CHARACTERIZING INFAUNAL ASSEMBLAGES IN COASTAL WETLANDS RESTORED WITH BENEFICIAL USES DREDGE MATERIAL

An Undergraduate Research Scholars Thesis

by

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ABSTRACT

Characterizing Infaunal Assemblages in Coastal Wetlands Restored with Beneficial Uses Dredge Material. (May 2015)

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Wetlands are important to the coastal environment because of the variety of purposes they serve to the area wildlife. The ecological and economic importance of wetlands makes it imperative to understand the benefits of different wetland restoration processes. Many wetland bird species forage in unvegetated areas called mudflats, yet these mudflats are rarely included in wetland restoration design. One method used for wetland restoration is known as Beneficial Uses Method. This restoration process involves using dredge material to create a continuous area of wetlands. Beneficial Uses Method can include different procedures that create small variation in elevation, soil moisture, and the amount of vegetation. These variations may increase the number and diversity of birds using the restored area. My objective was to compare populations of birds, and the small, mud-dwelling animals (infauna) that they eat, among planted, unplanted + high elevation (dry), and unplanted + low elevation (wet) areas of a restored coastal marsh near Port Arthur, TX. I hypothesized that unplanted, wet areas would have the most infauna, and would therefore support more birds. Replicate cores were taken from each habitat type, sieved, and infauna were identified to the lowest taxonomic group possible. To monitor bird use, game cameras were deployed in each habitat type and programmed to take pictures every 30 minutes and also when motion was present. The pictures were later analyzed and birds were identified to

species. Unplanted areas had 109 times more infaunal density than planted areas. Wet unplanted areas had 68 times more infaunal density than dry unplanted areas. Likewise, birds were most frequently observed in wet, unplanted areas. The most common birds in wet areas were ibis, herons, egrets, and ducks. When restoring wetlands, including areas that are wet and unplanted is important for providing habitat for the infauna that will support residential and migratory bird populations.

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CHAPTER I

INTRODUCTION

Background

The loss of coastal wetlands is a global issue. In the United States alone, about one third of the historical wetland area has been lost since the 1880s (Dahl, 1990). Wetland loss on the Gulf of Mexico coastline can be attributed to several anthropogenic factors such as river diversions, impoundments, levees, and belowground fluid withdrawal (Turner, 1990). Loss of wetlands has a negative effect on biodiversity of an area. The loss of biodiversity will cause a decline in subsistence and recreational benefits of coastal wetlands (Boesch et. al. 1994). The importance of wetlands and their vulnerability makes it imperative to understand the benefits of different wetland restoration techniques.

One of the key ecological functions of wetlands is to provide trophic support for the iconic upper consumers (birds, fish). Infauna is a big component of a wetland food web, and understanding how restoration affects their populations could lead to a better understanding of the effects it will have on organisms that consume them. Artificially established marshes have a lower density of infauna than naturally occurring marshes (Sacco, 1994). However, over time the infauna densities will become more similar to those of natural marshes (Posey, 1997). Understanding the conditions needed to restore wetland areas to become more similar to natural wetlands will create an area more usable by infauna, and consequently the wildlife, such as birds, that consume them.

There are many different techniques to restore coastal wetlands. One common approach is known as Beneficial Uses Method. This involves the placement of dredge material into subsided, submerged areas in order to create a continuous area of wetlands. Beneficial Uses Method creates wetland area that is more like a natural wetland than the area created by other more highly engineered methods such as construction of circular mounds that create edge habitat for use by fishery species. Edge habitat is beneficial to fishery species due to the increased area for feeding and protection from predation (Boesch et. al. 1994). Beneficial Uses Method creates an expansive area with small variations in elevation that form the mudflats, tide pools, and salt pans that are commonly used by wetland bird species.

Another important aspect of restoration is whether the area is planted. While restoring wetlands, a few quickly growing marsh plants may be planted so that the wetland will have a vegetated area more quickly. This planted method is commonly used to satisfy wetland restoration permits, and typically does not have any ecological designation. However, one benefit for planting an area is to prevent erosion (Boesch et. al. 1994). If an area goes unplanted, the natural plants will grow, but it will take more time. The types of vegetation associated with the age of a marsh can affect the composition of the infaunal community (Posey, 1997). This could cause planted areas to have different types of infauna than unplanted areas. Planting will also affect birds because more birds will use mudflats than salt marshes with high vegetation cover (Jing et. al., 2006).

