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A Comparison of Fish Assemblages in Eelgrass and Adjacent Subtidal Habitats Near Craig, Alaska

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ABSTRACT: Fish assemblages were compared between sites with eelgrass *Zostera marina* and sites with either kelp (e.g., *Laminaria saccharina*) or only filamentous algae (e.g., *Cladophora* and *Pilayella*). Four pairs of sites near Craig, Alaska, were seined monthly from April to June and in September 1998. Eelgrass in June averaged 1,001 shoots/m^2 (SE = 57), dry biomass was 145 g/m^2 (SE = 37), and blade length averaged 49 cm (SE = 5). Overall, more species were caught at sites with either eelgrass or kelp than at sites with only filamentous algae: 41 species in eelgrass, 38 in kelp, and 26 in filamentous algae. Total catch was greater at eelgrass than at non-eelgrass sites, principally because of large catches of bay pipefish *Syngnathus leptorhynchus*, crescent gunnels *Pholis laeta*, and shiner perch *Cymatogaster aggregata*. Juvenile rockfish (age ≥1) were caught frequently (94% of sites) in May to September in both eelgrass and kelp, but not at sites with only filamentous algae. Age-0 rockfish were caught only in September, nearly all (97%) in eelgrass. Catch of pink salmon *Oncorhynchus gorbuscha* fry, chum salmon *O. keta* fry, and coho salmon *O. kisutch* smolts was similar at eelgrass and non-eelgrass sites, except for chum salmon in June when catch was significantly lower at eelgrass sites. Gadids (96% *Microgadus proximus*) were uncommon; only 25 were caught, but most (72%) were in eelgrass. Catch of forage fish (Pacific herring *Clupea pallasi* and Pacific sand lance *Ammodytes hexapterus*) was similar at eelgrass and non-eelgrass sites. Eelgrass and kelp vegetation supported high biodiversity and provided important habitat for juvenile rockfish and other species. Because biological communities vary geographically, additional data from other areas are needed to obtain a full perspective of the role of eelgrass and kelp as fish habitat in coastal Alaska.

INTRODUCTION

Eelgrass *Zostera marina* is an important component of nearshore habitats and is distributed widely in lower intertidal and subtidal areas on both coasts of the United States (Fonseca 1992), including Alaska north to the Seward Peninsula (McRoy 1968). Eelgrass provides both trophic support and physical structure for the biological community and is nursery habitat for several commercial fisheries species (Stevens and Armstrong 1984; Fonseca et al. 1992; Gotceitas et al. 1997). Because of its value as fish habitat, eelgrass beds are legally identified as Special Aquatic Sites for protection in coastal zone management (Kurland 1994).

Eelgrass is abundant in Alaska and is assumed to be important fish habitat (Dean et al. 1998). Few studies in Alaska, however, have examined its use by fish and other fauna. McConnaughey and McRoy (1979) analyzed carbon isotopes to demonstrate that the animal community of Izembek Lagoon in the Bering Sea is sustained largely by eelgrass production. In Prince William Sound, Alaska, Jewett and Dean (1997) and Dean et al. (2000) found several species of fish, mostly juvenile gadids, in eelgrass beds.

Our objective was to determine the use of eelgrass by fish in the vicinity of Craig in southeastern Alaska (Figure 1). The area has many past and proposed development activities, such as filling of eelgrass beds,

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in intertidal and subtidal zones. The role of eelgrass as nursery habitat for commercial fish species should be documented to support decisions balancing development in the coastal zone with conservation of essential fish habitat.

METHODS

Study Area

The study area was on the western coast of Prince of Wales Island in southeastern Alaska near Craig and Klawock, on the outer coast, with several islands between it and the Gulf of Alaska (Figure 1). Shoreline in the area varies from protected coves to exposed rocky points. Rockweed *Fucus gardneri* is common in the intertidal zone, and eelgrass occupies many areas of the lower intertidal and subtidal zones from about +1 m to −6 m elevation relative to mean lower low water (MLLW). Understory kelp (e.g., *Laminaria saccharina*) occupies subtidal areas along rocky shorelines, and the giant kelps *Nereocystis* and *Macrocystis* occur in areas exposed to currents and waves. The maximum tidal range is approximately 8 m.

The area averages 280 cm of precipitation annually, resulting in numerous small streams flowing into the estuaries. The main drainage in the area is the Klawock River, which flows into Klawock Inlet and has runs of pink salmon *Oncorhynchus gorbuscha*, chum salmon *O. keta*, coho salmon *O. kisutch*, steelhead *O. mykiss*, and Dolly Varden *Salvelinus malma*.

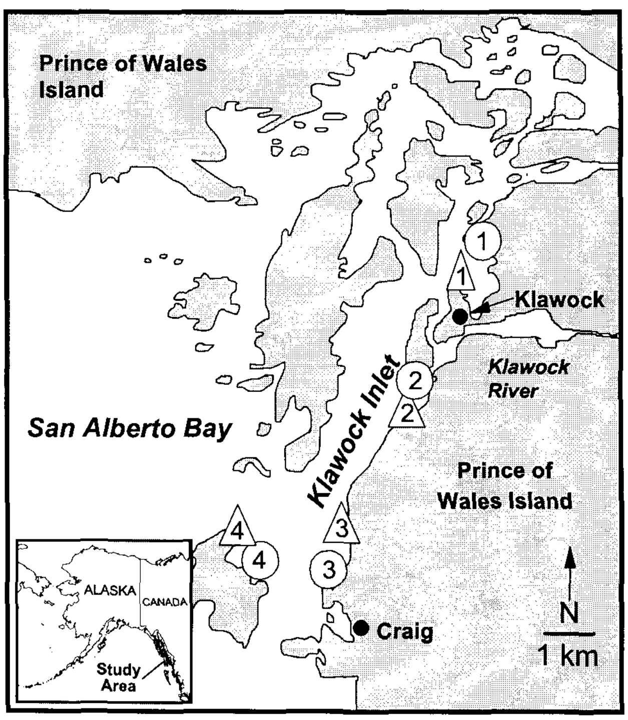

Figure 1. Location of 4 pairs of eelgrass (○) and non-eelgrass (△) study sites near Craig, Alaska.

