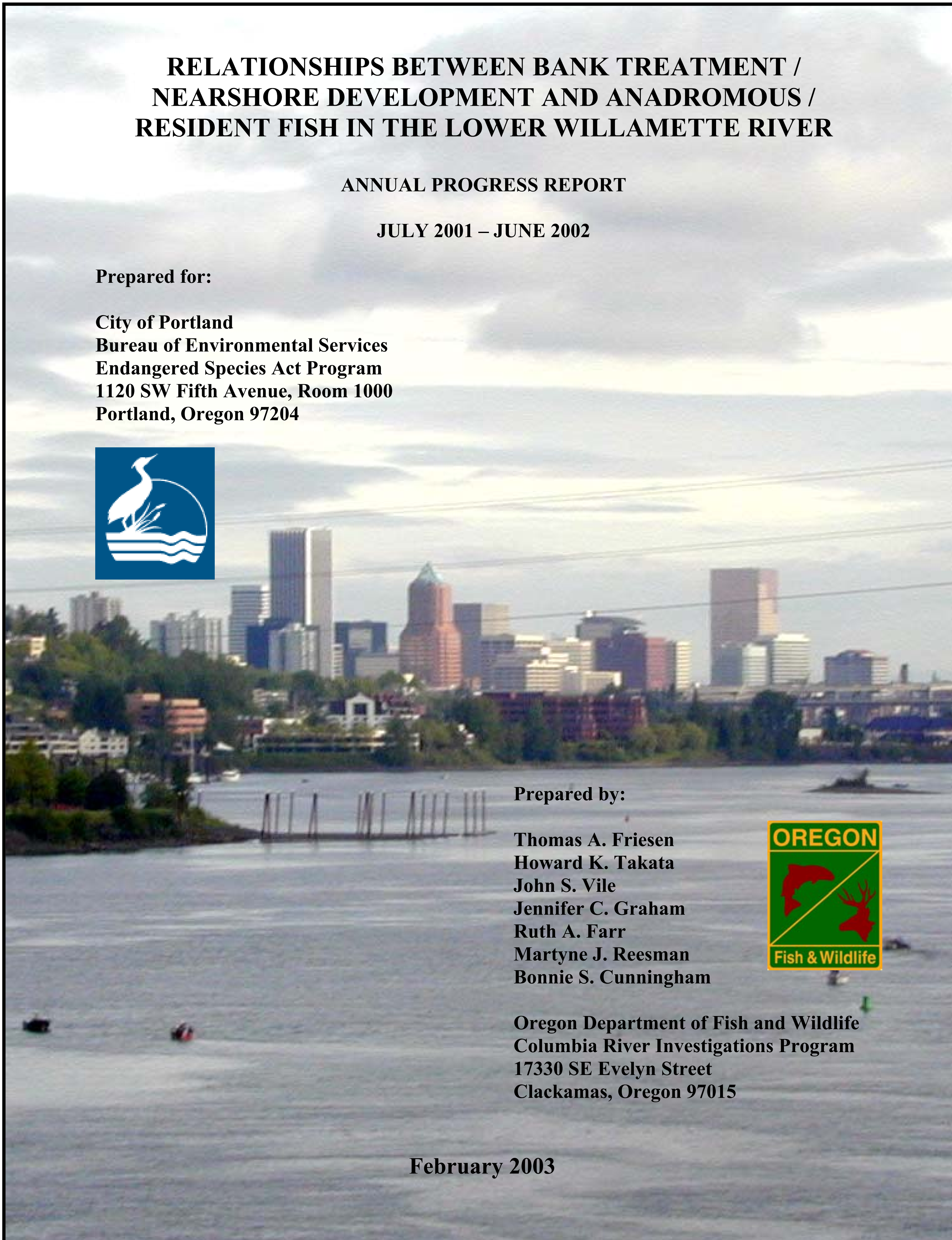

RELATIONSHIPS BETWEEN BANK TREATMENT / NEARSHORE DEVELOPMENT AND ANADROMOUS / RESIDENT FISH IN THE LOWER WILLAMETTE RIVER

ANNUAL PROGRESS REPORT

JULY 2001 – JUNE 2002

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REPORT SUMMARY

In response to recent Endangered Species Act listings of five salmonid stocks found in the lower Willamette River, the City of Portland and the Oregon Department of Fish and Wildlife initiated a four-year study to evaluate relationships between fish communities and waterway developments. In the second year of the study (2001-2002), we repeated much of the work conducted in 2000-2001 and began addressing additional tasks.

As in 2000-2001, juvenile salmonids *Oncorhynchus* spp. (including naturally propagated fish) were present in the study area during every month sampled. In both sampling years, abundance of all juvenile salmonids increased beginning in November, peaked in April, and declined to near zero by July. Unusually high catch rates observed during November - December 2000 were not repeated in 2001. We discerned several groups of unmarked juvenile chinook salmon *O. tshawytscha* from length-frequency analyses; these groups likely represent several races (spring and fall), ages (0+ and 1+), and origins (upper and lower Willamette River tributaries, mainstem Willamette River). We did not find any evidence of rearing among sub-yearling chinook salmon based on comparisons of fork length among upstream and downstream sites. However, some telemetry results suggested larger fish may spend extended periods of time in off-channel habitat.

Mean migration rates of juvenile salmonid cohorts ranged from 2.7 km/d for steelhead *O. mykiss* to 8.6 km/d for sub-yearling chinook salmon; residence time in the study area ranged from 4.9 d (sub-yearling chinook salmon) to 15.8 d (steelhead). In contrast to 2001, small fish exhibited slightly faster migration rates than large fish. Juvenile salmonids were not highly associated with nearshore areas (> 60% of telemetry recoveries occurred offshore). Relocations of radio tagged salmonids adjacent to different bank habitat types were relatively consistent with the availability of each habitat type, except for rock outcrops where recoveries of most species were higher than expected.

Significant differences in catch rates of juvenile salmonids and resident fishes among bank habitat types were rare; however, we identified several relationships not observed in 2000-2001. Electrofishing catch rates of salmonids and suckers were significantly higher at sites composed of natural habitat (e.g. beach, rock), and catch rates of sunfish were significantly higher at sites comprised of artificial (e.g. riprap, pilings) habitat. Juvenile salmonids were captured at higher rates at alcoves than at several other habitat types. Catch at seawall sites differed significantly from most other habitat types, but reduced sampling efficiency associated with water depth probably contributed to this relationship. Gillnet catch of predator fish (northern pikeminnow *Ptychocheilus oregonensis*, walleye *Stizostedion vitreum*, smallmouth bass *Micropterus dolomieu*, and largemouth bass *Micropterus salmoides*) at rock outcrop sites was significantly higher than catch at riprap or seawall sites.

Low catch rates of predator fishes hampered our ability to assess predation in relation to habitat types. Stomach samples collected from predators also indicated a very low level of piscivory among these species. Thus, predation does not appear to be a major factor influencing the survival of juvenile salmonids in the lower Willamette River.

We have primarily collected data and conducted simplified analyses during the first two years of this study. Additional data and more rigorous statistical tests are needed to address study hypotheses with certainty. In 2002-2003 we will continue conducting standardized electrofishing, gillnetting, and beach seining, and will repeat the juvenile salmonid radio telemetry work conducted during the past two years. Diet analysis of predator fish will continue, and we will begin collecting information on juvenile salmonid and resident fish diets. We plan to conduct additional radio telemetry of predator species, and we will begin macroinvertebrate community assessments.

INTRODUCTION

The lower Willamette River (downstream of Willamette Falls; Figure 1) is used by substantial numbers of hatchery and naturally propagated salmonids *Oncorhynchus* spp. These fish contribute to commercial, sport, and tribal fisheries throughout the basin, and are important indicators of biotic and environmental integrity. In 1998 and 1999, four evolutionarily significant units (ESUs) of naturally propagated anadromous salmonids in this area were listed as threatened under the federal Endangered Species Act (ESA): lower Columbia River and upper Willamette River chinook salmon *O. tshawytscha* (NOAA 1999a), upper Willamette River steelhead *O. mykiss* (NOAA 1999b), and lower Columbia River steelhead (NOAA 1998). Naturally propagated lower Columbia River coho salmon *O. kisutch* have also been listed as an endangered species under Oregon's Endangered Species Act (ODFW 1999). The lower Columbia River ESU includes the Willamette River up to Willamette Falls. Other species of social or economic importance in the lower Willamette River include white sturgeon *Acipenser transmontanus*, American shad *Alosa sapidissima*, and Pacific lamprey *Lampetra tridentata*.

