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Mid-Summer Abundance of Resident Sub-Adult Marsh Nekton at the Virginia Coast Reserve

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ABSTRACT

We compared mid-summer abundance of resident sub-adult finfish (*Fundulus* spp.) and daggerblade grass shrimp (*Palaemonetes pugio*) at mainland and back-barrier salt marshes. Pit traps were used to collect marsh surface nekton from June 10 - August 15, 1991 at two marshes located within the Virginia Coast Reserve Long-Term Ecological Research Site. Significantly greater abundance of fishes (but not grass shrimp) was observed at the mainland marsh. Bi-weekly periodicity in shrimp and finfish abundance was observed at the mainland site only. Site-specific and temporal patterns of sub-adult nekton abundance were determined primarily by differences in elevation and hydroperiod of each marsh. Spotfin killifish (*Fundulus luciae*), previously considered rare on Virginia's Eastern Shore, were frequently collected at the mainland marsh.

Key Words: mummichogs, *Fundulus heteroclitus*, grass shrimp, *Palaemonetes pugio*, salt marshes, Virginia Coast Reserve

INTRODUCTION

In summer, 1991, we conducted a 10 week pilot study in order to evaluate the effectiveness of pit traps (Kneib, 1978; 1984; Talbot and Able, 1984) as a technique for estimating relative abundance of marsh-surface nekton (primarily juvenile cyprinodont fishes and decapods) on the surface of coastal salt marshes within the Virginia Coast Reserve barrier island-lagoon complex. Previous studies of marsh dependent/resident nekton populations at the VCR are few, and mostly limited to seine and trawl surveys scattered widely in space and time (Richards and Castagna, 1970; Norcross and Hata, 1990).

The importance of the vegetated marsh surface as habitat for larval and juvenile marsh-resident finfish and invertebrates has been emphasized (Boesch and Turner, 1984; Zimmerman and Minello, 1984; Kneib, 1984; 1986; 1987a; 1987b). Larval and juvenile fishes and decapods may forage effectively on the flooded marsh surface, yet avoid predation by seeking temporary refuge in shallow intertidal pools and rivulets at low tide. (Kneib, 1984; 1986; 1987a). Few previous studies have compared use of the marsh surface by resident sub-adult nekton at disparate marsh sites within a single dynamic system such as the Virginia Coast Reserve (VCR).

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STUDY AREA

This study was conducted in marshes of the Virginia Coast Reserve Long-Term-Ecological Research Site (VCR-LTER). Within the VCR complex, salt marsh development occurs primarily as fringing coastal marshes associated with the mainland Delmarva Peninsula and as back-barrier marshes located on the landward side of barrier islands. Additional isolated marsh islands occur in mid-lagoon areas, however, they represent a relatively minor percentage of total marsh area in this system. Mainland marshes are accreting due to relative sea-level rise (subsidence) whereas back-barrier marshes are undergoing erosion (Hayden et al., 1991). A mainland salt marsh located in Northampton County, Virginia (USGS Nassawadox quadrangle) and a back-barrier marsh located on the northern end of Hog Island (USGS Quinby Inlet Quadrangle) were chosen for comparison (Figure 1). The mainland marsh was located along a second order tributary of Phillips Creek (hereafter referred to as Phillips Creek Marsh). Emergent vegetation at this site consisted primarily of medium to short form *Spartina alterniflora* with *Salicornia virginica* and *Distichlis spicatum* occurring throughout an extensive upper intertidal zone. This site was flooded entirely only on spring and storm tides and average depth of flooding in the lower intertidal zone was $\approx$10 - 15 cm. The topographic profile of this marsh was relatively level, with a distinct berm (levee) adjacent to the creekbank. Flooding water (and presumably marsh-dependent nekton) accessed the marsh via several intertidal rivulets located along the creek-bank, dissecting the berm.

The back-barrier marsh chosen for this study was a marsh island located at the northwest end of Hog Island. A tidal creek (Cattleshed Creek) flowed around the entire marsh, and a berm was present around the marsh perimeter. The tall form of *Spartina alterniflora* was the predominant vegetation present. Flooding water and nekton reached the marsh surface via a tributary creek entering at the western boundary of the marsh. The marsh was regularly flooded to depths of $>$ 0.5 m.

