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OYSTER REEFS AS FISH HABITAT: OPPORTUNISTIC USE OF RESTORED REEFS BY TRANSIENT FISHES

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ABSTRACT Under the Magnuson-Stevenson Fisheries Management Act of 1996, current fisheries management practice is focused on the concept of Essential Fish Habitat (EFH). Application of the EFH concept to estuarine habitats relates directly to ongoing oyster reef restoration efforts. Oyster reef restoration typically creates complex habitat in regions where such habitat is limited or absent. While healthy oyster reefs provide structurally and ecologically complex habitat for many other species from all trophic levels including recreationally and commercially valuable transient finfishes, additional data is required to evaluate oyster reef habitats in the context of essential fish habitat. Patterns of transient fish species richness, abundance, and size-specific habitat use were examined along an estuarine habitat gradient from complex reef habitat through simple sand bottom in the Piankatank River, Virginia. There was no clear delineation of habitat use by transient fishes along this cline of estuarine habitat types (oyster reef to sand bar). Atlantic croaker (*Micropogonias undulatus*), Atlantic menhaden (*Brevoortia tyrannus*), bluefish (*Pomatomus saltatrix*), silver perch (*Bairdiella chrysoura*), spot (*Leiostomus xanthurus*), spotted seatrout (*Cynoscion regalis*), striped bass (*Morone saxatilis*), and weakfish (*Cynoscion nebulosus*) were found in all habitat types examined. In general, the smallest fish were found on the sand bar, the site with the least habitat heterogeneity. As habitat complexity increased along the gradient from oyster shell bar through oyster reef, transient fish size and abundance increased. Opportunistic habitat use by this suite of generalists relates variations in habitat quality as related to habitat-specific productivity and suggests that oyster reefs may be important but not essential habitat for these fishes.

KEY WORDS: habitat use, essential fish habitat, oyster reef, transient fish, Chesapeake Bay

INTRODUCTION

There is growing recognition by government and management agencies of the importance of habitat to maintenance and sustenance of marine fishery species. The Magnuson-Stevens Fishery Conservation and Management Act of 1996 (Public Law 94-265) as amended by the Sustainable Fisheries Act established the concept of Essential Fish Habitat and provided for the management and protection of such habitat under the auspices of the National Marine Fisheries Service (Benaka 1999). Essential Fish Habitat (EFH) was defined as "those waters and substrate necessary for fish for spawning, feeding or growth to maturity". Under the law, "finfish, molluscs, crustaceans, and all other forms of marine animal and plant life other than marine mammals and birds" are protected. While protection of marine habitats is certainly needed, the scale of the Magnuson-Stevens Act, as established by its terminology, renders application of the law on a practical level next to impossible. The Magnuson-Stevens Act provides a means to classify fish habitats as essential (absolutely necessary per Webster's Dictionary 1983) but offers no opportunities to distinguish gradations in fish habitat quality. Functionally, the only habitat absolutely necessary for fish is reasonably clean water.

As restoration efforts in Chesapeake Bay and other estuaries continue to focus on oyster reef reconstruction and rehabilitation, the nature and importance of oyster reefs as habitat (the place where an animal lives sensu Odum 1971) bears further investigation. Oyster reefs, three dimensional structures created and maintained by living oysters (*Crassostrea virginica*), were historically a principal habitat type in shallow portions of estuaries such as Chesapeake Bay. The chronic decline of oyster populations in the 20th century due to a combination of overfishing, disease, and habitat degradation has reduced oyster populations and virtually eliminated natural oyster reef structures in Chesapeake Bay (Hargis 1999). Oyster reefs are ecologically valuable as habitat for oysters as well as a diverse suite of resident benthic fauna (e.g., oysters, barnacles, mussels, polychaetes, crabs, naked gobies (*Gobiosoma bosc*); Wells 1961, Bahr & Lanier 1981, Meyer & Townsend 2000) and recreationally and commercially valuable transient fishes (e.g., striped bass (*Morone saxatilis*), bluefish (Pomatomus saltatrix), Atlantic croaker (*Micropogonias undulatus*), spot (*Leiostomus xanthurus*); Breitburg 1999, Coen et al. 1999, Harding & Mann 1999, Posey et al. 1999).

The ecological function of oyster reef habitats is dependent upon both structural and ecological features inherent in living reef communities, namely the oyster's benthic-pelagic coupling capabilities and the resulting production of hard shell substrate (Coen et al. 1999, Mann 2000, Coen & Luckenbach 2000). Restored oyster reef communities should follow an ecological progression towards climax or stability in numbers and species (Sale 1980) over time. Various measures of reef community development have been proposed including abundance of adult oysters in relation to local (within 1 km) natural (not restored) oyster populations (Harding & Mann 1999) and larval production in relation to adult abundances for primary and secondary trophic levels of reef residents (Harding & Mann 2000).

There is merit in examining the use of restored oyster reef habitat by transient finfish particularly in relation to local non-reef habitats. Burchmore et al. (1985), Breitburg (1999), and Harding and Mann (1999) describe transient reef fishes as mobile schooling species that are found over a wide range of habitats including reefs. Descriptions of fish species richness in relation to oyster reefs have been made by Wenner et al. (1996), Nestlerode et al. (1998), Coen et al. (1999), Harding and Mann (1999), Minello (1999) and Posey et al. (1999) with the continuing observation that oyster reefs are home to diverse assemblages of transient fishes.

National Marine Fisheries Service guidelines (62 FR 66531, 1997) suggest delineation of EFH in light of four hierarchical information levels (Minello 1999): presence/absence data (Level 1), distribution and abundance (density) information (Level 2), functional relationships between species and habitats: reproduc-

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*Corresponding author. E-mail: jharding@vims.edu tion, growth, and survival (Level 3), and habitat-specific fish production (Level 4). Current designations of habitat as EFH rely on basic information as provided by Level 1 and 2 in the absence of comprehensive data sets addressing information Levels 3 and 4 (Able 1999, Minello 1999). The objectives of this paper are to compare the transient finfish assemblages associated with a gradient of habitats ranging from hard sand bottom to oyster reef within the same estuary and relate the observed patterns of species richness (Level 1), abundance (Level 2), and size-specific habitat use (Level 3) to habitat classifications sensu EFH.

