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Fish Assemblages and Juvenile Salmon Diets at a Breached-Dike Wetland Site, Spencer Island, Washington 1999

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Key Words

Snohomish River estuary, restoration, dike breaching, fish assemblages, juvenile salmon diet.

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Introduction

In this report, we describe the results of spring 1999 monitoring juvenile salmon presence at and use of a breached-dike restored tidal wetland at Spencer Island, which is located in the Snohomish River estuary near the city of Everett, Washington (Fig. 1). In November 1994, a dike dating from the early 1900s and enclosing the perimeter of the island was breached in three places, allowing inundation of approximately 23.7 ha of the south part of the interior by tidal water from the estuary. A cross levee constructed as part of the breaching project decreases surface water fluctuations in the ~140-ha north part of the island that is managed for waterfowl (Fig. 1). Since that time, the previously non-tidal freshwater wetland habitat dominated by dense, monotypic stands of the exotic reed canary grass, *Phalaris arundinacea*, has been undergoing ecological changes (Cordell et al. 1998). These include (1) die-off of non-native and other marsh and upland plants, resulting in increasing unvegetated patches; (2) colonization of the site by native plant species such as wapato (*Sagittaria latifolia*) and water plantain (*Alisma plantago-aquatica*), and (3) input of large amounts of detritus from the senescing plants into the system (Tanner et al. in revision). Cordell et al. (1998) predicted that fluctuations in assemblage structure and densities of invertebrates at the site would be the rule in its short-term development.

As part of the studies of biological assemblages at the restored site, fish sampling was conducted in 1995–96 (Tear et al. 1996; C. Tanner, USFWS, unpubl. data), 1997 (Cordell et al. 1998), and 1998 (Cordell et al. 1999). Data from 1995–96 studies, which were designed only to document fish access, suggested that project goals related to increasing fish access to the breached portion of the island were met (C. Tanner and J.K. Aitkin, U.S. Fish and Wildlife Service, unpubl. data). The latter studies analyzed diets of juvenile salmon caught within the restored area. These studies found that the diets of juvenile salmon at the Spencer Island breached-dike site were similar to those from a variety of other natural and restored sites in the region and that the salmon captured there had relatively high stomach fullness factors (Cordell et al. 1998, 1999). They also found that prey items were typical of those produced in the benthic and riparian habitats of the breached area but predicted that the food resources that fish find there will change as the site stabilizes.

At the request of the city of Everett, the Seattle District Corps of Engineers is studying the feasibility of restoring tidal flow to a portion of Smith Island at Union Slough, which is directly adjacent to Spencer Island (Fig. 1). Accordingly, we conducted fish sampling and diet analyses at the Spencer Island breached-dike site that are intended to provide valuable supporting information about the development trajectories and benefits of additional breaches in the Snohomish River estuary.

The specific objectives of this study were to:

1. Monitor juvenile salmon access to the restoration site using previously established successful methods.
2. Analyze diets of juvenile salmon captured within the restoration site.

The goal of this study was to provide data that will help to answer the following questions:

1. Are juvenile salmon continuing to access the inner portion of south Spencer Island?
2. Have there been large shifts in juvenile salmon diets between years?

Methods

Sampling Sites

We sampled fish at three areas that were established for 1998 fish sampling (Fig. 2). The first was located just inside the primary breach connecting the restoration site with Union Slough. The other two areas were located on a mudflat adjacent to the cross levee that separates the restoration site from managed waterfowl habitat: the east mudflat site was within a larger area of unvegetated mudflat, and the west mudflat site abutted an extensive *Typha* spp. and *Phalaris arundinacea* marsh that continues to dominate the restoration site.

