Colorado Lagoon

Baseline Summary 2012-2014

Colorado Lagoon Long Beach, California

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Executive Summary

Project Objective

The mission of Tidal Influence is to provide community-based volunteer opportunities to help restore wetlands, save and study endangered species, and educate the community about the environment. We are partnered with the City of Long Beach and the Friends of Colorado Lagoon (FOCL) in order to lead the restoration of the Colorado Lagoon. Tidal Influence is responsible for the implementation of the Colorado Lagoon restoration and monitoring plans.

The primary goal of the Colorado Lagoon Western Arm Monitoring Plan is to document the restoration strategies that will allow for a change of approach if needed in the future, and to measure the restoration success. In December 2013, Tidal Influence completed the first year of monitoring surveys at the Colorado Lagoon and then in September 2014 completed the second year of monitoring. These monitoring surveys include the study of vegetation, avifauna, ichthyofauna, and benthic invertebrates. The following report provides a summary and analysis of the data collected during the first and second year at the Colorado Lagoon Western Arm.

Vegetation

The objective of the vegetation surveys is to determine native versus non-native species richness, species percent cover, canopy height, and biodiversity within the re-vegetated regions. The goal is to obtain less than ten percent non-native cover of the re-vegetated areas by the end of 2013 and then to improve on that percentage by the end of the monitoring period in 2014. Surveys were conducted using a permanent transect and quadrat locations. These transects can traverse four different habitat types: coastal salt marsh, transition zone, coastal sage scrub, and coastal dune. The first year of monitoring began before re-vegetation commenced and was concluded after most of the re-vegetation occurred. Phase three transects (7-12) were excluded from this analysis because that phase was just planted and would not accurately depict the current vegetation coverage.

The vegetation surveys found sixty-two plant species in the Western Arm area between Year 1 and Year 2. Twenty-four species were non-native while thirty-eight were native. Native mean percent coverage increased from Year 1 (7.9%) to Year 2 (10.03%) with non-native mean percent coverage compromising less than 2.04 percent. Although Bare Ground percent coverage decreased from Year 1 to Year 2 overall and for each habitat classification there is still a significant amount present. This can be attributed to plants just becoming established in the Western Arm area and still competing with non-native vegetation. Looking at vegetation by species break down, we found that the most abundant native species was Fleshy Jaumea, *Jaumea carnosa*, followed by Common Pickleweed, *Salicornia pacifica* and Sand Spurry, *Spergularia marina.* The restoration goals set in the monitoring plan show that at the end of Year 2, the non-native percent coverage does achieve the restoration goal of less than ten percent. Unfortunately the second restoration goal of having 50%-70% native vegetation coverage verses bare ground for any of the habitat classifications was not achieved. The third goal of having no one species that compromised an average of more than fifty percent coverage was also achieved.

Avifauna

The objective of the bird surveys was to determine the different assemblage of birds between the inside of the restoration area and outside of the restoration area. Birds are the most commonly sited animal observed at the Colorado Lagoon and by regular observation, we see more birds using the Lagoon on their migratory paths in the winter months. Surveys are conducted by walking the perimeter of the Lagoon. The objective is to locate the various species, identify them, note their behavior, and where they are located within the Lagoon.

The avifauna surveys found that sixty-three species of birds have been documented in the past two years using the Colorado Lagoon. All but four of those species are native and protected by the Migratory Bird Treaty Act. The top three most abundant species sited are the American Coot, *Fulica americana*, Lesser Scaup, *Aythya affinis*, and the Ring Billed Gull, *Larus delewarensis*. The analysis showed that Lagoon has low Order diversity and evenness, but slightly higher species diversity and evenness. The Western Arm area when compared to the area outside of the Western Arm show that there is a higher effective number of species (9.61) and higher number of Orders (4.47). This highlights the beginging of how important the restoration is the avifauna communities. Also when examining which habitats the communities are using, seventy-seven percent of Orders used the wetlands habitat with the others used less than ten percent of the time. Of the observations within the Western Arm the wetlands habitat was used eighty-five percent of the time! Another point that indicates the imporants of this rare habitat.

Ichthyofauna

The objective of the ichthyofauna surveys is to determine the fish assemblages in the Colorado Lagoon and measure changes through time. These surveys are the best way to measure the success of the dredging that occurred in 2012. By looking at the types of fish and their abundance, we can tell how well the Lagoon is recovering from disturbance and past high toxicity levels. Our sampling methods included using a beach seine net that is walked into the water, pivoted, and pulled onto shore. Species identification, count, and length measurements are collected.

The ichthofauna surveys were conducted quarterly, with two extra beach seines conducted in the summer months of the first year. There was a total of nine beach seines that caught 4,068 fish from 14 species. The overall data shows that the Lagoon has a low diversity and low evenness for fish species with California Killifish, *Fundulus parvipinnis,* Arrow Gobi, *Clevelandia ios,* and Topsmelt, *Atherinops affins* as the most abundant species. When compared to a past study conducted in 1973, the only abundant comparable species was *Atherinops affinis*. Although, when comparing Shannon-Wiener Diversity Indices, this study has a higher H' value than in 1973 meaning that the fish diversity has increased. The mean length of the top five fish species caught is lower than historical means expect for *Clevelandia ios* which is just slightly higher. When comparing the mean length per site, the data shows that four out of the six species had the largest mean length within the Western Arm Reserve. Although, one species *Syngnathus griseolineatu* was not caught in with in the Western Arm Reserve area. This could be attributed to the minimal eelgrass or algae beds in this area, which is this species main habitat.

This baseline study of fish found in the Lagoon, directly following a dredging event, can be extremely valuable for comparing data down the line. Overall the results are positive, and within years to come, with the vegetation maturing, we can hope to see the abundance, diversity, and evenness grow to create a healthy, functioning ecosystem.

Benthic Invertebrates

Baseline invertebrate samples were taken at Colorado Lagoon in November 2012, only a few months after the completion of dredging. The second set of samples were taken nine months post dredging (June, 2013), which was used to compare to the baseline samples. Two methods were employed for the benthic invertebrate surveys, both methods include taking 15-18cm^2 by 2-4cm deep benthic core samples. One method (Method B) took only six samples at various locations around the Lagoon. The other method (Method A) took twelve samples along four transects within the Western Arm of the Lagoon only. Both of these Lagoon samples were compared to other samples taken at Zedler Marsh within the Los Cerritos Wetlands.

Results for Method A show that there is a higher abundance of organisms within the Western Arm of the Colorado Lagoon over the more mature Zedler Marsh. Method B displays the opposite results with finding fewer organisms than Zedler Marsh, this may be due to the choice of locations within the Colorado Lagoon, however. In Method B it was noted that the majority of organisms were found near the storm drains which may be due to a higher amount of nutrients in the soil in that area or due to less disruption from the dredging event. More samples will need to be consistently taken in the future to display more consistant results.

Introduction

Objective

The main objective of the Colorado Lagoon restoration project is to increase rare, native habitat in an area where it had formerly thrived, in order to create new habitat for both migratory and resident native and endangered species. The goal of the restoration project is to engage the community and increase awareness of the local habitat. By the end of the restoration, the Long Beach community will have the opportunity to explore and be informed on native habitats.

The Colorado Lagoon Western Arm Monitoring Plan states two overall goals for monitoring:

1. To guide implementation of restoration strategies and allow for adaptive management if necessary, and
2. To provide quantitative measures of the restoration project success.

This data will have the similar structure to ensure comparison for pre-restoration, post-restoration and to a mature local wetlands, Los Cerritos.

Protocol Development

Monitoring protocols were developed to document structural and functional properties of the Colorado Lagoon pre- and post-restoration. The protocols were developed by Tidal Influence LLC. and Dr. Christine R. Whitcraft, California State University, Long Beach, and President of Friends of the Colorado Lagoon (FOCL). This monitoring data will allow for adaptive management and provide quantitative measures of restoration success.

The monitoring program will include hydrological and biological aspects. The hydrological aspects will measure the tidal range starting in 2014. The biological aspects, such as avifauna and ichthyofauna are measured quarterly, while benthic invertebrates are measured annually and vegetation is measured monthly. Year one data was supplemented with extra surveys completed by California State University, Long Beach students for all chapters excluding vegetation. Year two data was not supplemented with extra surveys.

Site Description

History of Colorado Lagoon

Colorado Lagoon is a human-made geomorphological feature located within the historical range of Los Cerritos Wetlands, which once boasted more than 2400 acres of coastal wetlands at the heart of the incredibly diverse California Floristic Province. This wetland's acreage has been reduced to just 500 acres of open space, much of which is privately owned and operated for industrial purposes. Conversely, Colorado Lagoon has been managed by the City of Long Beach since the 1920s as a park and recreational area. In 1923, the naturally occurring tidal wetlands of Alamitos Bay were dredged to form the Lagoon and Marine Stadium. The lagoon became the site of the 1932 U.S. Olympic Diving Trials in Los Angeles and was separated from Marine Stadium (the site for rowing competitions) by tide gates designed to maintain an adequate water depth during diving events. Afterward the Lagoon became such a popular swimming and recreation site that lights were provided at night and lifeguards were on duty 24 hours per day, 7 days per week. It is even rumored that John Wayne was once a lifeguard at the Lagoon.

The late 1960s marked the decline of the lagoon's health with the first restriction of its connection to the ocean and subsequent drop in water quality. The north end of Marine Stadium was filled for a never-executed crosstown freeway; this filled area became Marina Vista Park. After this construction, the lagoon was reduced to an 18 acre tidal water body connected to Alamitos Bay via a 900 foot box culvert that runs under Marina Vista Park into Marine Stadium. Over the course of several decades a golf course, parking lots, recreational beaches, parks, and residential areas were built up around the Lagoon. Development entirely surrounded the lagoon's edges which resulted in an urban watershed impacting the Lagoon's water quality via 11 storm drains. These watershed impacts, coupled with the Lagoon's restricted tidal range, contributed to the gradual accumulation of contaminants in the water and sediment. Over time, the Colorado Lagoon earned the dubious honor of having one of the worst water quality conditions in the state. Heal the Bay ranked Colorado Lagoon as one of the "Top 10 Biggest Beach Bummers" in the organization's 2011 Annual Beach Report Card; since spring 2007, the Lagoon's beaches have received "F" grade each year regardless of the season. This poor water quality was of great concern as thousands of people come to Colorado Lagoon every summer to swim and fish.

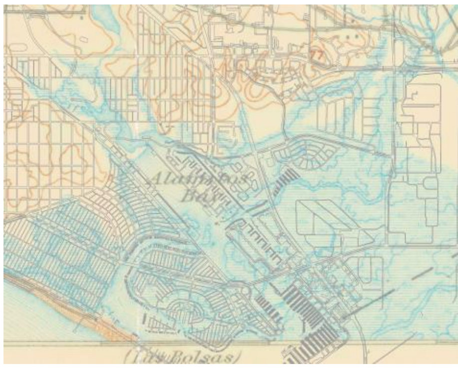

Photo 3: Overlay map of historical wetlands and the modern day Alamitos Bay

Photo 2: Aerial view looking north at Marine Stadium and Colorado Lagoon – 1929 (Long Beach City Engineer)

Photo 1: U.S. Olympic Trials swimming event – c.1932 (Recreation Department)

Restoration Efforts

Resulting from this concern were several large restoration projects that have vastly improved both public health and recreation opportunities and the ecological function of the lagoon:

<u>Storm Drain Improvements</u>:

1. Three of Colorado Lagoon's storm drains were upgraded by the installation of low flow diversion systems and trash separation devices. Via this system, dry weather drainage that would normally enter the lagoon through these drains was redirected into a vault, which releases the wastewater into the sewer system during much of the year.

2. The remaining seven storm drains have all been diverted away from the lagoon as part of Los Angeles County's Termino Avenue Drain Project. Water in the lagoon now has a 7.7 day residence period; additional restoration actions will be necessary to decrease this time to the 6.0 day residence time observed in Marine Stadium.

3. A 600 foot bioswale was constructed in the Western Arm between the golf course and the lagoon. This bioswale transformed a drain, which formerly transferred runoff directly to marine waters, into a phytoremediation system designed to filter out fertilizers and other pollutants before reaching the wetlands.

<u>Improvements to Tidal Flow</u>:
The culvert connection between the Lagoon and Marine Stadium was cleaned for the first time since its construction in the 1960s. This sensitive endeavor required the lagoon to be cut off from tidal influence for nearly two weeks in order to complete the cleaning. However, the removal of three feet of marine sediment, running the entire length of the culvert, decreased the residence time of tidal waters entering the lagoon.

<u>Removal of Contaminants</u>:
A large dredging and bank resloping project was performed to (1) remove numerous organic and inorganic pollutants that

contaminated the lagoon's sediment and (2) increase intertidal habitat. Approximately 74,000 cubic yards of sediment were removed from the lagoon during this phase.

Since February 2012, water quality ratings from Heal the Bay have been consistently high, with a few exceptions occurring during periods of heavy rainfall.

Photo 4: Newly contoured bioswale on the north bank of the Western Arm prior to planting (Zahn)

Photo 5: Inside view of an empty low flow-diversion chamber (Pirazzi)

Photo 6: Dredging in the Western Arm; over 70,000 cubic feet of dredge material were removed from the Lagoon and transported to the Port of Long Beach for use in their Middle Harbor project (Pirazzi)

Creation of Western Arm Natural Area

The large-scale construction projects executed at the Colorado Lagoon provided opportunity to establish a native plant regime and recreate habitats that may have once existed at Colorado Lagoon. Additionally, various areas in and near the Colorado Lagoon are designated for recreational activities such as swimming, fishing, hiking, and golf. Finding a balance between human activity and habitat is vital to the success of the lagoon's restoration; in Fall 2012 with funding provided several entities, the Western Arm Natural Area was created to help achieve this balance. Partners in restoration for this project included:

Rivers and Mountains Conservancy
National Fish and Wildlife Foundation
Port of Long Beach
California Office of Spill Prevention and Response
California Native Plant Society- South Coast Chapter
Society of Environmental Toxicology and Chemistry
Wells Fargo

Since the determination was made to create the Western Arm Natural Arm, many measures have been integrated into the restoration process to ensure the habitat's integrity and sustainability. Prior to the dredging and re-contouring efforts, salt marsh plant plugs were salvaged from the Western Arm and used as stock from which smaller plants were propagated. Additional propagules were collected from Los Cerritos Wetlands. These practices ensured that all salt marsh plants are genetically native to the area; this factor is especially important when working with coastal salt marsh plants, as these species hybridize easily.

After the dredging project was completed and the Colorado Lagoon was once again readily accessible, perimeter fences were installed to outline the Western Arm boundary and deflect windblown trash. Mulch was then applied to delineate habitat zones (which will be discussed in more detail in upcoming sections of this document), to increase water absorption and retention in the sediment, to curtail erosion, and to serve as a non-native plant control method.

After these efforts were completed, the installation of native plants commenced. To minimize the risk of trampling or other damage to the newly installed habitats, plantings were first performed in the intertidal zones and subsequently moved upwards in elevation. Care was taken to place any rare species in areas of least potential impact, and salt marsh areas – arguably the most sensitive habitat installed in the Western Arm Natural Reserve – were planted by a team trained in salt marsh restoration techniques and supervised by a salt marsh ecologist. Considerations given in the upland habitats included aesthetic values and neighborhood viewsheds.

The Western Arm Natural Area

The Western Arm Natural Area is located on the distal end of the west Arm of the Lagoon, easily viewed from Park Avenue and Appian Way. This area was created with the intent that it be accessed seldom by people and serve as a higher quality area of habitat for the animals utilize the Lagoon. However, as it is entirely surrounded by development, urban impacts will occur and measures have been taken to ensure that public interactions with the Western Arm Natural Area are positive.

Photo 7: A panoramic view of the Western Arm Natural Area post-restoration (Graves)

Habitat Classifications within the Western Arm Natural Area

Coastal Sage Scrub*:*

The coastal sage scrub community evolved in a Mediterranean climate, which occurs between 30 and 40 degrees latitude, rarely experiences freezing temperatures or prolonged periods of heat above 90ºF, and receives 10-20 inches of rainfall annually. Some species such as *Peritoma arborea* or *Artemisia californica* have specialized leaves that store moisture and reduce water loss during dry months, have very few signs of above-ground life, and expend energy growing a stronger root system. Having evolved in a dry, fire-prone climate, this plant community is fire adapted; several of the more succulent species are fire retardant.

Photo 8: Wildflowers blooming in the coastal sage scrub plant community (Tidal Influence)

Coastal Strand:

Dunes, sand beaches, and bluffs along the entire coast offer a harsh environment for the few plant species that inhabit them. Bluff and dune habitats are often adjacent to salt marshes. Loose sand, sea salt, fog, isolation, wind, and foot traffic create impossible conditions for some species. Plants such as verbena, beach evening primrose, and beach bur are adapted to survive under such impacts and are dominant species in the coastal strand plant palette for the Western Arm Natural Area.

Photo 9: Coastal strand habitat, with *Acmispon glaber* and *Ambrosia chamissonis* dominant (Graves)

Transition Zone:

The transition zone - also referred to as an "ecotone" – is a narrow strip of land that is situated between the coastal salt marsh and upland plant communities. It occurs directly above the mean high tide line, which produces highly saline soils that few plants are adapted to survive in. Here you find a mixture of upland and wetland plants, as well as certain species that are specialized to live in this ecotone. Some dominant species in this habitat type are *Suaeda taxifolia*, *Lycium californicum*, and *Isocoma menziesii*. Several of these endemic species have become rare in southern California due to encroachment from developments, the placement of walking trails along marsh edges, and from the invasion of non-native plant species. Many terrestrial animals that use the marsh during low tides depend on the transition zone for cover during high tides. Please refer to the section on sea level rise for other functions of the transition zone.

Photo 10: *Suaeda taxifolia*, a rare plant that thrives in the Lagoon's transition zone, living above the high tide line (Graves)

Intertidal Salt Marsh:

This is plant community is found within a 2 to 3 meter elevation range along sheltered margins of bays, lagoons, and estuaries that are subject to regular inundation by seawater. It is dominated by highly herbaceous plants that are adapted to tolerate high doses of water and salt. Plant species are segregated by elevation with *Spartina foliosa* (Pacific cordgrass) dominating the low marsh, *Salicornia pacifica* (Common pickleweed) and *Jaumea carnosa* (Fleshy jaumea) in the middle marsh, and *Distichlis spicata* (Salt grass) and *Distichlis littoralis* (Shoregrass) in the high marsh. Unvegetated tidal areas, known as salt pannes, often form in the upper marsh where soil salinities may reach as high as 200 parts per thousand (ppt); sea water is 35 ppt.

Photo 11 – A mature, diverse array of salt marsh plants (Graves)

Data Analysis Methods

Statistics

Several of the following chapters used the same statistical methodology. For those chapters, the data was analyzed for gamma (overall) diversity for each species and Order or Class hierarchy. Species richness (diversity of order zero), Shannon-Wiener Index (diversity of order one), and species evenness was calculated using the following equations:

Shannon-Weiner Index:

$$H= -\sum p_i \ln p_i \quad (1)$$

$$i = 1 - s \quad (2)$$

$$H_{max}= Ln(s) \quad (3)$$

$$E_H= H/H_{max} \quad (4)$$

$$\text{S-W's Effective number of species} = \exp(H) \quad (5)$$

With "i" values ranging from 1 to S, where S is equal to the total species present. Values for "pi" being equal to the proportion of total species of the $i'th$ species and "n" as the count of individuals per species. Due to species richness and species abundance both contributing to biodiversity, max biodiversity (3) and species evenness (4) will also be determined to better interpret the results. Shannon-Weiner index (1) is not itself a diversity, it is a highly nonlinear index which makes it difficult to compare communities (Jost, 2010). Therefore, this index will be converted to the effective number of species. The effective number of species is the number of equally common species in a community (5).

All statistics were run in Minitab 17 Statistical Software.In most cases of this report that the raw and transformed data did not meet the assumptions of ANOVA, therefore Kruskal-Wallis (non-parametric tests) were run. ANOVA tests are very robust to small sample sizes and if the variances are unequal then the probability of making a Type one error will be greater than alpha (Maxwell et al, 1990). If the normality deviates then the actual power of the test is considerably less (Glass et al, 1972). Using an alpha of 0.05, the p values of the ANOVA and Kruskal-Wallis were then compared. In cases where the p values qualitatively produced the same results for both tests, a Tukey's test was run and the ANOVA results reported, because minor violations in the data do not matter (Zar, 1996).

Report Structure

This report is divided into four chapters, one for each of the monitoring components (i.e vegetation, avifauna, ichthyofauna, and benthic invertebrates). Each chapter includes an introduction, description of the methods, results and discussion. Detailed monitoring protocols for each method can be found in the appendix of report. The appendix for each chapter is very detailed to allow for future reports to use the data for yearly comparisons.

Literature Cited

Glass, G. V, Peckham, P. D., and Sanders, J. R. (1972). *Consequences of failure to meet the assumptions underlying the fixed effects analysis of variance and covariance.* Review of Educational Research, 42, 237-288.

Jost, L., DeVries, P., Walla, T., Greeney, H., Chao, A. and Ricotta, C. (2010), Partitioning diversity for conservation analyses. Diversity and Distributions, 16: 65–76. doi: 10.1111/j.1472-4642.2009.00626.x

Zar, Jerrold H. (1996). *Biostatistical Analysis, 3rd edition.* Prentice Hall, Upper Saddle River, New Jersey, USA.

Chapter One: Vegetation

Julie McNamara

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Introduction

Vegetation forms the foundation of the ecosystem. These primary producers turn chemical energy into a useable form of sugar though the process of photosynthesis. The plant assemblage has many influences in the cycling of nutrients, but largely it can determine the associated wildlife and the health of a habitat. The Colorado Lagoon has been highly transformed from its original state as a functioning wetlands. The recent efforts to mitigate and restore the Lagoon has involved at the base, the re-vegetation of the uplands, transition zone and the salt marsh (figure 1). Monitoring the relative presences and absences of native and non-native plant species is one of the most common methods for evaluating the health and functioning of a wetlands system (Zedler 2001). This study will quantify the progression of the plant community from pre- and post-restoration efforts.

The objective of re-vegetation is to achieve less than ten percent non-native cover by the end of the second year, post construction. We are aiming to achieve between fifty and seventy percent native vegetation cover verses bare ground by the end of the monitoring period (May 2014). In order to ensure species diversity, we are striving to have no native species constitute more than fifty percent cover.

Methods

Field Methods

For Year One, vegetation was sampled fourteen times in the Western Arm of Colorado Lagoon on a dropping tide of 3.4ft or lower from October 2012 to November 2013. For Year Two, vegetation was sampled ten times on a tide of 2.7 or lower from December 2013 to September 2014. Twelve permanent transects were established with a total of 35 quadrats of one meter squared in size (figure 1, left). Four habitat classifications were sampled. There is one quadrat in Dune Transition, three quadrats in Dune, twenty-two quadrats in Coastal Salt Marsh, and nine quadrats in Coastal Sage Scrub (figure 1, right, Appendix 1.6). Each quadrat was sampled for epifauna and detritus percent cover, individual species, individual species percent cover and height for tallest plant per species in centimeters (Appendix 1.0). Detritus is not recorded in Coastal Sage Scrub because of the placement of mulch, therefore not accurately representing the habitats detritus coverage.

Figure 1. Transect locations (left) and habitat types delineated (right) of the Western Arm Natural Area.

Statistics

The species that were observed at the Colorado Lagoon were classified as native or non-native, with several native weed species for our purposes classified as non-native (Appendix 1.3). Non-native species also includes unknowns for all analyses. Due to the three phases of restoration at the Colorado Lagoon, phase three (transects 7-12) are excluded from all analyses except Shannon-Wiener Indices. This will highlight the successes of the revegetation in phase one and phase two that have had two years to become estabilished, while allowing the diversity indices to show and account for all species found at the Colorado Lagoon. Although there are four habitats at the Colorado Lagoon, the Dune Transistion quadrats are combined with the Dune habitat for the analyses. All analyses excluded bare ground unless specifically stated. Data was analyzed for species abundance, average percent coverage, and plant height.The data was analyzed seasonally for native versus non-native and for plant height (Appendix1.7).

Results

Sixty-two plant species were found at the Colorado Lagoon between Year 1 and Year 2. Twenty-four species were non-native while thirty-eight were native (Table 1). Native mean percent coverage increased from Year 1 (7.9%) to Year 2 (10.03%) with non-native mean percent coverage compromising less than 2.04 percent (Figure 2 and Figure 4). Analyzing the percent coverage seasonally shows a peak growth spurt in the June through August for Native vegetation where mean percent coverage is equal to 10.64% compared to the other season (Figure 3). Non-Native vegetation appears to have the same mean percent coverage throughout the year (Figure 3).

Table 1. Shannon-Wiener Diversity Indices, Max Biodiversity, Species Evenness and Effective number of Species for Both Years, Year 1 and Year 2 broken down by Native and Non-Native classification.

	Both Years			Year 1	Year 2
	All Species	**Non-Native**	**Native**	**Native**	**Native**
S	62	24	38	28	30
n	1422	284	1138	545	588
H	3.465	2.683	3.035	2.862	3.008
Hmax	4.127	3.178	3.637	3.332	3.401
EH	0.839	0.844	0.834	0.858	0.884
Effective number of Species	31.976	14.629	20.801	17.496	20.247

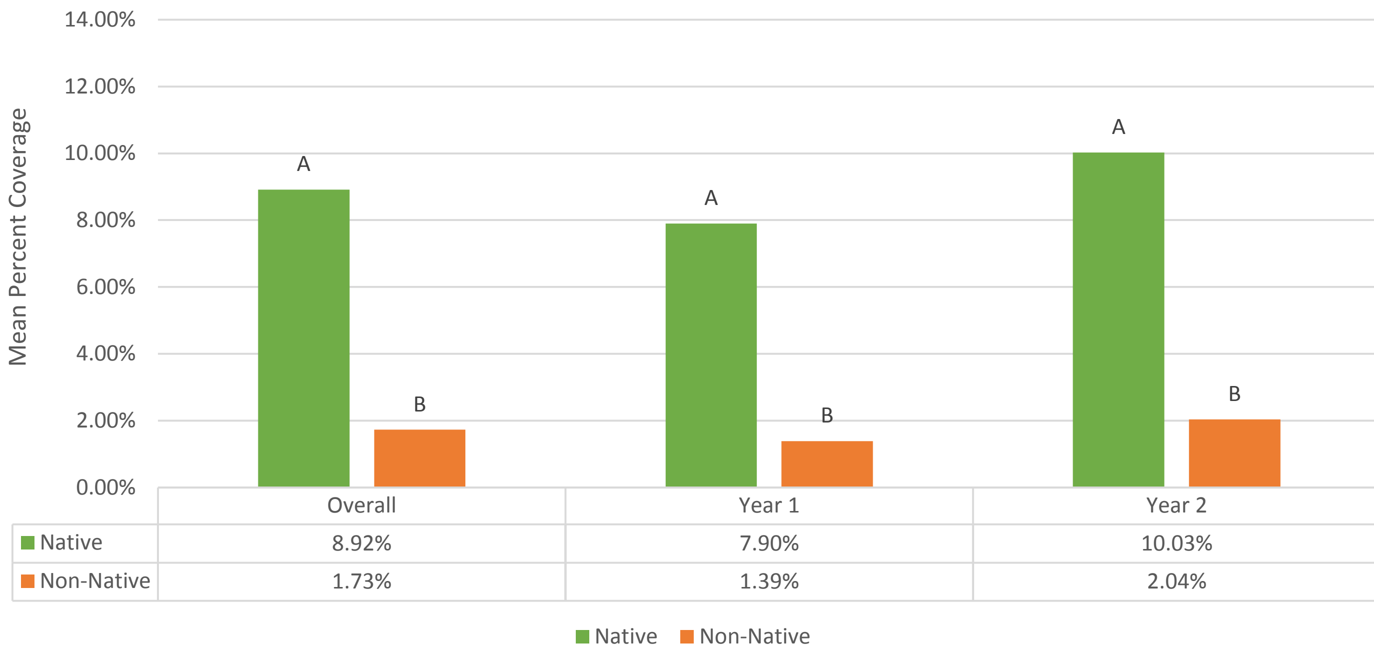


Figure 2. Graph depicting ANOVA results for Native verses Non-Native plant species for Overall ($F_{1,1025} = 42.68$, $p<0.001$), Year 1 ($F_{1,536} = 23.41$, $p<0.001$) and Year 2 ($F_{1,491} = 21.72$, $p<0.001$). Analyses were run individually for each classification. Bars not sharing a letter are significantly different.