Study Site

Field work was conducted in the Piankatank River, Virginia at three sites (Fig. 1): Palace Bar oyster reef, an oyster shell bar (Ginney Point), and a sand bar (Roane Point). Palace Bar reef is an intertidal oyster reef (210 × 30 m, reef depth range of 0.5 m above mean low water (MLW) to 3 m below MLW) adjacent to the historic Palace Bar oyster grounds. Palace Bar reef was built in 1993 by the Virginia Marine Resources Commission (VMRC) Shellfish Replenishment program as a series of 18 shell mounds centered on and around an east-west centerline 300 m long (Mann et al. 1996). Approximately 70% of the reef (0.63 ha) is composed of oyster shell, while the remaining area (0.27 ha) is crushed clam shell. Palace Bar reef has supported oyster densities similar to those observed on natural (i.e., not constructed) oyster bars in the Piankatank River since 1997 (Harding & Mann 1999, R. Mann, unpublished data). The Ginney Point site is a flat oyster shell bar with a depth range of 2.5–3 m below MLW (Fig. 1). The Roane Point site includes a sand bar (depth range 1.5–2 m below MLW) south and inshore of Palace Bar reef (Fig. 1). Mean tidal range in the Piankatank River is approximately 0.4 m and maximum tidal current at these sites is approximately 0.12 m^{-s} (Chen et al. 1977).

MATERIALS AND METHODS

Transient fishes were sampled using multi-panel experimental gill nets (one 30.5 m × 1.8 m and two 30.5 m × 3.0 m nets all with one 7.6 m panel each of stretch square mesh monofilament of 57.2, 63.5, 73.0, and 76.2 mm) deployed such that the entire water column was sampled (e.g., the smallest net at Roane Point, the shallowest site). Nets were deployed in a straight line parallel to tidal flow at each site. All fishes were removed from the gill nets identified, sacrificed, and measured (total length to the nearest mm) resulting in species-specific presence/absence, abundance, and size estimates across a gradient of habitat types (oyster reef to sand bar).

Transient fishes were collected during 8 thirty-six hour sampling events completed from May through September on the new and full moon (May 22–23, June 5–6, June 19–20, July 2–3, July 17–18, August 4–5, August 18–19, and September 2–3, 1997). Sampling periodicity incorporated complete diurnal and tidal cycles as well as seasonal progression. During each sampling sequence, reef and non-reef sites were sampled at three-hour intervals corresponding to changes in tidal stage for thirty-six consecutive hours. Water temperature and salinity were recorded weekly from May through September 1997 at Ginney Point and Palace Bar reef (Fig. 2).

Data Analyses

Significance levels for all statistical tests were established at $p = 0.05$ *a priori*. Bartlett's test for homogeneity of variance and the Ryan-Joiner test for normality were used prior to parametric analyses. When appropriate, Tukey's tests were used for post-hoc multiple comparisons.

Piankatank River Temperature and Salinity Data

Water temperature and salinity data for Ginney Point and Palace Bar reef were transformed (natural logarithm) to meet the assumptions of homogeneity of variance and normality prior to analyses with ANOVA.

Species-specific Abundance Data

Only the six species that were numerically dominant ($n > 5$ individuals per station for each of the three sites) were used in these analyses. For each species, the number of fish caught per gill net deployment were compared with an ANOVA using site, day of the year, and time of day as factors. Data for bluefish, striped bass, and weakfish met both the assumptions of homogeneity of variance and normality after transformation with the reciprocal transformation (Zar 1996). Data for croaker and spot satisfied the assumptions of homogeneity of variance and normality after logarithmic transformation. Counts for Atlantic menhaden satisfied the assumption of homogeneity of variance with the reciprocal transformation but not normality regardless of the transformation (log + 1, ln + 1, sqrt + 1, reciprocal).

Fish Assemblage-Habitat Relationships

Transient fish species abundance associations were compared across sites using detrended correspondence analysis (DCA). DCA was used as a descriptive tool to characterize the fish assemblages observed at each site on the basis of abundance. DCA ordinations spatially aggregate similar samples and separate dissimilar ones on the basis of species abundances within a sample. All DCA analyses (CANOCO for Windows version 4.0 1998) were detrended with second order polynomials (per ter Braak 1995) to avoid potential loss of gradient information during the detrending procedure (Minchin 1987). Species-samples biplots were made using CANODRAW software (version 3.1, Similauer 1998).

Species-specific Length Data

Total lengths (mm) for the six numerically dominant species were compared with species-specific one-way ANOVAs using site as a factor.

RESULTS

Analyses

Piankatank River Temperature and Salinity Data

Neither water temperatures nor salinity values were significantly different among sampling sites in 1997 (ANOVA, $p < 0.05$). Water temperature and salinity conditions observed in the Piankatank River during 1997 were similar to those observed during 1993–96 (Fig. 2, R. Mann, unpublished data).

Species-specific Abundance Data

Fourteen different transient fish species were observed in gill net collections from Palace Bar reef (Table 1). Ten of these fourteen species were observed at Ginney Point (oyster shell bar) and nine were observed at Roane Point (sand bar). Atlantic croaker, Atlantic menhaden, bluefish, spot, striped bass, and weakfish were the most abundant fish species at all three sites (Table 1).

