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A Survey of Fish Assemblages in Eelgrass and Kelp Habitats of Southeastern Alaska

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ABSTRACT

For most federally managed fish species in Alaska, basic information on distribution and use of nearshore marine habitats is lacking, especially for early life stages. To gain a better understanding on the use and importance of nearshore habitats as essential fish habitat (EFH), we compared fish assemblages between two distinct habitat types (eelgrass, *Zostera marina*, and kelp, mostly *Laminaria saccharina*) at 30 sites in southeastern Alaska from 1998 to 2000. Sites were selected in four regions to cover a geographical gradient from north to south and from inside to outside waters. Fish were collected by beach seine from June through August each year. A total of 102 seine hauls yielded more than 51,000 fish comprising 54 species; 23 of the species that we captured are included in a salmon or groundfish fishery management plan in Alaska.

Species richness was greater in eelgrass than in kelp, whereas the Shannon-Wiener diversity index (H') was similar between habitat types. Abundance of fish varied considerably between habitat types and among regions, often because of the patchy distribution of some species. Distribution patterns were evident for some species by differences in catch among regions.

Eelgrass and kelp support high biodiversity and are important habitats for juveniles of many commercially important or forage fish species. Knowledge of fish assemblages and their use of intertidal and shallow, subtidal vegetation will help managers identify EFH. Once

identified, managers can then make recommendations to protect or minimize impacts to EFH from human disturbance.

CONTENTS

INTRODUCTION

One of the most important changes in the 1996 reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act was a requirement to identify and describe essential fish habitat (EFH) for species included in federal fishery management plans (FMPs) (National Marine Fisheries Service 1999). The amended act gave heightened importance to fish habitat in resource management decisions. Essential fish habitat is defined as those waters and substrate necessary for spawning, breeding, feeding, or growth to maturity (North Pacific Fishery Management Council 1998). Identifying EFH requires basic information on fish distribution and habitat use. Such information is lacking, however, for many FMP species in Alaska, especially for early life stages.

Within federally mandated EFH habitat designations in Alaska, nearshore areas of intertidal and subtidal vegetation are considered habitat areas of particular concern because of their high value as fish habitat and their vulnerability to human disturbance (North Pacific Fishery Management Council 2002). Alaska has about 55,000 km of shoreline-- nearly two-thirds the coastline length of the conterminous 48 states (Heard and Andersen 1999)--and a wide diversity of vegetated estuarine and marine habitats (Glass 1996). Two types of submerged vegetation, eelgrass (*Zostera marina*) and kelps (e.g., *Laminaria saccharina*), are widely distributed in lower intertidal and shallow subtidal areas along the Pacific coast of the United States, including Alaska (McRoy 1968, Phillips and Watson 1984, Fonseca et al. 1998, O'Clair and Lindstrom 2000). Only about 35% of Alaska, however, has been mapped to determine the acreage of these vegetated habitat types (National Wetland Inventory staff, U.S. Fish and Wildlife Service, 1011

E. Tudor Rd., Anchorage, AK 99503. Pers. commun., October 2000) and few studies have examined eelgrass and kelp as fish habitat.

Submerged vegetation provides food resources, cover, and nursery habitat for many marine species important in sport and commercial fisheries (Thayer et al. 1978, Gotceitas et al. 1997, Valle et al. 1999, Dean et al. 2000). Worldwide, species from more than 50 families of fish have been found in seagrass habitats (Pollard 1984). Of the few studies done in Alaska, important commercial species found in eelgrass or kelp have included Pacific herring (*Clupea pallasi*), juvenile Pacific cod (*Gadus macrocephalus*), juvenile rockfish (*Sebastes* spp.), and juvenile salmon (*Oncorhynchus* spp.) (Laur and Haldorson 1996, Dean et al. 2000, Murphy et al. 2000, Byerly 2001).

To gather fish distribution and habitat use information necessary to identify EFH, we conducted a survey of eelgrass and kelp habitats throughout southeastern Alaska. Our objectives were to 1) identify and compare fish assemblages in each habitat type and 2) examine patterns in the distribution of fish within each habitat type among northern and southern, inside and outside waters. This report focuses on the most abundant species found in each habitat type and those species included in an FMP for Alaska (North Pacific Fishery Management Council 1998, 2002). Because nearshore, vegetated habitats have a high potential to be affected by shoreline development, the role of these habitats as rearing or spawning areas for commercially important species needs to be documented to identify and conserve EFH.

MATERIALS AND METHODS

Fish assemblages were sampled at 30 sites throughout southeastern Alaska from 1998 to 2000 (Fig. 1). Sampling was conducted from June to August each year. Sites were selected in four regions to cover a geographical gradient from north to south and from inside to outside waters. Marine waters of southeastern Alaska are characterized by an inshore-offshore salinity gradient (Murphy and Orsi 1999) and a north-south temperature gradient (Quast 1968). We chose Frederick Sound as the division between northern and southern regions, similar to the boundary chosen by Quast (1968) (Fig. 1). Sites on or near the outer coast or near major ocean entrances were considered outside waters, whereas all other sites were considered inside waters (Fig. 1). Initially, we attempted to sample eelgrass and kelp at all sites, but this was not possible because eelgrass or kelp habitats were absent or of minimal size at some sites. Thus, at 10 sites only eelgrass was sampled, at 5 sites only kelp, and at 15 sites both eelgrass and kelp were sampled (Fig. 1). Five sites were sampled in 1998, 11 sites in 1999, and 14 sites in 2000.

Most eelgrass sites were located inside protected bays and inlets with freshwater influence, whereas most kelp sites were more oceanic and located in exposed locations at the mouths of bays. Relative to mean lower low water (MLLW), eelgrass occupies areas of the lower intertidal and subtidal zones from +1 m to −6 m, and understory kelp occupies subtidal areas to depths of about −30 m. Eelgrass usually grows in soft substrates of sand or mud. Understory kelp often grows as dense, low-lying mats on rocky substrates. Kelp habitats that we sampled were dominated by *L. saccharina*. This is a brown kelp that has a smooth blade up to 3.5 m long and

18 cm wide (O'Clair and Lindstrom 2000). Other kelps commonly found with *L. saccharina* were *Cymathere triplicata* and two or more species of *Alaria*.

Fish were sampled with a 37-m long variable-mesh beach seine that tapered from 5 m wide at the center to 1 m wide at the ends. Outer panels were each 10 m of 32-mm stretch mesh, intermediate panels were each 4 m of 6-mm square mesh, and the bunt was 9 m of 3.2-mm square mesh. We set the seine as a "round haul" by holding one end on the beach, backing around in a skiff with the other end to the beach about 18 m from the start, and pulling the seine onto shore. The seine had a lead line and a float line so that the bottom contacted the substrate and the top floated. A more complete description of the beach seine and our methods of setting it are provided in Murphy et al. (2000).

Two beach seine hauls were usually made in each habitat type at each site. Exceptions were one seine haul at Auke Bay (Site 3) and from four to six hauls each at Yakobi Island (Site 6), Sitka (Site 18), Heceta Island (Site 26), and Craig (Site 27) (Fig. 1). Seine hauls were at least 50 m apart. All sampling occurred within 2 hours of low tide (range +1.0 to −1.5 m below MLLW).

Captured fish were identified to species and enumerated. Number of fish in large catches was visually estimated for some species (e.g., Pacific herring). Fork length (FL) was measured to the nearest millimeter for up to 50 individuals of selected species including gadids, Pacific herring, Pacific sand lance (*Ammodytes hexapterus*), and rockfish. Fish were anesthetized with MS-222 for identification and measurement. Fish that could not be identified in the field were frozen and later identified in the laboratory.

At most seine haul sites, we measured selected eelgrass and kelp characteristics and recorded temperature and salinity. At eelgrass sites, a transect was laid parallel to shore approximately 0.5 m below MLLW, and three 313-cm^2 quadrats were placed about 5 m apart on the transect. Eelgrass shoots within each quadrat were cut at the substrate surface and rinsed to remove sediments and detritus. Loose epiphytic algae was removed manually. We counted all eelgrass shoots in each sample and placed them in plastic bags. In the laboratory, samples were dried at 60°C to a constant weight and were weighed to the nearest 0.1 g. Similarly, at kelp sites, all kelp within three 0.5-m^2 quadrats was collected, identified, and weighed. Kelp was placed in a mesh bag and spun by hand for about 30 seconds to remove excess water and was then weighed to the nearest 0.1 kg. Temperature and salinity at 30-cm depth were measured with a thermometer and refractometer, respectively.

DATA ANALYSIS

This study was designed to provide a descriptive analysis of species presence or absence in two distinct habitat types. All catch data was standardized to catch per seine haul by dividing the total catch of each species by the number of seine hauls in each habitat type at each site. To show the wide distribution of catch data, we used box-and-whisker plots (Figs. 2 to 5). The bottom of the box represents the first quartile, the top of the box the third quartile, and a line drawn across the box represents the median. Whiskers extend from the top and bottom of the box to (usually) the lowest and highest observations; outliers are shown as solid circles (MINITAB 2000). Catch data was characterized by small numbers or zeros for many species, often resulting in a median catch of zero. Species richness refers to the total number of species found in a given habitat type or location. Species diversity was calculated by the Shannon-Wiener diversity index (H') described in the following equation

$$H' = -\sum_{i=1}^{s} p_i \ln p_i ,$$

where s is the number of species, and p_i is the proportion of the total number of individuals consisting of the i^{th} species (Poole 1974). Two components of diversity are combined in this index: 1) number of species and 2) evenness in number of individuals among species.

