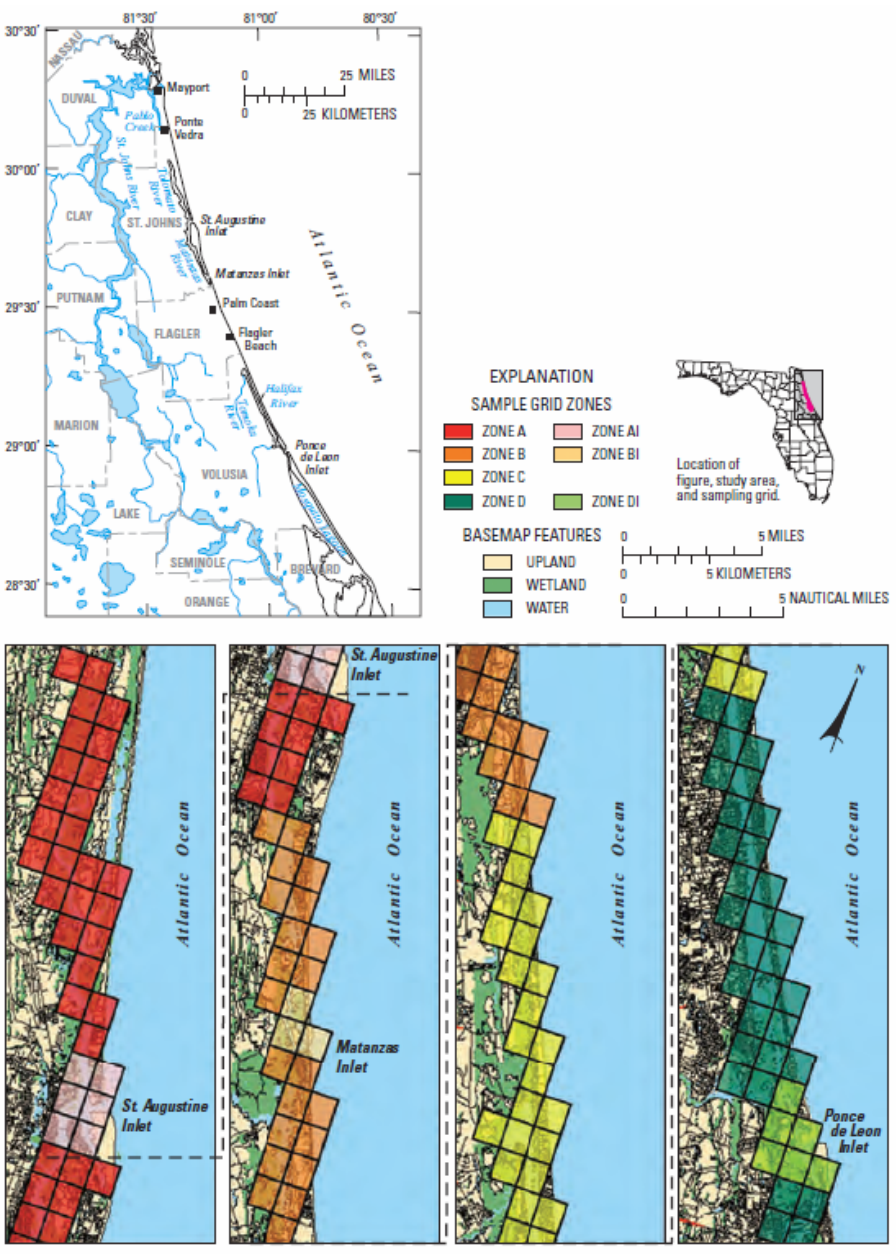
Effects on Fish

The district sponsored a survey of fish in the northeast region of Florida that was conducted by the U.S. Geological Survey from 2002-2004 (Turtora, M. and Schotman, E.M., 2010. Seasonal and spatial distribution patterns of finfish and selected invertebrates in coastal lagoons of northeast Florida: 2002-04. U.S. Geological Survey Scientific Investigations Report 2010-5131). Collections focused mostly on the main stem of the Intracoastal Waterway and some large creeks, with Zone C overlapping with the proposed site for the project (see figure below).



Study area and sampling grid.