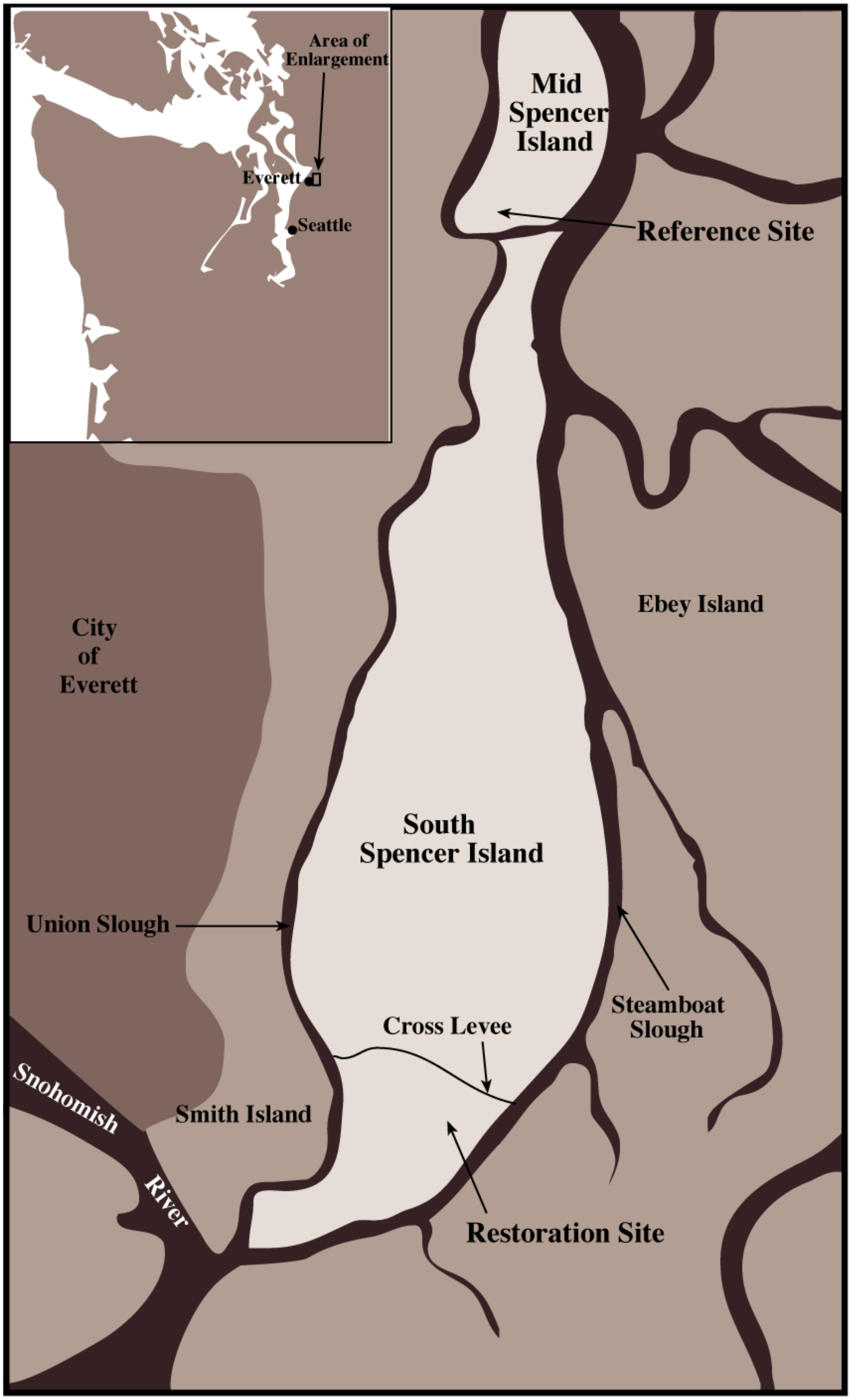

FIGURE 1. Location of breached-dike restoration site at Spencer Island, Washington.

