Ballona Wetlands

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Wetland Health and Assessment: An Information Inundation at the Ballona Wetlands Ecological Reserve

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Abstract

Coastal estuarine wetlands function as unique transitional areas between land and ocean and, in some places in Southern California, represent opportunities to restore degraded habitats to healthy wetland systems. Many of these wetland systems have suffered a significant number of anthropogenic stressors, and understanding the functionality of these systems is imperative for developing appropriate restoration actions. Monitoring programs, including baseline surveys, can provide pre-restoration assessments of the site, inform management actions, and help to understand the physical and biological functioning of the site. These monitoring programs are also tools used to detect change, develop restoration programs, and determine between-site variability with natural or reference wetlands.

The 600-acre Ballona Wetlands system encompasses the largest opportunity for coastal wetland restoration in the Santa Monica Bay and Los Angeles County. In 2009, the Santa Monica Bay Restoration Commission began assessing the current, biological condition of the Ballona Wetlands Ecological Reserve to increase the comprehensive knowledge of the site, inform adaptive restoration management, and assist in developing a long-term monitoring program. The baseline program incorporated comprehensive biological, chemical, and physical surveys across a two-year period. Results indicate a highly degraded system in many of the upland habitats due to the presence of dredge spoils and anthropogenic impacts. The results also indicate a muted tidal marsh system dominated by native vegetation but with limited natural functionality. Several restoration actions are discussed that would address many of these limitations and issues.

Introduction

While the specific definition of coastal wetland varies considerably based on country and even state (Turner et al. 2000), all coastal wetlands are unique transitional areas between land and ocean and contain distinctive and diverse groups of organisms capable of living in this challenging interface. Freshwater input from watersheds combined with tidally influenced saltwater conditions leads to habitats filled with organisms idiosyncratically adapted to conditions under which many life forms would not be able to survive.

Habitat Loss and Stressors

Since wetlands cover only a small fraction of Earth's surface, estimates of wetland area can be highly variable based on region, wetland type, anthropogenic factors, and other conditions, but scientists agree that significant wetland habitat loss has incurred on a global scale (Dahl and Allord 2004; Zedler and Kercher 2005). California has experienced more than 90% wetland loss since the time of European settlement (Dahl 1990; Sutula et al. 2008a), due mostly to agriculture and coastal urbanization. Drainage and other factors have converted many historically wetland areas into upland habitats.

Some of the most significant stressors to Southern California wetlands include dikes and levees, restricted tidal exchange and reduced flushing, and encroaching invasives (Sutula et al. 2008a, 2008b). Additional stressors unique to individual wetlands include, in no specific order, non-point source discharges, heavy metal impairments, bacteria and pathogen impairments, pesticide or trace organics impairments, nutrient impairments, predation and habitat destruction, habitat fragmentation, noise and light pollution, trash, excessive debris and runoff, culverts, paving, excessive human use, vector control, dredging,

Figure 1. Ballona Creek Trash Boom

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The objective of the Federal Clean Water Act (CWA) is to restore and maintain the chemical, physical, and biological integrity of the nation's waters, including estuarine waters and wetland habitats. In California, the California Wetlands Conservation Policy was created in 1993 by Governor Pete Wilson to eliminate the loss of wetlands in California. Wetland restoration is conducted for many reasons, primarily to restore functionality and the aforementioned services. The overall goals vary by individual project but strive to minimize the effects of anthropogenic impacts over time. Optimally, conditions are restored to those of similar reference sites, which may include remaining natural sites or previously restored wetlands.

modified hydrology, point source discharges, physical structural restrictions, and many others (Sutula et al. 2008a; Figure 1). Modified hydrology, common in Southern California, can cause altered sediment transport, physical barriers to movement of water, restriction of water movement across the site, and a decreased overall hydrologic capacity (Haltiner et al. 1997). Overall wetland health is impacted by different stressors in different regions; most of these stressors are anthropogenic.

