USING LONG-TERM SURVEY DATA TO PREDICT BLUE CRAB (*Callinectes sapidus*) ABUNDANCE AND COMMERCIAL LANDINGS IN CHARLESTON HARBOR, SOUTH CAROLINA

**A thesis submitted in partial fulfillment of the requirements for the degree**

**MASTER OF SCIENCE**

**in**

**ENVIRONMENTAL AND SUSTAINABILITY STUDIES**

**by**

**STEPHEN CZWARTACKI**

**SEPTEMBER 2020**

**at**

**THE GRADUATE SCHOOL OF THE UNIVERSITY**

**OF CHARLESTON, SOUTH CAROLINA AT THE COLLEGE OF CHARLESTON**

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# ABSTRACT

**USING LONG-TERM SURVEY DATA TO PREDICT BLUE CRAB (*Callinectes sapidus*) ABUNDANCE AND COMMERCIAL LANDINGS IN CHARLESTON HARBOR, SOUTH CAROLINA**

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Marked high fluctuations in blue crab (\*Callinectes sapidus\*) seasonal and annual abundance, and commercial landings are typical, but data from both fisheries independent and dependent surveys have shown declines in populations in recent years in South Carolina. Despite several long-term fisheries independent surveys encountering blue crab, predictive models have not recently been developed in South Carolina to quantify variation in abundance and commercial landings. The goal of this study is to assess the current status of blue crab in SC and explore the potential for developing a more predictive understanding of commercial landings. This goal is met through the following objectives: 1) assess long-term trends in blue crab landings and fisheries-independent abundance, 2) test the applicability of a juvenile index, where juvenile abundance in one year predicts adult abundance in a subsequent years (e.g. 1-yr and 2-yr lag), 3) explore other indices of abundance for size class and sexual maturity categories as they relate to total or adult blue crab abundance in subsequent years (e.g. 1-yr and 2-yr lag), and 4) explore predictive relationships between fisheries-independent size class and sexual maturity abundance categories and commercial landings. Data from several long-term South Carolina Department of Natural Resources (SCDNR) fisheries independent blue crab surveys were standardized for each of six surveys and commercial landings data were compiled. Analyses testing the application of a juvenile index of abundance show that no juveniles collected in surveys explain variation in annual survey abundances. The Creek Trawl survey was the only survey with significant, but weak, correlative relationships between multiple lagged population structure variables and its own annual adult or total abundance. Significant relationships were found with effort-corrected commercial landings predicted by the previous year’s abundance of male crabs. This relationship was most correlated for immature crabs collected in the Harbor Trawl survey, and for mature crabs collected in the Creek Trawl survey. These results suggest a larger influence on abundance of blue crab from fishing effort than population dynamics, and a potential influence from other external factors such as habitat or environmental variables.

# ACKNOWLEDGMENTS

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# INTRODUCTION

The blue crab (Callinectes sapidus) is a highly ranked commercial and recreational fishery in South Carolina with 3.9 million lbs. landed, and a value of $5.1 million in 2018 (ACCSP Non-confidential Landings by Species (Blue Crab) 2020.). To support management, it is important to understand recruitment dynamics of juvenile blue crab into the adult stage – the stage that is available to commercial and recreational fishers. Models can be developed to assess recruitment dynamics, including testing of crab abundance in any given year and its relationship to crab abundance in preceding years. If adult abundance in a year is predicted by juvenile abundance in the prior year (e.g., 1-yr lag), this may provide a more predictive understanding of the blue crab fishery. The South Carolina Department of Natural Resources (SCDNR) monitors the status of juvenile and adult blue crab across a range of habitat types using multiple fisheries independent surveys.

# CHAPTER 1 TITLE HERE

## Background

## Methods

### Survey Methods

A suite of fisheries independent monitoring surveys employed by the South Carolina Department of Natural Resources (SCDNR) encounter the blue crab using varying gear types in varying habitats with varying sampling regimes (Table 1).

Biotic data recorded as part of both surveys (size, sex, maturity). Size is determined by measurement of the carapace width. Sex and maturity are determined by presence of morphological characteristics of the abdomen.