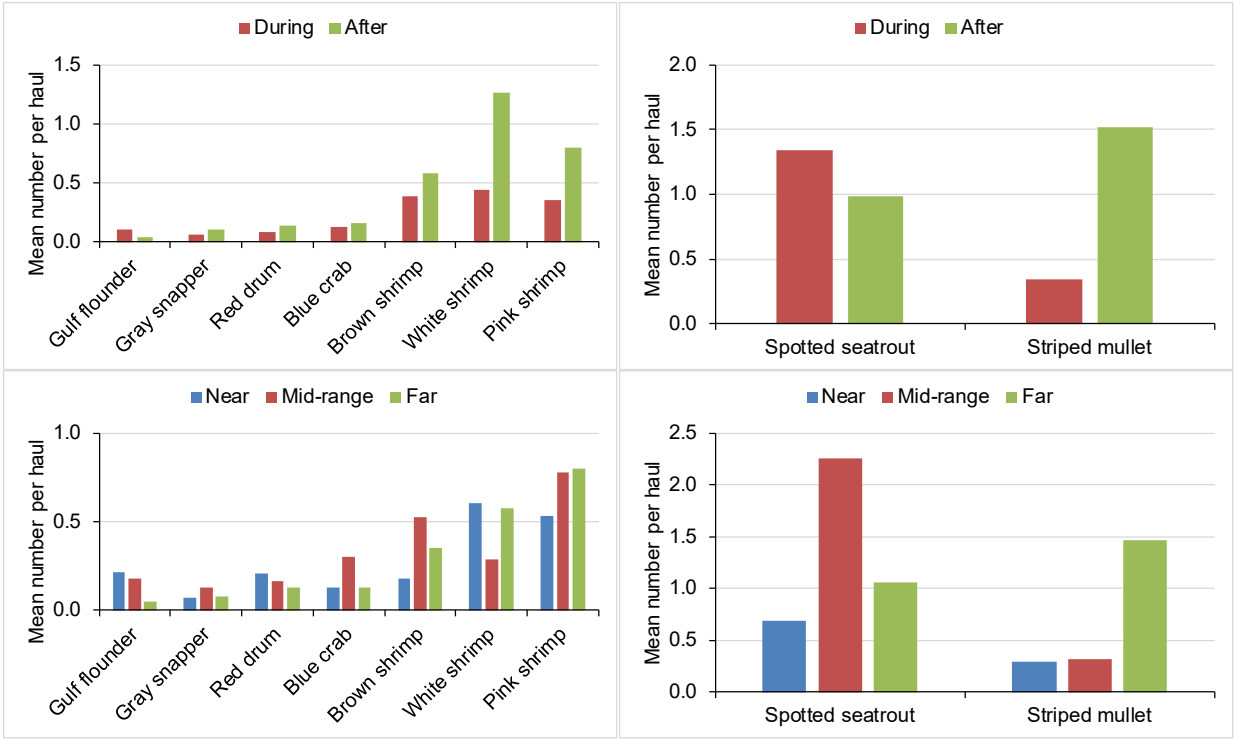
The species of fish and their abundances were similar to those sampled in other zones to the north and south. Seine nets caught 145 species, and these same species also were caught using the same method

in Mosquito Lagoon. Thus, an analysis of data from Mosquito Lagoon is relevant to the area to be restored, and such an analysis can examine the effects of the restoration that was completed in Mosquito Lagoon.

Data from Florida Fish and Wildlife Conservation Commission's Fisheries Independent Monitoring program in Mosquito Lagoon can provide insights into the effect of restoration on fish and invertebrates. Fish and invertebrates were sampled with a 21-meter long seine net in 2007–2009 and 2013–2016. The resulting data were classified as being collected during (2009) and after (2013 onward) restoration of dragline ditched wetlands, and they were classified according to distance from restoration: near (≤ 200 meters or 656 feet), mid-range (201 to 500 meters or 659 to 1,640 feet), and far (≥ 500 meters or 1,640 feet). A statistical analysis of the data did not detect a significant interaction between the timing of sampling and distance from restoration ($p > 0.05$, see table below), which would was expected if the restoration had a detrimental influence on the abundance of fish and invertebrates within the region. Variation in the numbers of animals caught was detected, but the mean numbers of common and highly valued fish and invertebrates did not vary in a consistent spatial or temporal pattern relative to restoration (see figure below).

