

Final Report

Project Title: Investigating trophic impacts and spread of invasive blue catfish in the Albemarle Sound.

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Project Number: R/MG-2401

Project Start Date: 01-01-2024

Project End Date: 05-31-2025

Final Report Submission Date: 05-31-2025

1. Abstract

The expanding presence of invasive blue catfish (*Ictalurus furcatus*), in the Albemarle Sound raises pressing concerns about their ecological impacts. Native to the Mississippi River Basin, blue catfish were introduced to Atlantic coast drainages to enhance recreational fishing and have since become invasive across many watersheds. This study provides critical insights into the extent of their invasion and effects on native organisms in the Albemarle Sound, NC. Dietary habits were investigated through stomach content analysis of blue catfish collected by gillnetting and electrofishing. In addition, we analyzed routine-annual data from two long-term fisheries independent surveys to discern patterns in spatial distribution over time. That historic survey data showed that blue catfish were first observed in this system in 1976 and were fully spread by 2016. Blue catfish were the second most frequently captured species in gillnets during 2023-25 sampling (n=675), surpassed only by white perch (*Morone americana*) in catch per unit effort. Blue catfish ranged from 164 to 771 mm in total length. They were found throughout the Roanoke, Chowan, Perquimans, and Pasquotank Rivers, as well as Bull Bay and the mid-Albemarle, across salinities from 0 to 9.1 ppt. Analysis of 929 stomachs revealed that filter-feeding bivalves, including clams (*Corbicula fluminea* and *Rangia cuneata*) and mussels (*Mytilopsis leucophaeta*), are primary prey (66% frequency of occurrence). Both the mean prey size and range of sizes consumed increased with catfish length, especially for bivalve prey. Other economically important species were found in their diet, including blue crabs, penaeid shrimp, and river herring. These findings suggest that invasive blue catfish might be contributing to a shifting ecosystem state in the Albemarle Sound, potentially leading to reduced fisheries productivity and increased frequency of harmful algal blooms.

2. Introduction

Aquatic invasive species can wreak havoc on ecosystems by outcompeting or consuming native species, reducing biodiversity, and eventually causing economic impacts to fisheries. Blue catfish (*Ictalurus furcatus*), native to the Mississippi River Basin, are a freshwater and brackish water species that has been spreading across Atlantic coast drainages in recent years. For example, in the Chesapeake Bay, invasive blue catfish became a nuisance species by the 1990s, and this population has been well studied. In this system they have been shown to be generalist omnivores primarily preying on bivalves, aquatic vegetation, and blue crabs (Schmitt et al., 2019). Blue catfish have replaced native white catfish as the most predominant benthic species in the Chesapeake (Schloesser et al., 2011). Certain biological characteristics make blue catfish particularly effective invaders, such as their ability to withstand salinities up to 15.7 ppt, likely facilitating further range expansion (Nepal & Fabrizio, 2019). Additionally, they are opportunistic consumers, capable of eating up to 10% of their body weight daily (Schmitt et al., 2021), and can live over 20 years and grow up to 100 lbs. (Graham, 1999). Blue catfish were introduced into the Cape Fear River in North Carolina in 1966 by state agencies to enhance recreational fishing (Guier et al., 1984), and their populations have since expanded into other systems including the Albemarle Sound.

In the Albemarle Sound, NC, the influence of blue catfish on the ecosystem remains unknown. In particular, there is growing concern that blue catfish expansion may be affecting iconic species in the Albemarle Sound including striped bass, river herring, southern flounder, blue crab, and endangered Atlantic sturgeon, all of which have already been experiencing population declines in this region. If blue catfish are feeding on or outcompeting these economically important species, or ecologically important species like filter-feeding bivalves, it

could lead to a restructuring of the ecosystem. The consumption of bivalves by blue catfish is of particular concern considering the rise in harmful algal blooms in the Albemarle Sound during the last decade. Indeed, the importance of clam filter feeders will become apparent if their depletion is contributing to diminished water quality.

To gain understanding of the scope of the invasion and its effects on native organisms and water quality in the Albemarle Sound, I investigated the trophic impacts and spatial distribution patterns of blue catfish. I hypothesized that blue catfish predatory impact on economically important prey varies spatially and seasonally, and that consumption of bivalves has led to a substantial decline in water filtration in the Albemarle Sound. The findings can be used to predict the future state of this important estuary and develop mitigation strategies, including a recalibration of natural resource management approaches.

3. Methods

3.1 Fish collection

Experimental-multi mesh size gillnets were deployed throughout the Albemarle Sound, targeting six main sampling locations (Fig. 1): Chowan River, western Albemarle/mouth of the Roanoke River, Pasquotank River, Perquimans River, Bull Bay/Scuppernong River, and lower Alligator River.

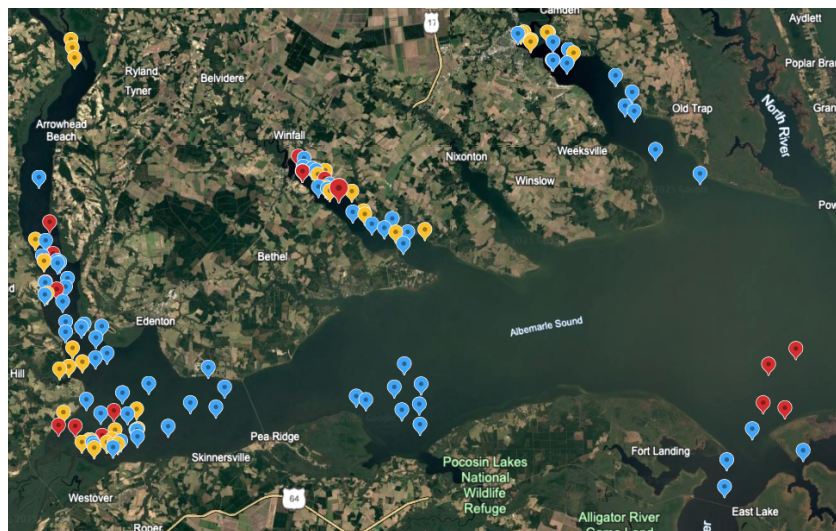


Figure 1. Sampling areas within Albemarle Sound, NC. Each point represents an individual gillnet gang set. Sets conducted during 2023 are in yellow, sets in 2024 are in blue, and sets in 2025 are in red. (Google Earth)

Each sampling day, 4 gillnet gangs (i.e., a “gang” of several mesh-size panels) were set haphazardly, aiming to target a variety of habitats and depths within the location. The gillnets were 9 ft tall sink nets, meaning they sit on the bottom. The water column was not completely covered unless the depth was under 9 ft. Sampling areas were 14 ft deep on average, with occasional sites as deep as 33 ft. As blue catfish are bottom feeders it is unlikely that they will utilize the upper part of the water column (Graham, 1999). In my sampling, each gang consisted of 4 or 5 40-meter panels of randomized mesh bar widths ranging from 2.5 to 8 inches (e.g., of gang 2.5, 3.5, 5, 6.5, and 8 inches). This variety in mesh sizes allows capture of a wide range of

fish sizes, because gillnets are highly size selective based on mesh size. Nets were typically soaked 1.5 to 2 hours to minimize prey digestion and prevent mortality of non-target species.