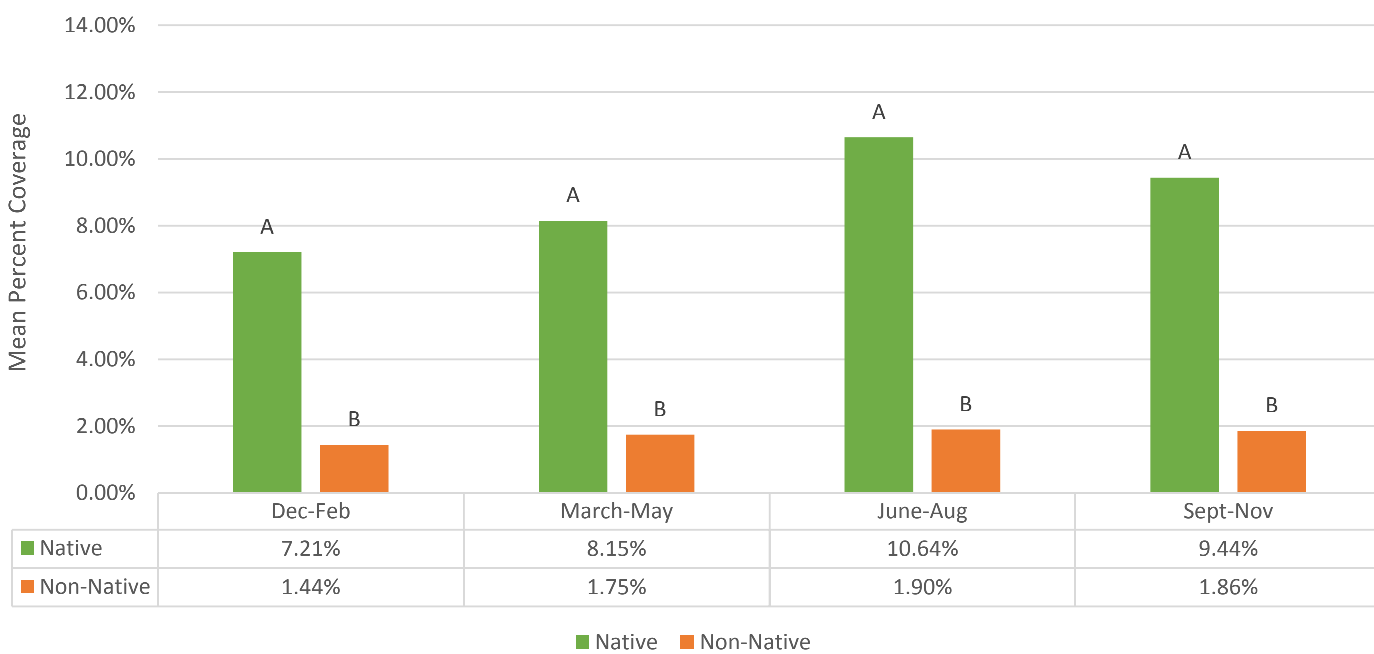


Figure 3. Graph depicting ANOVA results for Native verses Non-Native plant species per season. December- February ($F_{1,226} = 10.16$, $p=0.002$), March-May ($F_{1,321} = 20.95$, $p<0.001$), June-August ($F_{1,287} = 10.11$, $p=0.002$) and September-November ($H_{1,185} = 2.40$, $p=0.009$). Analyses were run individually for each classification. Bars not sharing a letter are significantly different.

Bare ground percent coverage averaged to be 86.63% for Year 1 and Year 2 combined (Figure 4). Year 1 monitoring started with 89.81% Bare Ground and decreased to 82.17% in Year 2 (Figure 4). Breaking down the native vegetation and bare ground coverage should bring some insight to what habitats are being productive. The Coastal Sage Scrub habitat classification consistently held a native mean percent coverage between 11.29%-11.91% for Year 1 and Year 2 (Figure 5). Bare Ground coverage decreased in this habitat by 17.64% from Year 1 to Year 2 (Figure 5). The Dune habitat classification increased in mean percent coverage from Year 1 (13.41%) to Year 2 (18.06%) (Figure 6). Bare Ground coverage decreased in this habitat by 15.33% from Year 1 to Year 2 (Figure 6). The Coastal Salt Marsh habitat classification increased in mean percent coverage from Year 1 (5.81%) to Year 2 (6.33%) (Figure 7). Bare Ground coverage decreased in this habitat by 1.24% from Year 1 to Year 2 (Figure 7).

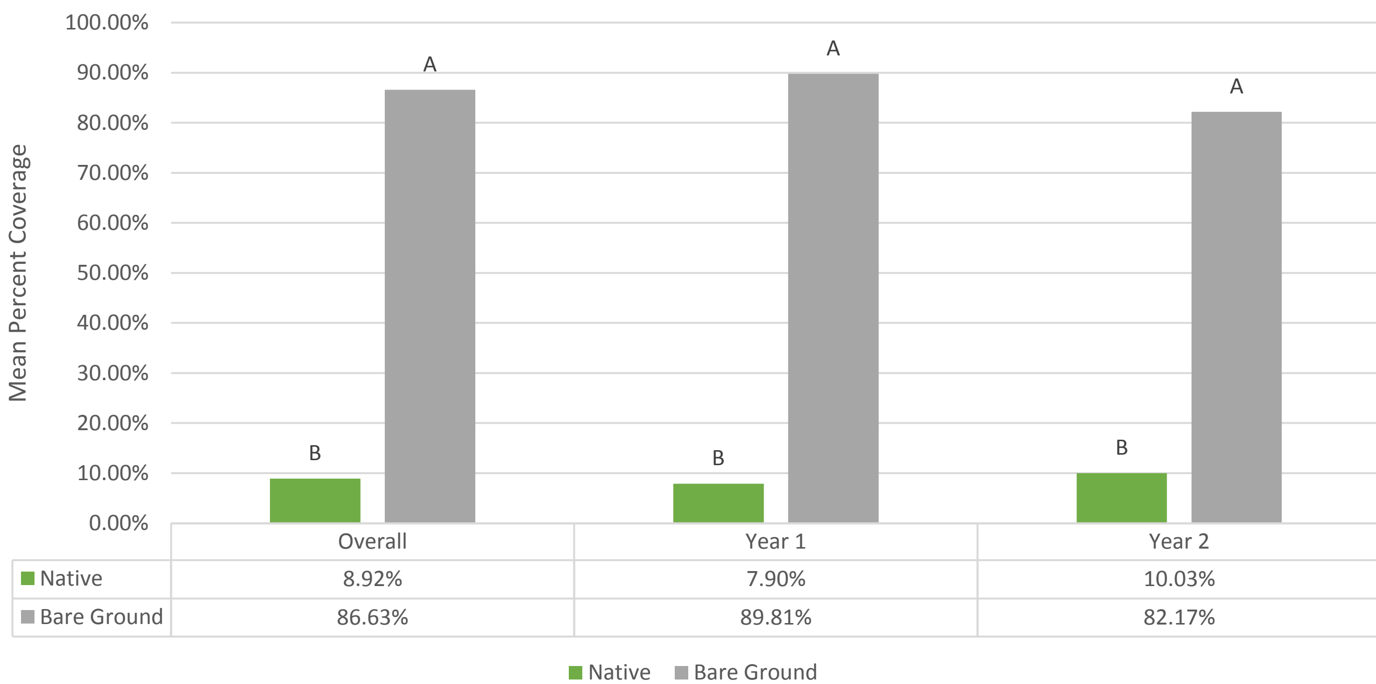
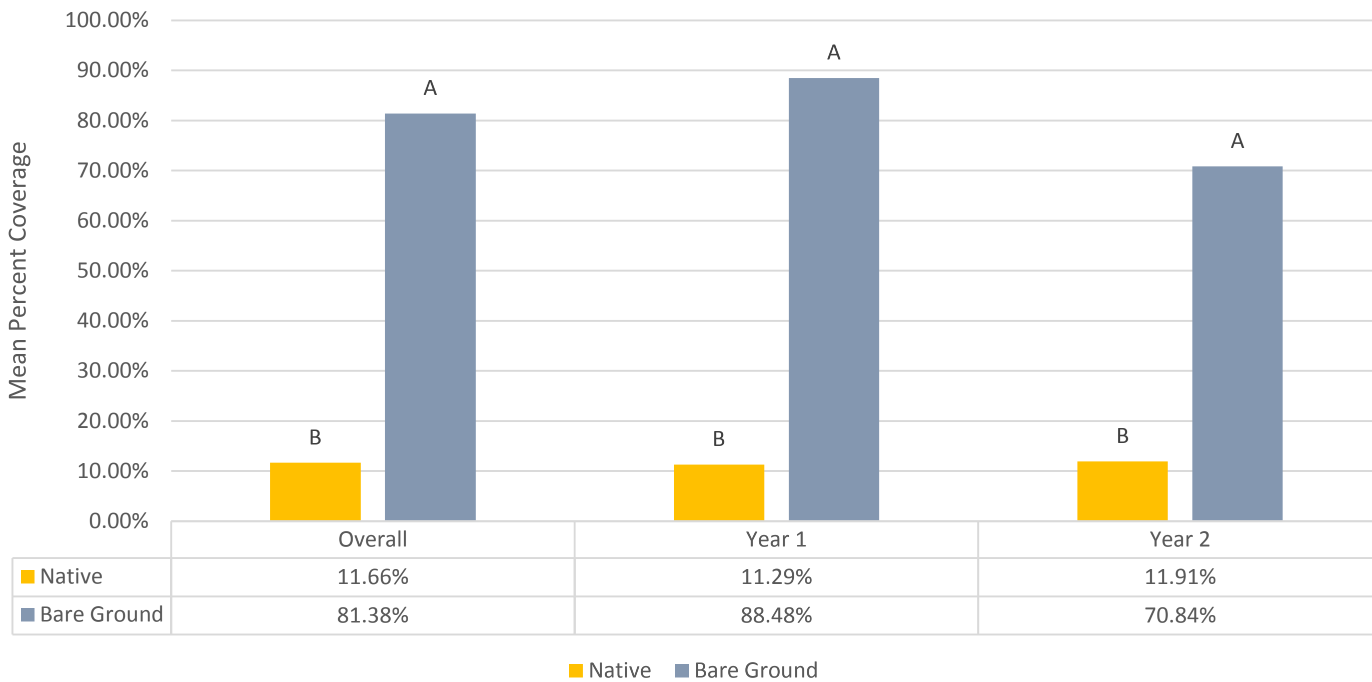
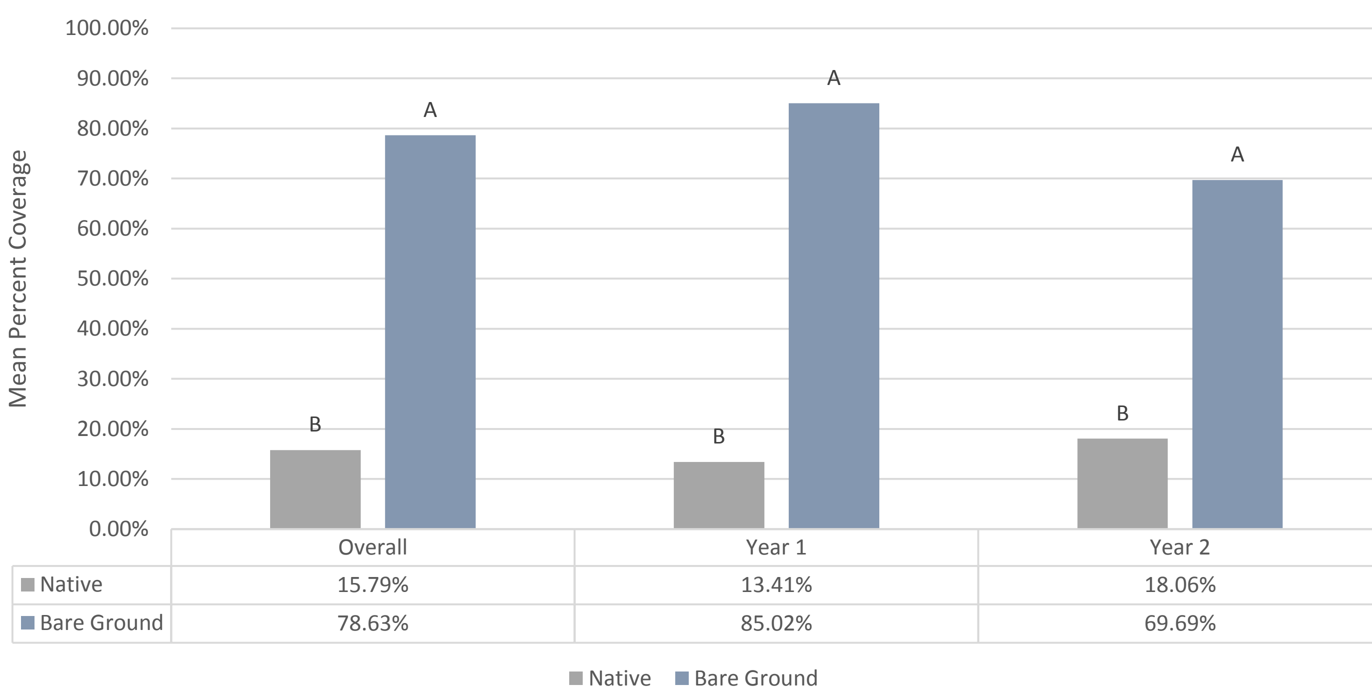


Figure 4. Graph depicting ANOVA results for Native verses Bare Ground for Overall ($F_{1, 1475}$ = 10398.28, p<0.001), Year 1 ($F_{1,805}$ = 8483.64, p<0.001) and Year 2 ($F_{1,668}$ = 3207.21, p<0.001). Analyses were run individually for each classification. Bars not sharing a letter are significantly different.



	Overall	Year 1	Year 2
Native	11.66%	11.29%	11.91%
Bare Ground	81.38%	88.48%	70.84%

Figure 5. Graph depicting ANOVA results for Native verses Bare Ground for Coastal Sage Scrub habitat classification and for time. Overall ($F_{1, 382}$ = 1787.84, p<0.001), Year 1 ($F_{1,178}$ = 1321.09, p<0.001) and Year 2 ($F_{1,202}$ = 627.15, p<0.001). Analyses were run individually for each classification. Bars not sharing a letter are significantly different.



	Overall	Year 1	Year 2
Native	15.79%	13.41%	18.06%
Bare Ground	78.63%	85.02%	69.69%

Figure 6. Graph depicting ANOVA results for Native verses Bare Ground for Dune habitat classification and for time. Overall ($F_{1, 225}$ = 392.23, p<0.001), Year 1 ($F_{1,805}$ = 8483.64, p<0.001) and Year 2 ($F_{1,105}$ = 106.02, p<0.001). Analyses were run individually for each classification. Bars not sharing a letter are significantly different.

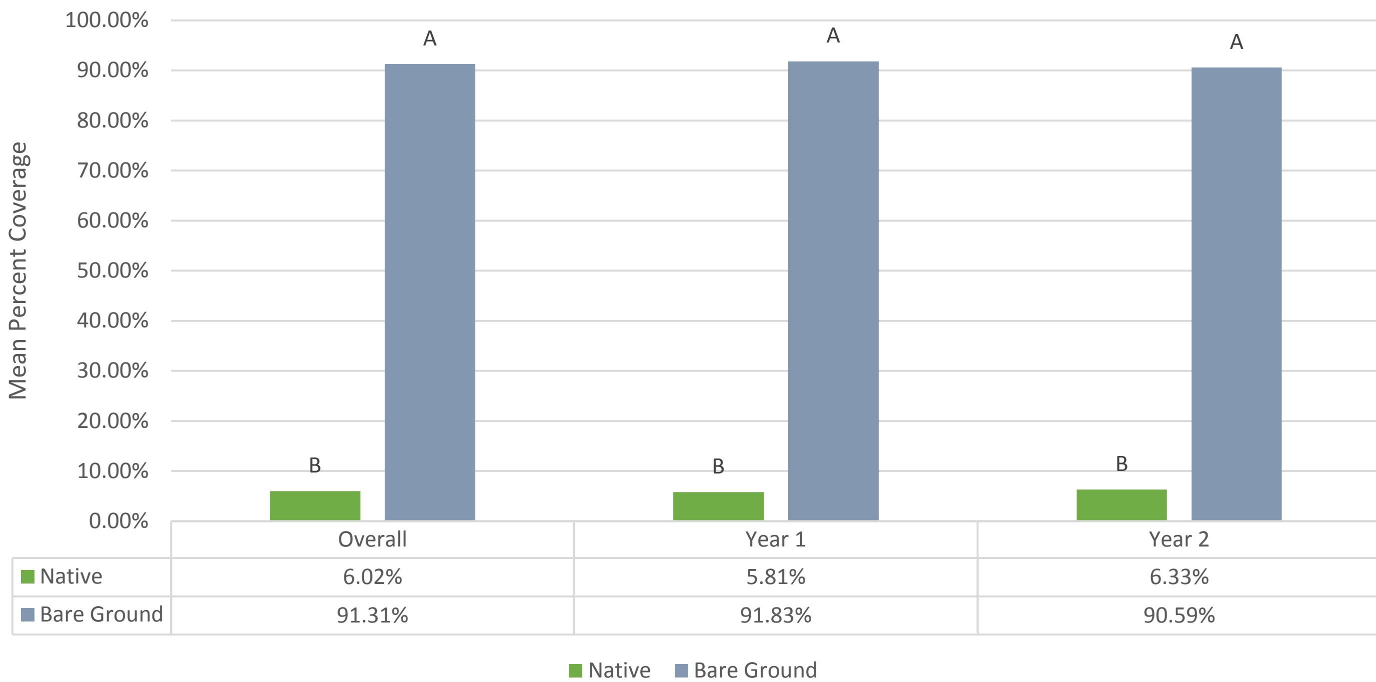
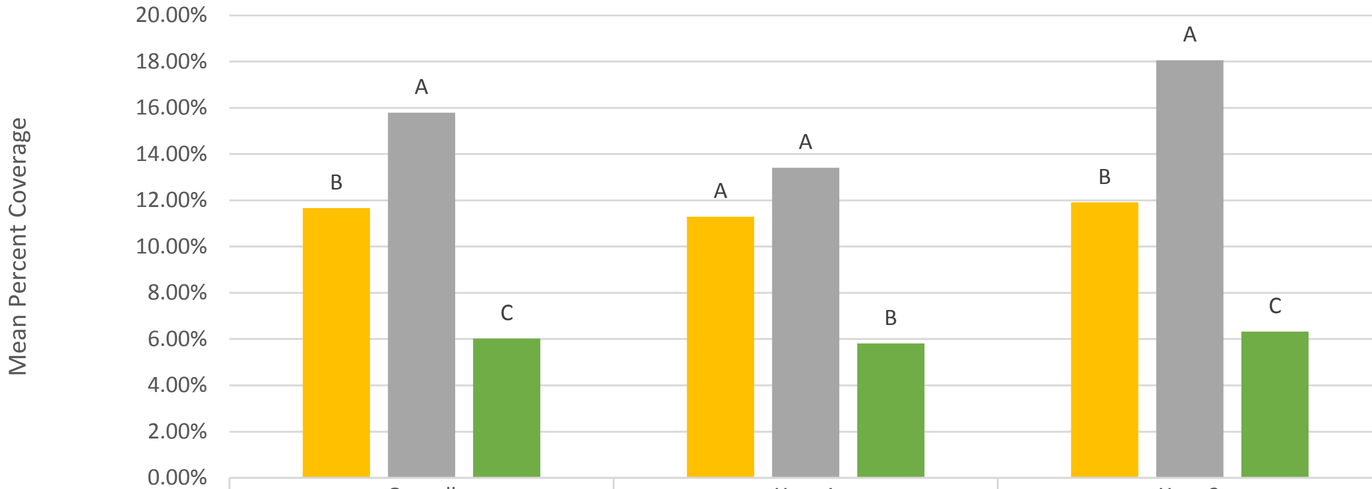


Figure 7. Graph depicting ANOVA results for Native verses Bare Ground for Coastal Salt Marsh habitat classification and for time. Overall ($F_{1, 864}$ = 25258.57, p<0.001), Year 1 ($F_{1,505}$ = 15378.59, p<0.001) and Year 2 ($F_{1,357}$ = 9934.21, p<0.001). Analyses were run individually for each classification. Bars not sharing a letter are significantly different.

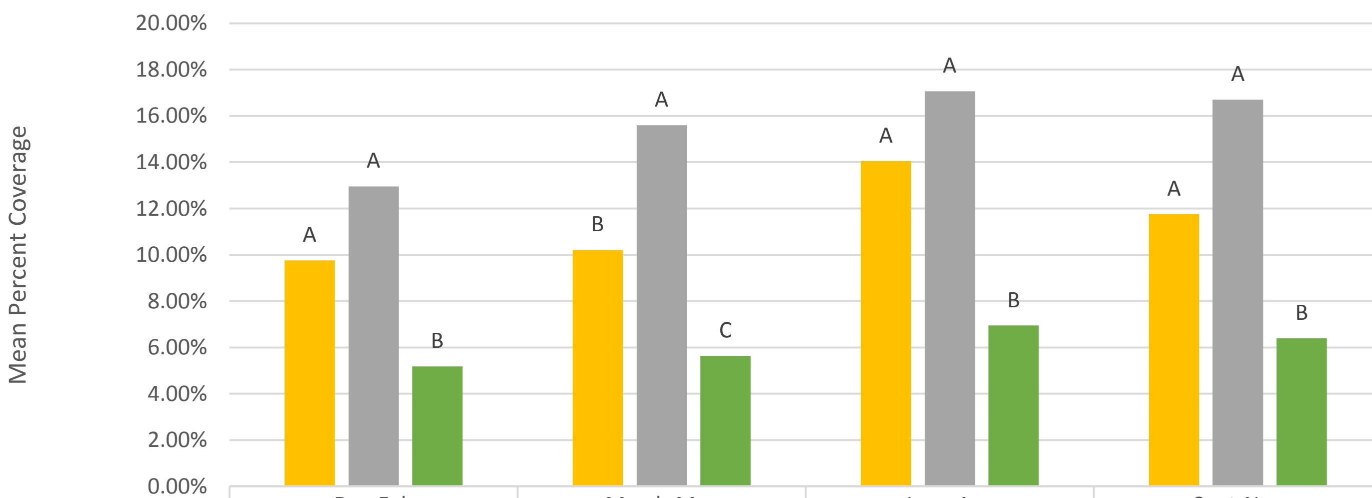
Figure 8 shows the mean percent coverage of the habitat classifications next to each other to clearly show the percent coverage of these various habitats. The Dune habitat shows a significantly greater mean than the two other habitats in Year 2 ($F_{2,427}$ = 23.50, p<0.001), but in Year 1 the Dune habitat is not significantly different than the Coastal Sage Scrub habitat ($F_{2,468}$ = 19.46, p<0.001) (Figure 8). The Coastal Salt Marsh has a significantly lower mean percent coverage than the two other habitats for both years combined ($F_{2,898}$ = 44.92, p<0.001), Year 1 ($F_{2,468}$ = 19.46, p<0.001) and Year 2 ($F_{2,427}$ = 23.50, p<0.001) (Figure 8). The seasonal growth of native vegetation shows a clear pattern that is shared between all of the habitat classifications. There is a peak in mean percent coverage in June through August followed by a decline in September through November (Figure 9).



	Overall	Year 1	Year 2
Coastal Sage Scrub	11.66%	11.29%	11.91%
Dune	15.79%	13.41%	18.06%
Coastal Salt Marsh	6.02%	5.81%	6.33%

Coastal Sage Scrub Dune Coastal Salt Marsh

Figure 8. Graph depicting ANOVA results for Native percent coverage for habitat classifications and year. Overall ($F_{2,898} = 44.92$, $p<0.001$), Year 1 ($F_{2,468} = 19.46$, $p<0.001$) and Year 2 ($F_{2,427} = 23.50$, $p<0.001$). Analyses were run individually for each time classification. Bars not sharing a letter are significantly different.



	Dec-Feb	March-May	June-Aug	Sept-Nov
Coastal Sage Scrub	9.76%	10.22%	14.05%	11.77%
Dune	12.96%	15.60%	17.07%	16.70%
Coastal Salt Marsh	5.18%	5.64%	6.94%	6.40%

Coastal Sage Scrub Dune Coastal Salt Marsh

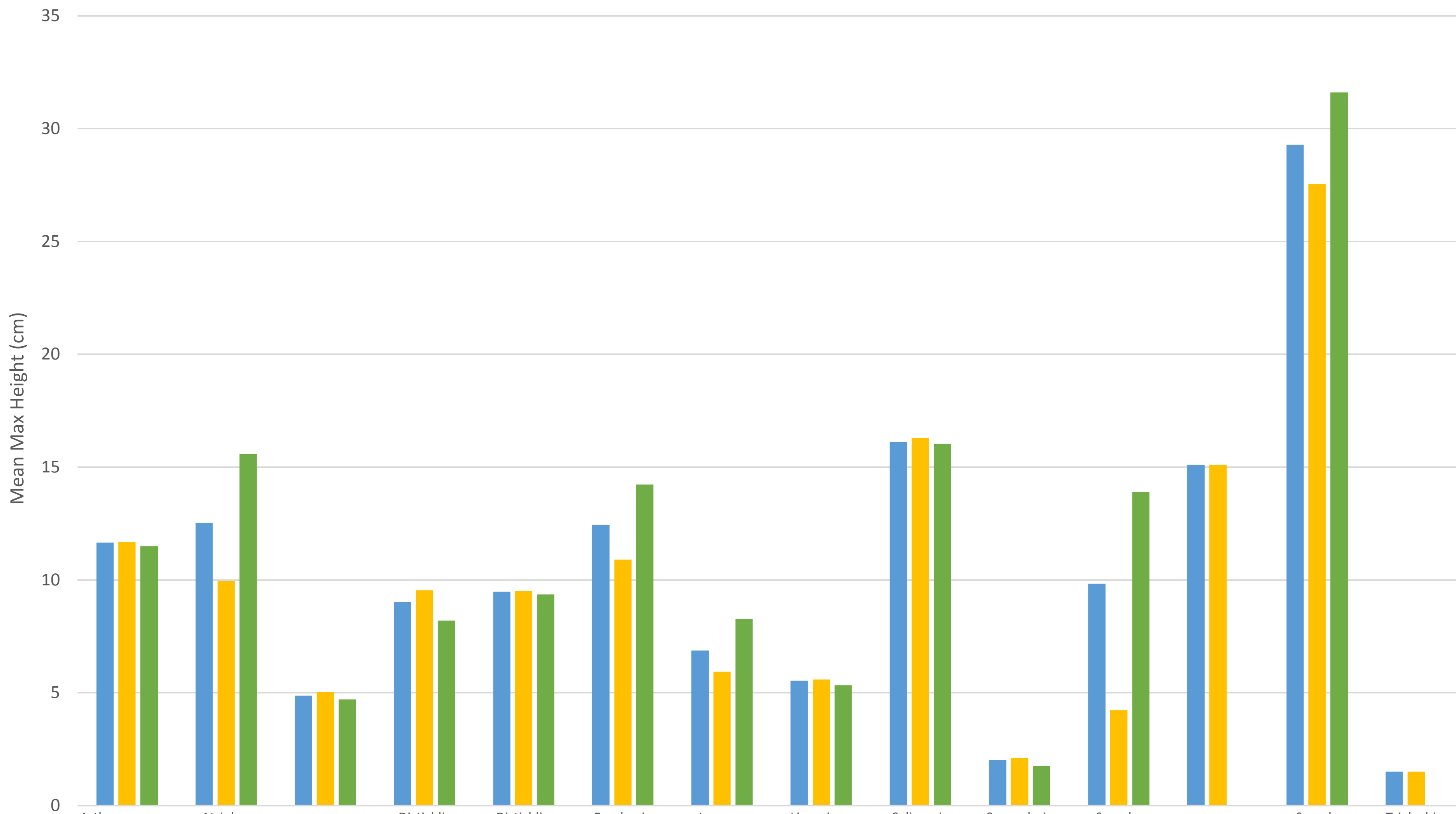
Figure 9. Graph depicting ANOVA results for habitat classification percent coverage per season for Native plants. December- February ($F_{2,200} = 11.55$, $p<0.001$), March-May ($F_{2,255} = 14.07$, $p<0.001$), June-August ($F_{2,257} = 11.36$, $p<0.001$) and September-November ($H_{2,177} = 8.60$, $p<0.001$). Analyses were run individually for each classification. Bars not sharing a letter are significantly different.

The Shannon-Wiener Indices show that the effective number of species increases from Year 1 to Year 2 for all habitats except the Coastal Salt Marsh which slightly decreases (Table 2). There is no clear pattern for the number of native species found for each habitat classification, but the communities are fairly even with species evenness values falling between 0.759-0.903 (Table 2).

Table 2. Shannon-Wiener Diversity Indices, Max Biodiversity, Species Evenness and Effective number of Species for Both Years, Year 1 and Year 2 broken down by Native and Non-Native classification as well as habitat classification.

	Coastal Sage Scrub			Dune			Coastal Salt Marsh		
	Overall	**Year 1**	**Year 2**	**Overall**	**Year 1**	**Year 2**	**Overall**	**Year 1**	**Year 2**
S	28	17	20	13	9	8	16	14	14
n	298	113	181	131	64	67	708	368	340
H	2.735	2.404	2.593	1.949	1.797	1.854	2.422	2.382	2.342
Hmax	3.332	2.833	2.995	2.565	2.197	2.079	2.772	2.639	2.639
EH	0.821	0.848	0.865	0.759	0.817	0.892	0.873	0.903	0.887
Effective number of Species	15.409	11.067	13.369	7.022	6.032	6.385	11.268	10.826	10.402

The Coastal Salt Marsh represent a biologically important area and was therefore analyze for species mean max height. *Suaeda taxifolia* had the largest plant height for Year 1 and Year 2, followed by *Salicornia pacifica* and *Atriplex watsonii* (Figure 10). By looking at Figure 10 it is clear that there is a good canopy variation between the species.