This reach of the Willamette River has been heavily modified to support commercial shipping. The channel has been dredged to accommodate large ships, a variety of structures have been constructed to aid docking and loading, and much of the natural shoreline has been replaced by rock revetment (riprap). Many natural flood plains have been filled and seawalls erected to control flooding. The recent ESA listings described above and recommendations by natural resource agencies have prompted increased concerns regarding the effects of these activities on fish populations.

A number of studies addressing fish communities in the lower Willamette River have been conducted, but there has not been a comprehensive investigation of the effects of bank habitat on anadromous and resident fishes. Dimick and Merryfield (1945) were among the first researchers to survey fish in this reach of the river; they described depauperate and unhealthy fish communities, generally attributed to pollution from point sources. Intensive cleanup efforts in the 1970s improved water quality dramatically. Hughes and Gammon (1987) calculated biotic integrity indices based on fish community metrics at sites in the Willamette River; the six stations sampled below Willamette Falls exhibited low biotic integrity relative to sites above the falls. Farr and Ward (1993) collected 39 fish species from 17 families in the lower Willamette during the late 1980s, though 19 species were exotic to Oregon. The influences of waterway development on juvenile salmonids in the lower Willamette River were previously investigated by the Port of Portland and the Oregon Department of Fish and Wildlife (ODFW) (Ward et al.

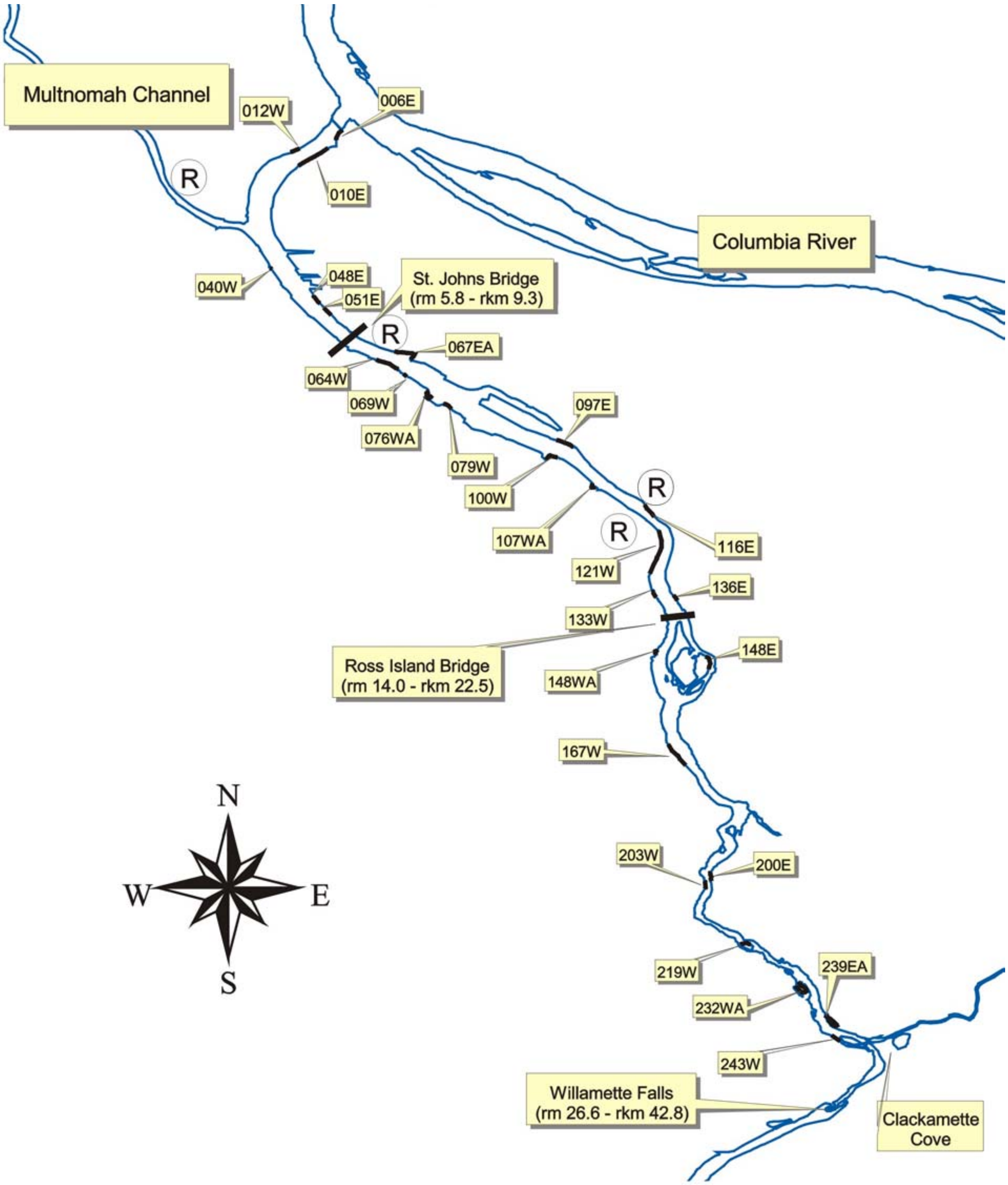

Figure 1. The lower Willamette River study area and associated features. Sampling site labels denote river mile (xx.x) and east (E) or west (W) shore. A = alcove site; rkm = river kilometer; ® = fixed radio telemetry site.

1994). They concluded development posed little risk to salmonids, but emphasized the need for a more comprehensive study.

In June 1999, the City of Portland's ESA Program conducted a workshop with regional scientists, agency representatives, and the National Marine Fisheries Service (NMFS) to address the state of the science of fish ecology and determine what environmental conditions salmon need to survive. The panel agreed the lower Willamette River is an important migration corridor for salmonids, and some areas may provide rearing habitat. Considering ESA listings and urban conditions facing the City of Portland, participants also concluded that detailed information on fish habitat use in the lower Willamette River is desirable. The Portland City Council thereafter provided funding to ODFW to complete a four-year study. The overall objective is to provide new and updated information regarding use of currently available habitat by anadromous and resident fish. This will improve the City's ability to make informed decisions regarding planning, permitting, and enforcement actions along the lower Willamette River. The results of the study will be used to help meet the City's goals of working proactively with NMFS, developing a citywide response to ESA listings, and supporting the recovery of native species. Specific study objectives include:

(1) Describe and quantify bank treatment and nearshore development types in the lower Willamette River.

(2) Evaluate relationships between bank treatment and nearshore development types in the lower Willamette River and habitat use / migration of juvenile salmonids.

(3) Evaluate relationships between bank treatment and nearshore development types in the lower Willamette River and distribution, abundance, and diet of native and introduced resident fish.

(4) Evaluate relationships between bank treatment and nearshore development in the lower Willamette River and distribution and abundance of native and exotic invertebrates.

In this report we describe progress from May 2000 through June 2002 toward study objectives and associated hypotheses (Table 1). We refer to the general sampling periods to date as year 1 (May 2000 – June 2001) and year 2 (July 2001 – June 2002) throughout the report. Habitats and structures manufactured or constructed by people (e.g., riprap, seawalls, pilings) are referred to as "artificial"; all others are referred to as "natural".

METHODS

Task 1.1: Selection of Sampling Sites

We conducted the study in the lower Willamette River from Willamette Falls at river mile (rm) 26.5; river kilometer (rkm) 42.6, downstream to the confluence with the Columbia River (rm 0.0, rkm 0.0) (Figure 1). General habitat categories included: 1) no riprap on shoreline, no structure present; 2) riprap on shoreline, no structure present; 3) no riprap on

Table 1. Objectives, tasks, and associated hypotheses for investigations in the lower Willamette River, May 2000 – March 2004.

