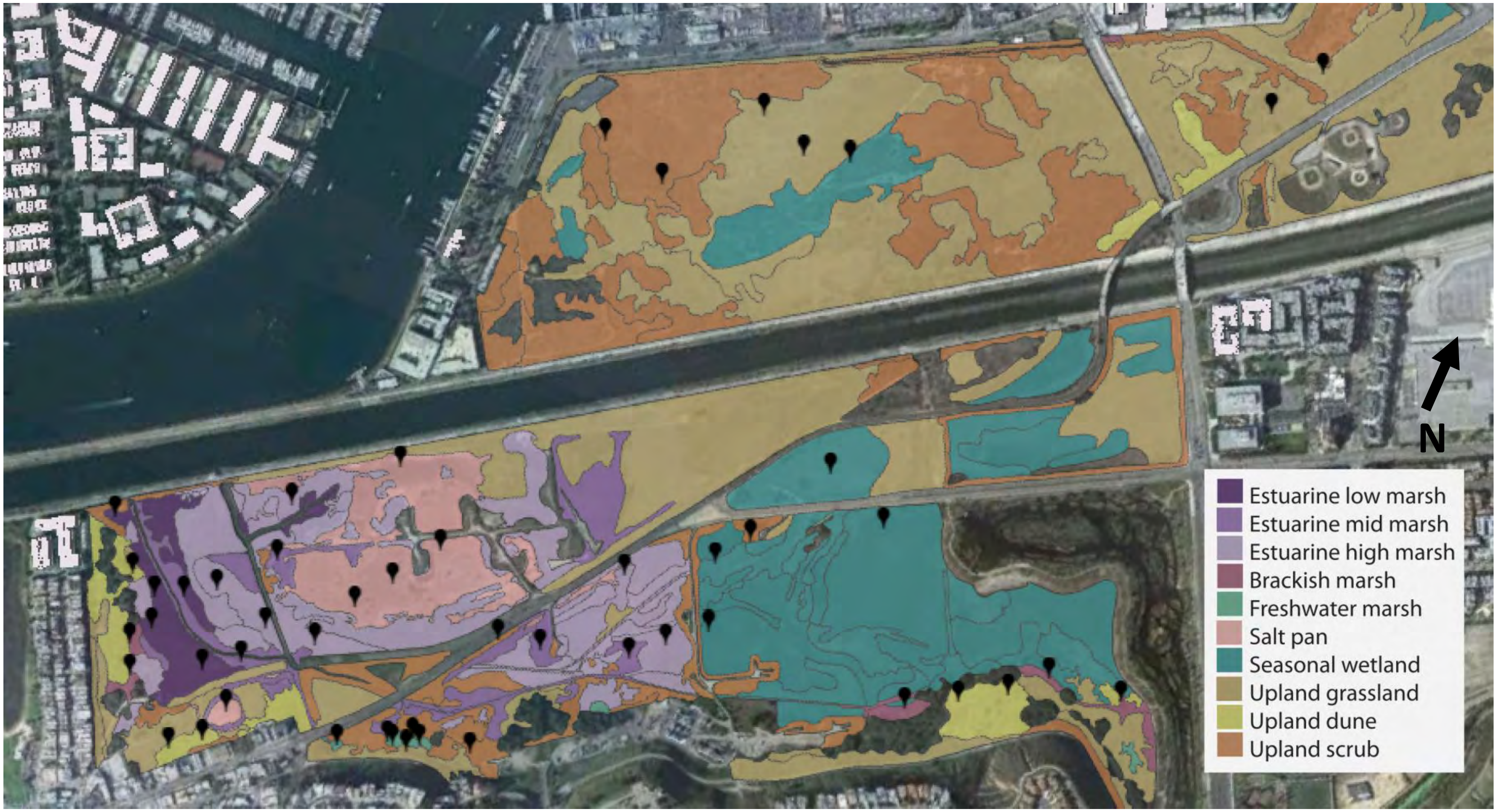

Figure 10.2. BAP Insect transects throughout the BWER by habitat type.

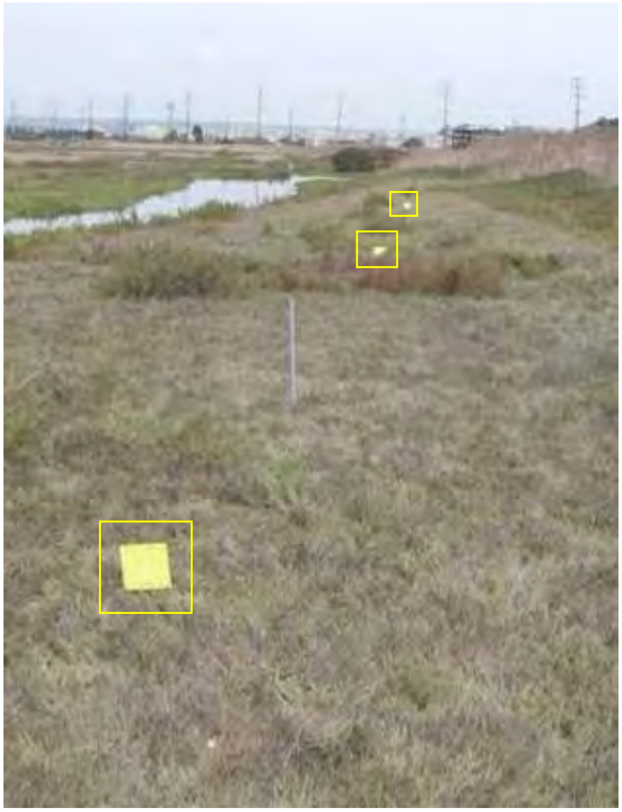

Figure 10.3. Deployed insect transect (photo: SMBRC 2010). Yellow boxes indicate traps along the transect.

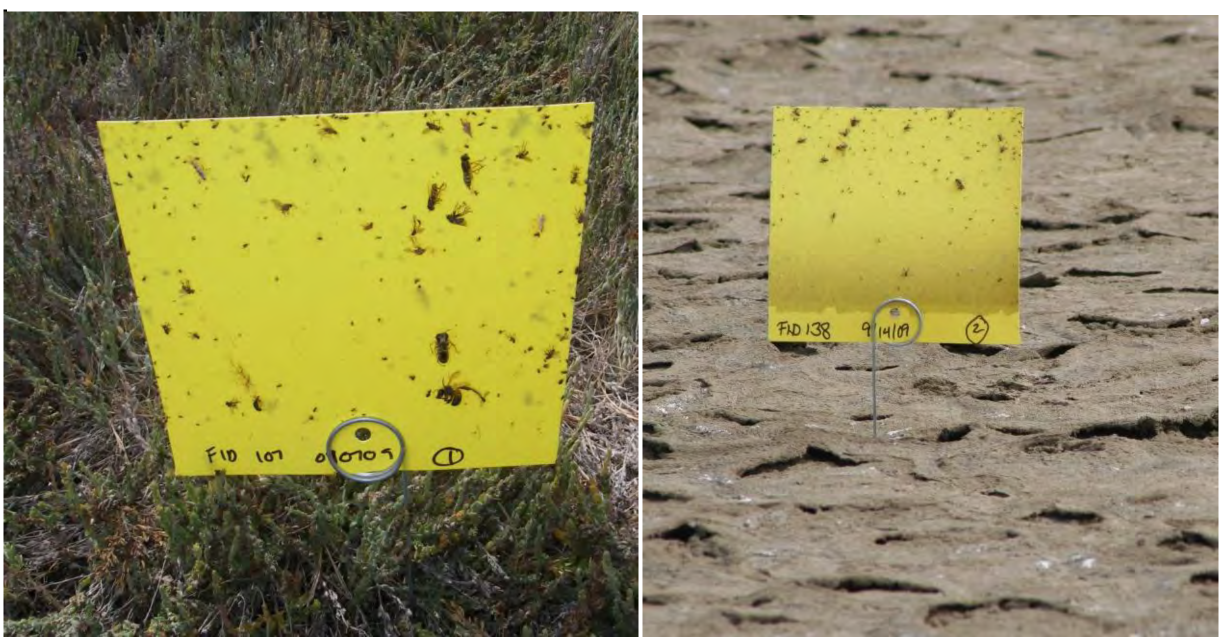

Figure 10.4. Deployed sticky trap (photos: S. Woodard 2009).

