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ScienceDirect
Estuarine, Coastal and Shelf Science 69 (2006) 591–606
ESTUARINE COASTAL AND SHELF SCIENCE
www.elsevier.com/locate/ecss

Use of submerged aquatic vegetation as habitat by young-of-the-year epibenthic fishes in shallow Maine nearshore waters

M.A. Lazzari*, B.Z. Stone

Maine Department of Marine Resources, P.O. Box 8, West Boothbay Harbor, ME 04575, USA

Received 3 October 2005; accepted 24 April 2006
Available online 12 July 2006

Abstract

Epibenthic fishes were collected with daytime beam trawl tows ($n = 1713$) in three shallow (<10 m) habitats of submerged aquatic vegetation (SAV), *Zostera marina* (eelgrass), *Laminaria longicruris* (kelp), *Phyllophora* sp. (algae), and unvegetated sandy/mud areas. We divided the Maine coast into three broad zones based upon geological features and sampled over five consecutive years; during April–November 2000 in the mid coast, in 2001 and 2002 along the south coast and in 2003 and 2004 along the eastern Maine coast. We quantified habitat use by eight economically important fish species (*Gadus morhua*, *Microgadus tomcod*, *Pollachius virens*, *Urophycis chuss*, *Urophycis tenuis*, *Osmerus mordax*, *Tautogolabrus adspersus*, and *Pseudopleuronectes americanus*) and 10 other common epibenthic species ($n = 18\,571$). We identified the physical and biological variables most important in discriminating between habitats with and without individual fish species. Logistic regression models based on nearshore habitat characteristics were developed to predict the distribution of these species along the three zones representing broad geological regions of the Maine coast. Logistic regression models correctly classified individual fish species 58.7–97.1% of the time based on the temporal and physical habitat variables (month, temperature, salinity, and depth) and the presence–absence of submerged aquatic vegetation (*Zostera*, *Laminaria*, or *Phyllophora*). Overall fish presence and economically important fish presence were correctly classified 61.1–79.8% and 66.0–73.6% of the time, respectively. The Maine shallow water fish community was composed primarily of young-of-the-year and juvenile fishes with all habitats functioning as facultative nursery areas. Presence of most fish species was positively associated with *Zostera*, *Laminaria*, and to a lesser extent, *Phyllophora*. This study provides direct evidence of shallow waters of the Gulf of Maine as critical facultative nursery habitat for juvenile *G. morhua*, *M. tomcod*, *P. virens*, *U. tenuis*, *U. chuss*, *T. adspersus*, *O. mordax* and *P. americanus*, and many ecologically important species.

Keywords: submerged aquatic vegetation; *Zostera*; *Laminaria*; Maine estuarine fauna

1. Introduction

The shallow three-dimensional subtidal communities formed by submerged aquatic vegetation (SAV) in nearshore areas of the Northwest Atlantic Ocean are important habitats for many fishes. Estuaries in coastal regions are highly dynamic and subject to tidal induced changes in temperature, salinity, oxygen and turbidity that affect fish abundance and composition (Gunter, 1961; Haedrich, 1983; Day et al., 1989; Methven et al., 2001; Able, 2005). Seasonal variation, habitat type and sampling gear are among the most important factors that influence patterns of species abundance, composition and size structure of estuarine fish (Blaber and Blaber, 1980; Lonegren and Potter, 1990; Whitfield, 1999; Methven et al., 2001). Determining habitat quality is difficult because links between fishes and their habitats are complex (Gibson, 1994; Able, 1999) but necessary to define habitat quality (Beck et al., 2001). A nursery for fishes has been defined on four comparative factors: (1) density, (2) growth, (3) survival and (4) movement to adult habitat, i.e., contribution to the adult population (Beck et al., 2001). Habitat features that

* Corresponding author.
E-mail address: mark.lazzari@maine.gov (M.A. Lazzari).

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doi:10.1016/j.ecss.2006.04.025

characterize fish distribution and abundance have become a common focus of research as populations of recreational and commercial species decline. Fishery managers must understand the environmental characteristics that control habitat and fish populations.