	Arthrocnemum subterminale	Atriplex watsonii	Batis maritima	Distichlis littoralis	Distichlis spicata	Frankenia salina	Jaumea carnosa	Limonium californicum	Salicornia pacifica	Spergularia marina	Suaeda calceoliformis	Suaeda esteroa	Suaeda taxifolia	Triglochin concinna
Overall	11.65	12.54	4.868	9.024	9.48	12.434	6.871	5.533	16.12	2.024	9.83	15.1	29.28	1.5
Year 1	11.67	9.96	5.036	9.54	9.5	10.9	5.931	5.583	16.29	2.105	4.231	15.1	27.54	1.5
Year 2	11.5	15.59	4.7	8.2	9.35	14.223	8.259	5.33	16.03	1.767	13.88	0	31.6	0

Overall Year 1 Year 2

Figure 10. Graph depicting ANOVA results for Native percent coverage within the Coastal Salt Marsh for time Overall, Year 1 and Year 2.

Discussion

After two years of vegetation monitoring, sixty-two plant species were identified in the Western Arm Restoration area. Thirty eight of the species were native with an average percent coverage of eight percent for Year 1 and ten percent for Year 2, while twenty-four species were non-native with an average percent coverage of two percent for Year 1 and Year 2. There was a seasonal peak in mean percent coverage from June to August for Native vegetation and for each habitat classification. This suggests that the best time to gain a mean max percent coverage would be to sample during these months.

Although Bare Ground percent coverage decreased from Year 1 to Year 2 overall and for each habitat classification there is still a significant amount present. This can be attributed to plants just becoming established in the Western Arm area and still competing with non-native vegetation. This number is expected to decrease significantly as the plants mature throughout the years. The most productive habitat classification was the Coastal Sage Scrub which had a decrease in bare ground coverage by 17.65% from Year 1 to Year 2 with only a 0.62% increase in mean percent coverage of Native species. This information suggests that the plants in the Coastal Sage Scrub habitat could be allocation their energy towards root growth and in subsequent years change that allocation to shoots and leave growth, upon which the above percent coverage will increase.

Looking at vegetation by species break down, we found that the most abundant native species was Fleshy Jaumea, *Jaumea carnosa,* followed by Common Pickleweed, *Salicornia pacifica* and Sand Spurry, *Spergularia marina.* The most abundant non-native species was Cheeseweed, *Malva parviflorum,* followed by Bermuda Grass, *Cynodon dactylon,* and Australian Salt Bush, *Atriplex semibaccata.*

The Shannon-Wiener Indices indicated that the effective number of species increased from Year 1 to Year 2 for all habitats except the Coastal Salt Marsh, which slightly decreased. The monitoring of the plant community may show that positive interactions, also known as facilitations, between the plant and wildlife community will help the Colorado Lagoon increase in species diversity, plant survival rate and overall health. This Year 2 report will allow management to be adaptive in the restoration processes for future surveys. The restoration goals set in the monitoring plan show that at the end of Year 2, the non-native percent coverage does achieve the restoration goal of less than ten percent. Unfortunately the second restoration goal of having 50%-70% native vegetation coverage verses bare ground for any of the habitat classifications was not achieved. The third goal of having no one species that compromised an average of more than fifty percent coverage was also achieved.

Literature Cited

Zedler, J.B., ed. 2001. *Handbook for Restoring Tidal Wetlands.* Baton Rouge*:* CRC Press.

Tidal Influence

Chapter Two: Avifauna

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Introduction

Historically the 2400 acres of the Los Cerritos Wetland was a major resting place for migratory birds and home to a varity of avian communities, but with the population growth and associated coastal development, over destroyed over ninety percent of wetlands habitat has been destroyed (Finstad 2008). This has a large impact on the avian communities and migratory birds that used the wetland area for foraging, breeding and resting location, now these species have to finding alternative locations for these activites.

Colorado Lagoon has historically been a good location for these avain communities, but due to past degradation and habitat destruction the diversity of the community declined. The original ecosystem has been severely damaged, but due to recent mitigation efforts an alternative state may have precipitated. This analysis will take into account the ecosystem functioning as determined by species diversity. Ecosystems with poor species diversity do not function properly and have a decreased productivity (Balun, 1999). The observations of the avian community at Colorado Lagoon will provide a baseline inventory of species, to allow for coorolations and comparisons in the assemblage of the avian community with the changes of the restoration processes.

Methods

Field Methods

For Year 1 fourteen avian surveys were conducted from October 2012 to July 2013, and for Year 2 four surveys were conducted from October 2013 to July 2014. Observational data was record on the data sheet (Appendix 2.2) prior to the start of the survey. The survey was conducted by walking around the perimeter of the Colorado Lagoon, starting at the Wetlands And Marine Science Education Center (WAMSEC) and heading East along the trail. Data recorded included avian species, count, behavior, and location (Figure 1). Table 1 shows the description for the behavorial actions and habitat usage. Behavior and location was recorded on a presence or absence basis for more than one individual.

Table 1. Avian Behavioral Actions Descriptions (left) and Habitat Usage Descriptions (right).

Behavior	**Descripion**
Aquatic feeding	Bird is actively searching for food in the water,or eating
Flight	Flying
Ground feeding	Bird is actively searching for food on the ground, pecking at ground
Other	Bird is doing a behavior not listed-in notes column indicate behavior (i.e. Mating)
Preening	Bird is actively preening its own feathers or another birds
Resting	Bird has its head resting on its dorsal side,or under its wing
Seeking in Flight	Bird is flying over area and scanning ground, shrubs, water
Seeking Standing	Bird is standing and seeking for food in the water or on the ground
Seeking Walking	Bird is actively walking seeking for food in the water or on the ground

Habitat	**Description**
A	Artificial-Telephone poles,fences,buildings
F	Flying
U	Uplands-Area above mudflats compromising Coastal Sage Scrub,Dune
W	Wetlands-on the mudflats,in the water,or in the Coastal Salt Marsh

Statistics

All birds were divided into twelve orders as determined by the California Bird Records Committee (2013) (Table 2). Each positively identified bird species was checked for protection status by the Migratory Bird Treaty Act (MBTA), Endangered Species Act (ESA), and California Endangered Species Act (CESA) using U.S. Fish and Wildlife's (2012) *MBTA list of Migratory Birds*, and the California's Bird Records Committee's (2013) *State Bird List*. Each species was also identified as native or introduced (California's Bird Records Committee, 2013). In order to understand the impact of the Western Arm Natural Area Restoration, bird assemblages were divided into two categories based on their location. Figure 2 highlights the Western Arm area in red, and the remaining parts of the Lagoon are classified as outside of the Western Arm Natural Area.

The data was also analyzed for gamma diversity (overall) for each species and Order. Species richness (diversity of order zero), Shannon-Wiener Index (diversity of order one) and species evenness were calculated (General Methods equations 1-5).

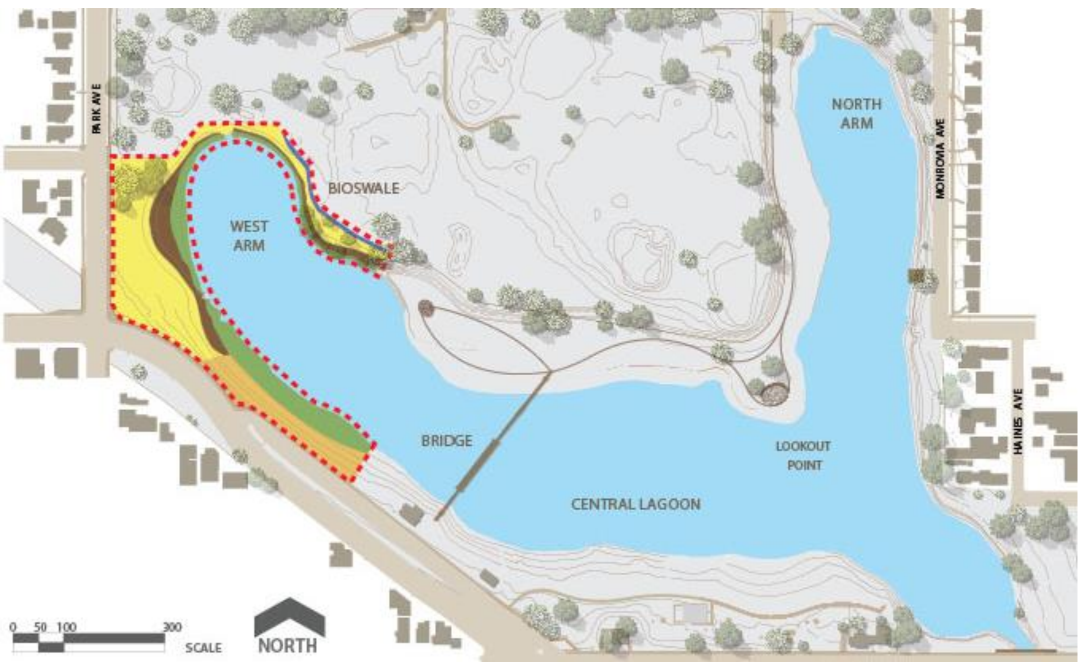

Figure 1. Map of the Colorado Lagoon, highlighting the Western Arm Natural Area.

Table 2. Descriptions of birds that fall into the Order as determined by the California Bird Records Committee.

Order	Description
Accipitriformes	Hawks, Kites, Eagles, and Allies
Anseriformes	Screamers, Swans, Geese and Ducks
Apodiformes	Swifts, and Hummingbirds
Charadriiformes	Shorebirds, Gulls, Auks, and Allies
Columbiformes	Pigeons, and Doves
Coraciiformes	Rollers, Motmots, Kingfishers, and Allies
Gaviiformes	Loons
Gruiformes	Rails, Cranes, and Allies
Passeriformes	Passerine Birds
Pelecaniformes	Pelicans, Herons, Ibises, and Allies
Podicipediformes	Grebes
Psittaciformes	Lories, Parakeets, Macaws, and Parrots
Suliformes	Frigatebirds, Boobies, Cormorants, Darters, and Allies

Results

Sixty-three species of birds were seen at the Colorado Lagoon for Year 1 and Year 2 combined. All but four species, the European Startling, *Sturnus vulgaris*, the House Sparrow, *Passer domesticus*, Mitred Conure, *Aratinga Mitrata*, and the Rock Pigeon, *Columba livia*, were native and protected by the Migratory Bird Treaty Act (Appendix 2.3).

The top three most abundant avian Orders was the Gruiformes with 2650 individuals, Anseriformes with 1420 individuals and Charadriiformes with 744 individuals (Appendix 2.4.1.1). The top three most abundant Species was *Fulica americana* with 2650 individuals, *Aythya affinis* with 801 individuals and *Larus delawarensis* with 364 individuals (Appendix 2.4.2.1).

According to the Shannon-Wiener diversity index, for an overall view (both years and location) Colorado Lagoon has a low diversity, low evenness, low number of avian species for Order classification, and low number for effective number of Orders (H=1.39, H_{max}=2.64, E_H=0.53, Effective number=4.047) (Table 3). For species classification, for an overall view Colorado Lagoon has a slightly higher diversity, and effective number of species (H =2.11, H_{max}=4.14, E_H=0.51, Effective number=8.22) (Table 3). The number of effective species dropped from Year 1 (15.66) to Year 2 (7.31), but the effective number of Orders increased from Year 1 (3.82) to Year 2 (5.54) (Table 3).

Table 3. Shannon-Wiener Diversity Indices, Max Biodiversity, Species Evenness and Effective number of Species for Year 1 and Year 2 broken down by Species and Order classification.

	Order			Species		
	Both Years	**Year 1**	**Year 2**	**Both Years**	**Year 1**	**Year 2**
S	14	11	13	63	52	48
N	5454	4813	707	5454	4813	707
H	1.398	1.341	1.712	2.106	2.751	1.989
Hmax	2.639	2.398	2.565	4.143	3.951	3.871
EH	0.529	0.559	0.667	0.508	0.696	0.514
Effective number of Species	4.047	3.823	5.54	8.215	15.658	7.308

For Order classification, outside the Western Arm had a lower effective number of Orders (3.94) than inside the Western Arm Reserve (4.47) (Table 4). Gruiformes composed 38% of individuals observed in the Western Arm area and 50% of individuals observed outside of the Western Arm (Figure 2). For species classification, Western Arm Reserve had the largest number of effective species (9.61) than outside the Western Arm (7.46) (Table 4).

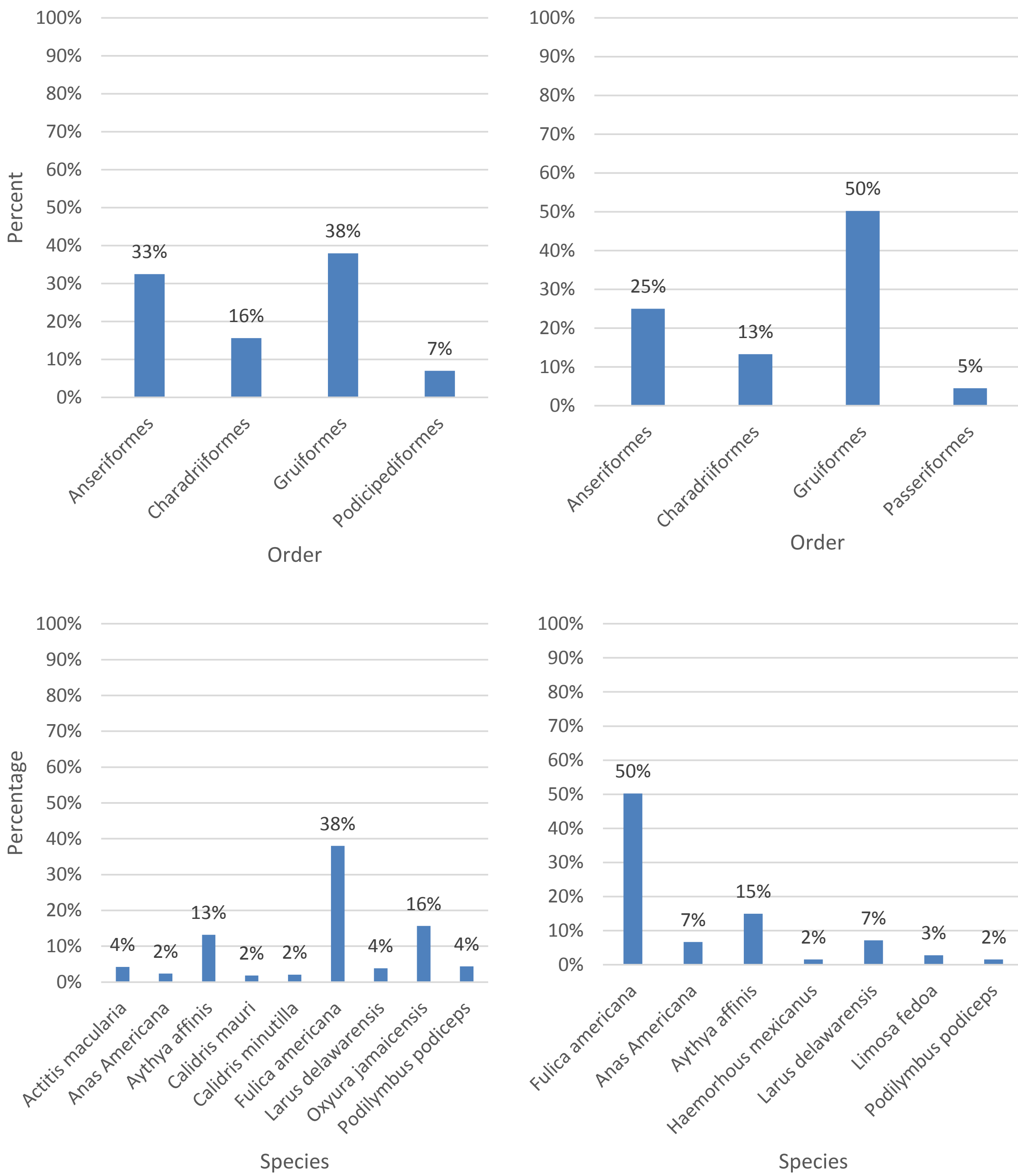

Figure 2. Graphs depicting the effective number of species or Order from inside the Western Arm area (left) and outside the Western Arm Area (right), the percentage is based off of total number of individuals observed.

Table 4. Shannon-Wiener Diversity Indices, Max Biodiversity, Species Evenness and Effective number of Species for Year 1 and Year 2 broken down by Species and Order classification per inclusion or exclusion of the Western Arm area.

	Western Arm Area		Outside Western Arm	
	Order	**Species**	**Order**	**Species**
S	11	32	12	59
n	729	729	4725	4725
H	1.498	2.263	1.372	2.01
Hmax	2.398	3.466	2.485	4.078
EH	0.625	0.653	0.552	0.493
Effective number of Species	4.473	9.612	3.943	7.463

By looking at the presence or absence of habitat usage by Order, overall we see that the wetlands habitat is used seventy-seven percent of the time (Table 5 and Figure 3). Of the observations with in the Western Arm, the usage of wetlands habitat increases up to eighty-five percent of the time. All other habitat usage (artificial, flying and uplands) was used no more than 10% of the time for the entire Colorado Lagoon, the Western Arm and outside the Western Arm (Table 5 and Figure 3).

Table 5. Chart depicting the presence or absence of habitat usage by Order for the entire Colorado Lagoon, the Western Arm and outside the Western Arm.

		Accipitriformes	Anseriformes	Apodiformes	Charadriiformes	Columbiformes	Coraciiformes	Gaviiformes	Gruiformes	Passeriformes	Pelecaniformes	Podicipediformes	Psittaciformes	Suliformes	Trochiliformes	**TOTAL**	PERCENT
Overall	Artificial	0	0	0	5	3	1	0	1	14	6	0	0	3	2	35	6
	Flying	1	3	1	27	0	0	0	0	11	8	1	1	1	2	56	9
	Uplands	2	5	0	6	5	0	0	4	21	1	0	0	0	3	47	8
	Wetlands	0	143	0	98	3	0	1	68	6	26	111	0	16	0	472	77
Western Arm	Artificial	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1
	Flying	0	0	1	2	0	0	0	0	4	0	0	1	0	1	9	7
	Uplands	0	0	0	1	1	0	0	0	4	0	0	0	0	2	8	7
	Wetlands	0	37	0	22	2	0	0	10	0	1	28	0	3	0	103	85
Outside Western Arm	Artificial	0	0	0	5	3	1	0	1	13	6	0	0	3	2	34	7
	Flying	1	3	0	25	0	0	0	0	7	8	1	0	1	1	47	10
	Uplands	2	0	0	5	4	0	0	4	17	1	0	0	0	1	34	7
	Wetlands	0	106	0	76	1	0	1	58	6	25	83	0	13	0	369	76

Analyzing what species perform what behaviors within the Western Arm area shows that 66% of the behaviors exhibited by the top nine most abundant species was aquatic feeding followed by resting (13%) (Table 6). The species that the highest precence for behaviors preformed was *Podilymbus podiceps* (25%) followed by *Aythya affinis* and *Oxyura jamaicensis* at 16%.

Although the majority of the habitat usage was outside the Western Arm area (79%) there is a clear pattern that emerges showing that the wetlands habitat is vital for avian species at the Colorado Lagoon.

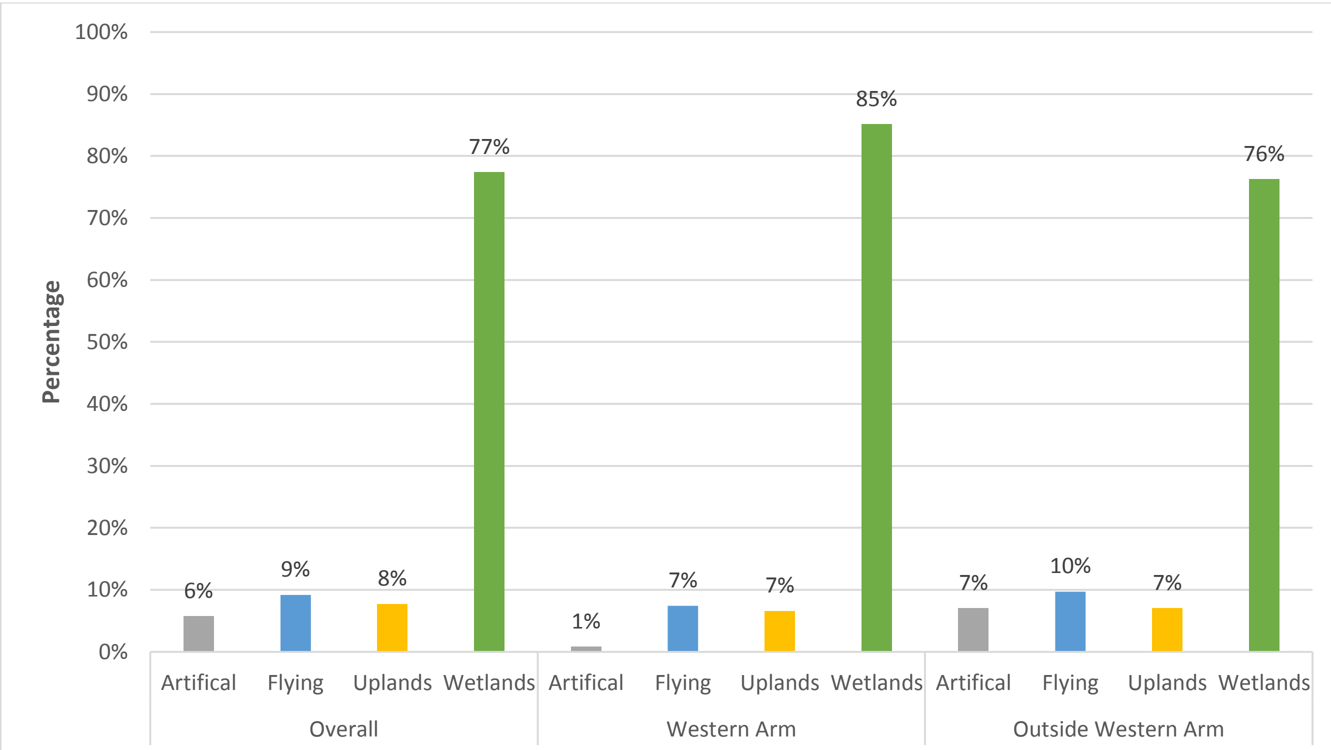

Figure 3. Graph showing the percentage of presence or absence of habitat usage by all Orders for the entire Colorado Lagoon, the Western Arm and outside the Western Arm.

Table 6. Chart depicting the presence or absence of behavior by Species within the Western Arm area.

	Aquatic Feeding	Ground Feeding	Preening	Resting	Seeking Standing	Seeking Walking	TOTAL	PERCENT
Actitis macularia	**2**	**1**	0	0	0	**3**	6	9%
Anas Americana	**4**	0	**1**	0	0	0	5	7%
Aythya affinis	**11**	0	0	0	0	0	11	16%
Calidris mauri	**1**	0	0	0	0	0	1	1%
Calidris minutilla	0	**1**	0	0	**5**	0	6	9%
Fulica americana	**6**	**1**	0	**1**	0	**1**	9	13%
Larus delawarensis	**1**	**1**	0	0	0	0	2	3%
Oxyura jamaicensis	**5**	0	0	**6**	0	0	11	16%
Podilymbus podiceps	**15**	0	0	**2**	0	0	17	25%
TOTAL	45	4	1	9	5	4	68	
PERCENT	66%	6%	1%	13%	7%	6%		

Discussion

This baseline inventory for the Colorado Lagoon for 2013-2014 found sixty-three species of birds in thirteen Orders. All of the species were native to California and protected by the Migratory Bird Treaty Act except four that have been introduced.

The Shannon-Wiener index showed that the Colorado Lagoon has a low diversity, low evenness, low number of avian species for Order classification, and low number for effective number of Orders (H=1.39, Hmax=2.64, EH=0.53, Effective number=4.047). The three most abundant Orders were Gruiformes (Rails, Cranes, and Allies), Anseriformes (Screamers, Swans, Geese, and Ducks), and Charadriiformes (Shorebirds, Gulls, Auks, and Allies).

The Shannon-Wiener index for species classification, showed that the Colorado Lagoon has a slightly higher diversity, and effective number of species (H =2.11, Hmax=4.14, EH=0.51, Effective number=8.22). It is interesting to see that the effective number of species drops from Year 1 (15.66) to Year 2 (7.31), but the effective number of Orders increases from Year 1 (3.82) to Year 2 (5.54). Comparing the Western Arm area and the area outside of the Western Arm, highlights important information about the restoration successes. The Western Arm has a higher number of effective Orders (4.47) and it also has the largest number of effective species (9.61). This may suggest that the new habitat is being used and new Orders are inhabiting these areas while the diversity of species within an Order drops. This also may suggest that the habitat is becoming more balanced and even, or is could just show the difference in sampling density between Year 1 and Year 2.

Examining the habitat usage and more specifically the use of wetlands in the Western Arm is useful to understand how the restoration area is being used. Over time and area the wetlands habitat is used seventy-seven percent of the time, and of the observations within the Western Arm the wetlands habitat usage increases to eighty-five percent of the time. The other habitats (artificial, flying and uplands) were used no more than 10% of the time by all orders. This sheds light on how important the wetlands habitat is for the avian communities. The behaviors of the top nine most abundant species in the Western Arm show that 66% of the time they are aquatic feeding or resting (13%).

The Colorado Lagoon ecosystem is currently functioning with a low diversity, but through time we expect to see different species use the area as the restoration process creates new habitats and matures. Avian species are a type of indicator, or species whose presence or absence is indicative of the environmental conditions by observing and recording the avian assemblage though time we may be able to show how the Colorado Lagoon habitat restoration process has changed the ecosystem into a developed community.

Literature Cited

Committee, The California Bird Records."Official California Bird Records Committee State Bird List."*California Bird Records Committee Home Page*. California Bird Records Committee, 7 Apr. 2013. Web. 1 Dec. 2013. <http://californiabirds.org/ca_list.asp>.

Balun, Robert."The Importance of Species Diversity to the Ecosystem."*eHow How to Videos, Articles & More - Discover the expert in you. |eHow.com*. eHow, 1 Jan. 1999. Web. 7 Dec 2013. <http://www.ehow.com/about_6508788_importance-species-diversity-ecosystem.html>.

"Bird Web."*Bird Web*. Seattle Audubon Society, 1 Nov. 2002. Web. 10 Dec.2013. <http://www.birdweb.org>.Finstad,Kristina.*Digging in:a guideto community-based habitat restoration*. SanFrancisco, CA: California

Coastal Commission's Public Education Program, 2008. Print.

Jost, Lou."Effective Number of Species is Diversity."*Home Page*. Chapman and Hall Publishers, 1 Apr. 2009. Web. 12 Dec. 2013. <http://www.loujost.com/Statistics%20and%20Physics/Diversity%20and%20Similarity/EffectiveNumberOfSpecies.htm>.

"MBTA List of Migratory Birds."*U.S. Fish and Wildlife Service Home*. U.S. Fish and Wildlife Service, 11 Apr. 2012. Web. 1 Dec. 2013. < http://www.fws.gov/migratorybirds/RegulationsPolicies/mbta/MBTANDX.HTML >.

Chapter Three: Ichthyofauna

Julie McNamara

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Introduction

Lagoons, bays, and estuaries are important feeding and nursery grounds for many fish species because they offer a safe haven. The fish assemblages are important to survey because these are often the first organisms to rapidly colonize restored habitats (Zedler, 2001). Past surveys have shown that many fish species used the Colorado Lagoon for different purposes throughout the year (Allen and Horn, 1975). By conducting fish seines directly after the dredging in 2009, and then quarterly for the next two years it maybe possible to see the growth of the fish population over time. The objective of the fish surveys is to measure the difference between species, abundance, and species length over time. This data will then be compared to historical data to determine recolonization success.

Past Fish Surveys

In 1973, L. G. Allen and M. H. Horn surveyed fish species and abundance in the Colorado Lagoon every month. A total of 152,169 fishes from 23 species were caught in 37 beach seine hauls. Over 99% of the total number of species collected were comprised of only four species—northern anchovy (*Engraulis mordax*), topsmelt (*Atherinops affinis*), slough anchovy (*Anchoa delicatissima*), and shiner surfperch (*Cymatogaster aggregata*). Northern anchovy alone made up 90% of the catch. This study looked at the seasonality of these fish and found that several of the species did display patterns of occurrence and abundance throughout the year. Five species were considered to be residents of the Lagoon. Allen and Horn's survey also looked at the relationship of temperature and number of species and individuals collected. In the future, temperature data should be collected while conducting the beach seines to better compare the current fish data with that of Allen and Horn's work.

Methods

Field Methods

Fish seines were conducted at three locations (North Beach, South Beach and Western Arm) at the Colorado Lagoon (Figure 1). For Year One, five samples were taken between January 2013 and August 2013. For Year Two, four samples were taken between October 2013 and September 2014. All surveys were conducted at a mid-tide using a 1.5 m deep by 30 m long net with a 3.2mm mesh size. The seine was set parallel to the beach and hauled to shore, upon which ten individuals of each fish species (if applicable) were measured for length (cm) and count total per species (Appendix 3.0). Fish were released after they were counted, and mortality after capture was not recorded.

