Restoration Project Planting

PHOTO: ABIGAIL SMIGEL

Establishing High Marsh Habitats within the San Dieguito Lagoon Wetland Restoration Project

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The goal of the 150-acre San Dieguito Lagoon Wetland Restoration Project is to restore the structure and function of coastal wetlands near the mouth of the San Dieguito River. This restoration effort is being carried out by Southern California Edison (SCE) and was required by the California Coastal Commission (CCC) to partially mitigate for the estimated impacts on marine fish populations resulting from the operation of cooling water systems for the San Onofre Nuclear Generating Station (SONGS, SCE 2005).

One of the project's main features is the creation of 34 acres of high coastal salt marsh habitat. Based on the experience gained from other coastal salt marsh restoration projects throughout Southern California, the high marsh habitat has been one of the most challenging habitat types to establish (Callaway and Zedler 2004; Zedler 1984, 1996; Kentula 2002). In these areas, tidal inundations typically occur only a few times per year, solar radiation is very high, and salinity levels within the soil are elevated. Before this project was implemented, several greenhouse nursery and field experiments were conducted, and a planting plan was developed to ensure the success of this project.

The San Dieguito Lagoon is located in the city of Del Mar, California, north of the city of San Diego (Figure 1), and was selected as the project site because the lagoon presented the best opportunity to meet the objectives required by the CCC.