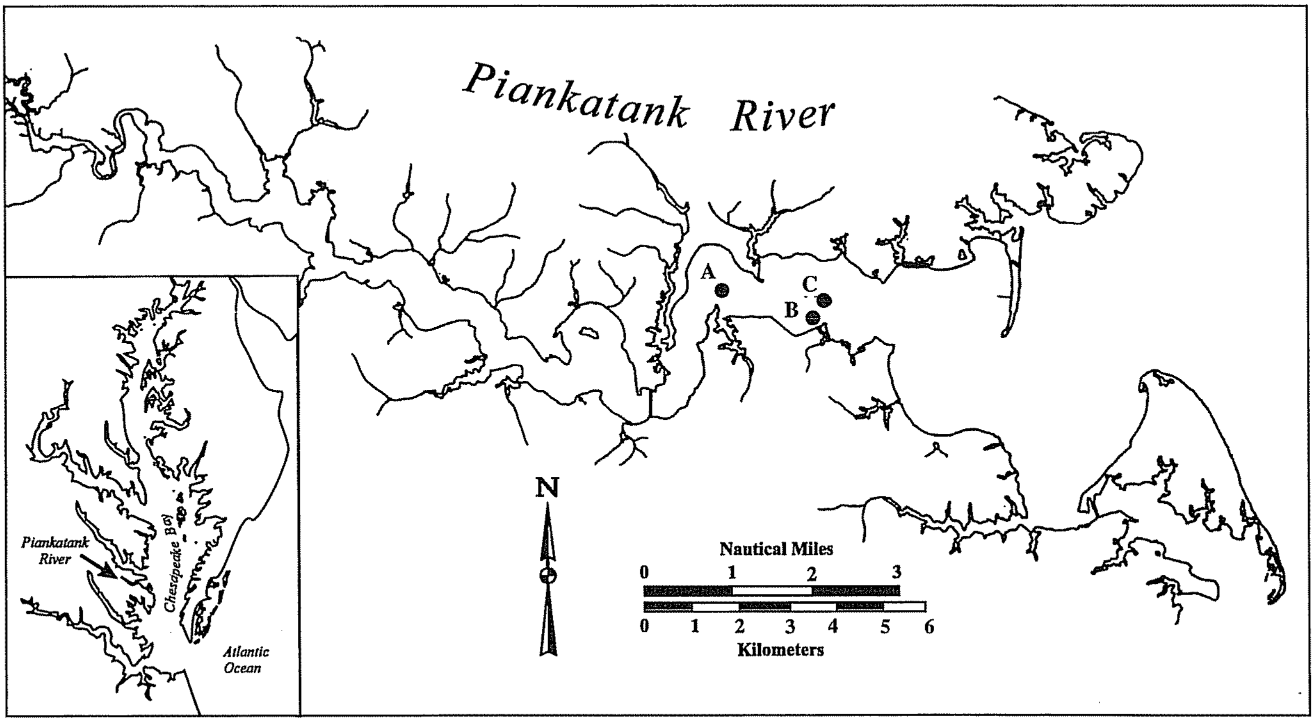

Figure 1. Map of the Piankatank River in relation to the Chesapeake Bay showing sampling locations after Harding and Mann (1999). Palace Bar reef (C), Ginney Point (an oyster shell bar, A) and Roane Point (a sand bar, B) were sampled to provide data for reef vs. non-reef habitat comparisons.

Abundances of Atlantic croaker, Atlantic menhaden, and striped bass were significantly greater at sites with oyster shell substrate (Palace Bar reef and Ginney Point) than at the sand bar site (Roane Point) but there was no significant difference in abundance of these three species between the oyster reef and the oyster bar (Table 2; ANOVA, Tukey test, $p < 0.05$; Figs. 3, 4, and 7). Bluefish were significantly more abundant at the oyster reef than at any other site (Table 2; ANOVA, Tukey test, $p < 0.05$). Spot were significantly more abundant at the oyster bar than at either the oyster reef or the sand bar (Table 2; ANOVA, Tukey test, $p < 0.05$). Weakfish abundance was low relative to the other species and similar across all three sites (Table 2; ANOVA, Tukey's test, $p < 0.05$).

In general, fish abundance increased at night across all sites. Atlantic croaker, bluefish, and spot were significantly more abundant from dusk to dawn (2000–0800) than during the day (Figs. 3, 5, 6; ANOVA, Tukey's test, $p < 0.05$). Striped bass were significantly more abundant from dusk to dawn than at mid-day (1200–1600; Fig. 7, ANOVA, Tukey test, $p < 0.05$). Atlantic menhaden and weakfish were significantly more abundant during darkness (2000–0800); abundances observed between midnight and 0400 were higher than at any other time for both menhaden and weakfish (Figs. 4 and 8; ANOVA, Tukey's test, $p < 0.05$).

Fish abundances varied seasonally. Bluefish were significantly more abundant in May and September than from June to August (Fig. 5, ANOVA, Tukey's test, $p < 0.05$). Striped bass and Atlantic menhaden were significantly more abundant in May than at any other time during the year and more abundant in late June than during late July and August (Figs. 4 and 7; ANOVA, Tukey's test, $p < 0.05$). Weakfish were significantly more abundant in late July (Fig. 8, ANOVA, Tukey's test, $p < 0.05$). Atlantic croaker abundance was significantly greater during July and early August while

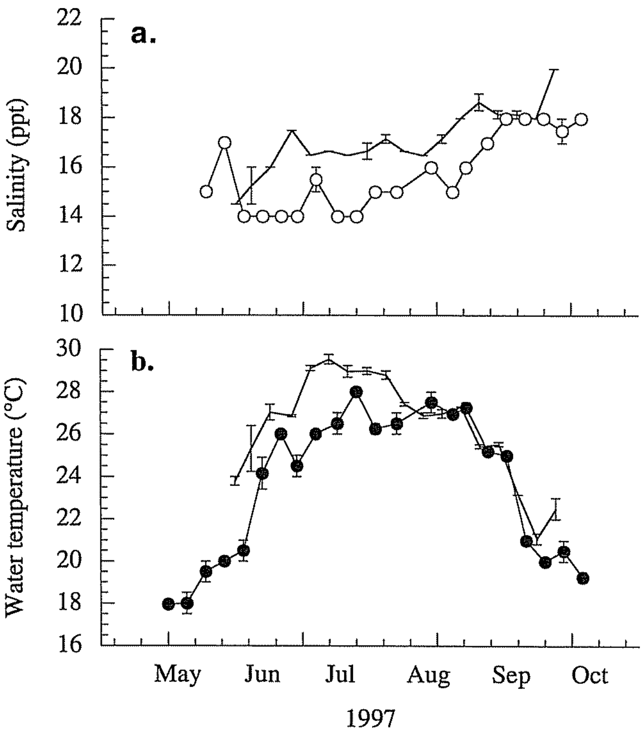

Figure 2. a-Mean salinity (ppt) and b-water temperature (°C) values (±standard error) for Ginney Point and Palace Bar reef, Piankatank River, Virginia from May through September 1997 after Harding and Mann (2001). Data from these two sites were averaged since there was no significant difference in temperature or salinity between sites (ANOVA, $p < 0.05$). Reference mean values for temperature and salinity data from 1993–1996 are plotted with a solid line (± standard error), 1997 data are indicated by lines with symbols (± standard error).

TABLE 1.

Total number of transient fish species collected with gill nets at Palace Bar oyster reef, Ginney Point (oyster bar), and Roane Point (sand bar), Piankatank River, Virginia during 8 thirty-six-hour stations conducted from May 22 to September 3, 1997.