METHODS

We installed 10 clay pots (18 cm diameter, 18 cm depth) at randomly selected locations within the low marsh at each site. These traps emulated the shallow intertidal microhabitats available to sub-adult nekton at low tide (Kneib, 1984) and collected resident fishes and decapods remaining on the marsh as the tide receded. Traps were sampled weekly for a total of 10 visits to each site from June 10 through August 15, 1991. We attempted to sample on mornings of consecutive days during each week, however, some samples from both sites were collected during mid-day, as dictated by tidal conditions. Larval and juvenile fishes and grass shrimp were removed from traps by repeated circular sweeps with a small dip net. Initially, traps were left uncovered between sampling intervals. However, within several days, fiddler crab (*Uca pugnax*) carcasses filled the traps. Installation of nylon mesh covers (12 mm diam.) during the second week of the study significantly reduced the accumulation of crabs in traps and did not appear to inhibit use of the traps by sub-adult finfish and decapods. On each sampling date, we measured surface water temperature, salinity and dissolved oxygen content within traps using a stem thermometer, a Reichert-Jung temperature-compensated refractometer, and a YSI Model 57 Oxygen Meter. In addition, average stem density of emergent

FIGURE 1. Map of the lower Delmarva peninsula and marsh study areas.

macrophytes was determined once in late July by counting individual plant stems in triplicate 0.0625 m^2 plots located randomly at each site. In the laboratory, larval and juvenile fishes and shrimp were identified to species, counted and measured (TL, in mm). Total (unpreserved) biomass of organisms (mg wet wt.) per trap was determined. All specimens were fixed in 10% buffered formalin. Following fixation, all specimens were preserved in 70% ethanol and archived at the University of Virginia's Long-Term Ecological Research Laboratory in Oyster, Virginia.

Statistical Analyses

We tested for differences in abundance of fishes and grass shrimp between each site using a repeated measures analysis of variance with SITE as the between subjects factor and SAMPLING DATE as the within subjects factor. Abundance data were normalized using a log (y + 1) transformation (Sokal and Rohlf, 1981). Statistical analyses were performed using SuperANOVA software for the Macintosh PC (Abacus Concepts, 1989).

RESULTS

Site Conditions

Artificial microhabitats at the mainland marsh were characterized by higher average salinity and temperature relative to back-barrier marsh microhabitats (Table 1). Mean dissolved oxygen content within traps was also higher at the mainland marsh. Hypersalinity in surface waters (66 ppt) was measured on July 16 at the mainland marsh. Maximum air temperature on this day was 30.0 °C . Average monthly precipitation (Painter, Virginia Climate Station) was 75.1 mm, a -29.5 mm departure from the monthly normal (1951-1980). The average daily temperature at this station was 27.0 °C., a 3.8° departure above the 1951-1980 station normal for July. (NOAA, 1991). Mean stem density of emergent macrophytes (primarily *Spartina alterniflora*) was nearly twice as high at the mainland marsh (mean = 502.4 ±41.1 m-2 vs. 249.9 ±13.0 m^{-2}).

Abundance and Composition

We collected a total of 546 fishes and 1182 decapods during the 10 week study interval. Mummichogs (*Fundulus heteroclitus*) represented 94% of all fishes collected. Spotfin killifish (*Fundulus luciae*) comprised the remaining 6%. The daggerblade grass shrimp *Palaemonetes pugio* was the sole decapod species captured (exclusive of fiddler crabs *Uca pugnax* which were not considered nekton). Significantly more fishes were collected at the mainland marsh site ($p = 0.0009$). Grass shrimp abundance did not differ significantly between marshes (Table 2). There were significant SITE x SAMPLING DATE interactions for both taxa ($p = 0.0001$) *Fundulus* spp. occurred at both sites on all sampling dates. Grass shrimp were not collected until week 5 (early July). The most striking difference in abundance between the two sites is the occurance of a distinct bi-weekly periodicity in shrimp abundance at the mainland marsh (Figure 2). This trend is absent at the island marsh. A similar, though less extreme, pattern is observed for fishes at the mainland marsh.