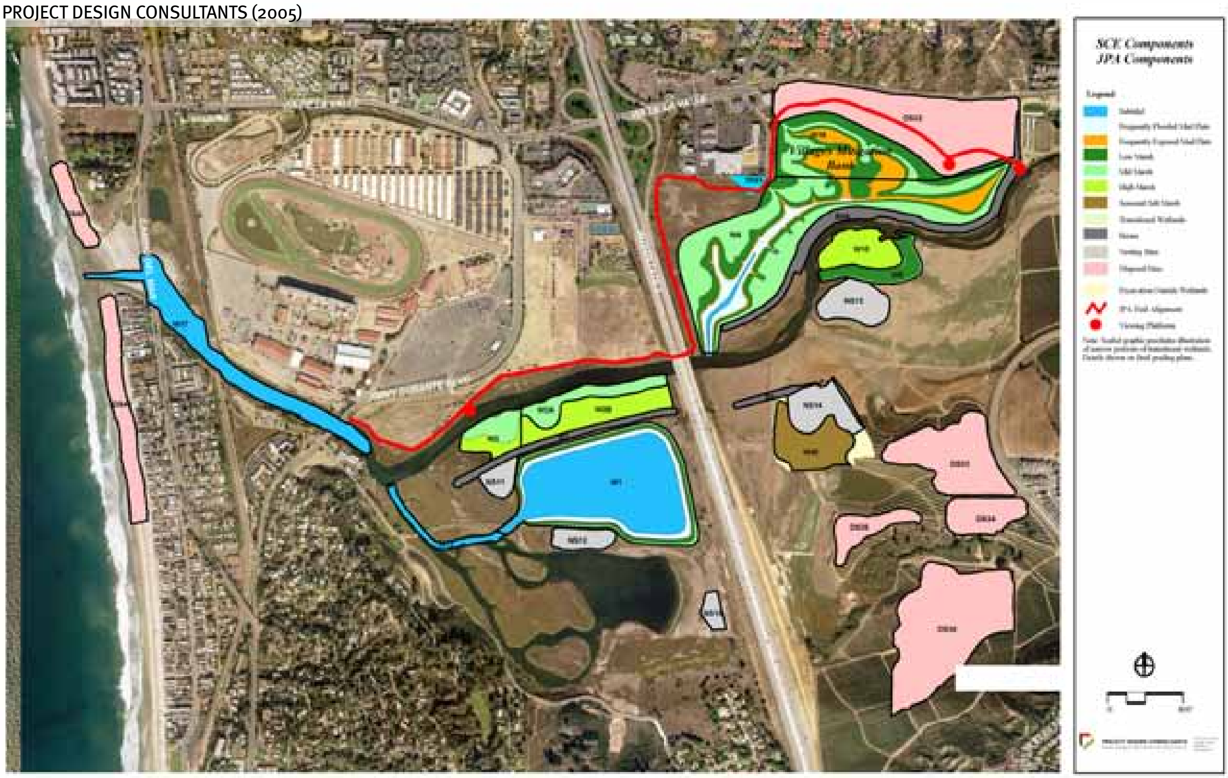
Project Background

The San Dieguito Lagoon was once the largest of six San Diego County coastal lagoons with the largest watershed. The marsh area alone has been estimated to have once covered more than 600 acres, while the entire lagoon encompassed more than 1,000 acres (SDRP 2010). Over the years, the lagoon has been subjected to major filling activities due to development and has lost more than half of its marshland. The filling activities have included the construction of Highway 101 (Interstate 5), Jimmy Durante Boulevard, residential development, the Del Mar Fairgrounds, and a World War II era airport. Two large dams have been constructed upstream of the lagoon on the San Dieguito River. All these activities have resulted in reduced freshwater flows through the river mouth and an eventual closure of the lagoon at the beach. The initial inlet closure to the ocean was documented in the 1940s. Since then, only large winter floods or dredging by earth moving equipment to flush the lagoon have opened the mouth periodically.

The $86 million San Dieguito Lagoon Wetland Restoration Project includes the following eight elements designed to expand and restore the marsh: 1) tidal inlet maintenance to promote regular tidal exchange through excavation of the river channel and periodic maintenance dredging, 2) excavation of tidal and upland areas to create a subtidal

Figure 1. Project Overview

IMAGE: PROJECT DESIGN CONSULTANTS (2005)



and intertidal habitat, 3) creation of a seasonal salt marsh, 4) creation of up to 19 acres of nesting habitat for the California least tern (*Sternula antillarum browni*) and western snowy plover (*Charadrius alexandrinus nivosus*), 5) construction of berms within the San Dieguito River's effective flow area to maintain the existing sediment flows within the river and to the beach, 6) creation of dredge disposal sites within the project boundary, 7) restoration of upland native habitat on dredge disposal sites, and 8) creation of public access trails and opportunities for public education (SCE 2005).

Pre-restoration Soil Analysis

Restoration of high intertidal habitat zones is difficult due to the infrequency of inundation and high soil salinities (Figure 2). This is especially true in the arid southwestern coastal region and with instances in which marsh restoration involves excavation and the underlying saline subsoils are left as the primary substrate remaining for planting (Josselyn, Acker, and Tomsovic 2006). In a study conducted by an environmental consulting firm, WRA, soils from six nearby coastal salt marsh reference sites and the subsoils at the San Dieguito Lagoon restoration site were analyzed for pH, salinity, organic matter, soil texture, and bulk density. The subsoils that were to be exposed following grading activities within the San Dieguito Lagoon were found to have a higher pH, higher bulk density, lower organic matter, and lower clay content (WRA 2006).

Based on the results of the soil sampling conducted by WRA, salt marsh plant growth experiments were conducted in a nursery to examine what soil amendments might improve the surface soil conditions at the restoration site to promote the survival of planted container stock. The selection of soil amendments was guided by existing salt marsh restoration literature and traditional soil-amendment practices used in wetland restoration projects within the region. The soil treatments included the following: 1) Biosol Mix®, a commercially available and general-purpose soil fertilizer, 2) clay, to increase clay content in soil, 3) diatomaceous earth, to increase water retention in soil, 4) wetland topsoil, harvested from existing areas of salt marsh vegetation to provide essential plant nutrients and mycorrhizae, 5) kelp, to increase organic matter, and

Figure 2. High Salinity Soil

PHOTO: RECON ENVIRONMENTAL

6) compaction of non-amended soil to approximately 80%. A control group was also created using non amended subsurface soils from the San Dieguito Lagoon.