Common Name	Scientific Name	Palace Bar Reef	Ginney Point	Roane Point
Atlantic croaker	*Micropogonias undulatus*	121	120	70
Atlantic menhaden	*Brevoortia tyrannus*	480	455	195
Bluefish	*Pomatomus saltatrix*	65	35	20
Spot	*Leiostomus xanthurus*	221	258	150
Striped bass	*Morone saxatilis*	62	98	10
Weakfish	*Cynoscion regalis*	14	11	7
Blueback herring	*Alosa aestivalis*	3	5	4
Butterfish	*Peprilus triacanthus*	1	0	0
Cownose ray	*Rhinoptera bonasus*	1	0	0
Gizzard shad	*Dorosoma cepedianum*	1	0	0
Hog choker	*Trinectes maculatus*	3	0	0
Silver perch	*Bairdiella chyrsoura*	38	3	2
Spotted seatrout	*Cynoscion nebulosus*	4	8	4
Summer flounder	*Paralichthyes dentatus*	0	2	0

spot were significantly less abundant in August (Figs. 3 and 6; ANOVA, Tukey's test, $p < 0.05$).

Fish Assemblage-Habitat Relationships

A detrended correspondence analysis (DCA) using all samples and all species (Fig. 9) aggregated all but one of fourteen species (summer flounder) and all but two of 231 samples (the two samples containing flounder) from all three sites along a single axis virtually on top of each other. This cohesive spatial grouping indicates strong similarity of most species and samples across all sites. Axis I describes a gradient in diurnal light levels moving from left (dark) to right (light). Axis II represents a seasonal gradient in water temperatures moving from bottom (lower water temperatures) to top (warmest water temperatures). The variance explained by the axes was 21.6% (Axis I) and 38.2% (Axis II).

If rare species or species where the total number of fish observed across all three sites was less than fifteen are removed from the analysis, eight species remain (Table 1). A second DCA using only these eight species in the gill net samples (Fig. 10) shows a lack of spatial aggregation of samples by site in ordination space as would be expected by site-specific fish assemblages. Thus, the samples from all three sites show a ubiquitous distribution. Axis I represents a gradient in diurnal light levels moving from left (dark) to right (light). Axis II represents a seasonal gradient in water temperatures moving from bottom (lower water temperatures) to top (warmest water temperatures). Fishes that were more abundant from dusk to dawn during late May, June, and early September (spot, bluefish) are grouped toward the middle of the plot to the left of fishes that were more abundant from dusk to dawn in July (silver perch, weakfish; Fig. 10). Primarily nocturnal species (Atlantic menhaden and spotted seatrout) are grouped to the left (dark) side of Axis I. Striped bass were most abundant in May and early June during daylight hours as indicated by their position in the lower right corner of the plot (Fig. 10). Atlantic croaker were frequently caught between dawn and dusk during the warmer months as indicated by their position in the upper right corner of the plot (Fig. 10). The variance explained by the axes was 28.5% (Axis I) and 48.8% (Axis II).

Species-specific Length Data

Atlantic croaker, Atlantic menhaden, and striped bass observed at Palace Bar reef are significantly larger than fishes of these species observed from either the oyster bar or the sand bar (Table 3; ANOVA, Tukey's test, $p < 0.05$). Spot from the oyster bar are larger than spot from any other site (Table 3; ANOVA, Tukey's test, $p < 0.05$). Bluefish from the reef are slightly but not significantly larger than fish from other sites and weakfish from all sites are of similar length (Table 3: ANOVA, Tukey's test, $p > 0.05$).

DISCUSSION

There was no clear delineation of habitat use by transient fishes along a gradient of estuarine habitat types (oyster reef to sand bar). Atlantic croaker, Atlantic menhaden, bluefish, silver perch, spot, spotted seatrout, striped bass, and weakfish were found in all habitat types examined. The ubiquitous distribution of these common species indicates a lack of site-specific fish assemblages in these habitats. It is unreasonable to expect site-specific groupings of

TABLE 2.

Summary of ANOVA results (p-values) for species-specific abundance (number of a species collected per gill net deployment) of the six most abundant transient fish species observed in the Piankatank River in relation to site, day of the year, and time of day. Asterisks indicate results that were significant at the p < 0.05 level.

Factor	df	Atlantic Croaker	Atlantic Menhaden	Bluefish	Spot	Striped Bass	Weakfish
Site	2	0.01*	0.01*	0.02*	<0.01*	<0.01*	0.12
Day of the year	7	0.01*	<0.01*	0.02*	<0.01*	<0.01*	<0.01*
Time of day	5	<0.01*	<0.01*	<0.01*	<0.01*	0.01*	<0.01*

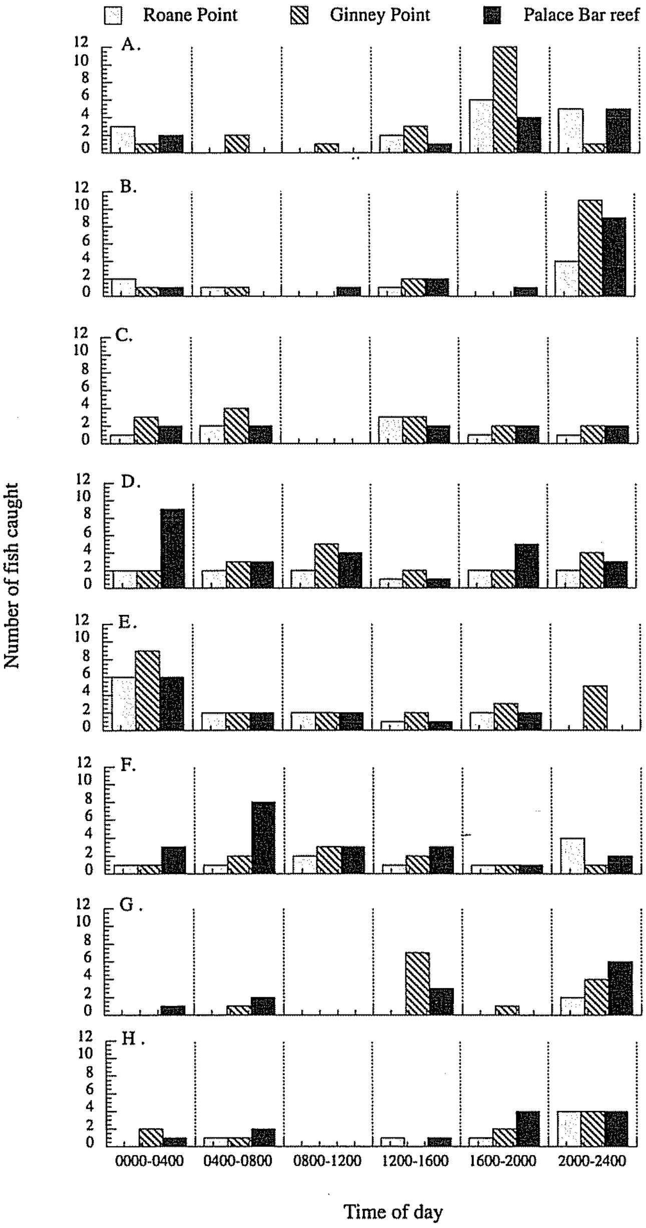

Figure 3. Species-specific abundance for Atlantic croaker in relation to time of day and day of the year for A.) May 22–23, B.) June 5–6, C.) June 19–20, D.) July 2–3, E.) July 17–18, F.) August 4–5, G.) August 18–19, and H.) September 2–3, 1997.

