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Estuarine–Open-Water Comparison of Fish Community Structure in Eelgrass (*Zostera marina* L.) Habitats of Cape Cod

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While it is generally accepted that eelgrass habitats support diverse and productive fish communities, most of our information about the ecological function of eelgrass habitats comes from estuarine environments. Research demonstrates a high correlation between estuarine eelgrass biomass and fish diversity, abundance, and biomass (1, 2). The few studies that have compared estuarine and open-water eelgrass habitats demonstrate that these habitats support similar species at different abundances (3, 4). Estuarine eelgrass habitats function as a nursery and feeding ground for many marine transient species (5, 6), and recent information suggests that open-water eelgrass habitats can support similar functions (7, 8). Our study tested whether estuarine and open-water eelgrass habitats support similar fish community structure (abundance, biomass, and number and type of species) and also contrasted these fish communities to those of nearby non-eelgrass habitats.

Life-history patterns of many fish species vary with geographical location (1, 9). We identified four major categories of life history patterns for nearshore fish species in southern New England, based on the literature (1, 9): estuarine resident (entire life history occurs primarily in-estuary; *e.g.,* northern pipefish [*Syngnathus fuscus*]), estuarine spawner (juveniles spawned in-estuary, adults occur in open waters; *e.g.,* Atlantic silverside [*Menidia menidia*]), marine spawner (adults spawn juveniles in open waters, development occurs in-estuary; *e.g.,* tautog [*Tautoga onitis*]), and marine species (spawning and juvenile development occurs primarily in open water, and juveniles and adults are estuarine "visitors"; *e.g.,* scup [*Stenotomus chrysops*]). Our study tested whether these life-history classifications were true for the nearshore species we collected.

We sampled five sites in estuarine and open-water environments in Cape Cod: West Falmouth Harbor (estuarine eelgrass habitat); Nobska Point and Falmouth Heights (open-water eelgrass habitats); South Cape Beach and Popponessett Beach (open-water non-eelgrass habitats). To complement our sampling, we randomly chose five sites sampled and analyzed by Hughes *et al.* (1) in the summer of 1998. At least three 1–2 min otter trawls (0.3-cm cod-end mesh aperture) were conducted at each site, and distance trawled was determined by GPS technology. We sorted, identified, and measured (wet weight and standard length) each specimen in the catch. Most fish caught were juveniles.

Our analyses compared location (estuarine, open-water) and habitat type (with and without eelgrass). Two-way ANOVAs (location $\times$ habitat type, with sampling sites nested within location and habitat) were used to test differences among means. Number of species was expressed per trawl sample because area trawled explained $<3\%$ of species variation. Abundance and biomass data (scaled to 100 m^{-2}) were ln-transformed to homogenize variances, and back-transformed means were reported. Probabilities were adjusted by the sequential Bonferroni method (10), and Tukey-Kramer tests ($\propto = 0.05$) were used for multiple comparisons of means.

Estuarine eelgrass habitats supported significantly more species than did open-water eelgrass habitats (Fig. 1A), although both contained similar fish abundance and biomass (Fig. 1B, C). Eelgrass appears to provide similar ecological benefits (*e.g.,* food, protection) at estuarine and open-water locations.

Non-eelgrass habitats maintained significantly higher fish abundance and biomass in open water than in comparable estuarine locations, suggesting that these environments better accommodate living requirements of fish (Fig. 1B, C). Estuarine non-eelgrass habitats are often eutrophic and hypoxic (1), whereas open-water habitats are better flushed and continually replenished with oxygen, which could produce these more beneficial conditions.

As found in previous research (1, 2), estuarine sites with eelgrass harbored significantly higher numbers of species, abundance, and biomass than estuarine sites without eelgrass (Fig. 1A, B, C). Yet surprisingly, open-water eelgrass and non-eelgrass habitats contained relatively similar numbers of species, numbers of individuals, or biomass (Fig. 1A, B, C).

Some of our life-history classifications were supported by differential abundances by habitat type (Fig. 1D). As expected, estuarine resident and estuarine spawner species existed predominantly in estuarine eelgrass sites. Marine species were significantly more abundant in open water than estuarine locations. Marine species showed no apparent preference for eelgrass in open-water habitats, implying that eelgrass presence does not greatly affect their habitat selection in the open-water habitats. However, marine spawner species displayed an affiliation primarily with eelgrass, suggesting that their abundance depended more on habitat type than on location. The habitat use by this species group needs to be reconsidered in light of these findings.

