YEAR TWO ANNUAL MONITORING REPORT
ONEONTA SLOUGH
TIDAL LINKAGE PROJECT
TIJUANA ESTUARY, CALIFORNIA

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1.0 INTRODUCTION

This report is the second annual report documenting biological monitoring of the Oneonta Tidal Linkage Project (Tidal Linkage) at Tijuana Estuary. The Tidal Linkage, or connector channel, is located at the northwestern end of Tijuana National Estuarine Research Reserve in Imperial Beach, California immediately adjacent to the Visitor's Center (Figures 1 and 2). It is the first phase of a multi-phase restoration program developed for Tijuana Estuary by the California Coastal Conservancy (Conservancy) and the U. S. Fish and Wildlife Service (USFWS). The objective of this first phase of the program is to increase salt marsh habitat in the estuary and to restore tidal flushing to portions of the estuary that have become silted-in over time. The first phase of the project consists of two related projects: the Tidal Linkage project and a 20-acre Model Marsh restoration that will incorporate lessons learned during construction and monitoring of the Tidal Linkage project. The larger project would restore 495 acres of degraded wetlands and upland located in the southern portion of the estuary. This larger project has been designed in modules that can be constructed singly or in groups as funding becomes available. The goal of the 495-acre restoration project is to restore the 1852 tidal prism of the estuary. The Tidal Linkage and Model Marsh projects were to be completed first so that information generated during their implementation could be applied to the subsequent 495-acre marsh restoration.

Construction of the Tidal Linkage was designed to restore tidal flow to the northern arm of the estuary, connecting Oneonta Slough with tidal ponds to the northwest thereby reducing sedimentation in the tidal channels. The project was constructed between December 1996 and April 1997. The project was carefully designed to salvage all plants and sediments that might be useful in construction of a wetland. The majority of the project was located on upland habitat with each end connecting to existing wetlands. Thus, there were few impacts to existing wetlands in the construction of the Tidal Linkage. Upland soils were deemed compatible for beach nourishment and were discharged as a slurry to the surf zone. All salt marsh plants that existed in the path of the proposed channel were salvaged and replanted as part of the project. In addition, the marsh sediments that were excavated in construction of the Tidal Linkage were salvaged and mixed with the excavated upland soils in an attempt to hasten the development of marsh-like soils from the upland soils. Although these procedures added to the expense of the project, it was the philosophy of the Conservancy and the USFWS that impacts and waste should be minimized and that the Tidal Linkage project should serve as a model for other coastal salt marsh restoration projects in the region.

A total of 0.07 acre of salt marsh habitat was permanently impacted by the project and 0.17 acre of tidal channels were temporarily impacted. However, the project created 1.84 acres of salt marsh and channel habitat and was therefore self-mitigating. Plants were salvaged from existing

Figure 1

Figure 2

salt marsh habitat at the east and west ends of the channel as sod blocks consisting of 8 inch square blocks of Pacific cordgrass (*Spartina foliosa*) and 6 inch square blocks of mixed salt marsh species. In addition, plugs of saltgrass (*Distichlis spicata*) and individual glasswort (*Salicornia subterminalis*) plants were planted. In all, more than 1,300 blocks of cordgrass were planted on 3-foot centers, 2,370 blocks of mixed marsh species were planted on 2.5-foot centers, 1,936 plugs of salt grass and approximately 8 individual glasswort plants were salvaged and replanted. A portion of the created salt marsh area was dedicated to researchers at the Pacific Estuarine Research Laboratory (PERL) at San Diego State University for the purpose of restoration research (Figure 3). The area set aside for PERL included 0.02 acre of low marsh, 0.25 acre of mid marsh, 0.04 acre of high marsh.

As required in the project specifications for the construction of the tidal linkage and in accordance with the U.S. Army Corps of Engineers Section 404 permit, a monitoring program was developed to ensure the successful establishment of salt marsh species. This assessment of the site was prepared to comply with the requirements of the monitoring program. This report includes qualitative observations gathered since the first annual report submittal, during the period spanning February 1998 to January 1998, and quantitative sampling conducted on January 28, 1999.

