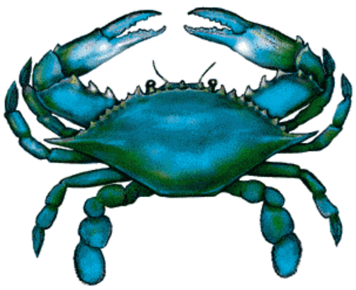
Clemson University

State of Basin Report

Status of Blue Crabs in South Carolina



Spring 2012

Volume 2, Issue 1

What is the state of the basin report?

- A newsletter to update the public about blue crab research in the ACE Basin NERR.
- A source of information regarding the life-history, ecology and behavior of blue crabs.
- A forum for opinions regarding the status, health and future of the blue crab fishery in South Carolina.
- A public service of the SC Sea Grant Consortium and Clemson University.

Inside this issue:

ACE Basin NERR Blue Crab Population Study Completed

Blue crabs make up one of the most important commercial fisheries in S.C. but there has been some concern over the health of crab populations due to the declines in landings seen in recent years. There is a significant positive correlation between river discharge and commercial landings suggesting that drought may be to blame for the recent decline in crab numbers. Our study tested multiple hypotheses examining the links between decreasing freshwater flow, the subsequent rise in salinity, and the blue crabs abundance in the ACE Basin National Estuarine Research Reserve.

The last blue crab, *Callinectes sapidus*, takes one final bow before returning to Mosquito Creek.

To address these hypotheses, a combination of laboratory studies, field observations, and field manipulations were performed over a four year time period from June 2008 through March 2012. Water quality, crab health, fishing effort, and *Hematodinium* sp. infection rates were measured quarterly at 27 stations. Field experiments were performed to estimate both blue crab settlement and survival. Statistical and simulation modeling were performed to predict the future of blue crabs in South Carolina

River discharge varied both seasonally and annually causing dramatic swings in the salinity profiles of each river. Increasing salinity increased crab survival, but also increased infection by *Hematodinium* sp, a lethal parasite. Settlement and fishing effort were not related to changes in salinity. Over the four years, crab abundances increased in the river with the highest freshwater input and decreased in the river with the lowest freshwater input. Computer models predict that rivers with high freshwater discharge rate increase crab numbers during droughts, but in most rivers, decreased freshwater flow means a decrease in crab numbers.

These results suggest that drought can have both positive and negative consequences to crab abundance and that further reductions in freshwater flow would likely have a net negative impact on future crab landings.

Commercial Crab Landings Correlate with River Flow

The annual landings for blue crabs fluctuated from 1979 to 1999, but since then have been on a steady decline until this past year. The environmental factor that is most correlated with this decline in crab numbers is annual freshwater flow. Figure 1 shows the annual discharge rate of the Edisto River in relation to the annual commercial landings of blue crabs in South Carolina. Both crabs landings and river flow are declining and are correlated with one another ($r2 = 0.109$, $p = 0.0340$).

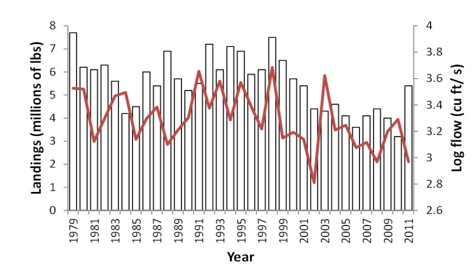


Figure 1. Annual landings of blue crabs track annual changes in freshwater flow. During drought years when flow is lowest, crab landings decrease.

Crab Numbers Vary Seasonally, Annually and Spatially

Crab abundance was estimated each quarterly census by summing the number of crabs caught in 36 crab traps distributed among nine locations in each river of the ACE Basin. All crabs collected were measured, sexed, photographed, and released unharmed. Over the sixteen quarterly samples, a total of 3,753 crabs were caught. Mature males accounted for 30% of the crabs caught, mature females accounted for 9.5%, immature males 37.7%, and immature females for 22.8% of the crabs caught. The Ashepoo River averaged 100 crabs per census, the Combahee River averaged 75 crabs per census, and the S. Edisto River averaged 50 crabs per census.

Crab numbers tended to be highest during the June and September when salinity was also the highest (Figure 2). Salinity was highest on average in the Combahee and lowest on average in the S. Edisto. The relationship between salinity and crab numbers appears to be curvilinear with a peak abundance of crabs near 20 psu within each river and in the river with the intermediate salinity profile (Ashepoo). Crab abundance decreases in the highest and lowest salinity portions of each river and in the highest (Combahee) and lowest (S. Edisto) salinity rivers. The steady increase in salinity each year is proportional to the steady decrease in freshwater flow into each river.