Figure 1. Map of the Colorado Lagoon showing the locations of the fish seines.

Results

The top three most abundant fish species caught was the California Killifish, Fundulus parvipinnis, with 1617 individuals caught, the Arrow Gobi, Clevelandia ios, with 1470 individuals, and Topsmelt, Atherinops affinis, with 897 individuals. This trend holds true for both Year 1 and Year 2 catches.

According to the Shannon-Wiener diversity index, for an overall view (time and location) Colorado Lagoon has a low diversity, low evenness, and a low number of fish species for Order classification ($H = 1.17$, $H_{max} = 2.08$, $E_H = 0.56$) and species classification ($H = 1.18$, $H_{max} = 2.64$, $E_H = 0.45$) (Table 1). Looking at the effective number of species, there are between 2.78–3.41 equally common species. For species classification, North Beach had the largest effective number of species (3.20) followed by South Beach (3.08) and Western Arm (2.66) (Table 2).

Table 1. Shannon-Wiener Diversity Indices, Max Biodiversity, Species Evenness and Effective number of Species for Year 1 and Year 2 broken down by Species and Order classification.

	Order			Species		
	Both Years	Year 1	Year 2	Both Years	Year 1	Year 2
S	8	8	8	14	13	10
n	4068	1722	2346	4068	1722	2346
H	1.17	1.208	1.021	1.179	1.226	1.021
Hmax	2.079	2.079	2.079	2.639	2.565	2.302
EH	0.563	0.581	0.491	0.447	0.478	0.444
Effective number of Species	3.222	3.347	2.776	3.251	3.408	2.779

Table 2. Shannon-Wiener Diversity Indices, Max Biodiversity, Species Evenness and Effective number of Species for both years combined per Species classification.

	Species		
	North Beach	South Beach	Reserve
S	10	8	9
n	1066	1342	1660
H	1.164	1.125	0.979
Hmax	2.302	2.079	0.445
EH	0.506	0.541	0.445
Effective number of Species	3.203	3.08	2.662

The fish length for the top 5 most abundant species and Diamond Turbot, *Hypospsetta guttulata*, which is an important fisheries species, were analyzed for statistical differences for both years of monitoring and all sites (Figure 2). *Syngnathus griseolineatu* had a statistically significant larger length than the other species ($F_{5,619} = 65.10$, $p<0.001$). *Clevelandia ios* had the smallest length and was only statistically different from *Leptocottus armatus*.

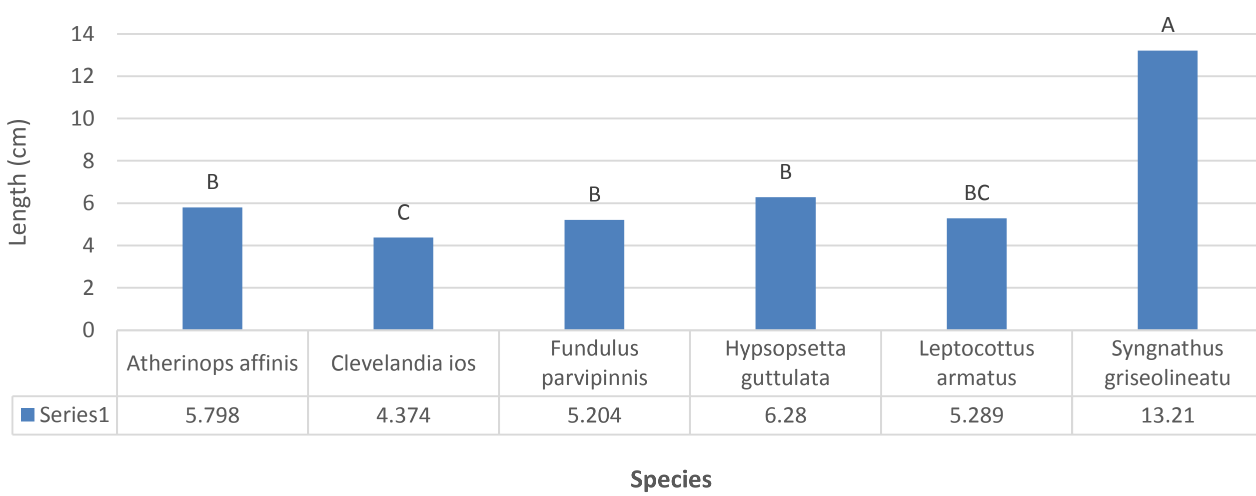


Figure 2. Bar graph showing the statistical difference in length (centimeters) of five across the three sides and two years, bars not sharing a letter are statistically different from one another (F5,619 = 65.10, p<0.001).

The fish length was further broken down per site to compare differences (Figure 3). The above trend of *Syngnathus griseolineatu* having a statistically larger length and *Clevelandia ios* having the smallest length holds true for each site. The only exception is that *Syngnathus griseolineatu* was not caught in the Western Arm Reserve area. Four out of the six species that were caught had the largest mean fish length in the Western Arm Reserve (Figure 4). North Beach had the other two species with the largest mean fish length with South Beach having none of the largest mean fish lengths.

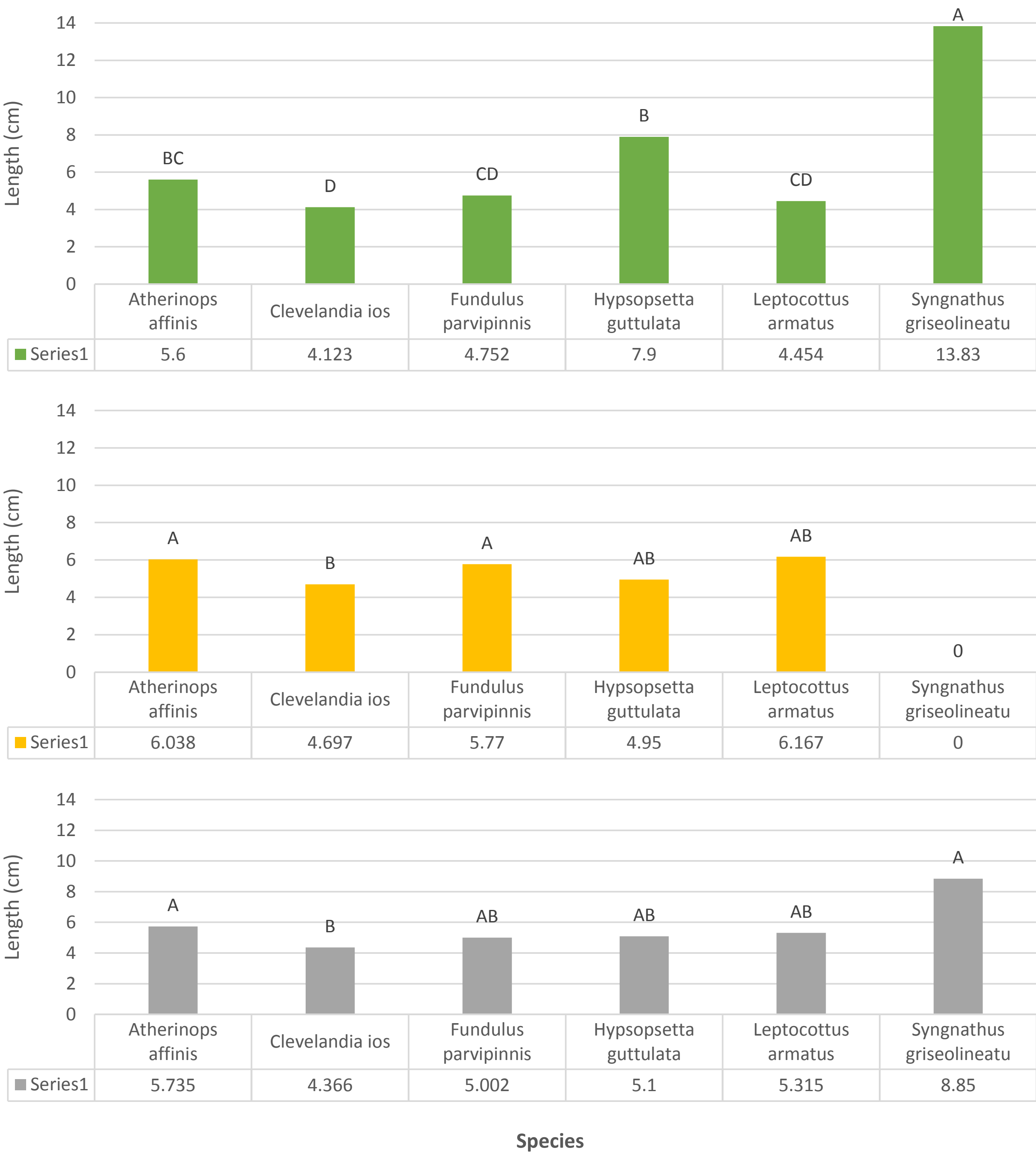
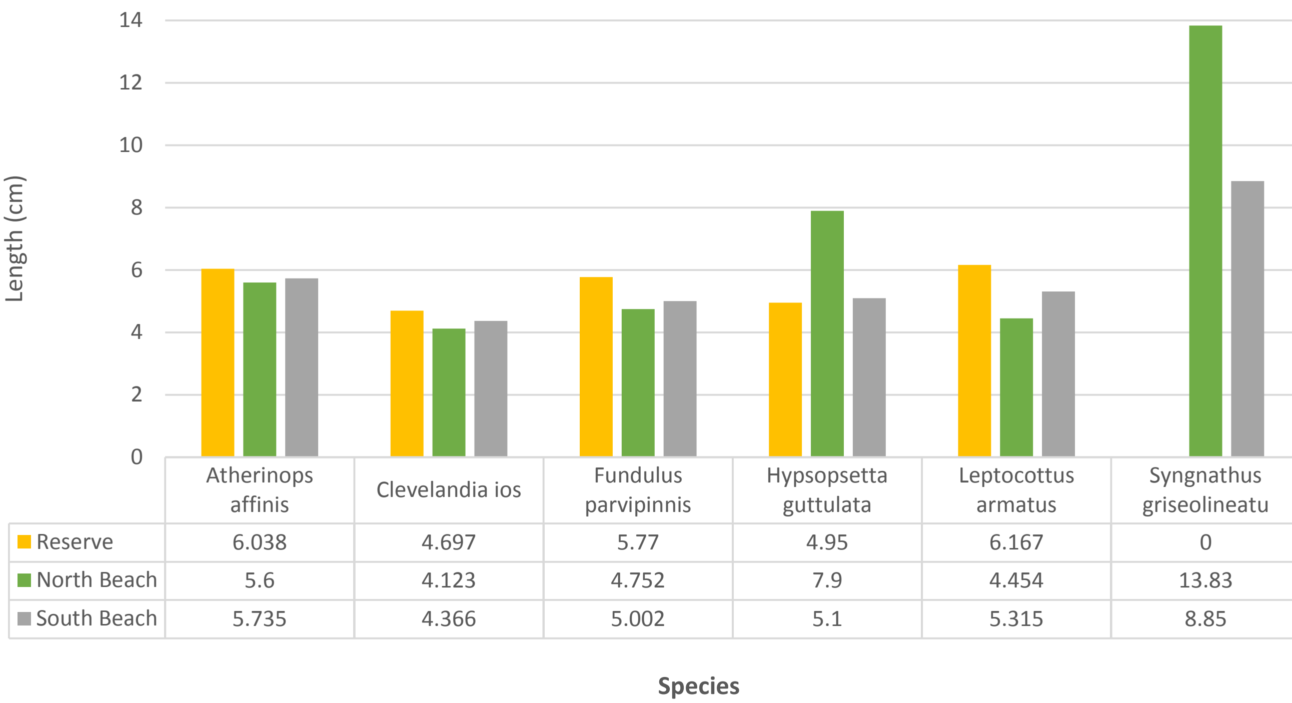


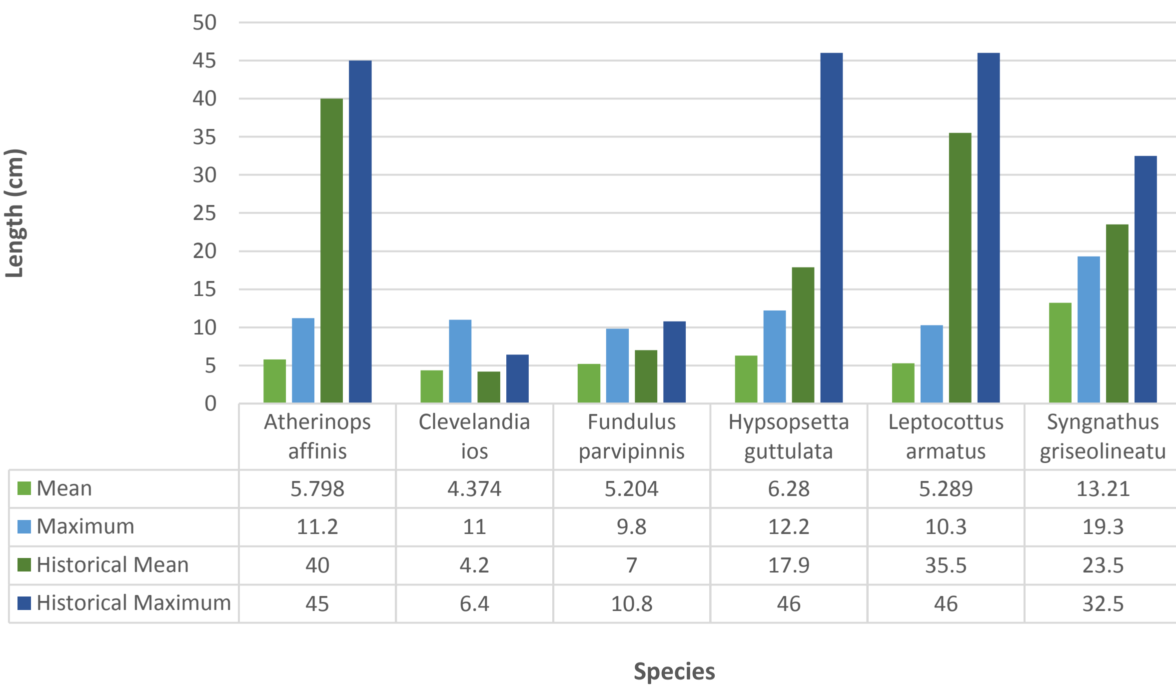
Figure 3. Bar graph showing the statistical difference in length (centimeters) of five species caught at North Beach (top) ($F_{5,223} = 67.23$, $p<0.001$), Reserve (middle) ($F_{4,201} = 4.59$, $p=0.001$), and South Beach (bottom) ($F_{5,184} = 4.88$, $p<0.001$), bars not sharing a letter are statistically different from one another.



	Atherinops affinis	Clevelandia ios	Fundulus parvipinnis	Hypsopsetta guttulata	Leptocottus armatus	Syngnathus griseolineatu
Reserve	6.038	4.697	5.77	4.95	6.167	0
North Beach	5.6	4.123	4.752	7.9	4.454	13.83
South Beach	5.735	4.366	5.002	5.1	5.315	8.85

Figure 4. Bar graph showing the length in centimeters of five species caught at North Beach, Reserve, and South Beach side by side.

The six fish species were also compared with literature maximum and mean lengths (Figure 5). For Topsmelt, *Atherinops affinis*, the average size caught at the Colorado Lagoon was 5.78cm, while literature reports an average size of 40cm (Appendix 3.5). For Arrow Gobi, *Clevelandia ios*, the average size caught was 4.37cm, while the average size that literature reports is 4.2cm. The maximum length for Arrow Gobi was 11cm, while literature reports a maximum of 6.4cm. For California Killifish, *Fundulus parvipinnis*, the average size caught was 5.20cm, while literature reports an average of 7cm. For Diamond Turbot, *Hypsopsetta guttulata*, the average size caught was 6.28cm, while literature reports an average of 17.9cm. For Staghorn Sculpin, *Leptocottus armatus*, the average size caught was 5.29cm, while literature reports an average of 35.5cm. Finally, for the Bay pipefish, *Syngnathus griseolineatu*, the average size that we caught was 13.21cm, while literature reports an average of 23.5cm.



	Atherinops affinis	Clevelandia ios	Fundulus parvipinnis	Hypsopsetta guttulata	Leptocottus armatus	Syngnathus griseolineatu
Mean	5.798	4.374	5.204	6.28	5.289	13.21
Maximum	11.2	11	9.8	12.2	10.3	19.3
Historical Mean	40	4.2	7	17.9	35.5	23.5
Historical Maximum	45	6.4	10.8	46	46	32.5

Figure 5. Bar graph showing the mean and maximum length in centimeters of five species caught compared to the historical mean and max for the species.

Discussion

Over the course of two years, beach seines were conducted to survey the fish within Colorado Lagoon. A total of 4,068 fishes from 14 species were caught in nine beach seines. The results display low diversity and evenness with the three most abundant fish species being the California Killifish, *Fundulus parvipinnis*, Arrow Gobi, *Clevelandia ios*, and Topsmelt, *Atherinops affinis*, for both Year 1 and Year 2 catches. The effective number of species, which is the number of equally common species in a community was equal to 2.78- 3.41 which coincides with the most abundant species caught. North Beach had the largest effective number of species and Western Arm Reserve had the smallest effective number of species.

Species diversity and evenness for both Order and Species classifications do not display a pattern over time. The Shannon-Wiener Diversity Indices (H') ranged from 1.021 to 1.226 for Year 1 and Year 2 data. When comparing this studies data to the Allen and Horn (1973) surveys at the Colorado Lagoon, the only comparable top abundant species is *Atherinops affinis*. Also the values for the Shannon-Wiener Diversity Indices are higher than the past Lagoon study which displays H' ranging from 0.03 to 1.11. Overall, the Colorado Lagoon has increased in the diversity value, meaning that there is more fish diversity than there was in 1973.

The mean fish length for the five most abundant species was *Fundulus parvipinnis* (5.20cm), *Clevelandia ios* (4.37cm), *Atherinops affinis* (5.72cm), *Leptocottus armatus* (5.29cm), and *Syngnathus griseolineatu* (13.21cm) was compared to that of quoted literature. The fish at the Colorado Lagoon exhibited a shorter length than the literature stated for all species except Arrow Gobi in which the fish at the Lagoon were larger than the historical mean. This is accurate considering the Lagoon was just dredged two years prior, which completely wiped away any habitat that these species use making the habitat conditions and food availability difficult for larger fish to succeed. When compared to a similar study done at Ballona wetlands, the mean length of these species are comparable (Ballona, 2010).

When comparing the mean length per site, the data shows that four out of the six species had the largest mean length within the Western Arm Reserve. Although, one species *Syngnathus griseolineatu* was not caught in with in the Western Arm Reserve area. This could be attributed to the minimal eelgrass or algae beds in this area, which is this species main habitat.

Literature Cited

Kutyrev, O. and A. Sherwood 2012. "Paralichthys californicus" (On-line), Animal Diversity Web. Accessed January 05, 2014 at http://animaldiversity.ummz.umich.edu/accounts/Paralichthys_californicus/

Allen, Larry G., and Michael H. Horn. "Abundace, Diversity and Seasonality of Fishes in Colorado Lagoon, Alamitos Bay, California." *Estuarine and Coastal Marine Science* 3 (1875): 371-380. Print.

"FishBase." *Search FishBase*. N.p., 1 Dec. 2013. Web. 5 Jan. 2014. <http://www.fishbase.org>.

"Friends of Colorado Lagoon." *Friends of Colorado Lagoon*. N.p., 1 Jan. 2013. Web. 5 Jan. 2014. <http://www.coloradolagoon.org/>.

Johnston, Karina. "Ballona Wetlands Ecological Reserve Baseline Assessment Program 2009-2010 Report." *Santa Monica Bay*. N.p., 1 Nov. 2011. Web. 5 Jan. 2014. <http://www.santamonicabay.org/BWRP/BWRP_Documents/Baseline%20Reports/YR1/BWER_YR1_Baseline_Report_full.pdf>.

Liang, Helena. "The Story of the Colorado Lagoon: A Community Collaboration." *prezi.com*. N.p., 18 Nov. 2013. Web. 5 Jan. 2014. <http://prezi.com/kvc9ayfzonpb/the-story-of-the-colorado-lagoon-a-community-collaboration/>.

"Two-spotted octopus." *, Reefs & Pilings, Octopus & Kin, Octopus bimaculoides*. N.p., 1 Jan. 2014. Web. 5 Jan. 2014. <http://www.montereybayaquarium.org/animals/AnimalDetails.aspx?enc=n3f4wmcSJaPjiSJLWX4luQ==>.

Chapter Four: Benthic Invertebrates

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Introduction

Invertebrates are vital to the success of a wetland due to proximity to the bottom of the tropic food web structure. Invertebrate presence can serve as an indication of wetland hydrologic features, vegetation presence and higher order organisms such as fish and birds (National Rivers and Streams Assessment, 2008). A profile of Colorado Lagoon and Zedler Marsh invertebrates will be used in order to determine the overall state.The profile will be in terms of species abundance or density, richness and community composition.

Baseline invertebrate samples were taken at Colorado Lagoon approximately two months (November2012) after the completion of Phase1b, dredging. This criterion will serve as an indicator of habitat restoration progress through time. Samples were also taken nine months post dredging (June, 2013) these samples will serve as the first comparative sample to the baseline.
When comparing the Colorado Lagoon and Zedler Marsh, the lagoon should exhibit less organism abundance because there has been ongoing disturbance and many communities are still establishing themselves.

Methods

All samples were placed in plastic jars, sealed, and transported to a nearby lab. Core samples were preserved with eight percent formalin solution and mixed with approximately two drops of highly concentrated Rose Bengal. Rose Bengal stains most organism tissue for better identification under a microscope. Samples were filtered with water in a 300 micronseine. The resulting sample is then sorted to the lowest taxonomic level using a microscope and tweezers. The organisms are then preserved in seventy percent ethanol.

Method A

Twenty-four 18.1cm^2 by 2cm deep benthic core samples were taken along four transects at two sites, Colorado Lagoon Western Arm (n=12) and Zedler Marsh (n=12) .Each transect had three habitat elevations, mid-wetland, low-wetland, and mudflats. Colorado Lagoon samples were collected on November 28, 2012 and Zedler Marsh samples were collected on April 6, 2013. Method A was completed by Brianna Pagan, Masters Candidate, Bren School of Environmental Science and Management, University of California, Santa Barbara.

Method B

Six 15cm^2 by 4cm deep benthic core samples were taken at the Colorado Lagoon on June 11, 2013 (Figure A). Six 15cm benthic core samples were taken at Zedler Marsh on August 12, 2013 (Figure B). Method B was completed by Kyra Barboza, Environmental Science and Police Undergraduate, California State University Long Beach.

Picture above is an Oligochaete.

Point Identification Number	Sample Name
0	Western Arm Culvert
1	Central Arm Swim line
2	Central Arm Opposite Lifeguard Tower
3	Western Arm Stop Sign
4	Northern Arm Culvert
5	Northern Arm Palm Tree

Figure A. Map of Colorado Lagoon within vertebrate sample locations for Method B.

Picture above is an Neomolgus littoralis.

Point Identification Number	Sample Name
0	Culvert
1	Right of Cord Grass patch
2	Entrance
3	West Bank
4	North Pool
5	West Pool

Figure B. Map of Zedler Marsh with invertebrate sample locations for Method B.

Analysis Method A

To determine the structural community between the two locations and tidal height, a two way analysis of variance (ANOVA) and the non-parametric Kruskal-Wallis analyses were employed. To determine community composition, a Primeranalysis of similarities (ANOSIM) and similarity percentage (SIMPER) were employed.

Analysis Method B

Method B data was analyzed for species abundance at Colorado Lagoon and Zedler Marsh. Organisms were also analyzed based on class divisions.

Results

Method A

The abundance of invertebrates was significantly higher in the mud flat habitatat both Colorado Lagoon and Zedler Marsh ($F=6.69$, $p=0.007$) (Figure C). There was no difference in species richness between the two sites, but the community composition differs ($p=0.003$, $R=0.372$) with Zedler Marsh being more variable than Colorado Lagoon (Figure D). The abundance of Dolichopdidae was significantly greater in all habitats at Colorado Lagoon than Zedler Marsh ($p=0.015$, pseudo $F= 8.02$) (Figure E).

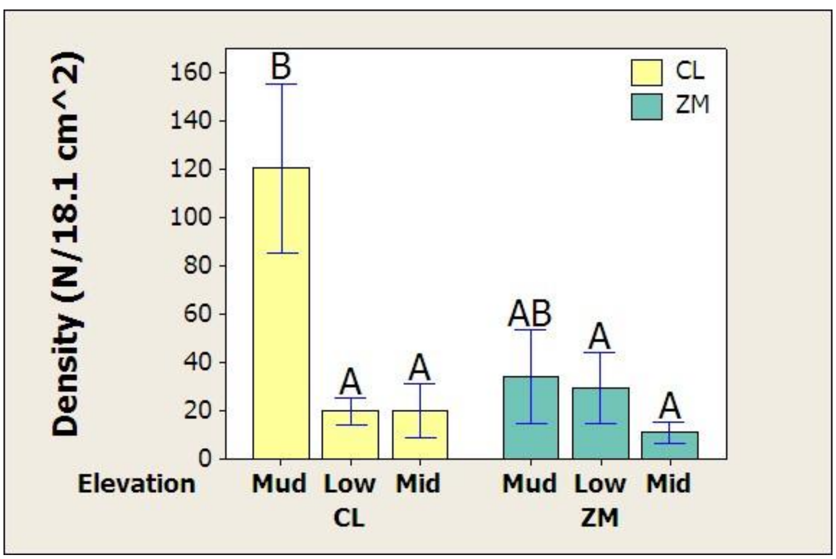

Figure C. Interval plot for abundance of benthic invertebrates versus elevation and site (CL=Colorado Lagoon, ZM=Zedler Marsh)($F=6.69$, $p=.007$).

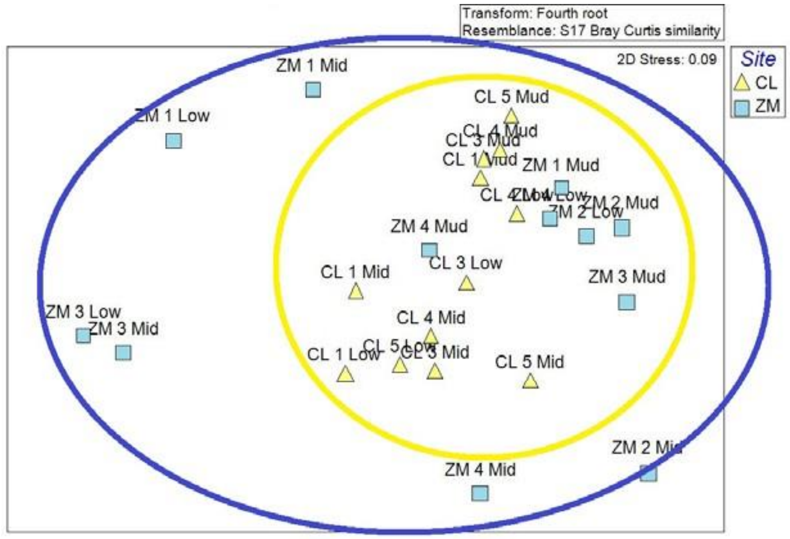

Figure D. Bray Curtis Similarity Plot of Zedler Marsh **(**ZM) and Colorado Lagoon (CL) (ANOSIMp=.003, R=.372).

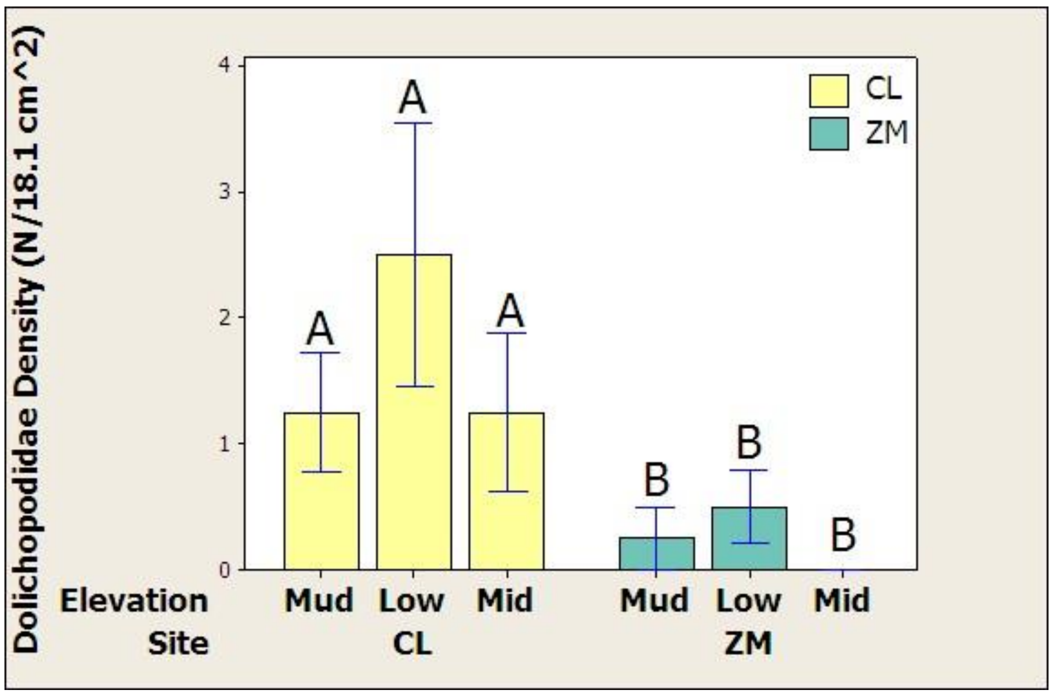

Figure E. Dolichopodidae Abundance (PERMANOVAp=.015, pseudo-F=8.02).

