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R J. Orth

Jacques van Montfrans
Virginia Institute of Marine Science

James Fishman
Virginia Institute of Marine Science

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Report To The Virginia Marine Resources Commission

A Preliminary Study of Predation on Blue Crabs by Three Fish Predators in a Seagrass Bed

Robert J. Orth

Jacques van Montfrans

James Fishman

Virginia Institute of Marine Science

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PREFACE:

This report serves as a preliminary assessment of potential feeding impacts on blue crab prey inhabiting a seagrass bed in the York River by three species of recreationally and commercially important fish (striped bass, croaker, and red drum). We also provide an historic perspective indicating possible changes in relative abundance of these predatory fish between the period 1978-1980 and 1998. In no way do we intend for this report to reflect an accurate, bay-wide assessment of these relationships; the extremely limited temporal and spatial scope of this effort precludes such conclusions. However, this report supports the contention that habitat-specific predation impacts on juvenile crabs inhabiting seagrass beds that serve as nurseries for blue crabs may be important to consider when examining sources of natural crab mortality. Definitive conclusions regarding such impacts await more comprehensive research efforts targeting these relationships at the appropriate bay-wide scale. Finally, it is important to recognize that mortality impacts on blue crab populations stem from a combination of causes. Natural mortality via predation (which is difficult to control) apparently impacts crabs less than 75 mm (3 inches) in carapace width (Moody, 1994; Smith, 1995), whereas those individuals larger than 75 mm likely experience heaviest mortality from commercial and recreational fisheries (which can be controlled through effective management policy).

INTRODUCTION:

The Chesapeake Bay reflects an ecosystem with complex predator-prey interactions that differ between various habitats and changes in time and space. Within the bay, seagrass habitats are clearly recognized as critical nursery habitat for numerous species of invertebrates and vertebrates. Nursery habitat function evokes, among other attributes, added protection from predation for resident prey populations and an increase in primary production allowing high rates of secondary production (Fredette et al., 1990) and growth of resident organisms. Such relationships have conclusively been demonstrated for juvenile blue crabs, which often attain densities in seagrass beds that exceed those in adjacent unvegetated areas by a factor of ten (Orth and van Montfrans, 1987) and also exhibit increased growth in seagrass beds (Perkins-Visser et al., 1996). In fact, these attributes of seagrass habitats appear to have such universal intrinsic value that The National Marine Fisheries Service has recently emphasized seagrass beds as "Essential Fish Habitat"(Magnuson-Stevens Act, 1996). Though the value of seagrass beds is broadly accepted, little is known about the impacts of large scale changes in this critical nursery habitat on various fisheries resources (including juvenile blue crabs) at the population level.

Seagrass habitats harbor high densities of prey organisms (Orth et al., 1984) and even though these habitats are extensively utilized by predators, crab mortality rates are lower than those in unvegetated habitats (Pile et al., 1997). However, impacts on prey populations are likely also influenced by the abundance of predator populations within the Chesapeake Bay, and consequently, when abundances of predators that forage in seagrass beds are high, predation effects may also increase. For example, striped bass populations, which were at critically low levels during the 1970s, have recovered to near record levels, illustrating one of the greatest success stories of management regulations in Chesapeake Bay. The consequences of increased abundances of opportunistic predators such as striped bass is felt throughout the forage base for these fishes, particularly in a habitat-specific manner. Thus, abundant blue crab prey in seagrass habitats are likely impacted by increased predator abundances. Similar increases in the abundance of other fish species (e.g., croaker) have also occurred in the recent past. Collectively, predation could play an important role in affecting overall blue crab abundance and such relationships may change over time with fluctuations in predator abundance. The historic abundance of striped bass has, in all likelihood, been comparable to or may have even exceeded that of current levels, so impacts of these and other fishes must be considered from a historical perspective.

