Predicting blue crab abundance and landings from fisheries independent surveys in Charleston Harbor, South Carolina

Abstract

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 me 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 following year, 3) explore predictive relationships between fisheries-independent abundance 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 6 surveys and commercial landings data were compiled. Long-term trends showed... Analyses testing the applicability of a juvenile index showed that the Creek Trawl survey was the only survey with significant, but weak, correlative relationships between multiple lagged population structure variables and its own annual abundance. Significant relationships were found with effort-corrected commercial landings predicted by the previous year's abundance of males crabs. This relationship was significant for immature crabs collected in the Harbor Trawl survey, and for mature crabs collected in the Creek Trawl survey. These results suggest effective population sampling, but a potential influence on abundance of blue crab from outside factors such as fishing, habitat or environmental variables.

Methods

Data were put through a rigorous data wrangling process to standardize each survey relative to its methods. Fisheries dependent commercial landings and fisheries independent survey abundances were truncated from statewide data to Charleston Harbor watershed data.

Table 1: SCDNR fisheries independent survey methodology

Survey	Gear Method	Gear Type	Sample Area	Sample Interval	Sample Method	N(events)	CPUE Standardization
CRMS							
Creek Trawl	Active	6m Trawl, 2.54cm stretch mesh	Ashley River, Wando River	Monthly, May-Sep	Fixed Stations	1827	Time
Harbor Trawl	Active	4.6m Trawl, 0.6cm D mesh	Ashley River, Charleston Harbor	Monthly	Fixed Stations	2956	Time, Gear
Ashley Fall Potting	Passive	0.6 x 0.6 x 0.46m Pot, 3.8 cm mesh	Ashley River	Monthly, Oct-Nov	Randomized Block w/in a Fixed Station	128	Time
ERS							
SCECAP Tidal Creeks	Active	5m trawl, 1.9cm bar mesh	Charleston Harbor Systemwide	Jun - Aug	Random Stratified	62	Volumetric
SCECAP Open Water	Active	5m trawl, 1.9cm bar mesh	Charleston Harbor Systemwide	Jun - Aug	Random Stratified	92	Volumetric
IFRS							
Trammel Net	Passive	183 x 2.1m trammel net	Charleston Harbor Systemwide	Monthly	Random Stratified	4736	None (Total)

Table 2: Lifestage data for blue crab by SCDNR fisheries independent survey

Survey	Total CPUE	Juvenile	Subadult	Adult	Legal	Sublegal	Immature Female	Mature Female	Immature Male	Mature Male
CRMS										
Creek Trawl	X	X	X	X	X	X	X	X	X	X
Harbor Trawl	X	X	X	X	X	X	X	X	X	X
Ashley Fall Potting	X				X	X				
ERS										
SCECAP Tidal Creeks	X	X	X	X	X	X				
SCECAP Open Water	X	X	X	X	X	X				
IFRS										
Trammel Net	X									