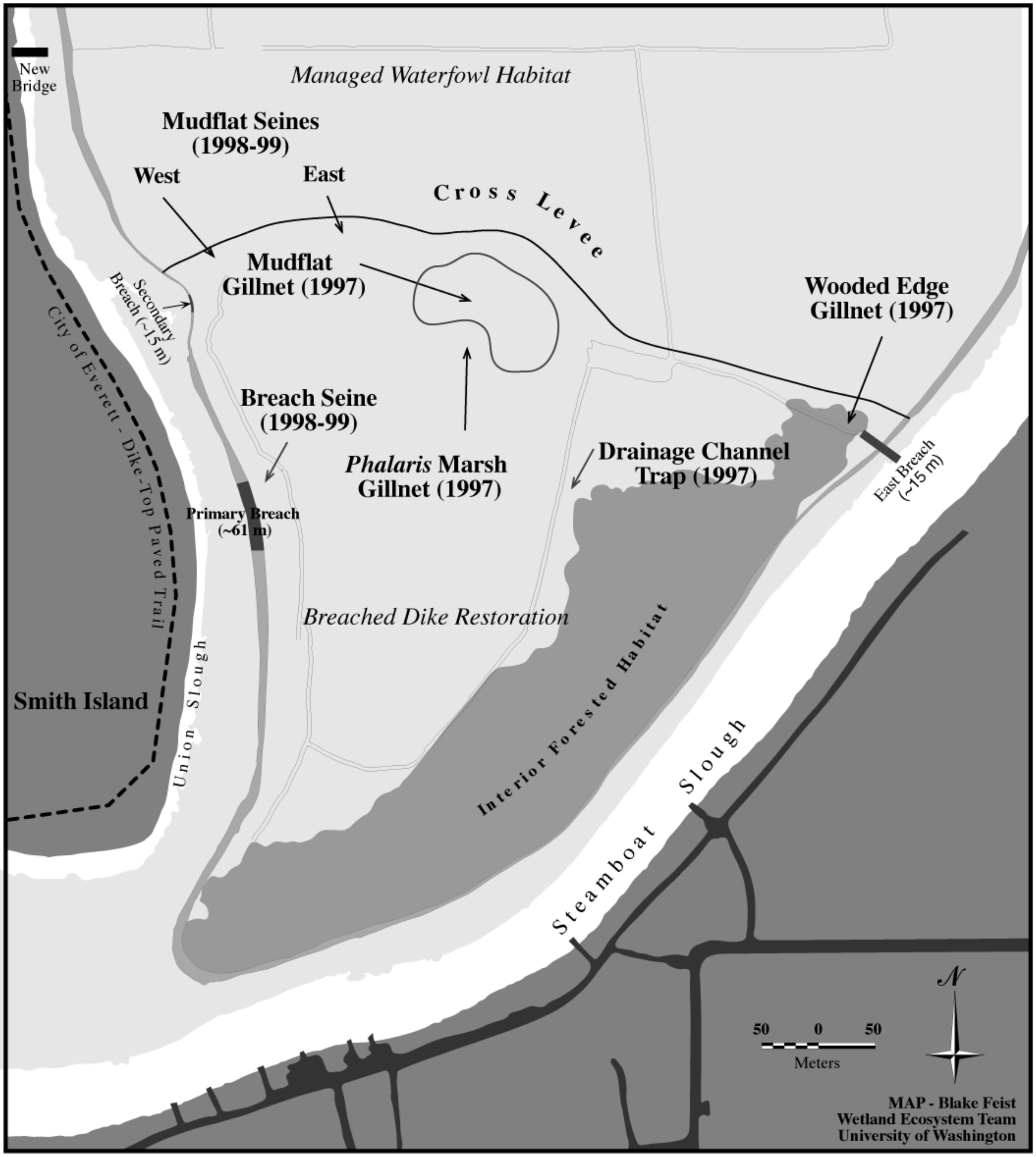

FIGURE 2. Spencer Island breached dike restoration site showing fish sampling locations 1997–99.

Fish Sampling

Fish were sampled at south Spencer Island restoration site approximately every 2 weeks from 2 April through 10 June 1999 for a total of six sampling dates (Table 1). Samples were taken with a 37-m floating beach seine. The net consisted of two 18-m panels made of 3-cm mesh with a 2-m x 2.4-m x 2.3-m bag made of 6-mm mesh. Sets were made within 1 hour of high tide to maximize the amount of water over the sites. The net was deployed from a small inflatable boat parallel to shore and was pulled in by two 2-person teams.