Water quality data including salinity, temperature, dissolved oxygen, and turbidity was measured at surface and depth for each gang set. Surface turbidity was also measured with a Secchi disc. Each species captured was counted, and fork length (mm) measured for up to 20 individuals captured in each mesh size for non-target species. Non-target species were released immediately. In adherence to ethical standards, sampled blue catfish were euthanized in accordance with the Institutional Animal Care and Use Committee (IACUC) protocol (ECU AUP #D385). Fish were then placed in an ice slurry until they were transported back to the lab on the same day for demographic measures and dissection. In the lab, weight (kg), fork length and total length (mm) of blue catfish were measured. Then the stomach and intestine were carefully removed by making a cut as close to the esophageal opening as possible and another near the vent. Excess organs and fat were removed from the stomach and intestine. Stomachs were then individually stored in sample bags and frozen for later analysis. Otoliths, liver, and muscle tissue samples were also collected for other ongoing studies.

3.2 Stomach content analysis

Stomachs were thawed in the lab and then cut open and contents removed from the stomach and intestine and weighed separately (0.01 g). Then the stomach and intestine contents were combined for assessment of diet. Prey were sorted by species, identified to the lowest taxonomic level using visual identification and keys or guides, counted, and weighed. Five randomly selected prey items were measured from each prey taxon. For fish prey, the eye diameter, fork length, and standard length were recorded when possible. Any outlier prey items that are particularly large or small were also measured for length and recorded as a non-random entry. For prey items that are challenging to identify, which includes most fish prey, DNA barcoding methods will be used, and so these prey items were refrozen and saved; this analysis will be done over the summer of 2025

Several indices of prey importance were calculated, including percent frequency of occurrence (%F), mean percent contribution by mass (%M), and mean percent numerical abundance (%N).

These indices were calculated as follows:

$$\%F_i = \frac{J_i \times 100}{N}$$

Where %F = percent frequency of occurrence of a given prey type i , J_i = number of stomachs in which prey i occurs; and N = total number of stomachs with food (Harrod & Stallings, 2022).

$$\%M_i = \frac{\sum_{j=1}^{N_{fish}} \left(\frac{M_{ij}}{M_j} \times 100 \right)}{N_{fish}}$$

Where %M = mean percentage contribution by mass of a given prey type i ; N_{fish} = total number of fish stomachs with food examined; M_{ij} = the mass of prey type i in stomach of fish j ; M_j = total mass of prey in stomach of fish j (Harrod & Stallings, 2022).

$$\%N_i = \frac{\sum_{j=1}^{N_{fish}} \left(\frac{N_{ij}}{N_j} \times 100 \right)}{N_{fish}}$$

Where $\%N$ = mean percentage contribution by number of a given prey type i ; N_{fish} = total number of fish stomachs with food examined; N_{ij} = the number of prey type i in stomach of fish j ; N_j = total number of prey in stomach of fish j (Harrod & Stallings, 2022).

Catfish diet data were analyzed in multiple ways. First, I calculated the above indices using R software across all non-empty stomachs. Second, I assessed the effects of sampling gear, season, and region on diet, I ran a permutational multivariate analysis of variance (PERMANOVA), on presence/absence of individual prey taxa using the *vegan* R package. Individual fish were treated as replicates. Variables were as follows: Seasons were defined as: Winter (December-February), Spring (March-May), Summer (June-August), and Fall (September-November). Gear types were electrofishing and gillnetting. Samples were given a numerical code corresponding to a region of the Albemarle Sound: 1: Roanoke River (West of 45) 2: West Albemarle (South of 17, East of 45, West of 32), 3: Chowan River (North of 17), 4: Perquimans River, 5: Mid Albemarle (East of 32), 6: Pasquotank River. Prior to the PERMANOVA, I tested for homogeneity of multivariate dispersion. Third, to explore the ontogenetic shifts in catfish diet, I ran a linear regression on clam length vs catfish length. I also used a quantile regression (*quantreg* R package) to assess how prey size breadth changes with catfish length. All analyses were performed using R version 4.4.1.

3.3 Bivalve filtration impact estimates

Calculations of lost bivalve filtration due to blue catfish predation were based on stomach content analysis data from regular gillnet sampling. During stomach content analysis, five individuals were randomly selected and measured per prey category, with additional individuals measured if they were identified as outliers (especially large or small). For *Rangia cuneata* clams, the measured lengths were extrapolated based on the number of clams counted in a stomach to represent the length distribution of all *Rangia* found in an individual catfish stomach. Shell lengths were converted to dry weight using the following allometric relationship by Wong (2010):

$$\text{Tissue dry weight (mg)} = 0.0047 \times [\text{shell length (mm)}]^3$$

Filtration rate per hour was calculated using:

$$\text{Lost Daily Filtration (per hr)} = 0.043 \times \text{dry weight (mg)}^{0.56} \text{ (Wong et al., 2010)}$$

Individual clam filtration rates were summed per fish to account for all clams found in a stomach, multiplied by 24 to get the daily filtration loss for each fish, and then averaged across fish to calculate the mean daily filtration lost per blue catfish consuming *Rangia cuneata* as well as per all gillnet captured catfish. This was only calculated for *R. cuneata* because they are the dominant prey in the brackish water areas of the Albemarle Sound.

3.4 Analysis of survey data

Long-term fisheries independent data from the P-135 Striped Bass Independent Gill Net Survey and P-100 Juvenile Anadromous Fish Survey were obtained from NCDMF. Blue catfish

catch and sampling effort were analyzed across all available years (1972-2020) to assess trends in range expansion. Four example years (2009, 2013, 2016, and 2019) were selected to plot in this report to illustrate the invasion progression. Seasonal comparisons were made by grouping data into seasons, specifically Winter (December-February), Summer (June-August), and Fall (September-November). Spring was excluded, because neither survey is conducted in the Spring months. Maps were generated in R version 4.4.1 using the *ggplot2*, *sf*, and *tidyverse* packages. Spatial data were projected using the WGS 84 coordinate reference system (EPSG:4326). P-100 gear types were not separated for final visualization because after 2004, only two gear types were used (bag seine and balloon trawl). Of these, the bag seine gear only caught 78 blue catfish from 2004-2020, thus most of the observed catches were from the trawl sampling.