Objective, Task	Year of study	Hypotheses/Tasks
Objective 1		
Task 1.1	1	Identify sampling sites between Willamette Falls and the confluence of the Willamette and Columbia rivers.
Task 1.2	1-3	Complete a detailed inventory of habitat characteristics at each sampling site.
Objective 2		
Task 2.1	2-3	*Ho*: Distribution of radio tagged juvenile salmonids among bank treatment and nearshore development does not differ from the distribution of bank treatment and nearshore development types.
Task 2.2	1-3	*Ho*: Mean weight of juvenile salmonids does not change during migration through the lower Willamette River.
	1-3	*Ho*: Catch of juvenile salmonids does not vary among bank treatment and nearshore development types.
Task 2.3	2-3	*Ho*: Diet composition of juvenile salmonids does not differ from food items available.
		Ho: Diet composition of juvenile salmonids does not differ from diet composition of introduced fish species.
Objective 3		
Task 3.1	1-3	*Ho*: Distribution of radio tagged resident predator fish among bank treatment and nearshore development types does not differ from the distribution of bank treatment and nearshore development types.
Task 3.2	1-3	*Ho*: Fish assemblages do not differ among bank treatment and nearshore development types.
Task 3.3	2-3	*Ho*: Diet composition of juvenile salmonids does not differ from diet composition of introduced fish species.
	2-3	*Ho*: Predation on juvenile salmonids does not differ among bank treatment and nearshore development types.
Objective 4		
Task 4.1	3	*Ho*: Benthic invertebrate assemblages do not differ among bank treatment and nearshore development types or time of year.
	2-3	*Ho*: Diet composition of juvenile salmonids does not differ from food items available.
Task 4.2	3	*Ho*: Sediment composition does not differ among bank treatment and nearshore development types or time of year.
Task 4.3	3	*Ho*: Surface invertebrate assemblages do not differ among bank treatment and nearshore development types or time of year.
	3	*Ho*: Diet composition of juvenile salmonids does not differ from food items available.

shoreline, structure present; 4) riprap on shoreline, structure present; 5) seawall shoreline; and 6) alcoves and other natural refugia (hereafter “alcove”). Alternative habitat type classifications also used for reporting results in this study are 1) natural beach and rock, 2) riprap, 3) piling structures, 4) floating structures, 5) rock outcrop, and 6) mixed and unclassified habitat (Table 2). For some analyses we divided habitat into only two categories, natural (e.g. beach, rock outcrop) and artificial (e.g. riprap, seawall). We did not include bio-engineered sites as a habitat category for analyses in this report. We surveyed only one relatively short bio-engineered site, and this site was functionally indistinct from other riprap and beach sites (depending on river levels).

Sampling site selection procedures are described in North et al. (2002). Several sites (031W, 118W, and 126E) were eliminated during 2001; we did not include these sites in subsequent analyses. We added an additional beach seining site (069W) during spring 2002, as we were occasionally unable to sample site 097E due to debris at the site. Throughout year 2, we sampled 27 individual sites: 17 “standard” sites sampled by electrofishing and gillnetting (2 were also sampled with beach seines), 4 sites sampled by beach seining only, and 6 alcove sites sampled by electrofishing only (Tables 3 and 4). Alcove sites were comprised of mixed habitat constituting natural or artificial refugia in off-channel areas.

Task 1.2: Habitat Evaluation

We conducted no new work on habitat evaluation (habitat inventory, habitat parameter surveys; Task 1.2) during year 2; however, we included the habitat results from year 1 in this report to provide context for work completed in other areas.

Characterization of bank habitat types was adjusted for varying river flows according to methods described by North et al. (2002). To assure catch rate data was applied to the appropriate habitat type, we assumed the waterline bank substrate should remain predominant (≥80%) to a depth 3 feet below the mean river stage (MRS-3). If a different substrate became predominant from MRS-3 and below, then the bank substrate was classified as such for that specific sampling season. If a site did not meet either of these criteria (no predominant substrate type), catch rate data specific to that site and season were not used in analyses. We adopted these rules to ensure the bank habitat type penetrated the water to a depth sufficient to realistically have an effect on fish use.

Task 2.1: Juvenile Salmonid Radio Telemetry

Tags and Tagging

We surgically implanted radio transmitters (radio tags) in juvenile salmonids to describe migration characteristics and monitor habitat associations. Coded microprocessor transmitters (NTC-2-1 NanoTags®) manufactured by Lotek Engineering were used. Tag size was 4.5 x 6.3 x 14.5 mm and averaged 0.8 g (air weight) including antennae. All tags were programmed with a

Table 2. Definitions of bank, nearshore, and offshore habitat types in the lower Willamette River, May 2000 through June 2001.

Habitat type	Description
Offshore	Not a bank habitat or bank treatment type; open water offshore. Arbitrarily defined as 10.1-89.9% of the river width (nearshore represents ≤ 10.0% and ≥ 90.0).
Beach	A shallow shelving shoreline consisting of sand, silt, or fine gravel up to 64 mm. This may also include native bank materials in their natural position and undisturbed by humans (e.g. clay bank). Vegetation cover varies but may include canopy, understory, and ground cover.
Rock outcrop	Natural bedrock formations consisting of angular ledges, protrusions, and sheer rock faces. May include some associated boulders.
Rock	Natural, round river rock >64 mm that does not fit into the riprap categories.
Seawall	Impervious vertical retaining walls, generally composed of concrete, timber, or sheet pile, that extend beyond ordinary low water. These habitats are uniformly deep and homogenous (e.g. house foundations in the water, bulkheads).
Vegetated riprap	Continuous stone revetments mechanically placed to curtail erosion and prevent alterations to the main channel. Vegetative cover varies but may include canopy, under story, and groundcover that occupy a minimum of 20% of the active bank below flood state (lower shore zone).
Non-vegetated riprap	Continuous stone revetment devoid (<20%) of vegetation.
Bio-engineered	Engineered banks that incorporate vegetation as a visible component of revetment banks, but inert and artificial materials provide the physical structure that ensures bank stability. Bio-engineered banks rely on vegetation and natural fabric materials for banks stability (e.g. site 133W, upstream of Newport Bay Restaurant).
Unclassified fill	These areas appear to have been filled over time with miscellaneous unconsolidated materials (e.g. cement slabs). The surfaces of banks composed of unclassified fill have not been covered with engineered riprap or structures. Such banks generally contain debris of various types and may have become unstable because of erosion by river forces.
Pilings-allowing light	Stationary support structures consisting of concrete, metal, or timber used to elevate docks, buildings, etc. above the water. Elements of construction allow varying amounts of light to penetrate to the underlying habitat (e.g. T-docks)
Pilings-limiting light	Stationary support structures used to elevate docks, buildings, etc above water. Construction is such that underlying habitat is not directly exposed to ambient light (e.g. site 100W).
Floating-allowing light	Structures such as loading docks and piers that maintain buoyancy atop the water and move with fluctuating river levels. Design and construction materials allow light to penetrate the habitat below.
Floating-limiting light	Buoyant structures that do not allow light to penetrate the underlying habitat.
Microhabitat	Any bank type with a linear shoreline distance less than or equal to 30m (~100') is classified as microhabitat.

Table 3. Description of standard sampling sites in the lower Willamette River, May 2000 through June 2002 (20 standard sites).

Habitat classification	Transect[a]	River kilometer	Length (m)	Gear[b]	General bank type[c]	Location/description
Undeveloped						
Beach (7)	006E	1.0-1.3	364	BS,ES,GN[1]	B	Kelley Point
	040W	6.4-6.5	64	BS	B	Across from Terminal 4
	097E	15.6-16.1	456	BS	B	Across from Terminal 2
	148E	23.8-25.0	526	ES,GN[1]	B	Behind Ross Island
	167E	26.9-27.8	804	BS,ES,GN[1]	B	Powers Marine Park
	243E	39.1-39.4	264	BS	B	Downstream of Goat Island
Rock outcrop (2)	200E	32.2-32.6	333	ES,GN[1]	RO	Lake Oswego Railroad Bridge
	219W	35.2-35.6	328	ES,GN[1]	RO	Hog Island
Rock revetment (riprap)						
Vegetated (2)	012W	2.0-2.3	240	ES,GN[1]	RR	Between Coast Guard #6 and #10
	136E	21.9-22.0	183	ES,GN[1,2]	RR	OMSI
Non-vegetated (2)	064W	10.3-11.0	564	ES,GN[1,2]	Mix (RR/B)	Doan Point
Bio-engineered (1)	133W	21.4-21.6	186	ES,GN[1]	Mix (BE/B)	Downstream of Marquam Bridge
Seawall						
Concrete wall (1)	121W	19.5-21.0	1,542	ES,GN[1]	SW	Waterfront Park seawall
Metal sheetpile (1)	048E	7.7-8.0	286	ES,GN[1]	SW	Terminal 4
Pilings						
Allowing light (3)	010E	1.6-2.4	905	ES,GN[1,2]	Mix (B/RR)	3 T-docks above Columbia Slough
	079W	12.7-13.0	255	ES,GN[1,2]	RR	Olympic Tug T-dock
	112E	18.0-18.2	141	ES,GN[1]	Mix (RR/UNC)	T-dock above Fremont Bridge
Limiting light (1)	100W	16.1-16.2	78	ES,GN[1,2]	RR	Terminal 2
Floating						
Allowing light (1)	203W	32.7-33.0	262	ES,GN[1]	Mix (RO/B)	Crown Zellerbach pulp mill dock
Limiting light (1)	051E	8.2-8.7	310	ES,GN[1,2]	Mix (RR/B)	Terminal 4 ship hull

[a] First two digits represent river mile, third digit represents river mile tenth. W=West bank, E=East bank
[b] BS=beach seine; ES=electrofishing; GN[1]=gillnet nearshore; GN[2]=gillnet near structure (mid-shore)
[c] B=beach; RO=rock outcrop; RR=riprap; BE=bedrock; SW=seawall; UNC=unclassified fill

Table 4. Description of supplemental alcove and refugia sampling sites in the lower Willamette River, May 2000 through June 2002. Sampling at supplemental alcove and refugia sites limited to electrofishing.