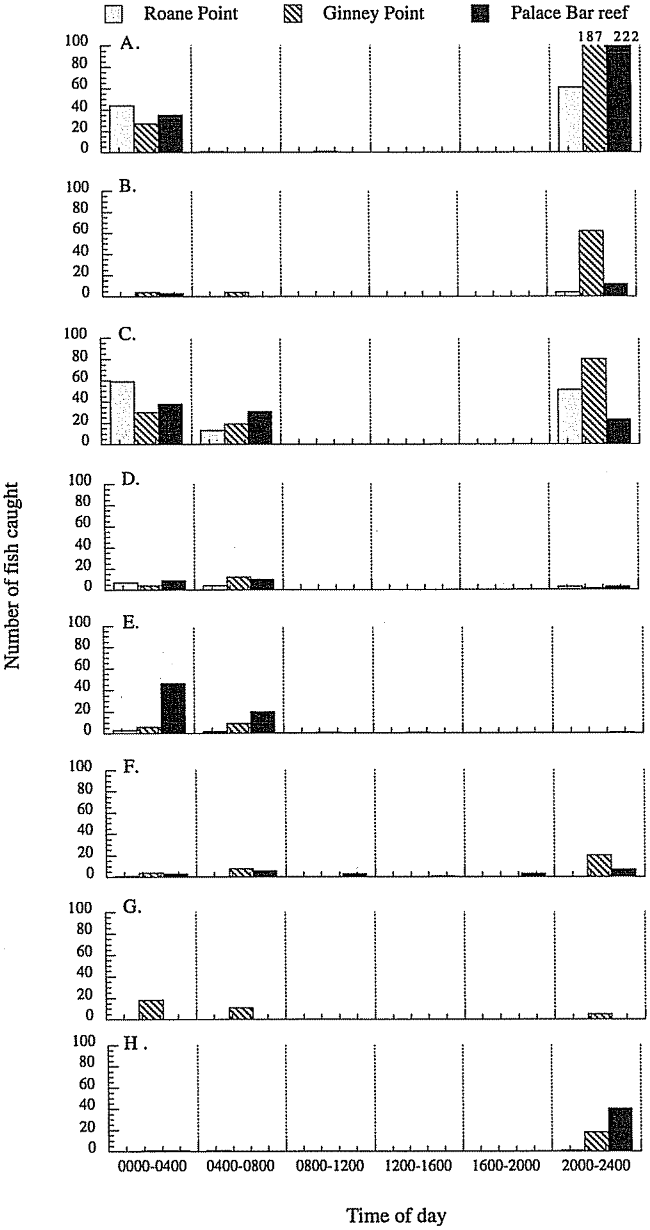

Figure 4. Species-specific abundance for Atlantic menhaden in relation to time of day and day of the year for A.) May 22–23, B.) June 5–6, C.) June 19–20, D.) July 2–3, E.) July 17–18, F.) August 4–5, G.) August 18–19, and H.) September 2–3, 1997.

generalist species such as these that are opportunistically using available habitat. It is more likely that habitat use by these eight fish species relates to variations in habitat quality indicated by habitat-specific productivity.

In general, the smallest fish are found on the sand bar, the site with the least habitat heterogeneity. As habitat complexity increases along the gradient from oyster shell bar through oyster reef, transient fish size and abundance increases. The oyster reef may have relatively higher food availability, a wider diversity of food types because of increased habitat heterogeneity, or greater abundance of high quality food relative to other habitat types. Dietary analyses on bluefish (Harding & Mann 2000) and striped bass (Harding & Mann, unpublished data) from these sites corroborate these functional relationships between reef habitats and transient fishes. Bluefish from sites with oyster shell substrate consume more teleosts than bluefish from the sand bar (Harding & Mann 2001). Bluefish from Palace Bar reef consume a wider diversity of prey items than fish from other sites (Harding & Mann 2001) while reef striped bass consumed more teleosts in general and naked gobies in particular than fish from other sites (Harding & Mann, unpublished data). In other words, the observed differences in fish abundance and size across habitat types may relate to habitat productivity as enhanced by ecological and structural complexity.

Presence/absence and abundance data from this study demonstrate that these transient finfish employ generalist lifestyle strategies (Sale 1980) and are opportunistically using the range of available habitat on a local scale. The habitats of interest herein