The initial infauna colonization of created marshes is by opportunistic species and is based on soil, vegetation, and hydrodynamic conditions (LaSalle et al., 1991). Organic matter content of the soil also affects the abundance of infauna because it provides food, refuge, and easier burrowing (Moy and Levin, 1991). Infauna populations can be affected by all of these factors, with different environmental conditions being preferred by different species. For this reason it is important to understand what environmental conditions in a restored wetland area are most conducive to infauna populations.

Infauna found in wetlands are an important source of food for area wildlife such as birds. Common bird families that consume infauna in wetland areas are Scolopacidae (sandpipers), and Threskiornithidae (ibis) (Frederick and Bildstein 1992, Piersma 1996). The birds in these families are equipped with beaks that can pick and probe through the soil for infauna. Shorebirds with different foraging strategies prefer different habitat types. Gastropods are the main prey for surface foraging shorebirds and bivalves are the main prey for substrate foraging shorebirds (Jing et. al., 2006). The population of the different species of infauna in an area may determine which species of birds will feed in that area.

Objectives

My objectives were to (1) analyze the infaunal composition of wetlands restored by the beneficial uses method to quantify how well this restoration method supports infauna populations and (2) determine if there is a relationship between infauna and bird abundances within restored areas.

CHAPTER II

METHODS

Study Site

The study site is a wetland area in the Texas Parks and Wildlife Department's Old River Unit of the Lower Neches Wildlife Management Area (LNWMA), Texas, USA (30˚00 N, 93˚51W), near Sabine Lake. In 1777 Sabine Lake was a freshwater lake. Over the years, natural and anthropogenic changes introduced salt water into Sabine Lake, making it a brackish lake and also causing loss of vegetation and erosion of the surrounding soil (Tatum, 2009). Because of the degraded habitat, restoration is currently occurring around Sabine Lake.

In 1902 the Gulf Oil Company built a refinery for crude oil. Chevron took over in 1984 and Premcor Refining Group bought it in 1995. Today they refine 250,000 barrels of crude oil per day (NOAA, 2004). In order to mitigate for refinery expansion, a restoration project of the surrounding degraded areas of the J.D. Murphree Wildlife Management Area was proposed. Restoration using Beneficial Uses Method began by adding dredge material into a subsided area to achieve a target elevation. The dredging was completed in February 2011 (Kerns, 2011). Three habitat types were created during restoration: planted, unplanted with low elevation (wet), and unplanted with high elevation (dry). Planted areas have a few quickly growing marsh plants planted so that the wetland will have a vegetated area more quickly (Fig. 1). Unplanted areas were left alone so that plants could colonize naturally. Wet areas had lower elevations of dredge material (Fig. 2), while dry areas had higher elevations (Fig. 3).

Infauna Sampling

Infauna were collected from restored wetland areas in the Lower Neches and J.D. Murphree Wildlife Management Areas. Three habitats with differing elevation and vegetation amounts were sampled: planted, unplanted wet, and unplanted dry. Twelve 10 cm diameter and 15 cm depth cores were collected from each area. Each core was placed in a Ziploc bag on ice until it was refrigerated for later processing, ideally within 48 hours. To preserve the infauna, the core was sieved through a 500 µm mesh and the collected contents was transferred to a glass scintillation vial. The sample was then fixed with a mixture of 0.5g of Rose Bengal stain added to 10% formalin for at least 48 hours before sorting and identification. Before identifying, the formalin mixture was drained from the vial through a 500 µm sieve into a waste container. The sample was rinsed in the sieve with deionized water and transferred to a petri dish. A dissecting scope was used to count and identify the organisms to the lowest practical taxonomic level. After identification, the sample was stored in 70% ethanol.

Bird Sampling

Game cameras were set up at each of the three habitats from infauna sampling. Photos were taken every 30 minutes from sunrise until sunset and motion activated photos were taken in a sequence of three photos every ten seconds. The photos were downloaded to a computer and analyzed to identify and quantify any bird species present.

Statistical Analysis

A one-way ANOVA was performed to test for differences in infauna and bird populations in wetlands restored by beneficial uses method among unplanted wet, unplanted dry, and planted areas.

Figure 1. Planted area.

Figure 2. Unplanted, low elevation (wet) area.

Figure 3. Unplanted, high elevation (dry) area.