Captured fish were anesthetized in a plastic bucket in which water with a small amount of MS-222 (tricaine) had been added. All fish were then identified to species and counted. Salmonids (*Oncorhynchus* spp.) were measured (fork length) and a subsample of up to 20 chum and coho salmon from each 10-mm size class were preserved immediately in a 10% formaldehyde solution. Chinook (*O. tshawytscha*) salmon were not retained because of restraints imposed by listing of Puget Sound chinook salmon under the Endangered Species Act. All other fish were placed in freshwater until they recovered, and were released.

Diet Analyses

In the laboratory, individual fish were measured (fork length) and weighed damp (excess water was blotted off with tissue) to the nearest 0.01 g. Stomachs were removed and opened, and each stomach was assigned a fullness rank (1 = empty, 6 = full) and digestion rank (1 = no prey identifiable, 6 = all prey identifiable). The contents were then weighed damp in their entirety, placed on a plastic petri dish, and separated into individual taxa under a dissecting microscope. Prey were identified to species level for crustaceans and to family level for insects. Each taxon was enumerated and weighed to the nearest 0.001 g. All data were entered on standard NODC (National Oceanographic Data Center) forms and analyzed using the University of Washington Fisheries Research Institute's GUTBUGS program. This program provides summary data for each group of fish analyzed, and data were taken from this summary for further graphical analysis.

Results

Fish Catches

Eleven species of fish were caught during the 1999 sampling effort (Table 2). Chum (*O. keta*) salmon dominated the overall catch (644 individuals) and most of these (399) were caught in a single beach seine haul at the west mudflat on 16 April (Tables 2,3). Threespine stickleback (*Gasterosteus aculeatus*) were the second most abundant fish caught (517 individuals) and most of these (318) were also caught in the 16 April haul at the west mudflat (Table 2). Peamouth chub (*Mylocheilus caurinus*) were also relatively abundant (265 individuals), with the majority of their number occurring toward the end of the sampling season (Tables 2,3). Overall catches of other salmonids were relatively small (69 individuals total) in comparison with chum salmon. These consisted of 29 coho (*O. kisutch*) salmon, of which 23 individuals were retained for diet analyses, 39 chinook salmon that were not retained, and one cutthroat trout (*O. clarki pallasi*) (Tables 2, 3).

Chum Salmon Diets

The diets of a total of 117 juvenile chum salmon stomachs were analyzed. Regardless of site or date, pupal and emergent adult chironomid flies dominated chum salmon diets in nearly every case, ranging from about 35% to 100% of diet by prey weight (Fig. 3). When combined with chironomid larvae, this taxon always dominated chum salmon prey. On two dates (30 April and 12 May), larval fish were prominent in chum diets, comprising from 11% to 40% of the prey weight. The only other prey taxa making up more than 15% of prey weight in juvenile chum salmon were *Corophium* spp. amphipods (two instances) and ceratopogonid fly larvae (once) (Fig. 3).

Stomach fullness and instantaneous ration (the percentage ratio of stomach content weight to fish weight) were similar among all but two sites/dates, averaging 4.32 and 2.72 respectively (Fig. 4). The exceptions were on 12 May at the west mudflat site where the average stomach fullness was 5.4 and the instantaneous ration was 5.56, and on 10 June at the large breach site where the instantaneous ration was 6.56.

Coho Salmon Diets

A total of 23 juvenile coho salmon stomachs from two dates were analyzed for the diet composition. In contrast to chum salmon, crustaceans were more important in the diets of coho salmon, constituting over 50% of the prey weight on three of the five sites/dates analyzed (Fig. 5). Crustacean prey was made up mainly of *Corophium* spp. with a smaller contribution by the mysid shrimp *Neomysis mercedis*. Chironomids were also an important prey category at all the sites and dates analyzed. As with juvenile chum salmon, chironomid prey consisted mostly of pupae and emergent adults, with a lesser contribution by larvae.

The stomach fullness and the instantaneous ration were similar among the sampling sites/dates, averaging 4.26 and 1.17 respectively (Fig. 6).