Sampling Design

A paired-site design was used to compare eelgrass habitat with adjacent non-eelgrass habitat. Four pairs of sites were established inside Klawock Inlet from near the mouth of the Klawock River to the opening of the inlet to San Alberto Bay (Figure 1). At each site, 2 adjacent beaches approximately 50 m apart were sampled for fish and eelgrass characteristics. All sampling occurred within 2 h of low tide (0–1.5 m below MLLW) monthly from April to June and again in September 1998. Because of stormy weather, samples were not taken at site pair 3 in April. Temperature and salinity were measured with each sample at 30-cm depth with a thermometer and refractometer, respectively. Beach exposure to wave energy, substrate sediment composition, and predominant vegetation were estimated visually.

The distribution of sites provided a gradient of conditions ranging from sheltered areas with freshwater influence inside Klawock Inlet to areas exposed to wind and higher salinity closer to San Alberto Bay (Figure 1). Mean salinity (practical salinity scale) was lowest at site pair 1, near the mouth of the Klawock River. Salinity averaged 22 (range = 12–30) at site pair 1, and 27 (23–32) at the other site pairs. Site pair 1 also had a wider range in water temperature, 6°C in April to 14°C in September, compared with 9°C in April to 12–13°C in September at the other site pairs.

Although we attempted to locate similar adjacent sites for each site pair, non-eelgrass sites were generally more exposed to wave action and had coarser substrate than eelgrass sites (Table 1). Sediment ranged from mud (particles <0.1-mm diameter) to mixed sand (0.1–4.0 mm) and gravel (4–64 mm) at eelgrass sites, and from mixed sand and gravel to cobble (64–256 mm) at non-eelgrass sites. Vegetation at the 2 non-eelgrass sites nearest Klawock River (site pairs 1 and 2) was predominantly filamentous green and brown algae (e.g., *Cladophora* and *Pilayella*), whereas vegetation at sites closer to San Alberto Bay (site pairs 3 and 4) was predominantly short (<1 m) kelp (e.g., *Laminaria saccharina*, *Alaria fistulosa, Agarum clathratum*).

Fish were sampled with a 37-m variable-mesh beach seine. Outer panels were each 10 m of 32-mm mesh, intermediate panels were each 4 m of 6-mm

Table 1. Substrate, energy exposure, and vegetation characteristics at 4 pairs of eelgrass and non-eelgrass sites near Craig, Alaska, 1998. Location of site pairs is shown in Figure 1. Algae = filamentous algae.

	Substrate[a]		Exposure[b]		Vegetation[c]	
Site Pair	Eelgrass	Non-Eelgrass	Eelgrass	Non-Eelgrass	Eelgrass	Non-Eelgrass
1	Mud	Mixed coarse	Partly enclosed	Open	Eelgrass	Algae
2	Mixed fine	Mixed coarse	Partly enclosed	Open	Eelgrass	Algae
3	Mixed coarse	Cobble	Open	Open	Eelgrass	Kelp
4	Mud	Mixed coarse	Partly enclosed	Partly enclosed	Eelgrass	Kelp

[a] Mud = fines (<0.1 mm) mixed with organics; mixed coarse = mixture of sand (0.1–4 mm), gravel (4–64 mm), and cobble (64–256 mm); mixed fine = mud and sand with some gravel.
[b] Partly enclosed = bay partially enclosed by land obstruction, with minimal wave action or currents; open = exposed to moderate to long fetch and receiving some wind waves.
[c] Prominent filamentous algae were *Cladophora*, *Odonthalia*, *Pilayella*; kelp was principally *Laminaria saccharina*, *Alaria fistulosa*, and *Agarum clathratum*.

mesh, and the bunt was 9 m of 3.2-mm mesh. The seine tapered from 5-m wide at the center to 1-m wide at the ends and conformed to the shape of the beach slope when set. 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 18 m from the start, and pulling onto shore. The seine had a lead line and float line so that the bottom contacted the substrate and the top floated. Based on observations of a scuba diver following the seine as it was pulled to shore, seining was more than 95% efficient at capturing epibenthic fish within the seined area. Salmonids were not seen by the diver who was oriented toward the bottom.

Captured fish were identified to species and enumerated, and fork length was measured to the nearest millimeter for up to 50 individuals of selected species including salmonids, flatfish, gadids, and rockfish *Sebastes* spp. Fish were anesthetized for identification and measurement. When large numbers of salmonids were caught, their number was estimated volumetrically by measuring water displacement in a 1-L beaker and calculating number and species composition based on a 100-fish subsample counted into a 500-mL graduated cylinder. Specimens of fish we could not identify in the field were taken to the laboratory for identification. We distinguished several rockfish species based on external characteristics and analyzed mtDNA of representative specimens by the method of Gray and Gharrett (1998) for confirmation.