CHAPTER III

RESULTS

Infauna

Eight groups of infauna were collected in the samples from April and June 2014. Gastropoda (snails), Pelecypoda (bivalves), and Oligochaeta (worms) were the most common infauna found across all the areas (Fig. 4). The highest abundance of infauna was found in low elevation (wet), unplanted areas, followed by unplanted, dry areas and then planted areas had the least (Fig. 5). There was a significant difference among unplanted wet, unplanted dry, and planted areas ($p < 0.001$). The infaunal density in unplanted areas was 109 times more than in planted areas. The infaunal density in wet areas was 68 times more than in dry areas. Oligochaeta occurred only in unplanted and wet areas. April samples contained 8 times more Oligochaeta than June. April samples contained more insect larvae and June samples contained more insects.

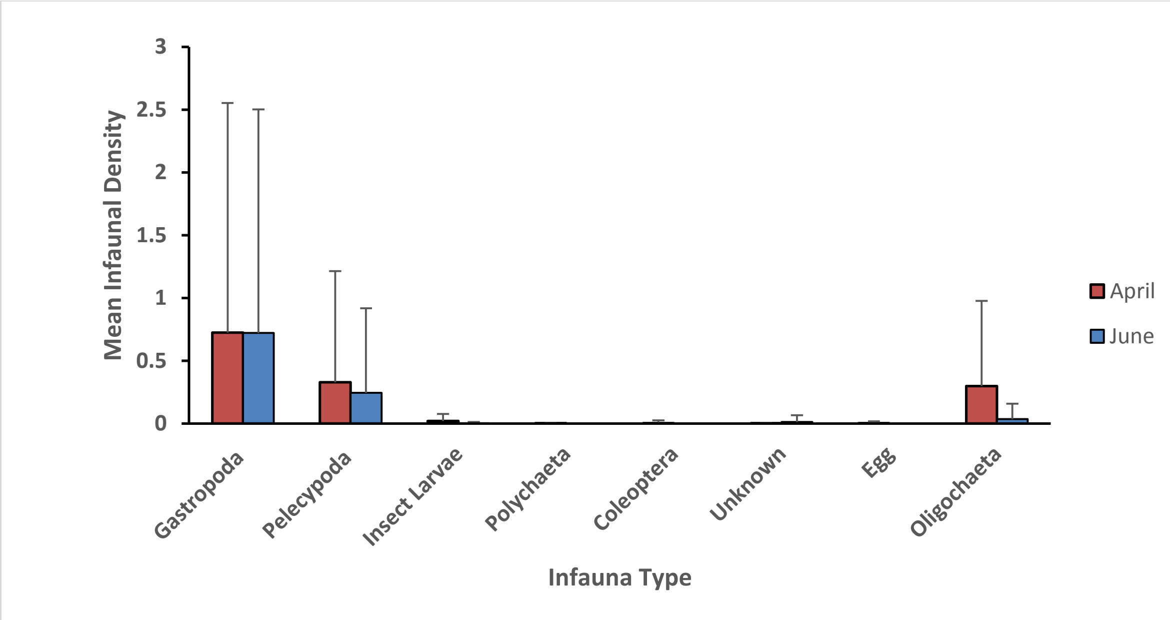

Figure 4. Mean infaunal density (number of infauna per 50 cm^3) by lowest possible identification level during April and June 2014. Data were pooled across unplanted wet, unplanted dry, and planted areas. Error bars represent standard deviation.