Discussion

In 1999 our catch of 713 salmonids was considerably higher than for the equivalent sampling effort in 1998 (398 total). However, the difference was due mainly to the large catch of 399 chum salmon on 16 April. Our catch of 39 chinook salmon was much lower than the 148 that were caught in 1998, and coho catches were also lower (39 vs. 59). Chinook catches were also much less consistent across the sampling dates than in 1998. All but eight of the chinook

TABLE 1. Tides and fish sampling periods for 1999 south Spencer Island sampling.

	Everett tides						Beach seine (30 m)										
	low		high		low		east mudflat			west mudflat			bridge				
Date	time	feet	time	feet	time	feet	start	end	total time	start	end	total time	start	end	total time	Crew [A]	Notes
2-Apr			5:33	10.7	11:54	1.4	7:15	7:25	0:10	7:30	7:40	0:10	8:45	8:55	0:10	KA, JC, CT & CM	
16-Apr			5:24	11.6	11:56	-0.2	7:20	7:40	0:20	8:00	8:20	0:20			0:00	KA, JC, CM & TW	The bridge site was not sampled due to low
30-Apr			5:16	10.4	11:53	0.4	7:00	7:20	0:20	7:45	8:00	0:15	8:30	8:50	0:20	KA, JC & SH	
12-May	9:28	1.8	15:35	9.2	21:17	3.3	16:30	17:00	0:30	17:30	18:00	0:30	18:30	18:50	0:20	KA, CT, & WB	
26-May	9:53	1.2	16:33	9.0	21:39	4.8	17:15	17:30	0:15	18:00	18:15	0:15	18:45	19:00	0:15	KA, JC & MK	
10-Jun	8:58	0.3	15:35	9.2	20:46	4.9	16:15	16:30	0:15	16:45	17:00	0:15	17:30	17:45	0:15	KA, JC, PR & IB	

A Crews consisted of Kevin Aitkin (KA), Wendy Bates (WB), Ian Butler (IB), Jeff Cordell (JC), Steve Hager (SH), Mike Kelly (MK), Carlos Madril (CM), Paul Renaud (PR), Curtis Tanner (CT), and Theo Willis (TW).

TABLE 2. All fish caught (top) and those retained for diet analyses (bottom) at Spencer Island, Washington in 1999.

Date	Chum	Chinook	Coho	Cut-throat	Threespine stickleback	Peamouth	Stag-horn sculpin	Prickly sculpin	Sculpin spp.	Starry flounder	Tadpole *(Rana* spp.)
2-Apr	75	1	0	0	1	1	2	0	0	0	0
16-Apr	399	2	0	0	318	0	0	0	0	0	0
30-Apr	116	1	1	1	9	1	0	0	0	0	0
12-May	43	4	1	0	120	2	0	1	0	0	2
26-May	8	0	23	0	9	176	1	0	1	0	0
10-Jun	3	31	4	0	60	85	0	0	0	42	2
TOTAL	644	39	29	1	517	265	3	1	1	42	4

Date	Chum	Chinook	Coho	Starry flounder	Threespine stickleback	Tadpole *(Rana* spp.)
2-Apr	22	0	0	0	0	0
16-Apr	21	0	0	0	0	0
30-Apr	36	0	0	0	0	0
12-May	32	0	1	0	0	2
26-May	8	0	23	0	0	0
10-Jun	3	1	4	32	16	2
TOTAL	122	1	28	32	16	4

TABLE 3. Salmonid fork lengths (mm) from 1999 south Spencer Island sampling.

	Sample date							
	2-Apr		16-Apr		30-Apr			
	Chum	Chinook	Chum	Chinook	Chum	Chinook	Coho	Cutthroat
n	75	1	180	2	116	1	1	1
mean	38.8	47.0	40.2	46.5	40.4	45.0	40.0	260.0
max	45	47	50	48	49	45	40	260
min	34	47	33	45	33	45	40	260
SD	2.2		3.0	2.1	2.9			
median	39.0	47.0	40.0	46.5	40.0	45.0	40.0	260.0

