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Continuing trophic studies on constructed “restored” oyster reefs

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Introduction

Historical perspective

Oyster reefs (*Crassostrea virginica*) developed in recent geological time as the current Chesapeake Bay was inundated by rising sea level, indeed, there is general consensus that oyster reefs were once the dominant feature for much of the Bay, contributing both biological and geological structures. Oysters dominated trophic interactions and enhanced overall system water quality while providing physical structure facilitating the development of complex benthic communities. By early Colonial times, oyster reefs had become significant geological and biological features of the Bay and were also major intertidal navigation hazards. Continuing harvest pressure since Colonial times has resulted in the transformation and degradation of the oyster reefs to subtidal “footprints” of former reefs that maintain drastically reduced populations of oysters. Reef degradation has been exacerbated by companion environmental degradation and a historical lack of consideration for water quality and natural resource management.

The past three decades have been defined by decline in the fishery production and the oyster resource under the added insult of two protistan parasites, *Perkinsus marinus* (“Dermo”) and *Haplosporidium nelsoni* (“MSX”). Since the disease organisms are active throughout most of the growing range of the oyster there have been few sanctuaries in which to plant oysters or in which naturally occurring oysters could be found in appreciable quantities. Indeed, these parasites have effectively eliminated oysters from many sections of the Bay. The native oysters have developed neither tolerance nor absolute resistance to these diseases, and do not exhibit any recovery in disease endemic areas in Virginia. The oyster fishery is in severe decline and there is a recognized and urgent need to restore the oyster resource: not just for the commercial fishery, but also to provide both the benthic filter feeder and structural foundation for reef communities that are so pivotal to the ecology of the Bay.

Current status of related oyster reef restoration activities

Oyster reef restoration has begun in the Virginia portion of the Chesapeake Bay as a collaborative effort between the Shellfish Replenishment Program of the Virginia Marine Resources Commission

(VMRC) and the Virginia Institute of Marine Science (VIMS). It is timely to examine trophic interactions on restored oyster reefs and use these interactions as an indicator of the success of restoration efforts. Quantitative assessment methods for oyster reef communities are challenging and must incorporate temporal, tidal, and structural attributes of these systems in order to accurately characterize these habitats. We promote the philosophy that current oyster restoration efforts in the Bay may be gauged with respect to the overall demographic and ecological health of existing reef communities. Larval and adult forms of oysters, a suite of other benthic species (ranging from attached filter feeders through detrital feeders to benthic predators such as crabs), intermediate fish species (e.g., gobies and blennies), and apex predatory species (e.g., striped bass, bluefish, weakfish, and spotted sea trout) interact to form the complex trophic structures responsible for creation and maintenance of the stable climax reef community observed historically. Any holistic approach to assessment of restoration must be cognizant of all “the players” in the trophic interactions.

To accurately assess oyster restoration efforts, it is necessary to either establish a “baseline” for comparison or have access to historical data characterizing oyster demographics and ecology. We have access to such a database of oyster information and are currently involved in several monitoring programs which contribute directly to the maintenance of this archive. Restored reef data sets may be compared to extensive historical data sets from productive areas within Virginia waters, most notably the James River. Current and historical maps of oyster aerial densities for all public oyster grounds in Virginia waters are also available. Thus, any data resulting from these restoration efforts can be placed in both historical and geographical context with little difficulty. Integration of these data sets provides context and perspective for oyster reef restoration efforts which, to our knowledge, cannot be duplicated.

To date our activities in reef restoration through active construction and subsequent monitoring and manipulative studies have focused on the Piankatank River (Figure 1). The initial reef, Palace Bar Reef, was constructed in May of 1993 as a joint venture between VMRC and VIMS. Since that time, three more reefs have been constructed in the Piankatank resulting in an available “time series” of reefs with respect to development to a mature standing stock of oysters and associated benthic organisms. It is important to note that these reefs were not initially seeded with oysters. All recruitment is from natural settlement originating from other typical “flat” reefs or rocks in the same river - the location of

the Piankatank relative to other known oyster resources strongly suggests this system is isolated with respect to recruitment. These reef restoration projects offer an unparalleled opportunity to document the development of “natural” reef communities on three dimensional structures against a background of typical “flat” reefs or rocks.

The Piankatank River is an excellent site to develop an oyster reef restoration program in that it has not supported a commercial oyster fishery for over a decade; however, it has been the site of a successful seed oyster program, and remains the site of an active blue crab pot fishery and a recreational rod and line fishery. A limited number of typical “flat” oyster rocks in the Piankatank have had applications of shell on a regular basis by VMRC with subsequent harvest of the settled seed after one or two summers of exposure (the summer being the period of oyster settlement) prior to transfer to public oyster bars elsewhere in Virginia. The shell deployment and harvest data are documented by VMRC, the temporal and spatial nature of settlement is documented by a continuing program at VIMS. Oyster spat (juvenile and newly settled oysters) counts of up to 1000 individuals per bushel of shell are commonplace in seed oyster dredging from these maintained and managed areas. The footprints of the former reefs are well documented from both historical sources (Baylor Surveys), recent surveys (Haven and co-workers in the early 1980’s, all material on file at both VIMS and VMRC), and continuing work by the VMRC staff. The reefs are not uniform in shape, this is clearly site specific and related to local circulation. The lack of a continuing commercial presence focused on oysters, the proven history of the site as one of good oyster settlement, the comparatively pristine environment at the site (there is essentially no industrial and very little agricultural development in the Piankatank watershed - even residential density is low), and the strongly supportive attitude of waterfront residents to environmentally sound management (illustrated by the support of the local residents through an environmentally oriented group called S.T.O.P - Save the Old Piankatank) combine to make this a unique and attractive site for continuing study.

Prior to the beginning of this study in 1996, little attention had been given to the trophic interaction of oysters with either fishes or benthic predators such as crabs on restored reefs. The relationship between oyster reefs and small intermediate reef fishes such as gobies and blennies is obvious in that oysters dominate the reef communities, and gobies (*Gobiosoma ginsburgi* and *G. bosc*) and blennies

(*Hypsoblennius hentzi* and *Chasmodes bosquianus*), which are some of the most abundant fish species in the Chesapeake Bay, are abundant in reef communities. Gobies and blennies are major food fishes for larger pelagic predatory species (*Morone saxatilis*, *Pomatomus saltatrix*, *Cynoscion regalis*, *Cynoscion nebulosus*) which potentially use reef communities as both nesting and nursery areas. It is reasonable to suggest a relationship between the developmental stage of a reef (maturity with respect to development of a stable oyster community over time, an index of the success of the restoration/rehabilitation process), the development of a goby population (and other “food” fish populations), and the abundance of major predatory finfishes.

We have examined and continue to examine this relationship through field studies focusing on the oyster (predominantly oyster larvae) - intermediate fish (predominantly larval goby/blenny) relationship (Harding, In review; Harding and Mann, In review 1) as well as the intermediate fish-apex predator fish relationship (Harding and Mann, In review 2). A significant portion of this effort has been directed towards water column processes (e.g., predation on oyster veligers by larval intermediate fishes (Harding, In review), predation on adult intermediate fishes by apex fish predators (Harding and Mann, In review 2; In review 3)), as directly related to the benthic community.

The dependent relationship between oyster reefs and crabs is equally obvious. Crabs, notably the blue crab, *Callinectes sapidus*, are well documented as predators on oysters, especially the smaller size classes. As oyster communities develop to include dense seasonal populations of rapidly growing recent recruits there is an expectancy of intensive blue crab predatory activity. We have examined blue crab abundance and population structure in proximity to the oyster reef over time.

Summary of previous research activities on Palace Bar Reef, Piankatank River, Virginia

In 1996, we conducted an intensive seasonal reef sampling program with U.S. E.P.A. Bay Program support. During this intensive Piankatank reef sampling program samples were collected over a twenty-two week period extending from May through September 1996. Mann and Harding (1997) provide an overview of this program and the resulting data types are summarized in [Table 1](#).

Our 1996 sampling program also incorporated two thirty-six hour sampling stations (June and August 1996). These were conducted at the oldest of the Piankatank reefs, Palace Bar Reef, on the full

moon to assess the diurnal variability of the reef community. Zooplankton and gill net samples were collected at three hour intervals corresponding to ebb, flood, and slack stages of the tide. Samples from these stations describe oyster-intermediate fish and apex predator-intermediate fish predator-prey interactions. Information from the 1996 field studies suggested that diurnal variability in the make up of the “user” fish community on the reefs was considerable and not completely represented by daytime sampling alone (Mann and Harding, 1997; Harding and Mann, In review 2; Harding and Mann, In review 3).

Field work during 1997 focused on diurnal variation in reef habitat use by both benthic and apex predators. These continuing oyster reef studies expanded sampling spatially to include a gradient of bottom types from three dimensional shell reef to two dimensional “oyster rock” to sand flat regions in proximity to both. Given the simultaneous sampling of non-reef and reef habitat, quantitative comparisons of bottom and community use by fish at each location are possible.

Relevance of this project to the Aquatic Reef Restoration Program

Restored oyster reefs are unique sites for examining oyster reef development and parallel development of associated communities within the Chesapeake Bay. The combination of Piankatank reef sites provides an unprecedented opportunity to quantitatively track the chronological development and maturation of “natural” reef sites of differing stages of maturity in a relatively undisturbed setting.

Objectives

The long term goal of our oyster reef community restoration research program is the understanding of reef function from an ecological community perspective (e.g. food web impacts).

In this program we specifically:

1. Build on existing oyster reef restoration database with continued monitoring efforts across all trophic levels.
2. Combine monitoring efforts with sampling of upper trophic levels in reef communities of differing maturity levels.
3. Synthesize oyster community and trophic data into models of oyster reef community interactions.

4. Use data - based models of community interaction to assess restoration efforts and management strategies.

Study Design

Site Description

Field studies were focused on Palace Bar Reef, Piankatank River, Virginia (N 37° 31' 41.69", W 76° 22' 25.98"; [Figure 1](#)) in 1996 and 1997. Palace Bar Reef is an intertidal oyster reef (depth range of 1-3 m) adjacent to the historic Palace Bar oyster grounds. Approximately 70% of the reef (0.63 ha) is composed of oyster shell, while the remaining area (0.27 ha) is crushed clam shell (see Bartol and Mann, 1997). This reef is constructed on the footprint of ancient reefs and is located in an area protected from commercial oyster fishing and other perturbations. There is a substantial oyster settlement database and a continuing program of reef study for the Piankatank site to provide supplemental information to the proposed community restoration program.

In 1997, oyster reef trophic monitoring efforts were expanded to include two off-reef sites within the Piankatank River ([Figure 1](#)). The Ginney Point site (N 37° 31' 52.78", W 76° 24' 08.40") is located on a natural oyster shell flat ([Figure 1](#)). The Roane Point site (N 37° 31' 37.48," W 76° 22' 39.63") includes a sand bar south and inshore of Palace Bar Reef ([Figure 1](#)).

We have both continuing long-term monitoring programs in the Piankatank River and focused efforts on reef biology. We maintain a program to describe temporal and spatial settlement of oysters (using shellstring substrates deployed for weekly intervals) in the Virginia subestuaries of the Chesapeake Bay, including the Piankatank River, throughout the summer months from June through late September. Dredge surveys are conducted in Spring and Fall throughout the Piankatank system. Diver surveys of selected reefs are completed in Spring and Fall. General patent tong surveys are completed in selected areas in the Fall for quantitative oyster stock assessment.