Anecdotal information from watermen and recreational fisherman suggests that young striped bass and large croaker may feed heavily on juvenile blue crabs, although quantitative data from a scientific perspective on such relationships are limited. Red drum are also known as voracious predators on decapod crustaceans, including blue crabs (Boothby and Avault, 1971). In a recent study of 2009 larger striped bass collected from fish processing houses and by using a variety of fishery-independent sampling gear, blue crabs occurred in less than 9.4 % of the fish with stomach contents (Austin and Walter, 1998). Crabs preyed upon averaged 1.6 inches (41mm) in carapace width and ranged from 0.4 (11 mm) to 6 inches (150 mm) wide. The fish sampled by Austin and Walter (1998) were greater than 18 inches (450 mm) in total length, and most were considerably larger and fed primarily on menhaden and other fish prey. The study did not focus on striped bass in a size range generally considered to consume crabs, nor did it concentrate on influences of fish foraging in blue crab nursery habitats (seagrass beds) where impacts would likely be greatest. Since blue crab stocks are currently at low levels the impacts that fishes have on the blue crab stock warrant concern and additional investigation. Potentially increased predation on juvenile crabs coupled with demonstrated decreases since 1993 in aerial cover of mid-bay seagrass nursery habitat (Orth et al., 1998) raises concerns over consequences for the blue crab population. Since the blue crab population is at historic low levels Bay-wide, and spawning stock biomass and abundance has been reduced by 70% since 1994 (Lipcius, personal communication), investigations into mortality impacts (e.g., natural mortality via predation and fishing-induced mortality) are particularly relevant.

The objectives of this preliminary study which was conducted on two days only (Oct. 20 and Nov. 5, 1998) were to: 1. quantify the abundance of selected commercially and recreationally important finfish predators in a lower bay seagrass bed using gill nets; 2. compare the relative abundance estimates of selected predatory fish in our study with those derived from an earlier study conducted during the fall over three years (1978-1980) at the same site using similar techniques; 3. ascertain feeding habits of three species of fish thought to consume blue crabs; and 4. compare the impacts of striped bass feeding in a nursery habitat with a feeding study that focused on striped bass from the bay at large (Austin and Walter, 1998).

STUDY SITE:

Sampling for adult finfish was conducted in a large seagrass bed along the north shore of the York River (Figure 1). This grass bed is contiguous with others in shoal areas along the York River mouth that form the extensive Guinea Marsh and adjacent Mobjack Bay seagrass system (Orth et al., 1998). Considerable research has been conducted at this site on environmental requirements for seagrass growth and survival (Dennison et al., 1993; Moore et al., 1996;1997), investigations into juvenile blue crab nursery habitat relationships (Pile et al. 1996; Chesapeake Bay Blue Crab Fisheries Management Plan, 1997) and studies on abundance of predatory fish (Orth and Heck, 1980; Heck and Thoman, 1984).

METHODS:

Six gill nets measuring 100 ft (30.5 m) in length and 6 ft (1.8m) in depth with a mesh size of 3.5 inches (8.9 cm) were deployed in Guinea Marsh seagrass beds between 0800 hrs. and 0900 hrs. on October 20. A similar effort was repeated on November 5, 1998 with three sets of paired 100 ft. by 6 ft. nets of two mesh sizes: 3.5 inches (8.9mm) and 5 inches (10mm). Nets were fished every three hours until 2100 hrs, yielding four samples from each of the six nets. Sampling occurred on both the falling and rising tide (October 20th: low tide - 1611 hrs., high tides - 0953 hrs. and 2206 hrs; November 5th: low tide - 1601 hrs., high tides- 934 hrs. and 2158 hrs.). Thus, three samples were taken during the daytime and one was collected at night.

Only fish known to forage specifically on mobile macroinvertebrates were selected for gut analysis during each sampling interval. Fish were removed from the nets, sorted into plastic bags and immediately covered with a thick layer of ice in coolers for return to the VIMS laboratory at Gloucester Point. Fish were processed for data on species identification, size, weight, and stomach fullness early the following day. Stomach and intestines were excised from individuals of all three species (striped bass, croaker, and red drum), and immediately frozen for detailed gut content analysis. In the laboratory, stomach and intestinal contents were enumerated and identified to species when possible. For those individuals containing dismembered and crushed prey items, body parts (e.g., eyes, rostral spines, swimming legs) were categorized to estimate the total number of prey consumed.

The prey community inhabiting the seagrass bed was sampled on October 22 only (since no fish predators occurred in November 5 samples) to ascertain whether size-selective feeding by predators occurred. A 1.5 m2 cylindrical drop net with a mesh size of 0.05 mm was deployed at each gill net site and the motile macroinvertebrates were quantified using a suction sampler (Orth and van Montfrans, 1987). The drop net was thrown haphazardly at each location, suctioned for six minutes and dipnetted for an additional two minutes. Samples were returned to the laboratory, frozen, and subsequently analyzed for prey items consumed by fish predators. Mean blue crab size (carapace width) of individuals from the seagrass bed was compared with the size of crab prey in fish guts.