Objective 1

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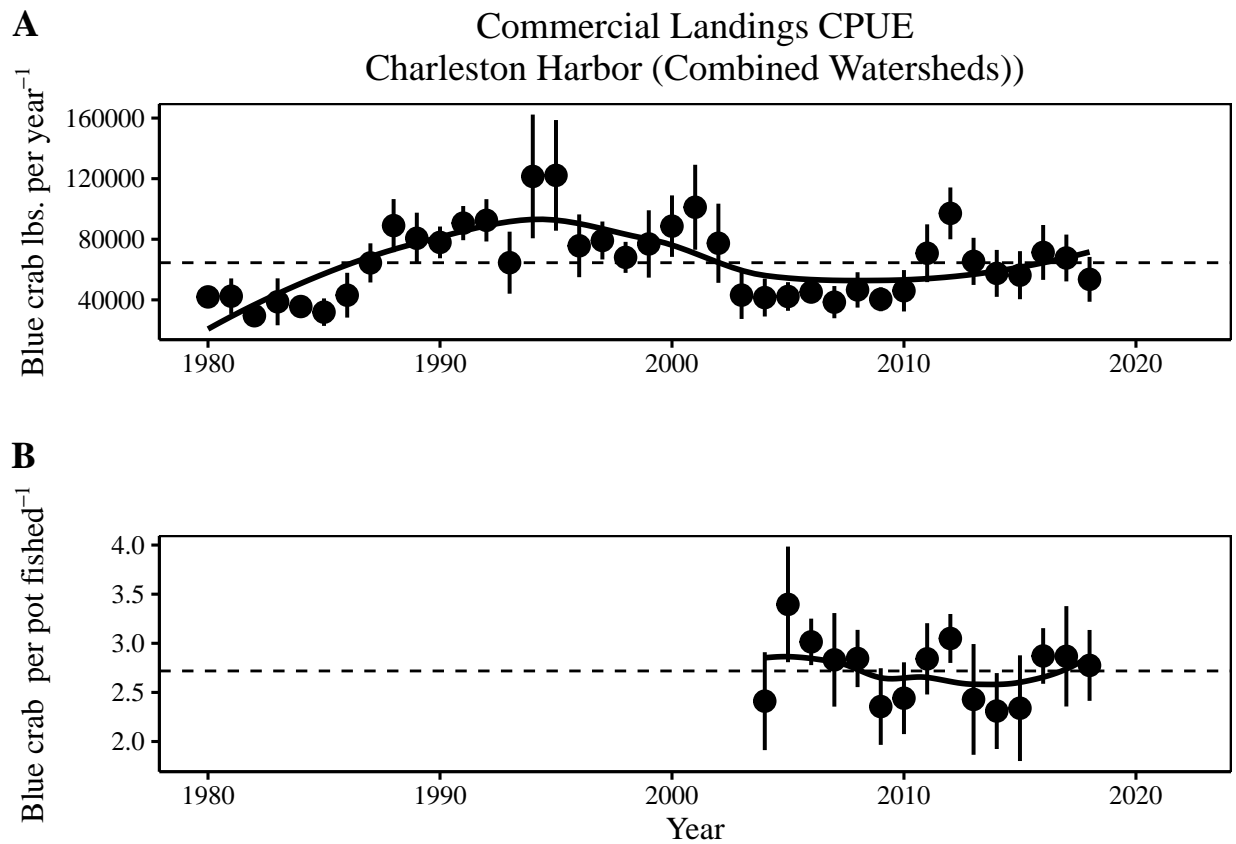