Methods and Results

Continuing VIMS-sponsored oyster monitoring studies have been combined with information on general community structure with the trophic levels directly above the oysters (intermediate fishes

(e.g. gobies and blennies) and their pelagic and benthic apex predators (e.g., striped bass, weakfish, bluefish, and blue crabs) to provide a more complete picture of oyster reef community function and restoration benefits to the overall ecosystem. The additional community and trophic information has been collected by pelagic adult fish sampling, plankton surveys, and crab pot deployments sponsored by the U.S. E.P. A. Chesapeake Bay Program.

Sampling schedule

Oyster reef community monitoring efforts during 1997 were designed to describe diurnal, tidal, and site - specific patterns of habitat use by reef community predators. Trophic monitoring samples were collected during nine 36 hour sampling stations focusing on the three sites described above (Table 2). Stations coincided with either the full or new moon; sampling intervals during the stations coincided with changes in tidal stage (Table 3). Field schedules from all of these 36 hour stations are included in Appendix 1.

Oyster monitoring data (shell strings) and reef monitoring physical data (water temperature, salinity, and dissolved oxygen measurements) were collected weekly.

Current sample status

A summary of all reef monitoring samples collected with U.S. E.P.A. Chesapeake Bay program support during both 1996 and 1997 field seasons is given in Table 4. The bongo and gut samples listed as archived have been preserved and are awaiting processing. These samples and the plankton samples will be analyzed and included in the annual report for the 1998 reef monitoring proposal that continues and expands the work described in this report and Mann and Harding (1997).

Oyster monitoring data

VIMS maintains an oyster monitoring program which provides data for oyster spat (shellstring program), small, and market-size oyster (annual dredge survey) abundance estimates. An extensive historic data set for both spatfall and adult abundance is available for Palace Bar (site of the primary study reef), Piankatank River. These data provide baseline information regarding the status of the Piankatank oyster populations in relation to Chesapeake Bay oyster populations. The trends observed

in both spatfall (Figure 2) and adult abundance (Figure 3) around Palace Bar Reef follow the general decline observed in the Virginia oyster fishery in recent years.

Physical oceanographic data

Water temperature, salinity, and dissolved oxygen measurements were made weekly at all three study sites from May through mid - September 1997. There were no significant differences between sites for water temperature, salinity, or oxygen data (ANOVA, $p < 0.05$); therefore data were combined (Figure 4). Water temperature and salinity data from 1997 were compared to 1996 data (Mann and Harding, 1997). Salinities, but not water temperatures, were significantly different between 1996 and 1997 (ANOVA, $p < 0.05$). Water temperatures and salinities during 1996 and 1997 were similar to those observed from 1993-95 at these sites (Figure 4; R. Mann, unpublished data). Dissolved oxygen values were at or near saturation values for measured field temperatures and salinities throughout the season.

Pelagic predator surveys

Relative abundance and distribution: Adults and juveniles of larger pelagic species were sampled using multi-panel experimental gill nets (one 30.5 m x 1.8 m and two 30.5 m x 3.0 m nets all with one 7.6 m panel each of stretch mesh monofilament of 57.2, 63.5, 73.0, and 76.2 mm). Gill nets were deployed such that the entire water column was sampled (e.g. the smallest net at the shallowest site) and were retrieved at three hour intervals corresponding with changes in tidal stage (See Harding and Mann, In review 2). Benthic fishes, resident on the reef, were sampled using nesting substrates deployed for another study (Harding and Mann, In review 1). Twenty - one fish species representing 15 families were collected during 1997 across all three sites (Table 5; Harding and Mann, In review 2). If pelagic fish data from the 1996 and 1997 field seasons are combined, 31 species of finfishes representing 25 families were collected on or adjacent to Palace Bar Reef, Piankatank River, Virginia (Table 6; Harding and Mann, In review 2).

The four most abundant non-menhaden pelagic fishes collected at all three of the sites are recreationally and commercially valuable and were also the four most abundant non-menhaden

fishes collected on Palace Bar Reef during 1996: Atlantic croaker (*Micropogonias undulatus*), bluefish (*Pomatomus saltatrix*), striped bass (*Morone saxatilis*), and spot (*Leiostomus xanthurus*). Abundance patterns of these fishes varied seasonally and diurnally (Tables 7-15). Abundance of each of these fishes varied seasonally (Figure 5).

Dietary analyses: As with 1996 samples, the entire digestive tracts of all pelagic fishes samples including all gut contents were collected and field preserved for subsequent laboratory quantitative gut content analyses. These analyses provide information on multi-species interactions and trophic relationships within and around the reef communities. Dietary analyses are in progress for all species observed during 1997 but are most complete for bluefish (*Pomatomus saltatrix*; Figure 6) and striped bass (*Morone saxatilis*; Table 16). Teleost fishes are dominant prey items for both of these species. Intermediate reef fishes (e.g., gobies and blennies) are found more frequently in the guts of bluefish caught on Palace Bar Reef than at either of the other sites (Harding and Mann, In review 3).

Benthic predators: Blue crabs

Abundance: Blue crab abundance information for all three study sites was obtained with baited crab pots (fishery independent data - 2' x 2' pots with a 2" cull ring) deployed in conjunction with 36 hour stations. Crab abundance increases as temperature increases seasonally from May through August (Figure 4, Figure 7).

Abundance patterns: males vs. females: Plots of male and female blue crab abundance over time indicate clear differences in habitat use by the sexes over time (Figure 8). It is important to note that all of these abundance data are relative and may have been influenced by commercial crabbing in the area which varied in intensity with the seasons e.g., the commercial crabbing presence was most noticeable immediately adjacent to the reef in June and July 1997.

Current status and connections with continuing research

The combination of the VIMS historic data archives and the abundant trophic data collected at Palace Bar Reef during 1996 and 1997 with EPA support places us in a unique position: we have the necessary monitoring data to establish a baseline of oyster reef community structure. The 1997 field season expanded our focus to include comparisons with local non-reef sites while maintaining monitoring efforts at the Palace Bar Reef site. The end product of the 1996 and 1997 field seasons is two years of intensive reef baseline data coupled with one year of parallel intensive data from a local flat oyster rock and a local sand-bar; an ideal scenario for establishing oyster reef impacts on the local biological landscape. Given the quantity of data involved in this project, our major limiting factors revolve around sample processing and analyses (i.e. time and money to do both properly). Both processing and analyses are currently underway and have been in progress since 1996. When all of these data are processed and analyzed, we will be able to quantitatively and qualitatively describe the development and function of oyster reef trophic structure at an unprecedented level of detail.

The 1997 field season provides comparative data from on-reef and off-reef sites across seasonal, diurnal, and tidal scales. The combination of these sites and scales and the focus on multiple trophic predator-prey relationships enables a better understanding of community dynamics than has been previously possible. The major benefit of this work is an understanding of the quantitative relationship between oyster reef community food chain levels in an ecological framework dependent upon the oyster (as both a physical habitat and a major prey item) as present on restored oyster reefs and typical “flat” oyster rocks.

Oyster reef restoration for the express purpose of oyster enhancement and water quality improvement may also contribute significantly to provision of habitat for blue crab predation, and to the success of recreational finfish species (probably more so than finfish reef enhancement alone in that oyster reefs provide a viable food chain to support the fishes). Dedicated oyster and finfish reef development will continue in the Bay, probably at accelerated rates in future years. It is fundamental that we understand the processes that dictate the success or failure of these activities, and maximize the

benefit of such activities for fisheries enhancement and environmental rehabilitation (that is oyster resource rehabilitation).

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Table 1: Summary of data types collected on/around Palace Bar Reef, Piankatank River, Virginia during intensive seasonal sampling with U.S. E.P.A. Chesapeake Bay Program support .

Sample type	n	Targeted trophic level	Duration of sampling
Plankton tows	198	Oysters - Intermediate fishes	May - October 1996
Bongo tows	48	Oysters - Intermediate fishes	May - October 1996
Fish traps	120	Intermediate fishes	May - September 1996
Quadrat counts	9	Intermediate fishes	May - September 1996
Crab pots	72	Intermediate benthic predators	May - September 1996
Gill nets	42	Apex pelagic predators	May - September 1996
Trawls	22	Apex and benthic predators	May - September 1996
Shell strings	32	Oysters	June - October 1996

Table 2: Summary of all biological samples collected on the Piankatank River during the 1997 field season with U.S. E.P.A. Chesapeake Bay Program support.

Trophic Level	Type of Sample	No. of samples	Processing status
Apex predators	Gill net deployment	255 sets	In progress
Benthic predators	Crab pot deployment	162 pots	Completed

Table 3: Summary of all gill net collections of non-menhaden species completed on the Piankatank River during the 1997 field season.

Sampling dates	Moon phase	Total no. of nonmenhaden fishes collected	Processing status
May 22-23, 1997	Full	257	In progress
June 5-6, 1997	New	205	In progress
June 19-20, 1997	Full	185	In progress
July 2-3, 1997	New	140	In progress
July 17-18, 1997	Full	238	In progress
Aug. 4-5, 1997	New	69	In progress
Aug. 18-19, 1997	Full	67	In progress
Sept. 2-3, 1997	New	212	In progress
Sept. 15-16, 1997*	Full	83	In progress

Table 4: Sample status for all of the Piankatank reef monitoring samples collected during both 1996 and 1997 with Bay Program support.

Trophic Level	Year	Type of Sample	# of Samples	Processing status
Oysters-Intermediate fishes	1996	Zooplankton tows	198	Under analysis
	1997	Zooplankton tows	120	Under analysis
Oysters-Intermediate fishes	1996	Bongo tows	48	In progress
Apex predators	1996	Gill net deployment	20 sets	Completed
	1997	Gill net deployment	270 sets	In progress

Table 5: Fishes collected during 1997 with gill nets, crab pots, and nest substrates in the Piankatank River, Virginia. This table is from Harding and Mann (In review 2).

Fish species	Ginney Point	Roane Point	Palace Bar Reef
American eel			X
Atlantic croaker	X	X	X
Atlantic menhaden	X	X	X
Black Sea bass	X		
Blueback herring	X	X	X
Bluefish	X	X	X
Butterfish			X
Carp		X	
Cownose ray			X
Hogchoker	X		X
Naked goby			X
Oyster toadfish			X
Silver perch	X	X	X
Skilletfish			X
Speckled trout	X	X	X
Spot	X	X	X
Striped bass	X	X	X
Striped blenny			X
Summer flounder	X		
Weakfish	X	X	X

Table 6: Family, common, and scientific names with species status for all fish species observed in the Piankatank River, Virginia during 1996-97. This table is modified from Harding and Mann (In review 2).