RESULTS

A total of 102 seine hauls yielded more than 51,000 fish comprising 54 species, including 23 FMP species (Table 1). Total catch for all years was dominated by Pacific herring and shiner perch (*Cymatogaster aggregata*) that were sometimes captured in large numbers. Based on percent of total catch, the 10 most abundant species were Pacific herring (50.9%), shiner perch (18.3%), crescent gunnels (*Pholis laeta*; 4.9%), juvenile chum salmon (*O. keta*; 4.7%), Pacific sand lance (3.4%), threespine stickleback (*Gasterosteus aculeatus*; 3.2%), bay pipefish (*Syngnathus leptorhynchus*; 2.6%), snake prickleback (*Lumpenus sagitta*; 1.7%), tube-snout (*Aulorhynchus flavidus*; 1.3%), and juvenile pink salmon (*O. gorbuscha*; 1.1%). In addition to Pacific herring and salmon, other species captured that are important in sport or commercial fisheries were cutthroat trout (*O. clarki*), Dolly Varden (*Salvelinus malma*), lingcod (*Ophiodon* *elongatus*), Pacific cod, rockfish (six species), and walleye pollock (*Theragra chalcogramma*). Capture locations for all FMP species are identified in Table 2.

Species richness varied by habitat type and region. For example, number of species ranged from 5 to 22 among eelgrass sites and from 7 to 20 among kelp sites (Table 3). Inclusive of all sites, number of species was greater in eelgrass (median = 14) than in kelp (median = 11). By region, median number of species in eelgrass ranged from 12 in northern outside waters to 20 in southern outside waters. Similarly, median number of species in kelp ranged from 9 in southern inside waters to 11 in northern inside and southern outside waters (Table 3).

Species diversity was similar between habitat types, but varied among regions, particularly among kelp sites (Table 3). Inclusive of all sites, the median Shannon-Wiener diversity index (H') was 1.52 in eelgrass (range 0.04−2.32) and 1.43 in kelp (range 0.06−2.23). Among eelgrass sites, (H') was lowest in southern inside waters (median = 1.34) and greatest in southern outside waters (median = 1.74) (Table 3). Among kelp sites, (H') was lowest in northern outside waters (median = 0.12) and greatest in southern outside waters (median = 1.98) (Table 3). High abundance of Pacific herring at two kelp sites (Port Althorp-Site 5 and Yakobi Island-Site 6) greatly reduced diversity in northern outside waters (Table 3; Fig. 1).

Catch per seine haul (all species) varied considerably between habitat types and among regions within habitat types (Fig. 2), often because of the patchy distribution of some species. Inclusive of all sites, median catch per haul was greater in eelgrass (199 fish) than in kelp (82 fish); catches ranged from a low of about 10 to more than 2,500 fish in both habitat types (Fig. 2). Large catches were often dominated by single species such as Pacific herring or shiner perch. By region, median catch per haul in eelgrass ranged from 159 fish in northern outside waters to 320 fish in southern outside waters. Similarly, median catch per haul in kelp ranged from 30 fish in northern inside waters to 2,528 fish in northern outside waters (Fig. 2).

Abundance of Pacific herring and sand lance, important forage species, was extremely variable with most fish only caught in a few seine hauls. For example, catch per haul of these species was greater than or equal to 2,500 fish at four sites (Bridget Cove-Site 1, Port Althorp-Site 5, Port Camden-Site 19, and Yakobi Island-Site 6; Fig. 1) and zero fish at 15 sites. Infrequent catches of forage fish in both habitat types resulted in a median catch per haul of less than or equal to 0.1 fish in most regions (Fig. 3). Of the more than 26,000 herring captured, 77% were in kelp, whereas of the more than 1,700 sand lance captured, 60% were in eelgrass (Table 1). All herring and most sand lance captured were juveniles. Mean FL was 55 mm (range 27−115 mm; n = 178) for Pacific herring and 82 mm (range 52−122 mm; n = 120) for sand lance.

Most chum, pink, and coho salmon were captured at one site that was sampled in June. Of the total 2,447 chum and 562 pink salmon captured, 62% and 95%, respectively, were captured in kelp at Kelp Bay (Site 14, Fig. 1). All chum and pink salmon were juveniles; mean FL was 58 mm (range 37−88 mm; n = 196) for chum salmon and 42 mm (range 30−64 mm; n = 52) for pink salmon. Of the 333 coho salmon captured, 73% were in eelgrass at Cosmos Cove (just south of Kelp Bay). Most coho salmon captured were smolts; mean size was 119 mm (range 90-135 mm; n = 26).

Of the 759 gadids captured, 57% were walleye pollock and 43% Pacific cod. Catch of gadids was similar in eelgrass and kelp (Table 1). Similar to Pacific herring and sand lance, catch of gadids was also extremely variable with most fish caught at only a few sites. Numerous low or zero catches of gadids (all species) in both habitat types, resulted in a median catch per haul of less than or equal to 1 in all regions (Fig. 4). All gadids captured were juveniles. Mean FL was 67 mm (range 25–148 mm; n = 189) for walleye pollock and 71 mm (range 35–190 mm; n = 156) for Pacific cod.

Of the 477 rockfish captured, most were copper (*S. caurinus*; 60%) and black (*S. melanops*; 25%) rockfish. Other species captured included brown (*S. auriculatus*), dusky (*S. ciliatus*), quillback (*S. maliger*), and yellowtail (*S. flavidus*) rockfish. For most rockfish species, total catch was greater in eelgrass than in kelp (Table 1). In each habitat type, median catch per haul of rockfish was greater in northern and southern outside waters (range 4.8-9.5 fish) than in northern and southern inside waters; few rockfish were captured in inside waters (Fig. 5). Most rockfish captured were juveniles; mean FL (all species) was 107 mm (range 49–231 mm; n = 475).

Other abundant species included bay pipefish, crescent gunnel, shiner perch, snake prickleback, threespine stickleback, and tube-snout. Total catch of these species was greater in eelgrass than in kelp; few bay pipefish, snake prickleback, threespine stickleback, and tubesnout were captured in kelp (Table 1). Catch of these species varied by region within each habitat type. For example, among eelgrass sites, median catch per haul of shiner perch was greater in northern and southern outside waters (64 and 18 fish, respectively) than in comparable inside waters ($\leq$5 fish); no shiner perch were captured in northern inside waters.

Some of the less abundant FMP species captured in eelgrass and kelp included flatfish, Arctic shanny (*Stichaeus punctatus*), Pacific sandfish (*Trichodon trichodon*), penpoint gunnel (*Apodichthys flavidus*), red Irish lord (*Hemilepidotus hemilepidotus*), and surf smelt (*Hypomesus pretiosus*) (Table 1). Only 68 flatfish were caught consisting of 6 species: 31 rock sole (*Lepidopsetta bilineata*), 17 Pacific sanddab (*Citharichthys sordidus*), 11 yellowfin sole (*Limanda *asper*), 4 starry flounder (*Platichthys stellatus*), 3 English sole (*Parophrys vetulus*), and 2 butter sole (*Isopsetta isolepis*). All were juveniles and most (59%) were captured in eelgrass. Mean FL of flatfish was 112 mm (range 92−150 mm; n = 7). For the rest of the species mentioned above, numbers captured were small (<180 fish) and most were in eelgrass (Table 1; Table 2).

Based on frequency of occurrence at all sites sampled, the two most ubiquitous species were crescent gunnels and northern sculpin (*Icelinus borealis*). Crescent gunnels were captured at all eelgrass and kelp sites, whereas northern sculpin were captured at 92% of the eelgrass sites and 94% of the kelp sites (Fig. 6). Species not already mentioned and found in at least 50% of all eelgrass or kelp sites were Pacific staghorn sculpin (*Leptocottus armatus*), buffalo sculpin (*Enophrys bison*), great sculpin (*Myoxocephalus polyacanthocephalus*), and silverspotted sculpin (*Blepsias cirrhosus*).

Eelgrass shoot density and biomass and kelp biomass were similar among regions (Fig. 7). Mean density ranged from 624 shoots/m^2 in northern inside waters to 985 shoots/m^2 in southern inside waters. Eelgrass biomass (dry weight) ranged from a mean of 62.3 g/m^2 in southern inside waters to 129.9 g/m^2 in southern outside waters. Kelp biomass (wet weight) was similar in all regions and averaged about 3.5 kg/m^2.

At the 15 sites where both habitat types were sampled, water temperatures were often higher (7 of 15 sites) and salinities lower (10 of 15 sites) in eelgrass than in kelp. Among eelgrass sites by region, mean water temperature ranged from 12.3°C in southern inside waters to 14.0°C in northern outside waters, and mean salinity ranged from 19.7 PSS in northern inside waters to 28.7 PSS in southern outside waters. Similarly, among kelp sites, mean water temperature ranged from 11.8°C in southern inside waters to 12.4°C in southern outside waters, and mean salinity ranged from 26.8 PSS in southern inside waters to 31.8 PSS in southern outside waters.