Laboratory and Analysis Methods

Processing of the samples followed methods developed by Dr. Sean Anderson, California State University Channel Islands. All individual invertebrates were counted and classed by size: ~0.5 mm, <2 mm, 2-5 mm, 5-10 mm, or >10 mm. Aerial arthropod biomass was estimated by extrapolation based on weight and number of individuals per size class, according to the following formula (S. Anderson, pers. comm. 2009):

(# arthropods in size class Y) x (fresh weight regression multiplier for size class Y) x (area) x (duration) = productivity of size class Y

Length-fresh weight regressions were developed by Dr. Anderson to determine average fresh weights by size class (S. Anderson, *unpublished data*, 2009). The number of arthropods in a given size category were multiplied by the average fresh weights and summed to produce total productivity in the form of grams of arthropods per m^2 per day. Each sticky paper (front and back together) was considered a single trap (i.e. a single spatial plane through which insects passed).

RESULTS

General Results and Overall Trends

Aerial arthropod productivity was based on the average available biomass per square meter per day. Productivity refers to the rate of *captured* aerial arthropod biomass on a particular transect or averaged within a particular habitat type during the time of sampling, and is not an indication of the *active production* of the system or habitat as a whole.

The brackish marsh habitat had the lowest average total aerial arthropod productivity at 3.50 ± 0.59 $mg/m^2/day$ (Figure 10.5). The high salt marsh had approximately twice the productivity of the brackish marsh, at 7.14 ± 1.37 $mg/m^2/day$, but approximately half of the total average productivity of the low salt marsh, mid salt marsh, and salt pan habitats (14.9 ± 3.96, 14.9 ± 3.07, and 14.7 ± 4.12 $mg/m^2/day$, respectively), which all expressed similar productivity results.

The upland grassland had the highest aerial arthropod productivity and the highest level of variability between transects at 29.0 ± 11.1 $mg/m^2/day$ (Figure 10.5).

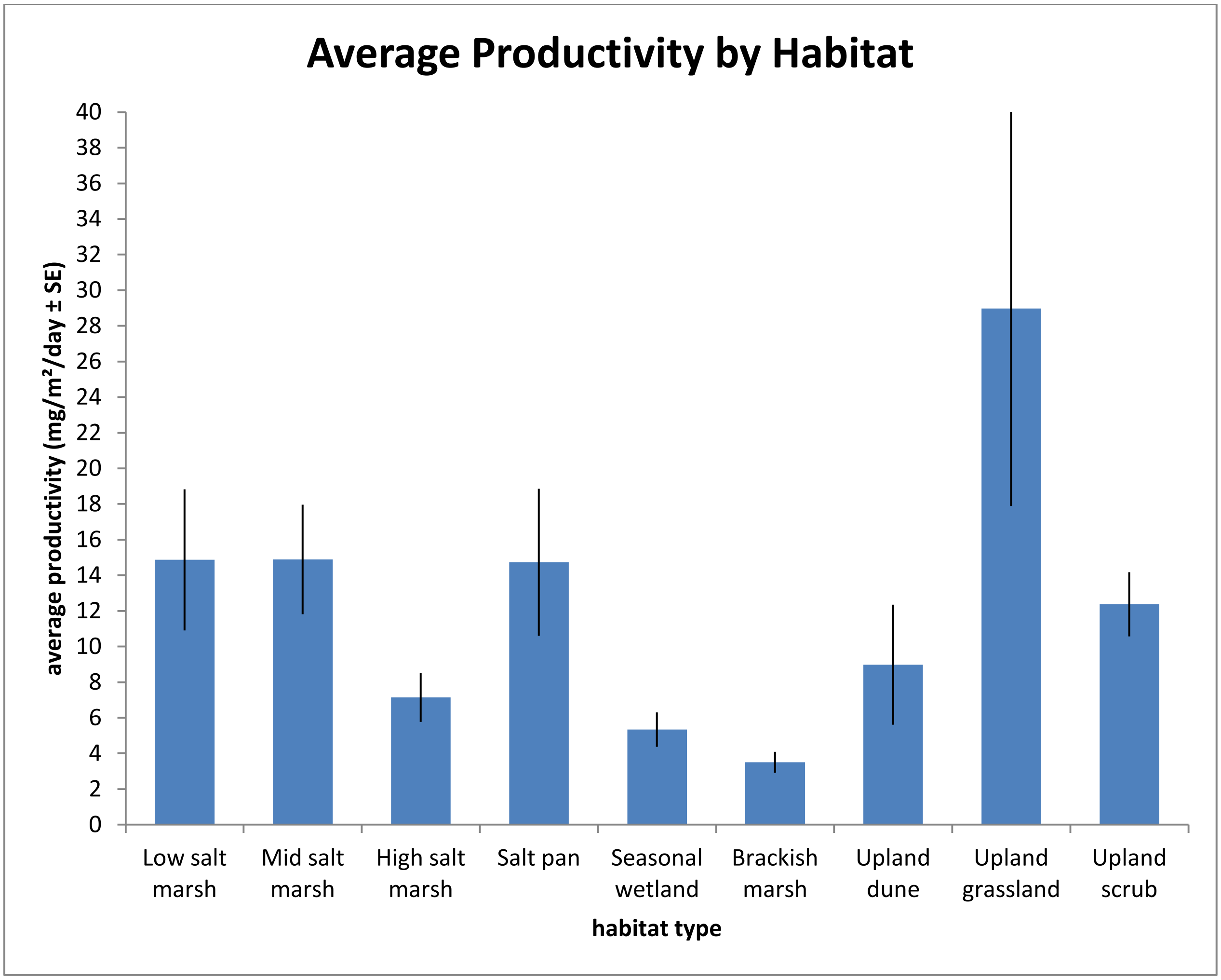

Figure 10.5. Average productivity (mg/m^2/day ± SE) within each habitat.

In addition to the aerial arthropod surveys, ancillary observations of the non-native milk snail (*Otala lacteal*; Figure 10.6) were common throughout the BWER, especially on non-native and upland vegetation. The snail was not surveyed quantitatively but was noted during sampling events.

Additionally, several terrestrial invertebrates were observed as incidental catch during the herpetofauna pitfall surveys (see Chapter 6 for herpetofauna survey protocols and results). Individuals of the beetles (Order: Coleoptera) and other invertebrates were not collected at this time, and therefore were not taxonomically identified to species or retained as voucher specimens.   Figure 10.7 displays two of the common beetles (*Eleodes sp.*) found in the pitfall traps.

Figure 10.6. The non-native milk snail seen throughout the BWER (photo: SMBRC 2010).

Figure 10.7. Incidental catch during herpetofauna pitfall surveys: desert stink beetles (*Eleodes* spp.) (photos: SMBRC 2010). Note: Individuals were released and therefore were not taxonomically identified to species.

Special Status Species

No special status species were identified on the aerial arthropod surveys; however, species-level taxonomic classifications were not conducted for the purposes of these surveys. Monarch butterfly presence was confirmed on 11 October 2010 during tree surveys in Area B, south of Culver Boulevard (Figure 10.8). Additionally, ancillary observations of the wandering skipper were visually confirmed in the lower marsh habitat of western Area B during vegetation surveys.

Figure 10.8. Monarch butterflies observed during tree surveys (photos: E. Del Giudice-Tuttle 2010).

FUTURE DIRECTIONS

Aerial arthropod surveys will continue in the second Baseline year. Although pitfall trapping may not be an effective method to determine actual terrestrial insect population sizes and abundances, it can be effective as both a relative comparison between sites and as an indicator of species presence. Species-level terrestrial surveys will be conducted in the second Baseline year utilizing pitfall traps. Voucher specimens of each species will be taxonomically identified. Pitfall traps will be deployed in the same locations and times as the aerial arthropod surveys and will be compared by habitat. The pitfall traps will be set up using 8 oz plastic cups placed in holes flush to ground level. The traps will be covered by a plate at a height of approximately 2.5 cm above the ground to reduce debris, while allowing invertebrate access.

APPENDIX H.1

Special status terrestrial invertebrate species with the potential to inhabit the Ballona Wetlands Ecological Reserve

Common Name	Species Name	Conservation Status in California
Belkin's dune tabanid fly	*Brennania belkini*	IUCN: Vulnerable; NatureServe: S1, S2
Dorothy's El Segundo dune weevil	*Trigonoscuta dorothea dorothea*	NatureServe: S1
El Segundo blue butterfly	*Euphilotes battoides allyni*	Federally Endangered; NatureServe: S1
Globose dune beetle	*Coelus globosus*	IUCN: Vulnerable; Nature Serve: S1
Hairy-necked Tiger Beetle	*Cicindela hirticollis gravida*	NatureServe: S1
Lange's El Segundo dune weevil	*Onychobaris langei*	NatureServe: S1
Monarch butterfly	*Danaus plexippus*	NatureServe: S3
Quino checkerspot butterfly	*Euphydryas editha quino*	Federally Endangered; NatureServe: S1
Riverside fairy shrimp	*Streptocephalus woottoni*	Federally Endangered; NatureServe: S1; IUCN: Endangered
San Diego fairy shrimp	*Branchinecta sandiegonensis*	Federally Endangered; NatureServe: S1; IUCN: Endangered
Wandering skipper	*Panoquina errans*	IUCN: Near Threatened; NatureServe: S1
Western mudflat tiger beetle	*Cicindela trifasciata sigmoidea*	NatureServe: SNR

NatureServe Conservation Rank Definitions

The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by a letter reflecting the appropriate geographic scale of the assessment (G = Global, N = National, and S = Subnational). The numbers have the following meaning: 1 = critically imperiled, 2 = imperiled, 3 = vulnerable, 4 = apparently secure, 5 = secure. SNR = Unranked

NOTE: Taxonomic nomenclature is from the Integrated Taxonomic Information System (ITIS; http://www.itis.gov/, searched January 2011).

