RIPARIAN HABITAT RESTORATION, CARMEL RIVER LAGOON
WILDLIFE CONSERVATION BOARD GRANT NUMBER – WC – 3048SC
FINAL REPORT

California Department of Parks and Recreation
Monterey District
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INTRODUCTION

The Carmel River Lagoon Enhancement Project involves the earthwork and vegetation management to expand lagoon, wetland, riparian, and upland habitats in a former agriculture field called Odello West. Major earthwork occurred in the summer of 2004 within Carmel River State Beach. The construction, or excavation portion of the project is complete, but the planting of native vegetation continues. A supplementary component of this project involves post-construction monitoring to evaluate project success and to increase our knowledge of the sensitive species populations in the lagoon. Exotic species control is another aspect of the post-construction phase of this project.

This enhancement project required permits and approvals from a number of agencies, some of which incorporated annual reporting requirements into their approval. The California Department of Fish and Game issued a 1601 Streambed Alteration Agreement for the project, which requires revegetation efforts to be monitored for five years after planting and an annual status report to be provided to them by December 31 of each year. The U.S. Fish and Wildlife Service issued a Biological Opinion, which requires an annual report documenting California red-legged frog observations, the presence of predators, and the size and location of enhanced red-legged frog habitat to be submitted by January 31 following each year of the restoration covered by the opinion.

PROJECT DESCRIPTION:

Carmel River Lagoon Enhancement Project involved to converting 100 acres of fallow land (recently farmed) to natural landforms and plant communities, similar to those that were historically present prior to modification for agricultural use. In addition to this primary “restoration” work, the project also improved plant diversity and wildlife values, creating suitable habitat for special status species.

The land included in the proposed project was farmed on a continuous basis from the Spanish mission period until the winter of 1998, when extensive flood damage resulted in a decision to remove approximately 100 acres from agricultural production. The natural restoration of the site to wetland and riparian habitat was accelerated by the landform, drainage, and planting modifications. The availability of water and existing soil conditions allowed creation of wetland habitats with moderate grading and planting. The restoration included active planting of the site, as well as allowing for natural recruitment.

Landscape modification required that soil be removed from portions of the site. Material generated by this earthwork was used to establish desirable drainage and flood flow conditions that will promote a self-perpetuating natural area. The excess material was deposited offsite, east of Hwy 1, on property owned by the Big Sur Land Trust.

The project goal of converting 100 acres of fallow agricultural land within Carmel River

State Beach to habitats intended to resemble historic natural landforms and plant communities has been accomplished. Key project components included excavation of a new South Arm of the Carmel River mouth lagoon and establishment of wetland, riparian forest, and oak woodland plant communities.

Key elements of the project are summarized below:

1. Recreate the South Arm of the Carmel River Lagoon to expand open water and wetland habitat.
2. Lower elevation of several acres of property adjacent to the recreated South Arm to expand wetland habitat.
3. Restore plant communities.
4. Lower the western one-third of the existing Carmel Area Wastewater District Treatment Plant Access Road to the elevation of the surrounding floodplain, to increase the volume of overbank flow entering the restoration site.
5. Regrade the eastern portion of the site to encourage overbank flow to the south and west, towards the recreated South Arm of the lagoon.
6. Remove setback levee to restore the hydrologic function of the floodplain.
7. Construct a low berm near the historic barn complex to reduce floodwater intrusion into the area.
8. Remove fill material excavated from the restoration project to agricultural property east of Hwy 1.
9. Accommodate continued public use on the site.

REVEGETATION

Revegetation efforts that began in 2005, continued at Odello West in 2006. The California Department of Parks and Recreation (DPR) has an Interagency Agreement with the California Conservation Corps (CCC) to provide much of the labor for this project. The CCC crews plant, water, and conduct weed control efforts. Another labor source that is used to a lesser degree is the California Department of Forestry and Fire Protection's Gavilan Conservation Camp. Various other groups are also involved with planting and growing the native plants for the site including school groups and other educational organizations: the Carmel River School, the Carmel Middle School, the Watershed Institute at California State University Monterey Bay, the Vocational Horticulture Program at the Soledad Correctional Training Facility, the Big Sur Land Trust, the Chuck Haugen Conservation Group, and the California Native Plant Society.

Plantings have consisted of wetland, riparian, and upland species from containers as well as on-site cuttings of arroyo willow (*Salix lasiolepis*) and divisions/transplants of bulrush (*Scirpus californicus*). To date, approximately 40,000 plants from various sized containers and approximately 4,000 cuttings and transplants have been installed. Records of the plantings have not been detailed enough to make it possible to determine exact survival rates. However, it is evident that the bulrush divisions/transplants have had a high survival rate, while there has been noticeable mortality among the willow cuttings and the container plants.