DISCUSSION

Submerged vegetation provides habitat structure and complexity and attracts diverse assemblages of fish. More than 50 species of marine fish, many of commercial importance, use eelgrass and kelp habitats in southeastern Alaska. Commercially important species that we captured, mostly as juveniles, included flatfish, Pacific cod, Pacific herring, rockfish, salmon, and walleye pollock. Most of these are target species in either a groundfish or salmon FMP in Alaska (North Pacific Fishery Management Council 1998, 2002). The presence of juveniles in eelgrass and kelp indicate that these habitats may be important nursery areas for some species. Abundant non-commercial species were shiner perch, crescent gunnel, threespine stickleback, and bay pipefish. Gunnels are included in the forage fish category in the FMP for groundfish in the Gulf of Alaska (North Pacific Fishery Management Council 2002). Similar fish assemblages in eelgrass and kelp have been observed in other areas of Alaska and the northeast Pacific Ocean (Phillips and Watson 1984, Laur and Haldorson 1996, Dean et al. 2000, Murphy et al. 2000).

Species richness was higher in eelgrass than in kelp, whereas species diversity was similar between habitat types. Near Craig, Alaska, Murphy et al. (2000) found no difference in species richness and diversity between eelgrass and kelp, but did catch significantly more fish in eelgrass. Although our catch data varied considerably between habitat types, median catch per haul (all species) was more than twice as great in eelgrass (199 fish) than in kelp (82 fish). Regardless of plant type, submerged vegetation offers increased habitat complexity (via plant density and morphology) otherwise lacking on bare or sparsely covered bottoms (Heck and Orth 1980). Higher species richness, diversity, and abundance of fish in vegetated versus unvegetated bottoms has been reported in many areas (Briggs and O'Connor 1971, Orth and Heck 1980, Orth et al. 1984, Lubbers et al. 1990, Sogard and Able 1991, Connolly 1994, Lazzari and Tupper 2002, Wyda et al. 2002).

Herring and sand lance may utilize eelgrass and kelp differently. Both of these species school, which may explain the highly variable and sometimes large catches at some sites. Herring are important in commercial and subsistence fisheries in Alaska, and along with sand lance, are key forage fish for other species of fish, birds, and marine mammals (Dick and Warner 1982, Paul and Paul 1998). Sand lance are included in the forage fish category in the FMP for groundfish in the Gulf of Alaska (North Pacific Fishery Management Council 2002), whereas herring are managed by the state of Alaska and are not an FMP species. The temporal extent to which herring and sand lance use eelgrass or kelp is unknown; we sampled only in summer. Because sand lance spawn on beaches of sand and gravel in fall (Dick and Warner 1982), use of eelgrass and kelp is probably limited to summer rearing of juveniles. Herring, however, use submerged vegetation for rearing and as a spawning substrate in spring (Phillips and Watson 1984). In Boca de Quadra, southeastern Alaska, eelgrass and kelp are the dominant vegetation types used as spawning substrates (Blankenbeckler and Larson 1982), whereas in Washington, eelgrass is the dominant vegetation type that receives herring spawn (Stick 1995).

At one of the few sites that we sampled in June, the catch was dominated by juvenile salmon and most were caught in kelp. Few salmon were captured at sites sampled in July and August.

Pink and chum salmon fry are abundant in nearshore waters of Alaska from mid-April to mid-June (Jaenicke et al. 1984, Celewycz et al. 1994), often in schools of thousands of fish (Heard 1991). Whether salmon fry only transit through eelgrass and kelp on their way from estuaries to offshore waters or use submerged vegetation as nursery areas is unclear. Nearshore habitats can provide food and cover for salmon fry, or protection from wind-generated waves and strong tidal currents (Celewycz et al. 1994). Murphy et al. (2000), however, found no difference in catch of juvenile pink and chum salmon between vegetated and sparsely vegetated sites near Craig, Alaska.

Juvenile Pacific cod and walleye pollock were captured in eelgrass and kelp but were not very abundant. Murphy et al. (2000) also found few Pacific cod or pollock in eelgrass or kelp. In Prince William Sound, Alaska, however, juvenile Pacific cod are abundant in eelgrass (Laur and Haldorson 1996, Dean et al. 2000). Similarly, in Nova Scotia, juvenile Atlantic cod (*Gadus morhua*) use eelgrass (Tupper and Boutilier 1995), possibly as refuge habitat from predators (Gotceitas et al. 1997). We cannot explain the lack of association between Pacific cod and eelgrass in southeastern Alaska. In another study, we captured with beach seines and observed with an ROV (remotely operated vehicle) hundreds of thousands of juvenile gadids (mostly pollock) in kelp near the Brothers Islands, southeastern Alaska[1], possibly indicating that gadids may have spatially discrete nursery areas.

Several species of rockfish recruit as pelagic larvae to some type of substrate including submerged vegetation (Love et al. 1991, Murphy et al. 2000, Byerly 2001). We found juveniles of

[1] S. W. Johnson, unpubl. data. Auke Bay Laboratory, Alaska Fish. Sci. Cent., 11305 Glacier Hwy., Juneau, AK 99801-8626.

six species of rockfish in eelgrass and kelp; copper and black rockfish were the two most abundant species. Three of the species that we captured (copper, dusky, and quillback rockfish) are included in the FMP for groundfish in the Gulf of Alaska (North Pacific Fishery Management Council 2002). Juvenile rockfish may use shallow, submerged vegetation for summer rearing only. In Puget Sound, Washington, brown, copper, and quillback rockfish occupy eelgrass and low-relief rocky areas with kelp in summer but are mostly absent in winter (Matthews 1990). In Yaquina Bay, Oregon, Bayer (1981) captured juvenile black rockfish in eelgrass from March through October. In a mark-recapture study near Sitka, Alaska, juvenile copper rockfish were found in the same eelgrass or kelp bed from May to August (Byerly 2001). Year-round sampling is needed to determine the seasonal utilization of vegetated habitats by juvenile rockfish in southeastern Alaska. Juvenile rockfish may migrate from shallow, nearshore habitats in summer to deeper water in winter (Moulton 1977). In Washington and British Columbia, copper rockfish hide in crevices of rocky substrates and become inactive in fall and winter (Patten 1973, Richards 1987).

Differences in water temperature, salinity, cover, food, and presence of predators likely accounts for some of the different distribution and abundance patterns that we observed among study sites. In Kachemak Bay, Alaska, differences in the distribution and abundance of nearshore fish between inner and outer bay sites corresponded to differences in temperature and salinity (Abookire et al. 2000). Many eelgrass sites that we sampled were inside sheltered bays with warmer, less saline surface waters than more exposed areas with kelp. Warmer water can enhance growth and survival of juvenile fish (Gadomski and Caddell 1991, Gibson 1994) and the input of stream nutrients can increase food production (St. John et al. 1992). This may partially explain why gunnels, pipefish, pricklebacks, sticklebacks, and tube-snouts were more abundant in eelgrass than in kelp. In addition, these species may be particularly well-adapted to eelgrass because they feed on small crustaceans (Hart 1973) that, in turn, depend on eelgrass detritus (Pollard 1984). Distribution may also be influenced by species seeking eelgrass or kelp to escape predators (Gotceitas et al. 1995). Greenlings (Hexagrammidae) and cottids, however, were common in both habitat types and are predators of juvenile salmon and gadids (Hart 1973, Celewycz et al. 1994). Thus, a trade-off exists between using vegetated habitats for food resources and increased risk to predation.

Proximity to spawning areas may also affect the geographical distribution and abundance of some species. For example, we captured most juvenile rockfish at sites on or near the outer coast; few rockfish were captured in inside waters. The two most abundant species that we captured in eelgrass or kelp were black and copper rockfish. Adult black rockfish are more abundant in outside coastal waters than in inside waters, often in large schools (Rosenthal et al. 1982, Humann 1996) and no adult copper rockfish were observed in an ROV survey of northern inside waters (S. W. Johnson, unpubl. data). Thus, larvae spawned from adults of these species are more likely to “settle and stay” in vegetated habitats near the outer coast than in inside waters. Reasons for the complete absence of rockfish at some inside sites (e.g., Auke Bay-Site 3, Bridget Cove-Site 1, Funter Bay-Site 4, St. James Bay-Site 2; Fig. 1), however, are unclear. Juvenile dusky, quillback, and yellowtail rockfish use submerged vegetation and adults of these species are present in northern inside waters (Carlson and Barr 1977, Carlson 1986, S. W. Johnson, unpubl. data). Assuming that these rockfish spawn in inside waters, we would expect some juveniles to rear in eelgrass or kelp. Natural variability among individual sites in temperature, salinity, or vegetation characteristics, however, may limit or exclude rockfish recruitment. Additionally, larval mortality may be higher in inside waters than outside waters or juveniles may utilize other habitats in inside waters that we did not sample.

Regional differences in distribution and abundance were expected for some species. For example, shiner perch were not captured in northern inside waters in eelgrass or kelp. This was expected because shiner perch prefer more outside coastal waters and our sites are north of their published range boundary (Wrangell, Alaska) (McConnaughey and McConnaughey 1998). We did, however, capture shiner perch at one of our northern outside sites (St. John Baptist Bay-Site 13; Fig. 1), extending the northern range of this species about 90 km.

The patchy distribution and variable abundance of many species, and the wide range in physical characteristics among individual sites, highlight the importance of site-specific evaluation by resource managers. No two eelgrass or kelp sites were identical; subtle differences in temperature, salinity, eelgrass shoot density, and exposure to adverse weather among sites can influence fish assemblages and abundance. Additionally, our sampling was limited to summer and needs to be expanded to other seasons of the year to gain a full understanding of the importance of submerged vegetation as fish habitat.