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Photo credit: K. Johnston

CHAPTER 11:
PHYSICAL CHARACTERISTICS

Ballona Wetlands Ecological Reserve, Los Angeles, California
Santa Monica Bay Restoration Commission

Prepared for: California State Coastal Conservancy
November 2011

Author: Karina Johnston

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INTRODUCTION

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

The Baseline Assessment Program (BAP) will complete surveys of the physical characteristics of the Ballona Wetlands Ecological Reserve (BWER) in the second Baseline year. This chapter presents a summary of data collected from external organizations during the first year of the BAP.

Existing Conditions Report Summary (Prior to 2005)

The soils of the BWER originally derived from both fluvial and marine environments (PWA 2006). The BWER was subsequently overlain by fill dredged during the construction of Marina del Rey and excavated during flood management projects along Ballona Creek (PWA 2006). Fill materials were comprised mostly of clay, silt, silty sand, and sand and ranged in depth from zero feet in several parts of Area B to 18 feet deep in Areas A and C (Law and Crandall, Inc. 1991a, 1991b).

There are four main sources of hydrologic inflows to the BWER: (1) Freshwater and marine inflows from Ballona Creek and the Santa Monica Bay to the muted tidal channels of Area B, (2) Marina del Rey inflows to the Fiji Ditch in Area A, (3) urban runoff, and (4) groundwater. Urban runoff and groundwater enter the BWER from many sources. The influence of Ballona Creek is restricted to the muted tidal portion of the southwest corner of Area B, accessible through the eastern self-regulating tide gate. The Ballona Creek Watershed drains approximately 130 square miles of land, about 80% of which is urbanized, while the remaining 20% are composed of partially developed foothills and mountains (Figure 11.1; PWA 2006). The majority of the Ballona Creek drainage network has been modified into underground pipes and culverts, and open concrete channels.

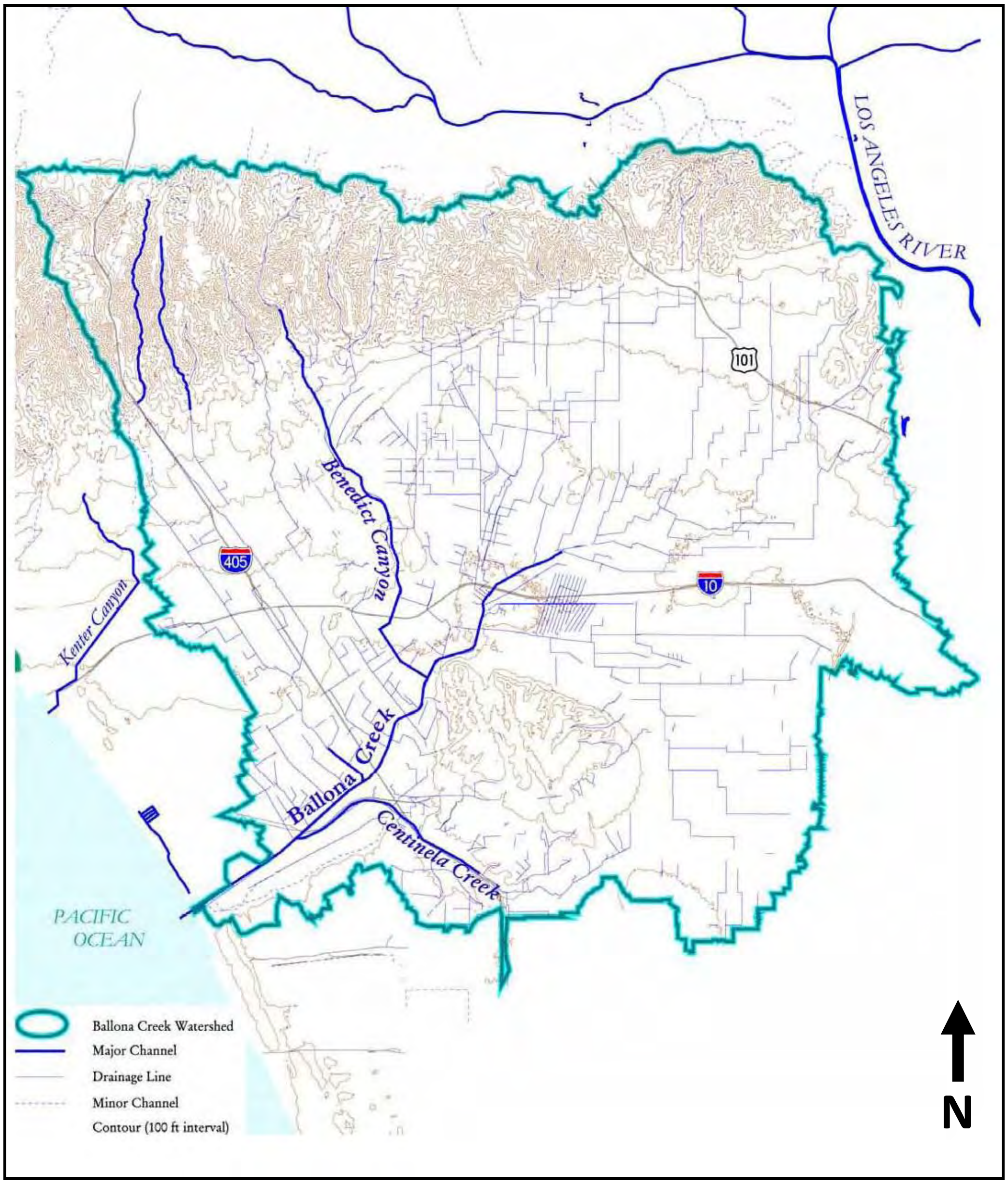

Figure 11.1. Ballona Creek watershed (reproduced from DPW 2004).

Marina del Rey is the largest artificial small-craft harbor in the U.S. and accommodates more than 5,000 privately owned pleasure crafts (PWA 2006, Kearney et al. 2010). The Marina was developed in the late 1950s and early 1960s on parts of the former Ballona Wetlands complex. The Marina del Rey watershed is approximately 2.9 square miles and is highly urbanized. The Fiji Ditch in the northern portion of Area A connects to Marina del Rey through a box culvert.

Groundwater is present in all three Areas (i.e. A, B, and C) (Straw 1987). Historically, the BWER received water through artesian upwellings (Henrickson 1991), although current conditions indicate much lower levels, with ranges in elevation depending on the specific location (Diaz, Yourman, and Associates 2010, Weston Solutions 2009).

Interim Research (2005-2010)

Four surveys of physical characteristics of the BWER were completed between 2005 and the Baseline year. In 2003, Moffat and Nichol prepared a report about the functionality of the newly installed self-regulating tide gates. In 2006, PWA collected elevation data for channel cross-sections both in the Fiji Ditch and the muted tidal portion of Area B. Lastly, in 2010 WRA conducted a wetland delineation survey throughout the BWER. Summarizations of two deep borehole surveys (Diaz, Yourman, and Associates 2010, Weston Solutions 2009) containing groundwater information, can be found in the terrestrial soil section of the Baseline Report. Additional research included a bathymetric elevation model made by PWA in 2008.

Tide Gate Evaluation

Moffat and Nichol (2003) surveyed the functionality of the self regulating tide gate by deploying internally logging instruments (SBE 26 Seagauge Wave and Tide Recorder) within the BWER and at an adjacent station within Ballona Creek (outside of the tide gate) (Figure 11.2). The instruments recorded conductivity, temperature, and depth every 15 minutes. Results indicated that the tide gate was functioning properly for muted tidal conditions (Moffat and Nichol 2003).

Figure 11.2. Map of tide gauge sampling stations (modified from Moffat and Nichol 2003).

