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Interannual Variation of Ichthyofaunal Utilization of a Man-Made Salt Marsh Creek in Mission Bay, California

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ABSTRACT: Southern California's wetlands are drastically declining due to human activities. Increasingly, marsh restoration and creation are being used to mitigate such losses. This study used minnow traps to resample the ichthyofauna of a created marsh (Crown Point Mitigation Site; CPMS) and an adjacent natural marsh (Kendall Frost) in Mission Bay, California, 26 years following the marsh creation. These data were compared to data collected from 1995-1998, immediately after marsh creation, and data from 2021. Fishes captured included *Fundulus parvipinnis, Gillichthys mirabilis, Acanthagobius flavimanus, Ctenogobius sagittula, and Mugil cephalus*. Species richness and dominance measures were higher in the natural relative to the created marsh. The size-structure of *F. parvipinnis* populations in the natural marsh were skewed towards larger sizes relative to those in the created marsh. These size differences were similar to 2021 but were opposite of those noted in the years immediately following marsh creation, suggesting that these represent long-term changes and not inter-annual variability. The changes in size structure appear to arise from differences in creek morphology between the created and natural systems, with the created marsh having become shallower through time. The differences in ichthyofaunal communities between the created and natural systems suggest that marsh and creek geomorphology may be affecting the suitability of habitat for resident fishes, and so should be more carefully considered when designing marsh restoration projects.

Keywords*: Fundulus parvipinnis*, Crown Point Mitigation Site (CPMS), Kendall Frost Northern Wildlife Preserve (NWP)

Introduction

Wetlands are important regulators for the global climate and hydrological cycle while also providing human welfare through shoreline erosion control, flood protection, natural filtration and other opportunities for recreation and aesthetic appreciation of nature (Xu et al., 2019). In addition, wetlands protect ecosystem diversity accounting for about 47% of the global ecosystem values (Xu et al., 2019). California specifically is climatically, topographically and geologically diverse which contributes to the great habitat richness their wetlands (Dertien et al., 2020).

California's wetlands are among the most threatened habitats on earth, having lost 90% of their historical acreage to human activities (Talley, 2000). Mission Bay, in San Diego, CA, was largely intertidal marsh and mudflat habitat as recently as 1940, but now consists of only three small, isolated remnant marshes (Talley, 2000). With wetland loss continuing, marsh restoration and creation have become a common action but with it, comes its effects of resident marsh fish communities in these areas. Resident fishes play a vital role in marsh ecosystems, both directly and indirectly, affecting organisms they prey and feed, and in the transfer of energy and nutrients from the marsh surface (Talley, 2000).

Despite their ecological importance, there is limited information on the ecology of marsh-resident ichthyofauna of southern California, with the *Fundulus parvipinnis* (California killifish) having even fewer studies of the effectiveness of marsh creation in restoring ichthyofaunal populations (Talley, 2000). An implication to the lack of information can be correlated to exotic

species invasions which have become one of the greatest threats to conservation, compromise the integrity of natural systems, impede restoration efforts, and incur tremendous economic costs (Levin and Talley, 2002). Extreme climatic events (ECEs), which facilitate biological invasions, are another rising threat to the ecological communities as these unpredictable and unusual weathers can promote the transport of propagules into new regions, decrease the resistance of native communities to establishment, and in intense regions, put existing non-native species at a competitive advantage over native species (Diez et al., 2012). Invasive species have consistently been associated with disturbance events, but the nature of this relationship has been unclear.

This study will address the following questions: (1) How has the resident fish community composition and abundance in the created creek changed over the last 21 years and what is its current resemblances to that in the natural creek? (2) What are the patterns of inter-annual variability in ichthyofaunal assemblages in the created and natural marsh creeks? (3) How has the size-structure of the dominant marsh-resident fish taxa in the created creek changed in relation to that of the natural creek? The answers to these questions will be used to provide insight on the interannual variation of salt marsh restoration and possible considerations for future usage of this conservation technique.

Methods

Study Site

Fishes were sampled in the same creeks of a natural (Northern Wildlife Preserve) (NWP) and adjacent created (Crown Point Mitigation Site) (CPMS) marsh in the northern part of Mission Bay, San Diego, California (32◦ 47" N, 117◦ 14'W) (Figure 1A). The NWP is a natural marsh of approximately 12 hectares which is managed by the City of San Diego and the University of California, San Diego. The NWP has three discrete creek systems; the system closest to the mitigation marsh will be used for this study (Figure 1B). The CPMS is a created salt marsh system (approximately 2.8 hectares of intertidal and subtidal habitat and approximately 0.8 hectares of upland habitat), established by the City of San Diego to mitigate for losses of intertidal habitat (Ferren et al., 1996). The created marsh was constructed by dredge spoils on what was formerly an unsuccessful Least Tern nesting site, and historically, was a tidal wetland (Marcus, 1989). The CPMS was first opened to tidal flushing on December 14, 1995, and planting took place from March 22–26, 1996.