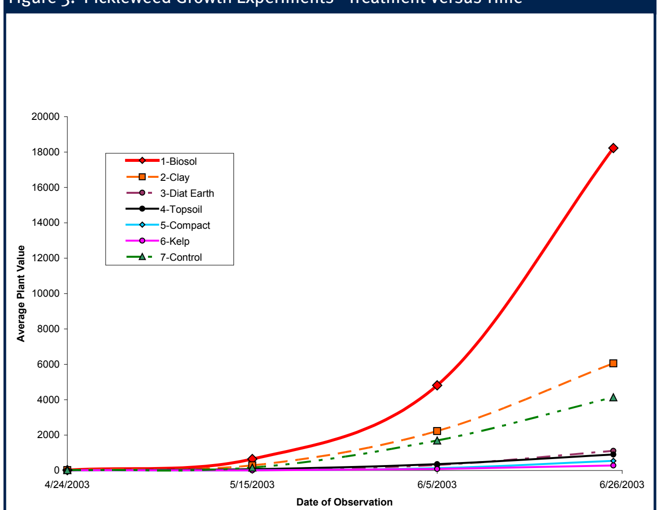
To create the experimental soil mixtures for planting, each soil amendment was added to subsoils harvested from the San Dieguito Lagoon in an approximate rate of 20% amendment to 80% subsoil blend. Soils were mixed thoroughly using shovels and then potted into 4-inch container pots. For the compaction group, pure subsoil was filled into 4-inch pots and then compacted with a 4- by 4-inch post.

Nursery Study

For this study, the survival and vigor of pickleweed (*Sarcocornia virginica*) plantings were measured to evaluate soil suitability for salt marsh restoration. Pickleweed was chosen because it tends to be the dominant plant species within Southern California salt marsh habitats and is the primary species to be planted at the San Dieguito Lagoon. In preparation for the nursery experiment, a single pickleweed cutting, between two and three inches in length, was planted in the center of each 2-inch container pot containing one of the seven soil amendments. One hundred plants were potted up for each treatment group for a total of 700 container plants.

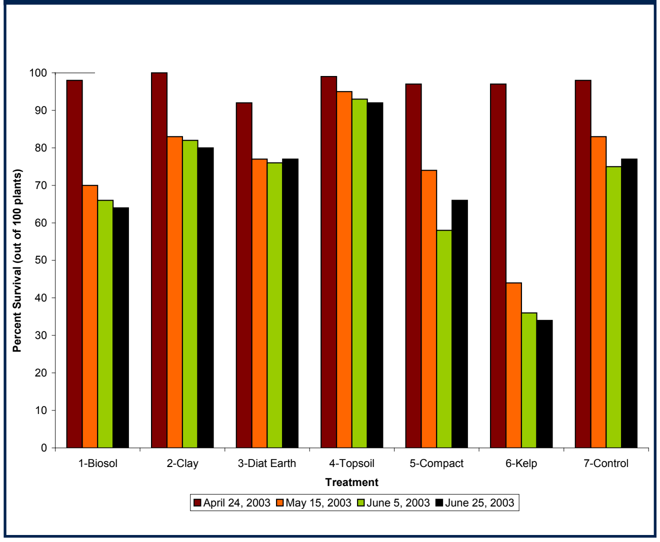
Data were collected once every three weeks over the course of two months. Data collection included survival (determined by visual observation whether the plant was still green) and vigor, which consisted of measuring the height, average canopy spread (in centimeters), and number of lateral branches of each container plant. A numerical representation quantifying the vigor of each individual was generated by multiplying the plant height by its average canopy spread and by the number of lateral branches (vigor = plant height (cm) x average canopy spread (cm) x number of lateral branches). This formula and a comparison of the averages of the treatment groups showed that the Biosol Mix® group outperformed in vigor the second-highest group by more than threefold (Figure 3).

Figure 3. Pickleweed Growth Experiments - Treatment Versus Time



However, the highest rate of survival of pickleweed was encountered in the topsoil-amended soil: 92% of the individuals were alive at the end of the study (Figure 4). Following the topsoil group was the clay group with 80% survival, the diatomaceous earth and control groups with 77% survival, the compaction group with 66% survival, the Biosol Mix® with 65% survival, and the kelp-amendment group with 35% survival.