4. Results

4.1 Field sampling

In 2023, we conducted sampling on 10 days for a total of 42 gillnet sets and 153 blue catfish collected. In 2024, we sampled on 18 days with a total of 75 gillnet sets and 464 blue catfish captured. In 2025 we have sampled on 3 days thus far with a total 11 gillnet sets and 58 blue catfish collected. A total of 675 blue catfish were collected via gillnetting, ranging in fork length from 142 to 755 mm and weighing up to 6.88 kg. A majority of fish were between 300 and 500 mm, and most effectively captured with 3.5 to 4 inch mesh gillnet panels (Fig. 2). Blue catfish have been captured across salinities from 0 to 9.1 ppt, although the majority were captured at salinities less than 2 ppt (Fig. 3). Blue catfish were the second most frequently captured species in our sampling after white perch (Fig. 4), followed by Atlantic menhaden, longnose gar, and gizzard shad.

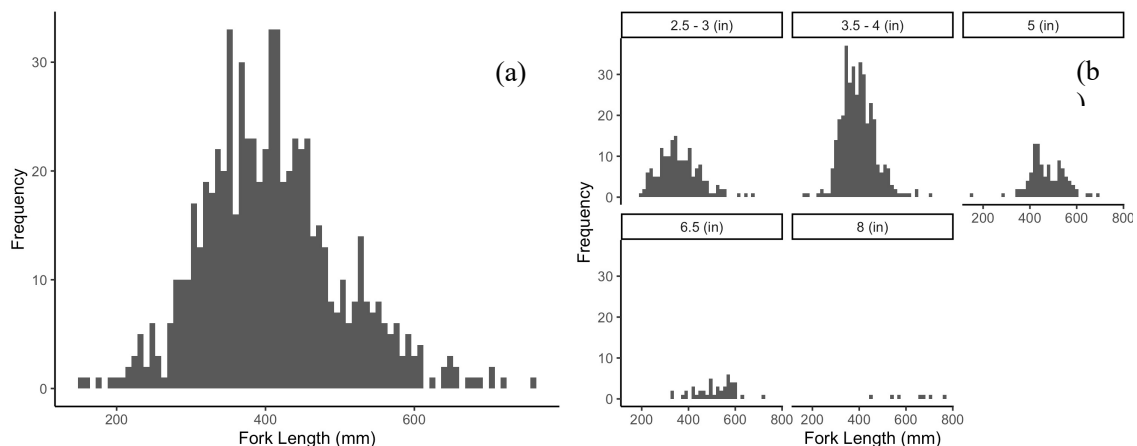


Figure 2. (a) Blue catfish fork length frequencies; (b) Blue catfish fork length frequencies by gill net stretched mesh size.

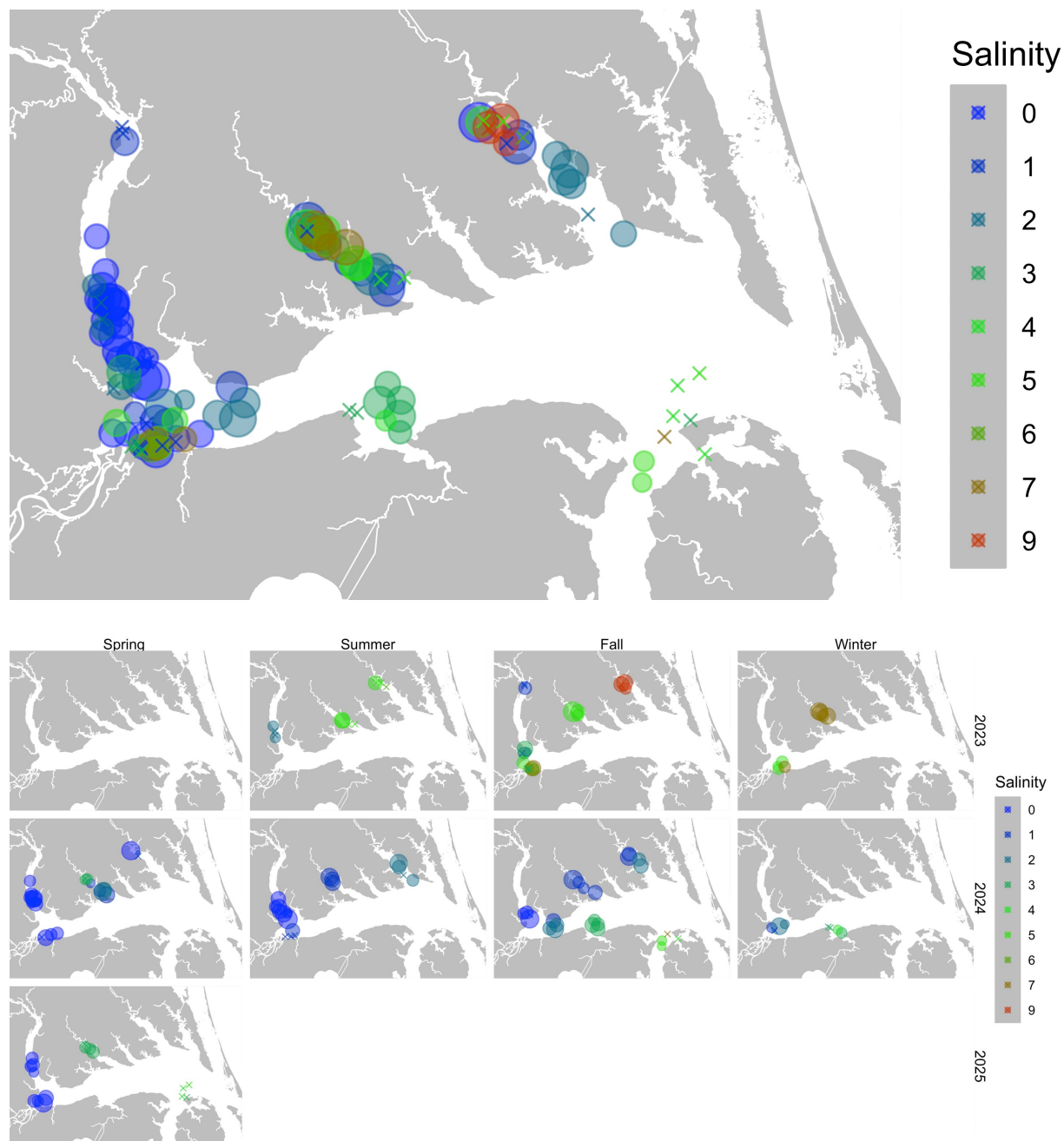


Figure 3. Blue catfish CPUE (catch per unit effort) for each gillnet gang Aug. 2023 – Mar. 2025. Size of the circle corresponds to size of catch, while color corresponds to salinity. X's represent zero blue catfish catch.
A: All samples B: Split by season and year.