### Analytical Methods

Data were put through a rigorous data wrangling process to standardize each survey relative to its own methods. Fisheries dependent commercial landings and fisheries independent survey abundances were truncated from statewide data to Charleston Harbor watershed data. Individual crabs were assigned to the following size and sexual maturity categories (Table 1): Size Classes - juvenile (>59mm), subadult (61mm - 126mm), sublegal (<127mm) and adult (>126mm); Sexual maturity classes: mature female, immature female, mature male, and immature male. Monthly means across all stations were used to calculate mean annual abundances as catch-per-unit-effort (CPUE). Adult CPUEs were compared to juvenile CPUEs 1 and 2 years prior to test the applicability of a juvenile index. Additional indices of adult CPUE and total CPUE were developed using single regression models (n=) for each life-stage specific category at 1-yr and 2-yr lags. Significant ($\alpha$ = 0.05) models were ranked by explanatory power (i.e., r^2^)

## Results

### Long-term Trends of Abundance

*\*Assess long-term trends in blue crab landings and fisheries-independent abundance\**

Time series of mean annual commercial landings (Fig. 1) and adult abundances from SCDNR fisheries independent surveys (fig. 2) show the high inter-annual variablility of legal-sized "adult" blue crab (>126mm). These figures both show crab >126mm, which is the minimum legal limit of blue crab in South Carolina.

The total pounds landed in the combined Charleston Harbor watersheds shows a trending decline from 2003 - 2010, but when these same landings data are corrected for effort in terms of number of pots pulled that trend is not observed. The year 2003 marks the first year of "trip ticket" reporting, in which all commercial blue crab license holders are required to report their catch. This is the same time (>2003) landings data have incorporated data from the Ashley River and Cooper River reporting areas. This could be due to not being actively fished for blue crab, underreported for these reporting areas or included in another reporting area (e.g. a line of crab pots beginning in the Ashley River and continuing into Charleston Harbor where landings are eventually reported). Adult abundances from some surveys (B-Creek Trawl, C-Ashley Potting and D-SCECAP Open-Water) show a slight decline in adult abundance shortly after 2000.

### Juvenile Index of Adult Abundance

*\*Test the applicability of a juvenile index, where juvenile abundance in one year predicts adult abundance in a subsequent years (e.g. 1-yr and 2-yr lag)\**

Mean annual juvenile CPUE is not significantly related to mean annual adult CPUE in subsequent years for any survey (Table 3).

\*\*Table 3:\*\* Insignificant and poorly correlated relationships of adult CPUEs by juvenile CPUEs

### Indices of Adult and Total Abundance

*\*Explore other indices of abundance for size class and sexual maturity categories as they relate to total or adult blue crab abundance in subsequent years (e.g. 1-yr and 2-yr lag)\**

The CRMS Creek Trawl is the only survey (see notes for Tables 5 & 6) with predictive relationships where size class and sexual maturity categories relate to total or adult abundance in succesive years (Table 4). Fifteen size class and sexual maturity variables with 1- and 2-yr lag explain total CPUE and explain adult CPUE. The highest ranked model total Creek Trawl CPUE explained by subadult CPUE with a 2-yr lag (\*p\*-value = <0.01, r^2^ = 0.24; Fig. 3).

### Commercial Landings Predictions

\*Explore predictive relationships between fisheries-independent size class and sexual maturity abundance categories and commercial landings\*

Nine total predictive models using several size class and sexual maturity categories with 1-yr lag to explain effort corrected landings were developed. No 2-yr lagged size class and sexual maturity categories predict effort corrected landings. Predictive relationships were only found using the CRMS Harbor Trawl (N = 3) and Creek Trawl (N = 6) surveys. The strongest relationships ranked by explanatory power (r^2^) use the Harbor Trawl subadults with a 1-yr lag (\*p\* = <0.01, r^2^ = 0.43) and the Creek Trawl immature males with a 1-yr lag (\*p\* = <0.01, r^2^ = 0.41; Table 7).

Total landings (not effort corrected) have only two predictive relationships were size classs and sexual maturity variables from any survey predict total annual lbs landed (Table 8). These two poorly correlated relationships use mature males with a 1-yr lag from the Harbor Trawl (\*p\* = <0.05, r^2^ = 0.10) and adults with a 2-yr lag from the Ashley Potting Survey (\*p\* = <0.05, r^2^ = 0.15) to predict total annual pounds landed. Total landings data are missing for the Ashley and Cooper Rivers prior to 2004.

\*\*Table 7:\*\* Objective 3 - All significant relationships of effort corrected Charleston Harbor watershed (Ashley, Cooper and Wando Rivers and Charleston Harbor) commercial Landings by size classs and sexual maturity variables from all surveys using OLS regression.

ACCSP Non-confidential Landings by Species (Blue Crab), generated by S. C. (3/19/2020). Atlantic Coastal Cooperative Statistics Program. Arlington, VA. https://safis.accsp.org:8443/accsp\_prod/f?p=1490:310:2664292005781::NO::P310\_GO\_FLAG:-1.