Eelgrass and kelp are widely distributed in southeastern Alaska and support high species richness, diversity, and fish abundance. Our results show that juveniles of many commercially important species use these habitats in summer. Eelgrass often occurs in discrete patches, and some of these discrete areas may be “essential” for rearing or spawning. Vegetated habitats on or near the outer coast may be particularly important to some species of rockfish as nursery areas. Similarly, herring may use eelgrass as a spawning substrate in discrete areas, and loss of this habitat could affect herring populations. Further studies are needed to identify the spatial coverage of eelgrass and kelp in Alaska and the function of these habitats as EFH. Information from this study on the distribution and habitat of nearshore fish assemblages will help resource managers identify and protect coastal areas at risk to human disturbance.

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CITATIONS

Abookire, A. A., J. F. Piatt, and M. D. Robards. 2000. Nearshore fish distribution in an Alaskan estuary in relation to stratification, temperature, and salinity. Est. Coast. Shelf Sci. 51:45-59.

Bayer, R. 1981. Shallow-water intertidal ichthyofauna of the Yaquina Estuary, Oregon. Northwest Sci. 55:182-193.

Blankenbeckler, D., and R. Larson. 1982. Pacific herring (*Clupea harengus pallasii*) spawning ground research in southeastern Alaska, 1978, 1979, and 1980. ADF&G Tech. Data Rep. No. 69, 51 p.

Briggs, P. T., and J. S. O'Connor. 1971. Comparison of shore-zone fishes over naturally vegetated and sand-filled bottoms in Great South Bay. N. Y. Fish Game J. 18:15-41.

Byerly, M. 2001. The ecology of age-1 copper rockfish (*Sebastes caurinus*) in vegetated habitats of Sitka Sound, Alaska. M.S. Thesis, University of Alaska, Fairbanks, 127 p.

Carlson, H. R. 1986. Restricted year-class structure and recruitment lag within a discrete school of yellowtail rockfish. Trans. Am. Fish. Soc. 115:490-492.

Carlson, H. R., and L. Barr. 1977. Seasonal changes in spatial distribution and activity of two species of Pacific rockfishes, *Sebastes flavidus* and *S. ciliatus*, in Lynn Canal, southeastern Alaska. Mar. Fish. Rev. 39(3):23-24.

Celewycz, A. G., A. C. Wertheimer, J. A. Orsi, and J. L. Lum. 1994. Nearshore distribution and residency of pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) fry and their predators in Auke Bay and Gastineau Channel, Southeast Alaska. AFSC Proc. Rep. 94-05, 39 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Auke Bay Laboratory, 11305 Glacier Highway, Juneau, AK 99801-8626.

Connolly, R. M. 1994. A comparison of fish assemblages from seagrass and unvegetated areas of a southern Australian estuary. Aust. J. Mar. Freshw. Res. 45:1033-1044.

Dean, T. A., L. Haldorson, D. R. Laur, S. C. Jewett, and A. Blanchard. 2000. The distribution of nearshore fishes in kelp and eelgrass communities in Prince William Sound, Alaska: associations with vegetation and physical habitat characteristics. Environ. Biol. Fish. 57:271-287.

Dick, M. H., and I. M. Warner. 1982. Pacific sand lance, *Ammodytes hexapterus* Pallas, in the Kodiak Island group, Alaska. Syesis 15:43-50.

Fonseca, M. S., W. J. Kenworthy, and G. W. Thayer. 1998. Guidelines for the conservation and restoration of seagrasses in the United States and adjacent waters. U.S. Dep. Commer., NOAA, Coastal Ocean Program, Decision Analysis Ser. No. 12, 149 p.

Gadomski, D. M., and Caddell S. M. 1991. Effects of temperature on early-life-history stages of California halibut *Paralichthys californicus*. Fish. Bull. 89:567-576.

Gibson, R. N. 1994. Impact of habitat quality and quantity on the recruitment of juvenile flatfishes. Neth. J. Sea Res. 32:191-206.

Glass, R. L. 1996. Alaska wetland resources, p. 107-114. *In* J. D. Fretwell, J. S. Williams, and P. J. Redman (editors), National water summary on wetland resources. U.S. Geol. Surv., Water-Supply Paper 2425.

Gotceitas, V., S. Fraser, and J. A. Brown. 1995. Habitat use by juvenile Atlantic cod (*Gadus morhua*) in the presence of an actively foraging and non-foraging predator. Mar. Biol. 123:421-430.

Gotceitas, V., S. Fraser, and J. A. Brown. 1997. Use of eelgrass beds (*Zostera marina*) by juvenile Atlantic cod (*Gadus morhua*). Can. J. Fish. Aquat. Sci. 54:1306-1319.

Hart, J. L. 1973. Pacific fishes of Canada. Fish. Res. Bd. Can., Bulletin 180, 740 p.

Heard, W. R. 1991. Life history of pink salmon (*Oncorhynchus gorbuscha*), p. 121-230. *In* C. Groot and L. Margolis (editors), Pacific salmon life histories. UBC Press, Vancouver.

Heard, W. R., and A. M. Andersen. 1999. Alaska salmon, p. 157-166. *In* Our living oceans: report on the status of U.S. living marine resources. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-41.

Heck, K. L. Jr., and R. J. Orth. 1980. Seagrass habitats: the roles of habitat complexity, competition and predation in structuring associated fish and motile macroinvertebrate assemblages, p. 449-464. *In* V. S. Kennedy (editor), Estuarine perspectives. Academic Press.

Humann, P. 1996. Coastal fish identification; California to Alaska. New World Publications, Inc. Jacksonville, Florida, 208 p.

Jaenicke, H. W., A. G. Celewycz, J. E. Bailey, and J. A. Orsi. 1984. Paired open beach seines to study estuarine migrations of juvenile salmon. Mar. Fish. Rev. 46(3):62-67.

Laur, D., and L. Haldorson. 1996. Coastal habitat studies: the effect of the *Exxon Valdez* oil spill on shallow subtidal fishes in Prince William Sound, p. 659-670. *In* S. D. Rice, R. B. Spies, D. A. Wolfe, and B. A. Wright (editors), Proc. of the *Exxon Valdez* oil spill symposium. Am. Fish. Soc. Symp. No. 18, Bethesda, Maryland.

Lazzari, M. A., and B. Tupper. 2002. Importance of shallow water habitats for demersal fishes and decapod crustaceans in Penobscot Bay, Maine. Environ. Biol. Fish. 63:57-66.

Love, M. S., M. H. Carr, and L. J. Haldorson. 1991. The ecology of substrate-associated juveniles of the genus *Sebastes*. Environ. Biol. Fish. 30:225-243.

Lubbers, L., W. R. Boynton, and W. M. Kemp. 1990. Variations in structure of estuarine fish communities in relation to abundance of submersed vascular plants. Mar. Ecol. Prog. Ser. 65:1-14.

Matthews, K. R. 1990. A comparative study of habitat use by young-of-the-year, subadult, and adult rockfishes on four habitat types in Central Puget Sound. Fish. Bull. 88:223-239.

McConnaughey, B. H., and E. McConnaughey. 1998. Pacific Coast. Chanticleer Press, Inc., New York.

McRoy, C. P. 1968. The distribution and biogeography of *Zostera marina* (eelgrass) in Alaska. Pac. Sci. 22:507-513.

MINITAB. 2000. User’s guide 1: data, graphics, and macros. Release 13 for Windows. MINITAB, Inc.

Moulton, L. L. 1977. An ecological analysis of fishes inhabiting the rocky nearshore regions of northern Puget Sound, Washington. Ph. D. Thesis, University of Washington, Seattle, 145 p.

Murphy, M. L., S. W. Johnson, and D. J. Csepp. 2000. A comparison of fish assemblages in eelgrass and adjacent subtidal habitats near Craig, Alaska. Alsk. Fish. Res. Bull. 7:11-21.

Murphy, J. M., and J. Orsi. 1999. Physical oceanographic observations collected aboard the NOAA ship *John N. Cobb* in the northern region of southeastern Alaska, 1997 and 1998. AFSC Proc. Rep. 99-02, 239 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Auke Bay Laboratory, 11305 Glacier Highway, Juneau, AK 99801-8626.

National Marine Fisheries Service. 1999. Our living oceans. Report on the status of U.S. living marine resources, 1999. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-41, 301 p.

North Pacific Fishery Management Council. 1998. Essential fish habitat. Draft environmental assessment for amendments 5, 8, and 55. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK, 364 p.

North Pacific Fishery Management Council. 2002. Fishery management plan for groundfish of the Gulf of Alaska. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK, 333 p.

O'Clair, R. M., and S. C. Lindstrom. 2000. North Pacific seaweeds. Plant Press, Auke Bay, AK.

Orth, R. J., and K. L. Heck, Jr. 1980. Structural components of eelgrass (*Zostera marina*) meadows in the lower Chesapeake Bay-Fishes. Estuaries 3:278-288.

Orth, R. J., K. L. Heck, Jr., and J. V. Montfrans. 1984. Faunal communities in seagrass beds: a review of the influence of plant structure and prey characteristics on predator-prey relationships. Estuaries 7:339-350.

Patten, B. G. 1973. Biological information on copper rockfish in Puget Sound, Washington. Trans. Am. Fish. Soc. 102:412-416.