2.0 METHODS

Since the Year 1 Annual Report, two quarterly quantitative assessments of the site have been conducted by Tierra on May 22, 1998 and August 20, 1998. Qualitative and quantitative data collection for this annual report was collected on January 28, 1999. Weather conditions during the survey consisted of clear skies with air temperature of approximately 65°F and wind from the west at 0 to 5 miles per hour. Both qualitative and quantitative data were collected as part of this monitoring survey. Collection of qualitative data involved documentation of the overall health and vigor of the plants as well as site conditions. Qualitative data collection also included photo documentation of site conditions from permanently established locations. These locations are depicted in Figure 3. During the first year of monitoring at this site, transects were established on the northern side of the channel through low, middle and high marsh habitat. The transects are illustrated in Figure 3. Unfortunately, stakes had been moved or washed away since the last monitoring visit and were replaced roughly in the same location. Consequently, a few of the transects surveyed for this report vary in length slightly from the previous surveys. Nevertheless, the data collected adequately represents the progress of canopy development on-site. The transects surveyed vary in length between 23.1 and 145.05 meters long and extend through representative portions of the three marsh zones.

Plant development and percent cover were assessed using the line intercept method. Along each transect, the distances covered by bare ground and individual plant species were recorded. In areas where two or more species overlapped in cover, the distance covered by each species was

Figure 3

recorded separately. If the species were completely intertwined, the distance covered by that assemblage was recorded for each species occurring within that segment.

3.0 RESULTS

3.1 QUALITATIVE ASSESSMENTS

All plantings have survived since the last monitoring visit in August 1998. However, at the time of the survey, the marsh plants were recovering from their dormant state and many plants throughout the site had browned leaves. There were, however, live green shoots visible on all or most of the plants (Figure 4).

Cordgrass in the low marsh appears to have expanded during the 1998 growing season. However, it has been subject to continued herbivory (Figure 5). Installation of 18" high chicken wire around the perimeter of the site eliminated grazing by rabbits that occurred during the first year after the marsh was installed.

Species planted in the mid and high marsh have continued to survive and expand such that the distinct blocks in which they were planted are no longer discernable. Coots have selectively grazed pickleweed, but there was otherwise little evidence of herbivory in the mid and high marsh areas.

Both low and mid marsh areas were covered by dense algal mats composed primarily of *Enteromorpha intestinalis*. These mats float during high tide and become draped over plants as the tide recedes, thereby limiting exposure to light. These mats have been observed over the plants during this entire year and while this does not appear to be fatal, it is likely that photosynthesis is somewhat impaired. Algal mats are also abundant in areas of apparent marsh plain subsidence (Figure 6). It appears that dense algae, in addition to constant inundation in these areas, has precluded the expansion of salt marsh species by limiting available light and oxygen (Figure 7).

The extreme upper marsh/upland transition area is comprised of both native and non-native species and unvegetated bare ground. Native species including glasswort (*Salicornia subterminalis*), salt wort (*Batis maritima*), shoregrass (*Monanthochloe littoralis*), salt grass (*Distichlis spicata*) and pickleweed (*Salicornia virginica*) dominate the slope. Other species observed include sea lavender (*Limonium californicum*), salt bush (*Atriplex* sp.) and alkali weed (*Cressa truxillensis*). Scattered weedy species include salt heliotrope (*Heliotropium curavassicum*), Bermuda grass (*Cynodon dactylon*) and Australian salt bush (*Atriplex semibaccata*). The spread of these non-natives has been controlled by weed maintenance performed by the USFWS. The upland area surrounding the Visitor's Center has been maintained by the USFWS and at the time of the survey was comprised of species such as California sagebrush (*Artemisia californica*), California encelia (*Encelia californica*) and salt bush, compared to large stands of garland which dominated the area at the time of the previous annual monitoring survey.

Figures 4 and 5

Figures 6 and 7

Erosion of the upper marsh/upland transition area has continued, apparently as a result of run-off from the upland area (Figure 8). While this condition does not appear to be detrimental to marsh species, it may interfere with the colonization of the transitional slope by native species.