Figure 4. Pickleweed Growth Experiment- Plant Treatment Percent Survival



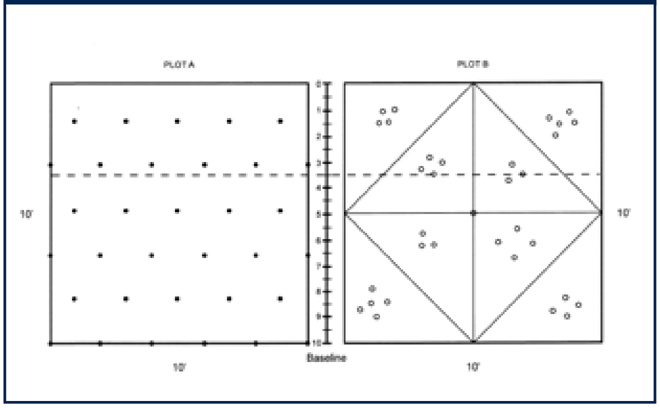
It is likely that the Biosol Mix® group had the greatest performance for individuals that survived because Biosol is a long-lasting balanced fertilizer that may increase humus growth, reduce pH and salt concentrations in soil, and increase root production in plants (Insam n.d.; Glatzel and Fuchs 1986). However, why the Biosol group exhibited poor plant survival when compared to the topsoil, clay, and diatomaceous earth treatment groups is unclear and may be a topic for a future study.

The results of the amendment study suggest that topsoil amendments may provide beneficial effects on wetland restoration plantings by increasing the short-term growth rate and overall survival of planted materials. Using topsoil was also an economically and logistically favorable amendment since topsoil was readily available on-site and was of low cost to salvage and distribute over the restoration areas.

Small-scale Field Experiment

Using topsoil as the preferred soil amendment, a field experiment was then conducted to demonstrate that transplanting container stock—healthy plants with established root systems—would help to establish the newly created restoration areas, resulting in rapid growth and colonization of the area by coastal salt marsh plants. The experiment was also designed to test the survival and growth of 2-inch containerized pickleweed individuals in two different planting layouts proposed for this project, 1) evenly spaced versus 2) a clustered pattern (Figure 5), to find out which planting layout would yield greater overall aerial plant canopy coverage over time.

Figure 5. Pickleweed Test Plots: Evenly Spaced Versus Clustered



In preparation for planting of the pickleweed test plots, an area was excavated to the approximate final grade elevation for pickleweed growth, between +3.5 and +4.5 feet National Geodetic Vertical Datum (NGVD) within one of the final planting areas of the San Dieguito Lagoon Restoration Project. The graded area was adjacent to the San Dieguito River and was sloped down toward the river at an angle of approximately 1% such that water would drain into the river following tidal inundation. During grading, the test plots were over-excavated and then backfilled to the final grade elevation with 12 inches of wetland topsoil containing plant fragments and seeds of native wetland species. Container plants for the pickleweed test plots had been propagated at RECON Native Plant Nursery (Figure 6) from seed collected in the San Dieguito Lagoon the previous winter. The seeds were initially sewn into flats containing a portion of topsoil that was collected at the lagoon and then transplanted into 2-inch containers following germination. Each month, survival and percent cover within each test plot were evaluated qualitatively and assessed quantitatively at four and six months following planting. The test plots were monitored for survival, percent canopy cover, and volunteer species natural recruitment.

The evenly spaced and the clustered planting layouts exhibited healthy pickleweed growth, aerial coverage, and recruitment of a variety of wetland species, indicating that either layout would allow for development of a healthy wetland marsh. Planting layout did not appear to affect the survival of the pickleweed container plants. A variety of wetland species such as pickleweed, coast saltgrass (*Distichlis spicata*), jaumea (*Jaumea carnosa*), sea-blite (*Suaeda sp.*), and alkali heath (*Frankenia salina*) had recruited into the sample plots, indicating that the graded elevations of the test plots and the viability of the wetland topsoil were functioning as designed. Four months after planting, the pickleweed in the evenly spaced planting group showed 3% greater aerial coverage than the clustered planting group (Figure 7). Six months after planting, the evenly spaced group had 11% greater aerial coverage of pickleweed. The evenly spaced group performed better in this study because, in the clustered group, the canopies of each plant began to overlap one another, and this overlap did not increase the overall aerial coverage of the planting group. Each plant within the evenly spaced planting group had more room to grow without overlapping adjacent plants. The conclusions from this study include the following:

Figure 6. RECON Native Plant Nursery

PHOTO: ABIGAIL SMIGEL

- An evenly spaced pickleweed planting layout appears to provide greater aerial percent cover than the clustered planting scheme.

- Survival of pickleweed container plants does not appear to be affected by planting layout.

- Natural recruitment within the test plots was low at less than 5% cover within the study period.

Figure 7. Percent Pickleweed Cover Versus Time

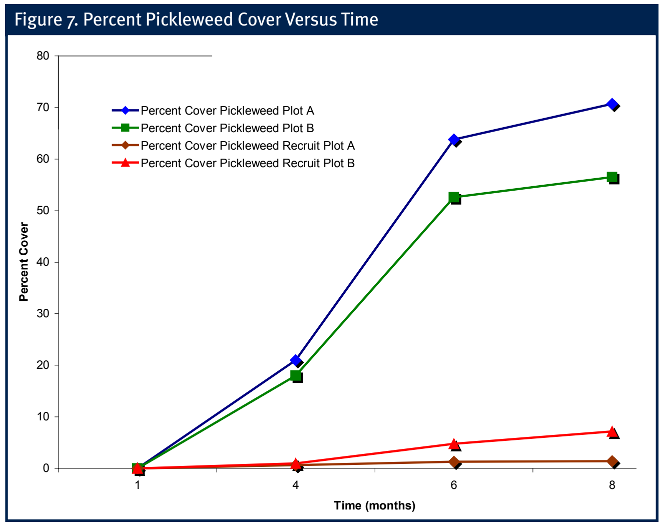


Figure 8. Month One: Shrunken Biomass

PHOTO: RECON ENVIRONMENTAL

Large-scale Field Experiment

In May 2008, to replicate coastal salt marsh vegetation establishment on a larger scale, a 3-acre test planting was conducted using the knowledge gained from the small-scale test plot. Unlike the small-scale field experiment, the site selected for the large 3-acre test plot was a broad, approximately 100 meters wide, shelf that was graded between 3.5 and 4.5 feet NGVD adjacent to the San Dieguito River. Additional comparisons conducted as part of this test plot included using container stock of various ages, introducing multiple associate native plant species, and planting across the entire mid- to high marsh zone between 3.5 and 4.5 feet NGVD. In this study, more than 22,000 container plants were planted.

In the first month following planting, a severe dieback was observed of the planted individuals. This was characterized by dry and shrunken above-ground biomass (Figure 8). At that time, mortality was estimated to exceed 80%. This occurrence was likely due to several factors, including lack of rainfall, extremely hot weather conditions immediately following planting, warm soil temperatures, lack of inundation by tidal action, immature plants upon planting, and high salt content and clay concentrations within the topsoil.

By the second month following planting, a large portion of the pickleweed plants that had once been observed to be desiccated showed signs of recovery by resprouting shoots from the base of the plant (Figure 9). At that time, mortality was estimated at approximately 70%.

During the third month, the plants that had survived continued to become established and showed signs of vigorous growth. Overall mortality of the planted individuals seemed to have stabilized at approximately 70% (30% survival). Survival of planted individuals was highest in the lowest elevations (3.5 feet NGVD) and lowest in the highest elevations (4.5 feet NGVD). This occurrence is likely due to the fact that lower elevations received tidal inundations more frequently than the upper end of the planting area. The lower elevations around 3.5 to 4.0 feet NGVD received several inundations per month, but the upper elevations of 4.0 to 4.5 feet NGVD were inundated maybe once every two months. The uppermost end of the planting area was never inundated throughout the study.