Method B

The abundance of organisms found in Zedler Marsh is higher than those found at Colorado Lagoon (Figure F), with Zedler Marsh exhibiting a higher diversity (Figure G). At Colorado Lagoon the highest species abundance was found at sample location four (NorthernArmCulvert) (Figure H). At Zedler Marsh the highest species abundance was found at sample location zero (Culvert) (Figure I). The dominant phylumin the Colorado Lagoon was Oligochaetes, which differs from the dominant phylumin Zedler Marsh which was Insecta (Figure J).

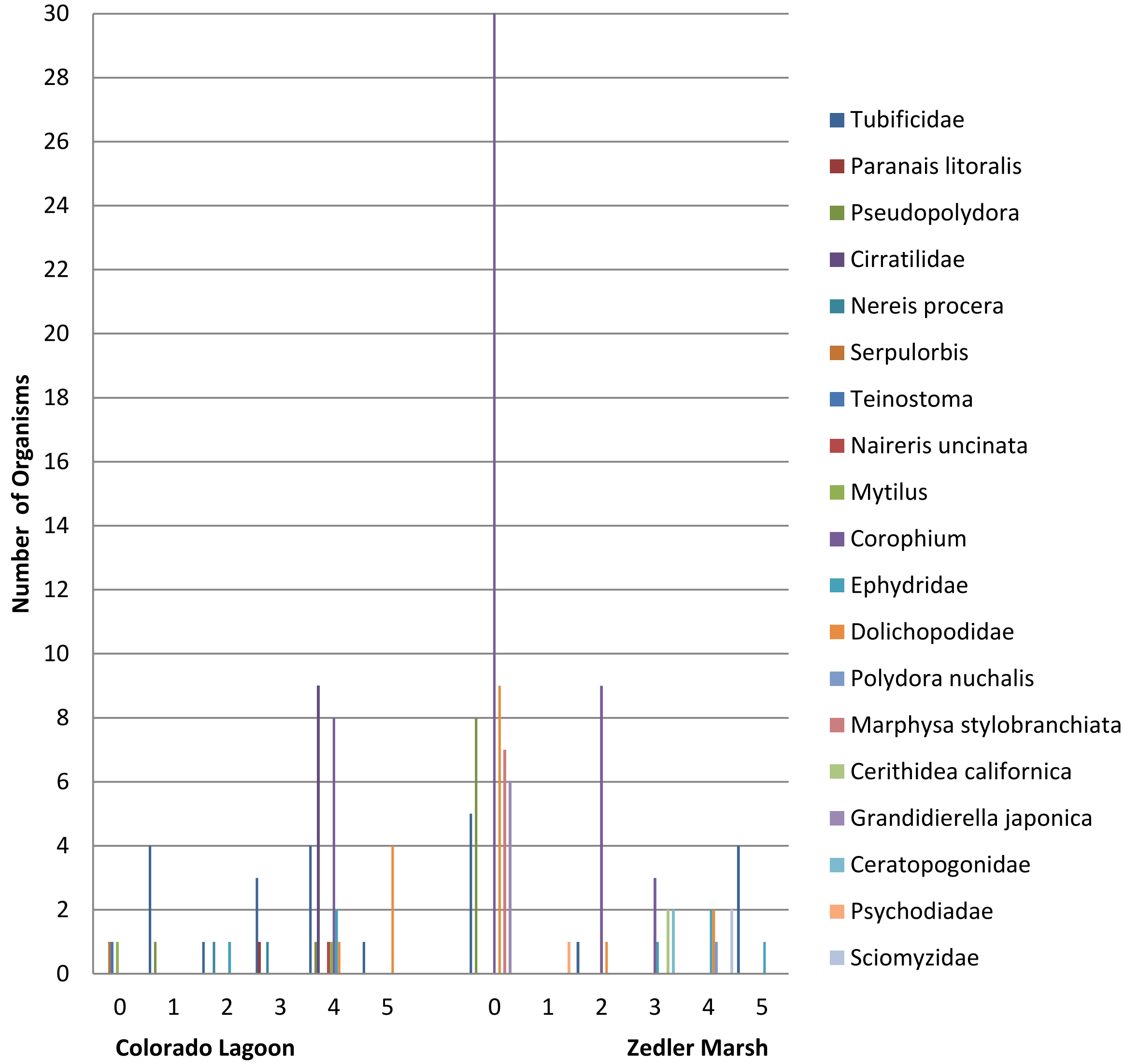

Figure F. Abundance of Invertebrate at Colorado Lagoon and Zedler Marsh per sample location.

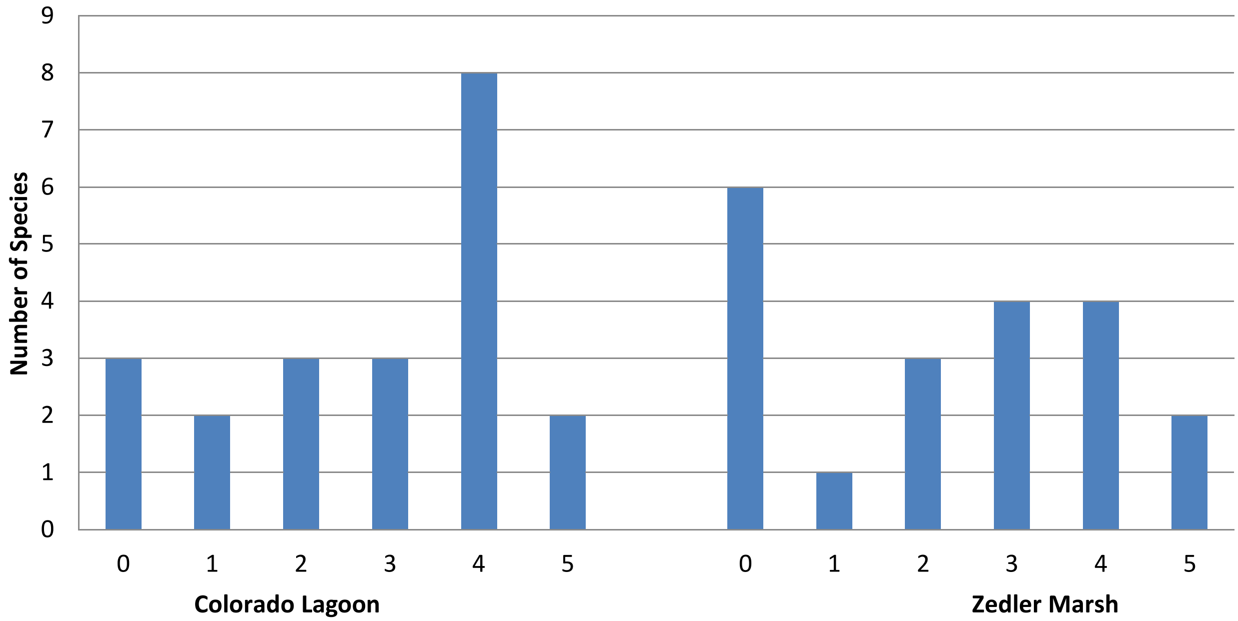

Figure G. Count of Species at Colorado Lagoon and Zedler Marsh per sample location.

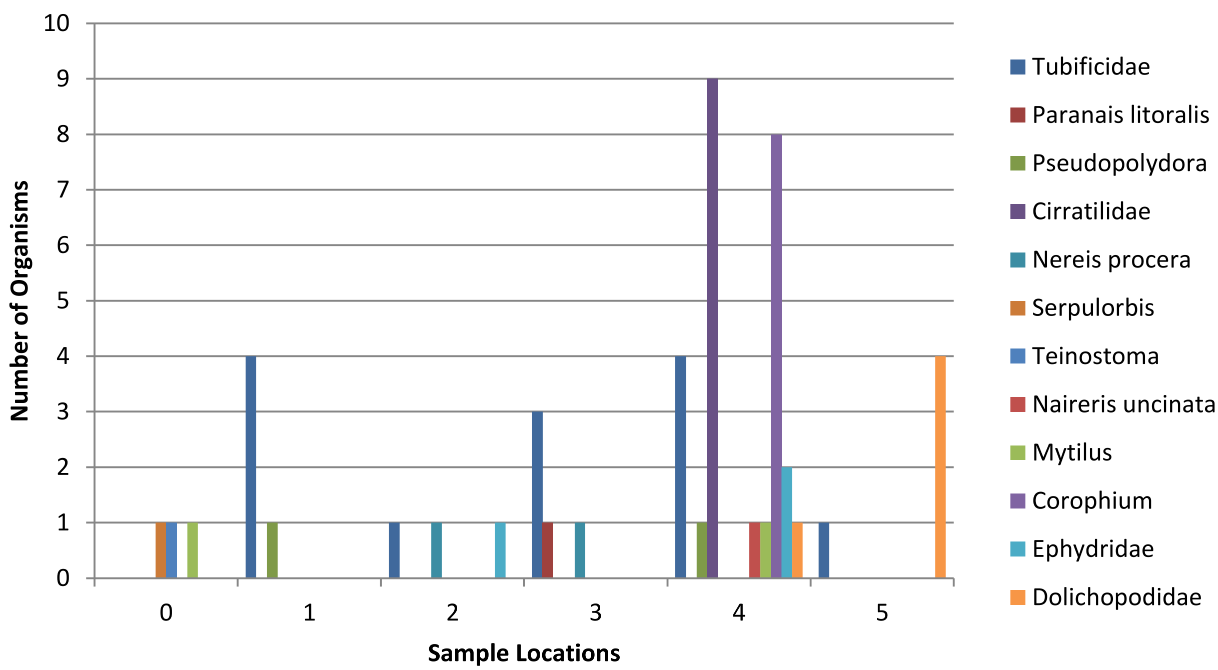

Figure H. Count of Species at Colorado Lagoon per sample point.

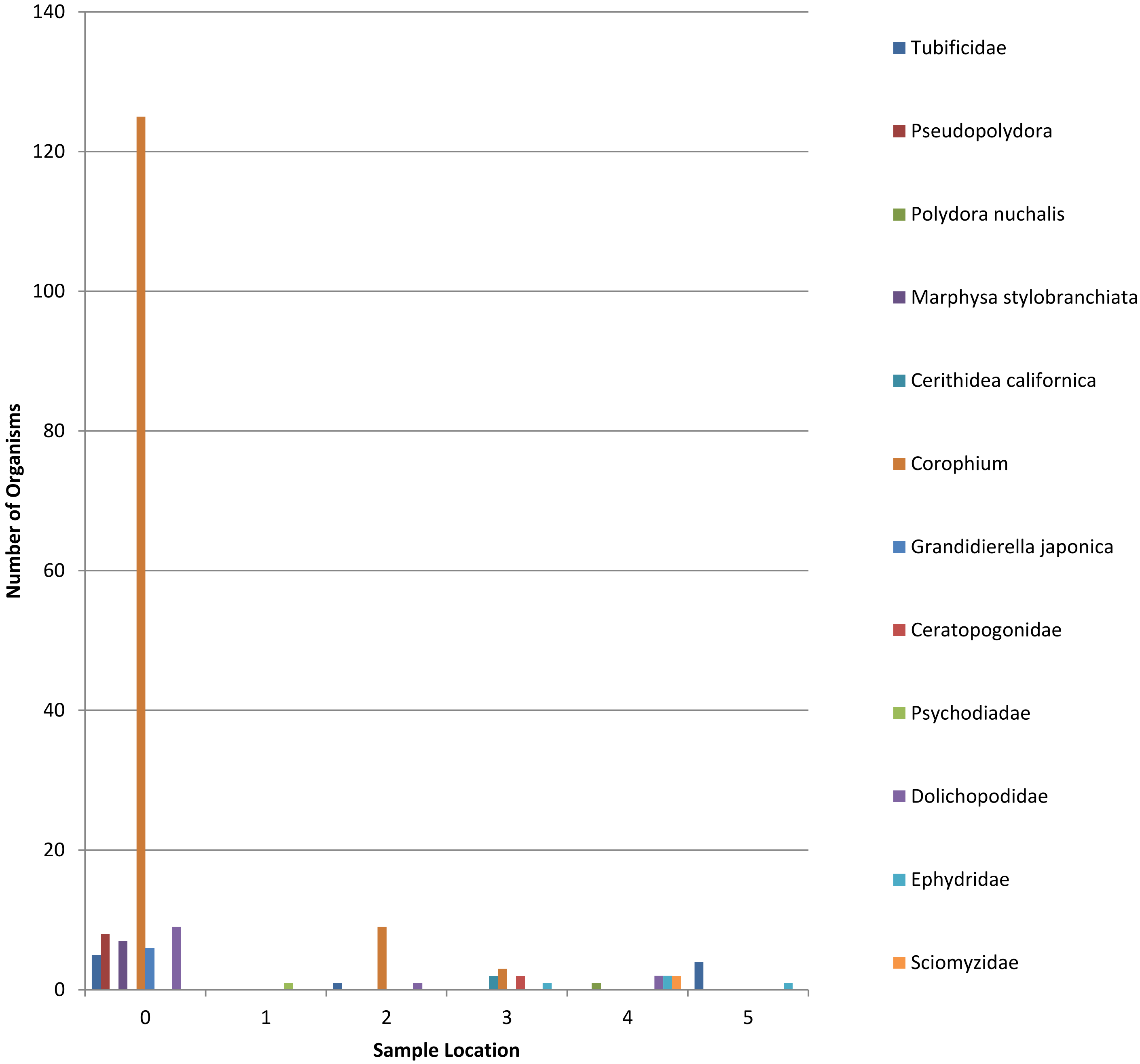

Figure I. Count of Species at Zedler Marsh per sample point.

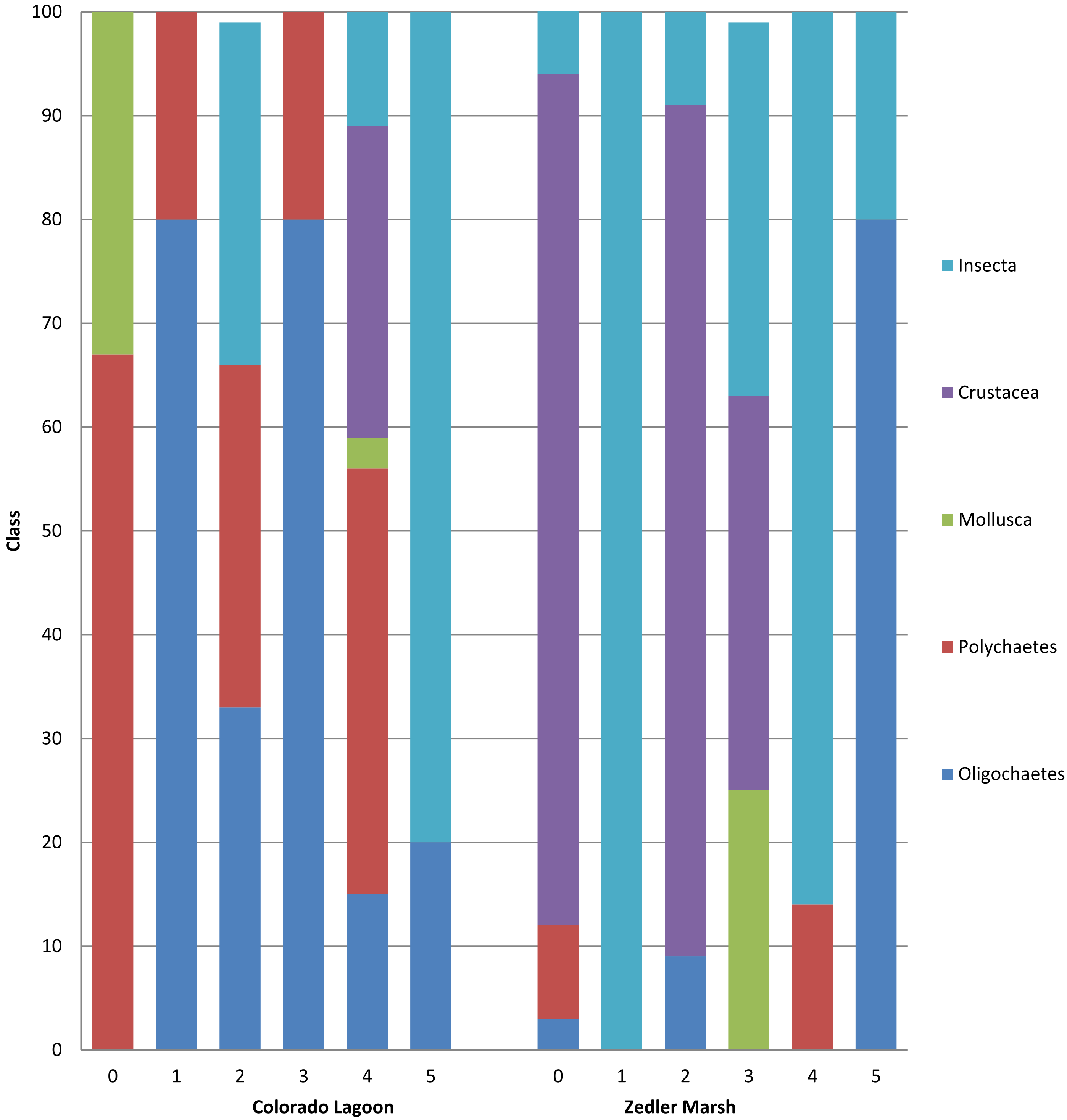

Figure J. Percent total by class for Colorado Lagoon and Zedler Marsh.

Discussion

A profile of Colorado Lagoon and Zedler Marsh invertebrates has emerged based on the two studies conducted in 2012-2013. The Colorado Lagoon in terms of abundance of invertebrates was higher for method A (641) than method B (48). This could be due to the number of samples collected per study, method A (n=12), method B (n=5), or it could be due to the locations of the samples. Method A sampled strictly in the Western Arm of the Colorado Lagoon where there is an extensive area of mudflat. Method B sampled various locations in the Colorado Lagoon where the soil profile could be rocky, sandy or lacking vegatation, leaving less habitat for a diversity of benthic invertebrates (figure K). Method B showed that sample four had the highest abundance of invertebrates (27), which is located at the Northern Arm Culvert.

Zedler Marsh in terms of abundance of invertebrates was higher for method A (305) than method B (204). These abundances are more comparable to each other and is most likely a result of the composition of Zedler Marsh's soil profile. The highest abundance for method B was at sample zero (Culvert).

Method B results agree with our hypothesis, Colorado Lagoon will exhibit less organism abundance then Zedler Marsh. Method A disproved our hypothesis showing that in the Western Arm of the Colorado Lagoon there is a higher abundance then Zedler Marsh. By looking at community composition we see that the Colorado Lagoon had a greater amount of insect larvae, which is similar to other new restorations and is lacking deposit feeders, such as oligochaetes.

The results of method A show that elevation is the major influence on the abundance not site, but site influences the community composition. This data indicates that Colorado Lagoon is a less mature wetlands then the reference site, Zedler Marsh. Usually abundance and species richness are used as parameters to assess post-restoration, however it appears that community composition may be more appropriate.

The results of method B, show a similarity between the sites in having the highest abundance located at culverts. The culverts are used for storm water runoff, which may bring in nutrients to support a larger population of invertebrates. Although samples were taken two months post dredging (method A) and nine months post dredging (method B) more samples through time will be necessary to see the progress of the habitat restoration.

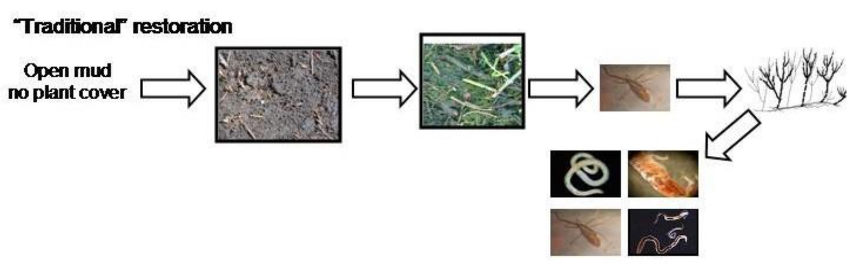

Figure K. Flow Chart of "Traditional" restoration processes

Acknowledgements

We would like to acknowledge the two individuals that collected and analyzed the data and were kind enough to allow us to use it in this report. Method A was completed by Brianna Pagan, Masters Candidate, Bren School of Environmental Science and Management, University of California, Santa Barbara. Method B was completed by Kyra Barboza, Environmental Science and Policy Undergraduate, California State University Long Beach. Thank you to Dr. Christine Witcraft as well, who kindly opened up her lab at California State University, Long Beach for use from both of these methods.

Literature Cited

National rivers and streams assessment 2008-2009: a collaborative survey, draft. Washington DC: U.S. Environmental Protection Agency, 2013. Print.

Appendices

Appendix 1

1.0 Standard Procedures for Vegetation Monitoring

Materials and Methods

1. Collect materials (2 pencils, 1 clipboard, 1 rubber band, hard copy of previous month's data, 6 blank data sheets, 1 square meter quadrat, 1 transect tape, 1 camera, 1 meter stick

2. Fill out top portion of "Colorado Lagoon Vegetation Field Sampling Data Sheet"

3. At the first transect in the Western Arm, extend transect tape down to 1m past the last quadrat marker. Align the transect tape so that it touches both PVC pipe markers (Photo 1).

Photo 1: Step 3 (Tidal Influence)

4. Take 2 pictures - 1 landscape and 1 portrait (Photo 2, 3) – from the top of the transect facing the water.

Photo 2: Step 4 (Tidal Influence)

Photo 3: Step 4 (Tidal Influence)

5. While facing the transect tape, place the PVC quadrat square on the ground with the quadrat marker (PVC pipe) resting in the bottom left hand corner of the quadrat (Photo 4).

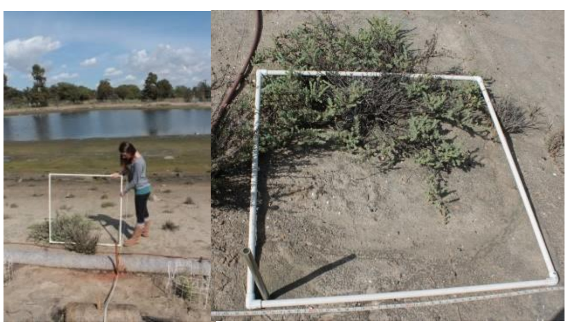

Photo 4: Step 5 (Tidal Influence)

6. On the data sheet, fill out the Transect #, Quad #, and Habitat column.

7. On the data sheet fill out the Epifauna & Detritus Structure Column:
    a. When the habitat is classified as Dune or Coastal Salt Marsh (CSM) record the visible epifauna and detritus. For example, Leaves and sticks, E is Enteromorpha (algae); an example of epifauna would be a horn snail.
    b. Estimate the observed percent coverage of all epifauna and detritus within the quadrat as a whole and write in the "% cov" column.
    c. When in the Coastal Sage Scrub Habitat (CSS), do not record the epifauna or detritus. Write "n/a" for both "species/ description" and "% cov" columns.

8. On the data sheet fill out the Vegetation column:
    a. Using the hard copy of the last vegetation survey, record the different plant species present. Each species receives a line on the data sheet.
    b. Estimate each species' percent coverage, record in the "% cov" column.
    c. Measure in centimeters, the tallest height per species, making sure that the tallest part is alive.

9. Repeat steps 2-7 for all 12 transects.

1.1 Vegetation Data Sheet

Colorado Lagoon Vegetation Field Sampling Data Sheet

Sampling Date: Observers: Tidal Height:
Start Time: Site: Up or Down:
End Time: Weather: Human Activity:

Trans	Quad	Habitat	Epifauna & Detritus Structure		Vegetation*			Notes:
1-12	#	CSS,DUNE,CSM	Species or Description	% cov	Species	%cov	Plant heights (cm)	

1.2 Vegetation Site Information

Date	Site	Observer 1	Observer 2	Start Time	End Time	Weather	Tidal Height (ft)	Up or Down
10/26/2012	Colorado Lagoon	Hardwick	Zahn	1:19pm	3:03pm	n/a	1.3	Down
11/28/2012	Colorado Lagoon	Hardwick	Blair	1:18pm	3:43pm	n/a	1	Down
12/12/2012	Colorado Lagoon	Hardwick	Blair	1:00pm	2:30pm	n/a	0	Down
1/9/2013	Colorado Lagoon	Blair	Dean	12:00pm	1:57pm	n/a	0	Down
2/7/2013	Colorado Lagoon	Blair	Dean	12:05pm	2:25pm	n/a	-0.5	Down
3/7/2013	Colorado Lagoon	Blair	Dean	11:05am	1:30pm	n/a	0	Down
4/5/2013	Colorado Lagoon	Blair	Dean	9:30am	11:40am	n/a	2.5	Down
5/2/2013	Colorado Lagoon	Blair	Dean	9:05am	11:03am	n/a	0.2	Down
6/21/2013	Colorado Lagoon	Blair	Dean	1:30pm	4:15pm	n/a	2	Down
7/23/2013	Colorado Lagoon	Blair	Dean	2:10pm	3:48pm	n/a	2.5	Down
8/12/2013	Colorado Lagoon	Blair	Dean	8:11am	9:56am	n/a	1.5	Up
9/27/2013	Colorado Lagoon	Blair	Dean	10:00am	11:30am	n/a	3.2	Down
10/26/2013	Colorado Lagoon	Blair	McNamara	11:10am	1:05pm	n/a	3.4	Down
11/26/2013	Colorado Lagoon	Blair	McNamara	10:41am	12:20pm	Partly Cloudy	2.25	Down
12/11/2013	Colorado Lagoon	Blair	McNamara	1:10pm	2:30pm	Sunny, Slight wind to N	?	Down
1/9/2014	Colorado Lagoon	Blair	McNamara	10:45am	12:16pm	Overcast	3.2	Down
2/12/2014	Colorado Lagoon	Blair	McNamara	2:30pm	4:15pm	Sunny, no clouds	0	Down
3/10/2014	Colorado Lagoon	Blair	McNamara	1:00pm	3:00pm	Sunny, hot	0.75	Down
4/7/2014	Colorado Lagoon	Blair	McNamara	12:15pm	2:00pm	Sunny, hot	0.6	Up
5/7/2014	Colorado Lagoon	Blair	McNamara	12:15pm	1:55pm	Windy	0.7	Down
6/18/2014	Colorado Lagoon	Bliar	McNamara	8:40am	10:20am	Partly Cloudy, Breezy	0	Up
7/24/2014	Colorado Lagoon	Blair	McNamara	1:16pm	2:50pm	Sunny	2.4	Up
8/20/2014	Colorado Lagoon	Blair	McNamara	12:40pm	2:10pm	Sunny	2.3	Down
9/4/2014	Colorado Lagoon	Blair	McNamara	11:10am	12:40pm	Overcast	2.7	Down

1.3 Species List

Code	Scientific Name	Common Name	Native (N) or Non-Native (NN)
ACGL	*Acmispon glaber*	Deerweed	N
AMPS	*Ambrosia psilostachya*	Western Ragweed	N
ARCA	*Artemisia californica*	California Sagebrush	N
ARSU	*Arthrocnemum subterminale*	Glasswort	N
ATSE	*Atriplex semibaccata*	Austrailian Salt Bush	NN
ATTR	Atriplex Triangularis	Fat Hen	NN
ATWA	*Atriplex watsonii*	Watson's Salt Bush	N
BAMA	*Batis maritima*	Saltwort	N
BRDI	*Bromus diandrus*	Ripgut Brome	NN
BRNI	*Brassica nigra*	Black Mustard	NN
CAMA	*Calystegia macrostegia*	Island Morning Glory	N
CASP	*Calochortus splenens*	Splendid Mariposa	N
CHAL	*Chenopodium album*	Lamb's Quarters	NN
CHMA	*Chamaesyce masculata*	Spotted Spurge	NN
CLIS	*Cleome isomeris*	Bladderpod	N
COAU	*Cotula australis*	Australian Cotula	NN
COCA	*Conyza canadensis*	Canadian Horseweed	N
CYDA	*Cynodon dactylon*	Bermuda Grass	NN
CYPR	*Cylindropuntia prolifera*	Coastal Cholla	N
DILI	*Distichlis littoralis*	Shore Grass	N
DISP	*Distichlis spicata*	Salt Grass	N
ENCA	*Encelia californica*	California Sunflower	N
EPCA	*Epilobium canum*	California Fuchsia	N
ERCI	*Eriogonum cinereum*	Ashyleaf Buckwheat	N
ERCIC	*Erodium cicutarium*	Common Stork's Bill	NN
ERFA	*Eriogonum fasciculatum*	California Buckwheat	N
ESCA	*Eschscholzia californica*	California Poppy	N
FRSA	*Frankenia salina*	Alkali Heath	N
HASQ	*Hazardia squarrosa*	Sawtooth Goldenbush	N
HOMU	Hordeum murinum	Fox Tail	NN
HOVU	*Hordeum vulgare*	Common Barley	NN
ISME	*Isocoma menziesii*	Coast Goldenbush	N
JACA	*Jaumea carnosa*	Fleshy Jaumea	N
LICA	*Limonium californicum*	Sea Lavender	N