	Sample date							
	12-May			26-May		10-Jun		
	Chum	Chinook	Coho	Chum	Coho	Chum	Chinook	Coho
n	42	4	1	8	23	3	31	4
mean	45.4	61.8	57.0	43.9	85.6	49.7	81.8	87.5
max	55	70	57	50	120	52	95	102
min	38	54	57	37	43	47	65	58
SD	3.9	8.4		4.7	20.0	2.5	7.1	19.9
median	44.5	61.5	57.0	44.0	92.0	50.0	81.0	95.0

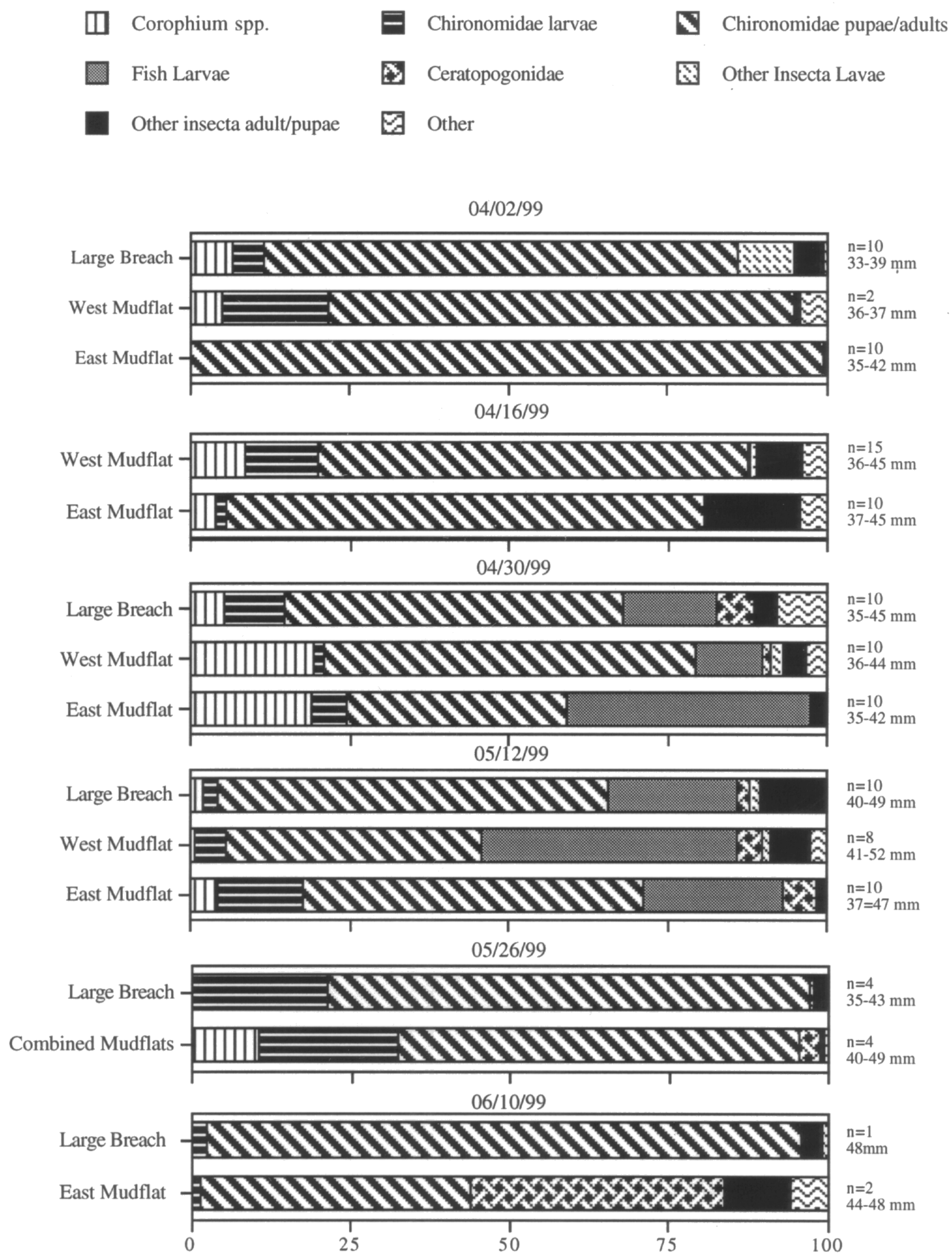

FIGURE 3. Percentage composition by weight of prey from juvenile chum salmon on six dates at three stations at Spencer Island, Washington, 1999.