Wetland Services and Values

Wetlands are valuable in an economic and ecological context. The economic valuation of wetlands is becoming more recognized in scientific literature (Dahl and Allord 2004) and is highly dependent on the individual characteristics of the site and surrounding environs. One of the more commonly cited economic benefits in recent literature is the ability of wetlands to sequester carbon (Brevik and Homburg 2004; Zedler and Kercher 2005). A superficial understanding of wetland value in the context of biodiversity and habitat value is generally understood. Even small wetlands exhibit vital services and are not as isolated as once believed (Semlitsch and Bodie 1998). They can be crucial for maintaining biodiversity in a region, especially for those populations philopatric to smaller areas (e.g., salamanders) (Semlitsch and Bodie 1998). However, wetland ecosystems are incredibly complex and have a multitude of components and variables, which taken alone are not descriptive of the system as a whole.

Zedler and Kercher (2005) define the primary global ecosystem services of coastal wetlands as biodiversity support, water quality improvement, flood abatement, and carbon management (Brevik and Homburg 2004; Crooks et al. 2011; Greb, DiMichele, and Gastaldo 2006). Additional ecosystem and economic services include, but are not limited to, groundwater recharge, rare species habitats, nutrient cycling, pollution control, fish nursery areas, avifauna Pacific Flyway connections, habitat value for other plants and animals, erosion resistance, air purification, moderation of temperature extremes, heavy metal retention, renewable resources, recreational benefits, cultural values, and many more (Clarkson et al. 2004; Kazmierczak 2001; Lin and Terry 2003; Page et al. 1997; Turner et al. 2000; Zedler 2001; Zedler and Kercher 2005). These benefits provide a strong argument for preserving, conserving, and restoring such unique and valuable habitats.

Importance of Monitoring

When planning and assessing wetland restoration projects, it is important to understand the biological conditions and the physical processes of the site, e.g., topography, hydrology, climate, geomorphology (Neckles et al. 2002). Physical alterations of a site can drastically alter the functioning of the restored tidal wetland system (Haltiner et al. 1997), as the primary influence on the structure and function of a salt marsh is often related to inundation (Neckles et al. 2002; Figure 2). Determining the health of individual wetlands is important to restoration project managers, and allows an assessment of whether the goals of the project have been met (Stein et al. 2007, Sutula et al. 2008b). One of the major issues in wetland protection and restoration is the lack of integrated, comprehensive, and transferrable data.

Monitoring programs gather scientifically valid information about a system (Yoccoz, Nichols, and Boulinier 2001, Stein et al. 2007, Sutula et al. 2008b). Agencies, scientists, and other organizations broadly recognize the importance of wetland monitoring, as wetlands have a high degree of within-site and between-site variability (Kentula 2007; National Research Council 2001; Zedler 1982, 2001). Scientifically accurate assessments are needed to make informed societal decisions (Karr 1987), and to preserve biological systems for the direct protection of human health.

Figure 2. Post-Rain Ballona Salt Pan

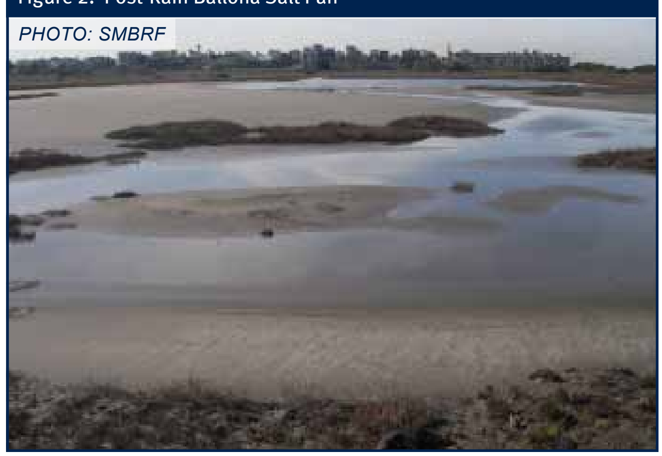

PHOTO: SMBRF

Figure 3. Map of Ballona Wetlands Ecological Reserve

Monitoring methods can be highly variable based on project goals, compliance requirements, and site variability (Neckles et al. 2002), but the methods must be capable of detecting changes temporally and spatially. Monitoring can assist in scientific and management objectives (Finlayson and Spiers 1999). Management assistance occurs in developing restoration programs, evaluating the efficacy of management policies, and improving the decision process (Yoccoz et al. 2001; Martin, Kitchens, and Hines 2006). Biological goals include assessing biodiversity, detecting species invasions, detecting significant or negative changes over time, or tracking conservation of rare species (Martin et al. 2006). Often comparing a monitoring site to reference wetlands can provide a valuable assessment tool to determine between-site variability and a more informed direction toward project goals (Brinson and Rheinhardt 1996; Neckles et al. 2002).