Paul, A. J., and J. M. Paul. 1998. Comparisons of whole body energy content of captive fasting age zero Alaskan Pacific herring (*Clupea pallasi* Valenciennes) and cohorts over-wintering in nature. J. Exp. Mar. Biol. Ecol. 226:75-86.

Phillips, R. C., and J. F. Watson. 1984. The ecology of eelgrass meadows in the Pacific Northwest: a community profile. U.S. Dep. Inter., Fish and Wildl. Serv. FWS/OBS-84/24, Portland, OR, 85 p.

Pollard, D. A. 1984. A review of ecological studies on seagrass-fish communities, with particular reference to recent studies in Australia. Aquat. Bot. 18:3-42.

Poole, R. W. 1974. An introduction to quantitative ecology. McGraw-Hill Book Company, New York.

Quast, J. C. 1968. New records of thirteen Cottoid and Blennioid fishes for Southeastern Alaska. Pac. Sci. 22:482-487.

Richards, L. J. 1987. Copper rockfish (*Sebastes caurinus*) and quillback rockfish (*Sebastes maliger*) habitat in the Strait of Georgia, British Columbia. Can. J. Zool. 65:3188-3191.

Rosenthal, R. J., L. Haldorson, L. J. Field, V. M. O'Connell, M. G. LaRiviere, J. Underwood, and M. C. Murphy. 1982. Inshore and shallow offshore bottomfish resources in the southeastern Gulf of Alaska. AK Dep. Fish & Game, Alaska Coastal Research, University of Alaska, Juneau.

Sogard, S. M., and K. W. Able. 1991. A comparison of eelgrass, sea lettuce macroalgae, and marsh creeks as habitats for epibenthic fishes and decapods. Est. Coast. Shelf Sci. 33:501-519.

Stick, K. 1995. Marine vegetation and their use for herring spawn deposition at Cherry Point, Washington, p. 5-9. *In* D.E. Hay and P. B. McCarter (editors), Proc. of the seventh Pacific Coast herring workshop. Can. Tech. Rep. of Fish. and Aquat. Sci. 2060, Nanaimo, British Columbia.

St. John, M. A., J. S. MacDonald, P. J. Harrison, R. J. Beamish, and E. Choromanski. 1992. The Fraser River plume: some preliminary observations on the distribution of juvenile salmon, herring, and their prey. Fish. Oceanogr. 1:153-162.

Thayer, G. W., H. H. Stuart, W. J. Kenworthy, J. F. Ustach, and A. B. Hall. 1978. Habitat values of salt marshes, mangroves, and seagrasses for aquatic organisms, p. 235-247. *In* P. E. Greeson, J. R. Clark, and J. E. Clark (editors), Wetland functions and values: The state of our understanding. Am. Water Res. Assoc., Minneapolis, Minnesota.

Tupper, M., and R. G. Boutilier. 1995. Size and priority at settlement determine growth and competitive success of newly settled Atlantic cod. Mar. Ecol. Prog. Ser. 118:295-300.

Valle, C. F., J. W. O'Brien, and K. B. Wiese. 1999. Differential habitat use by California halibut, *Paralichthys californicus*, barred sand bass, *Paralabrax nebulifer*, and other juvenile fishes in Alamitos Bay, California. Fish. Bull. 97:646-660.

Wyda, J. C., L. A. Deegan, J. E. Hughes, and M. J. Weaver. 2002. The response of fishes to submerged aquatic vegetation complexity in two ecoregions of the mid-Atlantic Bight: Buzzards Bay and Chesapeake Bay. Estuaries 25:86-100.

Table 1.--Mean catch per seine haul and total catch of fish in eelgrass (*Zostera marina*) and kelp (mostly *Laminaria saccharina*) habitats at 30 sites in southeastern Alaska from 1998 to 2000. Sampling was between June and August each year. Seine hauls totaled 56 in eelgrass and 46 in kelp. Species are listed in decreasing order of abundance based on total catch. An asterisk indicates that the species is included in a fishery management plan in Alaska.

		Mean Catch Per Haul		Total Catch (all years)	
Common Name	Scientific Name	Eelgrass	Kelp	Eelgrass	Kelp
Pacific herring	*Clupea pallasi*	109.05	437.39	6,107	20,120
Shiner perch	*Cymatogaster aggregata*	144.59	29.13	8,097	1,340
Crescent gunnel*	*Pholis laeta*	34.93	11.07	1,956	509
Chum salmon*	*Oncorhynchus keta*	5.75	46.20	322	2,125
Pacific sand lance*	*Ammodytes hexapterus*	19.09	15.30	1,069	704
Threespine stickleback	*Gasterosteus aculeatus*	29.16	0.30	1,633	14
Bay pipefish	*Syngnathus leptorhynchus*	23.41	0.24	1,311	11
Snake prickleback*	*Lumpenus sagitta*	14.86	0.76	832	35
Tube-snout	*Aulorhynchus flavidus*	11.75	0.76	658	35
Pink salmon*	*Oncorhynchus gorbuscha*	0.13	12.07	7	555
Pacific staghorn sculpin	*Leptocottus armatus*	7.84	0.28	439	13
Walleye pollock*	*Theragra chalcogramma*	4.20	4.24	235	195
Juvenile greenling	*Hexagrammos* spp.	4.77	3.02	267	139

Table 1 (cont.)--

Common Name	Scientific Name	Mean Catch Per Haul		Total Catch (all years)	
		Eelgrass	Kelp	Eelgrass	Kelp
Northern sculpin	*Icelinus borealis*	5.50	2.09	308	96
Tubenose poacher	*Pallasina barbata aix*	5.79	0.26	324	12
Coho salmon*	*Oncorhynchus kisutch*	4.63	1.61	259	74
Pacific cod*	*Gadus macrocephalus*	3.39	2.98	190	137
Copper rockfish*	*Sebastes caurinus*	3.34	2.11	187	97
Great sculpin*	*Myoxocephalus polyacanthocephalus*	2.32	1.07	130	49
Silverspotted sculpin	*Blepsias cirrhosus*	1.70	1.07	95	49
Black rockfish	*Sebastes melanops*	1.52	0.72	85	33
Kelp greenling	*Hexagrammos decagrammus*	0.91	1.07	51	49
Whitespotted greenling	*Hexagrammos stelleri*	1.14	0.52	64	24
Brown rockfish	*Sebastes auriculatus*	0.77	0.13	43	6
Buffalo sculpin	*Enophrys bison*	0.41	0.52	23	24
Lingcod	*Ophiodon elongatus*	0.50	0.22	28	10
Arctic shanny*	*Stichaeus punctatus*	0.29	0.46	16	21
Kelp perch	*Brachyistius frenatus*	0.50	0.13	28	6
Rock sole*	*Lepidopsetta bilineata*	0.14	0.50	8	23
Red Irish lord*	*Hemilepidotus hemilepidotus*	0.30	0.15	17	7

Table 1 (cont.)--

Common Name	Scientific Name	Mean Catch Per Haul		Total Catch (all years)	
		Eelgrass	Kelp	Eelgrass	Kelp
Tadpole sculpin	*Psychrolutes paradoxus*	0.32	0.00	18	0
Rock greenling	*Hexagrammos lagocephalus*	0.29	0.04	16	2
Dolly Varden	*Salvelinus malma*	0.09	0.28	5	13
Pacific sanddab	*Citharichthys sordidus*	0.25	0.07	14	3
Blackeye goby	*Coryphopterus nicholsi*	0.07	0.28	4	13
Dusky rockfish*	*Sebastes ciliatus*	0.20	0.04	11	2
Masked greenling	*Hexagrammos octogrammus*	0.20	0.04	11	2
Surf smelt*	*Hypomesus pretiosus*	0.16	0.09	9	4
Cutthroat trout	*Oncorhynchus clarki*	0.21	0.00	12	0
Yellowfin sole*	*Limanda asper*	0.16	0.04	9	2
Sailfin sculpin	*Nautichthys oculofasciatus*	0.16	0.02	9	1
Quillback rockfish*	*Sebastes maliger*	0.02	0.20	1	9
Brown Irish lord	*Hemilepidotus spinosus*	0.11	0.09	6	4
Cabezon	*Scorpaenichthys marmoratus*	0.00	0.17	0	8
Painted greenling	*Oxylebius pictus*	0.00	0.17	0	8
Penpoint gunnel*	*Apodichthys flavidus*	0.11	0.04	6	2
Tidepool snailfish	*Liparis florae*	0.04	0.09	2	4

Table 1 (cont.)--

Common Name	Scientific Name	Mean Catch Per Haul		Total Catch (all years)	
		Eelgrass	Kelp	Eelgrass	Kelp
Starry flounder*	*Platichthys stellatus*	0.07	0.00	4	0
Yellowtail rockfish*	*Sebastes flavidus*	0.00	0.07	0	3
English sole*	*Parophrys vetulus*	0.05	0.00	3	0
Pacific tomcod	*Microgadus proximus*	0.04	0.00	2	0
Butter sole*	*Isopsetta isolepis*	0.04	0.00	2	0
Pacific sandfish*	*Trichodon trichodon*	0.00	0.04	0	2
Northern ronquil	*Ronquilus jordani*	0.02	0.02	1	1
Smoothhead sculpin	*Artedius lateralis*	0.00	0.02	0	1
Total				24, 934	26, 596

Table 2.--Habitat type and capture locations of species included in a fishery management plan (FMP) in Alaska. Data is based on fish collected by beach seine at 30 sites throughout southeastern Alaska from 1998 to 2000. Sites were sampled from June to August each year. Habitat represents the vegetation type (eelgrass, *Zostera marina* or kelp, mostly *Laminaria saccharina*) where most fish were captured (>50% of the total catch for each species). See Figure 1 and Table 3 to match site numbers with site locations and names.