The Shannon–Weaver diversity index (H') was calculated by the 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).

Eelgrass shoot density, blade length, and dry mass were measured at the 2 beaches at each site. At each beach a transect was laid parallel to shore 0.5 m below MLLW, and three 313-cm^2 quadrats were located 5 m apart along the transect. Eelgrass shoots within the quadrat were cut at the substrate surface and rinsed to remove sediment and detritus. Loose epiphytic algae were removed manually. We counted all eelgrass shoots in each sample and measured maximum blade length of the 10 longest shoots to the nearest centimeter. Samples were dried at 60°C until weight stabilized and were weighed to the nearest milligram.

Data Analysis

We used 2 statistical models to test for significant differences in catch among habitat types. Because non-eelgrass sites consisted of 2 distinct vegetation types, kelp and filamentous algae, we first used two-way ANOVA with vegetation type (eelgrass, kelp, and filamentous algae) and month as fixed factors (Sokal and Rohlf 1969). If vegetation type was not significant, we pooled the data for filamentous algae and kelp sites and used a t test for paired comparisons (Sokal and Rohlf 1969) to test significance of the mean difference between paired eelgrass and non-eelgrass sites

Table 2. Mean catch per seine haul of fish at 8 sites with eelgrass, kelp (e.g., *Laminaria saccharina*), or filamentous algae (e.g., *Cladophora* and *Pilayella*) vegetation near Craig, Alaska, from April to September 1998. Seine hauls numbered 32 in eelgrass, 14 in kelp, and 16 in filamentous algae.

Family and Species		Mean Number of Fish per Seine Haul: Eelgrass	Kelp	Filamentous Algae
Salmonidae				
Pink salmon	*Oncorhynchus gorbuscha*	289.91	94.86	15.25
Chum salmon	*O. keta*	12.06	7.57	12.25
Coho salmon	*O. kisutch*	2.50	1.93	8.00
Sockeye salmon	*O. nerka*	0.03	0.07	0.00
Chinook salmon	*O. tshawytscha*	0.00	0.07	0.06
Steelhead	*O. mykiss*	0.00	0.07	0.00
Dolly Varden	*Salvelinus malma*	0.06	0.00	1.19
Scorpaenidae				
Copper rockfish (age ≥ 1)	*Sebastes caurinus*	6.09	5.43	0.00
(age 0)		1.78	0.07	0.06
Black rockfish	*S. melanops*	0.41	0.79	0.00
Brown rockfish	*S. auriculatus*	0.00	0.07	0.00
Bocaccio	*S. paucispinis*	0.03	0.00	0.00
Unidentified rockfish	*Sebastes* sp.	0.03	0.00	0.00
Bothidae				
Pacific sanddab	*Citharichthys sordidus*	0.28	0.00	0.75
Speckled sanddab	*C. stigmaeus*	0.34	0.14	0.38
Pleuronectidae				
Rock sole	*Pleuronectes bilineatus*	0.06	0.57	0.19
English sole	*P. vetulus*	0.16	0.07	0.25
C-O sole	*Pleuronichthys coenosus*	0.03	0.07	0.00
Starry flounder	*Platichthys stellatus*	0.06	0.00	0.00
Gadidae				
Pacific cod	*Gadus macrocephalus*	0.03	0.00	0.00
Pacific tomcod	*Microgadus proximus*	0.53	0.14	0.31
Clupeidae				
Pacific herring	*Clupea pallasi*	1.50	1.79	36.13
Ammodytidae				
Pacific sand lance	*Ammodytes hexapterus*	0.69	3.79	6.44
Cottidae				
Great sculpin	*Myoxocephalus polyacanthocephalus*	1.75	1.71	4.19
Northern sculpin	*Icelinus borealis*	3.47	3.43	2.13
Pacific staghorn sculpin	*Leptocottus armatus*	3.88	0.29	1.56
Buffalo sculpin	*Enophrys bison*	0.13	0.79	1.00
Brown Irish lord	*Hemilepidotus spinosus*	2.53	1.28	0.00
Sailfin sculpin	*Nautichthys oculofasciatus*	0.09	0.43	0.00
Fluffy sculpin	*Oligocottus snyderi*	0.03	0.14	0.00
Silverspotted sculpin	*Blepsias cirrhosus*	0.03	0.00	0.00
Embiotocidae				
Shiner perch	*Cymatogaster aggregata*	28.53	9.79	14.31
Kelp perch	*Brachyistius frenatus*	0.28	1.21	0.00
Hexagrammidae				
Juvenile greenling	*Hexagrammos* spp.	2.53	1.29	0.31
Kelp greenling	*H. decagrammus*	0.41	0.29	0.06
Whitespotted greenling	*H. stelleri*	0.22	0.93	0.19
Masked greenling	*H. octogrammus*	0.16	0.07	0.13
Painted greenling	*Oxylebius pictus*	0.06	1.79	0.00
Rock greenling	*H. lagocephalus*	0.00	0.07	0.00
Anoplopomatidae				
Sablefish	*Anoplopoma fimbria*	0.03	0.00	0.00

– *continued* –

Table 2. (continued)