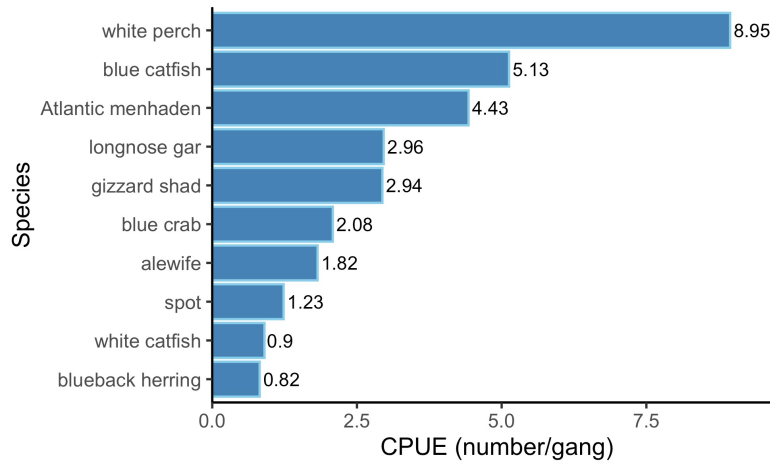


Figure 4. Catch per unit effort (CPUE) of the top 10 species caught in gillnet sampling.

4.2 Stomach content analysis

A total of 605 of the blue catfish stomachs collected via gillnetting have been analyzed. In addition, over 1200 stomachs have been collected by the University of North Carolina Wilmington using low frequency electrofishing in the Roanoke River east of Williamston, the Cashie River, and the Chowan River from Holladay Island to the Virginia Border. 324 of those stomachs have been analyzed and included in this report for a total of 929 stomachs analyzed. Almost 51% of electrofishing stomachs and 39% of gillnetting stomachs were empty.

Preliminary diet analysis of non-empty stomachs (n=526) indicated that bivalves are the primary prey of blue catfish (Table 1, Fig. 5). Bivalves were present in 66% of stomachs. The most common bivalves identified were *Rangia cuneata* (34.6%) *Mytilopsis leucophaeta* mussels (19%), and Asian clams (*Corbicula fluminea*) (10.7%). Fish were found in 6.3 % of stomachs containing prey including Atlantic menhaden, alewife, Atlantic croaker, and hogchoker. Four percent of stomachs contained crustaceans including blue crabs (2.9%), Harris mud crabs, penaeid shrimp, and isopods. The anthropogenic category includes human made items like fishing lures and plastic bags or debris.

While frequency of occurrence highlights how common each prey type is across stomachs, numerical abundance highlights smaller more numerous items, and percent mass shows the contributions of larger/heavier prey. For example, detritus (dead organic matter) appears in almost 28% of stomachs, while making up 11.6% by mean percentage by mass. Mussels make up ~18% by mass and number indicating a high count and substantial biomass. Together, these indices provide a more complete picture of diet composition.

Table 1. Summary of prey types identified from stomach content analysis, with the corresponding percentages for frequency of occurrence (%F), mass (%M), and numerical abundance (%N). These metrics represent the relative importance of each prey type in the overall diet.

Prey Type	%F	%N	%M
<i>Rangia cuneata</i> (clams)	34.6	33.46	32.67
detritus	27.95	1.49	11.6
<i>Mytilopsis leucophaeta</i> (mussels)	19.01	18.85	18.37
<i>Corbicula fluminea</i> (clams)	10.65	9.26	6.62
bivalve UI	5.51	3.22	3.12
fish	4.37	2.03	2.16
blue crab	2.85	1.84	1.89
unidentified (UI)	2.66	0.16	1.07

Atlantic menhaden	1.33	0.85	1.15
peanut	1.33	1.25	1.29
Harris mud crab	0.76	0.06	0.06
parasitic isopods	0.76	0.41	0.21
anthropogenic	0.57	0.29	0.14
insect	0.57	0.39	0
scales	0.57	0.19	0.19
seed	0.57	0.43	0.56
crustacean	0.38	0.19	0.19
plant matter	0.38	0.1	0.22
shrimp	0.38	0.23	0.03
tapeworm	0.38	0.11	0.03
alewife	0.19	0.19	0.19
barnacle	0.19	0	0.01
Atlantic croaker	0.19	0	0.08
hogchoker	0.19	0	0.05
wood chip	0.19	0.1	0.05

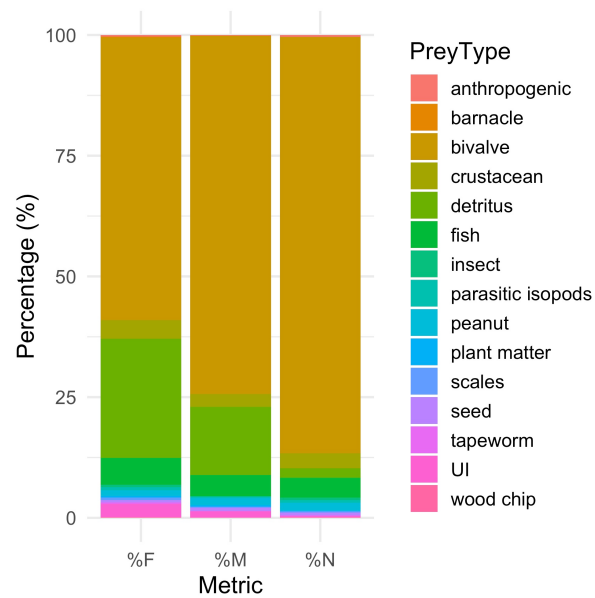


Figure 5. Stomach content analysis metrics showing the proportional contribution of prey types based on frequency of occurrence (%F), mass (%M), and numerical abundance (%N). Prey categories are color-coded, and percentages represent the relative importance of each prey type. Detailed percentage values can be found in Table 1.

Table 2. Percent frequency of occurrence (%F) for different prey types separated by (A) season and gear type, and (B) region. Region codes 1: Roanoke River (West of 45) 2: West Albemarle (South of 17, East of 45, West of 32), 3: Chowan River (North of 17), 4: Perquimans River, 5: Mid Albemarle (East of 32), 6: Pasquotank River.