Channel Cross-section Surveys

PWA (2006) collected elevation data from 13 stations within the BWER (Figure 11.3). Several of the PWA cross-sections corresponded with BAP sampling stations; PWA stations 148, 149, ‘150ft’, and 128 were in the same locations as BAP stations BW1, BW2, BW4, and BW7 respectively.

Figures 11.4 and 11.5 show elevation cross-sections from the Fiji Ditch that coincide with BAP stations BW1 and BW2. Figures 11.6 and 11.7 show elevation cross-sections from the tidal channel portion of Area B that coincide with BAP stations BW4 and BW7. Data collected by PWA were incorporated into a bathymetric model grid of the lower Ballona Creek estuary and the BWER. This grid was created from several sources of bathymetric and topographical data, including: aerial topography, photogrammetry (R. Lung and Associates 1998), Marina del Rey dredging surveys (USACE 2006, unpublished data), Ballona Creek channel design drawings (Los Angeles County Flood Control District 1959), and other sources (City of Los Angeles 1997, 2003), supplemented by the cross-section and spot elevation surveys. See Appendix C-1, section 2.2.3 Bathymetry in the Ballona Wetlands Feasibility Report for a list of data sources and references. The model grid is a coarse representation of the bathymetry and topography. Figure 11.8 shows the bathymetric model expressed in meters.

Figure 11.3. Map of cross-section survey locations in the Fiji Ditch (top) and the tidal channels (bottom).

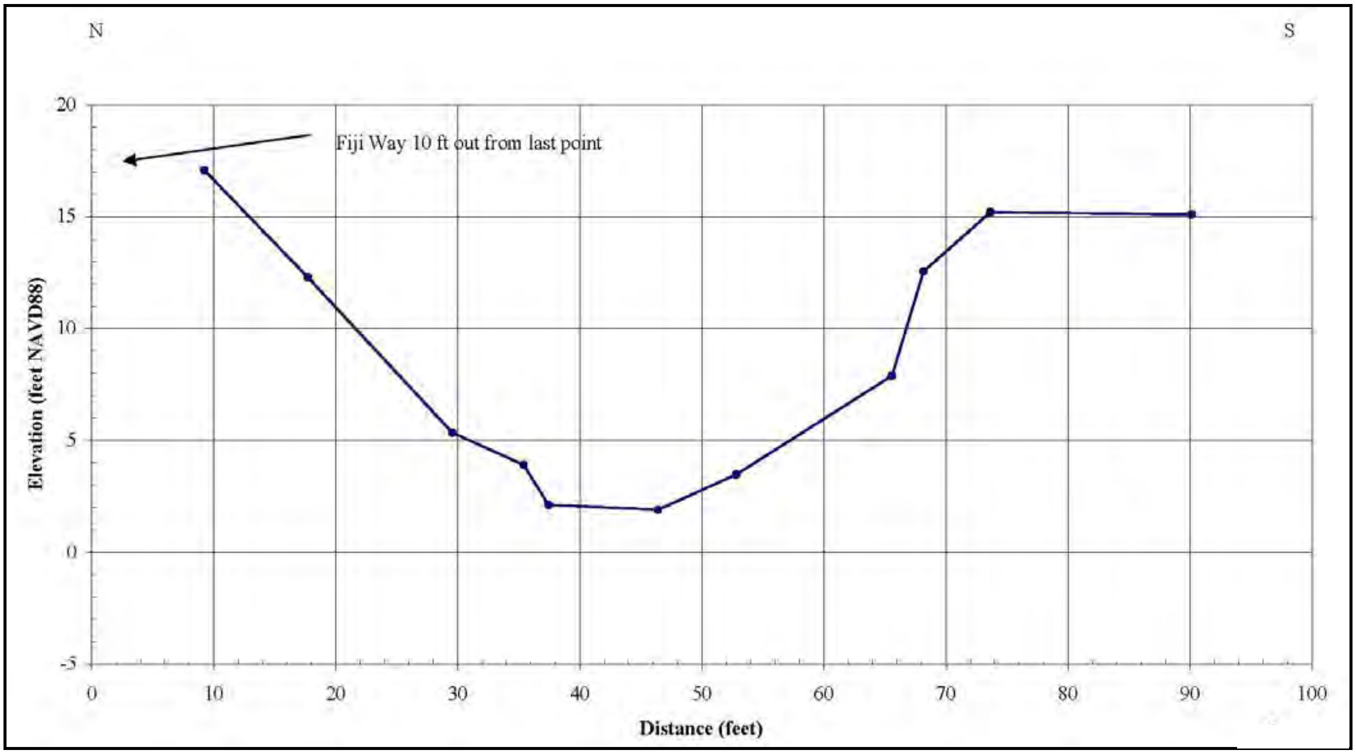

Figure 11.4. Cross-section 148 in the Fiji Ditch (modified from PWA 2006).

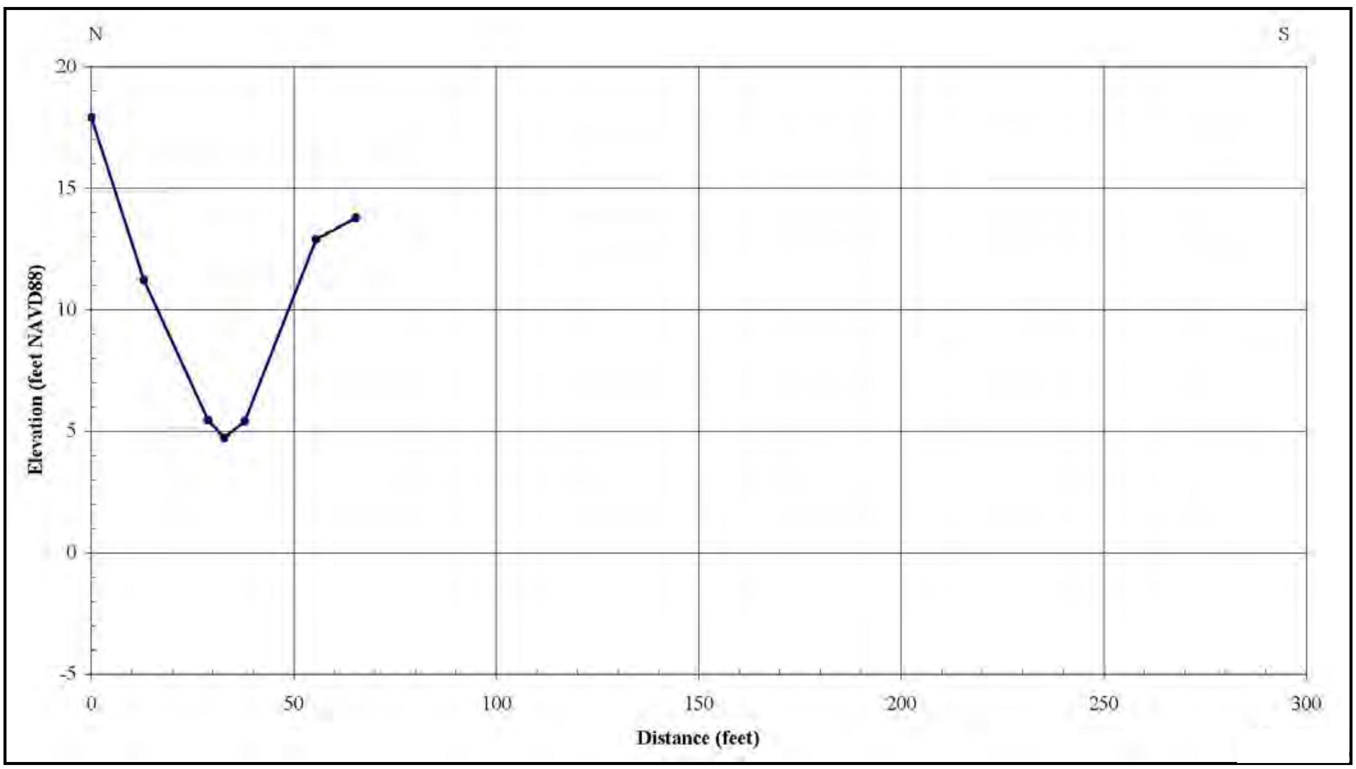

Figure 11.5. Cross-section 149 in the Fiji Ditch (modified from PWA 2006).