Since the last monitoring visit, additional erosion of the channel banks has occurred. However, the channel continues to function as planned, conveying water between the northern end of Oneonta Slough and the tidal ponds. Because the channel was over-excavated in anticipation of eventual sediment deposition, a refuge for aquatic organisms remains during low tide. This provides habitat for fish and birds which serves to enhance wildlife viewing opportunities at the Visitor's Center. Several wildlife species were observed during the January 1999 survey including brown pelican (*Pelecanus californicus browni*), great blue heron (*Ardea herodias*), American coot (*Fulica americana*), great egret (*Casmerodius albus*) and ruddy duck (*Oxyura jamaicensis*). Numerous California horn snail (*Cerithidea* sp.) were also observed throughout the site.

Quarterly Monitoring

Low Marsh. At the time of the survey, Pacific cordgrass (*Spartina foliosa*) planted in the low marsh were in moderate condition, with new green shoots emerging (Figure 4). Additional erosion of channel banks has caused the channel to widen, shifting the centerline of the channel to the north and eliminating much of the created low marsh habitat at the eastern end of the channel, directly adjacent to the bridge (Figure 9). As a result, many of the planted cordgrass plants in this area have fallen into the channel. However, low marsh habitat remains at the western end of the channel. Cordgrass in that portion of the site has thrived and expanded during the last year.

Mid-Marsh. Mid-marsh species observed include sea blite (*Suaeda californica*), saltwort (*Batis maritima*) and pickleweed (*Salicornia virginica*). The saltwort and sea blite appeared healthy and succulent. Pickleweed had numerous browned leaves and showed evidence of herbivory. However, newly emerging shoots were observed. Alkali heath (*Frankenia grandifolia*), sea lavender (*Limonium californicum*) and jaumea (*Jaumea carnosa*) observed in the mid marsh also appear to have thrived during 1998. Overall, this portion of the marsh is in good condition (Figure 6). As previously described, however, some portions of the mid marsh to the west of the site have subsided resulting in large areas of ponded water. These areas are devoid of vegetation with the exception of algal mats.

High Marsh. This portion of the site was in relatively good condition. Species planted in this area were generally healthy and include saltwort, pickleweed, glasswort, alkali heath, shoregrass, saltgrass, jaumea, sea lavender and sea blite. Although the transitional slope between high marsh and upland is still sparsely vegetated, additional native species appear to have colonized the area since last year.

Figures 8 and 9

Upland. The upland portion of the site consists of the top of the slope directly adjacent to the high marsh habitat. Whereas much of this area supported vegetation dominated by non-native, weed species at the end of 1997, the vegetation is currently dominated by native species with scattered weedy species.

Overall, the site is in good condition (Figure 10). Pooling is observed in portions of the mid-marsh and some areas have an approximately one-inch thick surface layer of anaerobic mud. These conditions indicate the development of soils favorable for the survival of salt marsh species. The general health of the system is also evidenced by the presence of wildlife species in the channel and associated marsh habitat. Some of these herbivores, however, are responsible for the damage to cordgrass plants. Species observed in the connector channel or associated salt marsh habitat during this and other monitoring surveys conducted during 1998 include swimming crab (*Callinectes arcuatus*), bubble snail (*Bulla gouldiana*), California horn snail (*Cerithidea californica*), western grebe (*Aechmophorus occidentalis*), mallard (*Anas platyrhynchos*), American coot (*Fulica americana*) and willet (*Catoptrophorus semipalmatus*). Despite herbivory, however, the site has been generally resilient and canopy cover has expanded during the last year. Continued expansion and general health are anticipated during the coming growing season.

3.2 QUANTITATIVE ASSESSMENT

Survival. Project specifications require that 100% of the planted species survive during the 120-plant establishment period and 80% survive thereafter. With the exception of the upper marsh/transition zone, this specification appears to have been met. In the case of the low marsh, it is difficult to assess the degree to which the sides of the channel have sloughed, making it difficult to quantify the number of plants that have fallen into the channel. The loss of this habitat as a result of changes in the channel was anticipated and erosion is expected to continue until the channel stabilizes. Nevertheless, due to expansion in cordgrass in other areas of low marsh on-site, it appears that 80% of the plants originally planted have survived and are thriving.