		Capture Locations (site numbers)	
FMP Species Group	Habitat	Eelgrass	Kelp
Target species			
Walleye pollock	eelgrass	2, 4, 10, 14	14, 17, 19, 21
Pacific cod	eelgrass	2, 5, 7, 16, 18, 26-29	12, 14, 18, 21, 22, 28
Yellowfin sole	eelgrass	7, 9, 10	7, 17
Rock sole	kelp	2, 9, 12, 14, 20, 30	11, 17, 19
Starry flounder	eelgrass	12, 20, 24	
Butter sole	eelgrass	14	
English sole	eelgrass	10, 23, 30	
Copper rockfish	eelgrass	15, 16, 18, 25-27, 29, 30	5, 6, 18, 21, 23, 25, 27-29
Quillback rockfish	kelp	14	6, 21
Dusky rockfish	eelgrass	5, 18	18, 21

Table 2 (cont.)--

FMP Species Group	Habitat	Capture Locations (site numbers) Eelgrass	Kelp
Yellowtail rockfish	kelp		21
Chum salmon	kelp	2, 14, 27, 29	12, 14, 17, 21, 27, 29
Pink salmon	kelp	2, 14	12, 14, 23
Coho salmon	eelgrass	2, 14, 20, 24, 29	12, 14, 20, 22, 27
Forage fish			
Arctic shanny	kelp	4, 7-10, 12	4, 7, 11, 12, 17, 19
Crescent gunnel	eelgrass	1-30	1-30
Penpoint gunnel	eelgrass	18	18
Snake prickleback	eelgrass	2, 4, 7, 9, 12-15, 18, 20, 22-30	7, 12, 14, 19, 20
Pacific herring	kelp	1, 4, 7, 10, 18, 26, 29	4-6, 18, 19, 29
Pacific sandfish	kelp		14, 24
Pacific sand lance	eelgrass	5, 20, 26-29	5, 14, 18, 19, 25, 29, 30
Surf smelt	eelgrass	20	19, 20, 24
Other species			
Great sculpin	eelgrass	2, 4, 7-10, 12, 14, 15, 20, 22-27, 29, 30	4, 7, 12, 14, 17, 19, 20, 22, 28, 29
Red Irish lord	eelgrass	2, 5, 18, 26-29	5, 6, 18, 27

Table 3.--Species richness (number of species) and Shannon-Weiner diversity index (H') for fish assemblages sampled with a beach seine at 30 sites in southeastern Alaska from 1998 to 2000. Eelgrass (*Zostera marina*) and kelp (mostly *Laminaria saccharina*) habitats were sampled from June through August each year. Missing values indicate no data collected. Regions are northern inside and outside and southern inside and outside waters. Refer to Figure 1 to match site number with location.

	Number of Species		Diversity Index (H')	
Site Name and Number	Eelgrass	Kelp	Eelgrass	Kelp
		Northern Inside		
Bridget Cove (1)	6.0		0.04	
St. James Bay (2)	17.0		1.32	
Auke Bay (3)	5.0		1.56	
Funter Bay (4)	12.0	11.0	1.95	2.09
Neka Bay (7)	14.0	9.0	1.55	1.63
Tenakee Inlet (8)	9.0		1.73	
Ushk Bay (9)	13.0		1.80	
Sitkoh Bay (10)	14.0		1.26	
Hobart Bay (11)		8.0		1.38
Pybus Bay (12)	12.0	14.0	1.42	1.11
Cosmos Cove/Kelp Bay (14)	16.0	20.0	1.89	1.18
Median	12.5	11.0	1.56	1.38
		Northern Outside		
Port Althorp (5)	12.0	10.0	2.03	0.12
Yakobi Island (6)		10.0		0.06
St. John Baptist Bay (13)	12.0		1.81	

Table 3 (cont.)--

Site Name and Number	Number of Species		Diversity Index (H')	
	Eelgrass	Kelp	Eelgrass	Kelp
Nakwasina Sound (15)	16.0		0.94	
Katlian Bay (16)	11.0		1.44	
Sitka Sound (18)	20.0	19.0	1.11	1.14
Median	12.0	10.0	1.44	0.12
		Southern Inside		
Farragut Bay (17)		12.0		1.48
Port Camden (19)		17.0		0.35
Kah Sheets Bay (20)	16.0	12.0	1.27	1.69
Exchange Cove (22)	14.0	9.0	1.36	1.84
Olive Cove (24)	14.0	8.0	1.34	0.72
Steamer Bay (25)	12.0	9.0	1.52	1.52
Twelvemile Arm (28)	14.0	8.0	0.83	0.55
Median	14.0	9.0	1.34	1.48
		Southern Outside		
Port Conclusion (21)		11.0		1.49
Calder Bay/Shakan Bay (23)	13.0	11.0	1.74	1.99
Warm Chuck Inlet (26)	20.0		1.80	
Craig/Klawock Inlet (27)	21.0	19.0	1.68	2.23
Port San Antonio (29)	22.0	12.0	2.32	1.98
Bostwick Inlet (30)	18.0	7.0	1.18	0.85
Median	20.0	11.0	1.74	1.98

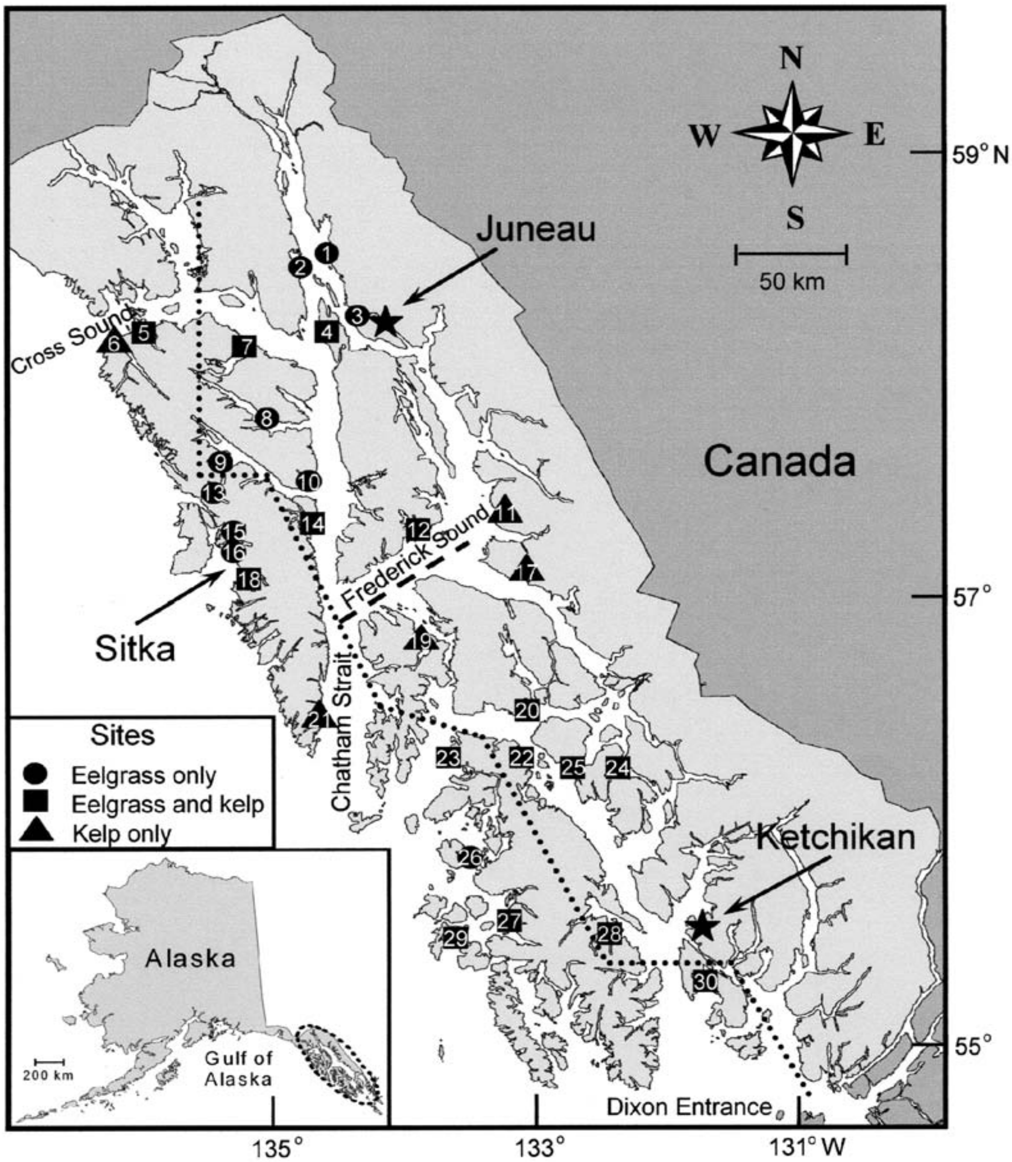

Figure 1.-- Locations of eelgrass (*Zostera marina*) and kelp (mostly *Laminaria saccharina*) sites sampled for fish assemblages in southeastern Alaska. Thirty sites were sampled by beach seine from 1998 to 2000. Sampling was between June and August each year. Dashed line (Frederick Sound) divides northern and southern regions, whereas dotted line separates inside from outside waters. See Table 3 to match site number with site name.