Family	Common name	<i>Scientific name</i>	Recreationally or commercially valuable species
Anguillidae	American eel	<i>Anguilla rostrata</i>	X
Batrachoididae	Oyster toadfish	<i>Opsanus tau</i>	
Blennidae	Striped blenny	<i>Chasmodes bosquianus</i>	
Bothidae	Summer flounder	<i>Paralichthyes dentatus</i>	X
Clupeidae	Atlantic menhaden	<i>Brevoortia tyrannus</i>	X
	Blueback herring	<i>Alosa aestivalis</i>	X
Engraulidae	Bay anchovy	<i>Anchoa mitchilli</i>	
Ephippidae	Spadefish	<i>Chateodipterus faber</i>	
Gadidae	Spotted hake	<i>Urophycis regia</i>	
Gobiesocidae	Skilletfish	<i>Gobiesox strumosus</i>	
Gobidae	Naked goby	<i>Gobiosoma bosc</i>	
Haemulidae	Pigfish	<i>Orthopristis chrysoptera</i>	
Labridae	Tautog	<i>Tautoga onitis</i>	X

Myliobatidae	Cownose ray	<i>Rhinoptera bonasus</i>	
Percichthyidae	Striped bass	<i>Morone saxatilis</i>	X
Pomatomidae	Bluefish	<i>Pomatomus saltatrix</i>	X
Rachycentridae	Cobia	<i>Rachycentron canadum</i>	X
Sciaenidae	Atlantic croaker	<i>Micropogonias undulatus</i>	X
	Silver perch	<i>Bairdiellal chrysoura</i>	
	Speckled trout	<i>Cynoscion nebulosus</i>	X
	Spot	<i>Leiostomus xanthurus</i>	
	Weakfish	<i>Cynoscion regalis</i>	X
Scombridae	Spanish mackerel	<i>Scomberomorus maculatus</i>	X
Serranidae	Black Sea bass	<i>Centropristis striata</i>	X
Soleidae	Hog choker	<i>Trinectes maculatus</i>	
Sparidae	Pinfish	<i>Lagodon rhomboides</i>	
Stromateidae	Butterfish	<i>Peprilus triacanthus</i>	
	Harvest fish	<i>Peprilus alepidotus</i>	
Syngnathidae	Lined seahorse	<i>Hippocampus erectus</i>	
Tetradontidae	Northern puffer	<i>Spheroides maculatus</i>	
Triglidae	Northern searobin	<i>Prionotus carolinus</i>	

Table 7: Summary of fishes caught with gill nets at Piankatank River, VA sites on May 22-23, 1997 during the 36 hour sampling station. Three sites were sampled: Palace Bar Reef (1), Roane Point (2), and Ginney Point (3). Site descriptions are provided in the text. Sampling was conducted on one of four tidal stages: Ebb, Slack onto Flood (SF), Flood, and Slack onto Ebb (SE).

Date	Moon Phase	Time	Tidal stage	Site	Striped bass	Bluefish	Croaker	Spot	Menhaden	Weakfish	Sea trout	Silver perch	Herring	Shad	Hog choker	Carp	Summer flounder	Butter fish
5/22/97	Full	1330	Ebb	1			X											
				2			X	X										
				3	X		X	X										
		1940	SF	1	X		X											
				2		X	X	X										
				3	X		X	X										
		2230	Flood	1	X	X	X	X	X									
				2	X	X	X	X	X	X								
				3	X		X	X	X	X					X			
5/23/97	Full	0222	SE	1	X	X	X	X	X	X								
				2			X	X	X		X							
				3	X		X	X	X									
		0600	Ebb	1	X			X										
				2	X			X	X									
				3	X		X	X	X									
		0920	SF	1	X			X										
				2	X													
				3	X		X	X	X									
		1130	Flood	1														
				2	X							X						
				3														
		1440	SE	1	X	X												
				2				X								X		
				3			X	X										
		1710	Ebb	1	X		X											
				2			X											
				3			X	X										

Table 8: Summary of fishes caught with gill nets at Piankatank River, VA sites on June 5-6, 1997 during the 36 hour sampling station. Three sites were sampled: Palace Bar Reef (1), Roane Point (2), and Ginney Point (3). Site descriptions are provided in the text. Sampling was conducted on one of four tidal stages: Ebb, Slack onto Flood (SF), Flood, and Slack onto Ebb (SE).

Date	Moon Phase	Time	Tidal stage	Site	Striped bass	Bluefish	Croaker	Spot	Menhaden	Weakfish	Sea trout	Silver perch	Herring	Shad	Hog choker	Carp	Summer flounder	Butter fish
6/5/97	New	1340	SE	1			X											
				2			X	X										
				3		X		X										
		1658	Ebb	1		X	X											
				2														
				3	X			X										
		2000	SF	1	X	X	X											
				2			X	X										
				3			X	X										
		2300	Flood	1		X	X	X	X									
				2	X	X	X	X	X									
				3			X	X	X									
6/6/97	New	0250	SE	1	X		X	X	X									
				2			X	X			X							
				3		X	X	X	X									
		0610	Ebb	1	X	X		X				X	X					
				2			X	X										
				3	X	X	X	X	X				X					
		0950	SF	1		X												
				2														
				3		X												
		1140	Flood	1	X	X	X											
				2		X												
				3														
		1445	SE	1														
				2				X										
				3		X	X											

Table 9: Summary of fishes caught with gill nets at Piankatank River, VA sites on June 19-20, 1997 during the 36 hour sampling station. Three sites were sampled: Palace Bar Reef (1), Roane Point (2), and Ginney Point (3). Site descriptions are provided in the text. Sampling was conducted on one of four tidal stages: Ebb, Slack onto Flood (SF), Flood, and Slack onto Ebb (SE).

Date	Moon Phase	Time	Tidal stage	Site	Striped bass	Bluefish	Croaker	Spot	Menhaden	Weakfish	Sea trout	Silver perch	Herring	Shad	Hog choker	Carp	Summer flounder	Butter fish
6/19/97	Full	1230	SE	1	X	X	X											
				2		X												
				3	X	X												
		1540	Ebb	1		X												
				2			X											
				3			X											
		1840	SF	1			X											
				2			X											
				3	X		X	X										
		2140	Flood	1		X	X	X	X									
				2	X	X	X	X	X									
				3	X		X	X	X									
6/20/97	Full	0115	SE	1		X	X	X	X									
				2	X	X	X	X	X		X							
				3	X		X	X	X									
		0436	Ebb	1			X	X	X									
				2		X	X	X	X									
				3	X	X	X	X	X									
		0715	SF	1	X	X		X	X									
				2				X	X									
				3	X	X	X	X	X									
		1020	Flood	1														
				2														
				3														
		1320	SE	1			X											
				2														
				3				X										

Table 10: Summary of fishes caught with gill nets at Piankatank River, VA sites on July 2-3, 1997 during the 36 hour sampling station. Three sites were sampled: Palace Bar Reef (1), Roane Point (2), and Ginney Point (3). Site descriptions are provided in the text. Sampling was conducted on one of four tidal stages: Ebb, Slack onto Flood (SF), Flood, and Slack onto Ebb (SE).

Date	Moon Phase	Time	Tidal stage	Site	Striped bass	Bluefish	Croaker	Spot	Menhaden	Weakfish	Sea trout	Silver perch	Herring	Shad	Hog choker	Carp	Summer flounder	Butter fish
7/2/97	New	1120	SE	1			X		X									
				2			X											
				3			X											
		1500	Ebb	1			X											
				2			X											
				3			X											
		1800	SF	1		X	X											
				2			X											
				3		X	X	X										
		2119	Flood	1			X	X	X	X								
				2			X	X	X									
				3	X	X	X	X	X	X								
7/3/97	New	0030	SE	1	X	X	X	X	X	X		X						
				2			X	X	X									
				3	X		X	X	X									
		0400	Ebb	1		X	X	X	X									
				2			X	X	X									
				3			X	X	X									
		0650	SF	1		X	X		X									
				2					X									
				3		X	X	X	X									
		0945	Flood	1			X											
				2			X											
				3			X	X										
		1240	SE	1														
				2		X												
				3														

Table 11: Summary of fishes caught with gill nets at Piankatank River, VA sites on July 17-18, 1997 during the 36 hour sampling station. Three sites were sampled: Palace Bar Reef (1), Roane Point (2), and Ginney Point (3). Site descriptions are provided in the text. Sampling was conducted on one of four tidal stages: Ebb, Slack onto Flood (SF), Flood, and Slack onto Ebb (SE).

Date	Moon Phase	Time	Tidal stage	Site	Striped bass	Bluefish	Croaker	Spot	Menhaden	Weakfish	Sea trout	Silver perch	Herring	Shad	Hog choker	Carp	Summer flounder	Butter fish
7/17/97	Full	1100	SE	1			X											
				2			X											
				3	X		X											
		1415	Ebb	1			X											
				2			X											
				3			X	X										
		1720	SF	1			X											
				2			X						X					
				3			X	X										
		2030	Flood	1				X	X	X								
				2	X					X								
				3				X										
7/18/97	Full	0010	SE	1		X	X	X	X		X							
				2			X	X	X		X							
				3	X	X	X	X	X	X								
		0320	Ebb	1		X	X	X	X		X							
				2			X		X			X						
				3			X	X	X		X							
		0630	SF	1		X	X	X	X		X				X			
				2		X	X	X	X									
				3			X	X	X	X								
		0950	Flood	1						X								
				2														
				3				X	X									
		1210	SE	1		X												
				2														
				3					X									

Table 12: Summary of fishes caught with gill nets at Piankatank River, VA sites on August 4-5, 1997 during the 36 hour sampling station. Three sites were sampled: Palace Bar Reef (1), Roane Point (2), and Ginney Point (3). Site descriptions are provided in the text. Sampling was conducted on one of four tidal stages: Ebb, Slack onto Flood (SF), Flood, and Slack onto Ebb (SE).

Date	Moon Phase	Time	Tidal stage	Site	Striped bass	Bluefish	Croaker	Spot	Menhaden	Weakfish	Sea trout	Silver perch	Herring	Shad	Hog choker	Carp	Summer flounder	Butter fish
8/4/97	New	1127	Flood	1			X		X				X					
				2			X						X					
				3			X											
		1420	SE	1			X											
				2			X											
				3			X											
		1740	Ebb	1			X		X				X					
				2			X											
				3			X	X										
		2045	SF	1			X											
				2			X	X										
				3			X		X									
		2350	Flood	1		X	X		X			X						
				2			X											
				3					X			X						
8/5/97	New	0315	SE	1			X		X	X		X						
				2		X	X		X									
				3		X	X	X	X									
		0630	Ebb	1			X	X	X									
				2			X	X		X								
				3			X	X	X									
		0930	SF	1			X											
				2	X	X												
				3														
		1200	Flood	1			X											
				2														
				3														

Table 13: Summary of fishes caught with gill nets at Piankatank River, VA sites on August 18-19, 1997 during the 36 hour sampling station. Three sites were sampled: Palace Bar Reef (1), Roane Point (2), and Ginney Point (3). Site descriptions are provided in the text. Sampling was conducted on one of four tidal stages: Ebb, Slack onto Flood (SF), Flood, and Slack onto Ebb (SE).

Date	Moon Phase	Time	Tidal stage	Site	Striped bass	Bluefish	Croaker	Spot	Menhaden	Weakfish	Sea trout	Silver perch	Herring	Shad	Hog choker	Carp	Summer flounder	Butter fish
8/18/97	Full	1415	SE	1			X											
				2														
				3			X											
		1630	Ebb	1														
				2				X										
				3			X											
		2020	SF	1				X										
				2				X										
				3			X	X									X	
		2300	Flood	1			X	X				X						
				2			X	X										
				3				X	X			X						
8/19/97	Full	0230	SE	1		X	X	X		X								
				2				X		X								
				3				X	X									
		0530	Ebb	1			X	X										
				2														
				3				X	X									
		0815	SF	1				X										
				2		X												
				3				X										
		1115	Flood	1														
				2														
				3														
		1430	SE	1														
				2														
				3														

Table 14: Summary of fishes caught with gill nets at Piankatank River, VA sites on September 2-3, 1997 during the 36 hour sampling station. Three sites were sampled: Palace Bar Reef (1), Roane Point (2), and Ginney Point (3). Site descriptions are provided in the text. Sampling was conducted on one of four tidal stages: Ebb, Slack onto Flood (SF), Flood, and Slack onto Ebb (SE).