The results of this study seemed inconclusive since there were several factors at play that could have contributed to poor survival. Following this study, an action plan was developed to increase the probability of success when full-scale restoration was to take place. These action items included using only mature plants and planting would occur only from December through March, which would coincide with periods of cooler temperatures, higher tides, the rainy season, and lower soil salinity levels.

Figure 9. Month Two: Resprouting Shoots

PHOTO: RECON ENVIRONMENTAL

Figure 10. Before: Planting

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Full-scale Restoration

Seed collection for container plant production began in late fall of 2006 and 2007. When available, all seeds were collected from remnant coastal salt marsh populations within the San Dieguito Lagoon. When plant populations on-site were in short supply for seed collection, adjacent lagoons were used as donor sites. Such was the case with shoregrass (*Monanthochloe littoralis*) seeds. Seeds were harvested three times during the period of seed dispersal in order to obtain seeds in all stages of maturity. For each seed collection visit, seeds were collected, bagged, and labelled, noting the collector, date, and location of collection. Seeds were then brought to RECON Native Plant Nursery for cleaning and propagation.

Containerized pickleweed plants were propagated at RECON Native Plant Nursery located in Imperial Beach, California. This nursery is situated within the floodplain of the Tijuana River Valley and in close proximity to the Pacific Ocean. The climate in this region is nearly identical to the conditions found at the San Dieguito Lagoon Restoration site. All pickleweed container plants were germinated under a shade structure and later moved out into the open as the plants matured. This process helps the plants adapt to local climatic conditions once transplanted.

Seeds were sewn directly into 2-inch pots containing a mixture of nursery and native wetland soils from impacted areas of the San Dieguito Lagoon. Native soil was used because of its beneficial properties (e.g., mycorrhizae) for native plant growth. Initially, the seeds and seedlings were watered using freshwater from the nursery. As the plants reached maturity in the 2-inch pots, approximately one month before transplanting, they were watered using brackish water. This process hardened the pickleweed plants by helping them acclimate to brackish water before transplanting.

Planting

Planting began on December 20, 2008, following approximately 2.8 inches of winter rains and continued through March 2, 2009—a duration of 45 work days (Figure 10). Nearly 6 inches of rain fell on the project site over the planting period. In total, 335,918 2-inch container plants were installed within 36 acres of designated high salt marsh habitat. Planting densities ranged from 1.5 to 2.1 feet between individuals. Higher planting densities occurred in areas of higher elevation (above the 4.0-foot NGVD contour), where past field experiments had indicated that container plantings may be more difficult to establish.

Figure 11. After: One Year Later

PHOTO: RECON ENVIRONMENTAL

First-year Results

One year after planting, beneficial results can be easily observed throughout most of the planting areas. Quantitative data have not yet been collected, but qualitative monitoring has indicated that coastal salt marsh plant species, including pickleweed, saltgrass, alkali heath, jaumea, and shoregrass, are rapidly becoming established (Figure 11).

One of the planting areas has had only marginal success. The area of the large-scale field experiment has continued to have poor pickleweed growth and establishment. An adaptive management approach is being taken to monitor and correct this area appropriately. Currently, the soil composition (higher clay content), soil compaction (much tighter soils), tidal regime (less frequent inundations), topographic placement (greater distance from river), and other environmental factors are being investigated as possible causes of the poor plant survival.

Signs of success are also indicated by the increased number of wildlife observed within the area. According to anecdotal evidence from a local birding observers group, a semipalmated plover (*Charadrius semipalmatus*) has been observed feeding on the mudflats, a species not commonly observed before within this lagoon. In addition, the same observer noted two light-footed clapper rails (*Rallus longirostris levipes*) calling to each other from two newly emerged stands of marsh vegetation created by this project.

The CCC has collected baseline vegetative data for comparison and will be monitoring and reporting on the performance of this site over the next several years.

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Before

PHOTO: RECON ENVIRONMENTAL

After

PHOTO: RECON ENVIRONMENTAL

Before

PHOTO: RECON ENVIRONMENTAL

After

PHOTO: RECON ENVIRONMENTAL

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