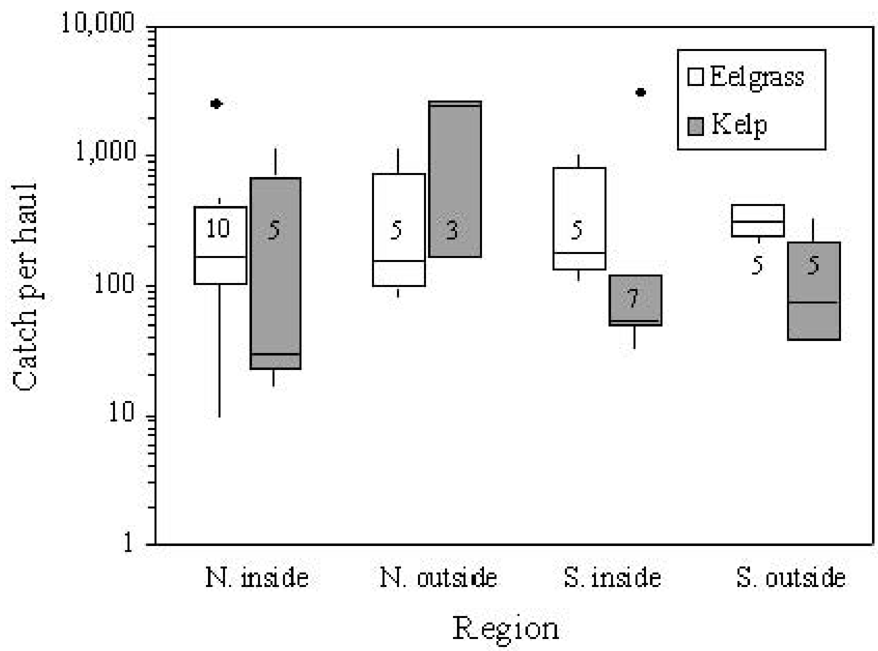

Figure 2.-- Box and whisker plots of catch per seine haul (all species) in eelgrass (*Zostera marina*) and kelp (mostly *Laminaria saccharina*) by region in southeastern Alaska. Twenty-five eelgrass sites and 20 kelp sites were sampled by beach seine from 1998 to 2000. Sampling was between June and August each year. Number of sites in each region is shown inside most boxes. Regions were northern inside and outside waters and southern inside and outside waters. Scale on ordinate is logarithmic.

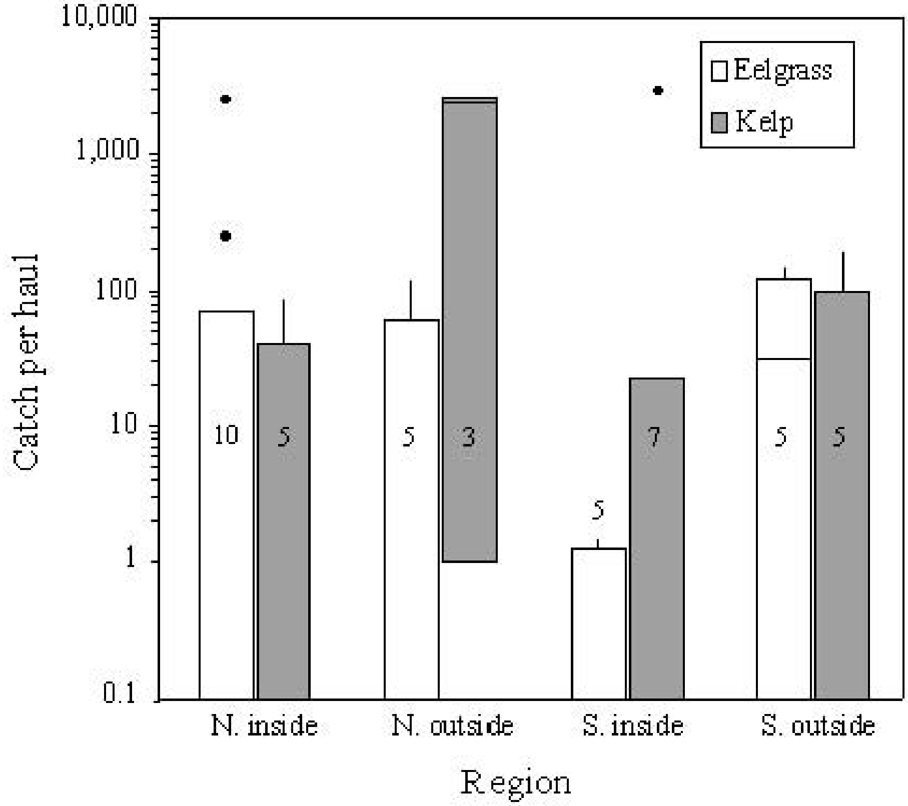

Figure 3.-- Box and whisker plots of catch per seine haul of forage fish (Pacific herring, *Clupea pallasi*, and sand lance, *Ammodytes hexapterus*, combined) in eelgrass (*Zostera marina*) and kelp (mostly *Laminaria saccharina*) by region in southeastern Alaska. Twenty-five eelgrass sites and 20 kelp sites were sampled by beach seine from 1998 to 2000. Sampling was between June and August each year. Number of sites in each region is shown inside most boxes. Regions were northern inside and outside waters and southern inside and outside waters. Median values are near or at zero when not obvious on graphs. Scale on ordinate is logarithmic.

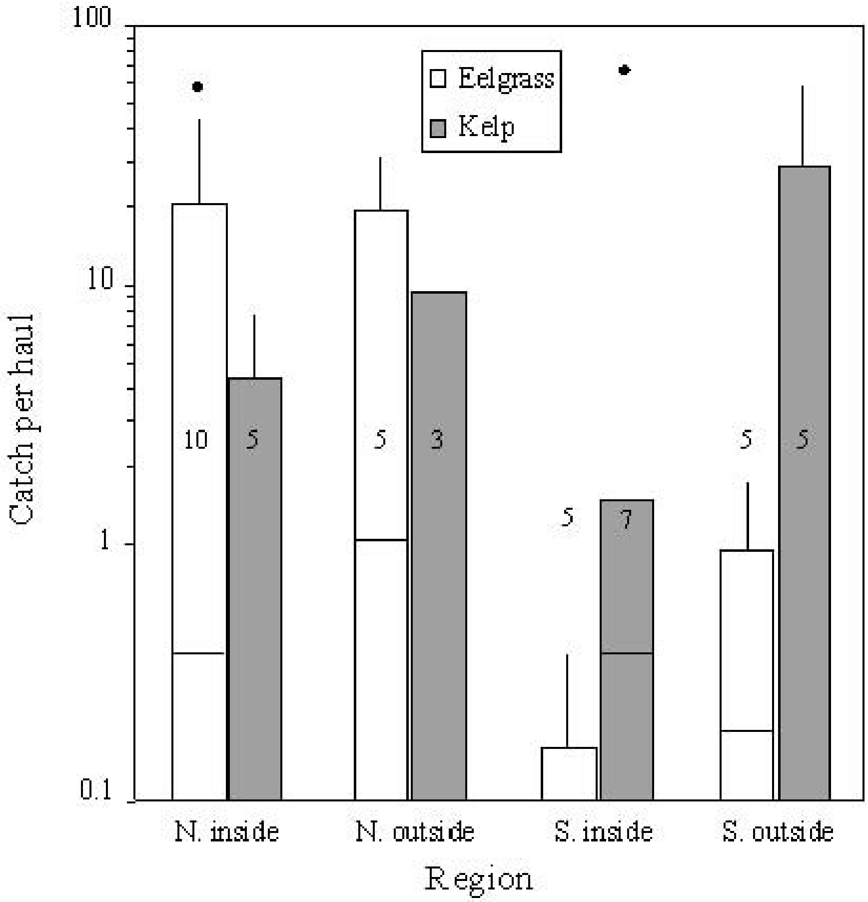

Figure 4.-- Box and whisker plots of catch per seine haul of gadids (Pacific cod, *Gadus macrocephalus,* and walleye pollock, *Theragra chalcogramma,* combined) in eelgrass (*Zostera marina*) and kelp (mostly *Laminaria saccharina*) by region in southeastern Alaska. Twenty-five eelgrass sites and 20 kelp sites were sampled by beach seine from 1998 to 2000. Sampling was between June and August each year. Number of sites in each region is shown inside most boxes. Regions were northern inside and outside waters and southern inside and outside waters. Median values are near or at zero when not obvious on graphs. Scale on ordinate is logarithmic.