Finally, the abundances of fish caught in gill nets on October 20, and November 5, 1998, were compared to fish abundances from a study conducted between 1978 and 1980 (Heck and Thoman, 1984). Both studies occurred in the same grassbed, and similar sampling techniques were employed to quantify resident or transient predators. Our study spanned both daylight and nighttime periods, whereas the Heck and Thoman (1984) investigation included only nighttime sampling periods. Thus, comparisons of nocturnal samples enabled insights into the potential changes that might have taken place in the abundance of the three predatory fishes discussed in this report, despite the very limited temporal scale of our sampling effort in 1998.

RESULTS:

Seven species of fish were collected in total during a 12 hour sampling effort on October 20 (though no fish were caught over 12 hours of sampling on November 5th) of which three (striped bass, Morone saxatalis; red drum, Sciaenops ocellatus; and Atlantic croaker, Micropogonias undulatus) were selected for detailed analyses, including an assessment of feeding habits. Striped bass were the most abundant of the three species (76 individuals collected in 12 hours), followed by croaker (28) and red drum (20). Mean sizes of striped bass, croaker, and red drum and were 17.6 (44.8 cm), 11.8 (27.7 cm), and 15.4 (38.6 cm) inches, respectively (Figure 2). A significantly higher percentage of the three species were collected during the night at high tide (2100 hrs; Figure 3). Large numbers of predatory fish were also caught at 1200 hrs. during the daytime falling tide. Few individuals were found in the nets at the low tides times (1500 and 1800), though red drum were common in the 1800 hr. sample.

One hundred percent of red drum contained an average of 4.5 (+ 2.8) juvenile blue crabs in their stomachs, whereas 60.5% of the striped bass had consumed 2.3 (+ 1.6) juvenile crabs on average at the time they were caught and 35.7% of the croaker averaged 1.4 (+ 0.7) crabs in their guts (Figure 4). Of the remaining striped bass and croaker that did not consume blue crabs, 14.5 and 39.3%, respectively, had empty stomachs, while 13.2 and 25%, respectively, contained food items other than blue crabs (Figure 4). The average size of blue crabs consumed by striped bass striped bass (23.0 mm) and red drum (22.0 mm) was significantly larger than the average size of crabs inhabiting the grass bed (12.0 m; Figure 5). Prey items collected in the suction samples were dominated by small blue crabs and grass shrimp; both are consumed by fish predators.

The abundance of predatory fish targeted in this study likely increased between the periods 1978/1980 - 1998. Not a single striped bass, croaker or red drum was collected during three years of night-time (encompassing the entire period of darkness) gill net sampling over seven fall months (from 1978 to 1980) whereas a total of 47, 19 and 9 individuals were collected in only one nocturnal sampling period spanning three hours of darkness in October, 1998 (Table 1).

DISCUSSION

Although our study encompassed only one seagrass bed and examined predator abundance during two limited 12 hour periods (October 20 and November 5), we believe our data are noteworthy. Significant numbers of recreationally and commercially important species, particularly striped bass, croaker and red drum, utilized the shallow seagrass flat and most individuals approached the legal recreational size limit. The large number of fish that were captured over a short time interval of 12 hours on October 20 in our study contrasts sharply with the fish assemblage characterizing the same area over a 25 consecutive months two decades ago. It is important to note that in our study, a second sampling effort in the seagrass habitat on 5 November, two weeks after the first, revealed no fish present over the same 12 hour time interval. It is likely that the rapid drop in water temperatures and high degree of turbulence in the shallows associated with passage of the first strong cold front of the year contributed to the exodus of these species into deeper water immediately prior to the November 5 sampling effort. This view is strengthened by the fact that virtually all species of fish, including the ones targeted in this report, were absent from the seagrass habitat indicating a general egress from the grassbed. A similar phenomenon occurred in 1997 while sampling in seagrass beds baywide for spotted sea trout. At locations where 47 juvenile trout were collected only a month earlier, only one was found immediately following the passage of a cold front.