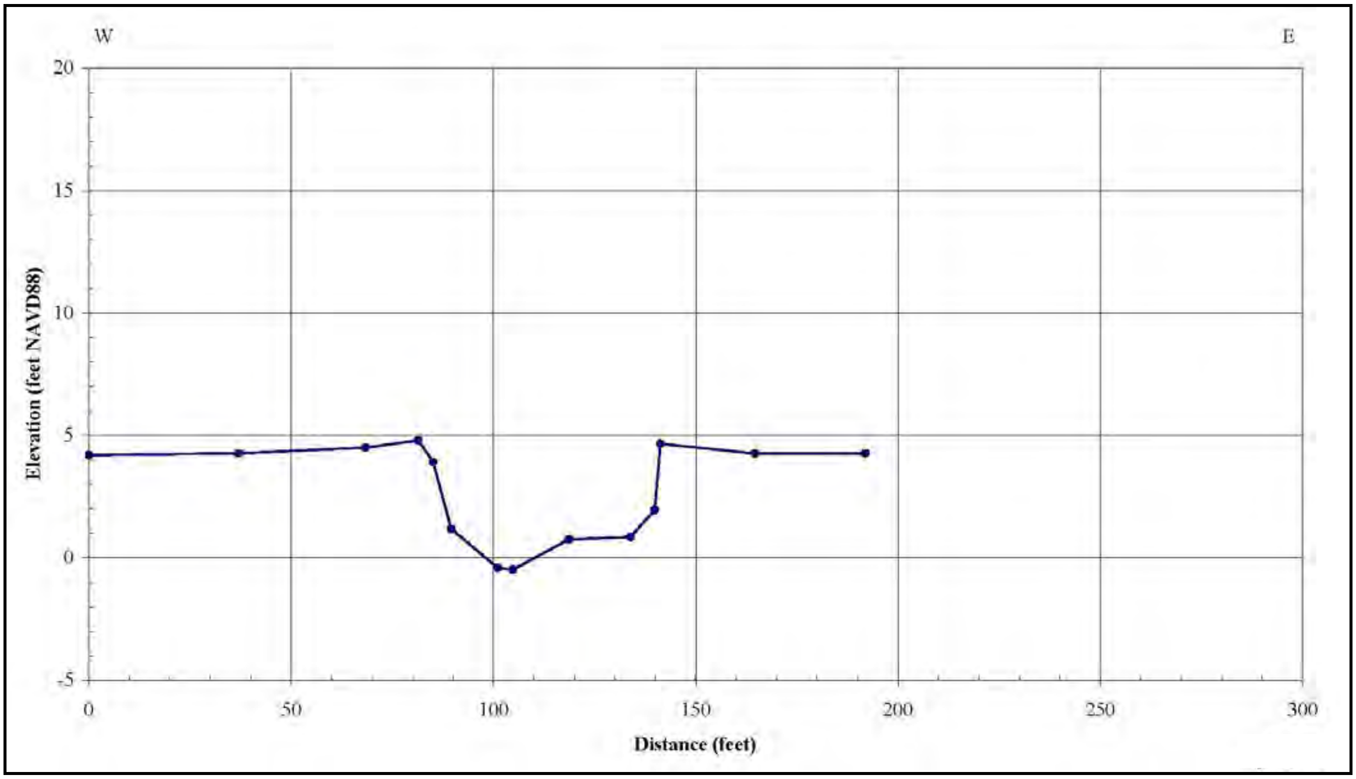

Figure 11.6. Cross-section '150ft' in the east tidal channel of Area B (modified from PWA 2006).

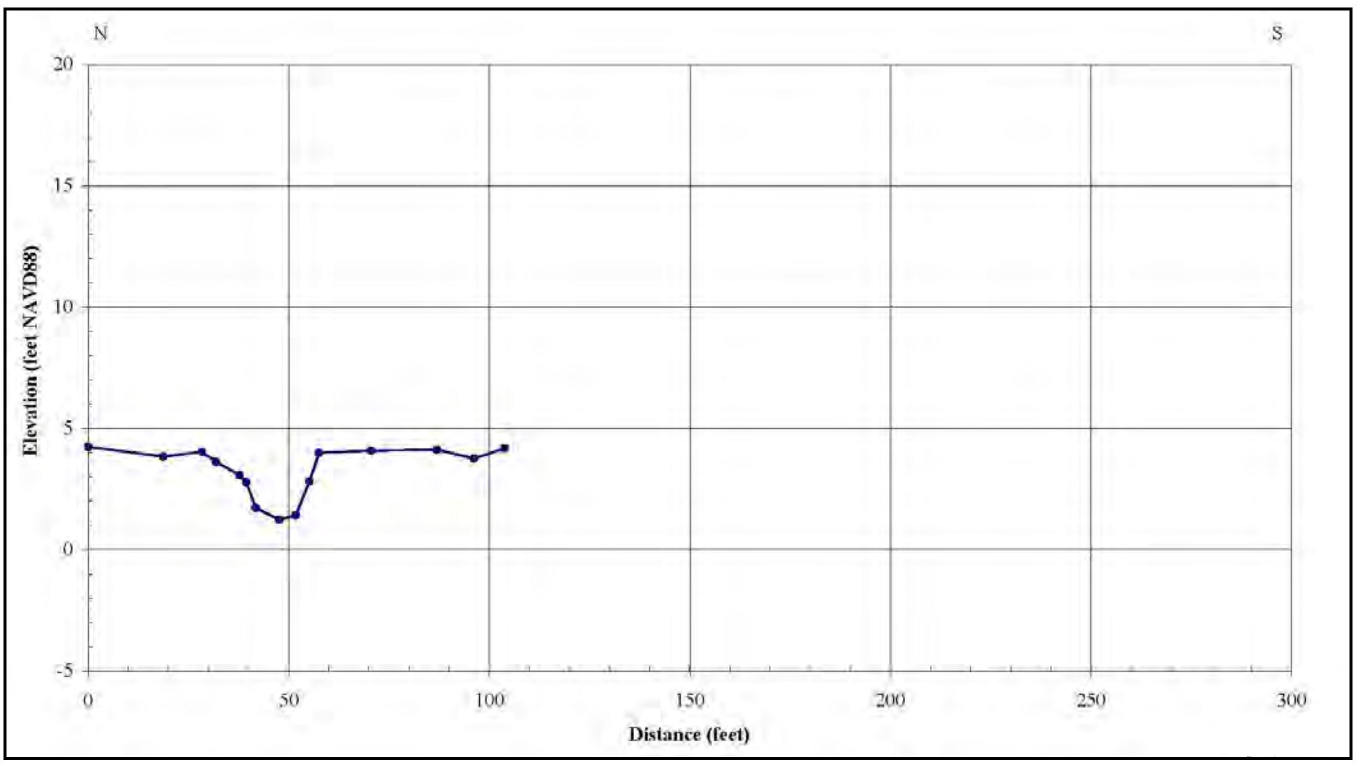

Figure 11.7. Cross-section 128 in the west tidal channel of Area B (modified from PWA 2006).