Date	Moon Phase	Time	Tidal stage	Site	Striped bass	Bluefish	Croaker	Spot	Menhaden	Weakfish	Sea trout	Silver perch	Herring	Shad	Hog choker	Carp	Summer flounder	Butter fish
9/2/97	New	1410	SE	1			X	X										
				2			X											
				3				X										
		1730	Ebb	1			X											
				2														
				3														
		2030	SF	1	X	X	X	X				X						
				2			X	X										
				3		X	X	X	X									
		2340	Flood	1		X	X	X	X	X		X						X
				2														
				3		X	X		X	X		X						
		0600	Ebb	1	X		X	X		X		X	X					
				2			X	X	X	X			X					
				3														
		0925	SF	1	X	X		X										
				2														
				3											X			
		1245	Flood	1														
				2														
				3														
		1645	SE	1		X	X											
				2			X											
				3			X	X										

Table 15: Summary of fishes caught with gill nets at Piankatank River, VA sites on September 15-16, 1997 during the 36 hour sampling station. Three sites were sampled: Palace Bar Reef (1), Roane Point (2), and Ginney Point (3). Site descriptions are provided in the text. Sampling was conducted on one of four tidal stages: Ebb, Slack onto Flood (SF), Flood, and Slack onto Ebb (SE). This station was not completed due to the presence of non-*Pfisteria* lesions on fishes.

Date	Moon Phase	Time	Tidal stage	Site	Striped bass	Bluefish	Croaker	Spot	Menhaden	Weakfish	Sea trout	Silver perch	Herring	Shad	Hog choker	Carp	Summer flounder	Butter fish
9/15/97	Full	1200	SE	1			X											
				2														
				3			X											
		1542	Ebb	1			X											
				2														
				3		X	X	X										
		1830	SF	1			X											
				2			X											
				3			X										X	
		2140	Flood	1		X		X		X		X						
				2			X	X	X									
				3		X	X	X	X									
9/16/97	Full	0100	SE	1	X	X	X	X	X	X		X						
				2		X		X				X						
				3			X		X									

Table 16: Preliminary diet summary for striped bass caught during the first four thirty-six hour gill netting stations on the Piankatank River calculated from guts processed to date. The “Teleost” category refers to gut contents not indentifiable beyond this level.

Date	Site	n	Mean TL (mm)	1° prey/ Diet %	2° prey/ Diet %	3° prey/ Diet %
22-23 May 97	PBR	25	322	Polychaete/39	Gobiidae/38	Teleost/15
	RP	4	278	Polychaete/53	Teleost/19	Mysid/15
	GP	28	273	Polychaete/90	Mysids/5	Teleost/2
5-6 June 97	PBR	7	270	Mysid/66	Polychaete/26	Gobiidae/3
	RP	0	-	-	-	-
	GP	10	269	Polychaete/96	Amphipod/33	Teleost/1
19-20 June 97	PBR	11	285	Mysid/93	Polychaete/6	Gobiidae/1
	RP	3	254	Mysid/100		
	GP	14	251	Mysid/51	Polychaete/40	Xanthid/5
2-3 July 97	PBR	0	-			
	RP	0	-			
	GP	9	281	Polychaete/50	Gobiidae/25	Teleost/25

Figure 1: Map of the Piankatank River in relation to the Chesapeake Bay showing sampling locations. Palace Bar Reef (C.) was sampled in 1996 and 1997. Sites at Ginney Point (A.) and Roane Point (B.) were established in 1997 to provide data for nonreef habitats. This figure is taken from Harding and Mann (In review 1).

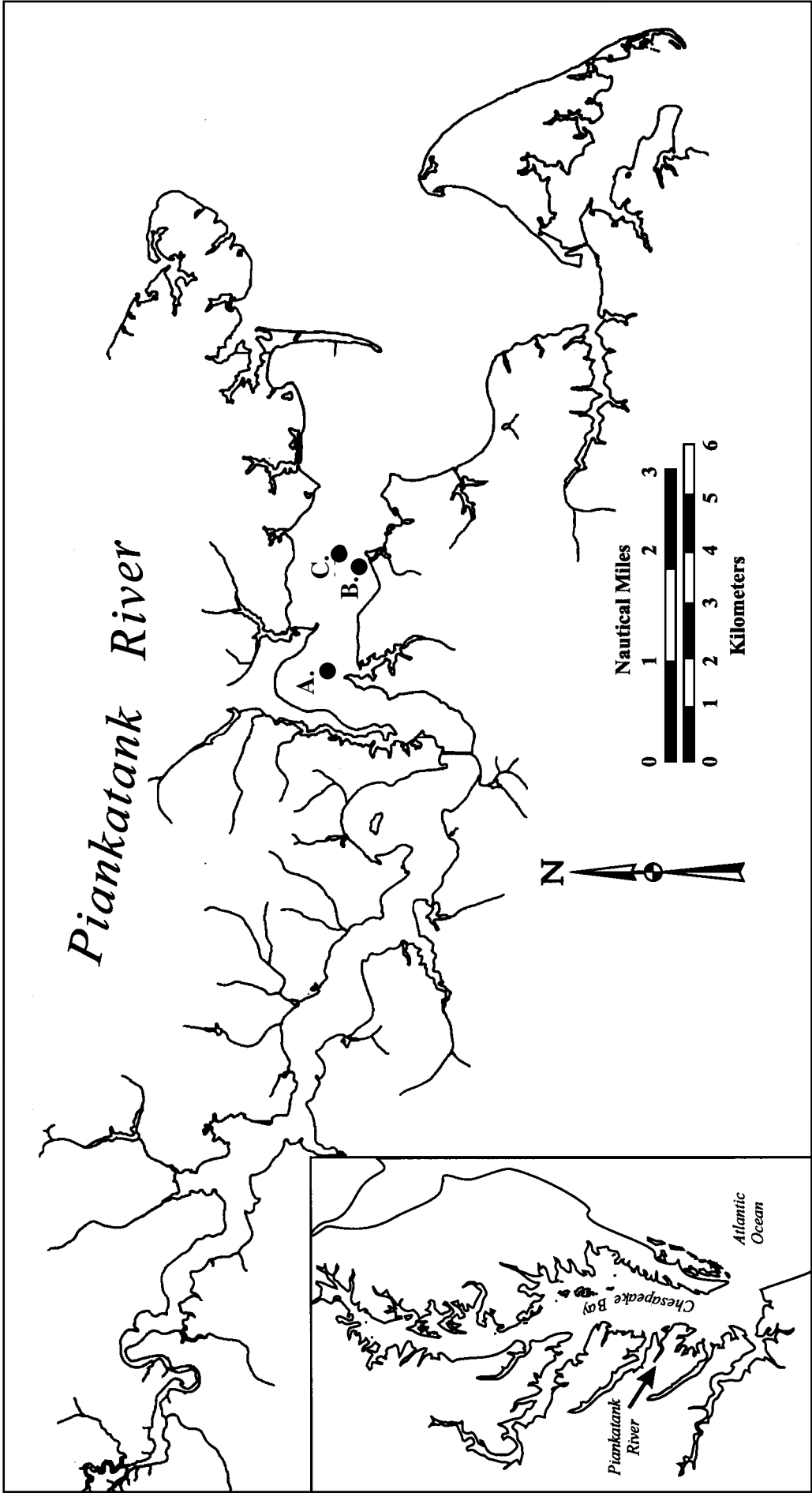


Figure 2: Average annual spatfall for 1967-97 (\pm standard error) recorded at Palace Bar Piankatank River, Virginia. Data provided courtesy of the VIMS Molluscan Ecology program.

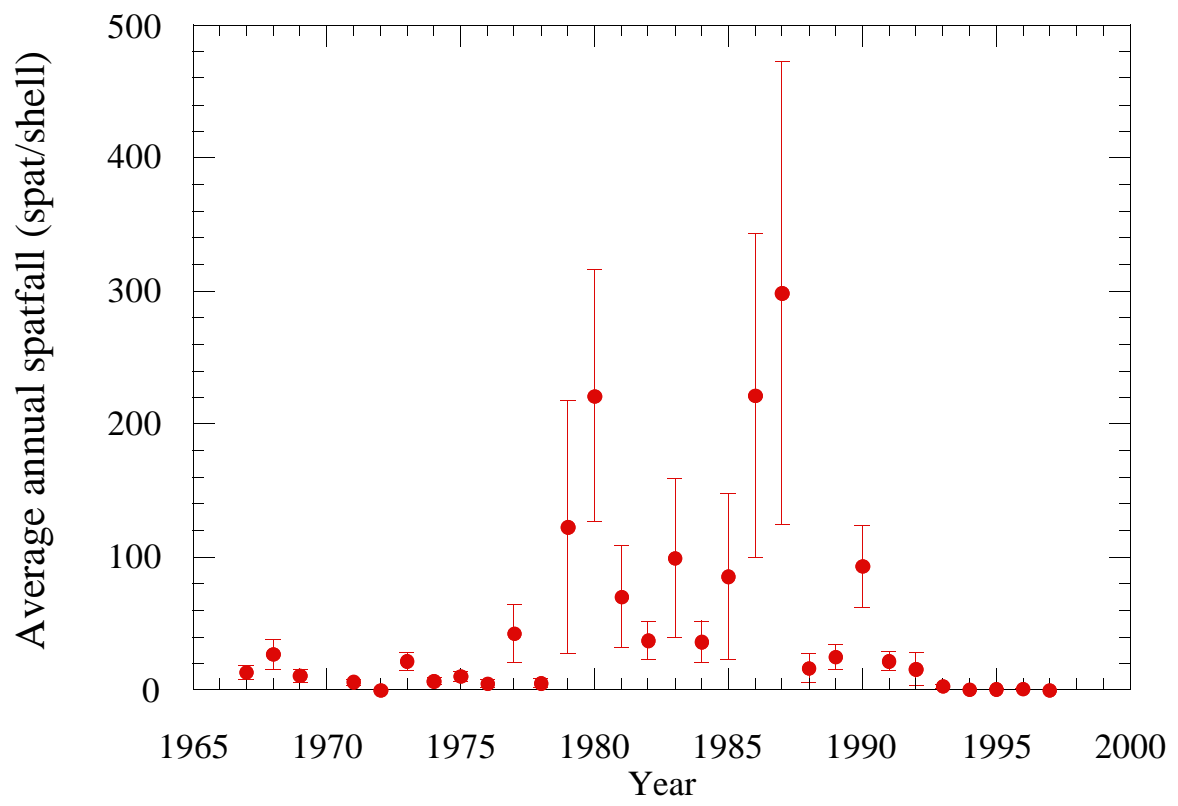


Figure 3: Average annual oyster abundance (1946-97) recorded through dredge surveys of Palace Bar Piankatank River, Virginia. Data for both small and market oysters are presented courtesy of the VIMS Molluscan Ecology program.