Family and Species		Mean Number of Fish per Seine Haul: Eelgrass	Kelp	Filamentous Algae
Agonidae				
Northern spearnose poacher	*Agonopsis vulsa*	0.00	0.07	0.00
Gasterosteidae				
Tube-snout	*Aulorhynchus flavidus*	2.53	2.07	1.69
Threespine stickleback	*Gasterosteus aculeatus*	57.53	2.57	91.88
Syngnathidae				
Bay pipefish	*Syngnathus leptorhynchus*	86.03	12.29	3.69
Gobiidae				
Blackeye goby	*Coryphopterus nicholsi*	0.03	1.64	0.00
Stichaeidae				
Snake prickleback	*Lumpenus sagitta*	7.47	1.79	0.75
Pholidae				
Crescent gunnel	*Pholis laeta*	42.63	20.00	11.56
Penpoint gunnel	*Apodichthys flavidus*	0.03	0.07	0.00

each month. Because sites were the sampling units, we combined the catch from the 2 seine hauls at each site. Catch data were lognormally distributed and were transformed to logarithms ($\ln(X+1)$) for analysis. For eelgrass characteristics, we pooled data for the 2 beaches at each site and used ANOVA with site as a fixed factor to test differences in mean eelgrass biomass among sites.

RESULTS

Fish Habitat Use

Overall, 46 species of fish were caught in a total of 62 seine hauls from April to September (Table 2). The most abundant fishes included pink and chum salmon, threespine sticklebacks *Gasterosteus aculeatus,* crescent gunnels *Pholis laeta,* bay pipefish *Syngnathus leptorhynchus*, shiner perch *Cymatogaster aggregata*, and copper rockfish *Sebastes caurinus*.

More species were caught at sites with either eelgrass or kelp than at sites with only filamentous algae: 41 species in eelgrass, 38 in kelp, and 26 in filamentous algae (Table 2). Most species of rockfish, some cottids, and several species not commonly found in our seine hauls were absent from sites with only filamentous algae. Species richness (number of species) was significantly greater in eelgrass and kelp than in filamentous algae ($P = 0.002$, ANOVA; Table 3). Species richness also differed significantly among months; it was lowest in April and highest in May and June ($P = 0.026$; Table 3). A decline in species richness was evident at one of our kelp study sites (site 4) in September, probably from a storm in early September, which removed much of the kelp.

The Shannon–Weaver diversity index did not differ significantly among the 3 vegetation types ($P = 0.46$, ANOVA; Table 3). The t test for paired comparisons also showed no significant differences ($P > 0.08$) in diversity index between eelgrass and adjacent non-eelgrass sites in any month. Dominance by a few species, such as bay pipefish, crescent gunnels, and shiner perch (Table 2), reduced the diversity index for eelgrass habitat.

Total catch did not differ significantly by month ($P = 0.295$, ANOVA) but did differ significantly among vegetation types ($P = 0.029$). Total catch averaged 755 (range = 596–956 for mean ±1 SE) in eelgrass, compared to 314 (216–455) in kelp, and 255 (183–356) in filamentous algae. Large catches of bay pipefish, crescent gunnels, and shiner perch contributed to the higher total catch in eelgrass (Table 2).

At least 4 species of rockfish were caught, including black rockfish *S. melanops*, brown rockfish *S. auriculatus*, copper rockfish *S. caurinus*, and bocaccio *S. paucispinis* (Table 2). Young of the year (age-0) rockfish were copper rockfish. The pattern of rockfish catch indicated movement of juveniles (age ≥ 1) into Klawock Inlet in May. Rockfish appeared first at sites closest to San Alberto Bay and later at sites inside Klawock Inlet (Figures 2 and 3). Catch was low in April, increased from May to June, and remained about the same in September as in June (Figure 2). Age-0 rockfish were caught only in September (Figure 3).

Juvenile rockfish were about equally abundant in eelgrass and kelp, but none were caught at sites with

Table 3. Species richness and Shannon–Weaver diversity index (H') for fish assemblages sampled with a beach seine at 4 pairs of eelgrass and non-eelgrass sites near Craig, Alaska, April to September 1998. Data for non-eelgrass sites are separated according to predominant vegetation type as either filamentous algae or kelp. Data are missing for non-eelgrass site 3 in April.

		Number of Species			Diversity Index (H')		
Site Pair	Month	Eelgrass	Filamentous Algae	Kelp	Eelgrass	Filamentous Algae	Kelp
1	April	8	9		0.46	1.53	
	May	15	14		1.83	1.55	
	June	16	10		1.59	1.67	
	September	13	10		0.63	0.54	
2	April	13	8		1.81	1.56	
	May	18	15		1.55	1.62	
	June	23	14		1.77	2.11	
	September	21	14		2.00	2.07	
3	April	13			0.25		
	May	16		21	1.65		2.32
	June	16		18	1.49		2.43
	September	19		19	1.71		2.31
4	April	10		16	1.29		0.69
	May	14		20	0.47		1.11
	June	16		19	1.71		2.23
	September	17		12	2.00		1.87

only filamentous algae (Figure 2). The difference in catch of juveniles among vegetation types in May to September was significant ($P < 0.001$, ANOVA). In September 59 age-0 rockfish were captured, 97% of them in eelgrass (Figure 3).

Length frequencies of rockfish indicated 2 age groups in May and June and 3 in September (Figure 4). In May and June frequencies had 2 modes at 50–60 mm and 100–120 mm, indicating groups that were probably age 1 and 2. In September these 2 modes had shifted to 80 mm and 150 mm, and a new mode representing age-0 rockfish appeared at 30 mm. The shift in modes from June to September indicated apparent growth of approximately 20 mm in 3 months.

Table 4. Fork length (mm) of pink, chum, and coho salmon from eelgrass and non-eelgrass sites near Craig, Alaska, April to June 1998. Asterisk indicates significant ($P < 0.05$, t test) difference between eelgrass and non-eelgrass sites that month.