Finally, the gill net data from the Heck and Thoman (1984) study spanned approximately 25 months from 1978 - 1980 Two months in 1978, nine in 1979 and seven in 1980 were sampled, and each sample consisted of a twelve hour soak time period per month for two nets deployed on the same night. This effort yielded a total of approximately 84 hours of nocturnal sampling during the fall (September - November), and 236 hours throughout the entire study. Not a single striped bass, croaker or red drum was caught during the entire Heck and Thoman (1984) study, whereas we captured a total of 78 striped bass, 28 croaker, and 20 red drum, all of which were captured on October 20 during the first of two twelve hour sampling efforts (Table 1). Most of these (47, 19 and 9, respectively) were captured after dusk over only six hours. The majority of striped bass, all of the red drum and a large percentage of croaker contained juvenile blue crabs in their guts. It is therefore likely that predation effects on juvenile blue crabs by these fish could be substantially greater than they were two decades ago, though local changes in fish abundance throughout the seagrass habitat may also explain the observed differences in predator abundance.

Stomach contents of the three targeted species revealed that they foraged on the dominant, motile macroinvertebrate species occurring in the seagrass habitat (particularly juvenile blue crabs). Over 60% of the striped bass, 100% of red drum, and 34% of the croaker contained blue crabs in their stomachs. For striped bass, this contrasts with data from a study conducted in 1998 on a bay-wide scale (Austin and Walter, 1998) in which an average of only 9.4 % of individuals (all larger than 18 inches; 450mm) consumed crabs. Striped bass in the latter study consumed crabs averaging 1.6 inches (41 mm) in carapace width, whereas the crabs consumed by fish in our study were smaller and averaged 0.9 inches (23mm) in carapace width. It is important to note that our study sampled smaller striped bass in seagrass beds, while Austin and Walter (1998) sampled larger fish outside of seagrass beds. The mean size of blue crabs in fish stomachs from our study was greater than the mean size of crabs within the seagrass bed indicating size selective predation by the three species. This likely occurred because seagrass beds contain large numbers of recently settled individuals (Orth and van Montfrans, 1987) that are below the sizes normally consumed by the fish species we targeted.

Though we consider the data from this study preliminary, possible increases in the abundance of predatory fish and concomitant decreases in primary settlement habitat for the blue crab in portions of Chesapeake Bay raise concerns over implications for the blue crab population. The overall effects of an increase in top level predators and a decrease in nursery habitat, though not yet quantified at appropriate scales, could be considerable. Loss of critical blue crab nursery habitat (SAV) occurred bay-wide in the 1970s and throughout the mid-bay area (Tangier and Smith Islands) between 1992 and 1998. Such losses could constrain survival and growth of juveniles in areas affected by SAV loss and even bay-wide. Furthermore, the reduction in secondary production, which is generally higher in SAV habitats than any other benthic habitat in the bay (Fredette et al., 1990), represents an overall loss of potential food resources for a variety of bay residents. Habitat area reductions may therefore affect not only the distribution and abundance of juvenile blue crabs, but consequences may be even more pervasive when considering other species. Additional increases in predation pressure by higher abundances of top-level predators (such as striped bass, red drum, and croaker) raise the possibility for unknown impacts on the blue crab fishery. However, more detailed research is needed to identify potential linkages between habitat availability, predator impacts and their significance to the blue crab fishery.

This report, though based on data of limited scale, is timely in that it indicates the likelihood of increased predatory fish abundance of recreationally and commercially important species and links these increases to potential impacts on juvenile blue crabs. We strongly recommend such studies be broadened in scope so that statistically sound conclusions can be derived on a bay-wide scale for estimating predatory fish assemblage composition and predation impacts on juvenile blue crabs. Such a study should derive estimates of predator abundance, prey consumption rates (especially of blue crabs), gut residency times, and seasonal trends in utilization of blue crab nursery habitats by predatory fishes. These studies require integration with investigations on habitat quality and habitat loss to provide a holistic view of these two factors and their consequences for the blue crab population. Finally, we wish to reiterate that predation, though it might have an impact on the juvenile blue crab abundance, is difficult to control. Current fishery-independent data on the blue crab spawning stock indicate abundances at historically low levels for the past five years. Influencing human impacts via sound management policies in the commercial and recreational fishing sectors can cause positive effects on the spawning stock.