Larvae and juveniles comprised 95% of total fishes collected. Larvae and juveniles comprised 68% of total grass shrimp collected. Greater proportions of

TABLE 1. Ranges and means (± 1 SE) of marsh surface water salinity, temperature and dissolved oxygen content at Phillips Creek Marsh and Cattleshed Creek Marsh, June 10 - August 15, 1991.

Site	Range	Mean (± 1 SE)
Phillips Creek (mainland)		
Salinity (ppt)	28 - 66	43.3 ± 2.3
Temperature (°C)	24 - 37	31.0 ± 1.1
Dissolved Oxygen (mg/L)	0.4 - 15.8	5.3 ± 1.0
Cattleshed Creek (back-barrier)		
Salinity (ppt)	30 - 40	24.9 ± 0.
Temperature (°C)	24 - 34	27.8 ± 0.9
Dissolved Oxygen (mg/L)	0.4 - 16.2	3.4 ± 1.1

TABLE 2. Repeated Measures ANOVA comparing *Fundulus* spp. and *P. pugio* abundance between mainland and back-barrier marsh sites.

Source	SS	df	MS	F	p
Fundulus spp.					
Site	2.843	1	2.843	15.945	0.0009
Week	4.802	9	0.534	8.262	0.0001
Site x Week	2.763	9	0.307	4.754	0.0001
P. pugio					
Site	0.032	1	0.032	0.193	0.6653
Week	43.327	9	4.814	91.411	0.0001
Site x Week	9.106	9	1.012	19.211	0.0001

total catch were represented by sub-adult fishes and shrimps at the mainland marsh (Table 3). A slightly greater range of sizes was also noted at the mainland marsh for both fishes and shrimps. Mean total length (mm) was greater for all three species at the back-barrier marsh.

DISCUSSION

Our results are consistent with previous studies of habitat use by sub-adult nekton in Atlantic Coast salt marshes. We observed an early summer abundance peak of cyprinodont (primarily *Fundulus heteroclitus*) larvae and juveniles in mainland marshes. A second peak, representing a later cohort, occurred in late summer. We did not sample into autumn, however, more recent data from mainland marsh sites indicates that an additional cohort is produced in September - October. These data are similar to patterns of abundance reported by Kneib (1986)

for *F. heteroclitus* at Sapelo Island, Georgia. He documented three distinct abundance peaks corresponding to full moon phases of the lunar cycle. Abundance data for *Palaemonetes pugio* also correspond to observations of this species in other coastal systems. We observed a distinct bi-weekly periodicity in abundance of *P. pugio* from early July, when young individuals recruited to the marsh, to mid-August. Kneib (1987b) reported a similar bi-weekly periodicity in abundance pulses of sub-adult *P. pugio* in Sapelo Island marshes. Curiously, bi-weekly periodicities were absent in back-barrier marsh populations of fishes and shrimp in our study. The major difference between the two sites in our study was hydroperiod. Our observations indicate that the back-barrier marsh flooded regularly and to a significant depth ($\approx$ 50 cm). In contrast, the mainland marsh was generally flooded only on spring tides and average flooding depth was relatively low ($\approx$ 10-15 cm). This marsh was subsequently instrumented with a Qualimetrics Richards-Type water level recorder. Recent data (March 1993 - present) confirm our earlier observations on flooding frequency/depth at this location.

Kneib (1993) reported that growth of *F. heteroclitus* larvae was positively associated with flooding duration, and hypothesized that tidal flooding controlled the renewal rate of prey resources available to larvae. Our size/age composition data support this, with larger individuals collected from the back-barrier marsh (Table 3), however, our sampling techniques were selective for larvae and juveniles, and likely excluded late juveniles and adults at both sites.

We sampled a single location (lower intertidal zone) at each marsh in our comparison. In an earlier study (Kneib, 1984), significant variation in abundance of larval and juvenile cyprinodonts (*Fundulus heteroclitus* and *Fundulus luciae*) was reported across an intertidal transect at a Sapelo Island, Georgia salt marsh, with greatest abundance occurring in the upper intertidal zone. Larvae and early juveniles were most abundant at higher elevations, whereas larger juveniles and adults dominated collections from the lower intertidal.