	April		May		June	
	Eelgrass	Non-Eelgrass	Eelgrass	Non-Eelgrass	Eelgrass	Non-Eelgrass
Pink salmon						
Mean	33.9*	36.0	45.6	47.3		
SE	0.2	0.5	0.6	0.7		
n	99	52	51	103		
Chum salmon						
Mean	41.5	43.2	52.9*	56.3	66.3*	84.6
SE	0.8	0.8	1.2	1.4	2.2	1.5
n	11	47	45	38	11	63
Coho salmon						
Mean			97.4*	108.9	112.1	106.0
SE			2.9	2.4	4.2	7.0
n			34	54	27	23

The maximum length of age-0 rockfish in September (43 mm) was the same as the minimum length of juveniles in May.

Pink salmon fry accounted for 84% of the total catch in April and 49% in May, and none were caught in June. Catch was highly variable because of the patchy distribution of salmon aggregations. Coefficient of variation (SD/mean) for the 2 seine hauls within sites ranged from 21% to 135%. Catch did not differ significantly among vegetation types ($P = 0.81$, ANOVA; Figure 5). The difference between paired eelgrass and non-eelgrass sites was also not significant in April ($P = 0.87$, paired t test) or May ($P = 0.71$). At one-half of the site pairs in April and May, fewer pink salmon were caught in eelgrass than in non-eelgrass sites.

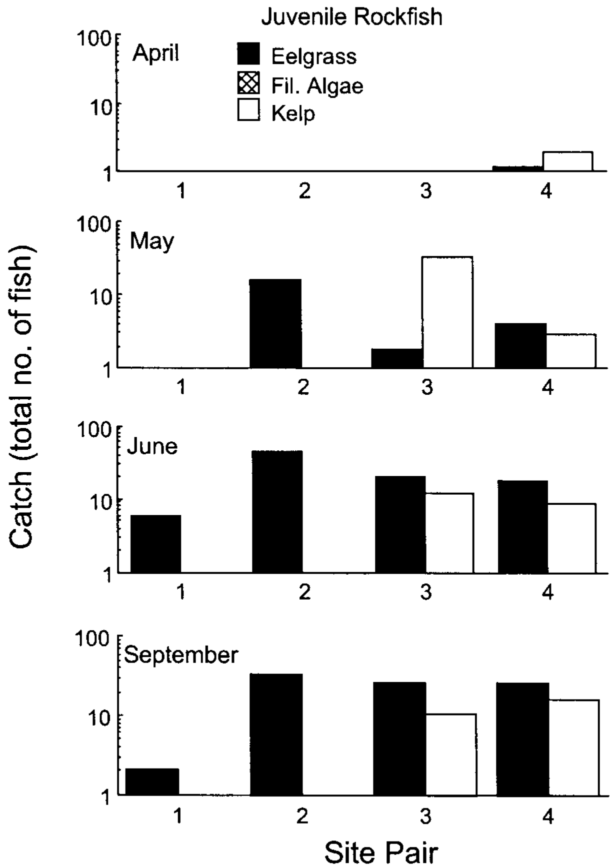

Figure 2. Catch of juvenile (age ≥ 1) rockfish *Sebastes* spp. at 4 pairs of eelgrass and non-eelgrass sites near Craig, Alaska, April to September 1998. Non-eelgrass sites had primarily filamentous algae in site pairs 1 and 2 and kelp (e.g., *Laminaria*) in site pairs 3 and 4. Data are total catch in 2 adjacent seine hauls at each site. Sites are arranged left to right from those near Klawock River (site 1) to the opening of San Alberto Bay (site 4; Figure 1).

Chum salmon were much less abundant than pink salmon (Table 2) and were caught in April, May, and June (Figure 6). Distribution of chum salmon in Klawock Inlet changed from April to June. Catch was highest near Klawock River in April and highest near the mouth of Klawock Inlet in June. Catch did not differ significantly among vegetation types ($P = 0.83$, ANOVA). A paired t test, however, showed that catch was similar in eelgrass and non-eelgrass sites in April ($P = 0.99$) and May ($P = 0.83$) but significantly lower in eelgrass than in non-eelgrass sites in June ($P = 0.01$; Figure 6). Although not significant, a possible association between eelgrass and chum salmon fry early in migration was indicated by greater catch in eelgrass than in adjacent filamentous algae at site pairs 1 and 2 near the Klawock River in April.

Coho salmon smolts made up 1–2% of the total catch in May and June, and catch did not differ significantly among vegetation types ($P = 0.56$, ANOVA). The greatest catch was at a filamentous algae site near Klawock River (site pair 1) in May. The paired t test also showed that catch was similar between eelgrass and non-eelgrass sites in May and June ($P > 0.46$).

Salmon fry and smolts from eelgrass were generally smaller than those from non-eelgrass sites (Table 4). Differences in mean lengths between eelgrass and non-eelgrass sites were significant for pink salmon in April, chum salmon in May and June, and coho salmon in May ($P < 0.05$, t test).