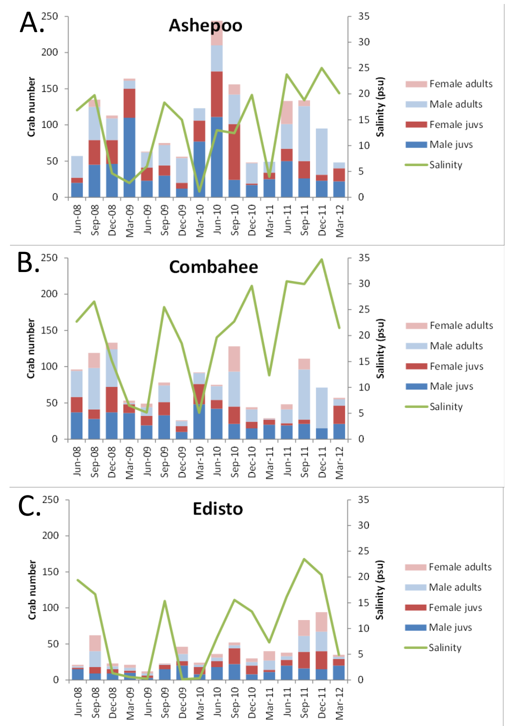
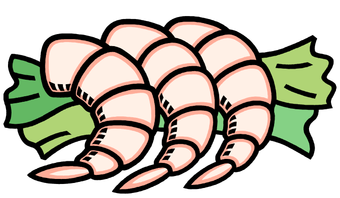


Figure 2. Crab number (by sex and maturity) for sixteen quarterly samples in (A) the Ashepoo River, (B) the Combahee River, and (C) the S. Edisto River. The green line represents the salinity at the marsh midpoint (station 5) in each of the three rivers.



Rare Crab Disease Is Highest in High Salinity Waters

Blue crabs in the southeastern US are often infected with a harmful algae called *Hematodinium* sp. This single-celled algae is a parasite of many species of lobsters, crabs and other crustaceans. The parasite lives in the blood and is fatal. In the early stages of infection, it is very difficult to detect an infected crab. However, once the parasite multiplies, the host crab becomes slow and unresponsive and eventually dies. To investigate the abundance and distribution of this parasite, we have analyzed blood samples from 2240 blue crabs and found only 44 infected crabs. The infected crabs were most common in 2008, in the month of December, and in the Combahee River. We also found a strong correlation with station. Those stations closest to St. Helena Sound, stations 1, 2 and 3 accounted for the majority of infected crabs with numbers as high as 18% of all crabs collected at Combahee River station 1 (Figure 3). Salinity appears to be the environmental variable most correlated with this pattern of disease prevalence. Disease is highest at the high salinity station 1 and drops off rapidly as you go up river. In the Combahee River, the salinity profile is more gradual which may explain why infected crabs are found much further upriver.

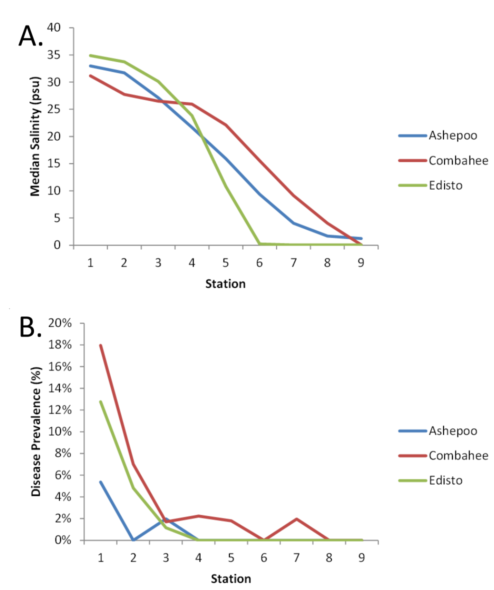


Figure 3. (A) Median salinity over 16 quarterly samples at each of 9 stations in the three rivers of the ACE Basin NERR. (B) Percent of crabs testing positive for *Hematodinium* disease at each of 9 stations in the three rivers of the ACE Basin NERR. There is significant positive correlation between disease prevalence and salinity.

High Salinity Favors Settlement and Reduces Predation

To measure larval crab (megalopae) settlement, we monitored 4 larval collectors per station at stations 1-4 in each of the three rivers of the ACE Basin NERR. Collectors were checked weekly for 12 weeks in August, September and October 2010 & 2011. All larvae were preserved, sorted, identified and counted in the laboratory under a dissecting scope. The peak settlement usually occurred sometime in September, but did not always occur at the same time in each river. Over the entire larval settlement period, station 1 typically had the highest larval settlement (Figure 4). However, there were also a peak of larval settlement at station 4 in the S. Edisto river close to the Intercoastal waterway.