Habitat classification	Transect[a]	River kilometer	Length (m)	Bank type[b]	Description
Alcoves (natural)					
	232WA	37.3-37.7	1029	B	Upstream of Cedar Oak boat ramp
	239EA	38.5-38.9	580	B	Back side of Meldrum Bar
Refugia (natural)					
	067EA	10.8-11.1	577	Mix (RR/B)	Downstream of Doane Point RR
	148WA	23.8-24.0	206	Mix (B/UNC)	Above Spaghetti Factory
Refugia (artificial)					
	076WA	12.2-12.4	317	Mix (B/PAL)	Downstream of Chevron piers
	107WA	17.2-17.4	396	Mix (PAL/UNC)	Below Fremont Bridge

[a] First two digits represent river mile, third digit represents river mile tenth. W=West bank, E=East bank.
[b] Bank habitat type: B=Beach; RR=Rock revetment (riprap); UNC=Unclassified fill; PAL=Pilings-allowing light. For sites with mixed bank substrates, the predominant type appearing above normal low water is listed first. For comparisons, bank types are classified seasonally to account for differences in river stage elevations.

continuous 4 s burst rate, and minimum estimated battery life was 11 d. Transmitting frequencies were 148.360 and 148.380 MHz (Table 5).

Fish were collected by electrofishing within the study area or were obtained at the smolt evaluator bypass facility (Portland General Electric Sullivan Plant) at Willamette Falls. Hatchery and naturally propagated fish including yearling (age 1+ and 2+) steelhead, yearling coho salmon, and both yearling and sub-yearling chinook salmon were tagged to approximately represent the salmonid population in the study area. Only fish in good condition were selected for tagging. Criteria for rejecting fish included de-scaling, injuries, excessive handling, or insufficient size. Weight of tags placed in yearling fish (all species) never exceeded 5.0% of the fish's weight; a level deemed acceptable by other researchers (Adams et al. 1998a; Brown et al. 1999). Very few sub-yearling chinook salmon met this size requirement; therefore, we selected only the largest sub-yearlings (≥ 15 g) for tagging, and tag weight never exceeded 5.3% of the fish's weight.

We transported fish suitable for tagging from collection sites to a holding site in Clackamette Cove near the confluence of the Clackamas and Willamette rivers (Figure 1). Fish collected from the Sullivan Plant were transported in covered 19-L plastic buckets, with a maximum loading density of ≤ 30 g/L, and transfer times were < 30 minutes. Fish collected by electrofishing were held in an aerated livewell on the boat and transferred to the holding site after collection was completed. At the holding site, fish were moved to covered, 125-L plastic refuse containers suspended in the cove within floating frames for approximately 16-48 hours pre-tagging to allow evacuation of stomach contents. Pre-tagging holding densities were ≤ 5g/L.

We surgically implanted radio tags in the body cavity of the fish using sterile procedures described by Adams et al. (1998b); proper function of all radio tags was verified at time of implantation. Tagged fish were held approximately 12-36 hours post-tagging to allow recovery from the surgical procedure and tag-weight compensation. We visually inspected all fish to ensure only actively swimming fish in good condition were released. Mortalities and fish in poor condition were sacrificed and necropsied to determine cause of death or injury.

We conducted four releases, of 6-21 radio tagged salmonids each, between 31 May and 22 June, 2002. Fish were released pre-dawn at mid-channel in the Willamette River between rm 20.2 and 24.6 (rkm 32.5-39.6). After checking the condition of the fish, we loaded the holding containers onto a boat and proceeded immediately to the release site. Fish were released by placing the holding container into the water and gently inverting it, producing a water-to-water release.

Fixed Sites

We employed stationary receivers to monitor migration of radio tagged juvenile salmonids through the study area. We reduced the number of fixed receiver sites from eight in 2001 to four in 2002 for several reasons. The Sellwood Bridge station (rm 16.6; rkm 26.7) was eliminated because it provided very little useful data in 2001, and preparing the site for a receiver required considerable time and expense. Three channel navigation aids, one at rm 3.0 (rkm 4.8)

Table 5. Summary of radio transmitters implanted in chinook salmon (CHN), coho salmon (COH), and steelhead (STH) in the lower Willamette River, May-June 2002.

Species	Channel	Code	Frequency	Species	Channel	Code	Frequency
CHN	3	141	148.360	COH	3	150	148.360
CHN	3	144	148.360	COH	3	151	148.360
CHN	3	147	148.360	COH	3	153	148.360
CHN	3	155	148.360	COH	3	154	148.360
CHN	3	161	148.360	COH	3	156	148.360
CHN	3	163	148.360	COH	3	157	148.360
CHN	3	165	148.360	COH	3	158	148.360
CHN	4	110	148.380	COH	3	159	148.360
CHN	4	138	148.380	COH	3	162	148.360
CHN	4	139	148.380	COH	3	166	148.360
CHN	4	141	148.380	COH	3	167	148.360
CHN	4	142	148.380	COH	3	168	148.360
CHN	4	143	148.380	COH	3	169	148.360
CHN	4	145	148.380	COH	4	166	148.380
CHN	4	153	148.380	STH	3	146	148.360
CHN	4	154	148.380	STH	3	149	148.360
CHN	4	161	148.380	STH	3	152	148.360
CHN	4	164	148.380	STH	3	160	148.360
CHN	4	167	148.380	STH	3	164	148.360
CHN	4	169	148.380	STH	4	140	148.380
COH	3	138	148.360	STH	4	144	148.380
COH	3	139	148.360	STH	4	146	148.380
COH	3	142	148.360	STH	4	148	148.380
COH	3	143	148.360	STH	4	160	148.380
COH	3	145	148.360	STH	4	163	148.380
COH	3	148	148.360				

and two at rm 0.7 (rkm 1.1) were eliminated because of U.S. Coast Guard restrictions. Fixed sites used in 2002 included (1) the Albers Mill Building, (2) the Cargill Inc. Irving Elevator (both sites at rm 11.6; rkm 18.7), (3) the City of Portland Water Pollution Control Laboratory (rm 5.9; rkm 9.5), and (4) a private residence in Multnomah Channel, 1.5 rm (2.4 rkm) downstream from the head of the channel (Figure 1).

Fixed sites consisted of a receiver (Lotek Engineering; model SRX-400), power supply (12-v deep cycle battery), single six-element (Cushcraft Corporation) yagi-style antenna arrays, antenna leads, and mounting hardware. Receivers were protected onsite within metal or wooden containers. A representative from Lotek Engineering assisted us in setting up and testing the fixed sites to eliminate noise and maximize signal strength.

Fixed site receivers were programmed to scan the two tag frequencies and record the tag code, date, time, and signal strength. Scan time was 4.5 s per frequency. We downloaded the data weekly to a laptop computer and replaced receiver batteries.

Mobile Tracking

Mobile radio tracking procedures were similar to those used in 2001 (North et al. 2002). We began searching for tagged fish approximately one hour after release, beginning about 1.6 km above the release point and traveling downstream at approximately 5-10 km/h. Mobile tracking was conducted from 5.5-6.7 m boats equipped with a receiver and a six-element, yagi-style antenna. To ensure random recoveries of fish in both nearshore (0-10% and 90-100% of the river width) and offshore (11-89% of river width) habitat, we utilized a zigzag search pattern downstream of Elk Rock Island (rm 19.0; rkm 30.6). Total tracking time conducted offshore and nearshore was recorded for each shift to maintain an approximate 50:50 ratio. Upstream of Elk Rock Island, the river is narrower and we were able to detect signals at either shoreline from mid-channel without using the zigzag pattern. We specifically targeted Multnomah Channel and the east side of Ross Island during some tracking shifts.

Once an audible signal was detected, we progressively decreased gain and monitored signal power levels to guide the boat to the approximate location of the fish. This process was then repeated with a coaxial antenna lowered 1-2 m underwater to pinpoint the location of the fish. Tag frequency, code, date, time, river mile, GPS waypoint (latitude and longitude), depth, surface temperature, and signal strength were recorded each time a tagged fish was located. We used a laser rangefinder to measure distance to shore and classified the bank habitat type based on criteria in Table 2 for fish relocated within 10% of the river width from either shore. This process of random searching and locating tagged individuals was repeated as the tracking crew progressed downstream with a release group. To maximize recoveries, the tracking crew returned to the midpoint of previously relocated fish if ≥ 2 hours elapsed without locating a fish.