Field Sampling Strategy

Sampling for fishes followed the protocols of Talley 2000, using the same locations, soak time, and assessment methods. The ichthyofauna were sampled with Gee minnow traps, 22-cm diameter from the center, tapering to 19 cm at each end, made of 0.6 cm wire mesh with 2 cm openings. Traps were baited with canned cat food, attached to stakes with 2–3 m of rope, and placed at four locations in the creek at CPMS and four locations in the NWP (Figure 1B). Between June 14, 2022, and August 10, 2022, traps were placed in creeks during daytime low tide and were recovered the following day at low tide (i.e., soak time ≈ 24 hours). During recovery, all fish were counted, identified to species, and measured (total length) to the nearest mm.

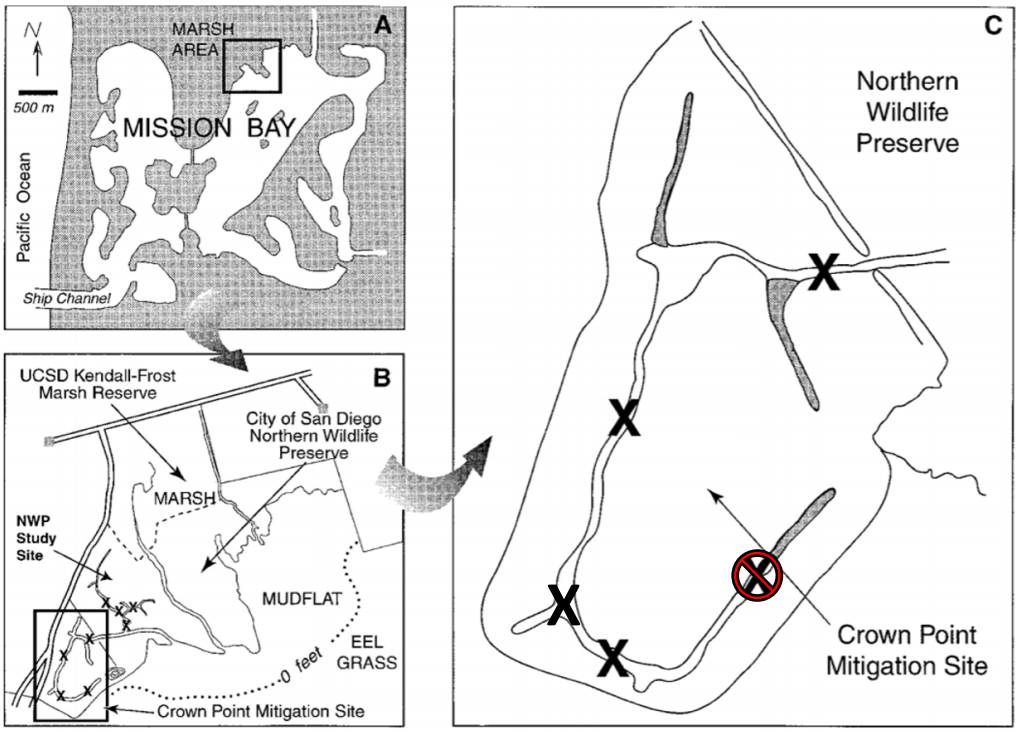

Figure 1: Map of study site, showing (A) Mission Bay, San Diego, CA and (B) the Crown Point Mitigation Site (CPMS) and Northern Wildlife Preserve (NWP) site. Shaded area in (C) indicates shallow subtidal habitat. Xs mark the locations of minnow traps. The prohibition sign marks a former minnow trap.

Results

The *F. parvipinnis* population size-structure showed noticeable differences between the created and natural creeks. Over the entire course of the sampling, a total of four species were recorded including the *F. parvipinnis, Gillichthys mirabilis, Ctenogobius sagittala* (long-tailed goby), and *Mugil cephalus* (mullet). All four species were captured in the NWP however, only the *F. parvipinnis* and *G.mirabilis* were present in the CPMS during the entire sampling. All sampling dates showed *F. parvipinnis* populations in the NWP skewed towards larger individuals relative to the CPMS (paired t-test, $p < 0.05$; Figure 2). Average *F. parvipinnis* total lengths from the CPMS and NWP marsh were compared with the average total lengths in 2021 where it was determined that the NWP's average total length increased while CPMS's decreased (Figure 3). Diversity patterns remained to be similar to that found in the previous study with the addition of the ichthyofaunal species richness being greater in the NWP natural marsh than the CPMS created marsh (Figure 4).