LIRA	*Limonium ramosissimum*	Algerian Sea-lavender	NN
LUBI	*Lupinus bicolor*	Minature Lupine	N
LUSU	*Lupinus succulentus*	Arroyo Lupine	N
MAPA	*Malva parviflorum*	Cheeseweed	N
MEIN	*Melilotus indicus*	Yellow Sweet-clover	NN
MEPO	*Medicago polymorpha*	Bur-clover	NN
MICA	*Mirabilis californica*	Wishbone Bush	N
OPLI	*Opuntia littoralis*	Coastal Prickly Pear	N
PAIN	*Parapholis incurva*	Sickle Grass	NN
PECL	*Pennisetum clandestinum*	Kikuyu Grass	NN
PLLA	*Plantago lanceolata*	English Plantain	NN
PLMA	*Plantago major*	Common Plantain	NN
POAV	*Polygonum aviculare*	Prostrate Knotweed	NN
SAAP	Salvia apiana	White Sage	N
SALE	*Salvia leucophylla*	Purple Sage	N
SAPA	*Salicornia pacifica*	Common Pickleweed	N
SCTE	*Schinus terebinthifolius*	Brazilian Pepper Tree	NN
SIIR	*Sisymbrium irio*	London Rocket	NN
SMPA	*Spergularia marina*	Sand Spurry	N
SOOL	*Sonchus oleraceus*	Sow Thistle	NN
SPMA	*Spergularia marina*	Sand Spurry	N
SUCA	*Suaeda calceoliformis*	Horned Sea-blite	N
SUES	*Suaeda esteroa*	Estuary Sea-blite	N
SUTA	*Suaeda taxifolia*	Woolly Sea-blite	N
TAOF	*Taraxacum officinale*	Common Dandelion	NN
TRCO	*Triglochin concinna*	Arrow-grass	N
TRTE	*Tribulus terrestris*	Puncture Vine	NN

1.4 Gamma Diversity Raw Data

1.4.1 All Species

Code	**N**	**Pi**	**Ln(Pi)**	**(pi)((ln(pi)))**
ACGL	1	0.000703	-7.25982	-0.005105358
AMPS	5	0.003516	-5.65038	-0.019867727
ARCA	54	0.037975	-3.27084	-0.124208945
ARSU	24	0.016878	-4.08177	-0.068890562
ATWA	24	0.016878	-4.08177	-0.068890562
BAMA	48	0.033755	-3.38862	-0.11438375
CAMA	14	0.009845	-4.62076	-0.045492737
CASP	1	0.000703	-7.25982	-0.005105358
CLIS	20	0.014065	-4.26409	-0.059973099
COCA	1	0.000703	-7.25982	-0.005105358
CYPR	8	0.005626	-5.18038	-0.02914418
DILI	84	0.059072	-2.829	-0.16711409
DISP	96	0.067511	-2.69547	-0.181972754
ENCA	24	0.016878	-4.08177	-0.068890562
EPCA	5	0.003516	-5.65038	-0.019867727
ERCI	1	0.000703	-7.25982	-0.005105358
ERFA	51	0.035865	-3.32799	-0.119358434
ESCA	1	0.000703	-7.25982	-0.005105358
FRSA	65	0.04571	-3.08543	-0.141035937
HASQ	3	0.00211	-6.16121	-0.012998328
HOVU	4	0.002813	-5.87353	-0.016521871
ISME	44	0.030942	-3.47563	-0.107544106
JACA	118	0.082982	-2.48913	-0.206552692
LICA	30	0.021097	-3.85862	-0.081405532
LUBI	6	0.004219	-5.46806	-0.023071984
LUSU	3	0.00211	-6.16121	-0.012998328
MICA	9	0.006329	-5.0626	-0.032041741
OPLI	11	0.007736	-4.86192	-0.037609823
SAAP	9	0.006329	-5.0626	-0.032041741
SALE	40	0.028129	-3.57094	-0.100448387
SAPA	109	0.076653	-2.56847	-0.196880041
SMPA	1	0.000703	-7.25982	-0.005105358
SPMA	5	0.003516	-5.65038	-0.019867727
SPMA	109	0.076653	-2.56847	-0.196880041
SUCA	56	0.039381	-3.23447	-0.127377077
SUES	6	0.004219	-5.46806	-0.023071984
SUTA	46	0.032349	-3.43118	-0.110994513
TRCO	2	0.001406	-6.56667	-0.009235826

ATSE	25	0.017581	-4.04094	-0.071043315
ATTR	2	0.001406	-6.56667	-0.009235826
BRDI	1	0.000703	-7.25982	-0.005105358
BRNI	1	0.000703	-7.25982	-0.005105358
CHAL	22	0.015471	-4.16878	-0.064495849
CHMA	24	0.016878	-4.08177	-0.068890562
COAU	11	0.007736	-4.86192	-0.037609823
CYDA	35	0.024613	-3.70447	-0.091178976
ERCIC	3	0.00211	-6.16121	-0.012998328
HOMU	2	0.001406	-6.56667	-0.009235826
LIRA	1	0.000703	-7.25982	-0.005105358
MAPA	42	0.029536	-3.52215	-0.104029747
MEIN	17	0.011955	-4.42661	-0.052920047
MEPO	7	0.004923	-5.31391	-0.026158485
PAIN	21	0.014768	-4.2153	-0.062251224
PECL	9	0.006329	-5.0626	-0.032041741
PLLA	3	0.00211	-6.16121	-0.012998328
PLMA	1	0.000703	-7.25982	-0.005105358
POAV	4	0.002813	-5.87353	-0.016521871
SCTE	20	0.014065	-4.26409	-0.059973099
SIIR	4	0.002813	-5.87353	-0.016521871
SOOL	3	0.00211	-6.16121	-0.012998328
TAOF	25	0.017581	-4.04094	-0.071043315
TRTE	1	0.000703	-7.25982	-0.005105358
TOTAL	1422			-3.464938312

1.4.2 Native Species

Code	N	Pi	Ln(Pi)	(pi)((ln(pi)))
ACGL	1	0.000879	-7.03703	-0.00618368
AMPS	5	0.004394	-5.42759	-0.023847055
ARCA	54	0.047452	-3.04804	-0.144634756
ARSU	24	0.02109	-3.85897	-0.081384333
ATWA	24	0.02109	-3.85897	-0.081384333
BAMA	48	0.042179	-3.16583	-0.133532229
CAMA	14	0.012302	-4.39797	-0.054105083
CASP	1	0.000879	-7.03703	-0.00618368
CLIS	20	0.017575	-4.0413	-0.071024523
COCA	1	0.000879	-7.03703	-0.00618368
CYPR	8	0.00703	-4.95759	-0.03485122
DILI	84	0.073814	-2.60621	-0.192374085
DISP	96	0.084359	-2.47268	-0.208591586
ENCA	24	0.02109	-3.85897	-0.081384333
EPCA	5	0.004394	-5.42759	-0.023847055
ERCI	1	0.000879	-7.03703	-0.00618368
ERFA	51	0.044815	-3.1052	-0.139161073
ESCA	1	0.000879	-7.03703	-0.00618368
FRSA	65	0.057118	-2.86264	-0.163507577
HASQ	3	0.002636	-5.93842	-0.015654873
HOVU	4	0.003515	-5.65073	-0.01986198
ISME	44	0.038664	-3.25284	-0.12576878
JACA	118	0.103691	-2.26634	-0.234998658
LICA	30	0.026362	-3.63583	-0.095847897
LUBI	6	0.005272	-5.24527	-0.027655192
LUSU	3	0.002636	-5.93842	-0.015654873
MICA	9	0.007909	-4.8398	-0.038276122
OPLI	11	0.009666	-4.63913	-0.044842228
SAAP	9	0.007909	-4.8398	-0.038276122
SALE	40	0.035149	-3.34815	-0.117685348
SAPA	109	0.095782	-2.34568	-0.224674069
SMPA	1	0.000879	-7.03703	-0.00618368
SPMA	5	0.004394	-5.42759	-0.023847055
SPMA	109	0.095782	-2.34568	-0.224674069
SUCA	56	0.049209	-3.01168	-0.148201979
SUES	6	0.005272	-5.24527	-0.027655192
SUTA	46	0.040422	-3.20839	-0.129688722
TRCO	2	0.001757	-6.34388	-0.011149175
TOTAL	1138			-3.035143656

1.4.3 Non-Native Species

Code	N	Pi	Ln(Pi)	(pi)((ln(pi)))
ATSE	25	0.088028	-2.4301	-0.213917114
ATTR	2	0.007042	-4.95583	-0.034900191
BRDI	1	0.003521	-5.64897	-0.019890754
BRNI	1	0.003521	-5.64897	-0.019890754
CHAL	22	0.077465	-2.55793	-0.198149645
CHMA	24	0.084507	-2.47092	-0.208810175
COAU	11	0.038732	-3.25108	-0.125922073
CYDA	35	0.123239	-2.09363	-0.258017311
ERCIC	3	0.010563	-4.55036	-0.048067204
HOMU	2	0.007042	-4.95583	-0.034900191
LIRA	1	0.003521	-5.64897	-0.019890754
MAPA	42	0.147887	-1.9113	-0.282657725
MEIN	17	0.059859	-2.81576	-0.168549068
MEPO	7	0.024648	-3.70306	-0.091272706
PAIN	21	0.073944	-2.60445	-0.192582704
PECL	9	0.03169	-3.45175	-0.109386433
PLLA	3	0.010563	-4.55036	-0.048067204
PLMA	1	0.003521	-5.64897	-0.019890754
POAV	4	0.014085	-4.26268	-0.060037745
SCTE	20	0.070423	-2.65324	-0.186848026
SIIR	4	0.014085	-4.26268	-0.060037745
SOOL	3	0.010563	-4.55036	-0.048067204
TAOF	25	0.088028	-2.4301	-0.213917114
TRTE	1	0.003521	-5.64897	-0.019890754
TOTAL	284			-2.683561347

1.4.3.1 Year 1 Native Species

Code	**N**	**Pi**	**Ln(Pi)**	**(pi)((ln(pi)))**
ACGL	1	0.001835	-6.30079	-0.01156
AMPS	5	0.009174	-4.69135	-0.04304
ARCA	24	0.044037	-3.12273	-0.13751
ARSU	18	0.033028	-3.41041	-0.11264
ATWA	13	0.023853	-3.73584	-0.08911
BAMA	14	0.025688	-3.66173	-0.09406
CAMA	8	0.014679	-4.22134	-0.06196
CASP	1	0.001835	-6.30079	-0.01156
CLIS	10	0.018349	-3.9982	-0.07336
DILI	48	0.088073	-2.42958	-0.21398
DISP	60	0.110092	-2.20644	-0.24291
ENCA	6	0.011009	-4.50903	-0.04964
EPCA	2	0.00367	-5.60764	-0.02058
ERFA	16	0.029358	-3.5282	-0.10358
ESCA	1	0.001835	-6.30079	-0.01156
FRSA	35	0.06422	-2.74544	-0.17631
ISME	12	0.022018	-3.81588	-0.08402
JACA	65	0.119266	-2.1264	-0.25361
LICA	24	0.044037	-3.12273	-0.13751
LUSU	2	0.00367	-5.60764	-0.02058
OPLI	1	0.001835	-6.30079	-0.01156
SALE	23	0.042202	-3.16529	-0.13358
SAPA	33	0.06055	-2.80428	-0.1698
SPMA	69	0.126606	-2.06668	-0.26165
SUCA	19	0.034862	-3.35635	-0.11701
SUES	6	0.011009	-4.50903	-0.04964
SUTA	27	0.049541	-3.00495	-0.14887
TRCO	2	0.00367	-5.60764	-0.02058
TOTAL	545			-2.86179

1.4.3.2 Year 2 Native Species

Code	N	Pi	Ln(Pi)	(pi)((ln(pi)))
ARCA	30	0.05102	-2.97553	-0.15181
ARSU	6	0.010204	-4.58497	-0.04679
ATWA	11	0.018707	-3.97883	-0.07443
BAMA	34	0.057823	-2.85037	-0.16482
CAMA	6	0.010204	-4.58497	-0.04679
CLIS	10	0.017007	-4.07414	-0.06929
CYPR	8	0.013605	-4.29729	-0.05847
DILI	36	0.061224	-2.79321	-0.17101
DISP	36	0.061224	-2.79321	-0.17101
ENCA	18	0.030612	-3.48636	-0.10673
EPCA	3	0.005102	-5.27811	-0.02693
ERCI	1	0.001701	-6.37673	-0.01084
ERFA	35	0.059524	-2.82138	-0.16794
FRSA	30	0.05102	-2.97553	-0.15181
HASQ	3	0.005102	-5.27811	-0.02693
ISME	32	0.054422	-2.91099	-0.15842
JACA	53	0.090136	-2.40644	-0.21691
LICA	6	0.010204	-4.58497	-0.04679
LUBI	6	0.010204	-4.58497	-0.04679
LUSU	1	0.001701	-6.37673	-0.01084
MICA	9	0.015306	-4.1795	-0.06397
OPLI	10	0.017007	-4.07414	-0.06929
SAAP	9	0.015306	-4.1795	-0.06397
SALE	17	0.028912	-3.54351	-0.10245
SAPA	76	0.129252	-2.04599	-0.26445
SMPA	1	0.001701	-6.37673	-0.01084
SPMA	5	0.008503	-4.76729	-0.04054
SPMA	40	0.068027	-2.68785	-0.18285
SUCA	37	0.062925	-2.76581	-0.17404
SUTA	19	0.032313	-3.43229	-0.11091
TOTAL	588			-3.00864

1.4.3.3 Coastal Sage Scrub Native Species

1.4.3.3.1 Overall

Code	N	Pi	Ln(Pi)	(pi)((ln(pi)))
ACGL	1	0.003356	-5.69709	-0.01912
AMPS	5	0.016779	-4.08766	-0.06858
ARCA	34	0.114094	-2.17073	-0.24767
BAMA	8	0.026846	-3.61765	-0.09712
CAMA	14	0.04698	-3.05804	-0.14367
CASP	1	0.003356	-5.69709	-0.01912
CLIS	20	0.067114	-2.70136	-0.1813
ENCA	24	0.080537	-2.51904	-0.20288
EPCA	3	0.010067	-4.59848	-0.04629
ERCI	1	0.003356	-5.69709	-0.01912
ERFA	51	0.171141	-1.76527	-0.30211
ESCA	1	0.003356	-5.69709	-0.01912
HASQ	3	0.010067	-4.59848	-0.04629
HOVU	4	0.013423	-4.3108	-0.05786
ISME	24	0.080537	-2.51904	-0.20288
JACA	1	0.003356	-5.69709	-0.01912
LUBI	3	0.010067	-4.59848	-0.04629
LUSU	2	0.006711	-5.00395	-0.03358
MICA	9	0.030201	-3.49987	-0.1057
OPLI	11	0.036913	-3.2992	-0.12178
SAAP	9	0.030201	-3.49987	-0.1057
SALE	40	0.134228	-2.00821	-0.26956
SAPA	6	0.020134	-3.90533	-0.07863
SMPA	1	0.003356	-5.69709	-0.01912
SPMA	15	0.050336	-2.98904	-0.15046
SUCA	3	0.010067	-4.59848	-0.04629
SUTA	3	0.010067	-4.59848	-0.04629
TRCO	1	0.003356	-5.69709	-0.01912
TOTAL	298			-2.73476

1.4.3.3.2 Year 1

Code	**N**	**Pi**	**Ln(Pi)**	**(pi)((ln(pi)))**
ACGL	1	0.00885	-4.72739	-0.04184
AMPS	5	0.044248	-3.11795	-0.13796
ARCA	14	0.123894	-2.08833	-0.25873
CAMA	8	0.070796	-2.64795	-0.18747
CASP	1	0.00885	-4.72739	-0.04184
CLIS	10	0.088496	-2.4248	-0.21458
ENCA	6	0.053097	-2.93563	-0.15587
ERFA	16	0.141593	-1.9548	-0.27679
ESCA	1	0.00885	-4.72739	-0.04184
ISME	6	0.053097	-2.93563	-0.15587
LUSU	1	0.00885	-4.72739	-0.04184
OPLI	1	0.00885	-4.72739	-0.04184
SALE	23	0.20354	-1.59189	-0.32401
SPMA	13	0.115044	-2.16244	-0.24878
SUCA	3	0.026549	-3.62878	-0.09634
SUTA	3	0.026549	-3.62878	-0.09634
TRCO	1	0.00885	-4.72739	-0.04184
TOTAL	113			-2.40376

1.4.3.3.3 Year2

Code	N	Pi	Ln(Pi)	(pi)((ln(pi)))
ARCA	20	0.110497	-2.20276	-0.2434
BAMA	8	0.044199	-3.11906	-0.13786
CAMA	6	0.033149	-3.40674	-0.11293
CLIS	10	0.055249	-2.89591	-0.16
ENCA	18	0.099448	-2.30813	-0.22954
EPCA	3	0.016575	-4.09988	-0.06795
ERCI	1	0.005525	-5.1985	-0.02872
ERFA	35	0.19337	-1.64315	-0.31774
HASQ	3	0.016575	-4.09988	-0.06795
ISME	18	0.099448	-2.30813	-0.22954
JACA	1	0.005525	-5.1985	-0.02872
LUBI	3	0.016575	-4.09988	-0.06795
LUSU	1	0.005525	-5.1985	-0.02872
MICA	9	0.049724	-3.00127	-0.14923
OPLI	10	0.055249	-2.89591	-0.16
SAAP	9	0.049724	-3.00127	-0.14923
SALE	17	0.093923	-2.36528	-0.22215
SAPA	6	0.033149	-3.40674	-0.11293
SMPA	1	0.005525	-5.1985	-0.02872
SPMA	2	0.01105	-4.50535	-0.04978
TOTAL	181			-2.59307

1.4.3.4 Coastal Salt Marsh Native Species

1.4.3.4.1 Overall

Code	**N**	**Pi**	**Ln(Pi)**	**(pi)((ln(pi)))**
ARSU	24	0.033898	-3.38439	-0.11473
ATWA	24	0.033898	-3.38439	-0.11473
BAMA	40	0.056497	-2.87356	-0.16235
CYPR	8	0.011299	-4.483	-0.05066
DILI	84	0.118644	-2.13163	-0.2529
DISP	81	0.114407	-2.16799	-0.24803
FRSA	65	0.091808	-2.38806	-0.21924
JACA	117	0.165254	-1.80027	-0.2975
LICA	30	0.042373	-3.16125	-0.13395
SAPA	102	0.144068	-1.93747	-0.27913
SPMA	2	0.002825	-5.8693	-0.01658
SPMA	54	0.076271	-2.57346	-0.19628
SUCA	50	0.070621	-2.65042	-0.18718
SUES	5	0.007062	-4.95301	-0.03498
SUTA	21	0.029661	-3.51792	-0.10435
TRCO	1	0.001412	-6.56244	-0.00927
TOTAL	708			-2.42185

1.4.3.4.2 Year 1

Code	**N**	**Pi**	**Ln(Pi)**	**(pi)((ln(pi)))**
ARSU	18	0.048913	-3.01771	-0.14761
ATWA	13	0.035326	-3.34313	-0.1181
BAMA	14	0.038043	-3.26903	-0.12437
DILI	48	0.130435	-2.03688	-0.26568
DISP	54	0.146739	-1.9191	-0.28161
FRSA	35	0.095109	-2.35273	-0.22377
JACA	65	0.17663	-1.7337	-0.30622
LICA	24	0.065217	-2.73003	-0.17805
SAPA	33	0.089674	-2.41158	-0.21626
SPMA	33	0.089674	-2.41158	-0.21626
SUCA	13	0.035326	-3.34313	-0.1181
SUES	5	0.013587	-4.29865	-0.05841
SUTA	12	0.032609	-3.42318	-0.11163
TRCO	1	0.002717	-5.90808	-0.01605
TOTAL	368			-2.38209

1.4.3.4.3 Year 2

Code	N	Pi	Ln(Pi)	(pi)((ln(pi)))
ARSU	6	0.017647	-4.03719	-0.07124
ATWA	11	0.032353	-3.43105	-0.111
BAMA	26	0.076471	-2.57085	-0.19659
CYPR	8	0.023529	-3.7495	-0.08822
DILI	36	0.105882	-2.24543	-0.23775
DISP	27	0.079412	-2.53311	-0.20116
FRSA	30	0.088235	-2.42775	-0.21421
JACA	52	0.152941	-1.8777	-0.28718
LICA	6	0.017647	-4.03719	-0.07124
SAPA	69	0.202941	-1.59484	-0.32366
SPMA	2	0.005882	-5.1358	-0.03021
SPMA	21	0.061765	-2.78442	-0.17198
SUCA	37	0.108824	-2.21803	-0.24137
SUTA	9	0.026471	-3.63172	-0.09613
TOTAL	340			-2.34197

1.4.3.5 Dune Native Species

1.4.3.5.1 Overall

Code	N	Pi	Ln(Pi)	(pi)((ln(pi)))
ARCA	20	0.152672	-1.87947	-0.28694
COCA	1	0.007634	-4.8752	-0.03722
DISP	15	0.114504	-2.16715	-0.24815
EPCA	2	0.015267	-4.18205	-0.06385
ISME	20	0.152672	-1.87947	-0.28694
LUBI	3	0.022901	-3.77659	-0.08649
LUSU	1	0.007634	-4.8752	-0.03722
SAPA	1	0.007634	-4.8752	-0.03722
SPMA	3	0.022901	-3.77659	-0.08649
SPMA	40	0.305344	-1.18632	-0.36223
SUCA	3	0.022901	-3.77659	-0.08649
SUES	1	0.007634	-4.8752	-0.03722
SUTA	21	0.160305	-1.83067	-0.29347
TOTAL	131			-1.9499

1.4.3.5.2 Year 1

Code	N	Pi	Ln(Pi)	(pi)((ln(pi)))
ARCA	10	0.15625	-1.8563	-0.29005
DISP	6	0.09375	-2.36712	-0.22192
EPCA	2	0.03125	-3.46574	-0.1083
ISME	6	0.09375	-2.36712	-0.22192
LUSU	1	0.015625	-4.15888	-0.06498
SPMA	23	0.359375	-1.02339	-0.36778
SUCA	3	0.046875	-3.06027	-0.14345
SUES	1	0.015625	-4.15888	-0.06498
SUTA	12	0.1875	-1.67398	-0.31387
TOTAL	64			-1.79725

1.4.3.5.3 Year 2

Code	N	Pi	Ln(Pi)	(pi)((ln(pi)))
ARCA	10	0.149254	-1.90211	-0.2839
DISP	9	0.134328	-2.00747	-0.26966
ISME	14	0.208955	-1.56564	-0.32715
LUBI	3	0.044776	-3.10608	-0.13908
SAPA	1	0.014925	-4.20469	-0.06276
SPMA	3	0.044776	-3.10608	-0.13908
SPMA	17	0.253731	-1.37148	-0.34799
SUTA	10	0.149254	-1.90211	-0.2839
TOTAL	67			-1.8535

1.5 Habitat Classification

Habitat Classification	Description
Coastal Salt Marsh	Is composed of the low, mid and high elevations upon which the area is regularly to intermittently inundated by tides. The low salt marsh occurs primarily along the channel edges and adjacent to the mudflat. The mid marsh is associated with plant species that area adapted to occasional prolonged inundation. The high salt marsh will range from saline to hypersaline conditions and the vegetation will vary based on drainage of the soil.
Dune and Dune Transition	This is a transition zone between the land and the sea, the vegetation associated with this habitat will stabilize the loose sand.
Coastal Sage Scrub	This zone is low, to soft to woody shrubs and sub-shrubs that occur in a variety of situations.

1.6 Quadrat Habitat Classification

Transect Number	Quadrat Number	Habitat Classification
1	1	Dune
	2	CoastalSaltMarsh
	3	CoastalSaltMarsh
2	1	Dune
	2	CoastalSaltMarsh
	3	CoastalSaltMarsh
3	1	DuneTransition
	2	Dune
	3	CoastalSaltMarsh
	4	CoastalSaltMarsh
4	1	CoastalSageScrub
	2	CoastalSaltMarsh
	3	CoastalSaltMarsh
5	1	CoastalSageScrub
	2	CoastalSageScrub
	3	CoastalSageScrub
	4	CoastalSaltMarsh
	5	CoastalSaltMarsh
6	1	CoastalSageScrub
	2	CoastalSageScrub
	3	CoastalSageScrub
	4	CoastalSageScrub
	5	CoastalSaltMarsh
	6	CoastalSaltMarsh
7	1	CoastalSaltMarsh
8	1	CoastalSaltMarsh
9	1	CoastalSageScrub
	2	CoastalSaltMarsh
10	1	CoastalSageScrub
	2	CoastalSaltMarsh
11	1	CoastalSageScrub
	2	CoastalSaltMarsh
12	1	CoastalSageScrub
	2	CoastalSaltMarsh
	3	CoastalSaltMarsh

1.7 Seasonal Classifications

Season Classification	**Months**
Winter	December
	January
	February
Spring	March
	April
	May
Summer	June
	July
	August
Fall	September
	October
	November

Appendix 2

Table 8: Avian Behavioral Actions

Behavior	Description
Aquatic feeding	Bird is actively searching for food in the water, or eating
Flight	Flying
Ground feeding	Bird is actively searching for food on the ground, pecking at ground
Other	Bird is doing a behavior not listed- in notes column indicate behavior (i.e. Mating)
Preening	Bird is actively preening its own feathers or another birds
Resting	Bird has its head resting on its dorsal side, or under its wing
Seeking in Flight	Bird is flying over area and scanning ground and/ or shrubs
Seeking Standing	Bird is standing and seeking for food in the water or on the ground
Seeking Walking	Bird is actively walking seeking for food in the water or on the ground

Photo 68: Clark's grebe – *Aechmophorus clarkii* (Pirazzi)

Table 9: Avian Habitat Usage

Habitat	Description
A	Artificial - Telephone poles, fences, buildings
F	Flying
U	Uplands - Area above mudflats compromising coastal sage scrub, dune or transition zone
W	Wetlands - On the mudflats, in the water, or in the coastal salt marsh

Materials and Methods

1. Collect materials:
   - Writing utensil
   - Clipboard
   - Camera
   - At least two blank data sheets
   - Pair of binoculars per person
   - Bird identification booklet

2. Fill out top portion of "Colorado Lagoon Avifauna Field Sample Data Sheet":
   - Sampling date
   - Start Time, End Time
   - Observers
   - Site
   - Weather (general description)
   - Tidal height
   - Tidal direction

3. For each survey, walk the full perimeter of the lagoon.

4. Note all bird species, count, behavior, and location on the data sheet (Tables 8 and 9). When multiple birds of the same species are present, count all individuals and their respective behaviors; avoid double counting individual birds.