Figure 1: Objective 1 - This plot shows the point that there is high annual variability in blue crab catches and a potential decline in population >2002. It also shows that It should be mentioned that statewide initial analyses of the data have indicated a sharp decline but that when corrected for effort, and post implementation of proper reporting, these data may not show the severe decline in populations that have been reported.
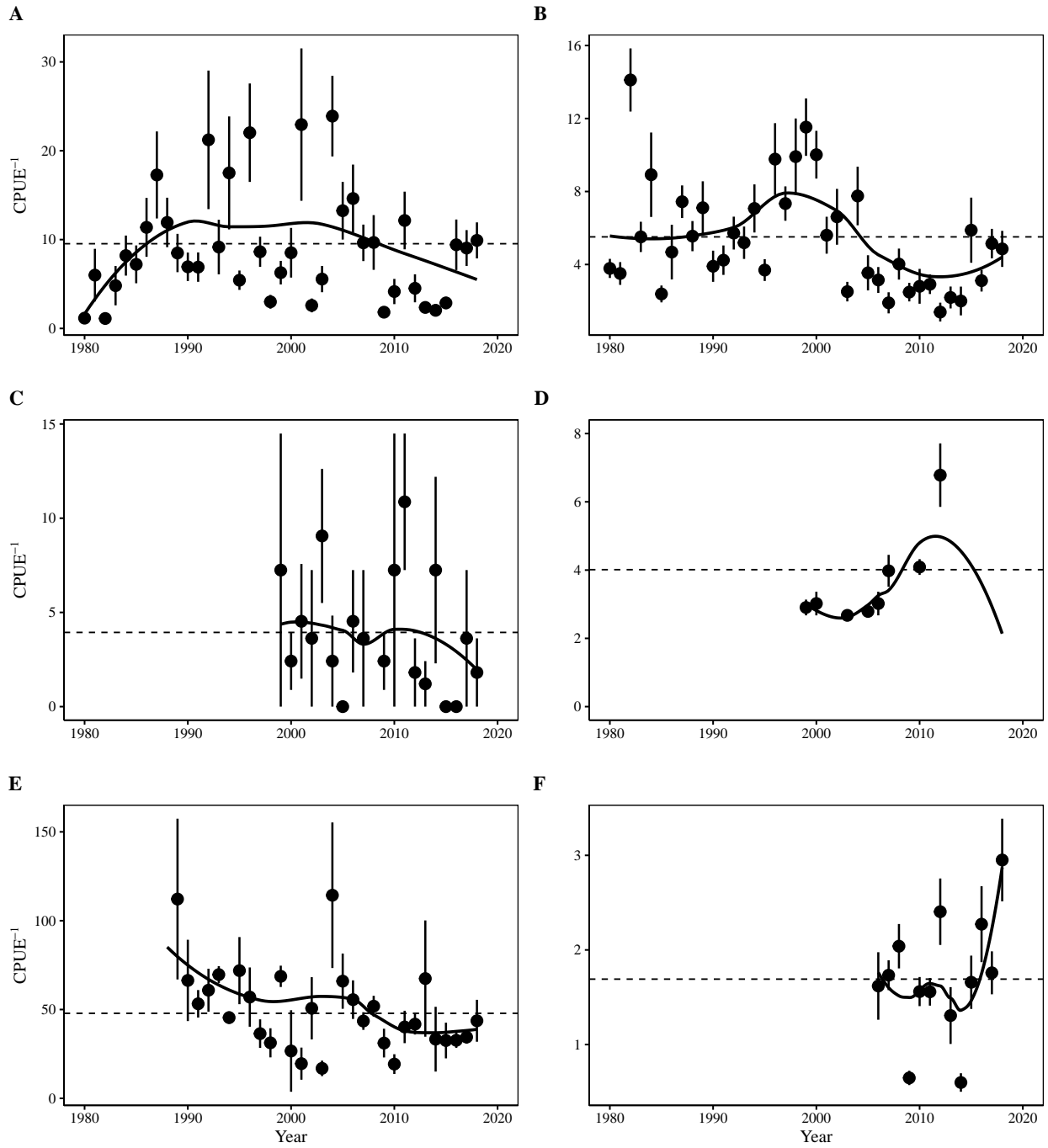
Figure 2: Objective 1 - This plot sshows the same high annual variabilty in our fish-independent surveys. This plot could also suggest different resiliency (? wrong word), and/or different responses of the population in different habitats.I'd love to add some sort of size/sex time series plot in

Discussion

Commercial landings (fig. 1) and survey abundance (fig. 2) time series show the high annual variablility of blue crab populations, but also may not agree totally on the decline in populations through the decade of the 2000's.

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 frame ($>$2003) the Ashley and Cooper Rivers are included in commercial landings, whether that is due to not being actively fished for blue crab, underreported, or included in another reporting area. Time series data from the abundance surveys (fig 2) show a more severe decline in surveys occuring in tidal creek areas (figs 2B and 2D) than in open water areas (figs 2A, 2C, 2E) with data from the SCDNR Trammel Net survey not showing a decline but no data available for comparison before 2006. This suggests influence of habitat or environmental conditions on blue crab populations in particular areas of the estuary.

Of note: for commercial landings (fig. 1), and the longer abundance surveys (figs 2A and 2B), variability is increased when CPUEs are above the long-term mean - could this indicate less 0-catch events and do we care?

Objective 2

Test the ability of a juvenile index, where juvenile abundance in one year predicts adult abundance in a following year

Table 3: These are all relevant explanatory variables. Only one survey has explanatory relationships. Juveniles do not predict abundances in later years. Maybe the subadults with a 2-yr. lag show that juveniles in this survey could be used with a 3-yr lag, or that the survey simply does not catch juveinles effectively.