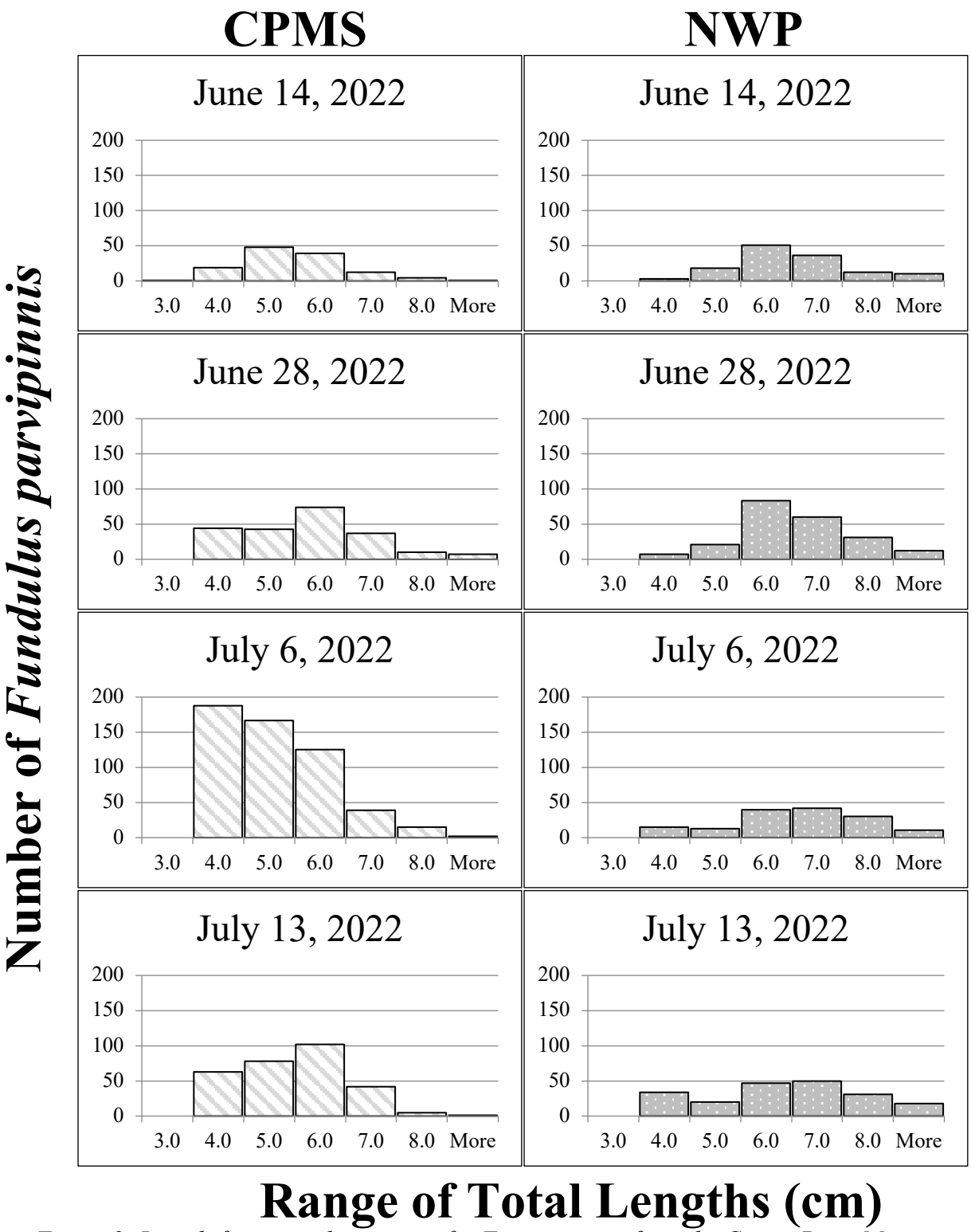

Figure 2: Length-frequency histograms for F. parvipinnis from the Crown Point Mitigation Site (CPMS) and the Northern Wildlife Preserve (NWP) marshes.