The Ballona Wetlands Baseline Assessment Program

The 600-acre Ballona Wetlands system encompasses the largest opportunity for coastal wetland restoration in the Santa Monica Bay and Los Angeles County (Figure 3); the system is one of approximately 40 coastal wetlands along the 1,045 miles of the Southern California coast between Point Conception and Mexico. In 2004, the State of California took title to the former Ballona Wetlands in Los Angeles and designated the wetlands as a permanent State Ecological Reserve. The property is owned by two state agencies, the California Department of Fish and Game (540 acres) and the State Lands Commission (60 acres, including a 24-acre freshwater treatment wetland).

The Ballona Wetlands Ecological Reserve (BWER) is an important wetland site located in the second most populous region in the United States (Figure 4). In 2009, under the auspices of the California Department of Fish and Game (CDFG) and the California State Coastal Conservancy (SCC), the Santa Monica Bay Restoration Commission (SMBRC) began assessing the current biological condition of the BWER. Site-specific monitoring data are currently being collected throughout the BWER as part of an intensive Baseline Assessment Program (BAP) and long-term

Figure 4. Ballona (foreground) and Development (background)

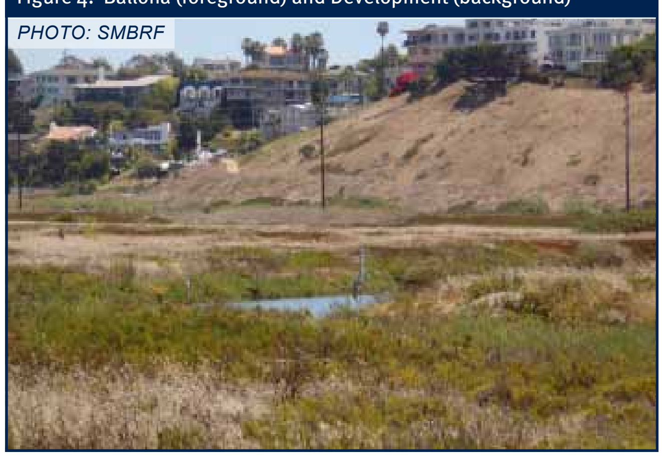

PHOTO: SMBRF

Figure 5. Student Survey Volunteers

PHOTO: SMBRF

Figure 6. Water Quality Sampling in Ballona Creek

PHOTO: SMBRF

monitoring program. The BAP was developed in partnership with the aforementioned agencies and wetland scientists in the region to collect biological, chemical, and physical data by employing a broad range of scientific monitoring methods.

In the past, scientists surveying the BWER focused largely on individual aspects of the ecosystem or on a limited area. The BAP provides a comprehensive baseline biological assessment, which is vital for determining 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). Integrative monitoring can give a balanced perspective to environmental assessments (Karr 1987).

The BAP encompassed a two-year period, including 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 were to:

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 BWER and develop protocols for addressing data gaps at other wetland projects.

5. Inform adaptive management and long-term restoration plans.

6. Inform a site-specific and regional long-term monitoring program.

7. Identify stressors to the site.

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.

Methods

In September 2010, the SMBRC completed the first year of surveys at the BWER. The first year of surveys incorporated monitoring and assessment strategies of biological, chemical, and physical components of the BWER ecosystem (Figure 5). 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 collection included surveys for small and large mammals, herpetofauna, ichthyofauna, benthic invertebrates, birds, and submerged aquatic vegetation. Water quality data collected included dissolved metals, fecal indicator bacteria, nutrients, and additional parameters.

Chemical Analyses

Extensive water quality surveys were a vital 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 derived using several methods. Two 24-hour studies for fecal indicator bacteria and nutrients were conducted within the wetland tidal channels, Fiji Ditch, and Ballona Creek (Figures 3 & 6) to assess conditions throughout the entire tidal cycle. Dissolved metals were sampled at eight water stations throughout the BWER on a quarterly basis. Runoff from twelve locations at small drainages and ponding areas during three storms (>1 inch) were also analyzed for metals to determine stormwater contamination in the BWER. Samples from terrestrial soils were also analyzed for phytoavailable trace metals.