To measure post-settlement survival of juvenile crabs, we tethered live crabs with steel fishing leaders to weighted lines at stations 1, 3, 5, and 7 in each of the three rivers of the ACE Basin NERR. A total of 20 crabs were tethered at each station and were checked for survival after 24 hours. Crab survival was influenced by crab size, crab shape, and salinity. Survival was highest in the high salinity portions of each river and in the river with the highest salinity (Combahee) (Figure 5). Predation increased in the upper regions of each river where the presence of alligators was noticeably higher.

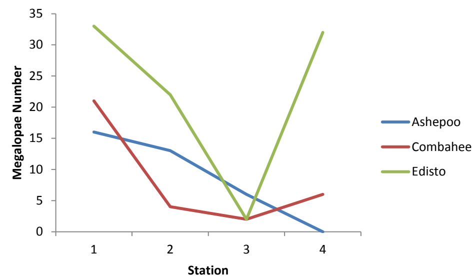


Figure 4. Total number of crab larvae (megalopae) observed at stations 1 through 4 in each of the three rivers of the ACE Basin NERR. Settlement is highest in the Edisto but is not predicted by salinity

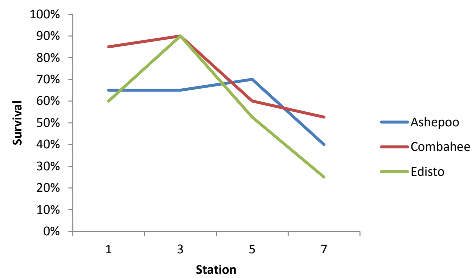
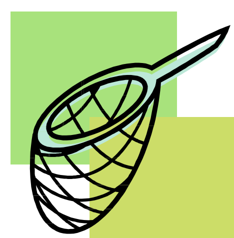


Figure 5. Relative 24-hour survival of 20 tethered crabs at stations, 1, 3, 5, and 7 in each of the three rivers of the ACE Basin NERR. Predation is highest in the low salinity portion of each river. This may be due to the increased presence of alligators in the upper stations.



Salinity Explains Both Increasing and Decreasing Crabs

Predicting the outcome of drought, reduced freshwater flow, and increasing salinity on the abundance of blue crabs is not a easy task. High salinity increases disease and decreases growth resulting in lower crab densities such as we observed in the Combahee River. Low salinity increases predation and decreases growth resulting in lower crab densities such as we observed in the Edisto River. Intermediate salinities are optimal resulting in the highest density of crabs in the Ashepoo River (Figure 2).

Over the past four years, flow has steadily decreased and salinity has steadily increased in the ACE Basin NERR (Figure 2). We used our four years of quarterly crab abundance data to construct a seasonal ARIMA forecast model. The model predicted that increasing salinity will continue having a positive affect on crab density in the low salinity river (S. Edisto) and a negative affect on crab density in the high salinity river (Combahee) (Figure 6). Thus, we can expect that with increasing drought conditions across the state of South Carolina, there will continue to be more negative effects of high salinity acting through increased disease and decreased growth of crabs (Figure 7).

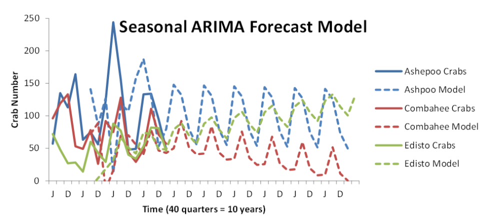


Figure 6. A seasonal forecast model of blue crabs in ACE Basin predicts a declining population in the Combahee River, and an increasing population in the Edisto River.

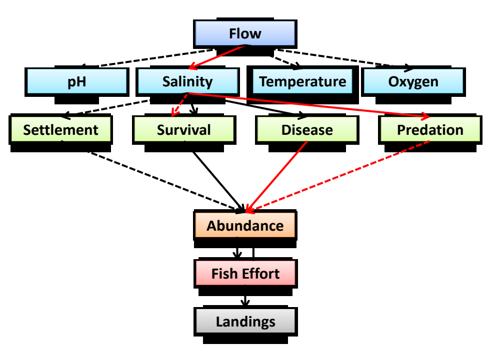
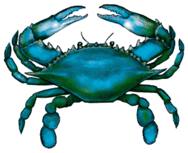


Figure 7. Summary of the positive (black lines) and negative (red lines) interactions linking flow to landings. Solid lines are significant ($p < 0.05$), dotted lines are not ($p > 0.05$).