EXOTIC PLANT CONTROL

Manual, chemical, and mechanical methods are being utilized to control invasive exotic plants at Odello West. Hoes, pulaskis, weed whips, and tri-blades have been used to remove weeds in areas that have been planted with native vegetation. Herbicide has been applied to poison hemlock (*Conium maculatum*) and cape ivy (*Delairea odorata*). A small tractor has been used to mow and to disk in areas that have not been planted in an attempt to control the weed seed bank.

EXOTIC ANIMAL CONTROL

Wild pigs (*Sus scrofa*) are known to frequent Odello West and the surrounding wetlands. The foraging habits of this non-native species cause extensive ground disturbance and vegetation damage. In order to protect the vegetation and habitat in the project area, DPR has contracted the services of the United States Department of Agriculture, Animal & Plant Health Inspection Service, Wildlife Services to control wild pigs. Wild pig control began at Odello West in January of 2005 and these efforts have continued through 2006. Although there is still evidence of pig activity in the area, no pigs were removed in 2006 (81 pigs were removed in 2005). Attempts were made in 2006 to trap the few pigs that have been documented using the area, but the population has been reduced to a level that has made capture more difficult. Pig control efforts will continue in 2007.

Efforts to control populations of the American bullfrog (*Rana catesbeiana*) at the Carmel River lagoon began in 2005 and continued through 2006. The decline of California's native frog species can partially be attributed to the presence of bullfrogs, which are efficient competitors to and predators of frogs and tadpoles. In 2006, bullfrog control at the lagoon consisted of 2 nights of concentrated efforts in October. A total of 12 adult bullfrogs were removed, and 3 additional bullfrogs were observed but not captured. Appendix A contains the bullfrog management plan for the Carmel River lagoon. Bullfrog control efforts will continue in 2007.

VEGETATION MONITORING

The vegetation at Odello West is best described as ruderal. It is dominated by exotic tall herbs including curly dock (*Rumex crispus*), wild radish (*Raphanus sativa*), mustard (*Brassica* sp.), bristly ox-tongue (*Picris echioides*), and poison hemlock. In 2006, vegetation monitoring was conducted in early June. Bermuda buttercup (*Oxalis pes-caprae*) is a prevalent weed at Odello West, but by June, the above-ground portions of the buttercup were desiccated and indistinct. For this reason, and to account for annual species that may have already died back, plant species that were still present, either dead or dying, were included in the surveys.

Methods

Twelve photo monitoring stations have been established in the project area. Four digital photos were taken at each photo monitoring station, and the general direction of each photo was recorded. Vegetation sampling was conducted in eight 50-meter point-transects centered in 50 meter by 5 meter plots. Each transect starting point is also a

photo monitoring station. Figure 1 illustrates the locations of the point-transects and the photo monitoring stations.

In two cases, a pair of transects begin from a single location (transects 7A and 7B from photo monitoring station 7; and transects 10A and 10B from photo monitoring station 10) resulting in an overlap in their 50 meter by 5 meter plots. The number of vegetation sampling plots established was determined by the floristic variability of the project area and the time available for vegetation sampling. The plots were established around the banks of the lagoon and at the site of the temporary haul road, where primary revegetation efforts will be focused. The

composition and structure of the eight plots were representative of the vegetation type of the entire project area. Additional plots can be added in the future if deemed necessary.

A vertical point was projected into the vegetation at each 0.5 meter interval (starting at the 50 cm mark) along each of the eight transects, and each species that was intercepted by the vertical point was recorded. Each species encountered was classified according to height class of herb (< 0.4 meter), tall herb or shrub (0.4- 2.5 meters), or tree (> 2.5 meters). Additional species within the 250 square meter plot that were not intercepted along the transect were recorded as well.

Results

A total of 51 different plant species were encountered within the eight point-transect plots. Of these 51 species, 14 are native (27%) and 37 are exotic (73%). One of the exotic species is a sterile wheat grass that was seeded at the project site post-construction, and two others are unidentified species that were presumed exotic. A total of 1905 plants were intercepted (or hit) along the 8 transects. Of these hits, 115 are native species (6%) and 1790 are exotic species (94%). Table 1 lists the 51 species identified within the plots and the total number of hits for each species.

The five most-intercepted species of all 8 transects were all non-native species: burclover (*Medicago polymorpha*) with 292 hits, ripgut brome (*Bromus diandrus*) with 200 hits, bristly ox-tongue with 198 hits, Bermuda buttercup (*Oxalis pes-caprae*) with 182 hits, and perennial ryegrass (*Lolium perenne*) with 175 hits. The two most-intercepted native species were California brome (*Bromus carinatus*) with 32 hits and willow herb (*Epilobium ciliatum*) with 29 hits. Two non-native species were identified at all 8 transects: bristly ox-tongue and rabbitsfoot grass (*Polypogon monspeliensis*).