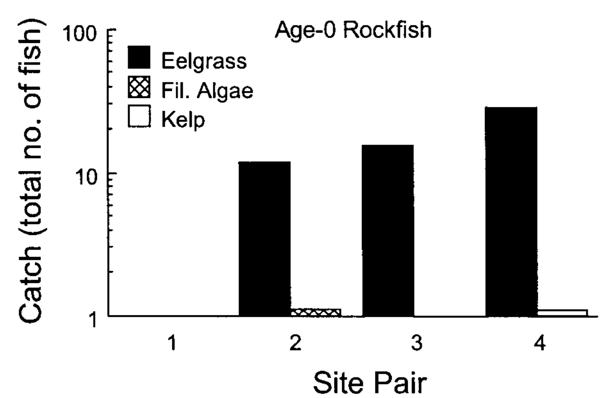

Figure 3. Catch of age-0 copper rockfish *Sebastes caurinus* at 4 pairs of eelgrass and non-eelgrass sites near Craig, Alaska, in September 1998. Data are total catch in 2 adjacent seine hauls at each site. Non-eelgrass sites had primarily filamentous algae in site pairs 1 and 2 and kelp (e.g., *Laminaria*) in site pairs 3 and 4. Sites are arranged left to right from those near Klawock River (site 1) to the opening of San Alberto Bay (site 4; Figure 1).

Six species of flatfish were caught during the study, mostly speckled sanddab *Citharichthys stigmaeus*, Pacific sanddab *C. sordidus*, rock sole *Pleuronectes bilineatus*, and English sole *P. vetulus* (Table 2). Total catch of flatfish from April to September did not differ significantly among months ($P = 0.23$, ANOVA) or vegetation types ($P = 0.75$). Length ranged from 35 mm for Pacific sanddab to 285 mm for rock sole.

Only 25 juvenile gadids were caught during the study, and nearly all were Pacific tomcod *Microgadus proximus* caught in May and June (Table 2). Although most (72%) gadids were caught in eelgrass, frequency of occurrence did not differ significantly among vegetation types ($P = 0.22$, chi-square test; Table 2). Pacific tomcod were 20–30 mm long in May and 46–157 mm long in June.

Pacific herring *Clupea pallasi* and Pacific sand lance *Ammodytes hexapterus* were caught frequently at both eelgrass and non-eelgrass sites. Of the 651 herring and 178 sand lance captured, however, most were from only one seine haul in filamentous algae in May (527 herring and 90 sand lance). Pacific herring were 68–124 mm long, and Pacific sand lance were 43–153 mm long.

Eelgrass Characteristics

Eelgrass shoot density was generally low in April and higher from May to September (Figure 7). Mean shoot density at the 4 eelgrass sites more than doubled from April to May: 438 shoots/m^2 (SE = 102) in April and 1,126 shoots/m^2 (SE = 140) in May.

Blade length reached a maximum about one month after shoot density (Figure 7). Maximum blade length at the 4 sites increased from a mean of 26 cm (SE = 2) in April to 49 cm (SE = 5) in June, and exceeded 90 cm in June at some quadrats. Maximum blade length remained the same or declined into September, when blade tips began to brown and break.

Biomass of eelgrass increased from April to June and was generally stable into September (Figure 7). Mean dry mass at the 4 sites increased from 62 g/m^2 (SE = 14) in April to 145 g/m^2 (SE = 37) in June and 148 g/m^2 (SE = 40) in September. In April and May eelgrass shoots carried a heavy load of epiphytic algae (e.g., *Monostroma*, *Scytosiphon*, *Cladophora*, and *Enteromorpha*) but were generally clear of epiphytes in June and September. Because attached epiphytes could not be completely removed, dry mass in April

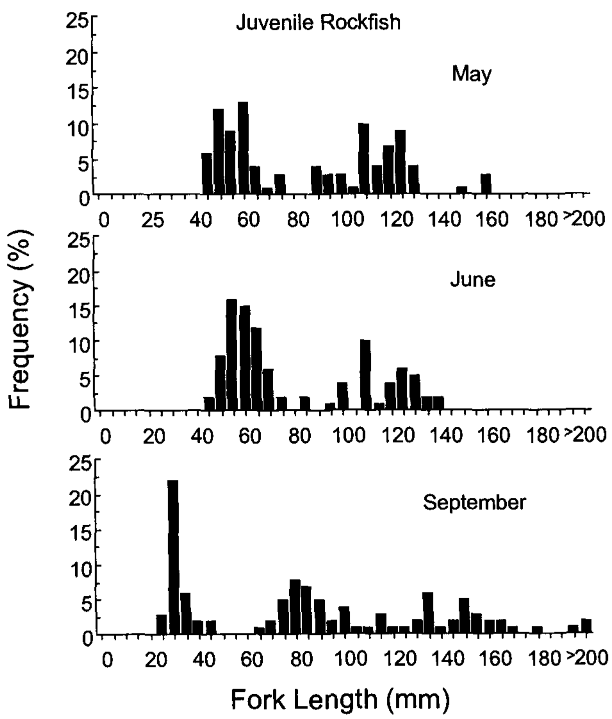

Figure 4. Length frequencies of juvenile rockfish *Sebastes* spp. at eelgrass and kelp sites near Craig, Alaska, May to September 1998.