taken in 1999 were caught on the 10 June sampling date. These between-year differences may be due to interannual variation in year-class strength and in amounts and patterns of use by juvenile salmon at the site. However, in aggregate, the 1998–99 fish sampling results continue to suggest that juvenile chinook and chum salmon regularly access the breached-dike restoration site.

In the predominance of chironomid larvae, pupae and emergent adults, the diets of chum salmon captured at the restoration site in 1999 were similar to those from previous sampling efforts at Spencer Island (Cordell et al. 1998, 1999). As discussed by Cordell et al. (1999), this dominance by chironomids is similar to results from a variety of other natural and created wetland sites in the region.

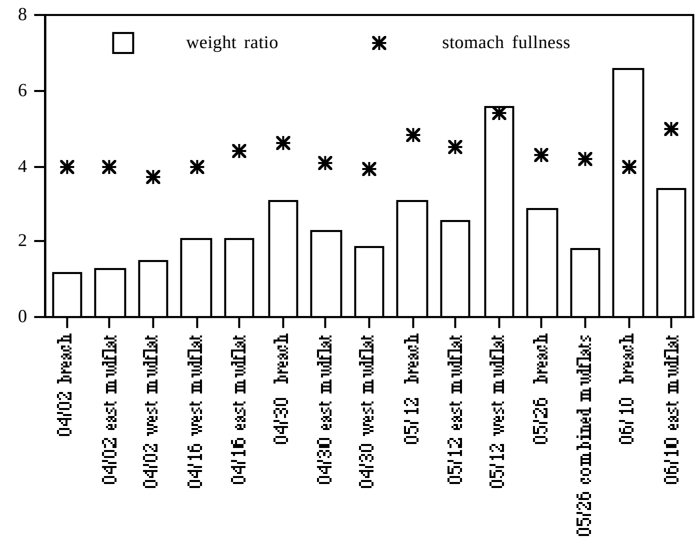

FIGURE 4. Stomach fullness factor (1 = empty, 6 = full) and index of percent ratio of stomach contents weight of fish weight for juvenile chinook salmon captured by beach seine at Spencer Island, Washington in 1999.

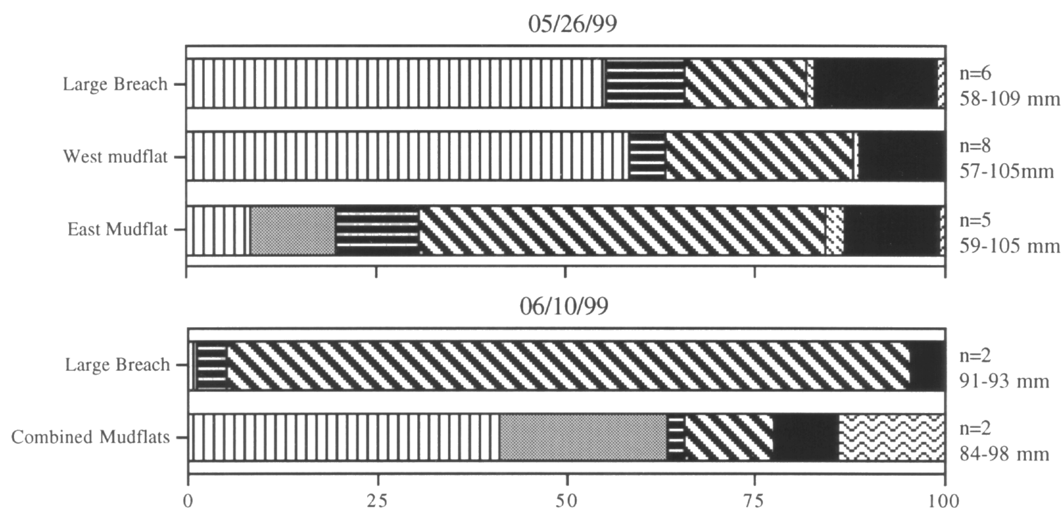

FIGURE 5. Percentage composition by weight of prey from juvenile coho salmon on two dates at three stations at Spencer Island, Washington, 1999.