Information on the nearshore distribution of epibenthic fishes is important due to the nursery function of shallow inshore habitats, the environmental variability of these areas, and the high potential for anthropogenic impact (Warfel and Merrimen, 1944; Horn, 1980; MacDonald et al., 1984; Black and Miller, 1991; Brown and McLachlan, 1991; Kneib, 1997; Simenstad et al., 2000). The importance of vegetation, particularly *Zostera marina* and other seagrasses as epibenthic fish habitat has been demonstrated outside the Gulf of Maine, GOM (Weinstein and Brooks, 1983; Huh, 1984; Orth et al., 1984; Sogard et al., 1987; Heck et al., 1989; Sogard and Able, 1991; Szedlmayer and Able, 1996; Paterson and Whitfield, 2000) with higher faunal densities found in seagrass relative to unvegetated sand or mud substrates. Seagrass functions as nursery habitat for newly settled juvenile fishes and decapods (Adams, 1976; Orth and van Montfrans, 1987; Bell and Pollard, 1989; Heck et al., 1989) and has a demonstrated value as a refuge from predation (Heck and Thoman, 1981; Stoner, 1982; Leber, 1985; Kneib, 1987; Paterson and Whitfield, 2000). Similar functions have been found in kelp habitats along the western U.S. coast (Dayton, 1985; Steneck et al., 2002; Hamilton and Konar, in press). These kelp forests are among the most productive aquatic biomes on earth and support numerous organisms, such as invertebrates, fishes, marine mammals, and other algal species (Steneck et al., 2002). However, many studies have been restricted to a single habitat and very few compared ichthyofaunal utilization of different habitats within the same estuary. Recent investigations over larger spatial scales have found both intra- and inter-estuarine differences in fish abundances within seagrasses and bare substrates (Ferrell and Bell, 1991; Gray et al., 1996). Comparative observations in multiple estuaries are necessary to determine if there are distinct patterns of habitat use.

The basic ecology of economically important finfish species along the entire Maine coast is poorly understood. Published studies on fish communities in the GOM region exist for deep water (Bigelow and Schroeder, 1953) as well as for shallow areas in Passamaquoddy Bay (Tyler, 1971; MacDonald et al., 1984), Penobscot Bay (Lazzari and Tupper, 2002), mid coast estuaries (Recksiek and McCleave, 1973; Targett and McCleave, 1974; Lazzari et al., 1999; Lazzari et al., 2003), and Wells Harbor (Ayvazian et al., 1992). However, many of these fish community studies were relatively short (Tyler, 1971; Recksiek and McCleave, 1973; Targett and McCleave, 1974; Ayvazian et al., 1992) often lasting a year or less and/or were over 30 years old. Recent impacts of intensive human development of the shoreline and increased exploitation of the fish on species composition, abundance and habitat use by many economically important species is unknown. In order to effectively manage marine economically important finfish species such as *Pseudopleuronectes americanus*, *Gadus morhua*, and *Pollachius virens*, information is needed on the distribution, abundance, and habitat requirements of the juvenile stages of these species in shallow habitats. Further, the 1996 Sustainable Fisheries Act (SFA) emphasized the importance of habitat protection to healthy fisheries and strengthened the ability of the National Marine Fisheries Service (NMFS) and the regional fishery management councils to protect and conserve essential marine, estuarine, and anadromous fish habitat (EFH).

Our purpose was to quantify habitat use by young-of-the-year (YOY) and juvenile forms of marine economically important fish species (*Gadus morhua*, *Microgadus tomcod*, *Pollachius virens*, *Urophycis chuss*, *Urophycis tenuis*, *Osmerus mordax*, *Tautogolabrus adspersus*, and *Pseudopleuronectes americanus*) and other common epibenthic species (*Gasterosteus aculeatus*, *Apeltes quadracus*, *Pungitius pungitius*, *Ammodytes americanus*, *Myoxocephalus aenaeus*, *Clupea harengus*, *Cyclopterus lumpus*, *Pholis gunnellus*, *Syngnathus fuscus*, and *Hemitripterus americanus*) in shallow water habitats along the entire Maine coast and to identify the physical variables that are most important in discriminating between shallow water habitats with and without individual fish species. We developed logistic regression models based on nearshore habitat characteristics to predict the distribution of these species along the Maine coast. The objective of this study was to assess the relationships of fish to habitat structure and to seasonal variations in the nearshore community. Relationships were determined among habitat descriptors by coastal location (month, temperature, salinity, and depth), the occurrence of submerged aquatic vegetation (SAV) and the presence of fishes.

2. Materials and methods

2.1. Study area

Twenty-eight estuarine locations with *Zostera marina* (eelgrass), *Laminaria longicruris* (kelp) and/or *Phyllophora* sp. (algae) located along the entire Maine coast from the Piscataqua River (70°43′, 43°04′) to Cobscook Bay (67°10′, 44°50′) were sampled in this study (Fig. 1). The coast was divided into three zones based upon geological features for sampling over five consecutive years. Nine estuaries within the mid coast region from Casco Bay to Weskeag River were sampled in 2000 (Table 1). In 2001 and 2002, we sampled five estuarine locations from the Piscataqua River to Richmond Island in southern Maine (Table 1). Fourteen eastern estuaries were sampled from Penobscot to Cobscook Bays in 2003 and 2004 (Table 1).

The southwest region of Maine's coastline, from Kittery to Cape Elizabeth, is characterized by arcuate embayments with intervening rock headlands and sediment derives from wave reworking of offshore deposits of sand (Timson, 1977; Kelley, 1987). The west central region (mid coast, Casco to Penobscot Bays) is characterized by alternating, northeasterly aligned peninsulas composed of high-grade metasedimentary rocks and deep, narrow, strike-aligned estuaries. Sediment is also from the reworking of offshore sand bodies (Belknap et al., 1986) with the possible contemporary contributions from the