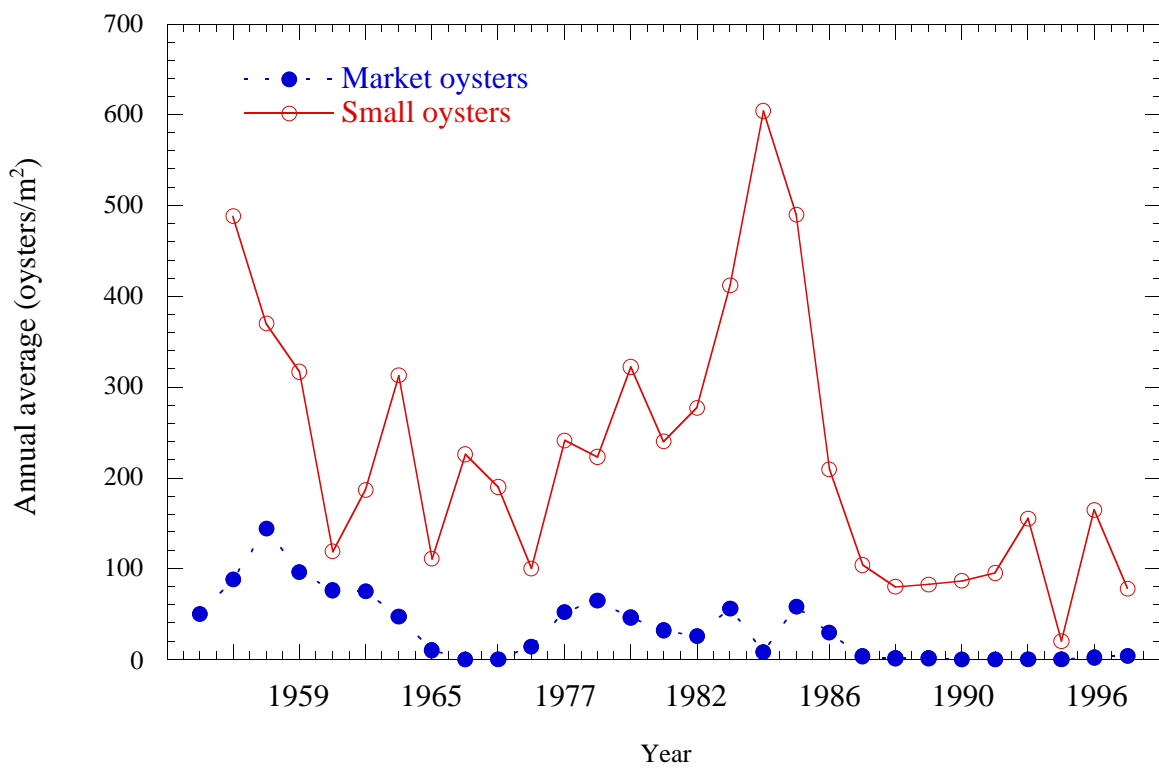


Figure 4: Mean salinity and water temperature values (\pm std. error) for Ginney Point and Palace Bar Reef Piankatank River, Virginia from May to October in 1996 and 1997. Data from these two sites were averaged since there was no significant difference in temperature or salinity measurements between sites (ANOVA, $p < 0.05$). Reference mean values for salinity (‰, A.) and temperature ($^{\circ}\text{C}$, B.) data from 1993-95 are plotted with a solid line (\pm standard error). Data from 1996 and 1997 are indicated by lines with symbols (\pm standard error). This figure is taken from Harding and Mann (In review 1).

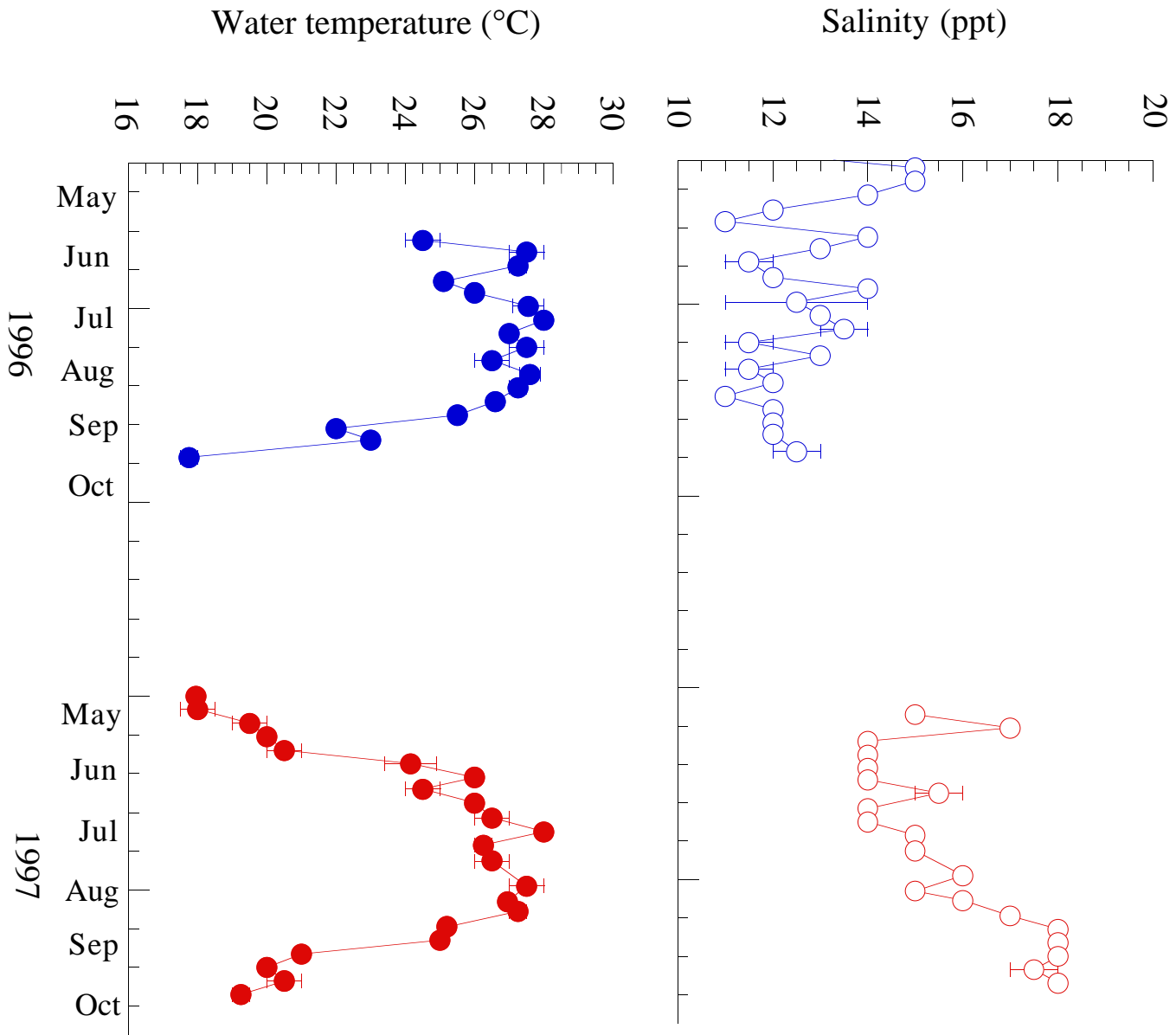
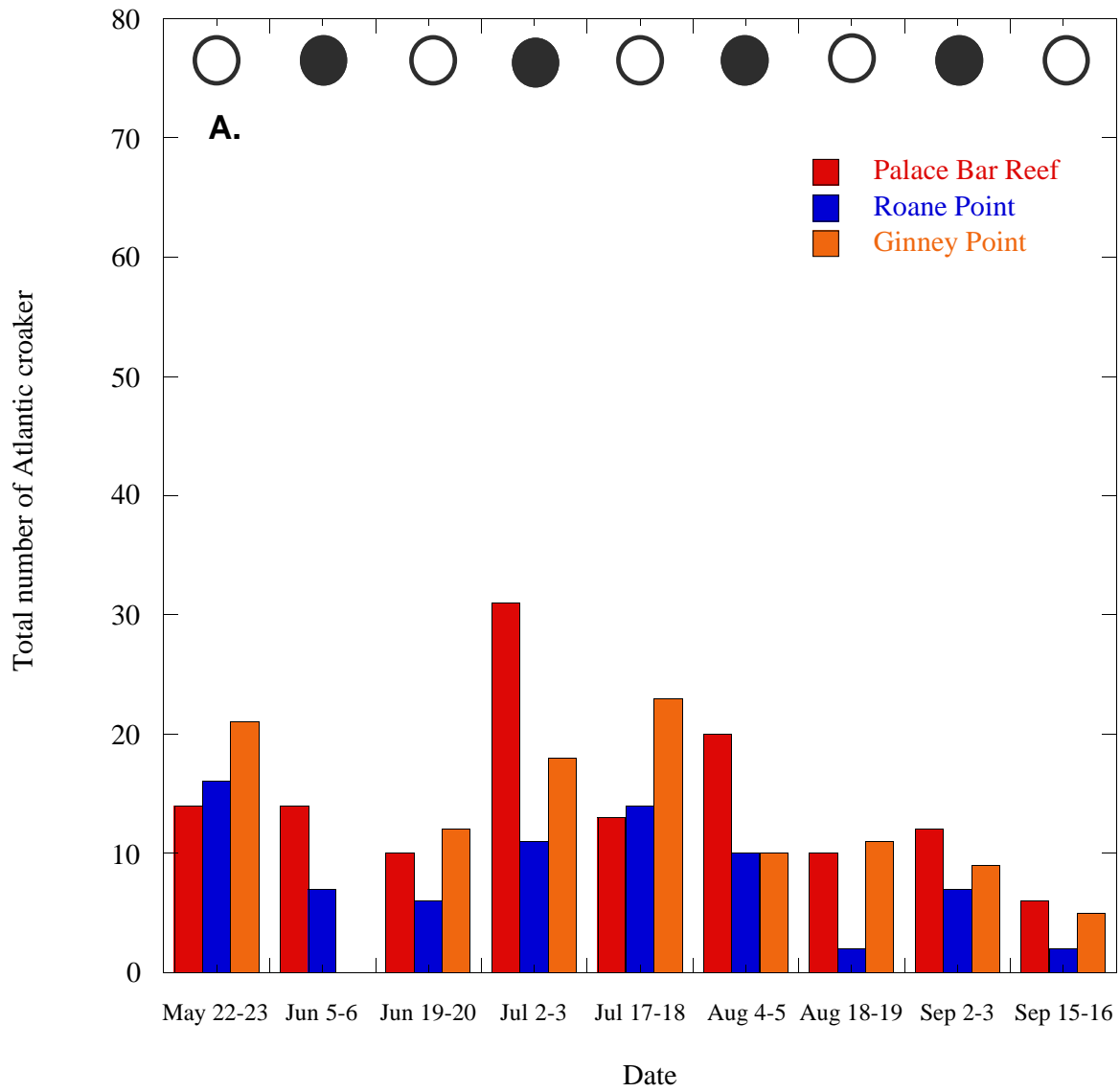
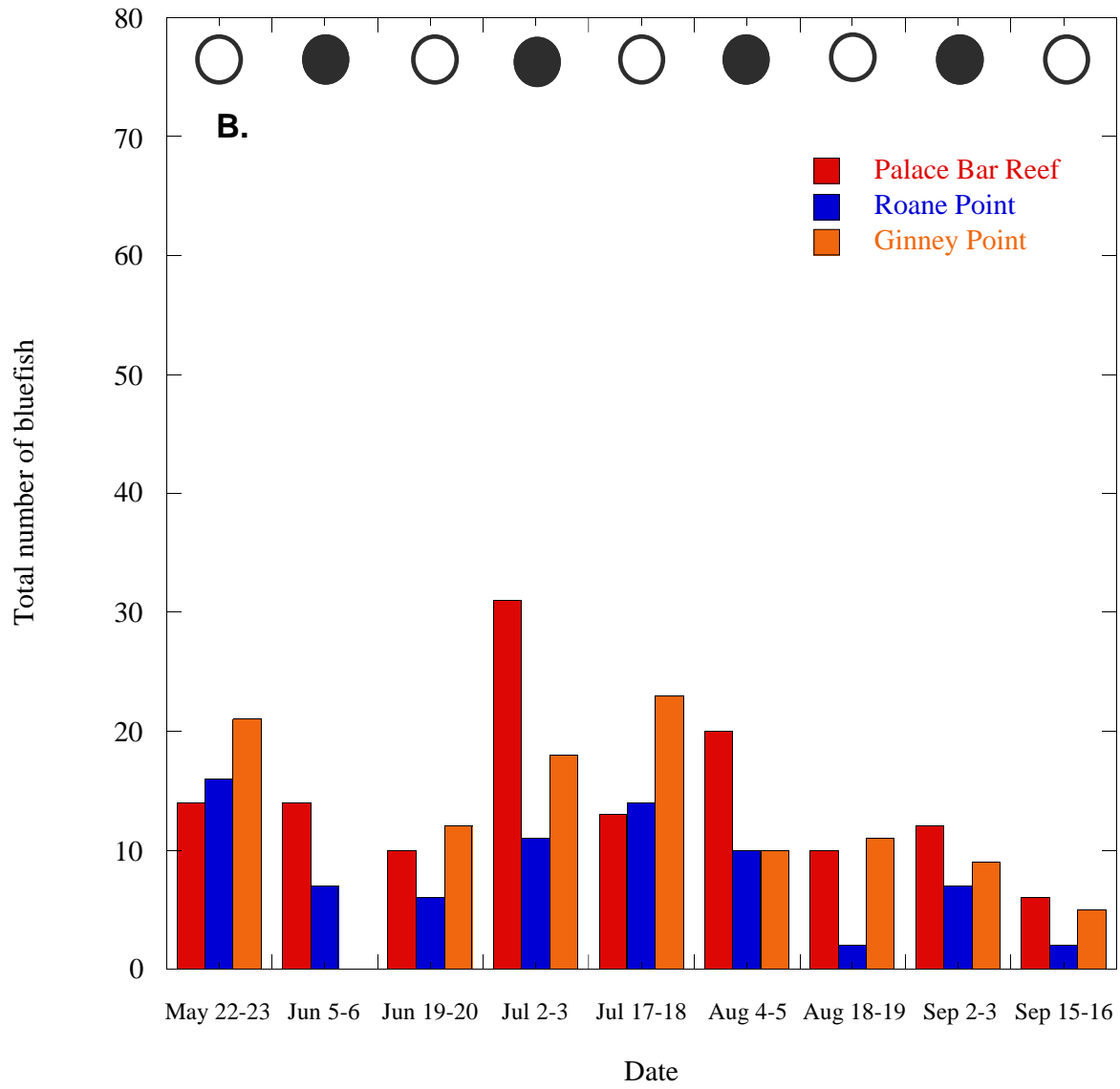
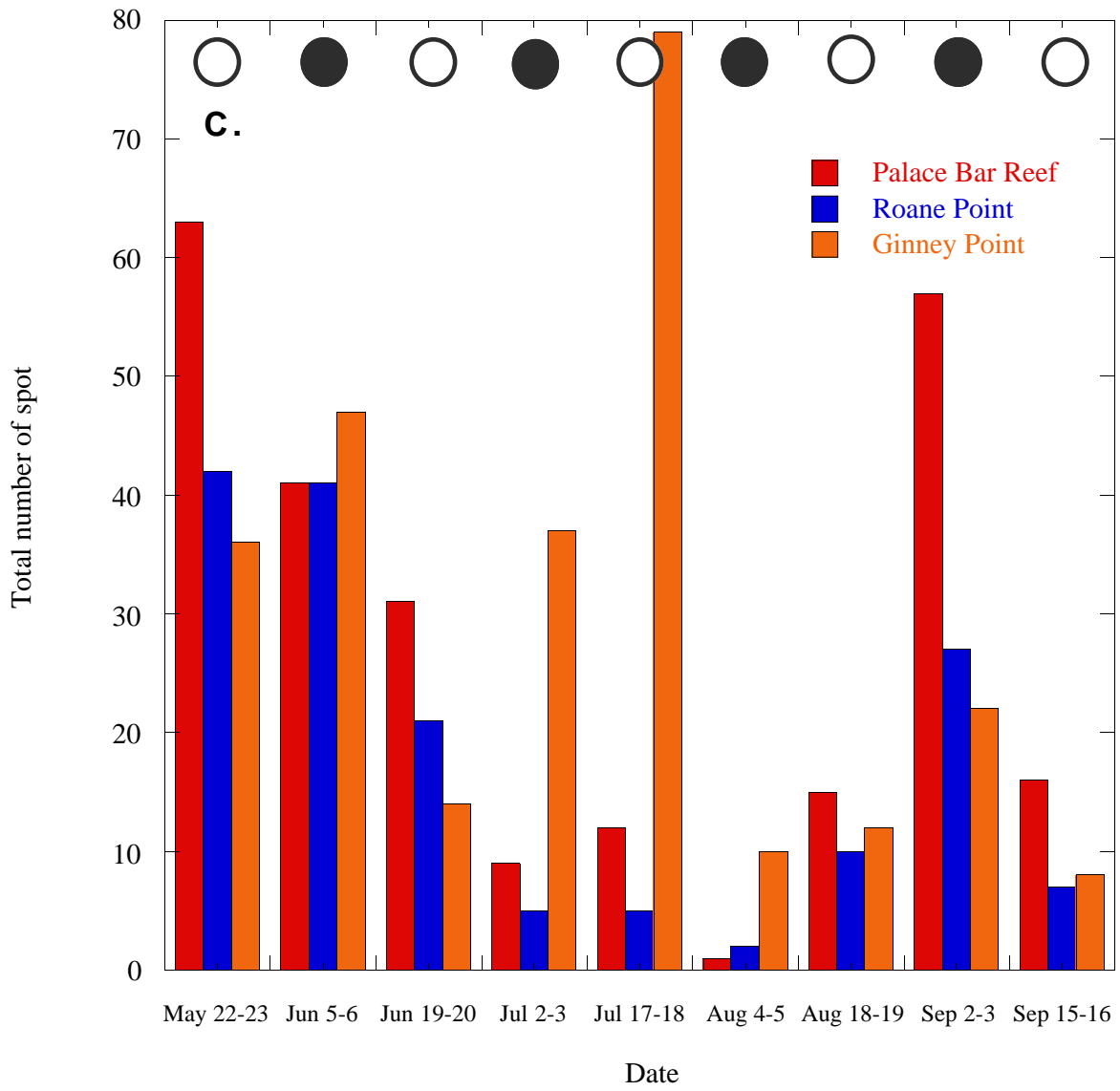