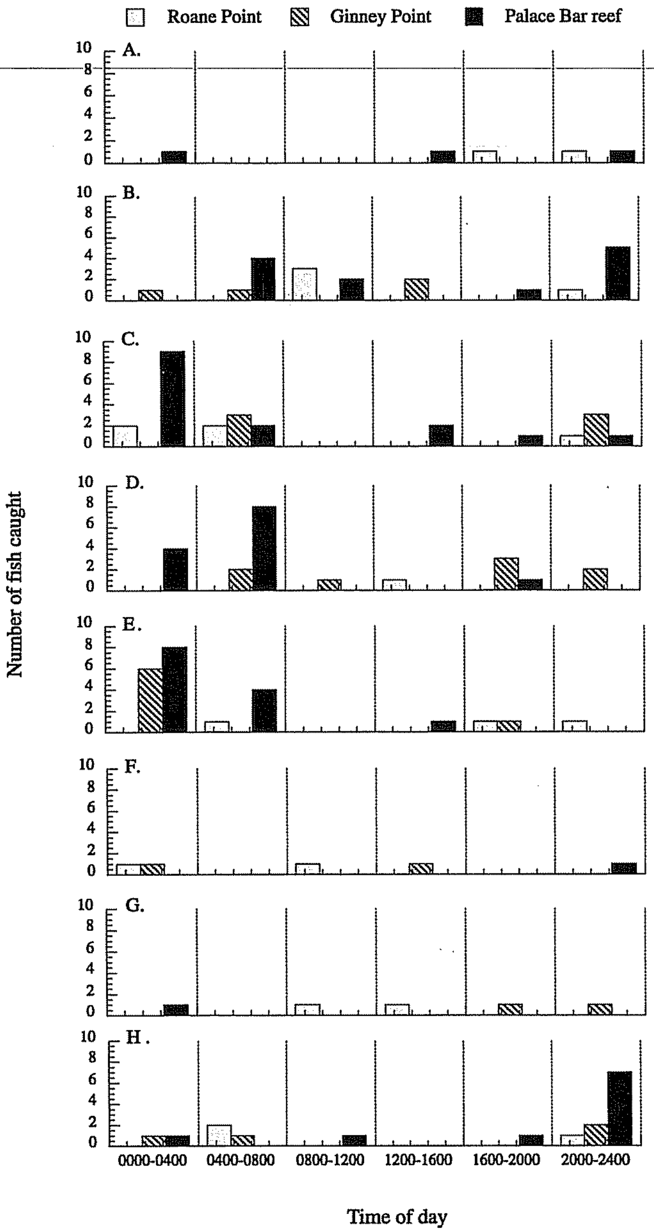

Figure 5. Species-specific abundance for bluefish in relation to time of day and day of the year for A.) May 22–23, B.) June 5–6, C.) June 19–20, D.) July 2–3, E.) July 17–18, F.) August 4–5, G.) August 18–19, and H.) September 2–3, 1997.

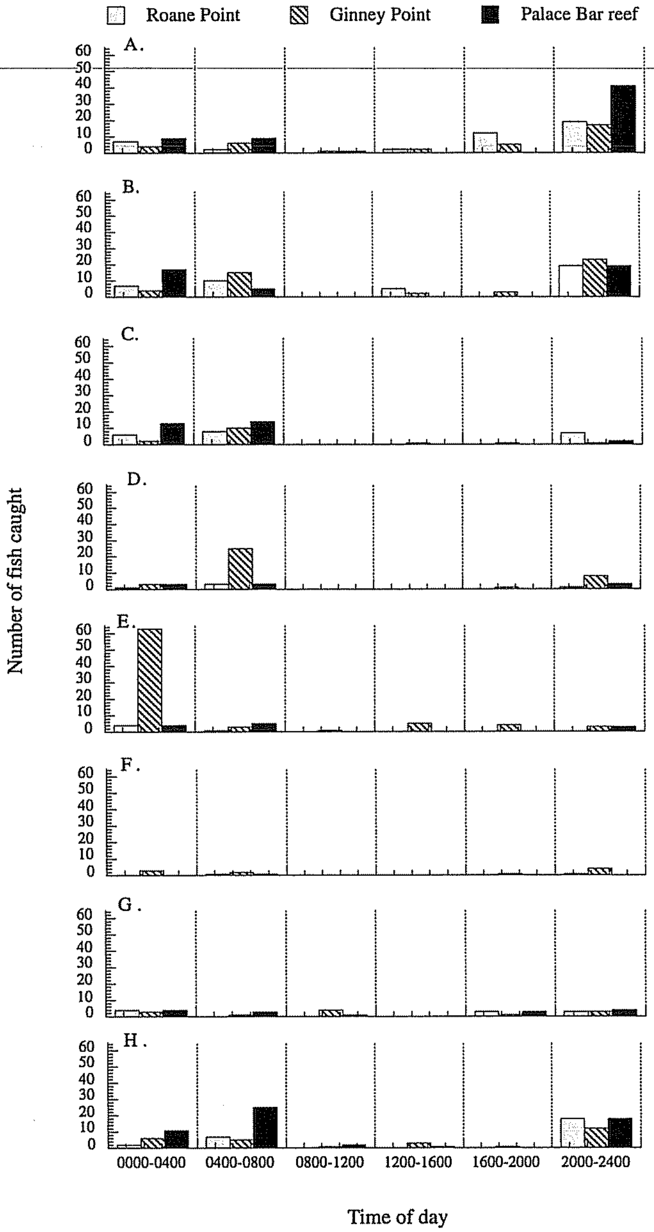

Figure 6. Species-specific abundance for spot in relation to time of day and day of the year for A.) May 22–23, B.) June 5–6, C.) June 19–20, D.) July 2–3, E.) July 17–18, F.) August 4–5, G.) August 18–19, and H.) September 2–3, 1997.

represent a gradient or cline of habitat complexity commonly observed in temperate estuaries; namely a cline moving from simple, unstructured hard sand bottom habitats through hard bottom shell habitats with little vertical relief culminating in complex, three-dimensional reef structures created and maintained by oysters. These biogenic reef structures naturally ranged in size from acres to hectares and historically were dominant habitat types in Chesapeake Bay.

This gradient of habitat types is a temperate analog to tropical coral reef systems ranging in scale from patch reefs through much larger reef systems (e.g., the Great Barrier Reef). The transient fish communities associated with temperate and tropical reef habitats are composed primarily of generalists that will opportunistically use available habitat (Sale 1980, Ebling & Hixon 1993, Roberts 1993). The structural and ecological complexity of reef habitats makes them attractive foraging habitat for transient finfish as well as aggregation sites. Historically, shallow portions of Chesapeake Bay were characterized by a mosaic of habitat types including biogenic structure ranging from seagrass beds to oyster reefs extending across spatial scales ranging from kilometers to 10s of kilometers. The development of large biogenic reef structures was facilitated by the evolution of the Chesapeake Bay estuary (Hargis 1999). The parallel development of the Bay's fish fauna favored transient fishes with broad habitat and dietary requirements (generalists) that were able to opportunistically use the dynamic estuarine habitat. These fishes successfully use the modern Chesapeake habitat in spite of relatively recent habitat alterations, namely the decline of both seagrass beds and oyster reefs during the late 20th century.

