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Spatial and temporal settlement patterns of blue crab (*Callinectes sapidus* and *Callinectes similis*) megalopae in a drought-prone Texas estuary

Tracy F. Weatherall, Lindsay P. Scheef, Edward J. Buskey*

University of Texas at Austin Marine Science Institute, 750 Channel View Drive, Port Aransas, TX, 78373, USA

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ABSTRACT

The Mission-Aransas Estuary is the wintering ground for the only sustained wild population of the endangered whooping crane (*Grus americana*), and blue crabs (*Callinectes sapidus*) are an important component of their diet as well as being a major food source for important sport fishes such as the red and black drum. Blue crabs also support a commercial crabbing industry, and fisheries data indicate that blue crab populations have been declining since the 1980s. Possible factors leading to decline in blue crab populations include overfishing, increased populations and predation by regulated sport fishes, reduced freshwater inflows into estuaries, and reduced larval recruitment. Little is known about blue crab recruitment dynamics in this region, but restricted passes between coastal estuaries and the Gulf of Mexico along with extended periods of drought that often lead to hypersaline conditions in coastal bays may limit larval recruitment from the Gulf into the bays. To investigate blue crab larval recruitment patterns, citizen scientist volunteers used hogshair settlement collectors to sample five monitoring sites over a four year period. Results show that large numbers of blue crab megalopae are common in nearshore waters of the Gulf of Mexico, but only a small fraction (~1%) recruit into the estuary. Peak periods of ingress into the estuary occur during fall and winter months, with *C. sapidus* primarily contributing to the fall peak and *C. similis* dominating the winter peak. Increased salinity in the estuary during droughts may reduce the ability of blue crab larvae to detect and enter passes into the estuary.

1. Introduction

Blue crabs (*Callinectes sapidus* and *C. similis*) are an important food source for the migratory endangered whooping crane (*Gus americana*, Linnaeus, 1758) population which overwinters in or near the Aransas National Wildlife Refuge in Texas (Westwood and Chavez-Ramirez, 2005). It is also a major food source for sport finfishes such as black drum (*Pogonias cromis*, Linnaeus, 1766), red drum (*Sciaenops ocellatus*, Linnaeus, 1766), and spotted seatrout (*Cynoscion nebulosus,* Cuvier in Cuvier & Valenciennes, 1830) in Texas bays and estuaries (Scharf and Schlicht, 2000, Vanderkooy 2013). The Atlantic blue crab (*C. sapidus*) is also regarded as an important commercial fishery throughout its range including Texas (Sutton and Wagner, 2007). Picariello and Rosenberg (2015) reported that 1.9 million pounds of blue crab, valued at 2.3 million dollars, were landed in Texas in 2013. However, the Texas Parks and Wildlife Department (TPWD, 2007) has reported declining commercial landings of Atlantic blue crab in Texas waters since 1987. Many factors could be contributing to the downward population trends such as limited freshwater inflow into the estuarine system (Guillory et al., 2001: Picariello and Rosenberg, 2015), habitat alteration and/or loss (Guillory et al., 2001), reduced larval recruitment (Longley, 1994), and increased predation by regulated sportfishes (Guillory and Prejean, 2001; Picariello and Rosenberg, 2015).

Interest in blue crab population dynamics in South Texas has increased due to their importance in the diet of the endangered whooping crane (Nelson et al., 1996). The whooping crane is the tallest bird in North America and nearly went extinct in the middle of the 20th Century (Urbanek and Lewis, 2015). In 2008, after years of steady population increases, 28 birds died in the winter of 2008–2009 and it was suggested that these deaths were due in part to reduced blue crab populations that resulted from drought conditions and diversions of freshwater from the Guadalupe and San Antonio Rivers (Gulley, 2014).

Atlantic blue crabs undergo a complex life cycle as they transition from larval to adult stages and utilize a variety of habitats including the lower, middle, and upper estuary as well as adjacent nearshore coastal waters of the Gulf of Mexico (Perry and McIlwain, 1986). Zoeae (first larval stage) hatch in the higher salinity waters of the Gulf of Mexico and drift among other plankton for several months undergoing 5–7 zoeal stages until metamorphosing into the megalopae postlarval stage (Epifanio, 2007). Megalopae are then transported into the estuary by

* Corresponding author.
E-mail address: ed.buskey@utexas.edu (E.J. Buskey).

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nearshore currents, flood tides, and wind driven processes (Tilburg et al., 2009; Epifanio and Garvine, 2001) where they settle into a primarily benthic existence and metamorphose a final time into the juvenile crab stage (Lipcius et al., 1990). As juvenile blue crabs grow and molt to maturity, they tend to utilize less saline shallow waters of the estuary, occupying areas of structured habitats such as seagrass beds, salt marshes, and oyster reefs as well as soft muddy and sandy non-structured substrates (Lipcius et al., 2005). As adults, males prefer less saline waters of the upper estuary whereas female crabs usually occupy the middle to lower estuary with higher salinities. Mating usually occurs in the lower saline waters of the upper estuary, then female blue crabs migrate to the higher saline waters of the lower estuary and adjacent coastal waters of the Gulf of Mexico when ready to release their larvae (Perry and McIlwain, 1986).