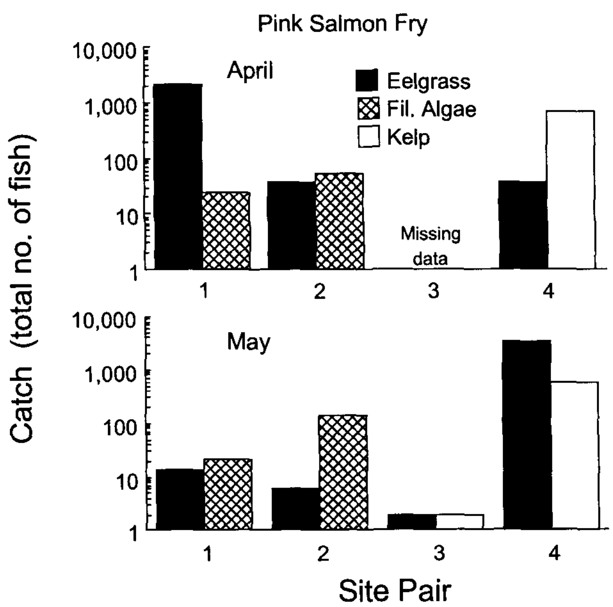

Figure 5. Catch of pink salmon fry at 4 pairs of eelgrass and non-eelgrass sites near Craig, Alaska, in April and May 1998. Non-eelgrass sites had primarily filamentous algae in site pairs 1 and 2 and kelp (e.g., *Laminaria*) in site pairs 3 and 4. Data are total catch in 2 adjacent seine hauls at each site. Sites are arranged left to right from near the Klawock River (site 1) to the opening of San Alberto Bay (site 4; Figure 1).

and May represented combined biomass of eelgrass and some algal material.

Biomass of eelgrass at sites 1 and 4 was significantly less than at sites 2 and 3 ($P < 0.025$, ANOVA). In June mean dry mass was 82 g/m^2 (SE = 13) at sites 1 and 4 and 208 g/m^2 (SE = 14) at sites 2 and 3. The lower biomass at sites 1 and 4 may have been caused by anaerobic conditions in the substrate. Both these sites had mud substrates (Table 1), and a hydrogen sulfide odor was evident during sampling, whereas sites 2 and 3 had coarse substrates and no discernible sulfide odor.

To identify possible relationships between eelgrass characteristics and fish assemblages, we tested correlations between total catch and diversity of fish and shoot density, blade length, and biomass of eelgrass in June and September. Fish diversity and eelgrass biomass in June were significantly correlated ($r = 0.98$, $P < 0.05$, $n = 4$). The other 11 correlations tested were not significant.

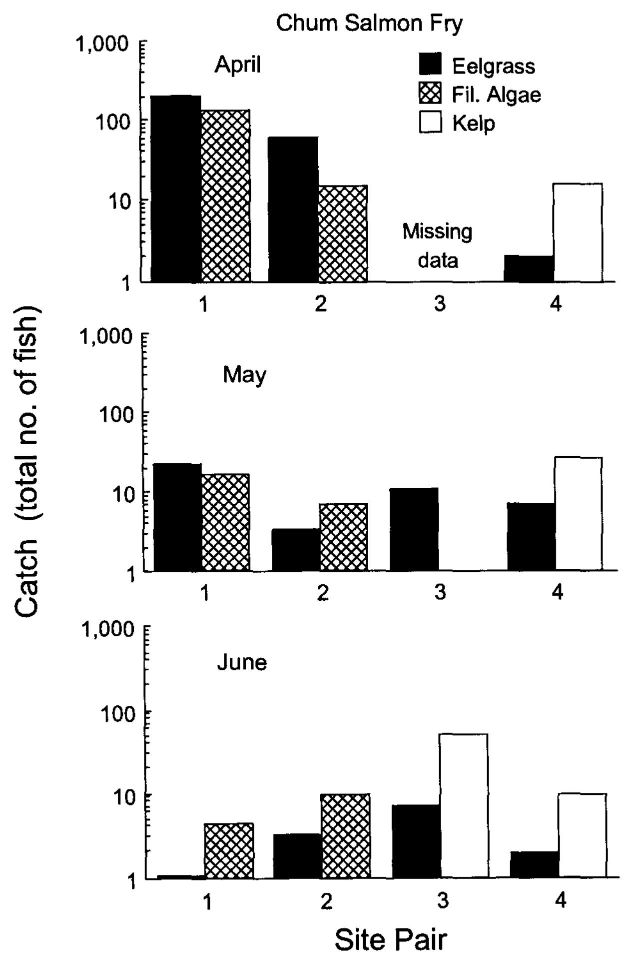

Figure 6. Catch of chum salmon fry at 4 pairs of eelgrass and non-eelgrass sites near Craig, Alaska, April–June 1998. Data are total catch in 2 adjacent seine hauls at each site. Non-eelgrass sites had primarily filamentous algae in site pairs 1 and 2 and kelp (e.g., *Laminaria*) in site pairs 3 and 4. Sites are arranged left to right from near Klawock River (site 1) to the opening of San Alberto Bay (site 4; Figure 1).

DISCUSSION

Eelgrass habitat supported high levels of species diversity and fish abundance, as has been observed in other areas (Bayer 1981; Lubbers et al. 1990; Fonseca et al. 1992). The fauna included both non-commercial species, such as bay pipefish, gunnels, and perch, as well as juveniles of commercial species such as salmonids, rockfish, gadids, and flatfish. By comparing eelgrass with non-eelgrass assemblages, we identified some fisheries species that were significantly associated with eelgrass.