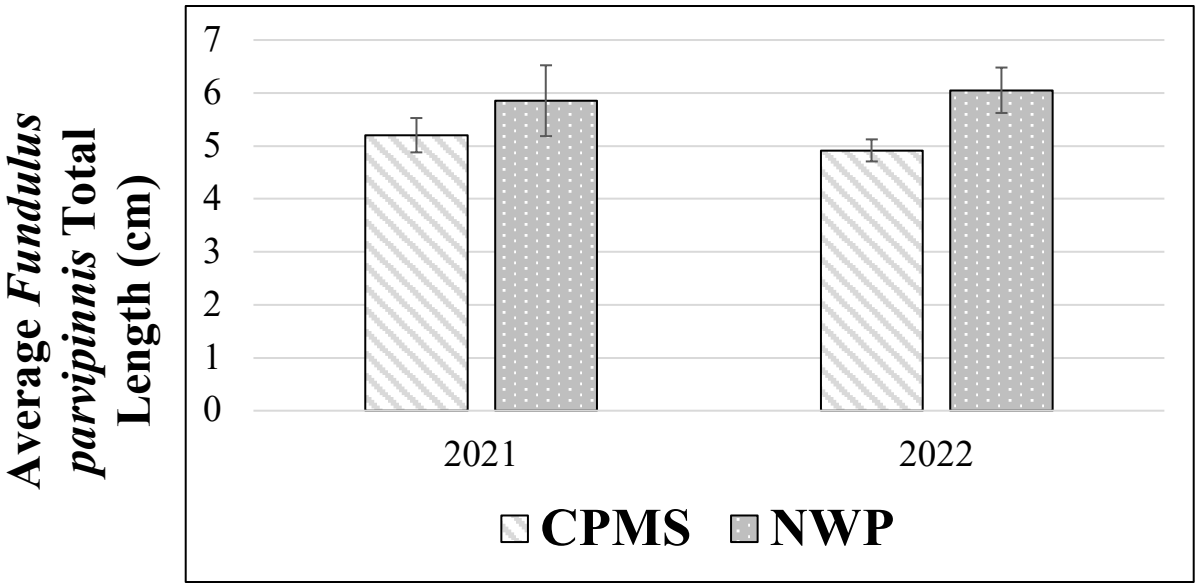

Figure 3: Calculated mean for F. parvipinnis from the Crown Point Mitigation Site (CPMS) and the Northern Wildlife Preserve (NWP) marsh in 2021 and 2022.

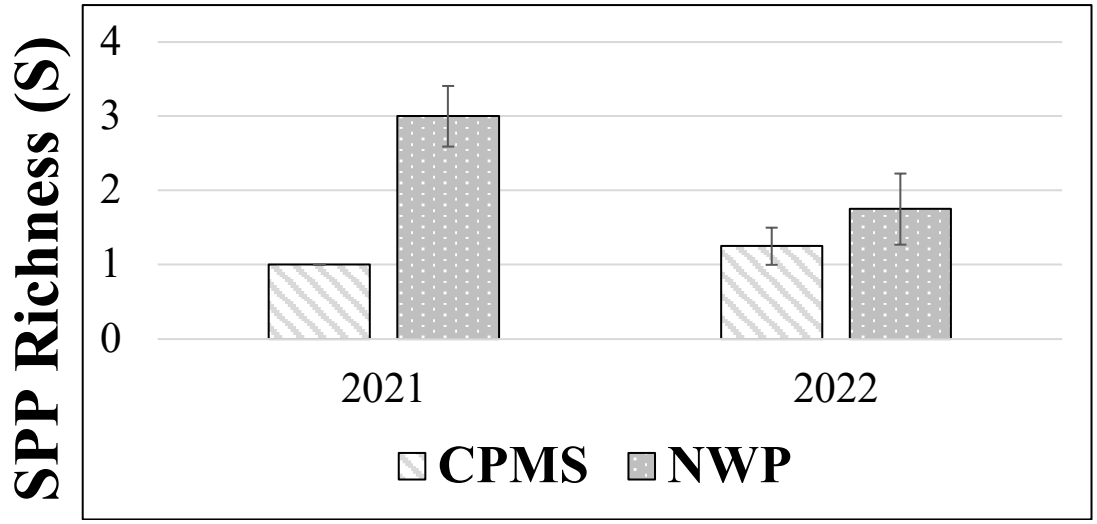

Figure 4: Calculated mean of species richness from the Crown Point Mitigation Site (CPMS) and the Northern Wildlife Preserve (NWP) marsh in 2021 and 2022.