It has been documented that spawning activity (as indicated by egg counts and gonadosomatic indices) in *Fundulus heteroclitus* peaks in concert with spring tides in mid-Atlantic marshes (Taylor et al., 1979). Kneib (1987b) suggested that grass shrimp temporal abundance patterns may be similarly influenced by lunar cycles, either via synchrony of reproductive activity or as a function of increased access to the marsh surface due to higher spring tides. The greater availability of high marsh at the mainland site may explain the higher abundance of resident finfish at that location. The back-barrier site was almost entirely low marsh, except for a restricted area of short-form *Spartina alterniflora* located upon the berm. If the high marsh environment is preferentially utilized as a spawning site and nursery area by *Fundulus heteroclitus* and *Fundulus luciae* (Byrne, 1978; Kneib, 1984; Talbot and Able, 1984) recruitment of larval and juvenile cyprinodonts would have been enhanced at our mainland site. Grass shrimp do not utilize the intertidal marsh surface as a spawning site. However, post-larval grass shrimp (6 - 8 mm) recruit from sub-tidal creeks to the intertidal marsh surface during mid- to late summer (Kneib, 1987). At this time, grass shrimp are the numerically dominant organism present on the lower intertidal marsh surface.

Our observations are not intended to suggest that all mainland marshes support greater abundance of marsh-resident nekton relative to all back-barrier locations