Results of a multivariate, permutation analysis of variance.

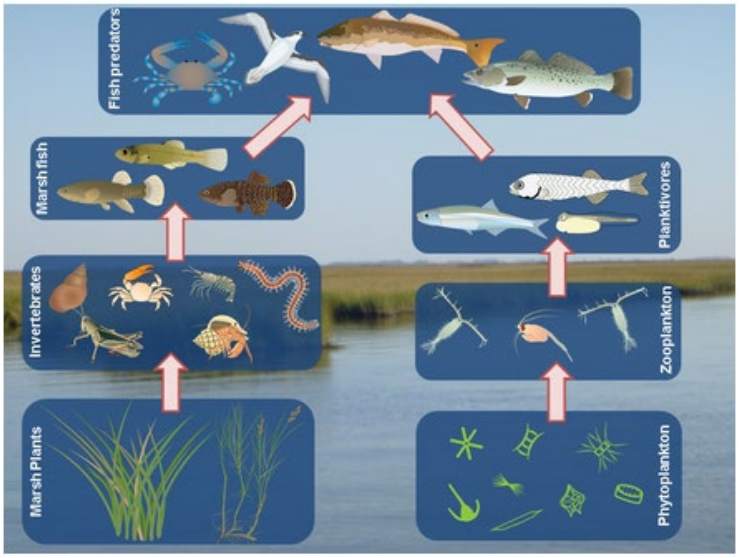
Source	df	SS	MS	F	p	Unique permutations
Time	1	2,510	2,510	3.02	0.001	998
Distance	2	7,853	3,927	4.72	0.001	997
Time x Distance	2	2,333	1,166	1.40	0.064	998
Residual	510	424,110	832			
Total	515	437,490				



Mean numbers of animals per haul.

When considering the effects of restoring ditched wetlands on fish populations, it is important to separate short-term effects, which are described above, and long-term effects, which will be influenced by a variety of factors other than restoration of wetlands. Functional wetlands produce food and provide habitat that ultimately support a variety of fish, with an estimate for a restored wetland in northern Brevard County being 50 pounds of fish per acre (Stevens, P.W., et al. 2006. Fate of fish production in a seasonally flooded saltmarsh. Marine Ecology Progress Series 327: 267-277). Moreover, research provides strong evidence that coastal marshes are preferred or essential habitats for key life stages of most fishery species in Florida (Seaman, W., ed., 1985. Florida aquatic habitat and fishery resources. Florida Chapter of American Fisheries Society). A review paper analyzing the eastern US and Gulf of Mexico shows that commercial landings of estuarine-dependent species on a unit area basis correlates with the ratio of marsh area/open water for many estuaries other than the unique Chesapeake Bay system (Nixon, S., 1980. Between coastal marshes and coastal waters-a review of twenty years of speculation and research on the role of saltmarshes in estuarine productivity and water chemistry. Estuarine Wetland Processes, Plenum Press). In fact, blue crab populations directly relate to wetland area in Florida (Seaman, W., ed., 1985. Florida aquatic habitat and fishery resources. Florida Chapter of American Fisheries Society). In addition, according to a study of 27 smooth cordgrass/black needlerush/mangrove locations worldwide, edible shrimp production is directly related to the area of wetland vegetation and not the area, average depth, or volume of estuaries themselves (Turner, R., 1977. Intertidal vegetation and commercial yields of penaeid shrimp. Transactions of the American Fisheries Society 106: 411-416).

In general, fish and other top predators tend to get food from multiple sources (see figure below), and restoring wetlands maintains one valuable source. Multiple sources of food enhance the resilience of a system, that is its ability to cope with unusual events. In addition, because it requires years for restored areas to recruit a full range of plants and build a fully functional habitat with productivity equivalent to natural marshes, research shows a time lag in the response of ecosystem services (Craft, C., et al.1999. Twenty-five years of ecosystem development of constructed *Spartina alterniflora* marshes. Ecological Applications 9: 1405-1419). Thus, restoring wetlands may not yield an immediate and obvious increase in fish, but it represents a sensible and proven strategy to safeguard fish populations in the long term.



Representation of two trophic webs leading to the same top predators (McCann, M, https://mccannecology.weebly.com/food-webs.html).