We generally conducted tracking efforts during one or two ten-hour shifts daily from about 0500-1500 and/or 1500-0100. For non-release day tracking, the starting point was determined as the midpoint of fish relocations from the previous shift(s) adjusted for migration rate. If no fish could be located during two hours of tracking in the primary area, the crew proceeded to an alternate site and repeated the process. The total distance covered each day was highly variable depending on fish densities, river width, and ease of locating fish. Fish from previous releases were tracked in the same manner as fish from the current release.

To determine species-specific and life stage-specific migration rates, mobile telemetry data was combined with the primary record for each unique fixed-site recovery and sorted by tag channel and code. We reviewed the data for peculiarities and edited it to remove suspected mortalities. Rates (distance/time) were calculated for all consecutive relocations of each fish and then averaged by species and geographic area. Criteria used to edit data included:

1) Multiple recoveries of an individual fish at the same location may indicate mortality. Most recoveries of fish downstream of the previous relocation are included. Fish relocated multiple times at the same position (± 0.1 mile) for ≥ 24 h are presumed dead. Only the initial data point at this location is included in calculation of migration rate. Fish found multiple times at the same river mile for < 24 h are included.

2) Recoveries of fish upstream of release location may be indicative of predation. Upstream movement with no subsequent downstream movement is not included. Relocations of fish upstream of release sites are included if followed by some (> 0.2 miles) downstream movement.

Waypoints of relocated fish were compiled by species and layered onto an Oregon Lambert-projected ortho-photo (2' resolution) with ArcView 3.2a (ESRI) software for visual presentation.

Task 2.2: Standardized Sampling for Juvenile Salmonids

As in year 1, beach seining and electrofishing (concurrent with Task 3.2; see methods below) were used in year 2 to determine relative abundance, species composition, timing, origin, and size of juvenile salmonids using the study area. Previously, we conducted sampling during a 4-6 week period each season (winter, spring, summer, and autumn), often resulting in temporal gaps in the data. To eliminate this problem, we redesigned the sampling scheme so all months were sampled equally. Beginning in winter 2001, electrofishing was conducted four days per month (each site sampled twice), and beach seining was performed once per week (each site sampled once). Electrofishing was not conducted in June 2002 to better facilitate radio tracking activities.

We identified juvenile salmonids to species whenever possible. Small individuals could not always be identified to species; these were recorded as unidentified salmonids. Salmonids observed, but not captured, by electrofishing were counted and recorded as unidentified salmonids. All fish captured were measured (fork length in mm) and examined for marks to determine origin. Most fish were weighed (g) with a 100-g Pesola spring scale equipped with a plastic weighing chamber. We noted the disposition (e.g. released alive, tagged, dead, etc.) of each fish prior to release, and recorded water temperature (^{o}C), depth (feet), and duration of sampling effort. Beginning in early 2002, we also recorded conductivity (µS) immediately after each electrofishing run.

Beach Seining

We conducted daytime beach seining at five sites (006E, 040W, 097E, 167W, and 243W) once per week. A sixth site (069W) was added in spring 2002. Beach seining was occasionally skipped to facilitate other tasks; however, most sites were sampled at least three times per month. Beach seine sites consisted of shallow, sandy beaches void of pilings and other obstacles that could snag or tear the seine, or allow escapement of fish underneath the net. The seine was a 2.4 x 45.7 m straight-wall, buntless net constructed of 4.8 mm Delta-style nylon mesh with a weighted line at the bottom and a floating line at the top. We deployed seines from a boat in a semi-circular pattern at each site.

Electrofishing

Although the primary use of electrofishing was to capture resident fish (Task 3.2; see below), juvenile salmonids were also incidentally collected. Because of the documented potential for injury (Reynolds 1996; Ainslie et al. 1998), many additional procedures were incorporated to reduce impacts on juvenile salmonids (Appendix A). These limitations often prevented us from collecting all observed juvenile salmonids when densities were highest. Therefore, a subsample of ≤ 30 unmarked and ≤ 30 hatchery salmonids of each species were measured and weighed after each electrofishing run. We counted juvenile salmonids not collected (± 10 fish) and identified individuals to species when possible.

Task 3.2: Standardized Sampling for Resident Fish

To index fish communities utilizing various habitat types by season, we conducted nighttime sampling with boat electrofishing and gillnetting during two weeks each month. Each site was sampled twice by electrofishing and once by gillnetting during this period. Two gillnets, one offshore and one nearshore, were deployed at some sites. Our target effort for electrofishing was 24 electrofishing runs/site/year, and target effort for gillnetting was 12-24 net sets/site/year (depending on the number of gillnets deployed at a site). No electrofishing was conducted during June 2002 because of juvenile telemetry work (Task 2.1); however, gillnetting was completed.

We measured (fork length in mm) and weighed (g) a maximum of 30 fish of each species for each unique sampling effort. Because of their extreme abundance at times, adult American shad, carp *Cyprinus carpio*, and suckers *Catostomus* spp. were enumerated only. We weighed small fish (<100 g) with a 100-g Pesola spring scale equipped with a plastic weighing chamber. Larger fish were weighed to the nearest 5 g with an Accu-weigh 4000 x 10 g platform scale. The disposition of each fish was noted prior to release. Since we did not attempt to collect adult salmonids because of ESA listings, these fish were only counted and identified to species (when possible). Additional information recorded for each sampling effort included date, time, site code, surface temperature, conductivity, duration of sampling effort, and minimum and maximum sampling depth.

Electrofishing

We conducted electrofishing after sunset in the littoral zone to evaluate nearshore resident fish use. Target water depth was 1-3 m along consistent bank habitat whenever possible, although some sites were much deeper (e.g. 048E, 121W, 200E, 219W) or had mixed bank habitat (e.g. 112E, 203W). The specific location of electrofishing runs at each of the sites was relatively consistent throughout the study because factors such as site length, depth, and obstacles often limited the area that could be sampled. Target effort was 750 s of continuous energized direct current (DC) output, but actual effort varied substantially because of variable site lengths.

Boats (5.5 m) were equipped with a 5.0 GPP generator and voltage regulator, and six-element anodes. From May 2000 through November 2000, voltage regulator settings were adjusted to produce an output of 2.0-4.0 amperes. Both 30 and 60 pulses/s at high and low range settings were used with output regulated by adjusting pulse width. To reduce potential harm to juvenile salmonids we evaluated alternative voltage regulator settings to identify a combination that maximized taxis (involuntary attraction) of juvenile salmonids and resident fish and minimized tetany (immobilization) of juvenile salmonids. The setting that best met these criteria was 30 pulses/s at 100% pulse width of the low range. Beginning in December 2000, this setting was used almost exclusively with sufficient results. Output averaged 2.0-2.4 amperes (range 1.0-3.9 amperes) depending on conductivity. After consulting Smith-Root, Inc. (the manufacturer of our electrofishing equipment), we changed output settings again in March 2002 to 30 pulses/s at ≤ 50% pulse width of the low range. Output with these settings was generally less than 2.0 amperes.

Gillnetting

We employed gill nets as an alternate method of collecting resident fish to evaluate habitat associations. Gill nets were 2.4 x 45.7 m and constructed of six alternating 7.6 m panels of monofilament nylon mesh. Stretched mesh sizes were 3.2, 4.4, and 5.1 cm (two panels each) from May through September 2000 and 3.2 and 5.1 cm (three panels each) thereafter. Nets were constructed with a foam-core floating line at the top and a 3.4-kg/net sinking line at the bottom. We used 3.6-7.3 kg anchors on both ends to keep the net on the river bottom and eliminate drifting. Target effort was 40 minutes, but varied with conditions. We deployed nets close to shore at all sites, either parallel or diagonal (≤ 45°), and adjacent to a specific bank habitat type. At six sites, an additional "mid-shore" net was set parallel to, or within a structure (four sites) or, when a structure was not present (two control sites), nets were set in similar depths and away from the shoreline.