Photo 67: Red-tailed hawk – *Buteo lineatus* (Pirazzi)

2.1 Colorado Lagoon Avifauna Field Sampling Data Sheet

Colorado Lagoon Avifauna Field Sampling Data Sheet

Sampling Date: | Observers: | Tidal Height:
Start Time: | Site: | Up or Down:
End Time: | Weather: | Human Activity:

Species Name and #			Behavior									Location	Notes
			Foraging					Other					
			seeking walking	seeking standing	seeking in flight	ground feeding	aquatic feeding	resting	flying	preening or stretching	other	wetlands (W), uplands (U), artificial (A), flying (F)	
1													
2													
3													
4													
5													
6													
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25													

2.2 Avian Site Information

Date	Observer 1	Observer 2	Observer 3	Start Time	End Time	Weather	Wind	Tidal Height	Up or Down	Human Activity:	NOTES
10.26.12	Eric Zahn	Chris Hardwick		10:04	11:00	Sunny, Dry, Windy	High Santa Anas	Mid to Low	n/a	Low, some dog walkers	
01.29.13	Eric Zahn			10:45	11:32	Sunny, Clear	Low	High	n/a	Medium	
02.03.13	Julie McNamara			9:00	10:30	min cloud cover, blue skys	Low	Low	n/a	High, 19 walkers and 10 dogs	
02.09.13	Julie McNamara			9:32	10:40	min cloud cover, blue skys	Low	high	n/a	High 70 walkers (group restoration) and 7 dogs	Day after heavy rain, very high water level
02.16.13	Julie McNamara			9:15	10:30	overcast, hazy	Low	Low	n/a	Medium 13 walkers and 4 dogs	
02.18.13	Julie McNamara			15:40	17:00	min cloud cover, blue skys	High	high	n/a	High, 22 walkers and 6 dogs	
03.02.13	Julie McNamara			11:38	12:46	min, blue skys	Low	High	n/a	High, 24 walkers and 2 dogs	
03.03.13	Julie McNamara			8:50	10:15	high cloud cover, little blue	Low	Low	n/a	Medium, 13 walkers and 9 dogs	
03.09.13	Julie McNamara			10:11	11:09	min, blue skys	Low	high	n/a	High, 47 walkers and 11 dogs	
03.21.13	Julie McNamara			16:22	17:28	no cloud cover, blue skys	Low	Low	n/a	Medium, 14 walkers and 2 dogs	
03.22.13	Julie McNamara			15:31	16:33	no cloud cover, blue skys	High	Low	n/a	High, 20 walkers	
03.23.13	Julie McNamara			9:02	10:00	overcast, hazy	Low	high	n/a	Medium, 16 walkers and 1 dog	
04.05.13	Erich Zahn	Tia Blair	Jade Dean	8:00	9:00	Overcast	Low	High	n/a	Low, a few dog walkers	
7.22.13	Tia Blair	Jade Dean		8:00	8:41	Partly Cloudy, Very hot	Low, West to East	Low	n/a	Very Low, a few dog walkers	There were no birds in WA today. It was weird. On 7/11 Jade observed 3 Black Skimmers at sunset foraging adjacent to the East Bank.
10.23.13	Tia Blair	Julie Mcnamara		9:00	9:56	Overcast	none	4.2	up	4 walkers, 2 dogs	

1.8.14	Tia Blair	Julie Mcnamara		8:30	10:40	Dense Fog	none	Low	n/a	min, 2 dogs and walkers	
4.16.14	Tia Blair	Julie Mcnamara		8:15	9:15	Overcast and Windy	Med	Low	up	Med, fishermen and ppl in water	
7.18.14	Tia Blair	Julie Mcnamara		8:10	10:00	Sunny, Partly Cloudy	Low	Low	Down	Moderate, few people on the pier	

2.3 *Avian Species List*

Species Name	**Common Name**	**Order**	**Native (N) or Introduced (I)**	**Protected/ Endangered/ Threatened**
Actitis macularia	Spotted Sandpiper	Charadriiformes	N	MBTA
Aechmophorus occidentalis	Western Grebe	Podicipediformes	N	MBTA
Anas Americana	American Wigeon	Anseriformes	N	MBTA
Anas clypeata	Northern Shoveler	Anseriformes	N	MBTA
Anas cyanoptera	Cinnamon Teal	Anseriformes	N	MBTA
Anas Platyrhynchos	Mallard	Anseriformes	N	MBTA
Anas Platyrhynchos hybrid	Mallard Hybrid	Anseriformes	N	MBTA
Ardea albus	Great Egret	Pelecaniformes	N	MBTA
Ardea herodias	Great Blue Heron	Pelecaniformes	N	MBTA
Aythya affinis	Lesser Scaup	Anseriformes	N	MBTA
Buteo jamaicensis	Red Tailed Hawk	Accipitriformes	N	MBTA
Butorides virescens	Green Heron	Pelecaniformes	N	MBTA
Calidris alba	Sanderling	Charadriiformes	N	MBTA
Calidris mauri	Western Sandpiper	Charadriiformes	N	MBTA
Calidris minutilla	Least Sandpiper	Charadriiformes	N	MBTA
Calypte costae	Costa's Hummingbird	Apodiformes	N	MBTA
Carduelis psaltria	Lesser Goldfinch	Passeriformes	N	MBTA
Carpodacus mexicanus	House Finch	Passeriformes	N	MBTA
Catoptrophorus semipalmatus	Willet	Charadriiformes	N	MBTA
Charadrius semipalmatus	Semipalmated Plover	Charadriiformes	N	MBTA
Charadrius vociferus	Killdeer	Charadriiformes	N	MBTA
Chen rossii	Ross's Goose	Anseriformes	N	MBTA
Columba livia	Rock Pigeon	Columbiformes	I	n/a
Corvus brachyrhynchos	American Crow	Passeriformes	N	MBTA
Egretta thula	Snowy Egret	Pelecaniformes	N	MBTA
Fulica americana	American Coot	Gruiformes	N	MBTA
Gavia immer	Common Loon	Gaviiformes	N	MBTA
Himantopus mexicanus	Blacked Necked Stilt	Charadriiformes	N	MBTA
Haemorhous mexicanus	House Finch	Passeriformes	N	MBTA
Hirundo rustica	Barn Swallow	Passeriformes	N	MBTA
Icterus cucullatus	Hooded Oriole	Passeriformes	N	MBTA
Larus californicus	California Gull	Charadriiformes	N	MBTA
Larus delawarensis	Ring Billed Gull	Charadriiformes	N	MBTA
Larus occidentalis	Western Gull	Charadriiformes	N	MBTA
Limosa fedoa	Marbled Godwit	Charadriiformes	N	MBTA

Megaceryle alcyon	Belted Kingfisher	Coraciiformes	N	MBTA
Melospiza melodia	Song Sparrow	Passeriformes	N	MBTA
Mergus serrator	Red Breasted Merganser	Anseriformes	N	MBTA
Myiarchus cinerascens	Ash-throated Flycatcher	Passeriformes	N	MBTA
Numenius phaeopus	Whimbrel	Charadriiformes	N	MBTA
Nycticorax nycticorax	Black-Crowned Night Heron	Pelecaniformes	N	MBTA
Oxyura jamaicensis	Ruddy Duck	Anseriformes	N	MBTA
Pandion haliaetus	Osprey	Accipitriformes	N	MBTA
Aratinga Mitrata	Mitred Conure	Psittaciformes	I	n/a
Passer domesticus	House Sparrow	Passeriformes	I	n/a
Pelecanus occidentalis	Brown Pelican	Pelecaniformes	N	Delisted in Recovery (MBTA, ESA, CESA)
Phalacrocorax auritus	Double Crested Comorant	Suliformes	N	MBTA
Pluvialis squatarola	Black-bellied Plover	Charadriiformes	N	MBTA
Podiceps auritus	Horned Grebe	Podicipediformes	N	MBTA
Podiceps nigricollis	Eared Grebe	Podicipediformes	N	MBTA
Podilymbus podiceps	Pie-billed Grebe	Podicipediformes	N	MBTA
Psaltriparus minimus	Bushtit	Passeriformes	N	MBTA
Sayornis nigricans	Black Phoebe	Passeriformes	N	MBTA
Selasphorus rufus	Rufous Hummingbird	Apodiformes	N	MBTA
Selasphorus sasin	Allen's Hummingbird	Apodiformes	N	MBTA
Setophaga coronata	Yellow Rumped Warbler	Passeriformes	N	MBTA
Sialia mexicana	Western Bluebird	Passeriformes	N	MBTA
Sterna antillarum	California Least Turn	Charadriiformes	N	ESA
Sterna forsteri	Forster’s Tern	Charadriiformes	N	MBTA
Sturnus vulgaris	European Starling	Passeriformes	I	n/a
Tyrannus verticalis	Westerm Kingbird	Passeriformes	N	MBTA
Tyrannus vociferans	Cassin’s Kingbird	Passeriformes	N	MBTA
Zenaida macroura	Mourning Dove	Columbiformes	N	MBTA
Zonotrichia leucophrys	White Crowned Sparrow	Passeriformes	N	MBTA

2.4 Avian Gamma Diversity Raw Data

2.4.1 Order

2.4.1.1 Both Years

Order	N	Pi	Ln(Pi)	(pi)((ln(pi)))
Accipitriformes	3	0.00055	-7.50549	-0.00413
Anseriformes	1420	0.260359	-1.34569	-0.35036
Apodiformes	1	0.000183	-8.6041	-0.00158
Charadriiformes	744	0.136414	-1.99206	-0.27174
Columbiformes	42	0.007701	-4.86643	-0.03748
Coraciiformes	1	0.000183	-8.6041	-0.00158
Gaviiformes	2	0.000367	-7.91096	-0.0029
Gruiformes	2650	0.485882	-0.72179	-0.3507
Passeriformes	235	0.043088	-3.14452	-0.13549
Pelecaniformes	45	0.008251	-4.79744	-0.03958
Podicipediformes	233	0.042721	-3.15307	-0.1347
Psittaciformes	3	0.00055	-7.50549	-0.00413
Suliformes	68	0.012468	-4.3846	-0.05467
Trochiliformes	7	0.001283	-6.65819	-0.00855
TOTAL	5454			-1.39759

2.4.1.2 Year 1

Order	N	Pi	Ln(Pi)	(pi)((ln(pi)))
Accipitriformes	1	0.000208	-8.47908	-0.00176
Anseriformes	1290	0.268024	-1.31668	-0.3529
Charadriiformes	607	0.126117	-2.07055	-0.26113
Columbiformes	22	0.004571	-5.38803	-0.02463
Gaviiformes	2	0.000416	-7.78593	-0.00324
Gruiformes	2395	0.497611	-0.69794	-0.3473
Passeriformes	124	0.025764	-3.65879	-0.09426
Pelecaniformes	35	0.007272	-4.92373	-0.03581
Podicipediformes	278	0.05776	-2.85145	-0.1647
Suliformes	58	0.012051	-4.41863	-0.05325
Trochiliformes	1	0.000208	-8.47908	-0.00176
TOTAL	4813			-1.34074

2.4.1.3 Year 2

Order	N	Pi	Ln(Pi)	(pi)((ln(pi)))
Accipitriformes	2	0.002829	-5.86788	-0.0166
Anseriformes	130	0.183876	-1.6935	-0.31139
Apodiformes	1	0.001414	-6.56103	-0.00928
Charadriiformes	137	0.193777	-1.64105	-0.318
Columbiformes	20	0.028289	-3.5653	-0.10086
Coraciiformes	1	0.001414	-6.56103	-0.00928
Gruiformes	255	0.360679	-1.01977	-0.36781
Passeriformes	111	0.157001	-1.8515	-0.29069
Pelecaniformes	10	0.014144	-4.25845	-0.06023
Podicipediformes	21	0.029703	-3.51651	-0.10445
Psittaciformes	3	0.004243	-5.46242	-0.02318
Suliformes	10	0.014144	-4.25845	-0.06023
Trochiliformes	6	0.008487	-4.76927	-0.04047
TOTAL	707			-1.71247

2.4.2 Species

2.4.2.1 Both Years

Species	N	Pi	Ln(Pi)	(pi)((ln(pi)))
Actitis macularia	91	0.016685	-4.09325	-0.0683
Aechmophorus occidentalis	75	0.013751	-4.28662	-0.05895
Anas Americana	331	0.060689	-2.80199	-0.17005
Anas clypeata	4	0.000733	-7.21781	-0.00529
Anas cyanoptera	12	0.0022	-6.1192	-0.01346
Anas Platyrhynchos	68	0.012468	-4.3846	-0.05467
Anas Platyrhynchos hybrid	7	0.001283	-6.65819	-0.00855
Ardea alba	10	0.001834	-6.30152	-0.01155
Ardea herodias	5	0.000917	-6.99467	-0.00641
Aythya affinis	801	0.146865	-1.91824	-0.28172
Buteo jamaicensis	2	0.000367	-7.91096	-0.0029
Butorides virescens	1	0.000183	-8.6041	-0.00158
Calidris alba	1	0.000183	-8.6041	-0.00158
Calidris mauri	22	0.004034	-5.51306	-0.02224
Calidris minutilla	27	0.00495	-5.30827	-0.02628
Calypte costae	1	0.000183	-8.6041	-0.00158
Carduelis psaltria	1	0.000183	-8.6041	-0.00158
Catoptrophorus semipalmatus	12	0.0022	-6.1192	-0.01346
Charadrius semipalmatus	7	0.001283	-6.65819	-0.00855
Charadrius vociferus	6	0.0011	-6.81235	-0.00749
Chen rossii	1	0.000183	-8.6041	-0.00158
Columba livia	25	0.004584	-5.38523	-0.02468
Corvus brachyrhynchos	36	0.006601	-5.02059	-0.03314
Egretta thula	22	0.004034	-5.51306	-0.02224

Fulica americana	2650	0.485882	-0.72179	-0.3507
Gavia immer	2	0.000367	-7.91096	-0.0029
Haemorhous mexicanus	71	0.013018	-4.34142	-0.05652
Himantopus mexicanus	1	0.000183	-8.6041	-0.00158
Hirundo rustica	3	0.00055	-7.50549	-0.00413
Icterus cucullatus	2	0.000367	-7.91096	-0.0029
Larus californicus	46	0.008434	-4.77546	-0.04028
Larus delawarensis	364	0.06674	-2.70695	-0.18066
Larus occidentalis	15	0.00275	-5.89605	-0.01622
Limosa fedoa	133	0.024386	-3.71376	-0.09056
Megaceryle alcyon	1	0.000183	-8.6041	-0.00158
Melospiza melodia	1	0.000183	-8.6041	-0.00158
Mergus serrator	29	0.005317	-5.23681	-0.02785
Myiarchus cinerascens	1	0.000183	-8.6041	-0.00158
Numenius phaeopus	1	0.000183	-8.6041	-0.00158
Nycticorax nycticorax	1	0.000183	-8.6041	-0.00158
Oxyura jamaicensis	167	0.03062	-3.48611	-0.10674
Pandion haliaetus	1	0.000183	-8.6041	-0.00158
Aratinga Mitrata	3	0.00055	-7.50549	-0.00413
Passer domesticus	29	0.005317	-5.23681	-0.02785
Pelecanus occidentalis	6	0.0011	-6.81235	-0.00749
Phalacrocorax auritus	68	0.012468	-4.3846	-0.05467
Pluvialis squatarola	9	0.00165	-6.40688	-0.01057
Podiceps auritus	2	0.000367	-7.91096	-0.0029
Podiceps nigricollis	50	0.009168	-4.69208	-0.04302
Podilymbus podiceps	106	0.019435	-3.94067	-0.07659
Psaltriparus minimus	6	0.0011	-6.81235	-0.00749
Sayornis nigricans	17	0.003117	-5.77089	-0.01799
Selasphorus rufus	3	0.00055	-7.50549	-0.00413
Selasphorus sasin	4	0.000733	-7.21781	-0.00529
Setophaga coronata	19	0.003484	-5.65967	-0.01972
Sialia mexicana	11	0.002017	-6.20621	-0.01252
Sterna antillarum	2	0.000367	-7.91096	-0.0029
Sterna forsteri	7	0.001283	-6.65819	-0.00855
Sturnus vulgaris	6	0.0011	-6.81235	-0.00749
Tyrannus verticalis	5	0.000917	-6.99467	-0.00641
Tyrannus vociferans	13	0.002384	-6.03916	-0.01439
Zenaida macroura	17	0.003117	-5.77089	-0.01799
Zonotrichia leucophrys	14	0.002567	-5.96505	-0.01531
TOTAL	5454			-2.10572

2.4.2.2 Year 1

Species	N	Pi	Ln(Pi)	(pi)((ln(pi)))
Actitis macularia	83	0.017245	-4.06024	-0.07002
Aechmophorus occidentalis	75	0.015583	-4.16159	-0.06485
Anas Americana	285	0.059215	-2.82659	-0.16738
Anas clypeata	4	0.000831	-7.09278	-0.00589
Anas cyanoptera	12	0.002493	-5.99417	-0.01494
Anas Platyrhynchos	53	0.011012	-4.50878	-0.04965
Ardea alba	9	0.00187	-6.28185	-0.01175
Ardea herodias	3	0.000623	-7.38046	-0.0046
Aythya affinis	746	0.154997	-1.86435	-0.28897
Buteo jamaicensis	1	0.000208	-8.47908	-0.00176
Calidris alba	1	0.000208	-8.47908	-0.00176
Calidris mauri	9	0.00187	-6.28185	-0.01175
Calidris minutilla	13	0.002701	-5.91413	-0.01597
Catoptrophorus semipalmatus	7	0.001454	-6.53317	-0.0095
Charadrius vociferus	4	0.000831	-7.09278	-0.00589
Columba livia	19	0.003948	-5.53464	-0.02185
Corvus brachyrhynchos	8	0.001662	-6.39963	-0.01064
Egretta thula	17	0.003532	-5.64586	-0.01994
Feral Duck	3	0.000623	-7.38046	-0.0046
Fulica americana	2395	0.497611	-0.69794	-0.3473
Gavia immer	2	0.000416	-7.78593	-0.00324
Haemorhous mexicanus	36	0.00748	-4.89556	-0.03662
Himantopus mexicanus	1	0.000208	-8.47908	-0.00176
Hirundo rustica	2	0.000416	-7.78593	-0.00324
Larus californicus	35	0.007272	-4.92373	-0.03581
Larus delawarensis	319	0.066279	-2.71388	-0.17987
Larus occidentalis	11	0.002285	-6.08118	-0.0139
Limosa fedoa	116	0.024101	-3.72549	-0.08979
Mergus serrator	29	0.006025	-5.11178	-0.0308
Numenius phaeopus	1	0.000208	-8.47908	-0.00176
Nycticorax nycticorax	1	0.000208	-8.47908	-0.00176
Oxyura jamaicensis	158	0.032828	-3.41648	-0.11216
Passer domesticus	29	0.006025	-5.11178	-0.0308
Pelecanus occidentalis	5	0.001039	-6.86964	-0.00714
Phalacrocorax auritus	58	0.012051	-4.41863	-0.05325
Pluvialis squatarola	4	0.000831	-7.09278	-0.00589
Podiceps auritus	68	0.014128	-4.25957	-0.06018
Podiceps nigricollis	48	0.009973	-4.60787	-0.04595
Podilymbus podiceps	87	0.018076	-4.01317	-0.07254
Sayornis nigricans	7	0.001454	-6.53317	-0.0095
Selasphorus sasin	1	0.000208	-8.47908	-0.00176
Setophaga coronata	14	0.002909	-5.84002	-0.01699
Sialia mexicana	3	0.000623	-7.38046	-0.0046

Sterna forsteri	3	0.000623	-7.38046	-0.0046
Sturnus vulgaris	2	0.000416	-7.78593	-0.00324
Tyrannus vociferans	12	0.002493	-5.99417	-0.01494
Zenaida macroura	3	0.000623	-7.38046	-0.0046
Zonotrichia leucophrys	11	0.002285	-6.08118	-0.0139
TOTAL	4813			-1.9896

2.4.2.3 Year 2

Species	**N**	**Pi**	**Ln(Pi)**	**(pi)((ln(pi)))**
Actitis macularia	8	0.011315	-4.48159	-0.05071
Anas Americana	46	0.065064	-2.73239	-0.17778
Anas Platyrhynchos	15	0.021216	-3.85298	-0.08175
Anas Platyrhynchos hybrid	4	0.005658	-5.17474	-0.02928
Ardea alba	1	0.001414	-6.56103	-0.00928
Ardea herodias	2	0.002829	-5.86788	-0.0166
Aythya affinis	55	0.077793	-2.5537	-0.19866
Buteo jamaicensis	1	0.001414	-6.56103	-0.00928
Butorides virescens	1	0.001414	-6.56103	-0.00928
Calidris mauri	13	0.018388	-3.99608	-0.07348
Calidris minutilla	14	0.019802	-3.92197	-0.07766
Calypte costae	1	0.001414	-6.56103	-0.00928
Carduelis psaltria	1	0.001414	-6.56103	-0.00928
Catoptrophorus semipalmatus	5	0.007072	-4.95159	-0.03502
Charadrius semipalmatus	7	0.009901	-4.61512	-0.04569
Charadrius vociferus	2	0.002829	-5.86788	-0.0166
Chen rossii	1	0.001414	-6.56103	-0.00928
Columba livia	6	0.008487	-4.76927	-0.04047
Corvus brachyrhynchos	28	0.039604	-3.22883	-0.12787
Egretta thula	5	0.007072	-4.95159	-0.03502
Fulica americana	255	0.360679	-1.01977	-0.36781
Haemorhous mexicanus	35	0.049505	-3.00568	-0.1488
Hirundo rustica	1	0.001414	-6.56103	-0.00928
Icterus cucullatus	2	0.002829	-5.86788	-0.0166
Larus californicus	11	0.015559	-4.16314	-0.06477
Larus delawarensis	45	0.063649	-2.75437	-0.17531
Larus occidentalis	4	0.005658	-5.17474	-0.02928
Limosa fedoa	17	0.024045	-3.72782	-0.08964
Megaceryle alcyon	1	0.001414	-6.56103	-0.00928
Melospiza melodia	1	0.001414	-6.56103	-0.00928
Myiarchus cinerascens	1	0.001414	-6.56103	-0.00928
Oxyura jamaicensis	9	0.01273	-4.36381	-0.05555
Pandion haliaetus	1	0.001414	-6.56103	-0.00928
Aratinga Mitrata	3	0.004243	-5.46242	-0.02318
Pelecanus occidentalis	1	0.001414	-6.56103	-0.00928

Phalacrocorax auritus	10	0.014144	-4.25845	-0.06023
Pluvialis squatarola	5	0.007072	-4.95159	-0.03502
Podiceps nigricollis	2	0.002829	-5.86788	-0.0166
Podilymbus podiceps	19	0.026874	-3.61659	-0.09719
Psaltriparus minimus	6	0.008487	-4.76927	-0.04047
Sayornis nigricans	10	0.014144	-4.25845	-0.06023
Selasphorus rufus	3	0.004243	-5.46242	-0.02318
Selasphorus sasin	3	0.004243	-5.46242	-0.02318
Setophaga coronata	5	0.007072	-4.95159	-0.03502
Sialia mexicana	8	0.011315	-4.48159	-0.05071
Sterna antillarum	2	0.002829	-5.86788	-0.0166
Sterna forsteri	4	0.005658	-5.17474	-0.02928
Sturnus vulgaris	4	0.005658	-5.17474	-0.02928
Tyrannus verticalis	5	0.007072	-4.95159	-0.03502
Tyrannus vociferans	1	0.001414	-6.56103	-0.00928
Zenaida macroura	14	0.019802	-3.92197	-0.07766
Zonotrichia leucophrys	3	0.004243	-5.46242	-0.02318
TOTAL	707			-2.75102

2.4.2.3 Western Arm

2.4.2.3.1 Order

Order	**N**	**Pi**	**Ln(Pi)**	**(pi)((ln(pi)))**
Anseriformes	237	0.325103	-1.12361	-0.365290015
Apodiformes	1	0.001372	-6.59167	-0.009042076
Charadriiformes	114	0.156379	-1.85548	-0.290156629
Columbiformes	14	0.019204	-3.95262	-0.075907585
Gruiformes	277	0.379973	-0.96766	-0.367682818
Passeriformes	20	0.027435	-3.59594	-0.098654087
Pelecaniformes	2	0.002743	-5.89853	-0.016182515
Podicipediformes	51	0.069959	-2.65985	-0.186079908
Psittaciformes	3	0.004115	-5.49306	-0.022605191
Suliformes	7	0.009602	-4.64576	-0.044609527
Trochiliformes	3	0.004115	-5.49306	-0.022605191
TOTAL	729			-1.498815542

2.4.2.3.2 Species

Species	N	Pi	Ln(Pi)	(pi)((ln(pi)))
Actitis macularia	31	0.042524	-3.1576865	-0.134277479
Aechmophorus occidentalis	12	0.0164609	-4.1067671	-0.067601104
Anas Americana	17	0.0233196	-3.7584604	-0.087645853
Anas Platyrhynchos	3	0.0041152	-5.4930614	-0.022605191
Aratinga Mitrata	3	0.0041152	-5.4930614	-0.022605191
Aythya affinis	96	0.1316872	-2.0273255	-0.266972911
Calidris mauri	13	0.0178326	-4.0267244	-0.071807156
Calidris minutilla	15	0.0205761	-3.8836235	-0.079909949
Calypte costae	1	0.0013717	-6.5916737	-0.009042076
Catoptrophorus semipalmatus	2	0.0027435	-5.8985266	-0.016182515
Charadrius semipalmatus	7	0.0096022	-4.6457636	-0.044609527
Charadrius vociferus	5	0.0068587	-4.9822358	-0.034171713
Columba livia	12	0.0164609	-4.1067671	-0.067601104
Corvus brachyrhynchos	8	0.0109739	-4.5122322	-0.049516951
Fulica americana	277	0.3799726	-0.9676562	-0.367682818
Larus californicus	2	0.0027435	-5.8985266	-0.016182515
Larus delawarensis	28	0.0384088	-3.2594692	-0.125192233
Larus occidentalis	6	0.0082305	-4.7999143	-0.039505467
Limosa fedoa	3	0.0041152	-5.4930614	-0.022605191
Mergus serrator	7	0.0096022	-4.6457636	-0.044609527
Oxyura jamaicensis	114	0.1563786	-1.8554753	-0.290156629
Pelecanus occidentalis	2	0.0027435	-5.8985266	-0.016182515
Phalacrocorax auritus	7	0.0096022	-4.6457636	-0.044609527
Pluvialis squatarola	2	0.0027435	-5.8985266	-0.016182515
Podiceps nigricollis	7	0.0096022	-4.6457636	-0.044609527
Podilymbus podiceps	32	0.0438957	-3.1259378	-0.137215378
Sayornis nigricans	1	0.0013717	-6.5916737	-0.009042076
Selasphorus rufus	2	0.0027435	-5.8985266	-0.016182515
Selasphorus sasin	1	0.0013717	-6.5916737	-0.009042076
Setophaga coronata	6	0.0082305	-4.7999143	-0.039505467
Tyrannus verticalis	5	0.0068587	-4.9822358	-0.034171713
Zenaida macroura	2	0.0027435	-5.8985266	-0.016182515
TOTAL	729			-2.263408925

2.4.2.4 Outside Western Arm

2.4.2.4.1 Order

Order	N	Pi	Ln(Pi)	(pi)((ln(pi)))
Accipitriformes	3	0.000635	-7.36201	-0.00467
Anseriformes	1183	0.25037	-1.38481	-0.34672
Charadriiformes	630	0.133333	-2.0149	-0.26865
Columbiformes	28	0.005926	-5.12842	-0.03039
Coraciiformes	1	0.000212	-8.46062	-0.00179
Gaviiformes	2	0.000423	-7.76748	-0.00329
Gruiformes	2373	0.502222	-0.68871	-0.34589
Passeriformes	215	0.045503	-3.08998	-0.1406
Pelecaniformes	43	0.009101	-4.69942	-0.04277
Podicipediformes	182	0.038519	-3.25662	-0.12544
Suliformes	61	0.01291	-4.34975	-0.05616
Trochiliformes	4	0.000847	-7.07433	-0.00599
TOTAL	4725			-1.37235

2.4.2.4.2 Species

Species	N	Pi	Ln(Pi)	(pi)((ln(pi)))
Charadriiformes	60	0.012698	-4.36628	-0.05544
Aechmophorus occidentalis	63	0.013333	-4.31749	-0.05757
Anas Americana	314	0.066455	-2.71123	-0.18017
Anas clypeata	4	0.000847	-7.07433	-0.00599
Anas cyanoptera	12	0.00254	-5.97572	-0.01518
Anas Platyrhynchos	65	0.013757	-4.28624	-0.05896
Anas Platyrhynchos hybrid	7	0.001481	-6.51471	-0.00965
Ardea alba	10	0.002116	-6.15804	-0.01303
Ardea herodias	5	0.001058	-6.85118	-0.00725
Aythya affinis	705	0.149206	-1.90243	-0.28385
Buteo jamaicensis	2	0.000423	-7.76748	-0.00329
Butorides virescens	1	0.000212	-8.46062	-0.00179
Calidris alba	1	0.000212	-8.46062	-0.00179
Calidris mauri	9	0.001905	-6.2634	-0.01193
Calidris minutilla	12	0.00254	-5.97572	-0.01518
Carduelis psaltria	1	0.000212	-8.46062	-0.00179
Catoptrophorus semipalmatus	10	0.002116	-6.15804	-0.01303
Charadrius vociferus	1	0.000212	-8.46062	-0.00179
Chen rossii	1	0.000212	-8.46062	-0.00179
Columba livia	13	0.002751	-5.89567	-0.01622
Corvus brachyrhynchos	28	0.005926	-5.12842	-0.03039
Egretta thula	19	0.004021	-5.51618	-0.02218
Fulica americana	2373	0.502222	-0.68871	-0.34589
Gavia immer	2	0.000423	-7.76748	-0.00329
Haemorhous mexicanus	71	0.015026	-4.19794	-0.06308

Himantopus mexicanus	1	0.000212	-8.46062	-0.00179
Hirundo rustica	3	0.000635	-7.36201	-0.00467
Icterus cucullatus	2	0.000423	-7.76748	-0.00329
Larus californicus	44	0.009312	-4.67643	-0.04355
Larus delawarensis	336	0.071111	-2.64351	-0.18798
Larus occidentalis	9	0.001905	-6.2634	-0.01193
Limosa fedoa	130	0.027513	-3.59309	-0.09886
Megaceryle alcyon	1	0.000212	-8.46062	-0.00179
Melospiza melodia	1	0.000212	-8.46062	-0.00179
Mergus serrator	22	0.004656	-5.36958	-0.025
Myiarchus cinerascens	1	0.000212	-8.46062	-0.00179
Numenius phaeopus	1	0.000212	-8.46062	-0.00179
Nycticorax nycticorax	1	0.000212	-8.46062	-0.00179
Oxyura jamaicensis	53	0.011217	-4.49033	-0.05037
Pandion haliaetus	1	0.000212	-8.46062	-0.00179
Passer domesticus	29	0.006138	-5.09333	-0.03126
Pelecanus occidentalis	4	0.000847	-7.07433	-0.00599
Phalacrocorax auritus	61	0.01291	-4.34975	-0.05616
Pluvialis squatarola	7	0.001481	-6.51471	-0.00965
Podiceps auritus	2	0.000423	-7.76748	-0.00329
Podiceps nigricollis	43	0.009101	-4.69942	-0.04277
Podilymbus podiceps	74	0.015661	-4.15656	-0.0651
Psaltriparus minimus	6	0.00127	-6.66886	-0.00847
Sayornis nigricans	16	0.003386	-5.68803	-0.01926
Selasphorus rufus	1	0.000212	-8.46062	-0.00179
Selasphorus sasin	3	0.000635	-7.36201	-0.00467
Setophaga coronata	13	0.002751	-5.89567	-0.01622
Sialia mexicana	11	0.002328	-6.06273	-0.01411
Sterna antillarum	2	0.000423	-7.76748	-0.00329
Sterna forsteri	7	0.001481	-6.51471	-0.00965
Sturnus vulgaris	6	0.00127	-6.66886	-0.00847
Tyrannus vociferans	13	0.002751	-5.89567	-0.01622
Zenaida macroura	15	0.003175	-5.75257	-0.01826
Zonotrichia leucophrys	14	0.002963	-5.82157	-0.01725
TOTAL	4722			-2.01059

Appendix 3

3.0 Standard Procedures for Ichthyofauna Monitoring

Materials and Methods

1. Collect materials (2 pencils, 5 blank data sheets, 1 clipboard, 1 rubber band, 3 large buckets, 5 small buckets, 1 metric measuring board, 1 camera, 1 large net, 1 pair of pliers, 2 wetsuits (optional)

2. Fill out top portion of "Colorado Lagoon Ichthyofauna Field Sample Data Sheet"

3. Lay out the net parallel to the water along the bank.

4. Fill the buckets with salt water from an area away from where the beach seine will be conducted. Place all the full buckets approximately 10 feet from the water, in the area that you presume the net will be pulled ashore.