Figure 5: Total abundance of the four most common pelagic fishes caught by gill netting on the Piankatank River, Virginia during the 1997 36 hour stations. Total number of fish captured during each station are presented by site for (A.) Atlantic croaker, (B.) Bluefish, (C.) Spot and (D.) Striped bass. Open circles indicate sampling stations on the full moon; closed circles represent stations completed on the new moon.







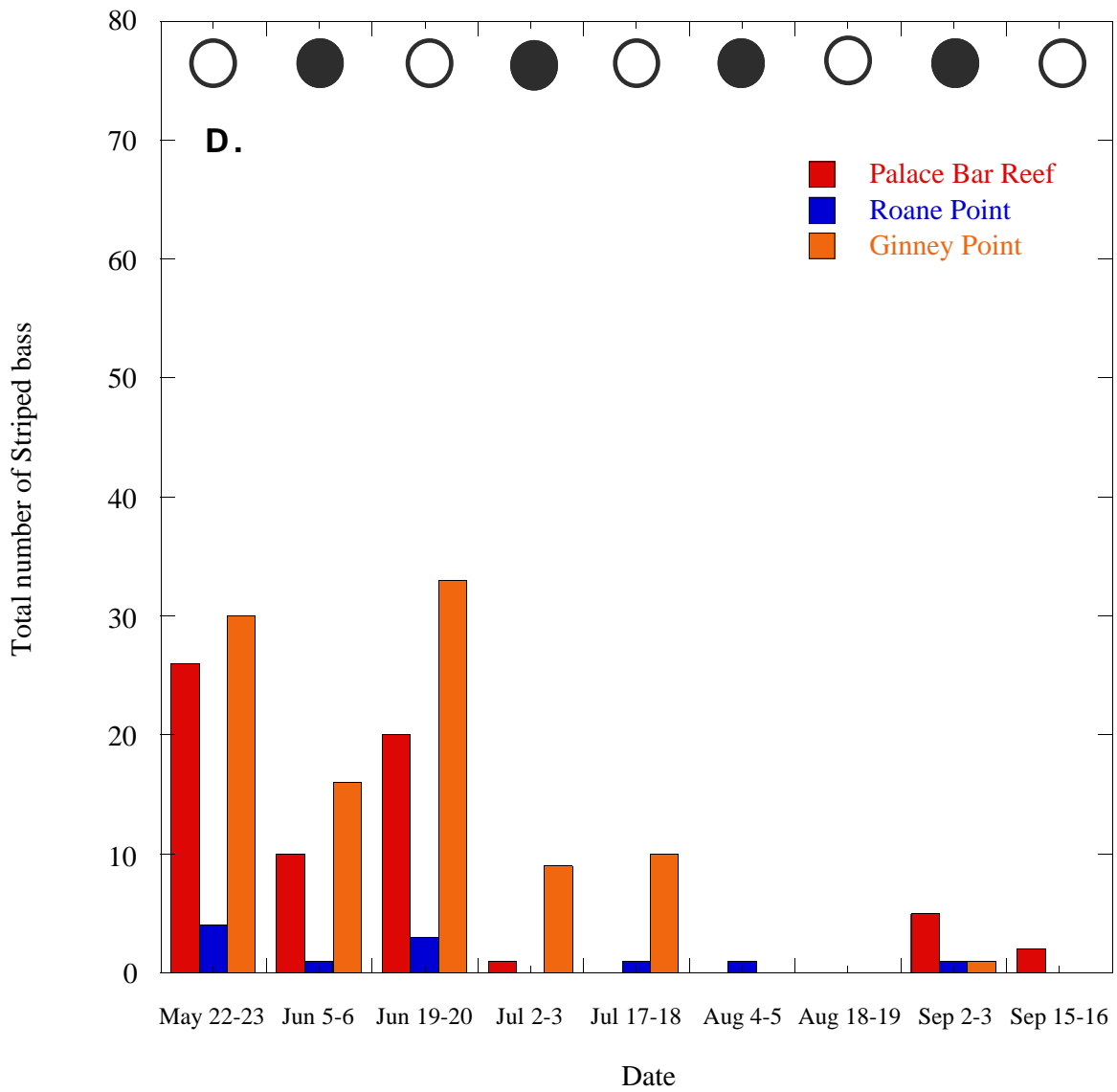


Figure 6: Summary of bluefish gut contents for fishes collected at Piankatank River sampling sites during the 1996 and 1997 field seasons. This figure is from Harding and Mann (In review 3).