Although herbivory has resulted in some damage to pickleweed, vegetation in the mid and high marsh areas has survived and has expanded considerably to since the Year 1 Annual Report. The existing vegetation in these areas appears to have surpassed the 80% survival criteria despite unvegetated open areas covered with algal mats and ponded water.

The exception to the 80% survival criteria is the upper marsh/upland transition area. At the time of the Year 1 Annual Report, most of the live vegetation in this portion of the marsh was composed of weed species. At that time, the area immediately adjacent to the upper marsh/transition zone was comprised primarily of weedy species such as chrysanthemum (*Chrysanthemum coronarium*), brome grasses (*Bromus* spp.), and Bermuda grass (*Cynodon dactylon*). A decision was made by the USFWS to allow voluntary colonization by natives throughout the 1998 growing season.

Figure 10

During the monitoring survey conducted for this report, vegetated portions of the upper marsh/upland transition area were comprised of both native and weedy, non-native species. Although a transect was not established through this area, the 80% survival criteria did not appear to have been met for 1998. Much of the slope remains relatively bare. Considering, however, the increased number of native species observed in the area this year, it is plausible that it may be naturally colonized by native species as long as upland weed control measures continue.

Percent Occurrence. Four transects (A through D) were established in the project area; two transects extend through low marsh habitat, one through mid-marsh habitat and one through the high marsh. These are depicted in Figure 3. Transect A extends approximately 55.7 meters across low marsh habitat consisting of bare ground, cordgrass and pickleweed. Of the 55.7 meters (100%), bare ground accounts for approximately 59%, compared to 94% at the end of Year 1, and cordgrass accounts for approximately 20%, compared to 6% at the end of Year 1. Pickleweed comprises 19% compared to less than 1% of the total percent cover, sea blite accounts for 2% and saltwort accounts for less than 1% of total percent cover. Of the vegetated portions of the transect, cordgrass comprises approximately 48% as opposed to 91% in 1998 and pickleweed accounts for approximately 47% as opposed to 1% in 1998. Sea blite comprises approximately 5% of vegetative cover and saltwort accounts for less than 1%. Data taken along transect A are summarized in Table 1. Overlap between species accounts for approximately 2.9 meters or 5% of the total transect distance.

Table 1. Summary of Species Coverage Along Transect A

Scientific Name	Common Name	Distance Covered (m)	% of Total Transect Distance	% of Total Vegetation
Batis maritima	saltwort	0.1	<1%	<1%
Spartina foliosa	Pacific cordgrass	11.53	20%	48%
Salicornia virginica	pickleweed	11.23	19%	47%
Sueda californica	sea blite	1.27	2%	5%
---	bare ground	34.47	59%	---
Total	---	**58.6**	100%	100%

Transect B extends approximately 136.72 meters across mid-marsh habitat consisting of bare ground, saltwort, alkali heath, jaumea, sea lavender, shoregrass, cordgrass, pickleweed and sea blite. Of the 136.72 meters (100%), bare ground accounts for approximately 32% compared to 83% at the end of Year 1, saltwort 7% versus 3% in 1998, alkali heath 3%, jaumea 6%, sea lavender, shoregrass and cordgrass each less than 1%, pickleweed 51% and sea blite 1% of total percent cover. Of the vegetated portions of the transect, saltwort accounts for 10% compared to 20% cover, alkali heath for 4%, jaumea 9%, sea lavender 1%, shoregrass and cordgrass less than

1%, pickleweed for 75% up from 70% in 1998, and sea blite for 2%. Overlap between species accounts for 2.8 meters or 2% of the total transect distance.