Discussion

Results from this study support the emerging view that functional equivalence of a created marsh requires more than simply abundance or diversity similarities. Size-structure of the numerical dominant, *F. parvipinnis,* was determined to be skewed towards larger size classes in the natural marsh, contrary to previous results (Talley 2000). This difference most likely resulted from an increase in shallow-water habitat now present in the created marsh. In 1998, the natural and created marshes themselves were not significantly different in depth, although the created marsh had less overall shallow water habitat than did the natural marsh (Talley, 2000); however, the CPMS is now shallower than it was during the previous study and even shallower than the NWP in 2021 (t-test, $p<0.05$; Figure 5). It appears the CPMS channel has filled with sediment, creating far more shallow-water habitat than it had in 1998 (Figure 4). This difference in depth between the marshes likely accounts for the differences in distribution and mean size being

shifted towards smaller fishes in CPMS relative to NWP, since juveniles prefer shallow water that provides protection from potential predators (Kneib, 1987).

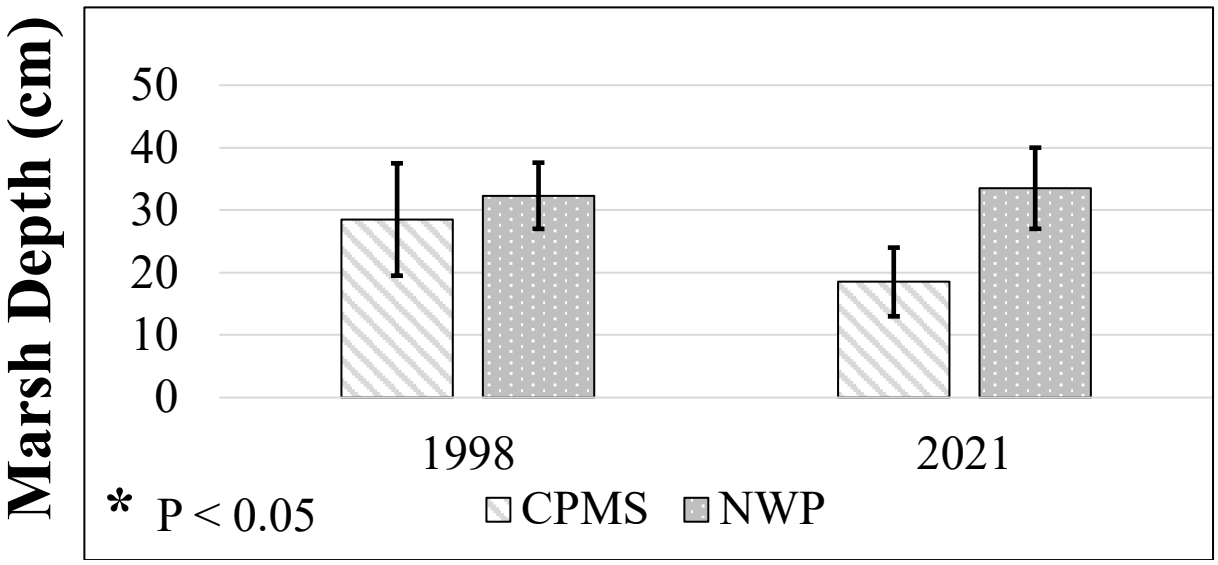

Figure 5. Depth of Crown Point Mitigation Site (CPMS) and the Northern Wildlife Preserve (NWP) marsh in 1998 and 2021.

This study has shown that the CMPS is still not functioning identically to the adjacent natural marsh, as determined in the previous study, but now is inhabited by a lower diversity and smaller size classes of fishes. After 25 years, the created marsh still does not have the equivalent ecosystem function of the natural marsh, from the perceptive of the ichthyofaunal species examined here. This implies the need for long-term monitoring of these dynamic systems and a reassessment of design in marsh restoration projects to understand more of the geomorphology and salt marsh functions under a wide range of natural variation in environmental settings. The size-structure of the numerical dominants *F. parvipinnis* was skewed towards larger size classes in the natural marsh, contrary to previous results (Talley 2000) which has been determined to be consistent annually.

In addition, though species richness remains similar to that of the previous study, annual results showed a decreased in species richness in the NWP marsh. Though the NWP continues to have a greater richness over the CPMS, the NWP's decrease may plausibly indicate that the increase of human development and ECEs are gradually affecting the loss and fragmentation of wetland habitat and ultimately, the decrease of species richness (Dertien et al., 2020). The differences in size-structure and species richness between the created and natural systems suggest that marsh and creek geomorphology may affect the suitability of habitat for resident fishes and should be considered when designing marsh restoration projects.

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