A. Prey Type	Gear Type		Season			
	Electrofishing	Gillnet	Winter	Spring	Summer	Fall
<i>Rangia cuneata</i> (clams)	0	49.59	48.84	55.56	34.83	26.34
<i>Mytilopsis leucophaeta</i> (mussels)	13.21	21.53	9.3	26.98	9.55	25.51
detritus	43.4	21.25	34.88	7.94	28.65	31.28
fish	4.4	7.08	13.95	6.35	5.06	5.76
blue crab	0	4.09	0	1.59	1.69	4.53
peanut	0	1.91	9.3	3.17	0	0.41
bivalve	15.72	1.09	0	0	10.67	4.12
Harris mud crab	0	1.09	0	4.76	0.56	0
parasitic isopods	0	1.09	4.65	0	0	0.82
<i>Corbicula fluminea</i> (clams)	33.33	0.82	4.65	1.59	19.66	7.41
tapeworm	0	0.54	0	1.59	0	0.41
crustacean	0.63	0.27	0	0	0.56	0.41
shrimp	0.63	0.27	2.33	0	0	0.41
barnacle	0	0.27	0	0	0	0.41
UI	10.06	0	0	0	5.06	2.88
anthropogenic	1.89	0	0	0	0.56	0.82
insect	1.89	0	0	0	0	1.23
plant matter	1.26	0	0	0	0.56	0.41
scales	1.89	0	0	0	0.56	0.82
seed	1.89	0	0	0	0	1.23
wood chip	0.63	0	0	0	0	0.41

B. Prey Type	Region Code					
	1 (n=113)	2 (n=162)	3 (n=95)	4 (n=89)	5 (n=15)	6 (n=52)
<i>Rangia cuneata</i> (clams)	0	42.59	18.95	74.16	26.67	48.08
<i>Mytilopsis leucophaeta</i> (mussels)	18.58	35.8	20	1.12	0	1.92
detritus	49.56	17.9	22.11	22.47	33.33	30.77
fish	3.54	5.56	6.32	5.62	40	5.77
peanut	0	3.09	2.11	0	0	0
blue crab	0	2.47	1.05	1.12	13.33	13.46
<i>Corbicula fluminea</i> (clams)	33.63	0.62	15.79	0	6.67	1.92
Harris mud crab	0	0.62	3.16	0	0	0
tapeworm	0	0.62	1.05	0	0	0
unidentified	9.73	0	5.26	0	0	0
anthropogenic	0.88	0	2.11	0	0	0
bivalve	9.73	0	15.79	3.37	0	0
insect	0.88	0	2.11	0	0	0
plant matter	0.88	0	1.05	0	0	0
scales	2.65	0	0	0	0	0
seed	1.77	0	1.05	0	0	0
crustacean	0	0	1.05	0	0	1.92
shrimp	0	0	1.05	0	6.67	0
wood chip	0	0	1.05	0	0	0
parasitic isopods	0	0	0	1.12	6.67	3.85
barnacle	0	0	0	0	0	1.92

Table 2 shows differences in the %F of prey types across categories chosen for the PERMANOVA. The PERMANOVA revealed that all three factors (gear type, season, and region) had significant effects on blue catfish diet (Table 3). Gear type explained the largest proportion of variation ($R^2 = 0.0479$, $p = 0.001$), followed by region ($R^2 = 0.0378$, $p = 0.001$), and

season ($R^2=0.0224$, $p=0.001$). Together, these factors explained approximately 11% of the variation in prey type composition. When testing for homogeneity of multivariate dispersion, no significant differences in dispersion were found for gear or season. However, dispersion differed significantly among regions ($p=0.001$).

Table 3. Results of PERMANOVA testing the effect of gear type, season, and region on blue catfish diet composition.

Factor	Df	SumOfSqs	R ²	F-value	p-value
Gear	1	6.70645027	0.04794286	20.8475721	0.001
Season	3	3.13315617	0.02239821	3.24656097	0.001
Region	1	5.28309141	0.0377676	16.4229398	0.001
Residual	387	124.493934	0.88997839		
Total	392	139.88422	1		

A simple linear regression revealed a significant positive relationship between blue catfish fork length and the average length of ingested clams ($F_{1,183} = 93.87$, $p < 0.001$, $R^2=0.339$) (Fig. 6) which indicates that larger catfish tend to consume larger clams.

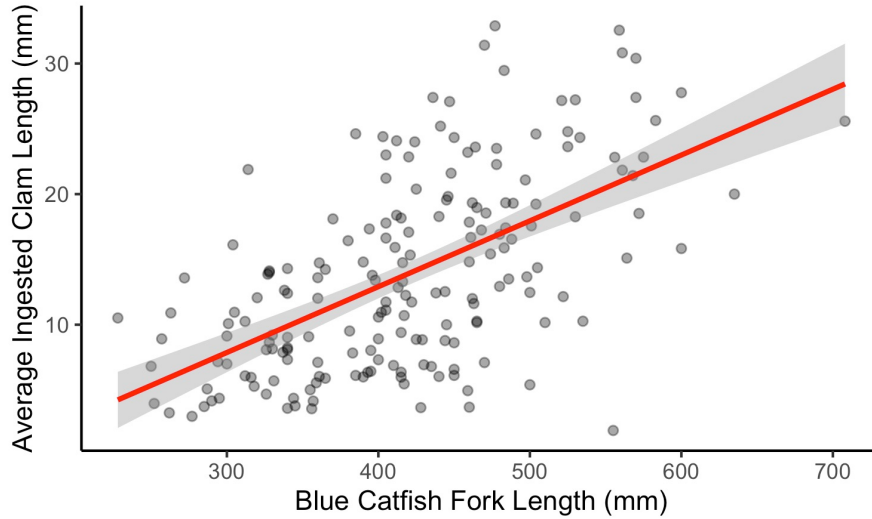


Figure 6. Relationship between blue catfish fork length and average ingested clam length. Each point represents an individual blue catfish ($n=185$) with a stomach containing clams. The red line represents the linear regression fit with a shaded area showing the 95% confidence interval.

Quantile regression analysis indicated a significant positive relationship between catfish length and average prey size across all quantiles (Fig. 7). The 90th percentile slope increased more rapidly than the lower quantiles (e.g., 10th percentile slope = 0.0179, 90th percentile slope = 0.0645) indicating that catfish incorporate larger prey into their diets as they grow larger but also retain smaller prey in their diet.