5. Place 1 person at each end pole. Walk the net into the water, orienting the net perpendicular to the shore (Photo 1).
    a. Poles must maintain contact with the ground for the entire seine.
    b. The lead individual will walk straight out into the water until they reach the deepest point where they can comfortably walk along the bottom of the Lagoon (Photo 2).
    c. Lead individual walks parallel to the shore for 5 to 10 feet. The trailing pole will also walk along the shore for the same distance (Photo 3).
    d. Once the walking distance has been reached, the trailing individual stops walking while the lead individual swings the net toward the shore (Photo 4). Keep the net at full, extended length during this time.
    e. When the net is close to shore, a third person standing on shore should drag the weighted, bottom edge landward to prevent organisms from escaping the net.

6. Once on shore, flatten net on the ground and collect all organisms, placing them in buckets containing salt water (Photo 5). Search algae for hidden fauna.

Photo 1: Step 5 (Tidal Influence)

Photo 2: Step 5.b (Tidal Influence)

Photo 3: Step 5.c (Tidal Influence)

Photo 4: Step 5.d (Tidal Influence)

7. Once all fish are collected from the net, begin measuring the length in centimeters of ten individuals per species. Use the measuring board over a water bucket (Photo 74).

8. After 10 individuals per species are measured, continue to count the number of individuals per species.

9. After all of the organisms have been measured and/or counted, gently empty buckets back into Lagoon.

10. Carry the net to the water (keeping it flat), and clear away any algae.

11. Carry materials to the next sample location and repeat steps 1, 3-10.

Photo 5: Step 6 (Tidal Influence)

Photo 6: Step 7 (Tidal Influence)

Date/Time Sampling location: Length

FISH SPECIES	ABUNDANCE TALLY (n)	1	2	3	4	5	6	7	8	9	10
Bay Pipe Fish (*Syngnathus griseolineatus*)											
Arrow Gobi (*Clevelandia ios*)											
Bat Ray (*Myliobatis californicus*)											
California Halibut (*Paralichthys californicus*)											
California Killifish (*Fundulus parvipinnis*)											
Diamond Turbot (*Hypsopsetta guttulata*)											
Electric Ray (*Torperdo californica*)											
Gray Smoothhound (*Mustelus californicus*)											
Jacksmelt (*Atherinops californiensis*)											
Longjaw Mudsucker (*Gillichthys mirabilis*)											
Round Sting Ray (*Urobatis haleri*)											
Shinner Perch (Cymatogaster aggregata)											
Shovelnose Guitarfish (*Rhinobatus productus*)											
Staghorn Sculpin (*Leptocottus armatus*)											
Stripped Mullet (*Mugil cephalus*)											
Thornback Ray (*Raja clavata*)											
Topsmelt (*Atherinops affinis*)											
Yellowfin Croaker (*Umbrina roncador*)											

3.2 Fish Site Information

Date	Observer 1	Observer 2	Observer 3	Start Time	End Time	Weather	Tidal Height	Up or Down	Human Activity:	NOTES
1.18.13	unknown	unknown	unknown	?	?	?	?	?	?	all of the site information was not recorded
4.5.13	unknown	unknown	unknown	14:45	3:30	?	?	?	?	all of the site information was not recorded
6.22.13	unknown	unknown	unknown	7:00	9:45	?	?	?	?	all of the site information was not recorded
7.22.13	unknown	unknown	unknown	12:10	13:00	?	?	?	?	all of the site information was not recorded
8.17.13	unknown	unknown	unknown	10:00	10:47	?	?	?	?	all of the site information was not recorded
10.25.13	Tia Blair	Julie McNamara	Kira (intern)	8:17	9:45	Overcast	Mid-tide	?	Min	Boat crossed in front of NB before sample was taken- could have skewed data. Also, net got stuck on something for NB-had to lift up.
1.9.14	Tia Blair	Julie McNamara	3 Interns	8:20	10:16	Partly Cloudy	3.2	Down	none	
4.9.14	Tia Blair	Julie McNamara	3 Inters, 1 Super Volunteer	9:15	10:45	Partly Cloudy		Down	Min	
7.29.14	Tia Blair	Julie McNamara	3 Contactors	8:12	9:53	Sunny	1	Up	Min	Tide was much lower than normal

3.3 Species List

Species Name	Common Name	Order	Native or Non-Native	Endangered or No concern
Syngnathus griseolineatu	Bay Pipe Fish	Syngnathidae	N	n/a
Clevelandia ios	Arrow Gobi	Perciformes	N	n/a
Myliobatis californicus	Bat Ray	Myliobatiformes	N	LC
Paralichthys californicus	California Halibut	Pleuronectiformes	N	LC
Fundulus parvipinnis	California Killifish	Cyprinodontiformes	N	n/a
Hypsopsetta guttulata	Diamond Turbot	Pleuronectiformes	N	LC
Atherinops californiensis	Jacksmelt	Atheriniformes	N	LC
Urobatis halleri	Round Sting Ray	Myliobatiformes	N	LC
Cymatogaster aggregata	Shinner Perch	Perciformes	N	n/a
Leptocottus armatus	Staghorn Sculpin	Scorpaeniformes	N	n/a
Atherinops affinis	Topsmelt	Atheriniformes	N	LC
Ilypnus gilberti	Cheekspot Gobi	Perciformes	N	LC
Tridentiger trigonocephalus	Chameleon Gobi	Perciformes	NN	n/a
Gibbonsia metzi	Striped Kelpfish	Perciformes	N	n/a

3.4 Gamma Diversity Raw Data

3.4.1 Order

3.4.1.1 Overall

Both Years				
Order	**N**	**Pi**	**Ln(Pi)**	**(pi)((ln(pi)))**
Atheriniformes	901	0.221485	-1.5074	-0.333866458
Carcharhiniformes	1470	0.361357	-1.01789	-0.367821274
Cyprinodontiformes	1617	0.397493	-0.92258	-0.366718308
Myliobatiformes	4	0.000983	-6.92461	-0.006808862
Perciformes	6	0.001475	-6.51915	-0.009615261
Pleuronectiformes	10	0.002458	-6.00832	-0.014769719
Scorpaeniformes	44	0.010816	-4.52672	-0.048961542
Syngnathidae	16	0.003933	-5.53832	-0.021782962
TOTAL	4068			-1.170344386

3.4.1.2 Year 1

Year 1				
Order	**N**	**Pi**	**Ln(Pi)**	**(pi)((ln(pi)))**
Atheriniformes	628	0.364692	-1.0087	-0.36787
Carcharhiniformes	667	0.38734	-0.94845	-0.36737
Cyprinodontiformes	374	0.217189	-1.52699	-0.33165
Myliobatiformes	3	0.001742	-6.35263	-0.01107
Perciformes	3	0.001742	-6.35263	-0.01107
Pleuronectiformes	2	0.001161	-6.75809	-0.00785
Scorpaeniformes	32	0.018583	-3.98551	-0.07406
Syngnathidae	13	0.007549	-4.88629	-0.03689
TOTAL	1722			-1.20782

3.4.1.2 Year 2

Year 2				
Order	**N**	**Pi**	**Ln(Pi)**	**(pi)((ln(pi)))**
Atheriniformes	273	0.116368	-2.151	-0.25031
Carcharhiniformes	803	0.342285	-1.07211	-0.36697
Cyprinodontiformes	1243	0.529838	-0.63518	-0.33654
Myliobatiformes	1	0.000426	-7.76047	-0.00331
Perciformes	3	0.001279	-6.66185	-0.00852
Pleuronectiformes	8	0.00341	-5.68103	-0.01937
Scorpaeniformes	12	0.005115	-5.27556	-0.02698
Syngnathidae	3	0.001279	-6.66185	-0.00852
TOTAL	2346			-1.02052

3.4.2 Species

3.4.2.1 Overall

Both Years				
Species	**N**	**Pi**	**Ln(Pi)**	**(pi)((ln(pi)))**
Atherinops affinis	897	0.220501	-1.51185	-0.33337
Atherinops californiensis	4	0.000983	-6.92461	-0.00681
Clevelandia ios	1470	0.361357	-1.01789	-0.36782
Cymatogaster aggregata	2	0.000492	-7.61776	-0.00375
Fundulus parvipinnis	1617	0.397493	-0.92258	-0.36672
Gibbonsia metzi	1	0.000246	-8.31091	-0.00204
Hypsopsetta guttulata	9	0.002212	-6.11368	-0.01353
Ilypnus gilberti	1	0.000246	-8.31091	-0.00204
Leptocottus armatus	44	0.010816	-4.52672	-0.04896
Myliobatis californicus	1	0.000246	-8.31091	-0.00204
Paralichthys californicus	1	0.000246	-8.31091	-0.00204
Syngnathus griseolineatu	16	0.003933	-5.53832	-0.02178
Tridentiger trigonocephalus	2	0.000492	-7.61776	-0.00375
Urobatis haleri	3	0.000737	-7.21229	-0.00532
TOTAL	4068			-1.17997

3.4.2.2 Year 1

Year 1				
Species	**N**	**Pi**	**Ln(Pi)**	**(pi)((ln(pi)))**
Atherinops affinis	624	0.362369	-1.01509	-0.36784
Atherinops californiensis	4	0.002323	-6.06495	-0.01409
Clevelandia ios	667	0.38734	-0.94845	-0.36737
Cymatogaster aggregata	1	0.000581	-7.45124	-0.00433
Fundulus parvipinnis	374	0.217189	-1.52699	-0.33165
Hypsopsetta guttulata	1	0.000581	-7.45124	-0.00433
Ilypnus gilberti	1	0.000581	-7.45124	-0.00433
Leptocottus armatus	32	0.018583	-3.98551	-0.07406
Myliobatis californicus	1	0.000581	-7.45124	-0.00433
Paralichthys californicus	1	0.000581	-7.45124	-0.00433
Syngnathus griseolineatu	13	0.007549	-4.88629	-0.03689
Tridentiger trigonocephalus	1	0.000581	-7.45124	-0.00433
Urobatis haleri	2	0.001161	-6.75809	-0.00785
TOTAL	1722			-1.22571

3.4.2.2 Year 2

Year 2				
Species	**N**	**Pi**	**Ln(Pi)**	**(pi)((ln(pi)))**
Atherinops affinis	273	0.116368	-2.151	-0.25031
Clevelandia ios	803	0.342285	-1.07211	-0.36697
Cymatogaster aggregata	1	0.000426	-7.76047	-0.00331
Fundulus parvipinnis	1243	0.529838	-0.63518	-0.33654
Gibbonsia metzi	1	0.000426	-7.76047	-0.00331
Hypsopsetta guttulata	8	0.00341	-5.68103	-0.01937
Leptocottus armatus	12	0.005115	-5.27556	-0.02698
Syngnathus griseolineatu	3	0.001279	-6.66185	-0.00852
Tridentiger trigonocephalus	1	0.000426	-7.76047	-0.00331
Urobatis haleri	1	0.000426	-7.76047	-0.00331
Total	2346			-1.02193

3.4.2.3 Per Site for Both Years

3.4.2.3.1 North Beach

Species	N	Pi	Ln(Pi)	(pi)((ln(pi)))
Atherinops affinis	162	0.15197	-1.88407	-0.28632
Clevelandia ios	553	0.518762	-0.65631	-0.34047
Fundulus parvipinnis	309	0.289869	-1.23833	-0.35895
Gibbonsia metzi	1	0.000938	-6.97167	-0.00654
Hypsopsetta guttulata	4	0.003752	-5.58537	-0.02096
Ilypnus gilberti	1	0.000938	-6.97167	-0.00654
Leptocottus armatus	20	0.018762	-3.97594	-0.0746
Paralichthys californicus	1	0.000938	-6.97167	-0.00654
Syngnathus griseolineatu	14	0.013133	-4.33261	-0.0569
Tridentiger trigonocephalus	1	0.000938	-6.97167	-0.00654
TOTAL	1066			-1.16436

3.4.2.3.2 South Beach

Species	N	Pi	Ln(Pi)	(pi)((ln(pi)))
Atherinops affinis	526	0.391952	-0.93662	-0.36711
Clevelandia ios	529	0.394188	-0.93093	-0.36696
Cymatogaster aggregata	1	0.000745	-7.20192	-0.00537
Fundulus parvipinnis	270	0.201192	-1.60349	-0.32261
Hypsopsetta guttulata	1	0.000745	-7.20192	-0.00537
Leptocottus armatus	12	0.008942	-4.71701	-0.04218
Myliobatis californicus	1	0.000745	-7.20192	-0.00537
Syngnathus griseolineatu	2	0.00149	-6.50877	-0.0097
TOTAL	1342			-1.12466

3.4.2.3.3 Western Arm Area

Species	N	Pi	Ln(Pi)	(pi)((ln(pi)))
Atherinops affinis	209	0.125904	-2.07224	-0.2609
Atherinops californiensis	4	0.00241	-6.02828	-0.01453
Clevelandia ios	388	0.233735	-1.45357	-0.33975
Cymatogaster aggregata	1	0.000602	-7.41457	-0.00447
Fundulus parvipinnis	1038	0.625301	-0.46952	-0.29359
Hypsopsetta guttulata	4	0.00241	-6.02828	-0.01453
Leptocottus armatus	12	0.007229	-4.92967	-0.03564
Tridentiger trigonocephalus	1	0.000602	-7.41457	-0.00447
Urobatis haleri	3	0.001807	-6.31596	-0.01141
TOTAL	1660			-0.97928

3.5 Top 5 Species Lengths

3.5.1 Overall

Species	Mean	Maximum	Historical Mean	Historical Maximum
Atherinops affinis	5.798	11.2	40	45
Clevelandia ios	4.374	11	4.2	6.4
Fundulus parvipinnis	5.204	9.8	7	10.8
Hypsopsetta guttulata	6.28	12.2	17.9	46
Leptocottus armatus	5.289	10.3	35.5	46
Syngnathus griseolineatu	13.21	19.3	23.5	32.5

3.5.2 North Beach

Species Name	Mean	Grouping	N
Atherinops affinis	5.6	B C	58
Clevelandia ios	4.123	D	88
Fundulus parvipinnis	4.752	C D	52
Hypsopsetta guttulata	7.9	B	4
Leptocottus armatus	4.454	C D	13
Syngnathus griseolineatu	13.83	A	14

3.5.2 South Beach

Species Name	Mean	Grouping	N
Atherinops affinis	6.038	A	12
Clevelandia ios	4.697	B	60
Fundulus parvipinnis	5.77	A	60
Hypsopsetta guttulata	4.95	A B	4
Leptocottus armatus	6.167	A B	70
Syngnathus griseolineatu	0		0

3.5.2 Western Arm Area

Species Name	Mean	Grouping	N
Atherinops affinis	5.735	A	46
Clevelandia ios	4.366	B	76
Fundulus parvipinnis	5.002	A B	52
Hypsopsetta guttulata	5.1	A B	1
Leptocottus armatus	5.315	A B	13
Syngnathus griseolineatu	8.85	A	2

Appendix 4

4.1 Invertebrate Data Sheet

Project:

Date sampled:

INFAUNA DATA SHEET

Core size: 18cm2 X 6cm deep; ≥0.3m

Block: Rep: Elevat'n: Treatment: Date(s) sorted:

	0-2 cm	2-6 cm		0-2 cm	2-6 cm		0-2 cm	2-6 cm
OLIGOCHAETES			**BIVALVES**			**AMPHIPODS**		
Tubificidae			*Musculista senhousia*			*Corophium spp.*		
Tubificoides brownae			*Geukensia demissa*			Grandidierella japonica		
Tubificoides fraseri			*Mytilus spp.*			Corophiidae		
Limnodriloides barnardi			Mytilidae					
Tectidrilus diversus			*Tagelus californianus*			Gammaridae a		
Monopylephorus rubroniveus			*Nuttallia nuttallii*			Gammaridae b		
			Myidae					
Paranais litoralis			*Macoma nasuta*					
Enchytraeidae			*Macoma spp.*			Caprellids		
Enchytraeus spp.			*Tellina spp.*					
			Tellinidae			**ISOPODS**		
			Mercenaria mercenaria			Sphaeromatidae		
POLYCHAETES			*Protothaca spp.*			*Peracerceis spp.*		
Pseudopolydora paucibranchiata			*Saxidomus spp.*			*Ligia spp.*		
Polydora ligni			*Chione spp.*			*Idotea resecata*		
Polydora nuchalis						Anthuridea		
Streblospio benedicti								
Spiophanes sp.						**TANAIDS**		
Spionidae						*Leptochelia dubia*		
						CUMACEAN		
Mediomastus ____			**GASTROPODS**					
Capitella sp.			*Cerithidea californica*			**Leptostraca**		
Capitellidae			*Nassarius tegula*			*Nebalia sp.*		
			Melampus olivaceus					
Exogone lourei			*Assiminea californica*			**INSECTS/arachnid**		
Brania spp.			*Barleeia subtenuis*			Chironomid		
Syllidae						Ceratopogonidae		
Eteone dilatae						Muscidae		
Eteone californica			*Acteocina inculta*			Dolichopodidae		
Phyllodocidae			*Acteocina culcitella*			Saldidae		
Fabricia limnicola			*Bulla gouldiana*			Poduridae		
Fabricia sabella			*Haminoea spp.*			Staphynidae (rove)		
Megalomma pigmentum			Cephalaspidea					
Sabellidae								
Cirraformia spirabrancha			*Alderia modesta*			mites		
Tharyx sp.								
Armandia brevis								
Cirratilidae								
Schistomeringos sp.			**DECAPODS**			**HOLOTHURIANS**		
Dorvilleidae			*Uca spp.*					
Maldanidae								
Ampharetidae			Grapsidae			**PHORONIDS**		
Lumbrinaridae			*Pachygrapsus crassipes*			**SEA ANENOME**		
Orbinidae			*Hemigrapsus oregonensis*					
Armandia brevis			*Callianassa californiensis*			**NEMERTEANS**		
Ophelidae								
						FLATWORMS		
						#macro/core		
						#spp/core		

4.2 Invertebrate Species List

4.2.1 Method A

Species Name	Class	Colorado Lagoon Count	Zedler Marsh Count
Neomolgus	Arachnida	0	3
Oribatid	Arachnida	0	67
Oligochaetes	Clitellata	0	4
Aceteocina inculta	Gastropoda	27	11
Assiminea californica	Gastropoda	9	2
Carabidae	Insecta	1	0
Ceratopogonidae	Insecta	0	2
Dolichopodidae	Insecta	0	29
Ephydridae	Insecta	65	0
Psychodiadae	Insecta	15	3
Staphylinidae	Insecta	9	0
Unknown Insect	Insecta	0	1
Gammaridae	Malacostraca	0	1
Grandidierella japonica	Malacostraca	108	27
Lais californica	Malacostraca	0	1
Monocorophium	Malacostraca	0	3
Capitellidae	Polychaeta	0	4
Pseudopolydora	Polychaeta	404	132
Spionidae	Polychaeta	3	15
Total:		641	305

4.2.2 Method B

Species Name	Class	Colorado Lagoon Count	Zedler Marsh Count
Cirratilidae	Clitellata	9	0
Paranais litoralis	Clitellata	1	0
Tubificidae	Clitellata	13	10
Nereis procera	Polychaeta	2	0
Pseudopolydora	Polychaeta	2	8
Serpulorbis	Polychaeta	1	0
Teinostoma	Polychaeta	1	0
Naireris uncinata	Polychaeta	1	0
Mytilus	Bivalvia	2	0
Aceteocina culcitella	Gastropoda	0	0
Aceteocina inculta	Gastropoda	0	0
Assiminea californica	Gastropoda	0	0
Barleeia subtenuis	Gastropoda	0	0
Cerithidea californica	Gastropoda	0	0
Dendrapoma lituella	Gastropoda	0	0
Corophium	Malacostraca	8	137
Linepithema humile	Insecta	0	0
Dolichopodidae	Insecta	5	12
Ephydridae	Insecta	3	4
Polydora nuchalis	Polychaeta	0	1
Marphysa stylobranchiata	Polychaeta	0	7
Cerithidea californica	Gastropoda	0	2
Grandidierella japonica	Malacostraca	0	6
Ceratopogonidae	Insecta	0	2
Psychodiadae	Insecta	0	1
Dolichopodidae	Insecta	0	12
Sciomyzidae	Insecta	0	2
Total:		48	204

4.3 Invertebrate Raw Data

4.3.1 Method A

4.3.1.1 Count of Species by Tidal Height and Location

Colorado Lagoon

1 MID

Oligochaetes	5
Ceratopogonidae larvae	43
Ephydra larvae	1
Unknown beetle larave	3
Total	**52**

1 LOW

Ceratopogonidae larvae	35
Ephydra larvae	2
Total	**37**

1 MUD

Oligochaetes	26
Spiodiae juvenile	3
Acteocina inculta	1
Monocorophium spp.	11
Dolichopodidae larvae	1
Total	**42**

3 MID

Ceratopogonidae larvae	12
Dolichopodidae larvae	1
Total	**13**

3 LOW

Oligochaetes	4
Spionidae juvenile	1
Ceratopogonidae larvae	3
Dolichopodidae larvae	5
Total	**13**

3 MUD

Oligochaetes	81
Pseudopolydora	9
Spiondiae	4
Monocorophium	20
Dolichopodidae larvae	2
Total	**116**

4 MID

Spionidae juvenile	1
Ceratopogonidae larvae	10

Zedler Marsh

1 MID

Pseudopolydora	2
Neomolgus	1
Orabatid	6
Total	**9**

1 LOW

Assiminea californica	2
Staphynidae juvenile (rove)	4
Unknown beetle larvae	2
Neomolgus	2
Orabatid	61
Total	**71**

1 MUD

Oligochaetes	6
Pseudopolydora	8
Capitellidae	1
Dolichopodiae larvae	1
Total	**16**

2 MID

Unknown snail	1
Iais californica	10
Psychodidae larvae	1
Total	**12**

2 LOW

Oligochaetes	15
Capitellidae	1
Dolichopodidae larvae	1
Large unknown insect larvae	1
Psychodidae larvae	1
Total	**19**

2 MUD

Oligochaetes	17
Capitellidae	2
Psychodidae larvae	1
Total	**20**

3 MID

Unknown beetle larvae	1

Dolichopodidae larvae	3
Total	**14**

4 LOW

Oligochaetes	12
Monocorophium	1
Dolichopodidae larvae	3
Total	**16**

4 MUD

Oligochaetes	181
Pseudopolydora	12
Monocorophium	17
Dolichopodidae larvae	2
Total	**212**

5 MID

Dolichopodidae larvae	1
Total	**1**

5 LOW

Ceratopogonidae larvae	5
Dolichopodidae larvae	2
Ephydra larvae	6
Total	**13**

5 MUD

Oligochaetes	100
Pseudopolydora	6
Monocorophium	16
Total	**122**

Total	**1**

3 LOW

Carabidae adult	1
Unknown beetle larvae	1
Total	**2**

3 MUD

Oligochaetes	6
Grandidierella japonica	1
Ceratopogonidae pupae	1
Total	**8**

4 MID

Gammaridae a	1
Ceratopogonidae larvae	3
Iais californica	18
Total	**22**

4 LOW

Oligochaetes	21
Pseudopolydora	1
Dolichopodidae larvae	1
Iais californica	1
Unknown insect larvae	1
Total	**25**

4 MUD

Oligochaetes	67
Spionidae juvenile	2
Ceratopogonidae larvae	23
Total	**92**

4.3.2 Method B

4.3.1.2 Abundance of Invertebrate at Colorado Lagoon and Zedler Marsh.

	Colorado Lagoon						Zedler Marsh					
Sample Location	0	1	2	3	4	5	0	1	2	3	4	5
Tubificidae	0	4	1	3	4	1	5	0	1	0	0	4
Paranais litoralis	0	0	0	1	0	0	0	0	0	0	0	0
Pseudopolydora	0	1	0	0	1	0	8	0	0	0	0	0
Cirratilidae	0	0	0	0	9	0	0	0	0	0	0	0
Nereis procera	0	0	1	1	0	0	0	0	0	0	0	0
Serpulorbis	1	0	0	0	0	0	0	0	0	0	0	0
Teinostoma	1	0	0	0	0	0	0	0	0	0	0	0
Naireris uncinata	0	0	0	0	1	0	0	0	0	0	0	0
Mytilus	1	0	0	0	1	0	0	0	0	0	0	0
Corophium	0	0	0	0	8	0	125	0	9	3	0	0
Ephydridae	0	0	1	0	2	0	0	0	0	1	2	1
Dolichopodidae	0	0	0	0	1	4	9	0	1	0	2	0
Polydora nuchalis	0	0	0	0	0	0	0	0	0	0	1	0
Marphysa stylobranchiata	0	0	0	0	0	0	7	0	0	0	0	0
Cerithidea californica	0	0	0	0	0	0	0	0	0	2	0	0
Grandidierella japonica	0	0	0	0	0	0	6	0	0	0	0	0
Ceratopogonidae	0	0	0	0	0	0	0	0	0	2	0	0
Psychodiadae	0	0	0	0	0	0	0	1	0	0	0	0
Sciomyzidae	0	0	0	0	0	0	0	0	0	0	2	0

4.3.2.2 Figure G- Count of Species at Colorado Lagoon and Zedler Marsh.

	Colorado Lagoon						Zedler Marsh					
Sample Location	0	1	2	3	4	5	0	1	2	3	4	5
Species Count	3	2	3	3	8	2	6	1	3	4	4	2

4.3.2.3 Figure H- Count of Species at Colorado Lagoon per sample point.

Colorado Lagoon						
Sample Locations	**0**	**1**	**2**	**3**	**4**	**5**
Tubificidae	0	4	1	3	4	1
Paranais litoralis	0	0	0	1	0	0
Pseudopolydora	0	1	0	0	1	0
Cirratilidae	0	0	0	0	9	0
Nereis procera	0	0	1	1	0	0
Serpulorbis	1	0	0	0	0	0
Teinostoma	1	0	0	0	0	0
Naireris uncinata	0	0	0	0	1	0
Mytilus	1	0	0	0	1	0
Corophium	0	0	0	0	8	0
Ephydridae	0	0	1	0	2	0
Dolichopodidae	0	0	0	0	1	4

4.3.2.4 Figure I- Count of Species at Zedler Marsh per sample point.

Zedler Marsh						
Sample Locations	**0**	**1**	**2**	**3**	**4**	**5**
Tubificidae	5	0	1	0	0	4
Pseudopolydora	8	0	0	0	0	0
Polydora nuchalis	0	0	0	0	1	0
Marphysa stylobranchiata	7	0	0	0	0	0
Cerithidea californica	0	0	0	2	0	0
Corophium	125	0	9	3	0	0
Grandidierella japonica	6	0	0	0	0	0
Ceratopogonidae	0	0	0	2	0	0
Psychodiadae	0	1	0	0	0	0
Dolichopodidae	9	0	1	0	2	0
Ephydridae	0	0	0	1	2	1
Sciomyzidae	0	0	0	0	2	0

4.3.2.5 Figure J- Percent total by class for Colorado Lagoon and Zedler Marsh.

	Colorado Lagoon							Zedler Marsh					
Sample Location	0	1	2	3	4	5		0	1	2	3	4	5
Oligochaetes	0	80	33	80	15	20		3	0	9	0	0	80
Polychaetes	67	20	33	20	41	0		9	0	0	0	14	0
Mollusca	33	0	0	0	3	0		0	0	0	25	0	0
Crustacea	0	0	0	0	30	0		82	0	82	38	0	0
Insecta	0	0	33	0	11	80		7	100	9	36	86	20