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FIGURES

FIGURE 1. Locations of gill net sampling at Guinea Marsh in the lower York River, October 20, 1998.

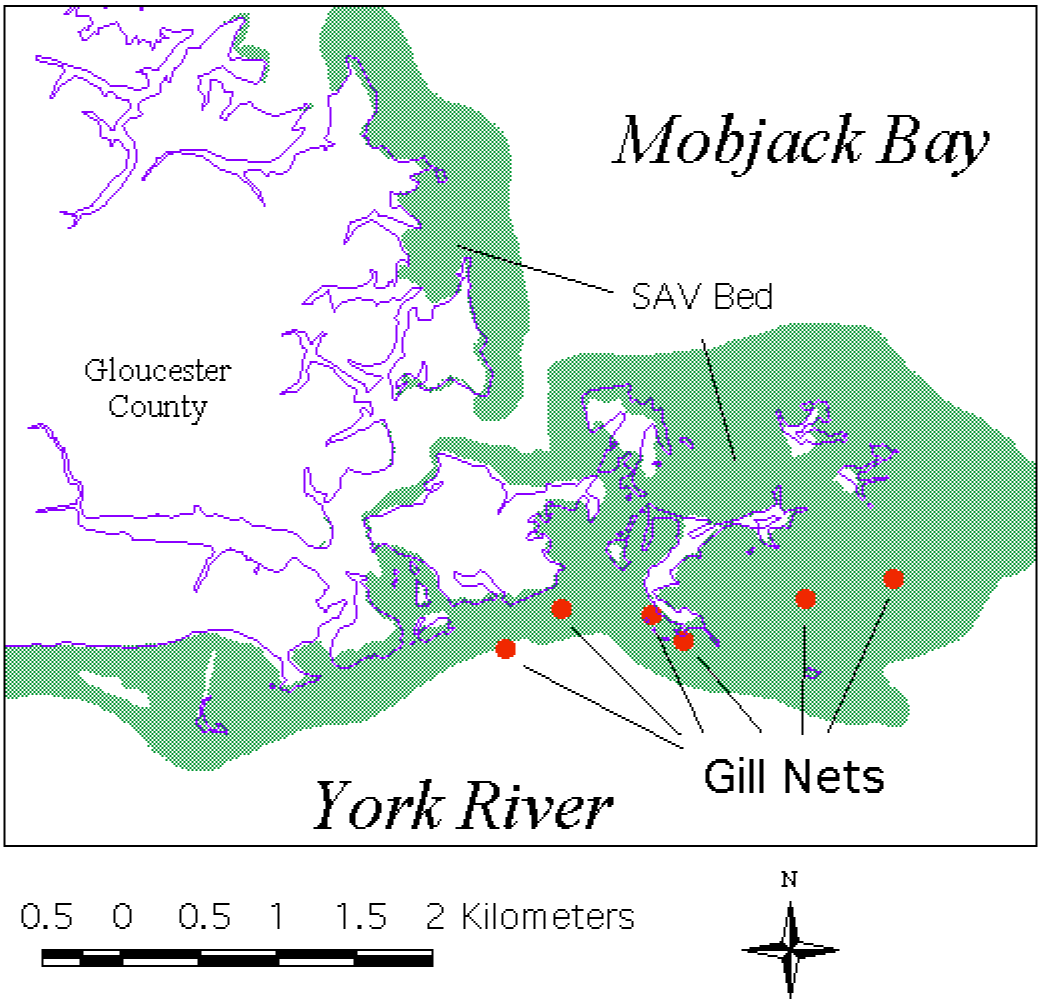


FIGURE 2. Mean sizes of fish collected during the October 20,1998 sampling period. No fish were caught on the November 5th sampling.