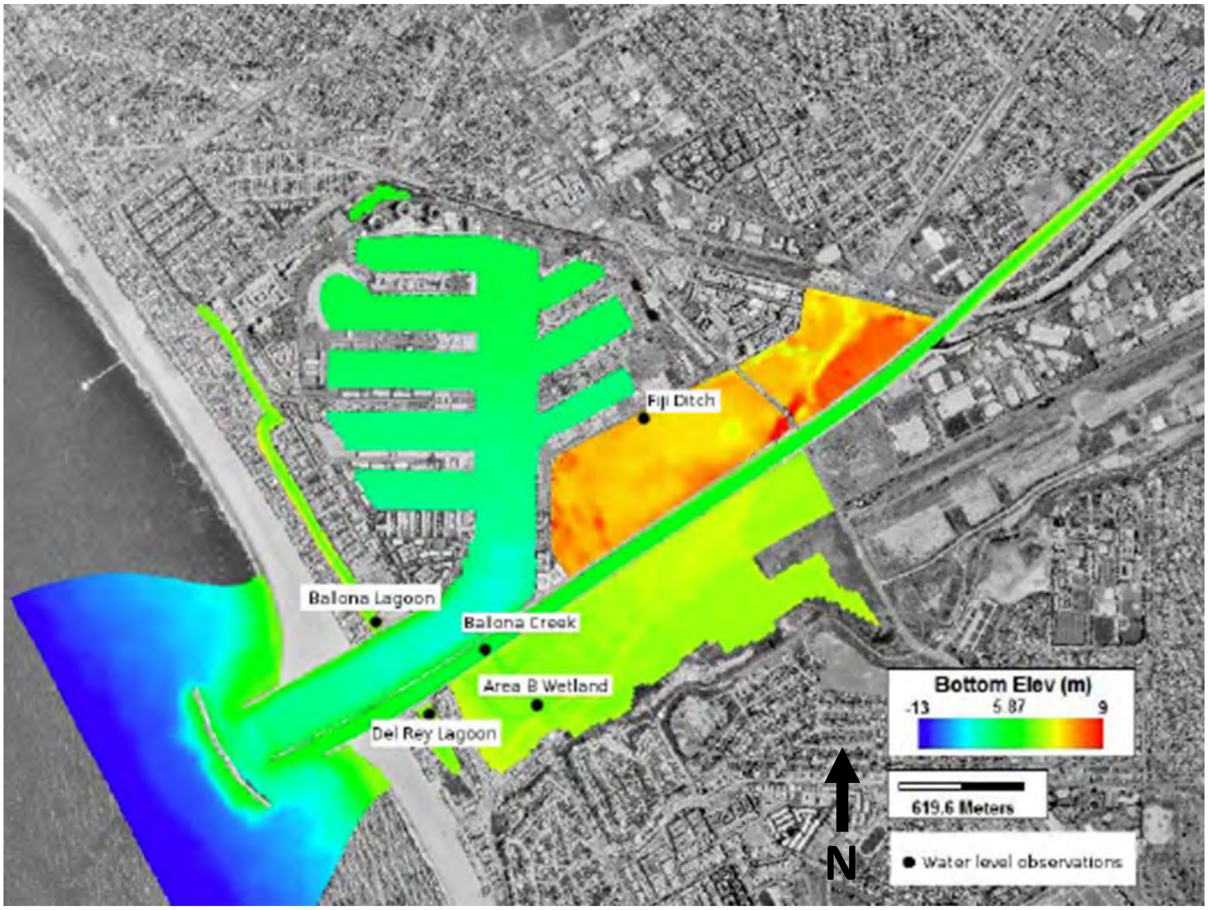

Figure 11.8. Bathymetric model of the BWER (reproduced from PWA 2008).

Wetland Delineation

Between 22 and 24 March 2010, WRA conducted a jurisdictional delineation of waters in the BWER to determine federal jurisdiction under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act, and state jurisdiction under the California Coastal Act and Coastal Zone Management Act. Subsequent visits by the CDFG, USACE, the State Coastal Conservancy (SCC) and other researchers have led to revisions to the wetland map and the inclusion of streams, tributaries and riparian habitat that are under state (CDFG) jurisdiction. The revised map and wetlands delineation will be presented in a separate report (WRA 2010, *in prep*).

METHODS

Field elevation surveys began in the first Baseline year (2009-2010) and will be completed in the second year for inclusion in the second annual Report (see 'Future Directions').

All results were compiled from either permanent stations (e.g. the self regulating tide gates from the City of Los Angeles), or external sources (e.g. precipitation from National Oceanic and Atmospheric Administration). Detailed sources are included in the results section.

The City of Los Angeles (LA City) monitored the tide gates throughout the Baseline year and reported the status of the tide gate functionality approximately every two weeks. Functionality was measured through two depth sensors, one from within the BWER on the south side of the tide gate, and one from the north side of the tide gate within Ballona Creek. The target water level (surface elevation) within the BWER was 1.1 m. To achieve this approximate depth, the tide gate was shut at around 0.5 m, to allow for subsequent water leakage. Actual shut depth and timing for the gate varied depending on tidal conditions.

RESULTS

Tide Gate Results

The Santa Monica Bay, and consequently the tidal portion of Ballona Creek through the Centinela Bridge (USACE 2000), experiences mixed semidiurnal tides, with two low and two high tides of unequal heights each day. The spring and neap tides vary on an annual basis as well. Figure 11.10 is a graph of the elevation data recorded by the tide gate sensors from 26 October 2009 through 11 November 2009. The tide gate records from LA City indicate an average target water level (surface elevation) within the wetlands of 1.1 m. As the graph displays, the 'target wetland elevation' is often an approximate average, and depends on the height of the tide, the functionality of the tide gate, the water level at which the self-regulating gate closed, and the amount of leakage into the BWER. The difference between the Ballona Creek levels (represented by 'channel elevation' in blue) and the wetland elevation levels (pink) is due to the muted tidal conditions caused by the tide gate.

Figure 11.11 is a graph of tidal elevations from 5 October 2009 through 26 October 2009. This graph includes high spring tides (approximately 13 October 2009 through 20 October 2009) during which the tide gate was not meeting the average target water elevation of 1.1 m. Elevations are as much as 0.5 m below the desired 1.1 m maximum elevation. This could be due to a number of causes relating to the tidal regime, water levels in Ballona Creek, and/or tide gate functionality. The gate was not directly observed during this time period.

Figure 11.12 is a graph of the tidal elevations from 24 December 2010 through 07 January 2011 during which the tide gate sensor malfunctioned during 30 and 31 December 2010. It was subsequently fixed by Los Angeles County on 1 January 2011.

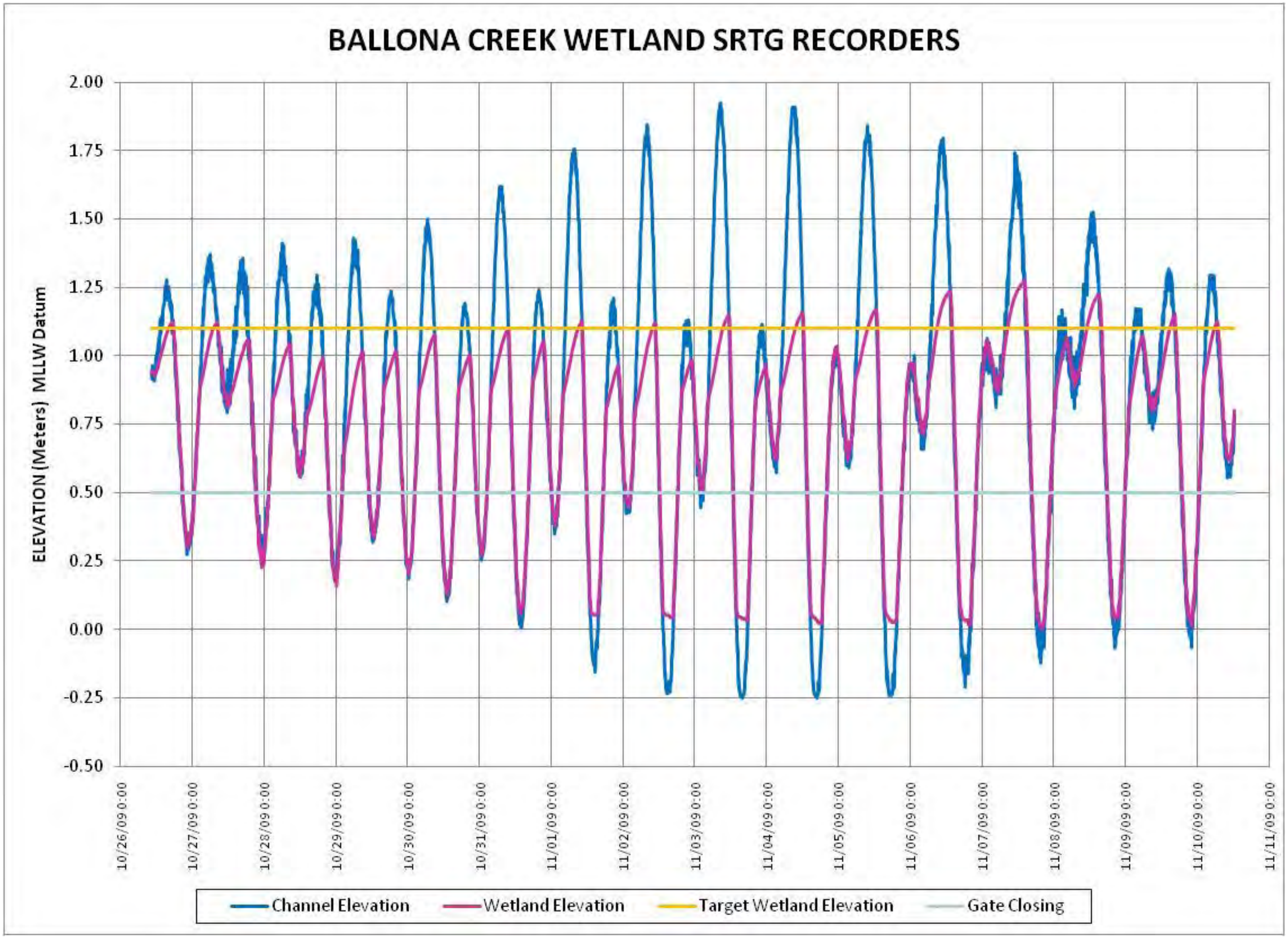

Figure 11.9. Water elevations (m) within the wetlands and Ballona Creek between 26 October and 11 November 2009 (reproduced from LA City 2009).