| Dependent Variable	Explanatory Variable	Summary Statistics			
		p-value	r2	F-statistic	Degrees of Freedom
Total CPUE	Subadult (1-yr. lag)	0.007774	0.1809	7.949	36
Total CPUE	Adult (1-yr. lag)	0.031200	0.1225	5.028	36
Total CPUE	Immature Female (1-yr. lag)	0.050070	0.1025	4.111	36
Total CPUE	Immature Male (1-yr. lag)	0.048540	0.1038	4.169	36
Total CPUE	Mature Male (1-yr. lag)	0.002197	0.2321	10.880	36
Total CPUE	Sublegal (1-yr. lag)	0.025290	0.1314	5.448	36
Total CPUE	Legal (1-yr. lag)	0.031200	0.1225	5.028	36
Total CPUE	Total CPUE (1-yr lag)	0.019060	0.1434	6.027	36
Total CPUE	Subadult (2-yr. lag)	0.001926	0.2432	11.250	35
Total CPUE	Immature Female (2-yr. lag)	0.010380	0.1733	7.337	35
Total CPUE	Immature Male (2-yr. lag)	0.004023	0.2131	9.481	35
Total CPUE	Mature Female (2-yr lag)	0.019000	0.1473	6.048	35
Total CPUE	Mature Male (2-yr. lag)	0.030760	0.1265	5.067	35
Total CPUE	Sublegal (1-yr. lag)	0.004317	0.2102	9.316	35
Total CPUE	Total CPUE (2-yr lag)	0.004898	0.2050	9.024	35
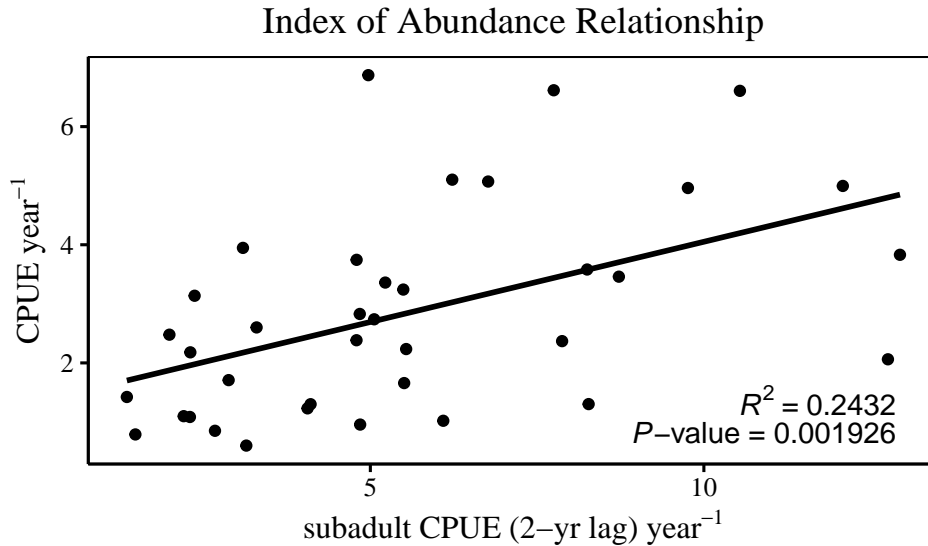
Figure 3: Objective 2 - Shows the potential to predict, but poor correlation. Being subadult with a 2-yr lag suggests that either juveniles are underrepresented in sampling, or maybe they do not congregate until this size? THIS PLOT IS NOT NEEDED

OLS regression models using all lifestages from all surveys with a 1- and 2-yr lag to predict all survey's total CPUEs were constructed to find all explanatory relationships. All significant relationships are displayed in the following tables. The CRMS Creek Trawl is the most consistently responsive of the surveys when used in regression modeling. Fifteen significant relationships exist between total CPUEs from the Creek Trawl survey and several 1- and 2-yr.lagged lifestage variables (Table 3). The CRMS Harbor Trawl had one significant explanatory relationship with subadults from the same survey lagged 1-yr (Table 4). The Trammel Net survey had one significant explanatory relatioship with mature females from the Harbor Trawl lagged 1-yr (Table 4), which is the highest correlation (r2=0.36) of all the single regression models.

Although there were several significant regression models constructed using fisheries independent survey life stage abundance CPUEs, no relationships correlate strong enough to be effective models. Using OLS single regression modeling, the six SCDNR fisheries independent surveys used to monitor blue crab populations in the Charleston Harbor watershed are ineffective are ineffective predictors of their own abundance CPUEs.

The next step in this chapter is to put all relevant variables for the Creek Trawl into an exploratory dredge to find combinations of variables to populate multiple regression models. These models will be constucted using the suggestions of the dredge.