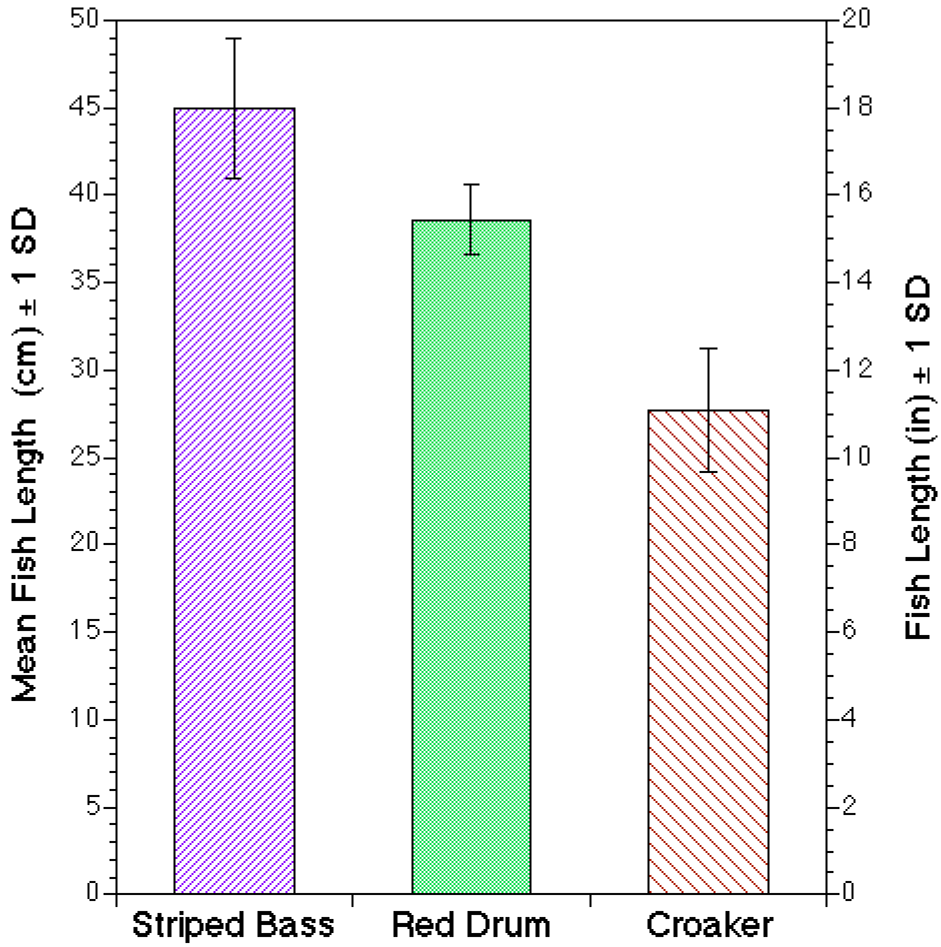


FIGURE 3. Fish abundances at each sampling period on October 20, 1998. Nets were sampled every 3 hours. High tide was at 0953 hrs. and 2206 hrs., low tide was at 1611.