Table 2. Summary of Species Coverage Along Transect B

Scientific Name	Common Name	Distance Covered(m)	% of Total Transect Distance	% of Total Vegetation
Batis maritima	saltwort	9.4	7%	10%
Frankenia grandifolia	alkali heath	3.6	3%	4%
Jaumea carnosa	jaumea	8.1	6%	9%
Limonium californicum	sea lavender	0.64	<1%	1%
Monanthochloe littoralis	shoregrass	0.12	<1%	<1%
Spartina foliosa	Pacific cordgrass	0.04	<1%	<1%
Salicornia virginica	pickleweed	70.71	51%	75%
Suaeda californica	sea blite	1.72	1%	2%
---	bare ground	45.21	32%	---
Total	---	**139.54**	100%	100%

Transect C extends approximately 145.05 meters across high marsh habitat. Of the 145.05 meters (100%), bare ground comprises approximately 26% compared to 68% at the end of Year 1, saltwort 6%, salt grass 6%, alkali heath 7%, jaumea 2%, sea lavender 1%, shoregrass 12%, glasswort less than 1%, pickleweed 35% instead of 12%, sea blite 3% and bush seepweed 1%.

Overlap between high marsh species accounts for approximately 32.9 meters or 18% of the total transect distance. Of the vegetated areas, saltwort accounts for 7% compared to 19% in 1998, salt grass 9% instead of 4%, alkali heath 9%, jaumea 3%, sea lavender 4%, shoregrass 16%, glasswort less than 1%, pickleweed 47% compared to 38% in 1998, sea blite 4% and bush seepweed 1%.

Table 3. Summary of Species Coverage Along Transect C

Scientific Name	Common Name	Distance Covered(m)	% of Total Transect Distance	% of Total Vegetation
Batis maritima	saltwort	9.91	6%	7%
Distichlis spicata	salt grass	11.34	6%	9%

Frankenia grandifolia	alkali heath	12.07	7%	9%
Jaumea carnosa	jaumea	3.96	2%	3%
Limonium californicum	sea lavender	4.81	1%	4%
Monanthochloe littoralis	shoregrass	20.54	12%	16%
Salicornia subterminalis	glasswort	0.05	<1%	<1%
Salicornia virginica	pickleweed	62.72	35%	47%
Suaeda californica	sea blite	4.64	3%	4%
Sueda moquinii	bush seepweed	1.85	1%	1%
---	bare ground	46.04	26%	---
Total		**177.93**	100%	100%

Transect D extends approximately 23.1 meters across low marsh habitat. Bare ground accounts for approximately 50% compared to 95% at the end of Year 1, pickleweed accounts for 17% compared to 14% and cordgrass for 33% instead of 25% cover. Of the vegetated portions of this transect, pickleweed comprises 34% and cordgrass 66%.

Table 4. Summary of Species Coverage Along Transect D

Scientific Name	Common Name	Distance Covered (m)	% of Total Transect Distance	% of Total Vegetation
Salicornia virginica	pickleweed	3.95	17%	34%
Spartina foliosa	Pacific cordgrass	7.58	33%	66%
---	bare ground	11.64	50%	---
Total	---	**23.1**	100%	100%

To summarize, quantitative data collected along these transects indicate that canopy cover has expanded during 1998 resulting in bare ground coverage of 40 to 60% less of the transect distances than last year.

4.0 RECOMMENDATIONS

Based on the results of this assessment and on discussions with USFWS Refuge personnel, the following actions are recommended:

- Previously recommended fencing along the channel to discourage access to the marsh plain is not required. Herbivory by American coot does not appear to have been a detriment to the overall development of the salt marsh canopy.

- It has been determined that additional seeding of this area with the appropriate native species will not be necessary. The condition of the upper marsh/transition zone has improved since last year. Native species have colonized the area and also appear to have been planted. Weed species were observed but were not the overwhelming dominant species.

- Although algae plays an important role in salt marsh function and should not be considered a nuisance, the absence of other plant species from areas of dense algae suggest a possible need for remedial action. Open mud flats on the marsh plain currently covered with algal mats or ponded water should be observed for an additional growing season to allow natural colonization by pickleweed. These areas should be re-evaluated at the end of the year and a decision regarding replanting in these areas will made at that time.

- Based on the progress of the site during the 1998 growing season, it has been determined that the addition of kelp amendment, utilized on the PERL site to facilitate growth, is unnecessary.

- Reduce monitoring surveys to every 6 months. The salt marsh has thrived during both the 1997 and 1998 growing seasons and appears stable and generally healthy despite the anticipated continuing channel bank erosion.