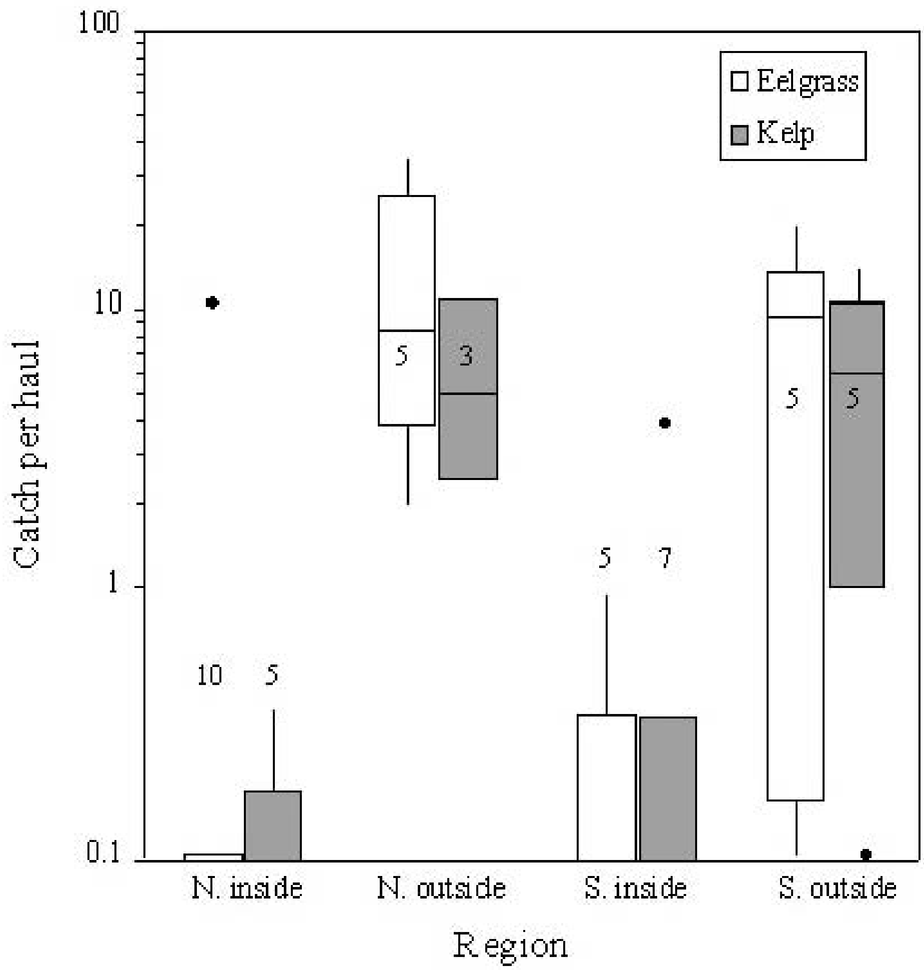

Figure 5.-- Box and whisker plots of catch per seine haul of juvenile rockfish (*Sebastes*, six species) in eelgrass (*Zostera marina*) and kelp (mostly *Laminaria saccharina*) by region in southeastern Alaska. Twenty-five eelgrass sites and 20 kelp sites were sampled by beach seine from 1998 to 2000. Sampling was between June and August each year. Number of sites in each region is shown inside most boxes. Regions were northern inside and outside waters and southern inside and outside waters. Median values are near or at zero when not obvious on graphs. Scale on ordinate is logarithmic.

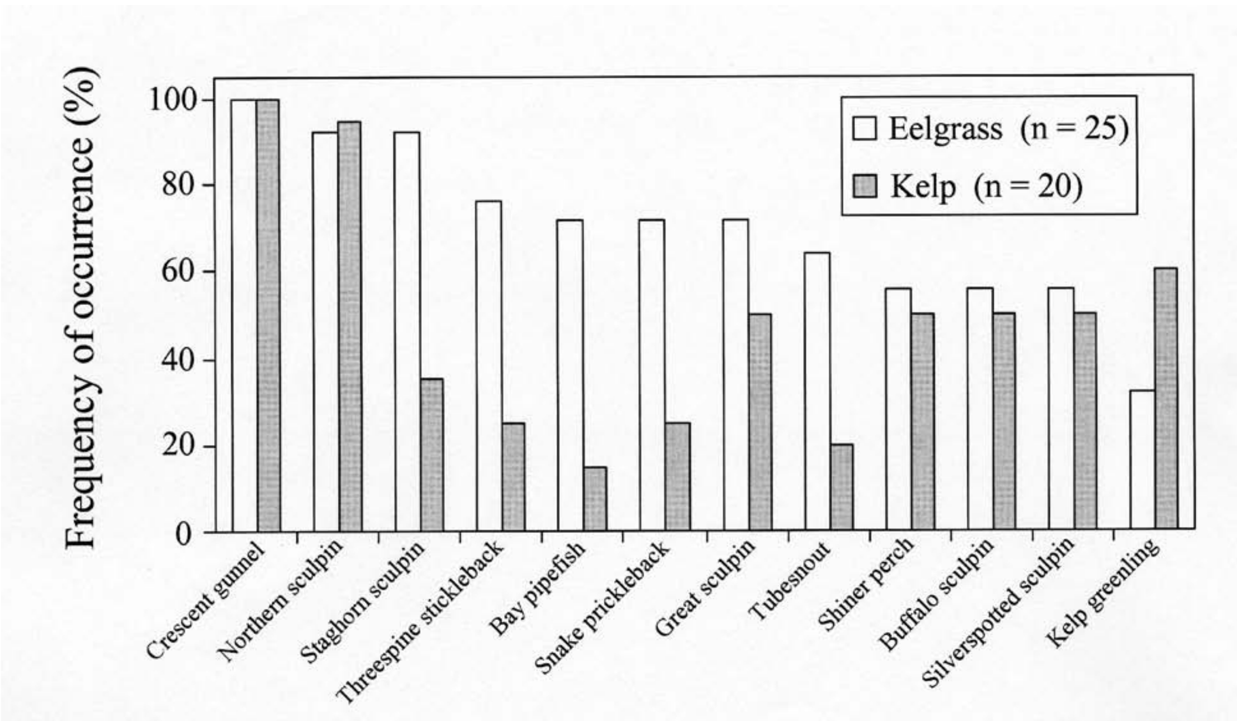

Figure 6.-- Frequency of occurrence by site of 12 common species of fish captured in eelgrass (*Zostera marina*) and kelp (mostly *Laminaria saccharina*) in southeastern Alaska. For example, crescent gunnels were captured at all eelgrass and kelp sites. Twenty-five eelgrass sites and 20 kelp sites were sampled by beach seine from 1998 to 2000. Sampling was between June and August each year.

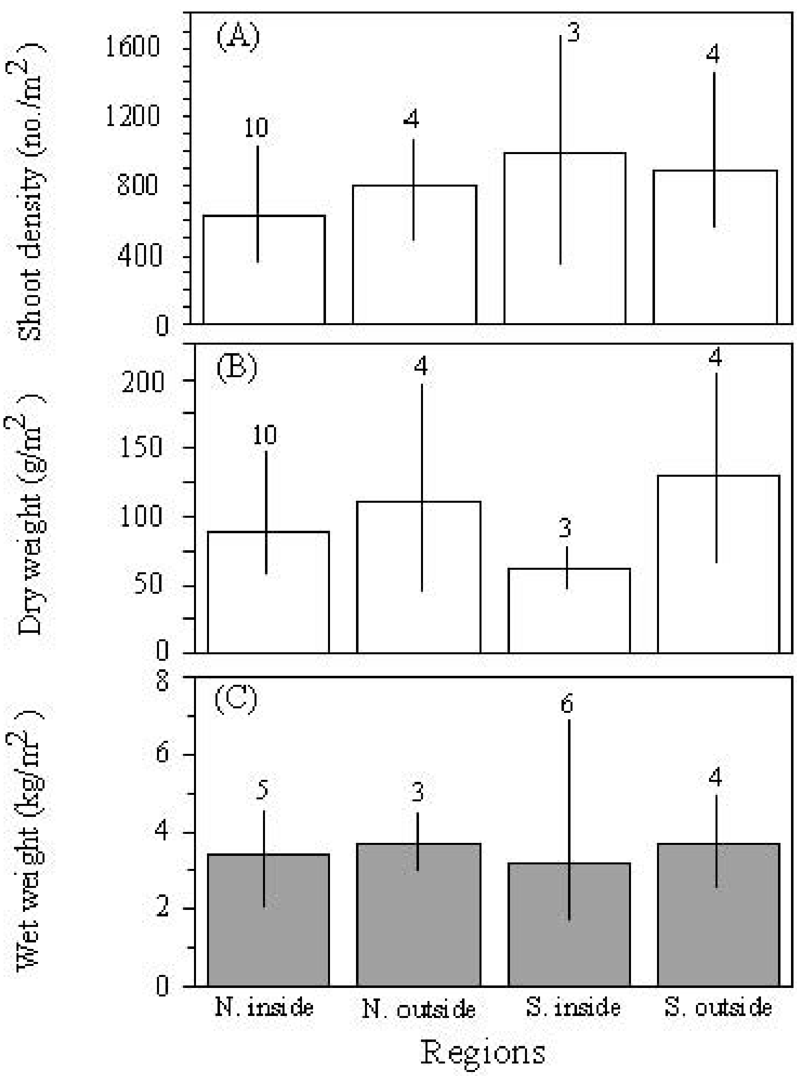

Figure 7.-- Eelgrass (*Zostera marina*) shoot density (A) and biomass (B), and kelp (mostly *Laminaria saccharina*) biomass (C) from sites sampled for fish assemblages in southeastern Alaska from 1998 to 2000. Twenty-five eelgrass sites and 20 kelp sites were sampled by beach seine from 1998 to 2000. Sampling was between June and August each year. Data are means and ranges; number of sites above bars.

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