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SC Blue Crab Research

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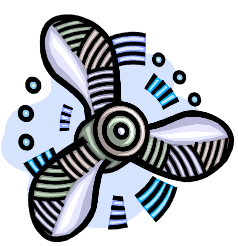

Computer Model Forecasts Future ACE Basin Crab Abundance

To examine the long-term effects of drought on crab population structure, we created a spatially-explicit, individual-based model (IBM) of the ACE Basin NERR (Figure 8). We used USGS historical flow rates from the Edisto River (02705000) to parameterize the seasonal cycle of freshwater flow and our spatial data of water quality to link flow to the salinity profile along each river.

Data from our crab census and field experiments were used to describe the links between salinity and crab settlement, growth, movement, disease, predation and fishing effort. We then conducted an 75-year hindcast / forecast simulation to examine how declining freshwater might impact crab population structure. We started with the historical average flow from 1975 and programed a linear decline in flow that we have observed for the past 35 years. We then projected this rate of decline ahead for another 40 years. Five replicate runs of the model were conducted and the mean and standard deviation of total crab number and % infected crabs are in Figure 9.

The model predicts that initial decreases in river discharge will have a positive effect on crab population density as more of the marsh reaches optimal intermediate salinity. This confirms our observation that increasing salinity can have a positive effect in high flow rivers. The optimal flow rate is about 80% of the historical average, the flow rate we observed in 2009. However, any further reduction in flow below the 80% historical level results in a higher proportion of crabs with *Hematodinium* disease and a lower total number of crabs. This decline continues so long as the freshwater flow continues to decline. This confirms our observation that increasing salinity can have a negative effect in low flow rivers.

The most surprising outcome of this simulation model is that relatively small increases in disease prevalence (about 1%) can ultimately lead to a declining crab population. Based on the key factors in this model, the only way to reverse this decline in crab numbers is to restore freshwater discharge to the marsh. Changes in fishing effort or fishing boundaries were found to have little impact on the number of crabs in the model. Perhaps our greatest concern is the fact that the actual decline in crab numbers in South Carolina appears to already have begun.

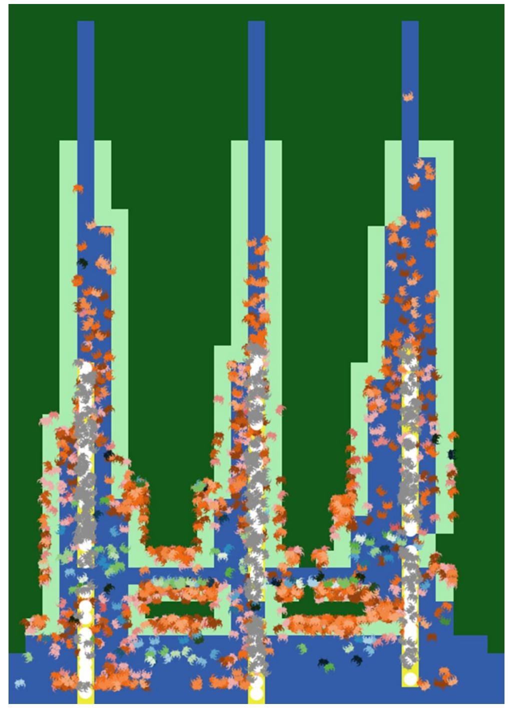

Figure 8. A visual output of the SCBCRABS-ACE simulation model. Red are juveniles, blue are adult males, green are adult females and gray are trapped crabs. Light green is shallow marsh grass habitat and dark green is upland habitat and blue is open water habitat. Crabs move according to stage specific rules that vary with season and water quality conditions including temperature and salinity.

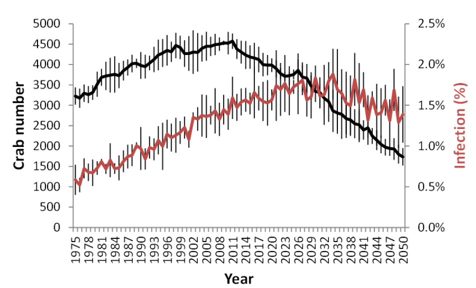

Figure 9. Crab number (black line) and % infected crabs (red line) from five replicate runs of the SCBCRABS-ACE simulation model. The run began in 1975 with the historical average freshwater discharge which was decreased each year thereafter at the current rate of decline. The model was then projected forward an additional 40 years to forecast the future of blue crabs if freshwater flow continues to decline at the current rate.

Childress, M.J. and K.J. Parmenter. 2012. Dying of thirst: impact of reduced freshwater flow on South Carolina blue crabs . Proceedings of the 2012 SC Water Conference.

Parmenter, K.J. 2012. The effects of drought on the abundance of the blue crab, *Callinectes sapidus*, in the ACE Basin NERR in South Carolina. PhD Dissertation. Clemson University.

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