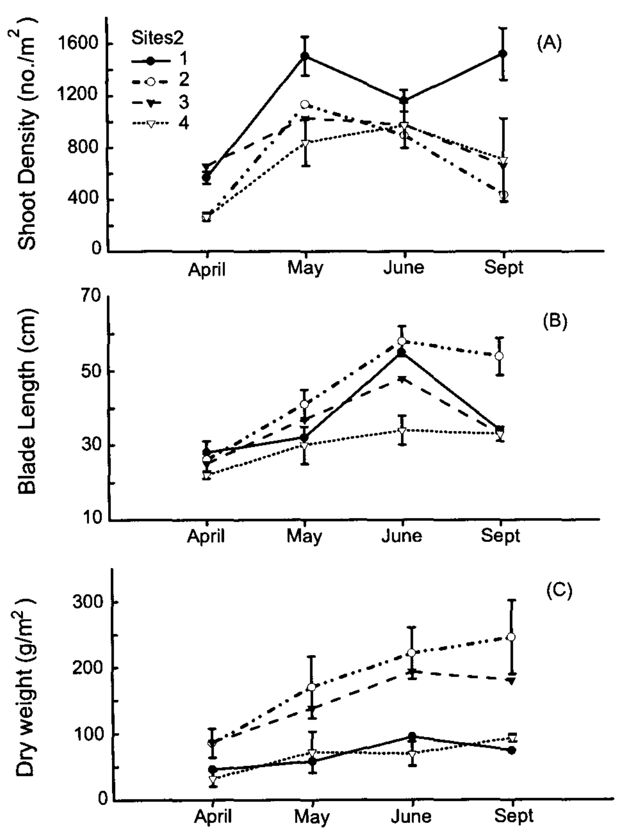

Figure 7. Eelgrass shoot density (A), blade length (mean of 10 longest shoots; B), and dry weight (C) at 4 sites near Craig, Alaska, April to September 1998. Data are means and standard errors from 6 quadrats at each site. For clarity, standard errors are shown only for 2 representative sites in each graph. Site locations are shown in Figure 1.

Rockfish were closely associated with submerged vegetation, both eelgrass and kelp. Nearly all age-0 rockfish were caught in eelgrass, whereas older juveniles used both eelgrass and kelp. Seasonal trends in catch indicated that juvenile rockfish moved into vegetated inshore areas in April and May, and age-0 rockfish moved into eelgrass in August and September. These fish probably move away from shallow vegetated areas in late autumn and winter. Studies in Puget Sound confirmed juvenile rockfish use shallow vegetated areas mainly in summer and use rocky reefs in fall and winter (Patten 1973; Matthews 1990). In winter and early spring rockfish are inactive and inside rock interstices (Patten 1973). Rockfish need a combination of vegetated shallows and rocky reefs to provide both summer and winter habitat (West et al. 1994).

Juvenile salmon were not significantly associated with eelgrass. Although previous authors have suggested juvenile salmon in Puget Sound use eelgrass for feeding and cover (Thayer and Phillips 1977; Phillips 1984; Simenstad 1987, 1994), direct evidence is lacking. To our knowledge, our study is the first to compare the distribution of juvenile salmon between eelgrass and non-eelgrass habitats in an estuary. Chum salmon showed a tendency to be more abundant in eelgrass early in their migration. In April, catch was greater at eelgrass than at adjacent non-eelgrass sites at the 2 pairs of sites near Klawock River, suggesting a preference for eelgrass habitat for a short period immediately after emigration from fresh water. Because chum salmon in eelgrass were smaller than at non-eelgrass sites, they may use eelgrass early in migration and move away from it as they grow; our sample size in April was insufficient to substantiate this association during the earliest part of the migration.

Salmon fry may have occurred in eelgrass areas because of factors other than the presence of eelgrass. During early migration salmon fry spend more time in protected areas than in areas exposed to currents (Celewycz et al. 1994). Thus, fry may have been in eelgrass areas early in their migration because of low exposure to currents and waves rather than because of the presence of eelgrass.

Eelgrass is thought to provide salmon fry with food and cover from predators (Simenstad 1987, 1994). Sogard and Olla (1993) showed that juvenile walleye pollock *Theragra chalcogramma* avoided artificial seagrass in the absence of predators but entered seagrass when a predator was present. We found potential predators, such as cottids and greenlings, were more abundant in eelgrass than in non-eelgrass habitats, representing a predation risk to juvenile salmon.

Our low catch of gadids contrasted with results of Jewett and Dean (1997) and Dean et al. (2000) who found Pacific cod was the dominant species in eelgrass beds in Prince William Sound, Alaska, in mid summer; we can not explain the difference. Gotceitas et al. (1997) found Atlantic cod *Gadus morhua* used eelgrass beds in Newfoundland.

Pacific herring spawn in eelgrass and other submerged vegetation (Phillips 1984). In our study area herring spawn in eelgrass and submerged kelp in April but have not spawned heavily inside Klawock Inlet for several years (unpublished data, R. Larson, Alaska Department of Fish and Game, Petersburg). This explains why we did not observe any adult herring or deposits of eggs in our sites in mid April.

Kelp sites had high species richness, nearly as great as eelgrass sites; juvenile rockfish used both about equally. Kelp provides both cover (Ebeling and Laur 1985) and an energy base (Dunton and Schell 1987) for invertebrates and fish. Our data indicate kelp beds support high biodiversity and provide important nursery habitat for rockfish and other species.

The species composition in eelgrass, kelp, and other subtidal communities in Alaska probably varies substantially depending on physical and biological factors such as salinity, temperature, turbidity, nutrient levels, proximity to spawning populations, and predator or competitor interactions. Annual variation in recruitment could also affect species composition. Species assemblages differed greatly between our sites and those in Prince William Sound (Jewett and Dean 1997) and near Juneau, Alaska (D. Love, University of Alaska, personal communication, 1998). Additional data on eelgrass and other habitat types from other areas of Alaska are needed to obtain a full perspective of the role of eelgrass and other nearshore areas as fish habitat in Alaska.

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