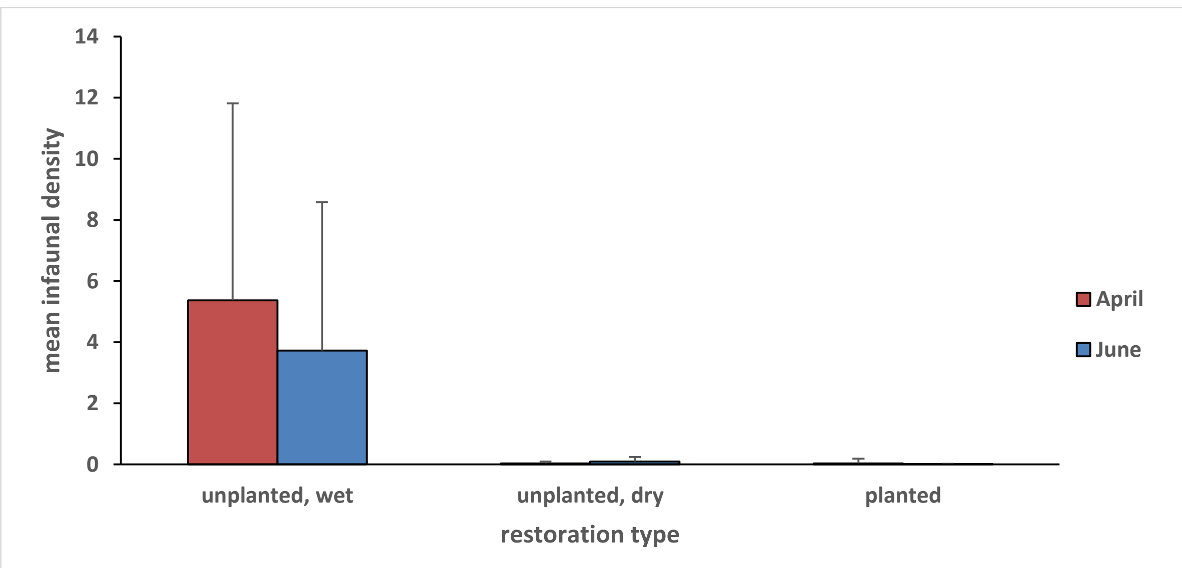

Figure 5. Mean infaunal densities (number of infauna per 50 cm^3) for unplanted wet, unplanted dry, and planted areas during April 2014 and June 2014. Error bars represent standard deviation.

Birds

Nine families of birds were identified during the study. Anatidae (ducks) and Threskiornorthidae (herons) were the most common families seen across all areas. Significantly more birds were found in unplanted wet areas ($p < 0.001$). Both infauna and birds were most abundant in wet, unplanted areas (Fig. 6). There were 496 times more birds in unplanted than planted areas and 2.5 times more in wet than dry areas. Unplanted, wet areas had the highest species richness (eight species), followed by unplanted dry areas (six species), and then planted areas (two species). The most abundant bird family in unplanted, wet areas and planted areas was Threskionorthidae (ibis). The most abundant bird family in unplanted, dry areas was Scolopacidae (sandpipers) (Fig. 7).

Figure 6. Mean number of birds per picture for unplanted wet, unplanted dry, and planted areas during April 2014. Error bars represent standard deviation.

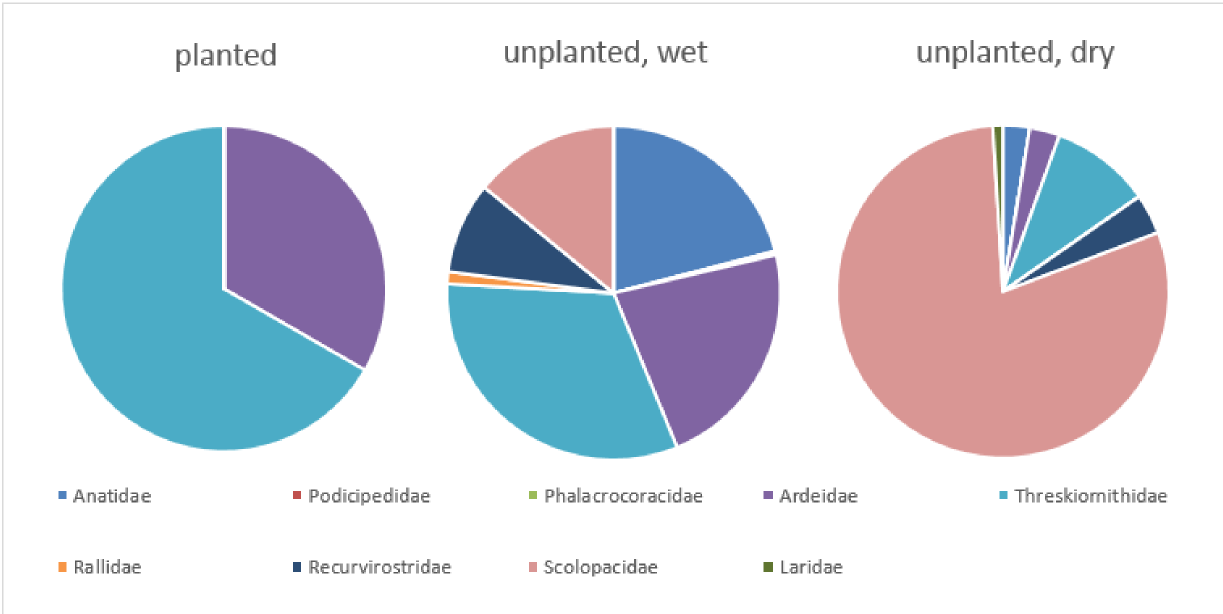

Figure 7. Bird species composition in planted, unplanted wet, and unplanted dry areas during April 2014.