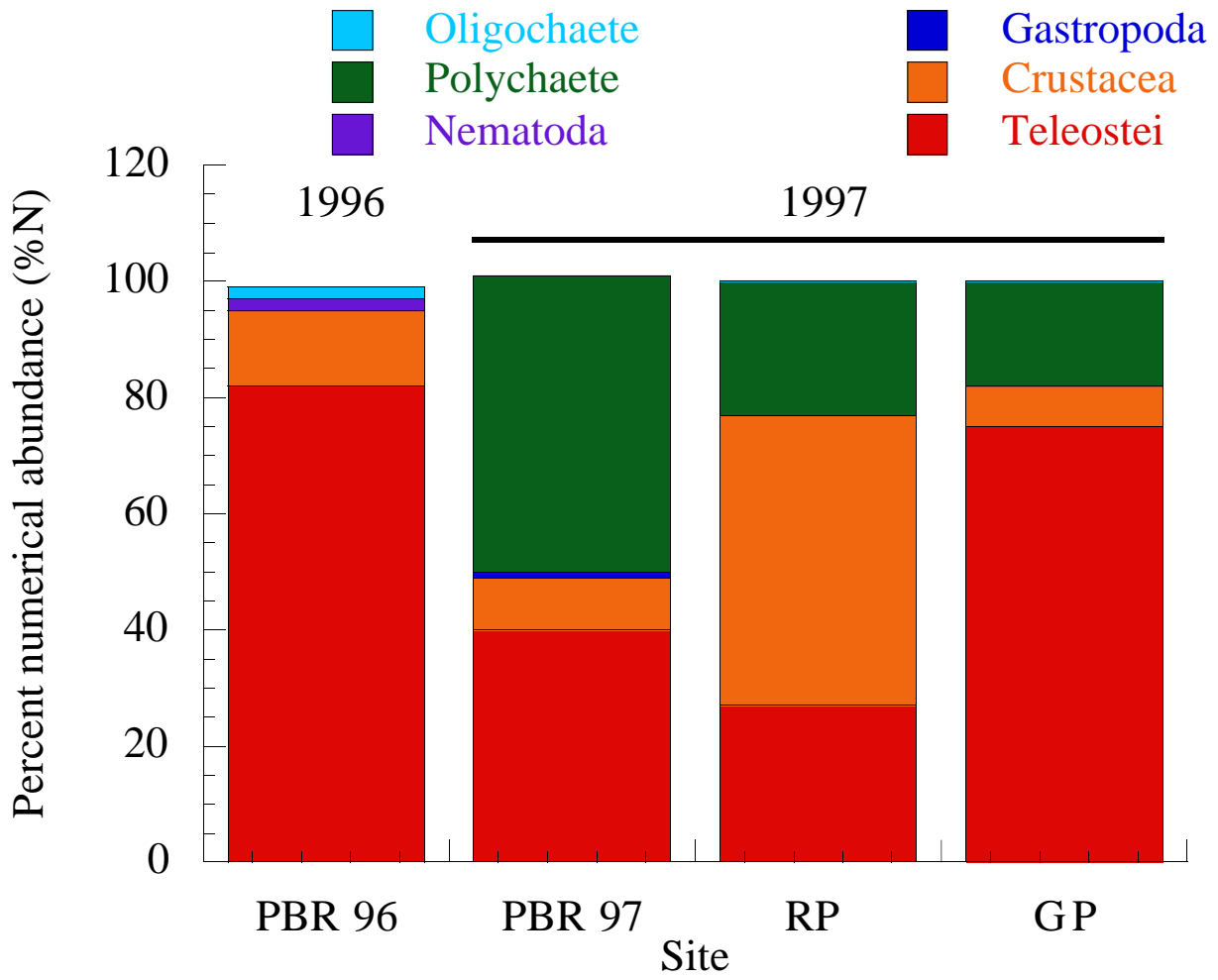


Figure 7: Total blue crab abundance by site during the 1997 field season for the Piankatank River, VA.

Total number of blue crabs

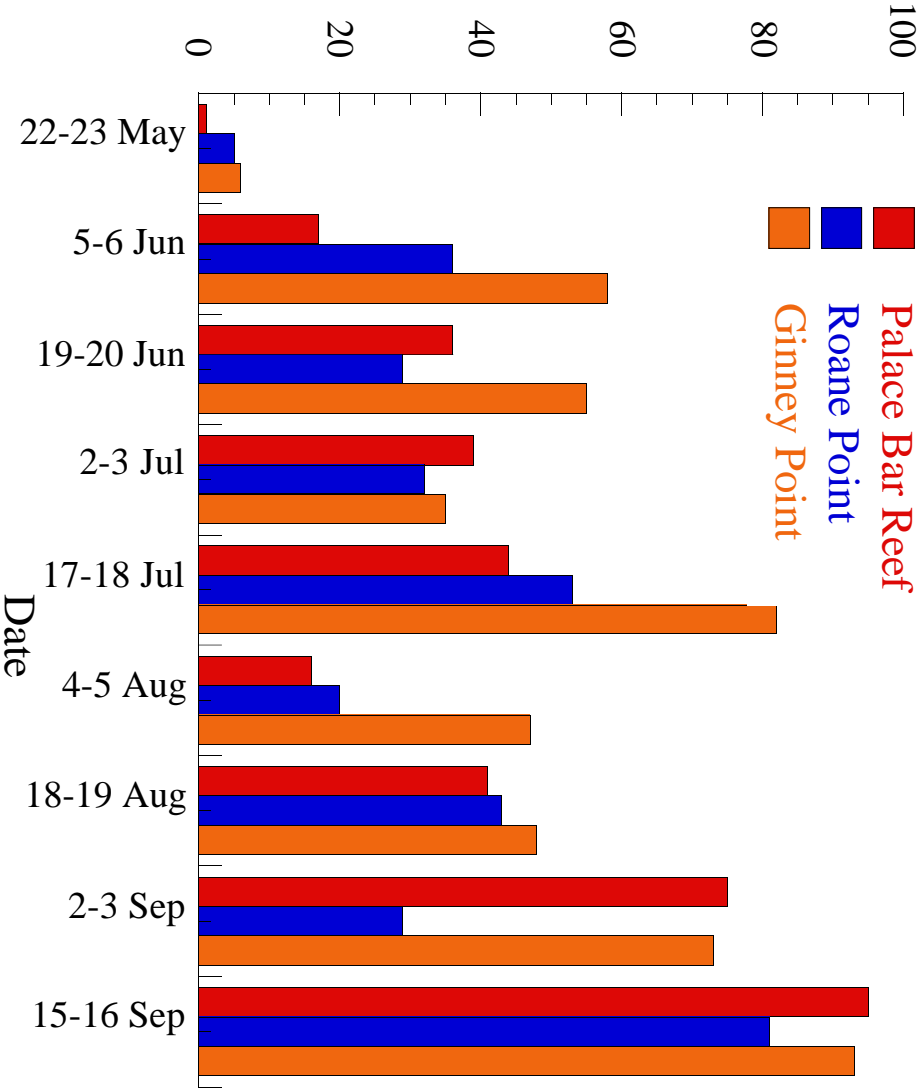
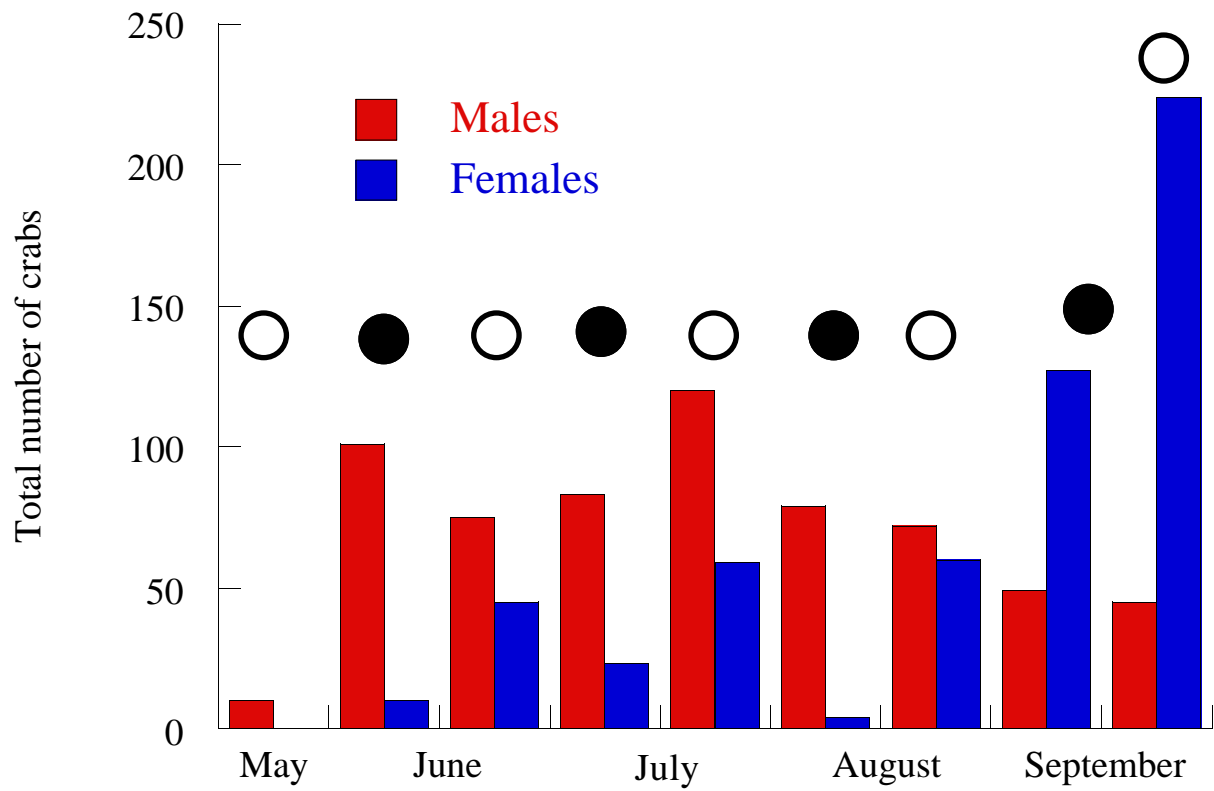


Figure 8: Total abundance of blue crabs by sex for all three Piankatank River, Virginia study sites.

Open circles indicate sampling conducted on the full moon; closed circles represent new moon sampling dates.