Vegetation

A primary goal of the BAP was an intensive cross-habitat vegetation assessment. Vegetation cover surveys were conducted on stratified random transects throughout each habitat. In addition to vegetation surveys, terrestrial invertebrate, soil, and elevation surveys were conducted on a subset of these transects to evaluate ecosystem-level function of the habitat. The objective of the vegetation surveys was to determine the average percent cover of species using transect- and habitat-level assessments (Figure 7).

Figure 7. Combination of Native and Invasive Plants

Several methods were used to accurately 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 the laser quadrat method. Size class estimate percent cover was employed to survey the upland dune, scrub, and grassland habitats; canopy heights were also recorded. Targeted surveys for all plant 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. Plant cover was also correlated with elevation.

Figure 8. Preparing a Camera Station

Vertebrates

Ichthyofauna surveys were conducted 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, Fiji Ditch, and the tidal channels within Area B of the BWER (Figure 3). Six permanent stations were positioned within the BWER: 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 250 m trawls were conducted in Ballona Creek.

Herpetofauna surveys during the first baseline year were conducted over the course of 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 used throughout the site. Pitfall and driftnet arrays were employed in several of the major habitats; site searches, cover board flipping, and targeted surveys for a California Species of Special Concern, the California legless lizard, were conducted within potential habitat areas.

Mammal surveys during the first baseline year were conducted with baited Sherman live traps and pitfall traps for small mammals and baited wildlife motion camera stations (Critter Cams) for medium and large mammals (Figure 8). Habitats targeted for small mammals included seasonal wetland, upland grassland, scrub, and high marsh. The Critter Cams were located throughout the BWER and deployed for approximately two to four weeks at each station.

Although birds are one of the most commonly observed groups of organisms at the BWER, they are seldom studied comprehensively or scientifically. Site-wide surveys were performed quarterly in October 2009 and January, April, and July 2010 to produce digitized spot-maps, which 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 additional information to the professional-level avian surveys.

Invertebrates

Benthic infaunal and epifaunal 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. For the BAP, infaunal benthic invertebrate sampling was conducted semiannually in seven locations within tidal channels: two in Area A and five in Area B (Figure 3). Existing protocols were used and adapted to the specific needs of the BWER. Presence and relative abundance were calculated for general taxonomic groups at each location. Average densities, as individuals/m^2, were calculated for each station by month and core size.

Figure 9. Sampling Preparation, Including a Sticky Trap (center)

Figure 10. Water Quality Sampling in Ballona's Main Tide Channel

Species-level taxonomic identification will be conducted in year 2. Epifaunal benthic invertebrate surveys for the California horn snail (*Cerithidea californica*) were conducted using transects on the mudflat habitats and assessed as average densities per transect (individuals/m^2) as part of a regional assessment.

Flying aerial arthropod biomass surveys were also conducted using sticky traps (Figure 9). The objective was to extrapolate productivity using arthropod biomass by invertebrate weight and size class for each habitat.

Summary Results

Chemical Analyses

Bacteria levels at most sites consistently exceeded Total Maximum Daily Load (TMDL) targets, 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 (Figure 10). 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 twelve stations. Lead, selenium, and zinc all exceeded the TMDL wet weather numeric target at least once. Aluminum, boron, and cadmium exceeded acute toxicity levels1 at multiple stations.

Vegetation

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 (Figure 11), though the native habitats tended to have a lower overall species richness. The most common native species in the tidal marsh habitats based on percent cover, included common pickleweed (*Salicornia virginica*), marsh jaumea (*Jaumea carnosa*), alkali weed (*Cressa truxillensis*), and Parish's pickleweed (*Salicornia subterminalis*). The most common non-native species in upland areas included ice plant (*Carpobrotus edulis*), black mustard (*Brassica nigra*), ripgut chess (*Bromus diandrus*), and crown daisy (*Chrysanthemum coronarium*), though many additional species were identified, with several highly invasive species expanding their range during the baseline years (e.g., *Arundo donax, Euphorbia spp.*).

Percent native cover was negatively correlated with elevation; percent non-native cover was positively correlated with elevation. Inundated areas had the lowest non-native cover. Elevation, native cover, and non-native cover were significantly different among habitat types; the low salt marsh habitat had the highest native plant average percent cover (91.0 ± 5.2%). The upland grassland and scrub habitats had the highest non-native plant average percent cover (77.1 ± 1.1%, and 58.8 ± 1.1%, respectively).