CHAPTER IV

CONCLUSIONS

The use of different wetland restoration methods was shown to have an effect on infauna and bird abundance. Bird abundance was affected by both planting strategy and elevation. The unplanted method created open space for birds and the lower elevation likely facilitated infaunal production. Unplanted wet areas had the highest abundance of birds and infauna. Birds were likely attracted to the unplanted wet areas to feed on the infauna. Infauna are found to be more abundant at lower elevations than higher elevations (Moy and Levin 1991, Whaley and Minello 2002). The hydrological conditions at lower elevations could cause infauna to be more abundant. Birds were likely attracted to areas with infauna, but limitation based on body type could have limited which areas birds could forage at.

Birds are equipped with different anatomical characteristics that allow them to forage in different areas. Bill length and shape, neck length, leg length, and body size are characteristics that determine what water depths birds can forage in. Bolduc and Afton (2004) found that water depth caused the most differentiation among bird species in wetland areas. Unplanted wet areas could have contained the most favorable conditions for the longest period of time that allowed the most birds to forage in that area. The presence of specific types of infauna may have also attracted birds to certain areas.

Oligochaetes were only found in wet unplanted areas. Threskiornithidae (herons) are known to eat oligochaetes as well as arthropods and gastropods (Frederick and Bildstein 1992).

Threskiornithidae were the most abundant bird family found in unplanted wet areas; this could have been due to the presence of oligochaetes in these areas. Other bird families could have been found in different areas based on the food source and accessibility. Scolopacidae (sandpipers) were the most common bird family found in unplanted dry areas. Scolopacidae have shorter beaks and legs than Threskiornithidae; they probe in the sediment for gastropods and bivalves (Piersma 1996). The muddy areas with the absence of water could have been ideal for them because of their anatomical characteristics. Anatidae (ducks) was the bird family commonly seen in planted areas. Anatidae can be herbivores or carnivores and their diet differs among species. Dabbling ducks commonly consume invertebrates during the spring (Swanson 1977). The planted areas could have provide plants as well as infauna for Anatidae to consume.

Infaunal abundance varied between April and June, possibly due to differing environmental conditions. One observed difference was the hydrological conditions; the observed areas contained less water when sampled in June than in April. The drier mud could have been less hospitable to the infauna. Creating lower elevation and wetter areas could provide habitat for infauna throughout seasonal changes. Oligochaeta had the highest seasonal difference in abundance. A study in Hong Kong found that Oligochaeta, Gastropoda, and Polychaeta had seasonal differences in abundance (Shen et. al. 2006). Another difference is that there were more insect larvae found in April than in June, but more beetles in June. This could show the progression of insect larvae to beetles between April and June. Seasonal variation during summer, fall, and winter could be analyzed in future studies.

Although this study found that infauna were more abundant in unplanted areas, other studies found that they were more abundant in planted areas. Brusati and Grosholz (2006) found that areas planted with *Spartina foliosa* contained significantly more infauna than nearby umplanted areas. However, an area planted with hybrid *Spartina* did not contain more infauna than nearby unplanted areas. The compact roots of the *Spartina* hybrid kept infauna from colonizing those areas. The planted area in my study could have also had compact roots that infauna could not move through. Another study found that *Spartina* vegetated areas contained less infauna than nearby unvegetated areas (Neira et al. 2005). Plant structure and type may affect the area where infauna are found, creating differences among locations. By continuing to monitor infauna in the future, it will provide an understanding of how populations change over time. This information can be used to further assess the success of restoration.

The information found in this study can help to improve restoration methods and include areas available for birds to use by creating habitat suitable for infauna. Previous restoration of coastal wetlands have focused on edge habitat that is important for fish species (Rozas and Minello 2001). Although edge habitat is important, future restoration projects should also consider birds while making restoration plans. Birds are important components of the food web of coastal wetlands, and can also provide income to the area by attracting bird watchers (Mitsch and Gosselink 2000, Davenport and Davenport 2006). Restoration that provides habitat for these birds will keep bird watchers coming to these areas, which will result in an economic gain for the area.

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