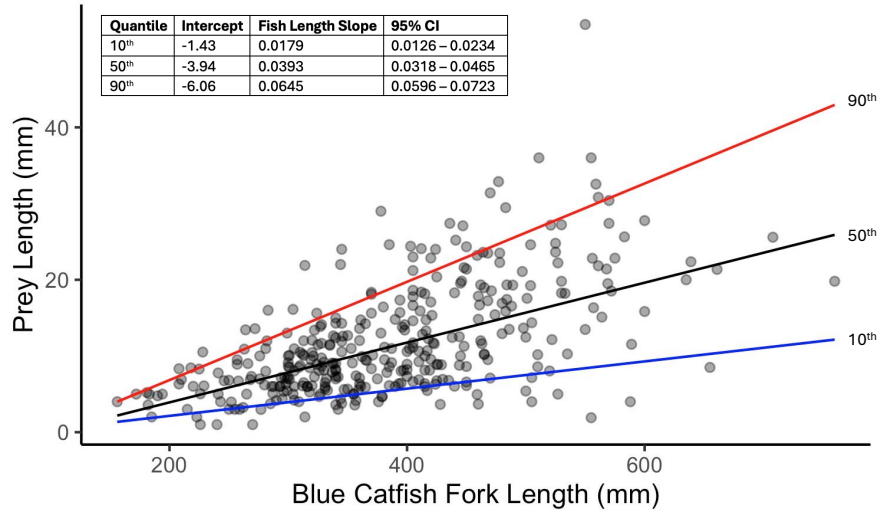


Figure 7. Quantile regression between blue catfish fork length and prey length. Each point represents an individual blue catfish with a stomach containing prey that were measurable.

4.3 Clam filtration results

The average daily filtration volume lost per individual fish that consumed *Rangia cuneata* clams was estimated at 191.22 liters. Across all catfish collected via gillnets, the average daily filtration lost per individual catfish was 62.67 liters. Figure 8 displays the frequency of daily filtration losses per individual catfish while Figure 9 shows the relationship between catfish size and filtration loss. Although most catfish contributed to filtration losses of less than 200 liters per day, larger individuals had a higher impact, with losses reaching as high as 1829.5 liters per day.

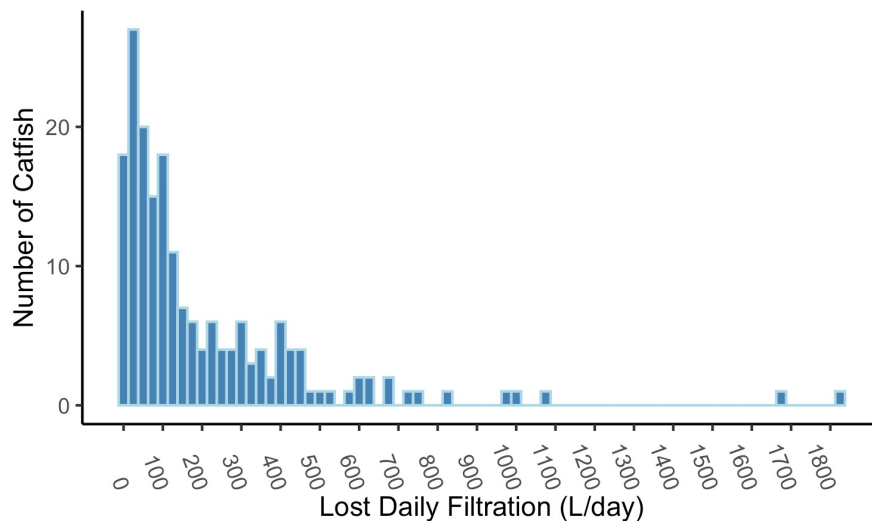


Figure 8: Estimated lost daily filtration among blue catfish that had *Rangia cuneata* in their stomachs. Bars represent the number of individual catfish within each 100-liter filtration loss bin.

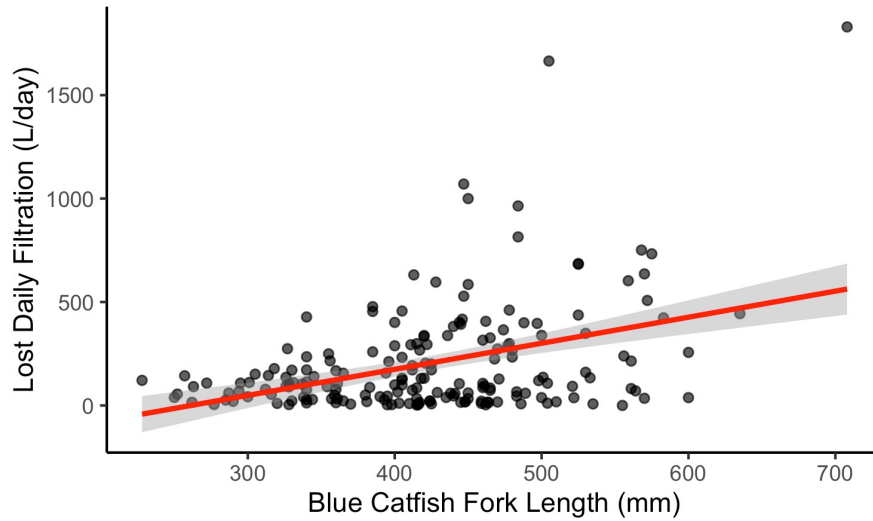


Figure 9: Relationship between blue catfish fork length and lost daily filtration due to *Rangia cuneata* clam consumption. Each point represents an individual catfish (n=187) with a stomach containing clams. The red line represents the linear regression fit with a shaded area showing the 95% confidence interval.

4.4 Survey data analysis

Analysis of P135 and P100 surveys revealed a dramatic increase in blue catfish catch from 2004 to 2020. Prior to 2004, only 19 blue catfish were caught across both surveys for an average of less than 1 blue catfish per year. In 2009, catfish catches start to show a sharper increase, and by 2019, the P-135 survey recorded over 3000 blue catfish in a single year (Table 4). Spatial analysis shows a steady geographic expansion. In earlier years blue catfish are concentrated in the Chowan River and western Albemarle. By 2019, they have a much broader distribution extending up throughout most tributaries (Fig. 10). Catches occurred across all surveyed seasons (Winter, Summer, and Fall) by 2019, demonstrating year-round presence.

Table 4. Number of blue catfish caught per year per survey from 2004 - 2020.

Year	P135 Blue Catfish	P100 Blue Catfish
2004	7	10
2005	1	2
2006	20	56
2007	2	4
2008	0	32
2009	29	32
2010	140	286
2011	307	346
2012	248	278
2013	582	338
2014	379	991
2015	823	1782
2016	1719	2299
2017	1631	1555
2018	2595	1878
2019	3098	2719
2020	1476	1310