Task 3.3. Predation and Resident Fish Diets

In January 2002 we began collecting stomach samples from potential predator fish captured in the course of standardized electrofishing and gillnetting. Potential predators included those species in the region that are known to prey heavily on juvenile salmonids (northern pikeminnow, smallmouth bass, and walleye; Rieman et al. 1991) and other species known to be piscivorous (Wydoski and Whitney 1979). Only fish ≥ 250 mm fork length were classified as predators, as smaller individuals are not likely to consume large numbers of salmonids (Vigg et al. 1991). We used a modified Seaburg sampler (Seaburg 1957) to collect stomach content samples from all species except northern pikeminnow. Contents were pumped from the stomach with a strong stream of water from the Seaburg sampler and into a sieve. Fish sampled in this manner were released unharmed. Northern pikeminnow do not possess a true stomach; we sacrificed these fish and removed the entire digestive tract. All stomach samples were placed in Whirl-Pak® bags on ice and later stored in a freezer. We processed samples in the laboratory using methods described by Zimmerman (1999). All identifiable stomach contents were weighed, and we used diagnostic bones (dentaries, cleithra, pharyngeal arches) to identify prey fish to species.

Sampling Permits and Reporting Procedures

Because of potential take of federal- and state-listed salmonids, a variety of permits and reporting procedures were required to conduct sampling in the lower Willamette River. Beach seining and gillnetting activities were authorized under the 4(d) Research Limit of the Endangered Species Act. We filed an application with NMFS for 2002 work in December 2001 and received authorization for these activities on 26 April 2002 (permit number OR2002-05).

In October-November 2000, the NMFS determined that boat electrofishing is not authorized under the 4(d) Research Limit on take of listed salmonids. A Section 10(a) application for take authorization of juvenile salmonids by boat electrofishing was initiated in December 2001, and we received official authorization on 8 March 2002 (permit number 1318). No break in sampling occurred between application and approval of 4(d) and 10(a) activities. We will submit annual reports summarizing activities authorized under Sections 4(d) and 10(a) each calendar year.

An ODFW incidental take permit was also required to conduct sampling because naturally produced coho salmon in the lower Columbia River are listed as endangered by the State of Oregon. Authorization for seining, gillnetting, and boat electrofishing was received from ODFW in April 2002 (Permit 2002-INC-4).

DATA ANALYSES

We used mean catch per unit effort (CPUE) to compare relative abundance of fish among sites and habitat types. To adjust for unequal electrofishing effort expended at each site, we standardized all efforts to the overall mean of all electrofishing runs (681 s). Beach seining and gillnetting efforts were not standardized because sampling effort was relatively consistent. We compared catch rates of electrofishing with beach seining and gillnetting before and after November 2000 and March 2002 to determine if reduced electrical output affected CPUE comparisons.

To simplify analyses and presentation of results, comparisons were limited to several groupings of fish based on taxonomic, behavioral, and body size similarities (Table 6). Chinook salmon were classified as sub-yearling based on length-frequencies whenever possible. Many

Table 6. Fish species groupings used for habitat use and abundance comparisons in the lower Willamette River, May 2000 - June 2002.

Juvenile salmonids	Coho salmon	*Oncorhynchus kisutch*
	Chinook salmon	*Oncorhynchus tshawytscha*
	Steelhead	*Oncorhynchus mykiss*
	Unidentified salmonids	*Oncorhynchus* spp.
Sunfish	White crappie	*Pomoxis annularis*
	Black crappie	*Pomoxis nigromaculatus*
	Smallmouth bass (< 250 mm)	*Micropterus dolomieu*
	Largemouth bass (< 250 mm)	*Micropterus salmoides*
	Bluegill	*Lepomis macrochirus*
	Pumpkinseed	*Lepomis gibbosus*
	Yellow perch	*Perca flavescens*
Minnows	Northern pikeminnow (< 250 mm)	*Ptychocheilus oregonensis*
	Peamouth	*Mylocheilus caurinus*
Suckers	Largescale sucker	*Catostomus macrocheilus*
	Unidentified sucker	*Catostomus* spp.
Predators	Northern pikeminnow (≥ 250 mm)	*Ptychocheilus oregonensis*
	Smallmouth bass (≥ 250 mm)	*Micropterus dolomieu*
	Largemouth bass (≥ 250 mm)	*Micropterus salmoides*
	Walleye (≥ 250 mm)	*Stizostedion vitreum*

comparisons are limited to chinook salmon because coho salmon and steelhead were not collected in sufficient numbers.

We combined CPUE data for some bank habitat types (e.g. beach and rock; vegetated and non-vegetated riprap) to increase sample size and reduce comparisons. Site-specific CPUE data was pooled by habitat classification regardless of whether a nearshore structure was present. For comparisons of different nearshore structures, we limited data to sites where bank types were classified alike and used mid-shore gillnet CPUE.

Statistical differences in pooled electrofishing CPUE of the five fish groups among general and bank habitat types were evaluated on transformed [$\log_{10}$(catch+1)] catch-per-set data with Statistical Analysis System (SAS 1988; 1990). We used analysis of variance (ANOVA) followed by a Tukey's studentized range test to determine pairwise differences among three or more categories (e.g. bank treatment types); the *t*-test was used to determine differences if only two categories were present (e.g. upstream sites vs. downstream sites). Comparisons were made at both $\alpha = 0.05$ (95% confidence level) and $\alpha = 0.10$ (90% confidence level). The Pearson product moment correlation was used to determine the strength of association between catch rate and fish size. Migration rates among salmonid cohorts and section of the study area were evaluated for significant differences ($P \leq 0.05$) with ANOVA and by individual *t*-test.

Statistical tests were conducted only for select comparisons to investigate if specific observed differences were statistically significant. Detailed statistical analyses will be conducted in future years as sample sizes increase.

RESULTS

Task 1.2: Habitat Evaluation

Habitat Inventory of Study Area

The majority (59.2%) of the riverbank habitat available in the study area was classified as undeveloped, and had not been modified by an obvious bank treatment or nearshore development (Table 7; Figure 2; Appendix B). Beach was the most abundant habitat type in both the upper (above Ross Island Bridge) and lower (below Ross Island Bridge) sections of the study area, but distribution of other bank habitat types was quite different (Table 7; Figure 3). Undeveloped or "natural" bank habitat occurred throughout 81.1% of the upper section but only 32.8 % of the lower section. Riprap and unclassified fill were two and four times more abundant, respectively, in the lower section than above Ross Island Bridge. Nearshore structures were found adjacent to 18.7% of the study area shoreline. Approximately 75% of these structures were classified as allowing light and 25% limited light penetration. The record low water levels observed during year 1 were not repeated during year 2; most sampling sites during this period had consistent bank habitat types (Table 8).

Table 7. Summary of bank habitat types and nearshore structures by area in the lower Willamette River, January-August 2001.

Bank habitat and nearshore structure type	Bank habitat below Ross Island Bridge (rm 0.0-13.9) Length (m)	% of total	Bank habitat above Ross Island Bridge (rm 14.0-26.5) Length (m)	% of total	Total bank habitat (rm 0.0-26.5) Length (m)	% of total	Total nearshore structures (rm 0.0-26.5) Length (m)	% of total	Total bank habitat and nearshore structures (rm 0.0-26.5) Length (m)	% of total
Beach	13,471	29.1	21,826	38.8	35,297	34.4	0	0.0	35,297	29.0
Rock outcrop	0	0.0	14,763	26.3	14,763	14.4	0	0.0	14,763	12.1
Rock	1,687	3.7	8,974	16.0	10,661	10.4	0	0.0	10,661	8.7
Seawall	3,036	6.6	467	0.8	3,503	3.4	0	0.0	3,503	2.9
Vegetated riprap	11,358	24.5	6,773	12.0	18,131	17.7	0	0.0	18,131	14.9
Non-vegetated riprap	3,482	7.5	445	0.8	3,927	3.8	0	0.0	3,927	3.2
Bio-engineered	389	0.8	0	0.0	389	0.4	0	0.0	389	0.3
Unclassified fill	9,421	20.4	2,980	5.3	12,401	12.1	0	0.0	12,401	10.2
Pilings-allowing light[a]	1,315	2.8	0	0.0	1,315	1.3	6,793	35.0	8,108	6.6
Pilings-limiting light[a]	2,127	4.6	0	0.0	2,127	2.1	2,734	14.1	4,861	4.0
Floating-allowing light	0	0.0	0	0.0	0	0.0	7,659	39.5	7,659	6.3
Floating- limiting light	0	0.0	0	0.0	0	0.0	2,202	11.4	2,202	1.8
Total	46,286	100	56,228	100	102,514	100	19,388	100	121,902	100

[a] Classified as bank habitat instead of a nearshore structure type when highly incorporated into the bank and no separate bank habitat classification could be determined.