Vertebrates

The beach seine surveys identified eight native species (Table 1) and one non-native species, western mosquitofish (*Gambusia affinis*). In the wetland and ditch sites, 2,618 fish were caught using the beach seine method, 286 were caught in the minnow traps, and 10 fish were caught in the trawls of Ballona Creek. Arrow goby, killifish, and topsmelt had the highest relative abundances. Macroinvertebrates caught in the surveys were also identified. The most common invertebrate collected in the seines was the California horn snail (*Cerithidea californica*).

The herpetofauna pitfall traps had widely varying success rates, depending on the habitat. The dune habitat had a

Figure 11. Water Droplets on Pickleweed

Table 1. Fish Results

	COMMON NAME	SCIENTIFIC NAME	STATUS
FISH	Arrow / cheekspot goby	*Clevelandia ios or Ilypnus gilberti*	Native
	California killifish	*Fundulus parvipinnis*	Native
	Diamond turbot	*Hypsopsetta guttulata*	Native
	Longjaw mudsucker	*Gillichthys mirabilis*	Native
	Pacific staghorn sculpin	*Leptocottus armatus*	Native
	Round stingray	*Urobatis halleri*	Native
	Striped mullet	*Mugil cephalus*	Native
	Topsmelt	*Atherinops affinis*	Native
	Western mosquitofish	*Gambusia affinis*	Non-native

Table 2. Herpetofauna Results

	COMMON NAME	SCIENTIFIC NAME	STATUS
HERPETOFAUNA	Baja California treefrog	*Pseudacris hypochondriaca hypochondriaca*	Native
	California kingsnake	*Lampropeltis getula californiae*	Native
	California legless lizard	*Anniella pulchra*	Native, California Species of Special Concern
	Great Basin fence lizard	*Sceloporus occidentalis longipes*	Native
	San Diego alligator lizard	*Elgaria multicarinata webbii*	Native
	San Diego gopher snake	*Pituophis catenifer annectens*	Native
	Southern Pacific rattlesnake	*Crotalus oreganus helleri*	Native
	Western side-blotched lizard	*Uta stansburiana elegans*	Native

Table 3. Mammal Results

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

Figure 12. Karina (author) Holding a California Kingsnake

Figure 13. Sorting Invertebrate Samples

significantly greater overall capture rate than any of the other habitats (34.62%). Herpetofauna identified during the first baseline year included eight species (Table 2). Great Basin fence lizards (*Sceloporus occidentalis*) were the most commonly caught herpetofauna species, and they were found throughout the site. Gopher snakes and California kingsnakes (Figure 12) were common throughout the upland habitat types and bermed areas (e.g., gas company roads). Amphibian and reptile surveys continued in year 2 using cover board array surveys to provide a better assessment of the snake population, reduce site impacts, and survey more habitat areas.

The California legless lizard, a California Species of Special Concern, was confirmed in several locations during the first-year BAP surveys, including one dune habitat area where the species had not been found in almost twenty years, according to previous BWER reports.

Nine native and six non-native mammal species were live captured via Sherman trap or observed via Critter Cams during the first baseline year (Table 3). Of the three species caught in the small mammal live traps, western harvest mice were the most common and found in all surveyed habitat types except upland scrub. The South Coast marsh vole was the only Species of Special Concern captured or observed during the first baseline year; this species was found only in the high marsh habitats.

A total of 156 avifauna species and distinctive subspecies were recorded during the first year of baseline assessment with all survey types combined. A total of 11 special status species were confirmed on-site during the quarterly surveys: Belding's Savannah sparrow, brown pelican (*Pelecanus occidentalis*), Cooper's hawk (*Accipiter cooperii*), elegant tern (*Thalasseus elegans*), least Bell's vireo, 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 first year of baseline surveys was completed and is included in year 2.

Invertebrates

Benthic invertebrate density at the BWER, when averaged for all cores and all organisms combined, increased with increased distance from the tide gates. Seasonal variations in composition and abundance were recorded at all sampling stations (Figure 13). The group of organisms that consistently had the highest proportion of the samples at each station was gastropods, dominated by the California horn snail, when all samples for each station were combined. The groups that were the next highest proportion of the samples were mollusks and gammarids.