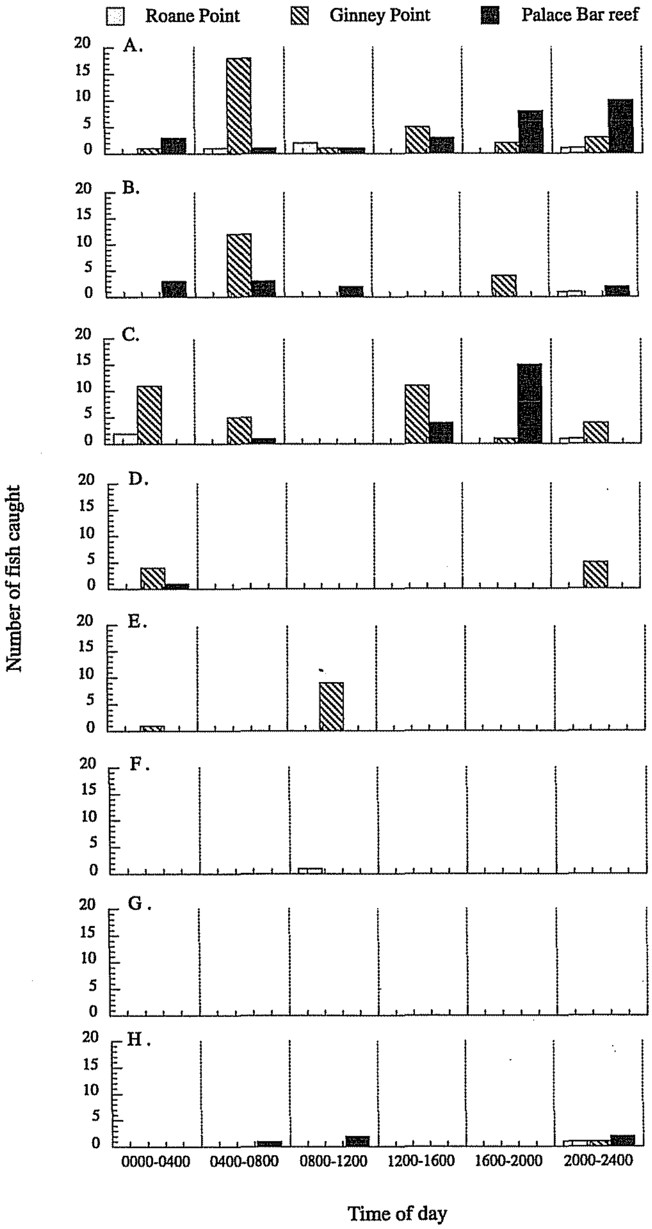

Figure 7. Species-specific abundance for striped bass in relation to time of day and day of the year for A.) May 22–23, B.) June 5–6, C.) June 19–20, D.) July 2–3, E.) July 17–18, F.) August 4–5, G.) August 18–19, and H.) September 2–3, 1997.

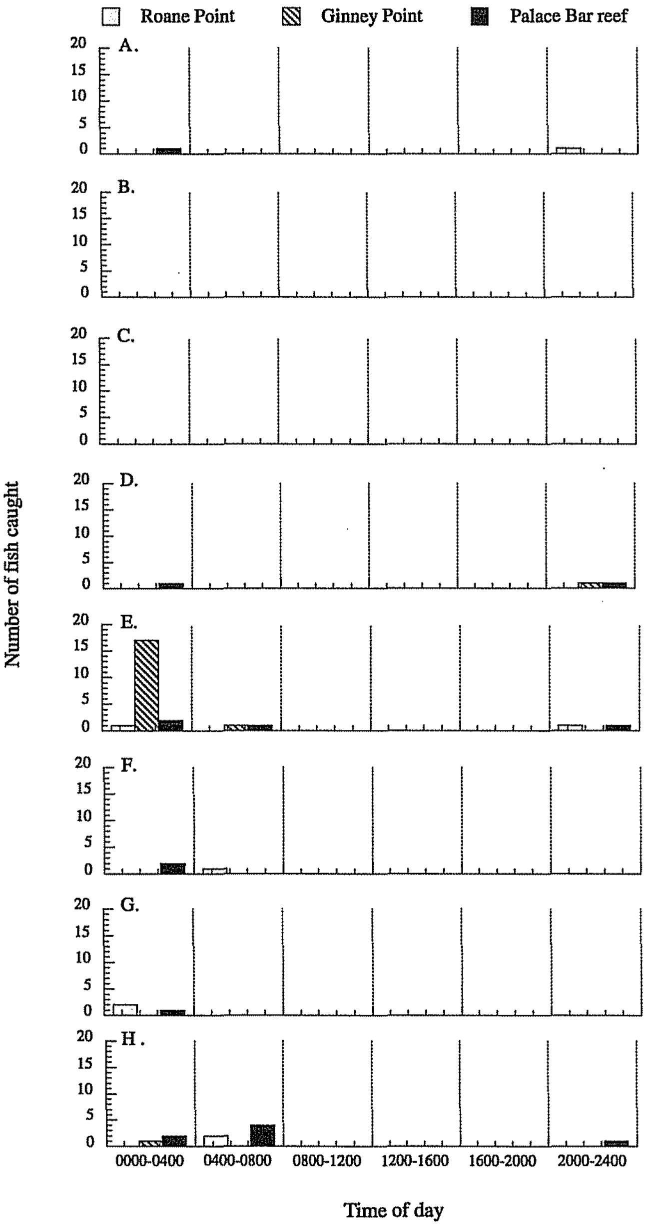

Figure 8. Species-specific abundance for weakfish in relation to time of day and day of the year for A.) May 22–23, B.) June 5–6, C.) June 19–20, D.) July 2–3, E.) July 17–18, F.) August 4–5, G.) August 18–19, and H.) September 2–3, 1997.

Previous discussions of oyster reef habitats as essential fish habitat for transient finfish (Breitburg & Miller 1998, Coen et al. 1999) have examined fish species richness data from a geographic range of oyster reef habitats including both natural and restored reefs of varying ages. Coen et al. (1999) suggest that the use of oyster reef habitats by transient fish species "portends the reef habitats' importance as essential fish habitat, but many functional relationships remain to be evaluated". This study presents a unique comparison of transient fish use of oyster reefs in relation to other locally available habitat types and is the first to provide data to describe fish habitat use at Level 1 (presence/absence), Level 2 (abundance) and Level 3 (size) levels of EFH designation. These data clearly show that these transient generalist fishes do not rely exclusively on oyster reef habitats. From a local historical perspective, the continued presence of these species in the lower Chesapeake in the absence of natural oyster reefs for the past 20+ years (Hargis 1999) is an obvious indicator that oyster reef habitat is not essential for these opportunistic fishes.