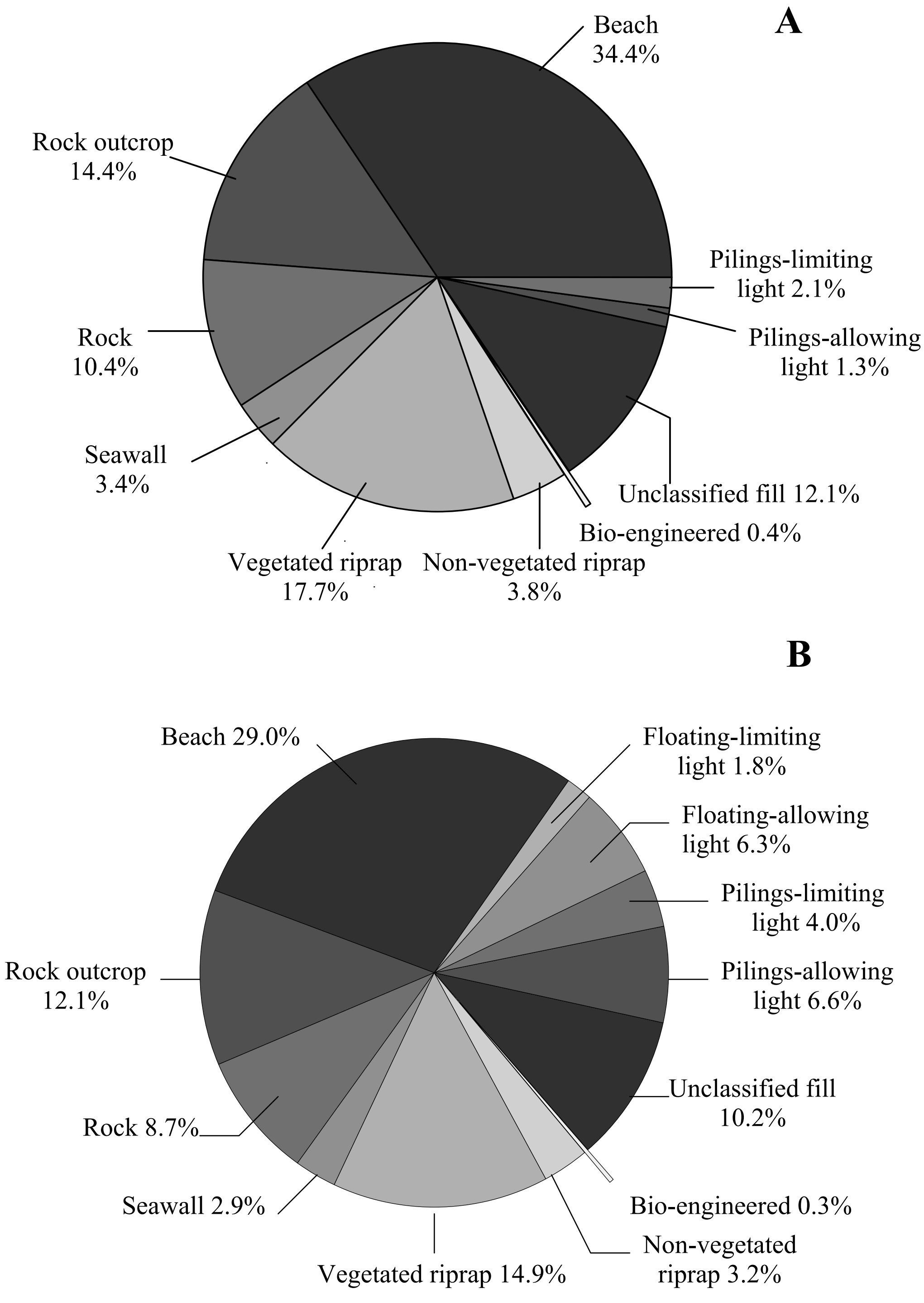

Figure 2. Percent of available A) bank habitat types and B) bank habitat and nearshore structure types in the lower Willamette River, January-August 2001. Piling structures in chart A were classified as bank habitat instead of a nearshore structure type because they were highly incorporated into the bank and no seperate bank habitat classification could be determined.

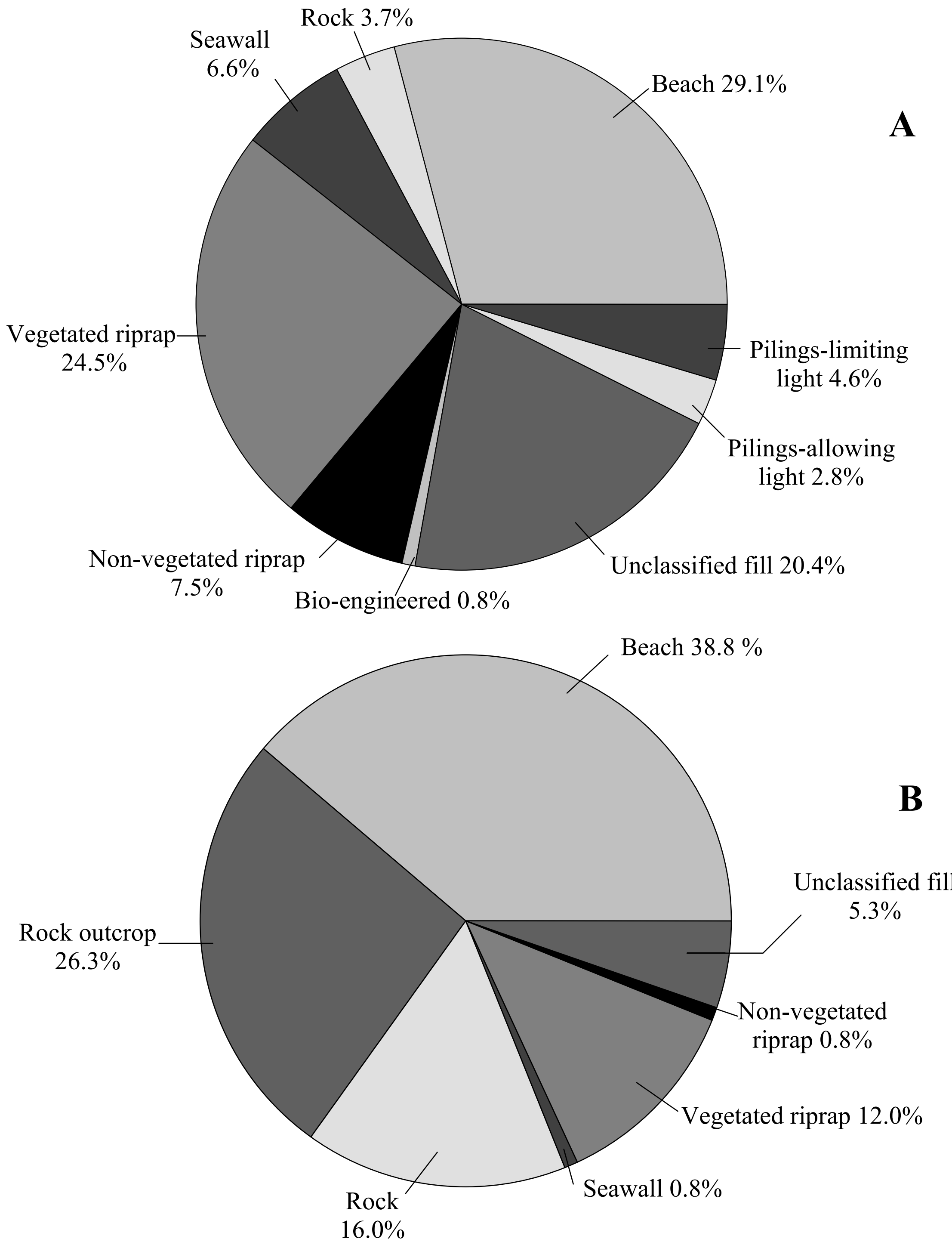

Figure 3. Percent of available bank habitat types A) below and B) above Ross Island Bridge in the lower Willamette River, January-August 2001. Piling structures were classified as bank habitat instead of a nearshore structure type when highly incorporated into the bank and no seperate bank habitat classification could be determined.

Table 8. Bank substrate of sampling sites in the lower Willamette River by season and year, July 2001 through June 2002. Classifications are based on a minimum of 80% similar substrate existing within -3' of the sampling period mean river stage (MRS).