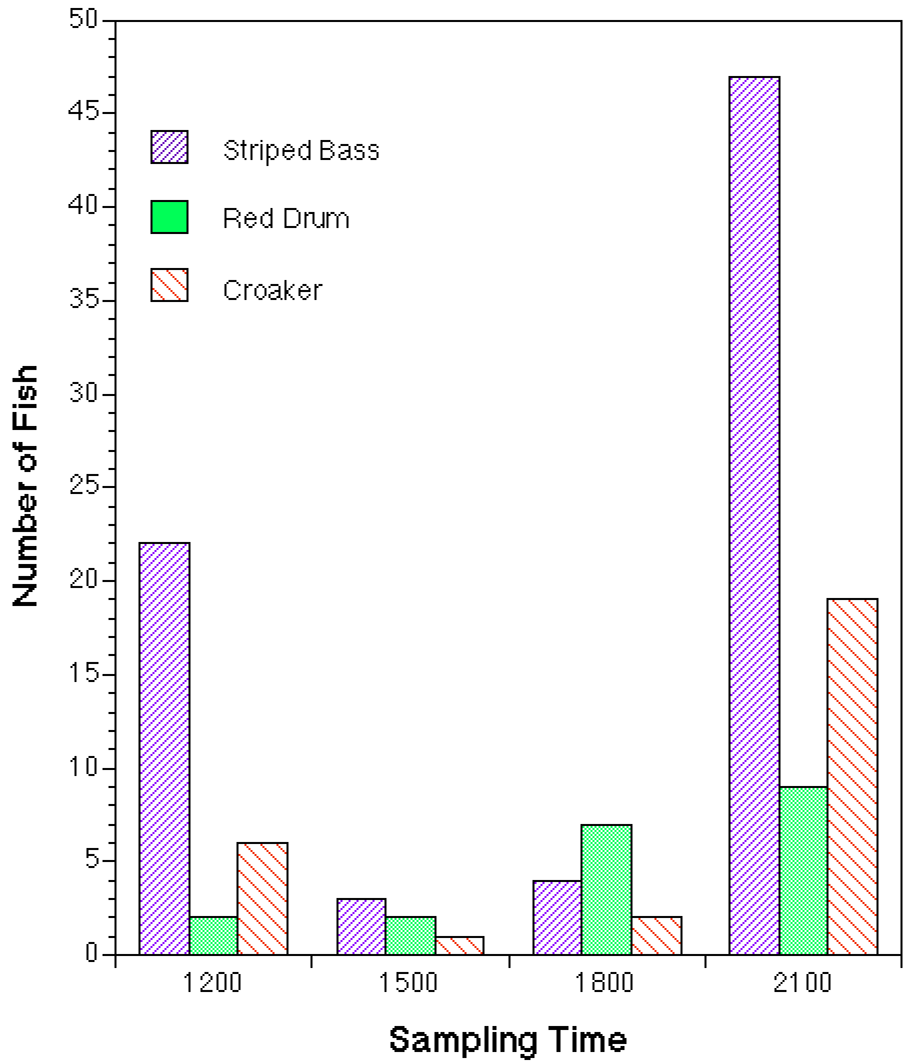


FIGURE 4. Gut contents of fish sampled on October 20, 1998. Fish categorized as "blue crab" had at least some blue crab remains identifiable, regardless of the presence of other food items in that fish. Fish categorized as "other" contained food items such as fish, shrimp, and other prey items.