Furthermore, chironomids were also dominant in benthic core and fallout trap samples collected at Spencer Island in 1997 (Cordell et al. 1998).

The diets of juvenile chinook salmon were not studied in 1999, but results from 1998 samples indicated that diets of juvenile chinook using the Spencer Island breached dike site were also very similar to those of chinook from other restored and natural habitats in the Pacific northwest (Cordell et al. 1999).

Juvenile coho salmon did not occur as consistently at the Spencer Island breached dike site as did chum and chinook salmon. However, when they were present their diets were similar to those analyzed in 1998, containing relatively high proportions of benthic and epibenthic crustaceans, with the remainder consisting mainly of chironomids and other insects (Cordell et al. 1999). As discussed by Cordell et al. (1999), these results are consistent with the few other studies of coho salmon diets that have been conducted in estuaries from this region.

The design of the Spencer Island site, with multiple

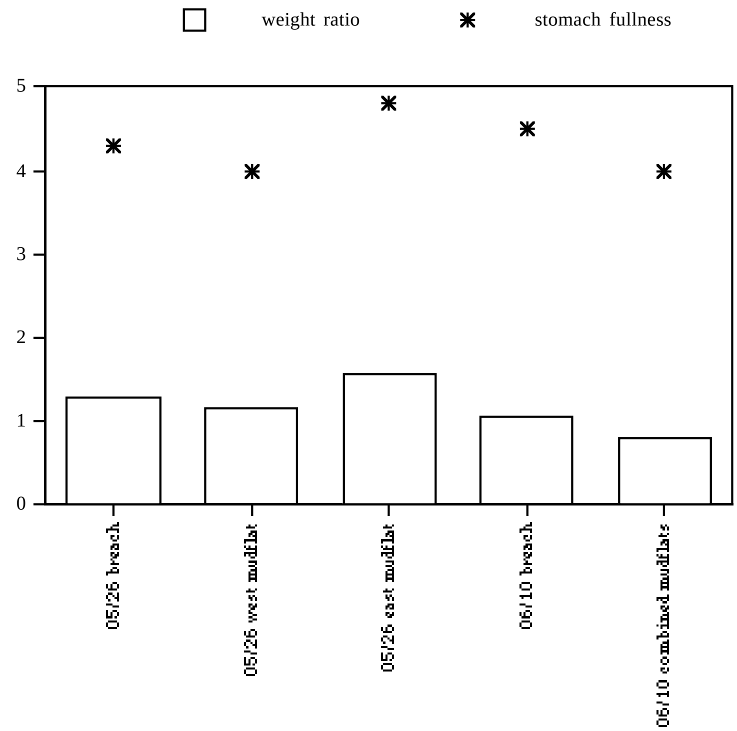

FIGURE 6. Stomach fullness factor (1 = empty, 6 = full) and index of percent ratio of stomach contents weight of fish weight for juvenile coho salmon captured by beach seine at Spencer Island, Washington in 1999.

breaches, precludes direct measures of fish foraging, such as knowing how long captured fish had been feeding on the site. However, several corroborating metrics suggest that juvenile salmon succesfully access and forage at Spencer Island. First, as mentioned above, salmon occurred consistently across sampling dates. Second, in both 1998 and 1999, stomach fullness indices were relatively high (averaging about 50–75% full). Third, capacity metrics such as on-site prey assemblages that have been previously sampled indicate that the Spencer Island restoration site produces juvenile salmon prey organisms in densities that equal or exceed those at a reference site (Cordell et al. 1998, Simenstad and Cordell 2000). And fourth, the types of prey consumed by juvenile salmon at Spencer Island are the same that occur in invertebrate samples from the site, and are similar to salmon prey found from a variety of other estuarine wetland sites in the region.

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