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Shallow-water habitat use by Bering Sea flatfishes along the central Alaska Peninsula

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ABSTRACT

Flatfishes support a number of important fisheries in Alaskan waters and represent major pathways of energy flow through the ecosystem. Despite their economic and ecological importance, little is known about the use of habitat by juvenile flatfishes in the eastern Bering Sea. This study describes the habitat characteristics of juvenile flatfishes in coastal waters along the Alaska Peninsula and within the Port Moller–Herendeen Bay system, the largest marine embayment in the southern Bering Sea. The two most abundant species, northern rock sole and yellowfin sole, differed slightly in habitat use with the latter occupying slightly muddier substrates. Both were more common along the open coastline than they were within the bay, whereas juvenile Alaska plaice were more abundant within the bay than along the coast and used shallow waters with muddy, high organic content sediments. Juvenile Pacific halibut showed the greatest shift in distribution between age classes: age-0 fish were found in deeper waters (~ 30 m) along the coast, whereas older juveniles were found in the warmer, shallow waters within the bay, possibly due to increased thermal opportunities for growth in this temperature-sensitive species. Three other species, starry flounder, flathead sole, and arrowtooth flounder, were also present, but at much lower densities. In addition, the habitat use patterns of spring-spawning flatfishes (northern rock sole, Pacific halibut, and Alaska plaice) in this region appear to be strongly influenced by oceanographic processes that influence delivery of larvae to coastal habitats. Overall, use of the coastal embayment habitats appears to be less important to juvenile flatfishes in the Bering Sea than in the Gulf of Alaska.

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1. Introduction

Flatfishes support a number of important commercial fisheries in the Bering Sea. Harvested species include yellowfin sole (YFS, *Limanda aspera*), northern rock sole (NRS, *Lepidopsetta polyxystra*), and Pacific halibut (PH, *Hippoglossus stenolepis*). In addition, flatfishes play a significant role in the ecosystem dynamics of the Bering Sea; for example, the piscivorous arrowtooth flounder (ATF, *Atheresthes stomias*) comprises the largest demersal fish species biomass in Alaskan waters. The distributions of subadult and adult life stages of Bering Sea flatfishes have been described from large-scale fishery surveys on the Bering Sea shelf (McConnaughey and Smith, 2000; Spencer, 2008; Kotwicki and Lauth, 2013). Ichthyoplankton sampling has also been used to describe the timing and distribution of pelagic larval stages of many flatfish species (Matarese et al., 2003) and has been combined with oceanographic models to infer larval transport pathways for some species (Lanksbury et al., 2007; Duffy-Anderson et al., 2010). In contrast, the juvenile nursery phase remains poorly described for all of these species. The most recent evaluation of Essential Fish Habitats for Alaskan fishery species (NPFMC, 2010) found insufficient information to define the essential habitats for early juveniles of any flatfish species in the Bering Sea.

The distribution and habitat associations of juvenile flatfishes have been extensively examined in the central and western Gulf of Alaska. Data from several small-mesh trawl surveys of coastal embayments and the continental shelf have been used to develop habitat models for some species (Norcross et al., 1999, 1997; Wilson et al., 2016). These models relate flatfish presence/absence to habitat variables including depth, temperature, sediment characteristics, and geographic position (e.g., distance from shore or inside/outside bay mouth). In addition, fine-scale video observations and laboratory studies have demonstrated the micro-habitat association of juvenile flatfishes with biogenic habitat features (Stoner and Titgen, 2003; Stoner et al., 2007). In particular, the presence and density of tube-forming polychaete worms (*Sabellides sibirica*) significantly affect the distribution of juvenile northern rock sole (Stoner et al., 2007; Ryer et al., 2013). The "worm-tube" areas have been shown to provide both forage base and predator refuge (Ryer et al., 2013; C. Ryer, unpublished data).

While general aspects of primary habitat associations are likely to be consistent across species' ranges, there may be important differences

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associated with regional variation in the types of available habitats and their spatial arrangement (Hurst et al., 2015). Habitat use models can have limited power in predicting the distributions of fishes in areas for which they were not developed. For example, only two of six models developed for juvenile flatfishes from coastal sampling in the Gulf of Alaska (Norcross et al., 1999) accurately predicted habitat use on the deeper continental shelf (Wilson et al., 2016).

Similar limitations might be expected when attempting to apply flatfish habitat use models developed for the Gulf of Alaska to the Bering Sea due to overall differences in basin characteristics and hydrography. The Gulf of Alaska is characterized by highly articulated shorelines, large areas of sheltered, shallow-water embayments, and narrow continental margins. In contrast, the southeast Bering Sea is dominated by a broad, shallow continental shelf. Much of the coastline is straight with sand/gravel beaches and broad mud/sand/gravel flats and there are few sheltered bays and inlets.