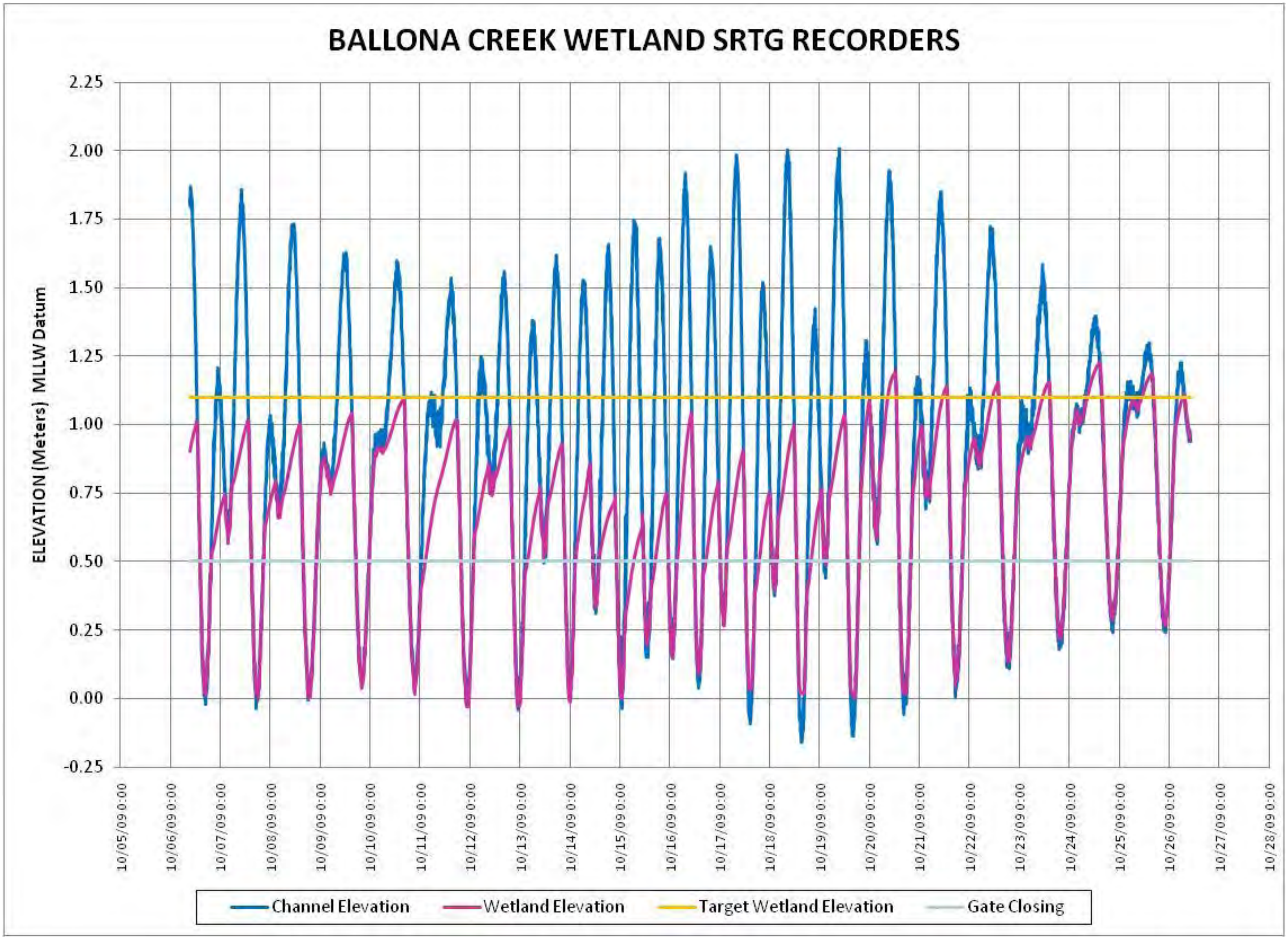

Figure 11.10. Water elevations within the wetlands and Ballona Creek between 5 October and 28 October 2009 (reproduced from LA City 2009).

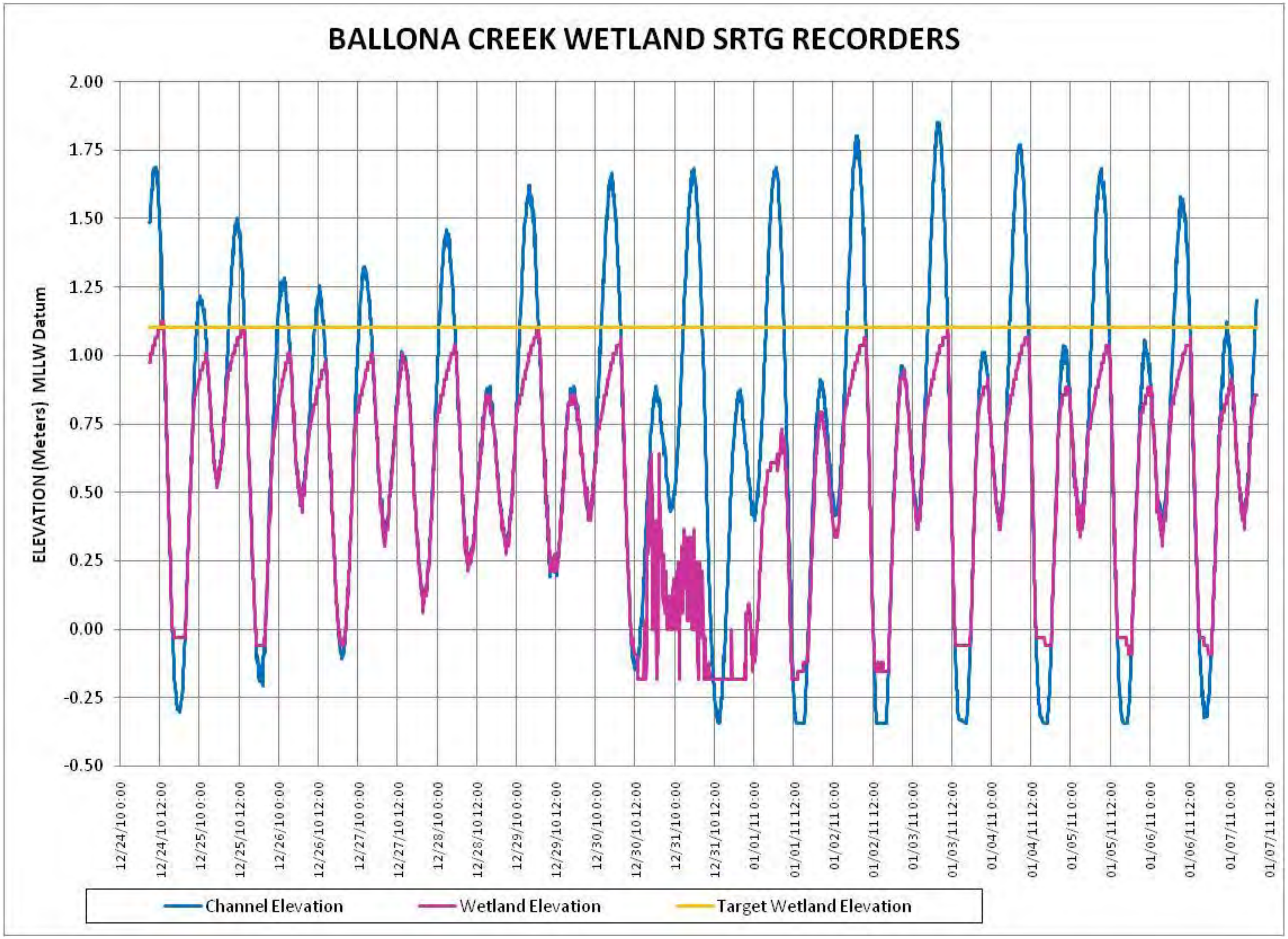

Figure 11.11. Water elevations within the wetlands and Ballona Creek during a gate malfunction between 24 December and 7 January 2011 (reproduced from LA City 2011).

Climate Results

Climate data were obtained from the National Oceanic Atmospheric Administration (NOAA) Western Regional Climate Center using the closest long term weather station to the BWER at the Los Angeles International Airport (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?calosa).

There was a total precipitation of 31.57 cm during the Baseline year (from September 2009 through September 2010). Figure 11.13 displays total monthly precipitation throughout the year.