The difference in community structure between open-water and estuarine locations indicates that fish populations obtain different ecological benefits from each location. However, more extensive research will be necessary to ascertain the ecological function of open-water eelgrass habitats.

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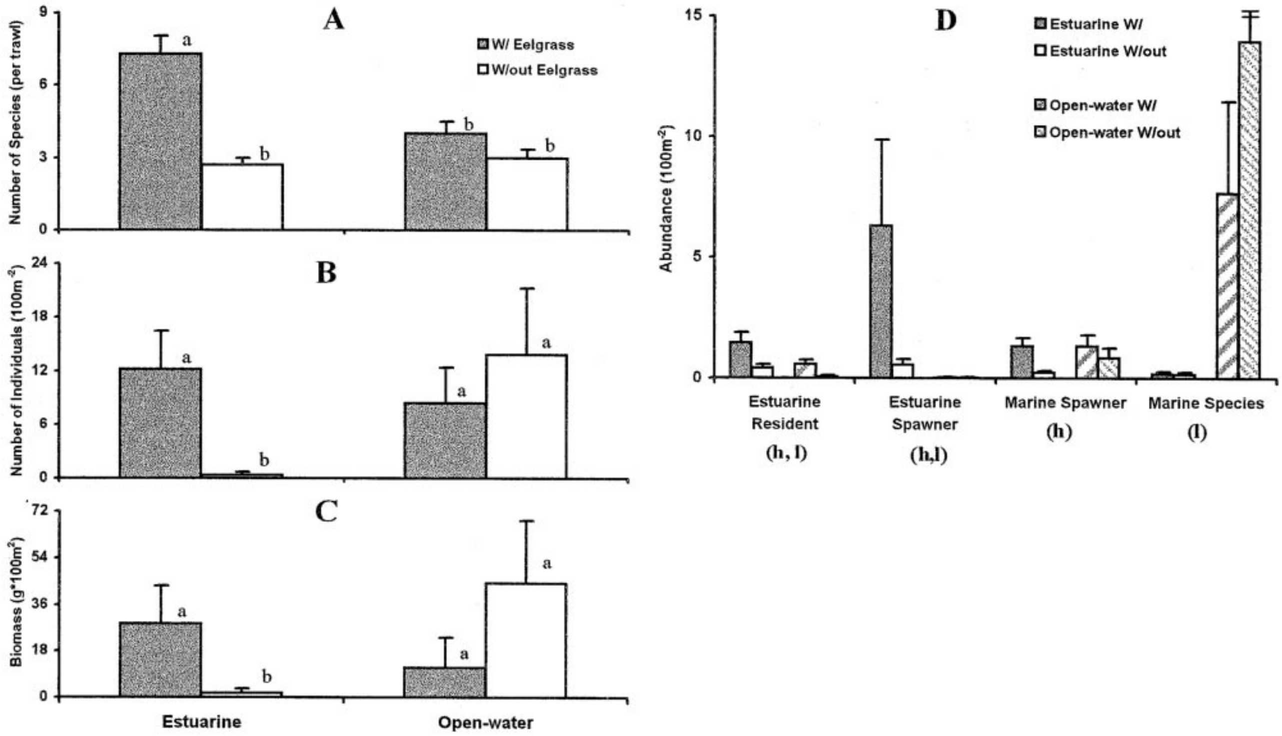

Figure 1. *Mean number (+ SE,* n = *6–17) of species (A), abundance (B), and biomass (C) in habitats with eelgrass and without eelgrass at estuarine and open-water locations. Different letters represent statistically different (*$P < 0.05$*) means. (D) Abundance (+ SE,* n = *6–17) by life-history classifications. h, significantly (*$P < 0.05$*) habitat-dependent. l, location-dependent.*

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Influence of Epiphytic Algal Coverage on Fish Predation Rates in Simulated Eelgrass Habitats

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The effects of ever-increasing anthropogenic nitrogen loads on marine ecosystems have been well documented (1, 2, 3). Nitrogen from fossil-fuel emissions, fertilizer application, and wastewater discharge increases the total nitrogen load to local bays and estuaries, leading to the accelerated growth of macroalgae and epiphytic algae (2, 3). Epiphytic algae grow on a variety of surfaces such as rocks, eelgrass, and other algae. These fast-growing algae can out-compete eelgrass (*Zostera marina*) for light (2, 3). However, the effects of epiphytic algal proliferation on estuarine communities are not well known (2). One consequence could be increased canopy structure in eelgrass beds, which could decrease foraging efficiency of fish and decrease the rate of predation on small invertebrates. Our study focused on how increased canopy

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