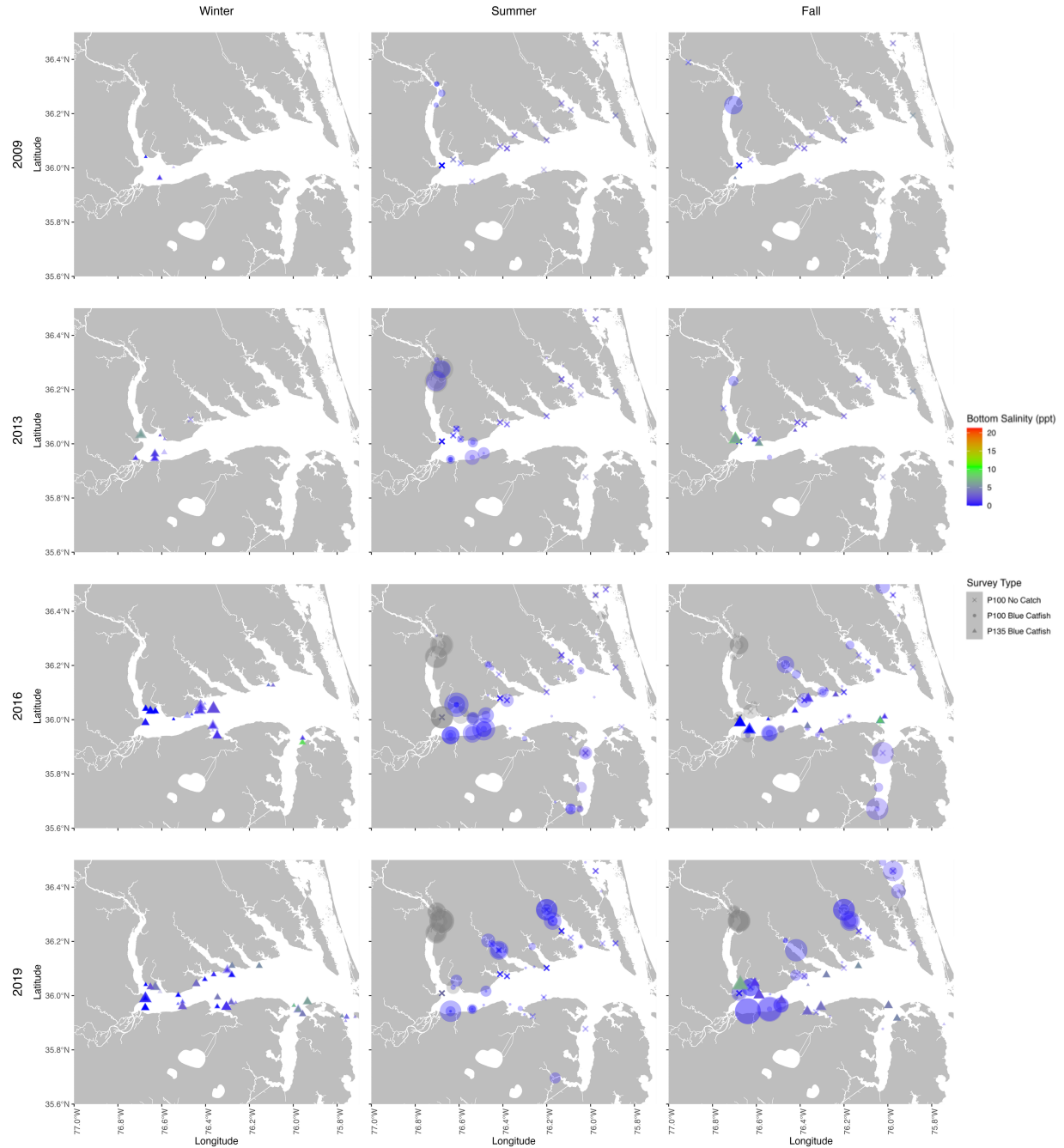


Figure 10. Blue catfish invasion progression. P-135 Striped Bass Independent Gill Net Survey and P-100 Juvenile Anadromous Fish Survey data over time. Four years (2009, 2013, 2016 and 2019) were chosen to show the progression. Triangles depict positive blue catfish catches from the P135 survey, Circles depict positive blue catfish catches from the P100 survey, and X's are areas that were sampled for the P100, but no blue catfish were caught. The color of the symbol corresponds to bottom salinity in ppt on the capture date. The size of the symbol corresponds to the number of blue catfish collected. Symbols colored gray indicate missing salinity data.

5. Discussion

This study aimed to assess the dietary habits and spatial expansion of invasive blue catfish in the Albemarle Sound to better understand their ecological impacts. Analysis of 929 stomachs revealed that blue catfish in this system feed primarily on bivalves. The presence of detritus in their stomachs further indicates benthic foraging. Their diet included infaunal clams, such as *Rangia* and *Corbicula*, as well as mussels (*Mytilopsis leucophaeta*), which are ubiquitous throughout the Sound, often growing on hard structures like submerged vegetation and woody debris. Fish prey were not commonly found in their diet. This contrasts with studies in the Chesapeake Bay where fish are more frequently consumed. For example, white perch alone accounted for 7% frequency of occurrence in blue catfish diet from the James River (Schmitt et al., 2019). Blue crabs were a relatively minor component of blue catfish diet overall in the Albemarle Sound, but their occurrence was greater in higher salinity areas. This pattern is similar, though less pronounced, than in the Chesapeake Bay where blue crabs comprised less than 5% of the diet across the whole system, but were found to be as high as 15-32% in mesohaline areas (Schmitt et al., 2019). In contrast to other locations such as the Cape Fear River (NC), Chesapeake Bay, and Altamaha River (GA), where the invasive Asian clam (*Corbicula fluminea*) is a primary prey item for blue catfish, (Belkoski et al., 2021; Bonvechio & Jennings, 2011; Schmitt et al., 2019), it has not been the dominant prey item in gillnet samples. However, it was frequently observed in electrofishing samples, suggesting a community shift in bivalve species between freshwater areas and oligohaline areas.

In addition to regional variation, seasonal differences in bivalve consumption were also observed. The highest consumption of *R. cuneata* and *M. leucophaeta* occurred in the spring while *C. fluminea* was most frequently consumed during the summer. Fish and crustacean prey also showed spatial variation, with fish prey reaching up to 40% frequency of occurrence in the Mid Albemarle region and blue crabs comprising ~13% frequency of occurrence in both the Mid Albemarle and Pasquotank River areas. It should be noted that the Mid Albemarle region had a relatively small sample size, so these values should be viewed with caution. Across all regions and seasons, blue catfish largely depend on bivalves but are also capable of opportunistically feeding on a large variety of prey types, particularly as they grow larger.

Body size had a significant influence on diet patterns. Quantile regression analysis showed an ontogenetic shift in blue catfish diet towards larger prey as they grow, suggesting their ecological impact intensifies with size and age. Similar patterns have been observed in other systems, like the Chesapeake Bay, where blue catfish shift towards a piscivorous diet at sizes ranging from 500-900mm depending on the river (Schmitt et al., 2019). This indicates that larger catfish may have more impact on economically important fish species. In our study, relatively large catfish were not commonly encountered, which may reflect targeted fishing pressure on larger individuals.