During the California horn snail epifauna surveys, the main tide channel of Area B was found to have the highest average number of snails (77.3 individuals/m^2) in June; the western (outflow) tide channel had the highest average number of snails (102.4 individuals/m^2) in September.

Aerial arthropod productivity was based on the average available biomass per meter squared per day. Productivity refers to the rate of *available* 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. Results of flying invertebrate data indicate the lowest productivity in the brackish marsh (3.50 ± 0.59 mg/m^2/day) and fairly uniform productivity in 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). The upland grassland had the highest aerial arthropod productivity (29.0 ± 11.1 mg/m^2/day) and the highest level of variability between transects (Figure 14). Species-level terrestrial surveys will be conducted in year 2.

Discussion and Restoration Recommendations

Monitoring allows assessments that contribute key components of adaptive restoration management. Additionally, the comprehensive nature of the baseline surveys allows more extensive analyses across a range of ecological factors. These data can be used for analyses of individual biological or physiochemical parameters, or as part of higher-level ecological assessments and evaluations. For example, vegetative cover can be analyzed in conjunction with elevation, inundation, soil characteristics, or even invertebrate productivity by transect or habitat level to determine the overall health and functionality of a system. Additionally, the individual factor assessments will help to determine sensitive areas within the site based on rare species presence, and to help answer targeted questions about presence and abundance for a number of parameters.

The results suggest that areas with higher degrees of anthropogenic impacts (e.g., fill soils, berms, and disturbed areas) have more non-native species and that marsh habitats have a higher presence of native species (e.g., vegetation, mammals). Upland grassland and scrub habitats had the highest overall cover of non-native vegetation, although there was a high degree of habitat patchiness throughout Areas A and C (Figure 3). Restoration actions should thus seek to remove berms and focus restoration efforts on highly disturbed areas to increase the potential for native species to thrive and/or recolonize disturbed habitats. Plants that are highly invasive and have been spreading during the baseline program should receive removal precedence and might need to be removed before the start of the full-scale restoration process (e.g., *Arundo donax*).

The native cover within the marsh habitats was likely related to areas with more frequent inundation and lower, more natural marsh elevations. The tide gate continues to restrict tidal inundation and the natural hydrologic impacts of a full tidal cycle, including restricted water movement, water column stratification, decreased sediment movement, and channel widening. A tidal connection between the wetland habitat and Ballona Creek should be permanently reestablished to achieve a fully tidal coastal wetland system reconnected to the watershed. This will encourage native diversity and improve water quality. A tidal connection will also encourage wetland habitats (e.g., mudflats) not currently present as significant portions of the BWER to be further used by benthic invertebrates and juvenile fish as a nursery habitat.

When habitat- and ecosystem-level assessments are compared, the unique characteristics of several systems are revealed. For example, the Fiji Ditch and tidal channels of Area B (Figure 3) appear to function differently. Soil characteristics, fish composition, and benthic composition all differed between stations. This is likely due to the full tidal connection of the Fiji Ditch to Marina del Rey for stingrays, and the use of the wetland channels as nursery habitats for the juvenile flatfish. The steep banks and narrow width channels would have a higher wetland habitat value with more gradual sloping. This would allow for better transitional zones, and more tidally exposed area. Additionally, the dune habitats displayed unique characteristics when compared with the other habitat types within the BWER, such as the presence of several rare plant species (Figure 15), the California legless lizard, and soils with unique infiltration capabilities.

Data suggest that the restoration project at the BWER should work toward sustaining higher ecological function and biotic integrity, with goals that include biological, chemical, hydrological, and physical parameters. This higher-level functionality can be encouraged by reducing habitat fragmentation, establishing natural elevation levels, gradual gradients, and transition zones, and increasing native plant biodiversity to incorporate more Southern California wetland species.

Figure 14. Monarch Butterfly on Coyote Brush

Figure 15. Sand Verbena

Future Directions

Surveys at the BWER will continue with a refinement of protocols based on data gaps identified during the baseline years. Further comparisons of the two years of baseline data will allow higher-level ecological analyses, and a measure of short-term temporal variability (especially when assessing highly mobile species such as fish). Further in-depth water quality analyses will continue to address questions raised by the data collected in year 1, such as the association of particular constituents of concern with resuspended sediment. Regional data collection will begin to compare the functionality of the BWER to other wetlands within the region.

[1] Toxicity levels based on Environmental Protection Agency (EPA) Ambient Water Quality Criteria

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