Table 2 lists the percent cover of each species by transect and height class. Percent cover is calculated by dividing the number of hits for a species by the total number of points in the transect and multiplying by 100. Percent cover of species at a given transect can equal to or add up to more than 100% because, due to overlap, multiple plants can be intercepted at a single point on a transect. This is particularly common in herb-dominated areas like Odello West.

Photographs from the 2006 photo monitoring are in Appendix B.

Discussion

The vegetation at Odello West is clearly dominated by exotic species. The revegetation and weed eradication efforts to date have not made a significant difference in the vegetative composition of the area. However, as native trees and shrubs become established and grow in size, it is expected that the herbaceous exotic weeds that dominate the site will be displaced.

An integrated adaptive weed management approach is necessary for this area. Weed control efforts such as mowing, disking, hand removal, and herbicide application should continue where they are found to be effective. Additional weed control methods like solarification and/or sheet mulching with cardboard should be experimented with where feasible. Plantings should be concentrated so that maintenance and weed control efforts can also be concentrated.

STEELHEAD MONITORING

The primary objective of the post-construction steelhead trout (*Oncorhynchus mykiss*) monitoring has been to document the presence of steelhead within the restoration area. In 2006, two separate steelhead sampling events were undertaken, the first in July and the second in December.

In addition to DPR staff, steelhead monitoring efforts were made possible with the support of Central Coast Watershed Studies, NOAA Fisheries, the Monterey Peninsula Water Management District, the Carmel River Lagoon Steelhead Association, and the California Department of Fish and Game.

Methods

Beach seining was conducted on July 27 and December 13, 14, and 15, 2006. The July sampling event consisted of one day of seining to document steelhead presence. The December sampling event was a more intensive 3 days of seining organized by the Monterey Peninsula Water Management District to estimate the steelhead population in the lagoon.

A beach seine was used to document presence of steelhead throughout the lagoon. On July 27, five seine hauls were conducted in the restoration area and four hauls were conducted around the main body of the lagoon. On December 13, four seine hauls were conducted in the restoration area and six hauls were conducted throughout other parts of the lagoon. On December 14, nine seine hauls were conducted in the lagoon, but none were conducted in the restoration area. On December 15, two seine hauls were conducted in the restoration area, and seven hauls were conducted throughout other parts of the lagoon. On December 14 and 15, captured steelhead were marked with a blue dye before they were released. Seine hauls varied in deployment methodology, and different beach seines were used for the two separate sampling events.

Results

On July 27, in two of the four seine hauls conducted in the restoration area, a total of 18 steelhead were documented. An estimated 1000 fish were collected in the lower north arm of lagoon and 15 from the main lagoon near the sandbar. There was one mortality, but all other fish collected appeared to be healthy and were released. Approximately 130 of the fish were measured. The majority of these fish had a fork length between 90 and 100 mm, with the largest around 185 mm.

On December 13, in two of the four seine hauls conducted in the restoration area, 11 steelhead were documented. On December 15, in the two seine hauls conducted in the restoration area, 16 steelhead were documented. During the three sampling days in December, in 18 of the 22 seine hauls conducted outside of the restoration area, 256 steelhead were captured. Like in July, there was one mortality, but all other fish collected appeared to be healthy and were released. Two-hundred and seven of the fish were marked before being released. Six of the marked fish were recaptured on the third day of sampling. The majority of the fish that were measured had a fork length between 175 and 210 mm.

The mark and recapture data summarized in Table 3 was used with the Schnabel method to estimate the steelhead population size in the lagoon. The formula for this estimator is

$$N = \text{Sum } (M_t C_t)/((\text{Sum } R_t) + 1)$$

where N is the population estimate, t is each sample, M_t is the number of marked individuals in the population just before sample t is taken, C_t is the total individuals caught in sample t, and R_t is the number of individuals that were marked when caught in sample t. The lagoon's steelhead population estimate is 3,734 with a 95% confidence interval of 2,212 to 11,886.

Table 3. Steelhead mark and recapture data for December 2006.

Sample (t)	Previously Marked Steelhead (M)	Steelhead Captured (C)	Marked Steelhead Recaptured (R)
12/13/06	0	121	0
12/14/06	121	86	0
12/15/06	207	76	6

In July, two non-native fish species were found in the restoration area, one striped bass (*Morone saxatilis*) and one hitch (*Lavinia exilicauda*). Additional native species that were found throughout the lagoon include the three-spine stickleback (*Gasterosteus aculeatus*) and the staghorn sculpin (*Leptocottus armatus*). In December, the only non-steelhead fish species that were incidentally captured in the lagoon were the three-spine stickleback and the staghorn sculpin.