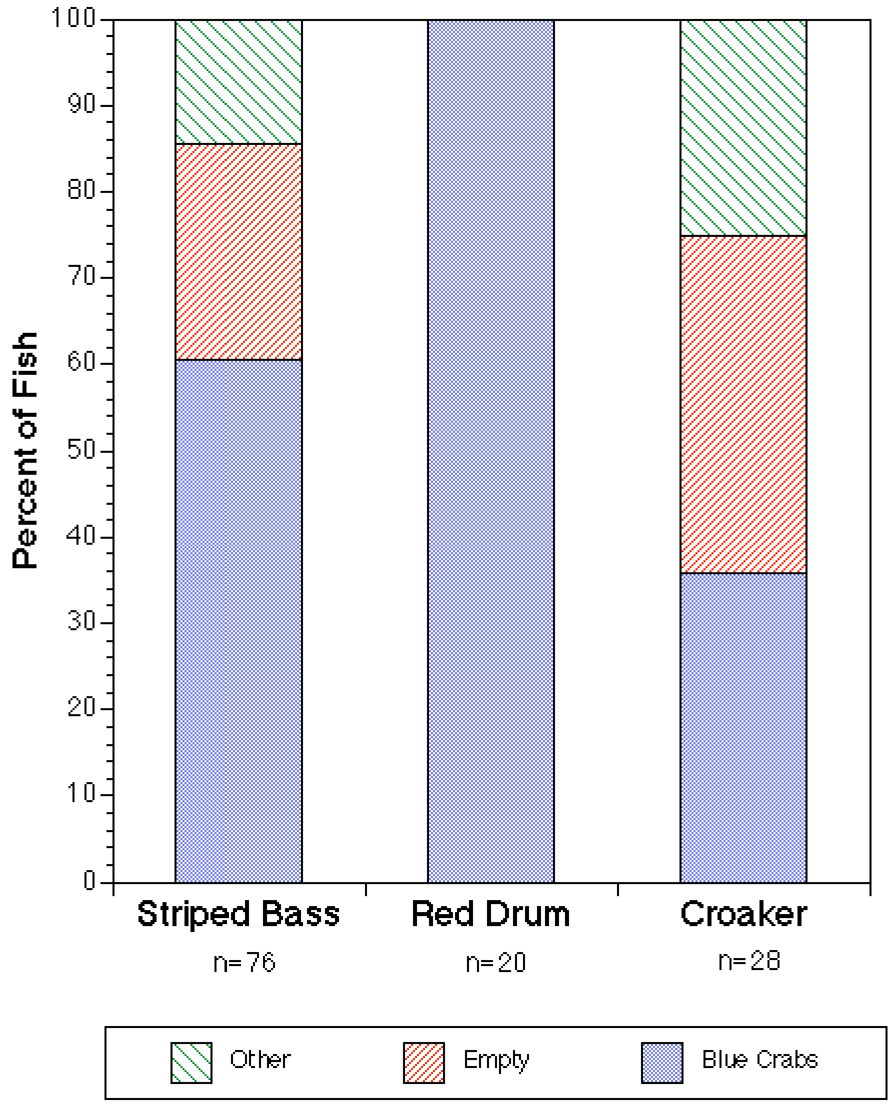
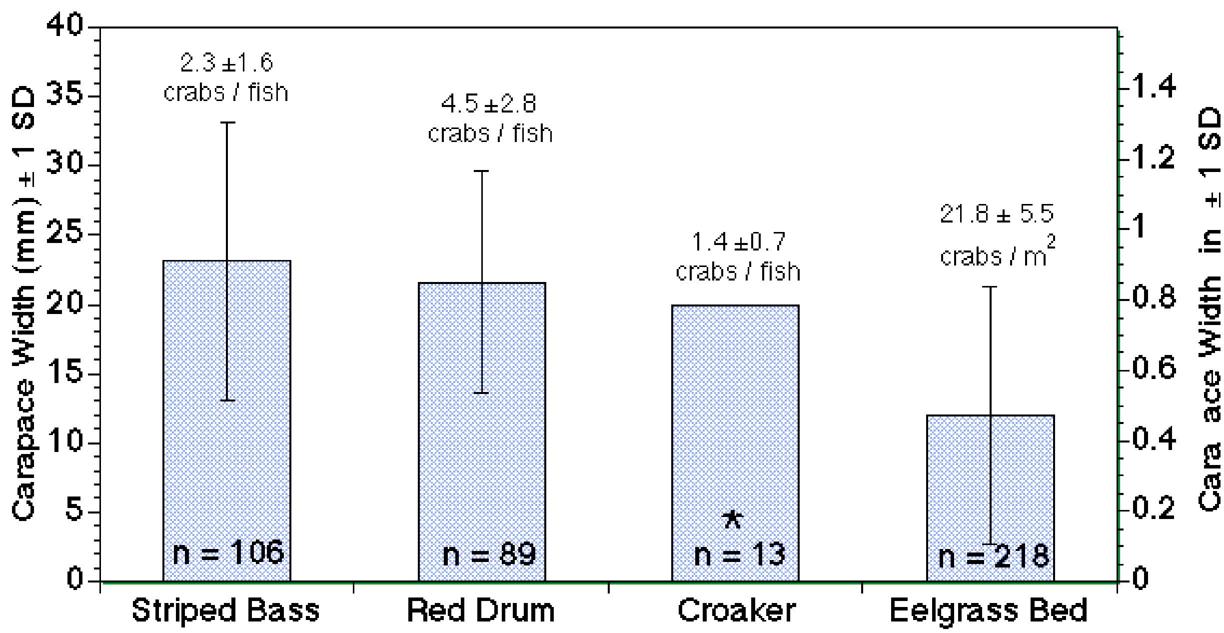


FIGURE 5. Mean carapace width and mean abundance of blue crabs found in fish sampled. Crabs from the eelgrass bed were collected using a suction pump. The crabs found in the Croaker were fragmented to such a degree that crab widths were measurable from only 1 specimen.



* Only 1 measurement. Crabs were fragmented so only counts were possible in most samples.

TABLES

TABLE 1. Fish species caught in York River Guinea Marsh gill netting. Data from this study are divided into day (9 hours) and night (3 hours) totals. In addition, abundance data from Heck and Thoman (1984) are presented for these same species at Guinea Marsh between 1978 and 1980 (*). Heck and Thoman data are from 2 gill nets (300 ft, 3.0 inch mesh) over a 13 hour night-time sampling period.

Species	1998 (This study)					1978*		1979*			1980*	
	Oct 20			Nov 5								
	Day	Night	**Total**	Day	Night	Sep	Nov	Sep	Oct	Nov	Sep	Oct
Morone saxatilis (Striped Bass)	29	47	**76**	0	0	0	0	0	0	0	0	0
Micropogonias undulatus (Croaker)	9	19	**28**	0	0	0	0	0	0	0	0	0
Sciaenops ocellatus (Red Drum)	11	9	**20**	0	0	0	0	0	0	0	0	0