In the past decade, several small-mesh trawl studies have been conducted over the eastern Bering Sea shelf to fill this recognized gap in our understanding of the habitat ecology of Alaskan flatfishes (e.g., Norcross and Holladay, 2005). Cooper et al. (2014) found that a seasonally persistent oceanographic front restricts transport of northern rock sole larvae to some inshore nursery areas which resulted in a poor fit of the Gulf of Alaska-derived habitat model in the southeastern Bering Sea. While that work included sampling in the Kuskokwim Bay region (Norcross and Holladay, 2005), sampling was limited to waters >18 m depth. There has not been any sampling of flatfish in shallow waters and coastal embayments along the Alaska Peninsula. As a result, the importance of these nearshore waters and embayments as multi-species nursery areas for commercially and ecologically important Alaskan flatfishes remains unknown.

In this study, I describe habitat use by juvenile flatfishes in nearshore waters of the southeastern Bering Sea (SEBS) along the central Alaska Peninsula and within the Port Moller–Herendeen Bay system (PM-HB), the largest marine embayment of the SEBS. As the first study to examine nearshore habitat use along the Alaska Peninsula, I focus on (a) characterizing biotic and abiotic aspects of demersal fish habitats, (b) describing distribution of flatfishes in relation to primary habitat features, and (c) identifying general factors influencing flatfish species composition in this region. This work is part of a larger project examining juvenile flatfish habitat associations in the Bering Sea and will improve our understanding of basin-wide patterns in flatfish habitat use and the identification of critical nursery areas.

2. Materials and methods

2.1. Study area

The SEBS is a broad continental shelf bordered on the east and south by the Alaska mainland and the Alaska Peninsula, respectively (Fig. 1). The steep shelf break marks the western boundary with the deep Aleutian Basin. Water flows weakly over the shelf to the northwest with the stronger Bering Coastal Current running northeast along the Alaska Peninsula before turning north along the mainland Alaska coast (Coachman, 1986). Sediments on the shelf are generally sandy with coarser grains near the coastal margins and finer muds in deeper areas (McConnaughey and Smith, 2000).

The north side of the Alaska Peninsula is perforated by several inlets, the largest of which is the Port Moller–Herendeen Bay (PM-HB) system (Fig. 1). PM-HB is a tidally dominated marine system with only minor freshwater inputs. The head of Herendeen Bay is fjord-like with depths reaching to 100 m. Otherwise, PM-HB is characterized by extensive areas of intertidal and shallow subtidal (< 10 m) sand/mud flats with deeper, narrow tidal channels (to 20 m depth). These channels are naturally maintained and have coarser sediment with rocks and boulders. Outside the mouth of PM-HB, the Alaska Peninsula shoreline consists

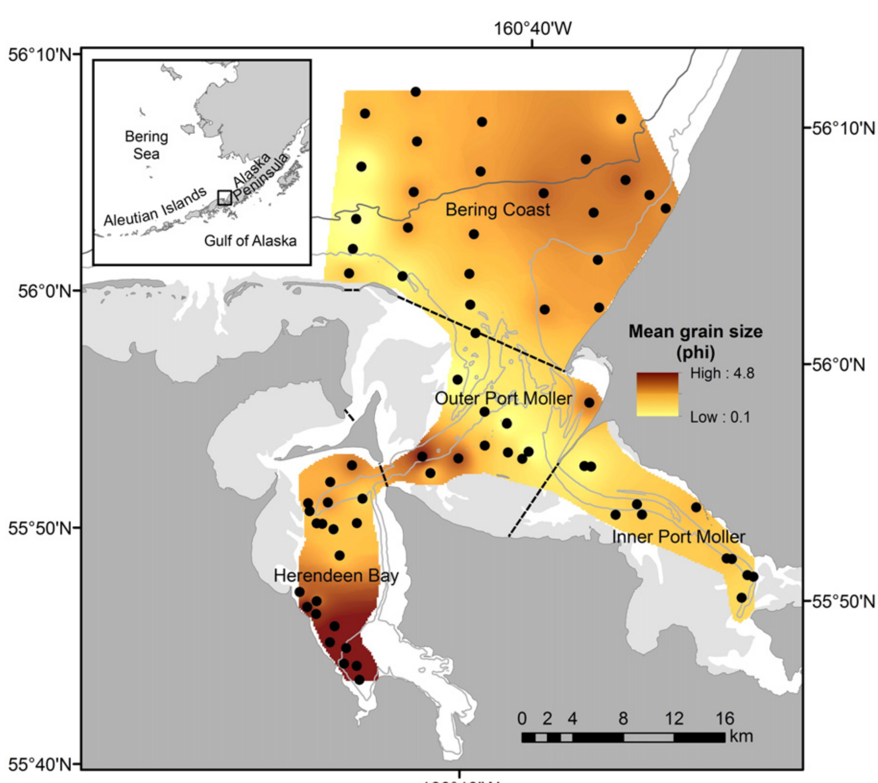

Fig. 1. Map of study region in the southeastern Bering Sea. Points are sampling locations and color scale is mean grain size determined from surficial sediment samples taken at each location.