Discussion

With consideration given to the well-being of the steelhead, the difficulties associated with population quantification, complementary lagoon monitoring efforts, and economic constraints, steelhead monitoring efforts for the purpose of this project are focused on determining steelhead presence. Various public agencies and other organizations have considerable interest in the status of the Carmel River steelhead population. For this reason, the Monterey Peninsula Water Management District spearheaded the efforts to conduct December's mark-recapture survey.

Although the monitoring efforts conducted to date do not quantify the extent to which the lagoon restoration has affected the steelhead population, they do substantiate the

presence of apparently healthy steelhead in the restoration area. This indicates, when considered with water quality and aquatic invertebrate presence, that the restoration has provided beneficial habitat for steelhead trout.

CALIFORNIA RED-LEGGED FROG MONITORING

The lagoon was surveyed for California red-legged frog (CRLF) 8 times between March and October, consisting of 4 daytime and 4 nighttime surveys. Surveys were conducted on foot by walking the banks of the restoration portion of the south arm and any additional wet areas in Odello West where frogs could be expected.

The greatest number of CRLF observed at one time was 10 adults and 1 juvenile in October. No egg masses, tadpoles, or juveniles from the present year's reproduction were observed in the lagoon in 2006, therefore reproduction cannot be documented. This year, for the first time CRLF were observed on the banks of the restoration portion of the south arm. Emergent vegetation (primarily bulrush) has become established along these banks, which has increased the amount of suitable habitat available to CRLF.

WATER QUALITY AND AQUATIC INVERTEBRATE MONITORING

DPR has contracted with the Central Coast Watershed Studies Team, Watershed Institute through the Foundation of California State University Monterey Bay to monitor water quality and aquatic invertebrates in the Carmel River lagoon during and after project construction through June of 2007. A detailed description of the methods and results of this monitoring are in the Carmel River Lagoon Enhancement Project: Water Quality and Aquatic Wildlife Monitoring, 2005-6 report in Appendix C. This report covers monitoring conducted during the period of time between July 2004 and June 2006, and the July 2005 through June 2006 results are very briefly summarized here. The monitoring conducted after June 2006 will be described in subsequent reports.

Water quality data was collected at 5 sites, 3 sites in the restoration portion of the south arm, 1 site in the former south arm, and 1 site in the main body of the lagoon. The water quality parameters that were monitored included salinity, temperature, dissolved oxygen, pH, suspended sediment concentration, and turbidity. In general, water quality parameters for quality steelhead lagoon habitat include large volume, cool temperatures, high dissolved oxygen, and low salinity.

The salinity layer in the lagoon thickened in October and November of 2005 when waves washed over the sandbar. The shallower portions of the lagoon also became more saline at this time. The first storm of the season in December did not change the salinity in the lagoon. Salinity in the shallower portions of the lagoon did not decrease until the river connected to the lagoon in late December. These shallow portions became fresher when the sandbar was closed and stage was increasing. Salinity was highest when the stage was low.

Water temperatures increased during July and August, after the river stopped flowing into the lagoon. Temperatures gradually cooled from August through the first storm in December. During the winter months, temperatures in the main lagoon remained relatively constant from the river flow. The temperatures gradually increased, particularly at the shallow sites, through the spring as lagoon stages stayed low.

In addition to diffusion from the air at the water surface, dissolved oxygen in the lagoon is produced in a photosynthetic layer in the water column. In the main lagoon and in the restoration portion of the south arm, low dissolved oxygen coincided with low stages of the lagoon. At times when the lagoon drained rapidly (following the breaching of the sandbar), dissolved oxygen levels dropped in both forks of the restoration portion of the south arm. In early December 2005, the southeastern fork of the restoration portion of the south arm was anoxic throughout the entire depth profile.

Suspended sediments include clay, silt, plankton, and other organic and inorganic matter. Suspended sediment concentrations in the lagoon correlate with its turbidity, which is a measurement of the cloudiness of water. Suspended sediment concentrations and turbidity were highest in the lagoon during periods of high precipitation. The greatest spikes occurred in the restoration portion of the south arm. This area has experienced quite a bit of localized erosion, which is evident from the gully formation along the banks.

Lagoon macro-invertebrates were sampled at 7 sites, 3 of which were within the restoration portion of the lagoon. Both water column and epibenthic samples were collected. Sampling was conducted at three-month intervals. Twenty-two different taxa have been identified to date, while a few taxa were found one only one or two occasions. Taxa abundance and diversity were highest in the late summer and fall. The most common and abundant groups of taxa identified throughout the lagoon were the peracarid crustaceans that are known to be food sources for juvenile steelhead.