Although reduced recruitment of blue crab at the megalopae stage may be a factor contributing to their declining populations in the Mission-Aransas Estuary, very little is known about their recruitment patterns in the area. Larval recruitment may be an especially important component of blue crab population dynamics on the South Texas coast, since connections between local estuaries and the Gulf of Mexico are limited by nearly continuous barrier islands with widely separated narrow passes. The behavioral adaptation that allows weakly swimming planktonic blue crab larvae to be transported from the coastal ocean to estuaries is known as selective tidal-stream transport (Forward et al., 2003). By responding to environmental variables including light, changes in salinity, and turbulence, blue crab larvae move into the estuary by swimming up into the water column during nocturnal flood tides of increasing salinity and remain on the bottom during ebb tides with decreasing salinity. Freshwater inflows into South Texas estuaries are often reduced due to extended periods of drought, increased demand for freshwater by agriculture and municipal purposes, and capture of water in reservoirs (Montagna and Kalke, 1992). These factors lead to increased salinity in South Texas estuaries, and experimental and modeling studies indicate that increased salinity can lead to reduced transport of blue crab larvae by selective tidal-stream transport (Bittler et al., 2014).

A simple but labor-intensive method for estimating the recruitment of blue crab larvae involves the deployment of standardized settlement collectors constructed of an artificial substrate (air-conditioning filter) in a cylindrical design over a 24 h period (Metcalf et al., 1995). A citizen science larval blue crab monitoring project was started in 2012 to better understand the potential role of larval recruitment in the population dynamics of blue crabs in the winter feeding grounds of the whooping crane, and to investigate whether reduced freshwater inflows and resulting hypersalinity in estuaries of south Texas affected larval recruitment. Using settlement collectors this study gained insight into the proportion of blue crab larvae that recruit into the estuary from the Gulf of Mexico, how far these larvae travel into the estuary before metamorphosing into juveniles, and the seasonal pattern of larval recruitment in subtropical south Texas.

2. Methods

2.1. Study area

The Mission-Aransas National Estuarine Research Reserve (NERR), located along the south-central coast of Texas, encompasses 751.5 sq. km of terrestrial, wetland and marine habitats characteristic of western Gulf of Mexico estuaries (Diener, 1975; Mission-Aransas NERR, 2015) and includes the Aransas National Wildlife Refuge, winter home to the last wild whooping crane flock. The extensive shallow bays within the reserve boundaries are diverse with an array of complex habitats such as seagrass meadows, oyster reefs, mangroves, and wind driven tidal flats, as well as tidal marshes that provide essential habitat for the endangered whooping crane. Hydrology is primarily influenced by freshwater inflow from the Mission and Aransas Rivers, and to a lesser extent by inflow of the Guadalupe and San Antonio Rivers into San Antonio Bay to the northeast. Exchange with the Gulf of Mexico occurs via the Aransas Ship Channel (southern extent of the Reserve) and, to a lesser degree, at Cedar Bayou at the Reserve's northern boundary (Mission-Aransas NERR, 2015).

2.2. Sample collection

Blue crab megalopae tend to have very patchy spatial and temporal distributions, and they are rarely collected in samples using plankton nets, especially when nets are deployed during the day (unpublished data). Instead, settlement collectors designed to retain settling megalopae are commonly used to investigate crab megalopae recruitment (Lipcius et al., 1990; van Montfrans et al., 1990; Metcalf et al., 1995). Settlement collectors are deployed over 24 h periods, allowing for sampling over extended periods during day and night and during various phases of the tidal cycle. Each sampling site in the present study was supplied with three replicate settlement collectors, which consisted of a piece of synthetic “hogshair” air conditioner filter sleeve (45 × 25 × 1.0 cm) wrapped around a weighted 10 cm diameter, 25 cm long PVC pipe. Each collector was suspended just below mean low tide level for ~24 h per day. Trained citizen scientist volunteers collected crab megalopae samples daily from the collectors and, at the same time, deployed replacements. Collector sleeves were removed from each trap and rinsed with freshwater into a 19-L bucket to remove all accumulated crab megalopae. The sample was then filtered through a 16 cm diameter 105 μm mesh sieve, and material retained in the sieve was rinsed into a vial and preserved in ethanol.

2.3. Sampling sites and dates

To investigate larval blue crab settlement and distribution patterns, *Callinectes* spp. megalopae were collected by citizen scientist volunteers approximately daily from a total of 4 sites within the Mission-Aransas estuary and 1 site just outside the estuary on Mustang Island (Fig. 1, Table 1). These study sites were selected to represent the upper (R1/R2), middle (AP), and lower (LH and UT) reaches of the Mission-Aransas estuary and the adjacent coastal waters of the Gulf of Mexico (HC).

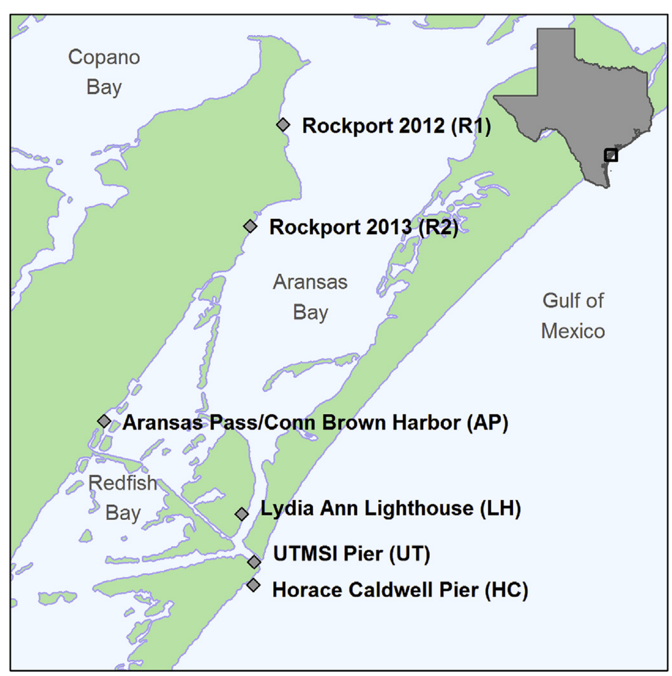

Fig. 1. Map showing the locations of the megalopae settlement monitoring sites.