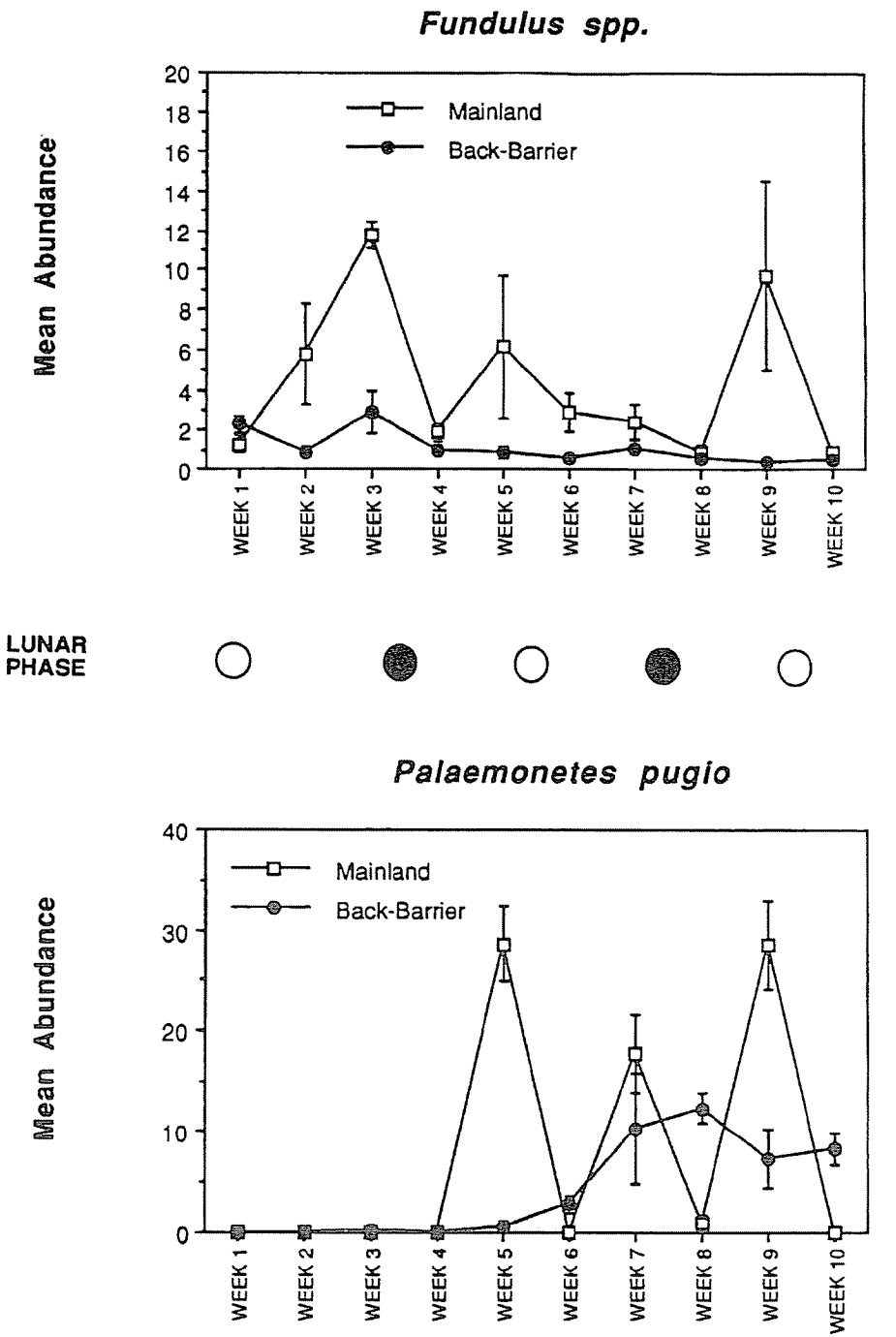

Figure 2. Mean weekly abundance of fishes (*Fundulus* spp.) and decapods (*Palaemonetes pugio*) on the surface of mainland and back-barrier marsh study sites; June 10 - August 15, 1991.

TABLE 3. Total length ranges and means and age class composition of fishes and grass shrimp at Phillips Creek Marsh and Cattleshed Creek Marsh, June - August, 1991.

Site	n	TL range (mm)	mean TL (mm)	% sub-adult	% adult
Phillips Creek (mainland)					
F. heteroclitus	404	6 - 35	11.9	96	4
F. luciae	29	9 - 24	14.4	97	3
P. pugio	763	6 - 25	11.3	76	24
Cattleshed Creek (back-barrier)					
F. heteroclitus	110	6 - 34	16.8	92	8
F. luciae	3	22 - 27	24.7	0	100
P. pugio	418	8 - 20	13.2	64	36

at the VCR. Many back-barrier marshes at the VCR are contiguous with terrestrial island environments and contain substantial high marsh. However, marsh islands such as Cattleshed Creek Marsh are common at back-barrier locations. Our intention was to illustrate variation in marsh types within the VCR and compare patterns of habitat utilization by resident sub-adult nekton between disparate marshes.

We collected 29 sub-adult and adult spotfin killifish (*Fundulus luciae*) at the mainland marsh site. Three adults were collected at the back-barrier marsh. Richards and Bailey (1967) concluded that this species is either rare or occupies a limited niche on the seaside of Virginia's Eastern Shore. Byrne (1978) reported on the life history of this species from the York River drainage, Virginia and suggested that populations of this species may have been previously overlooked in Virginia. Similarly, Able et al., (1983) and Shields and Hayes (1983) have reported spotfin killifish to be locally abundant in New Jersey and North Carolina high marshes, respectively. We have collected this species from high marsh shallows, ponds and ditches at the VCR-LTER on numerous occasions in 1991 - 1993 and concur with the previously mentioned studies that *F. luciae* is underepresented in conventional seine and trawl surveys of coastal marshes due to the dependence of this species on upper intertidal marsh habitats.

CONCLUSIONS

Resident sub-adult finfish (*Fundulus* spp.) were more abundant at a mainland salt marsh relative to a back-barrier marsh. Abundance of daggerblade grass shrimp (*Palaemonetes pugio*) did not significantly differ between marshes. Between-site differences in elevation and hydroperiod and the relative availability of high marsh habitat are potential factors influencing the observed patterns of abundance.

Spotfin killifish were frequently encountered in this study and are apparently not uncommon in high marsh habitats at the VCR-LTER. As suggested by previous investigators, the purported rarity of *Fundulus luciae* in mid-Atlantic salt marshes

is due to under-representation by conventional sampling techniques combined with specific habitat requirements.

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