The habitat value of oyster reefs to transient fishes is much more complicated than a binary distinction (essential or not essential). Evaluations of oyster reefs as fish habitat must consider reefs in the context of locally available habitat types (per Minello 1999; this study) if accurate descriptions of habitat importance are to be made, particularly for transient finfish species. Continued examination of the functional ecological relationships between oyster reefs and the trophic communities that they support will provide data on which to base habitat distinctions at all four levels of EFH description and related resource management decisions. Gradients

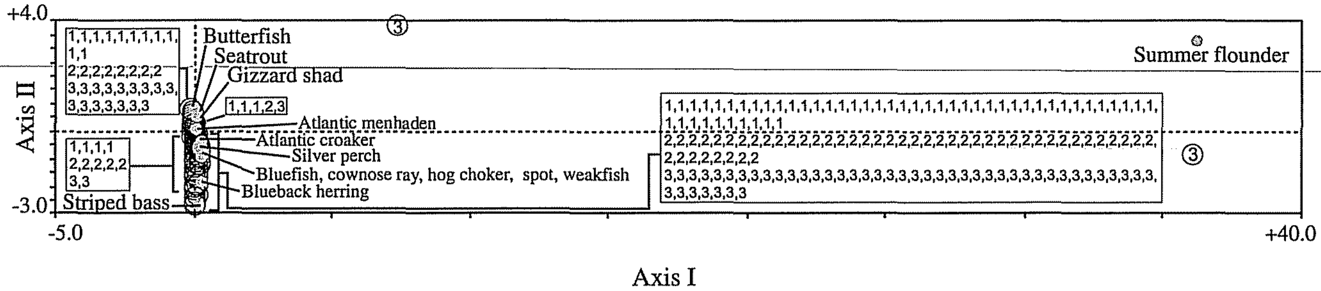

Figure 9. Species-sample biplot for detrended correspondence analyses (DCA) describing transient finfish assemblages and species abundances across a gradient of habitat types ranging from sand bar through three dimensional oyster reef. Fourteen species from two hundred and thirty-one samples collected at Palace Bar reef (1), Roane Point (2), and Ginney Point (3) with gill nets are presented. Axis I represents a gradient in diurnal light levels moving from left (dark) to right (light). Axis II represents a seasonal gradient in water temperatures moving from bottom (lower water temperatures) to top (warmest water temperatures).

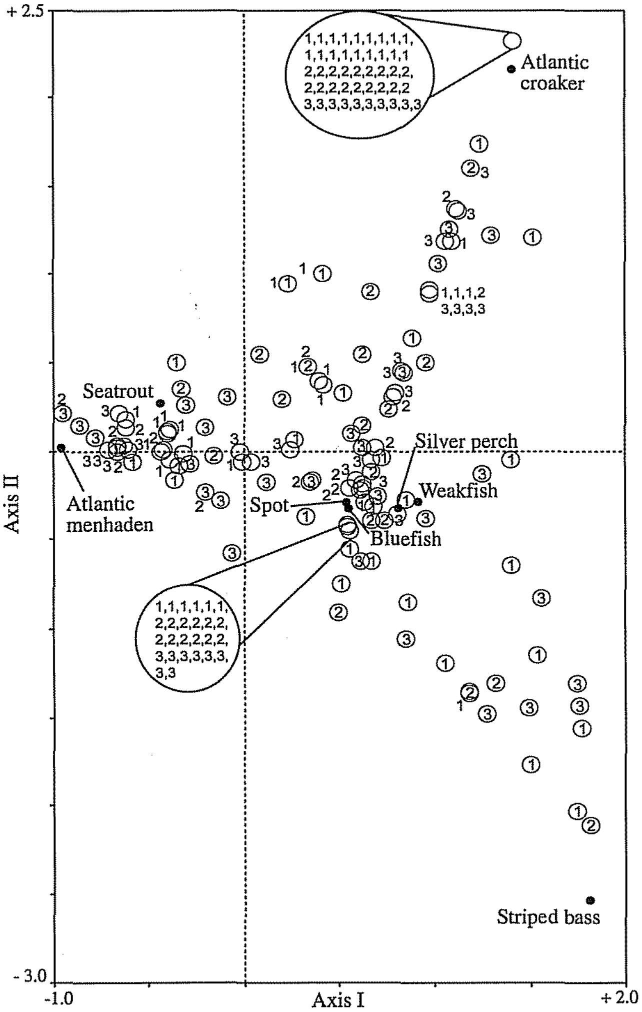

Figure 10. Species-sample biplot for detrended correspondence analyses (DCA) of common fish species across a gradient of habitat types ranging from sand bar through three dimensional oyster reef. Eight species from 201 samples collected at Palace Bar reef (1), Roane Point (2), and Ginney Point (3) with gill nets are presented. Axis I represents a gradient in diurnal light levels moving from left (dark) to right (light). Axis II represents a seasonal gradient in water temperatures moving from bottom (lower water temperatures) to top (warmest water temperatures).

TABLE 3.

Average total length (mm) of the most common transient fish species (standard error) collected with gill nets at Palace Bar oyster reef, Ginney Point, and Roane Point, Piankatank River, Virginia. Site-specific species total lengths were compared with species-specific ANOVAs. Horizontal lines under site-specific species average lengths values indicate sites where statistically similar sizes of a particular species were observed (ANOVA, Fisher's test; $p < 0.05$).

Fish	Palace Bar Reef	Ginney Point	Roane Point
Atlantic coaker	311.6 (3.3)	295.1 (2.8)	290.2 (3.9)
Atlantic menhaden	262.1 (1.9)	246.8 (1.6)	239.7 (1.0)
Bluefish	307.1 (5.7)	298.3 (5.8)	297.1 (6.1)
Spot	199.1 (1.6)	205.1 (1.4)	198.5 (1.7)
Striped bass	294.5 (5.1)	261.7 (3.3)	278.6 (10.7)
Weakfish	286.4 (8.9)	312.4 (20.8)	302 (20.7)

in physical habitat complexity relate to gradients in habitat productivity and thus habitat value or importance. A gradient of terms to describe habitat value that reflects the ecological value of a habitat would be a more realistic tool for habitat distinction. Given their physical and trophic complexity, oyster reefs are important habitat for transient estuarine finfish, however, on the basis of these data, we question the use of term "essential" with regard to oyster reef habitats given the generalist nature of the transient fish species that use these habitats. We suggest that oyster reef habitats are not essential for these fishes but that oyster reef habitats are of higher quality than other locally available estuarine habitat types and thus are better or perhaps even optimal for these fish in terms of growth, reproductive success, and survival.

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