Assessing resistance to recovery in oyster populations – inferences from inadequate monitoring programs

Cognitive dissonance

*Introduction* - Eastern oyster populations in the northern Gulf of Mexico are depressed from historic levels for reasons that are poorly understood. Since 2010, the states of Florida, Alabama, Mississippi, Louisiana, and Texas have all declared state or federal level oyster fishery disasters citing reasons including prolonged drought, intense rain events, or freshwater releases from water management structures (refs) and Florida has engaged in litigation at the US Supreme Court level over oyster population collapse in Apalachicola Bay (ref). Several of these states have implemented fishery closures in response to depressed status of oyster stocks (i.e., Mobile Bay in Alabama, Apalachicola in Florida) but only one of these stocks (Mobile Bay) has reopened to harvest with Apalachicola scheduled to re-open in 2025. Oyster populations in the Gulf of Mexico were also damaged by the sinking of the *Deepwater Horizon* and subsequent oil spill (Deepwater Horizon Natural Resources Damage Assessment Trustees, 2016) which created substantial funding opportunities (more than $199M US) for oyster restoration in the Gulf of Mexico exceeding the annual value of oyster landings (Pine et al. 2022).

Many proposed, ongoing, recent, and historical oyster restoration efforts focus on the addition of various materials for oyster spat (larvae) to settle and grow. Adding this material to substrate is an effort to promote a positive oyster shell budget (harvest removes shell stock, Pine et al. 2015). This is done by providing material from outside of the system of management interest to replace degraded (but natively created), displaced (from culling during harvest) or removed (from harvest) cultch to mimic natural oyster cultch; a complex matrix of living and dead material where oyster larvae settle and grow. These restoration efforts are an attempt to shift oyster reefs from an observed low but resilient state to a more desired productive state Pine et al. 2022) through restoration actions.

We used opportunistic sampling from ongoing and recently completed efforts to shift oyster populations from undesired to desired states through restoration and fishery closure projects in estuaries in the northern Gulf of Mexico. Many of the large restoration programs that are currently funding these efforts are long-term (10-year) projects, but information as learning is needed over shorter time scales to inform other proposed restoration and management projects in similar systems. This is an issue of both temporal and spatial scale (Pine et al. 2022). To facilitate learning under an adaptive management framework as programmatically adopted by these funders, these restoration efforts should be assessed in-progress, and if necessary, corrective changes made to improve the likelihood of the restoration objective of shifting the oyster population from an undesired low-level, to a more desired level. This desired state can vary by location, and type of oyster bar (intertidal vs. subtidal), and management goals. But in general, the desired expectation motivating these restoration efforts are to provide and promote both ecosystem services (ref) and create opportunities for oyster harvest through fishery recovery.

*Site description* – We assessed trends in oyster populations in three estuaries in the Florida panhandle that currently have ongoing or recently completed oyster restoration projects. Pensacola Bay (F1) in northwest Florida (Santa Rosa and Escambia counties) is the fourth largest estuary in Florida with a surface area of approximately 126,000 total acres. Reported oyster landings and trips for Pensacola Bay in recent decades have suggested XYZ (F2) since the current mandatory TRIP ticket program was implemented in 1986. The East Bay (F1) arm of St. Andrew Bay, near Panama City (Okaloosa and Walton Counties) is one region of St. Andrew Bay with a total surface area of approximately XYZ acres. Reported oyster landings and trips for Easy Bay are not available, but for the counties comprising St. Andrew Bay oyster trips and landings in recent decades have ??? (F2). Apalachicola Bay is a large estuary in Franklin County which historically supported the largest oyster fishery in Florida before collapsing in fall of 2012 (Pine et al. 2015) and was closed to commercial harvest in December 2020 through December 2025.

*Management actions* – Cultch material was deposited in each bay in phases by individual state management agencies (Florida Department of Environmental Protection, DEP; Florida Fish and Wildlife Conservation Commission, FWC; Florida Department of Agriculture and Consumer Services, FDACS) as part of three different projects funded to the State of Florida with funds made available following the *Deepwater Horizon* oil spill. In Pensacola Bay approximately 20,103 cubic yards of limerock aggregate were distributed at 17 different sites at an approximate density of 228 cubic yards per acre (FDACS 2016a) during September and October 2016. In St. Andrews Bay approximately 17,000 cubic yards of crushed granite was distributed on nine different oyster reefs at a density of about 200 cubic yards per acre (FDACS 2016b) in June 2016. In Apalachicola Bay two different restoration projects with similar objectives and methodologies occurred during this time. In the first (FDEP), approximately 95,500 cubic yards of limerock aggregate was deployed as part of an FDEP project on fourteen different oyster reef sites. Average density of cultch material was 300 cubic yards per acre. The second (FWC) deployed 9600 cubic yards of shell material in sites 2-acres in size at densities of 100, 200, 300, or 400 cubic yards per acre. Across all studies the actual area and density of cultch material deployed varied due to construction challenges and storm events that occurred during the study period.

*Methods*

to assess oyster population responses to the addition of cultch material and persistence of this cultch material over time.

of oyster reefs in three estuaries in the Florida panhandle, northern Gulf of Mexico, to assess trends in oyster populations and persistence of substrate material following restoration.