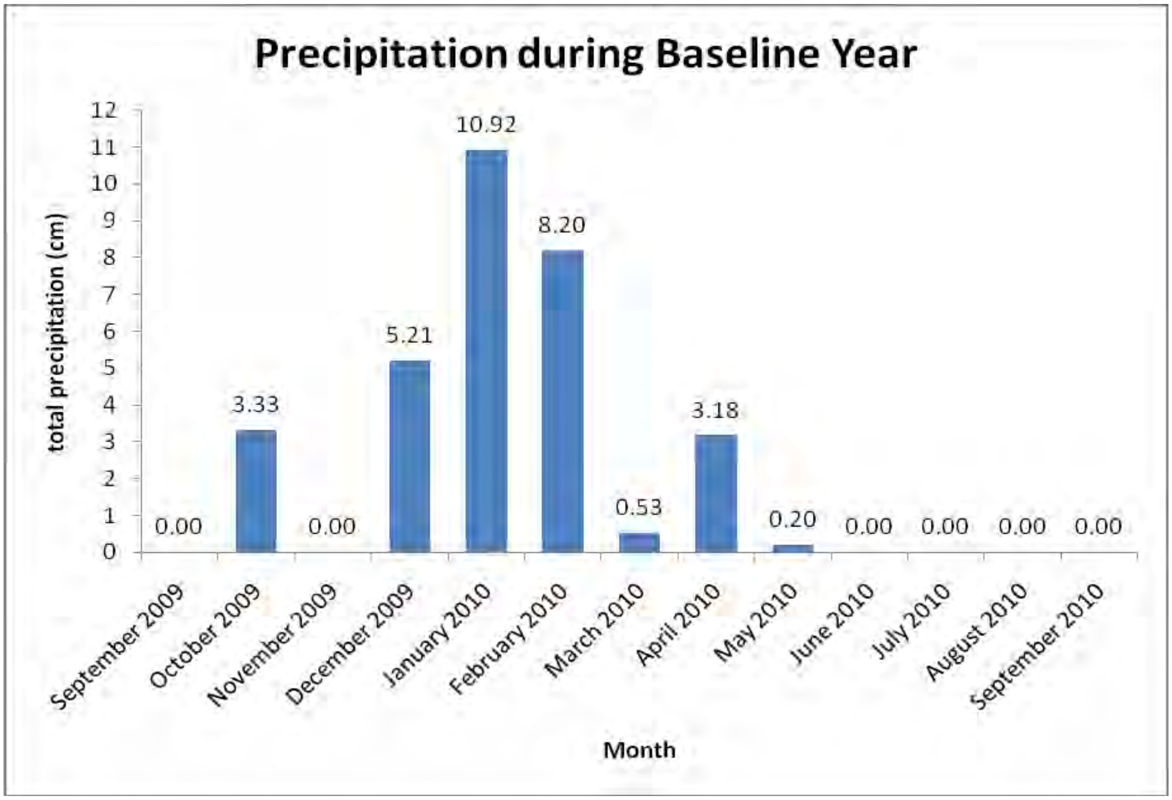

Figure 11.12. Precipitation throughout the Baseline year (data courtesy NOAA, National Weather Service).

Sea Level Rise

The mean sea level trend in the Los Angeles, California region is a rise of 0.83 mm/yr with a 95% confidence interval of ± 0.27 mm/yr based on monthly mean sea level data (NOAA 2011). Figure 11.14 illustrates the monthly mean sea level from 1923 to 2010 with the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, and atmospheric pressures removed (NOAA 2011). The long-term linear trend is shown, including the 95% confidence interval. Plotted values are relative to the most recent Mean Sea Level datum established by the NOAA Center for Operational Oceanographic Products and Services.

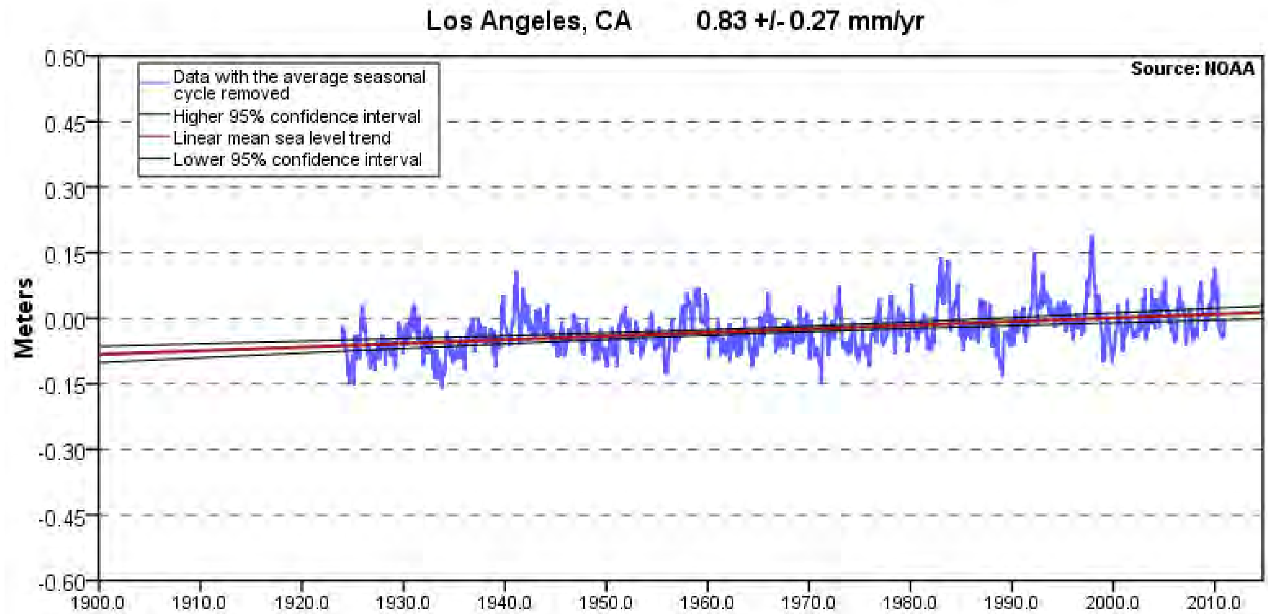

Figure 11.14. Mean sea level trend by decade for Los Angeles, California (0.83 mm/yr ± 0.27; reproduced NOAA, Sea Levels Online).

FUTURE DIRECTIONS

Elevation Surveys

Elevation surveys will be completed on the same subset of vegetation transects used for soil, terrestrial invertebrates, and seed bank surveys. The elevation surveys will use U.S. Geological Survey (USGS) provided by the City of Los Angeles (Bureau of Engineering) and other published benchmarks and will include measurements every 5 meters along each transect, with a total of 5 elevation points per transect. Data will be surveyed using the National Geodetic Vertical Datum of 1929 (adjusted 1985). Benchmark leveling (vertical control surveys) will be measured using a Trimble GPS, tilting level, a tripod and No. 1 SK rod (ft), 10ths and 100ths.

Surveys began at the end of the first Baseline year; they will be completed in the second Baseline year and will be subsequently analyzed in a future report.

Channel Cross-Section Surveys

Channel cross-sections will be surveyed within the tidal channels of Area B and the Fiji Ditch once every 2-3 years on a subset of the same permanent survey locations from the PWA 2006 survey (Figure 11.2). A survey tape will be attached to station endpoint pins on the right and left banks and stretched taut. Using a level transit and stadia rod, measurements will be taken every 50 cm and at every break in slope. Distance and elevation data will be recorded. Cross-sectionally averaged channel water velocity (including a vertical velocity profile) will be recorded, corresponding with the locations of the cross-sections. Measured velocity will be used in combination with cross-sectional area to calculate discharge.

Piezometer Surveys

Several piezometers will be installed in the brackish marsh habitat of the BWER in the southeast portion of Area B. Piezometers will be installed using PVC piping where freshwater input is present or draining. Hobo sensors will be added to the bottom of the piezometers to record inundation and depth and will be checked once monthly.

Inundation Surveys

Inundation within the salt marsh of the BWER will be mapped several times during a high spring tide using a Trimble Geo XH GPS unit. All tidal creeks throughout Ballona will be surveyed by following the outline of inundation. The maps will be compared to tidal charts and available topographical data to determine the length of time that a particular area is submerged throughout the year in varying tidal regimes. The information may be linked to current aerials of the BWER to develop complete inundation maps.

Sea-Level Rise Study

The Center for Santa Monica Bay Studies, a joint program of Loyola Marymount University and the Santa Monica Bay Restoration Commission, will conduct a study on the effects of climate change on the Ballona Creek Watershed and the BWER. This study will be based on theoretical modeling of sea-level rise scenarios based on current data. Modeling will include projected scenarios that include improved watershed management and restoration projects. The full report will be available electronically via website (www.ballonarestoration.org).

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