Gear type can influence stomach content analysis results due to differences in fish capture methods, which can mask or exaggerate dietary patterns (Chipps & Garvey, 2007). Passive gears such as gillnets can increase stress in fish as they remain entangled for longer periods, potentially leading to regurgitation. However, while a high percentage of empty stomachs were observed in our samples, they were highest in fish collected using electrofishing rather than gillnetting. In this study, gear type had the strongest influence on diet composition in the PERMANOVA analysis. This may reflect both capture-related biases as well as differences in fish size and habitats (salinity zones and depths) that are sampled by each gear. Although the PERMANOVA model explained only a modest proportion of total variation (11%), this is

typical in ecological field studies due to many uncontrolled factors and natural variability. Additional biases include challenges in identification of prey that are highly digested. To address this, in the future I will be conducting DNA analysis of samples that couldn't be identified visually.

Due to the high consumption of benthic filter feeders by blue catfish, we hypothesized that this predation may reduce filtration capacity, potentially contributing to eutrophication and subsequent algal blooms. In this study, published filtration estimates were coupled with *Rangia* clam lengths found in stomachs to estimate average lost daily filtration per blue catfish consuming *Rangia* clams (191.22 L/day). Estimated losses were as high as 1829.5 liters for a single 708 mm blue catfish (Fig. 8). Larger individuals were associated with greater estimated filtration loss, likely due to both the size and quantity of *Rangia* clams consumed by larger individuals (Fig. 9). My filtration estimates were based on Wong et al. (2010), and their experiments were conducted at 21-22° C. These temperatures are cooler than typical summer temperatures in the Albemarle Sound, so my filtration impact estimates are probably biased low for the summer season. These filtration losses may be very impactful to water quality, considering that blue catfish are the most abundant benthic fish, and most abundant fish overall by biomass in my gillnet sampling.

My approach of estimating *Rangia* filtration impacts was based on a “snapshot” of using all the prey found in blue catfish stomachs at one time (i.e., at the time of capture). Thus, I assumed that all prey in the stomach and intestines observed represents 24 hours of feeding. Initially I planned to use results from 24-hour consumption field-experiments to better estimate lost filtration due to blue catfish consumption (i.e., biomass consumed per 24 h). However, a limited number of trials (n = 2) prevented me from using this data as intended, although more trials are planned for 2025. Also, there was a lack of necessary conversions between wet clam weight (as is recorded in gut contents) and dry weight of whole clam tissue. Considering the potential impact on water filtration that I have shown here, it is vital that future studies improve filtration loss estimates. First, effective measures of blue catfish field consumption, when feeding on bivalves, are needed. Second, the necessary conversion equations to go from wet clam mass (as consumed by catfish) to filtration rates. Finally, *Rangia* filtration rate estimates across temperature and clam size would further refine our ability to estimate filtration rate impacts.

Survey data from the P-100 and P-135 indicated that blue catfish have successfully colonized most of the Albemarle Sound over the past two decades, with both geographic and seasonal presence expanding substantially. While blue catfish are known to tolerate relatively high salinities (Nepal & Fabrizio, 2019), they appear to prefer freshwater habitats, as their distribution remains concentrated in low-salinity areas. The P-100 survey primarily uses a semi-balloon trawl targeting juvenile anadromous fish. It showed an earlier and sharper increase in blue catfish abundance, likely detecting younger, smaller individuals during early expansion. In contrast, the P-135 targets larger fish with gillnets and showed a delayed but substantial rise in catch, potentially reflecting establishment of larger, mature fish. Together, these trends suggest a successful and persistent invasion.

The growing dominance of blue catfish in Albemarle Sound raises concerns about their potential to displace native species. This is already evident, as blue catfish are caught more frequently than native white catfish in our gillnet sampling, mirroring patterns in the Chesapeake Bay (Schloesser et al., 2011). Their high consumption of bivalves highlights the importance of monitoring clam populations and water quality to assess long-term ecological impacts. This study provides the first detailed assessment of blue catfish diet in the Albemarle Sound, North

Carolina. My work is already finding in-roads to management and policy decisions. For example, my data will be used by researchers at University of North Carolina at Chapel Hill as they model the statewide predation impact on blue crabs. Anecdotally, I have also had interest expressed from blue crab fishers and policy makers (NCDFM personnel, pers. comm., 2025), which further underscores the need for continued research and monitoring to support informed management decisions.

6. References

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7. Outreach

I have presented my research at multiple scientific conferences. In February 2024, I presented a poster on this project at the annual American Fisheries Society Tidewater Chapter meeting. I also shared this work at the NCSG Advisory Board meeting in June 2024 and during the NCSG Federal Site Review in January 2025. Additionally, I presented a poster at the North

Carolina Coastal Conference in November 2024 and ECU's Research and Creative Achievement Week in April 2025. I plan to give an oral presentation at the Coastal and Estuarine Research Federation Meeting in November 2025.

I have also been involved with multiple events that targeted the broader community. In April of 2024 and May of 2025, the Morley Lab participated in the Coastal Studies Institute (CSI) Open House where we showcased the blue catfish project. Further, my catfish project is used as a demonstration project at CSI; where 100+ people hear about my research per month as part of regularly conducted tours for visiting groups (e.g., K-12 school groups, local K-12 teachers or groups renting space at CSI for workshops, visiting donors). Finally, I participated in outreach activities like ECU's sustainability day, the Tar River Community Science Festival in 2024, and Shad in the Classroom in 2024 and 2025.

8. Students supported

This fellowship helped to support my thesis research. Also, Rahdiaz Delvillar was brought on as a paid technician for this project while he was an undergraduate student to assist with fieldwork and stomach content analysis. He has now started his MS at ECU and continues to work on the blue catfish study concurrently with his own research. My research has provided hands on experience for several student volunteers, including seven graduate students and two undergraduate students. Finally, an undergraduate summer intern in our lab from the U. of Delaware is participating in lab and fieldwork for my research during the summer of 2025.

In March 2024, I attended and presented a poster at the ECU Biology Department's Research Expedition event, which aimed to facilitate connections between undergraduates and the research occurring at the university. Unfortunately, this event did not yield any viable candidates to join our project. We also applied for the Hutton Junior Fisheries Biology Scholar program through the American Fisheries Society but were not accepted.

9. News/Media coverage of this project

None yet.

10. Data Management Plan Progress

All data has been initially recorded on waterproof paper, and then subsequently scanned to make digitized copies. Paper data sheets are kept at ECU Life Science and Biotechnology building. Data has been entered and stored in spreadsheets (.csv) for analyses, both raw and edited formats will be retained. Spreadsheets and digital PDFs of field data sheets are stored on ECU OneDrive cloud storage and regularly backed up to an external hard drive. Data collection started on August 8th, 2023, and will conclude in July/August of 2025. Since data collection is ongoing, the data has not yet been made available on an open-access website, but this will occur when we publish, likely in 2026.