Appendix 1

Field schedules for 1997 Piankatank River 36 hour sampling stations

36 hour sampling stations
 Piankatank River
 May 22-23 1997

PBR = Palace Bar Reef
 RP = Roane Point
 GP = Ginney Point

Date	Time	Tidal stage	Event	
22 May	0700		Crew 1 assembles @ VIMS	
	0730		Crew 1 leaves VIMS	
	0830		Launch @ Harcum	
	0900		Set RP crab pots	
	0930		Set GP crab pots	
	1000		Set PBR crab pots	
			Take oxygen @ PBR	
	1040	Max Flood	Gill net set #1 (PRB, RP, GP)	
	1115		Take oxygen @ RP, GP	
	1200		Lunch	
	1350	Slack onto Ebb	Gill net Check #1/Set #2	
	1600		Crew change @ Harcum	
	1655	Max Ebb	GNC #2/set #3	
	1830		Pizza pick-up/water refill	
	1915		Glo stick deployment	
	1955	Slack onto Flood	GNC #3/set #4	
	Sunset	2014		
		2258	Max Flood	GNC #4/set #5
	23 May	0100		Crew change @ Admiral's
0222		Slack onto Ebb	GNC #5/set #6	
0544		Max Ebb	GNC #6/set #7	
Sunrise	0551			
	0750		Crew change @ Harcum	
	0830	Slack onto Flood	GNC #7/set #8	
	1125	Max Flood	GNC #8/set #9	
	1300		Lunch	
	1430	Slack onto Ebb	GNC #9/set #10	
	1730	Max Ebb	GNC #10	
	1900		Boat recovery @ Harcum	

36 hour sampling stations
 Piankatank River
 June 5-6 1997

PBR = Palace Bar Reef
 RP = Roane Point
 GP = Ginney Point

Date	Time	Tidal stage	Event	
5 June	0700		Crew 1 assembles @ VIMS	
	0730		Crew 1 leaves VIMS	
	0830		Launch @ Harcum	
	0900		Set RP crab pots	
	0930		Set GP crab pots	
	1000		Set PBR crab pots	
			Take oxygen @ PBR	
	1048	Max Flood	Gill net set #1 (PRB, RP, GP)	
	1115		Take oxygen @ RP, GP	
	1200		Lunch	
	1350	Slack onto Ebb	Gill net Check #1/Set #2	
	1600		Crew change @ Harcum	
	1702	Max Ebb	GNC #2/set #3	
	1830		Pizza pick-up/water refill	
	1915		Glo stick deployment	
	2002	Slack onto Flood	GNC #3/set #4	
	Sunset	2024		
		2309	Max Flood	GNC #4/set #5
	6 June	0100		Crew change @ Admiral's
0220		Slack onto Ebb	GNC #5/set #6	
Sunrise	0545			
	0551	Max Ebb	GNC #6/set #7	
	0750		Crew change @ Harcum	
	0830	Slack onto Flood	GNC #7/set #8	
	1133	Max Flood	GNC #8/set #9	
	1300		Lunch	
	1440	Slack onto Ebb	GNC #9/set #10	
	1747	Max Ebb	GNC #10	
	1900		Boat recovery @ Harcum	

36 hour sampling stations
 Piankatank River
 June 19-20 1997

PBR = Palace Bar Reef
 RP = Roane Point
 GP = Ginney Point

Date	Time	Tidal stage	Event	
19 June	0700		Crew 1 assembles @ VIMS	
	0730		Crew 1 leaves VIMS	
	0830		Launch @ Harcum	
	0930	Max Flood	Gill net set #1 (PRB, RP, GP)	
	0930		Set PBR, RP, GP crab pots	
	1230	Slack onto Ebb	Gill net Check #1/Set #2	
	1345		Lunch	
	1542	Max Ebb	GNC #2/set #3	
	1730		Crew change @ Harcum	
	1840	Slack onto Flood	GNC #3/set #4	
	2000		Glostick deployment	
	Sunset	2030		
		2149	Max Flood	GNC #4/set #5
20 June	0030		Crew change @ Admiral's	
	0115	Slack onto Ebb	GNC #5/set #6	
	0436	Max Ebb	GNC #6/set #7	
Sunrise	0545			
	0715	Slack onto Flood	GNC #7/set #8	
	0845		Crew change @ Harcum	
	1015	Max Flood	GNC #8/set #9	
	1145		Lunch	
	1330	Slack onto Ebb	GNC #9/set #10	
	1630	Max Ebb	GNC #10	
	1800		Boat recovery @ Harcum	

36 hour sampling stations
 Piankatank River
 July 2-3 1997

PBR = Palace Bar Reef
 RP = Roane Point
 GP = Ginney Point

Date	Time	Tidal stage	Event	
2 July	0600		Crew 1 assembles @ VIMS	
	0630		Crew 1 leaves VIMS	
	0745		Launch @ Harcum	
	0852	Max Flood	Gill net set #1 (PRB, RP, GP)	
	0900		Set PBR, RP, GP crab pots	
	1120	Slack onto Ebb	Gill net Check #1/Set #2	
	1200		Lunch	
	1506	Max Ebb	GNC #2/set #3	
	1700		Crew change @ Harcum	
	1800	Slack onto Flood	GNC #3/set #4	
	1945		Glostick deployment	
	Sunset	2031		
		2119	Max Flood	GNC #4/set #5
3 July	0000		Crew change @ Admiral's	
	0030	Slack onto Ebb	GNC #5/set #6	
	0402	Max Ebb	GNC #6/set #7	
Sunrise	0550			
	0630	Slack onto Flood	GNC #7/set #8	
	0900		Crew change @ Harcum	
	0942	Max Flood	GNC #8/set #9	
	1130		Lunch	
	1230	Slack onto Ebb	GNC #9/set #10	
	1555	Max Ebb	GNC #10	
	1730		Boat recovery @ Harcum	

36 hour sampling stations
 Piankatank River
 July 17-18 1997

PBR = Palace Bar Reef
 RP = Roane Point
 GP = Ginney Point

Date	Time	Tidal stage	Event	
17 July	0600		Crew 1 assembles @ VIMS	
	0630		Crew 1 leaves VIMS	
	0745		Launch @ Harcum	
	0806	Max Flood	Gill net set #1 (PRB, RP, GP)	
	0900		Set PBR, RP, GP crab pots	
	1110	Slack onto Ebb	Gill net Check #1/Set #2	
	1200		Lunch	
	1422	Max Ebb	GNC #2/set #3	
	1645		Crew change @ Harcum	
	1720	Slack onto Flood	GNC #3/set #4	
	1945		Glostick deployment	
	Sunset	2026		
		2030	Max Flood	GNC #4/set #5
2330			Crew change @ Admiral's	
18 July	0010	Slack onto Ebb	GNC #5/set #6	
	0322	Max Ebb	GNC #6/set #7	
Sunrise	0559			
	0630	Slack onto Flood	GNC #7/set #8	
	0830		Crew change @ Harcum	
	0900	Max Flood	GNC #8/set #9	
	1130		Lunch	
	1210	Slack onto Ebb	GNC #9/set #10	
	1516	Max Ebb	GNC #10	
	1730		Boat recovery @ Harcum	

36 hour sampling stations
 Piankatank River
 August 4-5 1997

PBR = Palace Bar Reef
 RP = Roane Point
 GP = Ginney Point

Date	Time	Tidal stage	Event	
4 August	0630		Crew 1 assembles @ VIMS	
	0700		Crew 1 leaves VIMS	
	0745		Launch @ Harcum	
	0830	Slack onto Flood	Gill net set #1 (PRB, RP, GP)	
	0900		Set PBR, RP, GP crab pots	
	1127	Max Flood	Gill net Check #1/Set #2	
	1200		Lunch	
	1435	Slack onto Ebb	GNC #2/set #3	
	1700		Crew change @ Harcum	
	1745	Max Ebb	GNC #3/set #4	
	1945		Glostick deployment	
	Sunset	2011		
		2040	Slack onto Flood	GNC #4/set #5
2340		Max Flood	GNC #5/set #6	
5 August	0130		Crew change @ Admiral's	
	0315	Slack onto Ebb	GNC #6/set #7	
Sunrise	0614			
	0616	Max Ebb	GNC #7/set #8	
	0845		Crew change @ Harcum	
	0910	Slack onto Flood	GNC #8/set #9	
	1130		Lunch	
	1200	Max Flood	GNC #9/set #10	
	1510	Slack onto Ebb	GNC #10	
	1730		Boat recovery @ Harcum	

36 hour sampling stations
 Piankatank River
 August 18-19 1997

PBR = Palace Bar Reef
 RP = Roane Point
 GP = Ginney Point

Date	Time	Tidal stage	Event	
18 August	0800		Crew 1 assembles @ VIMS	
	0830		Crew 1 leaves VIMS	
	1000		Launch @ Harcum	
	1030	Max Flood	Gill net set #1 (PRB, RP, GP)	
	1100		Set PBR, RP, GP crab pots	
	1245		Lunch	
	1335	Slack onto Ebb	Gill net Check #1/Set #2	
	1648	Max Ebb	GNC #2/set #3	
	1825		Crew change @ Harcum	
	1900		Glostick deployment	
	1940	Slack onto Flood	GNC #3/set #4	
	Sunset	1954		
		2247	Max Flood	GNC #4/set #5
	19 August	0200		Crew change @ Admiral's
0215		Slack onto Ebb	GNC #5/set #6	
0522		Max Ebb	GNC #6/set #7	
Sunrise	0625			
	0820	Slack onto Flood	GNC #7/set #8	
	1000		Crew change @ Harcum	
	1115	Max Flood	GNC #8/set #9	
	1300		Lunch	
	1430	Slack onto Ebb	GNC #9/set #10	
	1742	Max Ebb	GNC #10	
	1900		Boat recovery @ Harcum	

36 hour sampling stations
 Piankatank River
 September 2-3 1997

PBR = Palace Bar Reef
 RP = Roane Point
 GP = Ginney Point

Date	Time	Tidal stage	Event	
2 September	0900		Crew 1 assembles @ VIMS	
	0930		Crew 1 leaves VIMS	
	1030		Launch @ Harcum	
	1100	Max Flood	Gill net set #1 (PRB, RP, GP)	
	1130		Set PBR, RP, GP crab pots	
	1245		Lunch	
	1410	Slack onto Ebb	Gill net Check #1/Set #2	
	1615		Crew change @ Harcum	
	1722	Max Ebb	GNC #2/set #3	
	1900		Glostick deployment	
	Sunset	1933		
		2020	Slack onto Flood	GNC #3/set #4
		2300		Crew change @ Admiral's
	2330	Max Flood	GNC #4/set #5	
3 September	0240	Slack onto Ebb	GNC #5/set #6	
	0541	Max Ebb	GNC #6/set #7	
	Sunrise	0638		
		0715		Crew change @ Harcum
		0840	Slack onto Flood	GNC #7/set #8
		1150	Max Flood	GNC #8/set #9
		1300		Lunch
		1500	Slack onto Ebb	GNC #9/set #10
		1800	Max Ebb	GNC #10
		1930		Boat recovery @ Harcum

36 hour sampling stations
 Piankatank River
 September 15-16 1997

PBR = Palace Bar Reef
 RP = Roane Point
 GP = Ginney Point

Date	Time	Tidal stage	Event	
15 September	0730		Crew 1 assembles @ VIMS	
	0745		Crew 1 leaves VIMS	
	0830		Launch @ Harcum	
	0900	Max Flood	Gill net set #1 (PRB, RP, GP)	
	1000		Set PBR, RP, GP crab pots	
	1150		Lunch	
	1220	Slack onto Ebb	Gill net Check #1/Set #2	
	1540	Max Ebb	GNC #2/set #3	
	1750		Crew change @ Harcum	
	1820	Slack onto Flood	GNC #3/set #4	
	1900		Glostick deployment	
	Sunset	1914		
	16 September	2130	Max Flood	GNC #4/set #5
0030			Crew change @ Admiral's	
0100		Slack onto Ebb	GNC #5/set #6	
0410		Max Ebb	GNC #6/set #7	
Sunrise		0649		
0705		Slack onto Flood	GNC #7/set #8	
0900			Crew change @ Harcum	
1000		Max Flood	GNC #8/set #9	
1130			Lunch	
1315		Slack onto Ebb	GNC #9/set #10	
1630	Max Ebb	GNC #10		
1745		Boat recovery @ Harcum		