	Sampling season and mean river stage			
	Summer 2001	Autumn 2001	Winter 2002	Spring 2002
Site	MRS 2.2	MRS 4.3	MRS 5.4	MRS 7.6
006E	Beach	Beach	Beach	Beach
010E	Beach	Beach	Beach	Beach
012W	Beach	Riprap	Riprap	Riprap
048E	Seawall	Seawall	Seawall	Seawall
051E	Beach	Mixed	Riprap	Riprap
064W	Beach	Mixed	Mixed	Riprap
079W	Beach	Mixed	Riprap	Riprap
100W[a]	Riprap	Riprap	Riprap	Riprap
116E	Riprap	Riprap	Riprap	Riprap
121W	Seawall	Seawall	Seawall	Seawall
133W	Beach	Beach	Mixed	Mixed
136E	Mixed	Riprap	Riprap	Riprap
148E	Beach	Beach	Beach	Beach
167W	Beach	Beach	Beach	Beach
200E	Rock outcrop	Rock outcrop	Rock outcrop	Rock outcrop
203W[b]	Mixed	Mixed	Mixed	Mixed
219W	Rock outcrop	Rock outcrop	Rock outcrop	Rock outcrop

[a] Site classified as riprap although bank substrate was not positively identified below MRS 3.0.

[b] No predominant bank substrate existed at any river stage.

Habitat Characteristics of Sampling Sites

We found substantial differences in mean values of some habitat parameters among sampling sites, but confounding factors may affect these results (e.g. tidal effect on velocity). Other parameters including temperature, dissolved oxygen, and conductivity were very similar at all sites, suggesting nearly-complete mixing of the water column. A detailed summary of habitat characteristics at each sampling site is provided in Appendix B.

Task 2.1: Juvenile Salmonid Radio Telemetry

Tagging summary

In year 2, we released a total of 51 radio tagged juvenile salmonids from 31 May to 22 June, 2002 (Table 9). These included 20 coho salmon, 14 yearling chinook salmon, 11 steelhead, and 6 sub-yearling chinook salmon. We released 31 unmarked fish and 20 fish of hatchery origin (Table 10). Mean fork length of radio tagged fish ranged from 115 mm (sub-yearling chinook salmon) to 172 mm (yearling chinook salmon). Individual fish weights ranged from a 15 g sub-yearling chinook salmon to a 77 g yearling chinook salmon.

Through June 2002 (years 1 and 2 combined), we released a total of 117 radio tagged juvenile salmonids, including 32 yearling chinook salmon, 20 sub-yearling chinook salmon, 38 coho salmon, and 27 steelhead (Table 9). Slightly more than half (56%) of these were of hatchery origin; the remainder were unmarked, naturally produced fish (Table 11). The mean fork length of all radio tagged fish through year 2 ranged from 114 mm (sub-yearling chinook salmon) to 190 mm (steelhead). Individual fish weights ranged from a 13 g sub-yearling chinook salmon to a 97 g steelhead.

Recovery of Tagged Fish

The amount of tracking time in year 2 was similar to the previous year's effort; 150 hours of on-the-water mobile tracking effort (63% offshore and 37% nearshore) was expended in 2002 compared to 169 hours in 2001. Fewer fish were tagged and relocated in year 2; 38 of the 51 juvenile salmonids (75%) released were relocated compared to 57 of the 66 fish (86%) tagged in year 1. We recorded 129 independent recoveries in year 2 with an average of 3.4 relocations per tagged fish (Table 12). Species-specific recovery rates were 90% for coho salmon, 79% for yearling chinook salmon, 67% for sub-yearling chinook salmon, and 45% for steelhead; recovery rates were lower than in year 1 for all salmonid groups except coho salmon. As a result of interference and operational difficulties with the Lotek receivers, the year 2 fixed site data were not incorporated into the analysis or report. We are consulting with Lotek Engineering technical support to determine if useable data can be recovered.

Migration Rates

Migration rates varied among juvenile salmonid groups with sub-yearling chinook salmon exhibiting the fastest migration rate (8.62 km/d), followed by yearling chinook salmon (6.16 km/d), coho salmon (5.26 km/d), and steelhead (2.69 km/d) (Table 12). All cohorts except

Table 9. Summary of releases of radio tagged juvenile salmonids in the lower Willamette River, May-June 2002.

Release information		Species[a], number released				
Date	Location (rm;rkm)	CHS	CHY	STH	COH	Total
May 31	24.6; 39.6	3	4	0	0	7
June 7-8	24.6; 39.6	1	1	3	16	21
June 10-11	24.6; 39.6	1	4	8	4	17
June 21-22	20.2; 32.5	1	5	0	0	6
2002 Total		6	14	11	20	51
2001 Total		14	18	16	18	66
Grand Total		20	32	27	38	117

[a] CHS (sub-yearling chinook); CHY (yearling chinook); STH (yearling steelhead); and COH (yearling coho).

Table 10. Lengths and weights of radio tagged juvenile salmonids (hatchery and unmarked) in the lower Willamette River, May-June 2002.

		Fork length (mm)			Weight (g)		
Species[a]	N	Min	Max	Mean	Min	Max	Mean
Chinook yearling (all)	14	116	186	147	20	77	37
Chinook yearling (W)	9	116	166	133	20	51	27
Chinook yearling (H)	5	147	186	172	27	77	56
Chinook sub-yearling (all)	6	112	117	115	15	17	16
Chinook sub-yearling (W)	6	112	117	115	15	17	16
Chinook sub-yearling (H)	0	0	0	0	0	0	0
Coho yearling (all)	20	112	161	136	17	48	28
Coho yearling (W)	15	112	152	131	17	31	24
Coho yearling (H)	5	140	161	153	43	48	39
Steelhead yearling (all)	11	120	193	165	17	68	43
Steelhead yearling (W)	1	156	156	156	33	33	33
Steelhead yearling (H)	10	120	193	166	17	68	44

[a] W=unmarked; H=hatchery

Table 11. Lengths and weights of juvenile salmonids (hatchery and unmarked) fitted with radio transmitters in the lower Willamette River through June 2002.

		Fork length (mm)			Weight (g)		
Species[a]	N	Min	Max	Mean	Min	Max	Mean
Chinook yearling (all)	32	116	186	143	19	77	30
Chinook yearling (W)	10	116	166	132	19	51	26
Chinook yearling (H)	22	130	186	148	20	77	32
Chinook sub-yearling (all)	20	108	118	114	13	17	15
Chinook sub-yearling (W)	19	108	118	114	13	17	15
Chinook sub-yearling (H)	1	118	118	118	17	17	17
Coho yearling (all)	38	112	161	139	17	48	28
Coho yearling (W)	16	112	152	130	17	31	24
Coho yearling (H)	22	132	161	146	21	48	31
Steelhead yearling (all)	27	120	227	187	17	97	60
Steelhead yearling (W)	6	156	215	178	33	85	51
Steelhead yearling (H)	21	157	227	190	17	97	62

[a] W=unmarked; H=hatchery

Table 12. Summary of migration parameters for radio tagged juvenile salmonids in the lower Willamette River, May - June 2002. Mean d = mean number of days present in the study area, extrapolated from migration rate data.

Species	N	Number relocations	Mean fork length (mm)	Mean weight (g)	Mean km/d	Range km	Mean d
Mouth to Willamette Falls (river kilometer 0.0-42.6)							
Chinook sub-yearling	4	13	115	16	8.62	0.12-18.07	4.9
Chinook yearling[a]	11	37	139	30	6.16	0.01-32.03	6.9
Coho yearling[a]	18	65	137	28	5.26	0.06-25.25	7.6
Steelhead yearling[a]	5	14	167	43	2.69	0.03-9.85	15.8
Mouth to Ross Island (river kilometer 0.0-22.5)							
Chinook sub-yearling	2	7	114	16	5.88	0.19-15.72	7.3
Chinook yearling[ab]	5	13	136	29	7.12	0.01-0.65	6.0
Coho yearling	11	20	139	29	5.82	0.06-25.25	7.3
Steelhead yearling	1	3	157	36	4.29	0.83-9.78	9.9
Ross Island to Willamette Falls (river kilometer 22.6-42.6)							
Chinook sub-yearling	3	6	116	16	11.83	0.86-29.07	3.6
Chinook yearling[a]	11	24	139	30	5.63	0.15-32.03	7.6
Coho yearling[a]	17	45	137	28	5.01	0.28-15.03	8.5
Steelhead yearling[a]	4	10	170	45	2.21	0.19-9.85	19.3

[a]Fish with zero or negative migration rates were not included in mean km/d, range km, mean d, or range d columns

[b]Includes one fish relocated in Multnomah Channel

sub-yearling chinook salmon exhibited slower mean migration rates in year 2 than were observed in year 1 (Table 13). Yearling coho salmon and steelhead displayed the largest difference in migration rates between years (>8.5 d). Mean duration of residency within the study area based on extrapolated migration rates was also dissimilar between years. In year 1, mean residence times ranged from 2.7 d (steelhead) to 5.9 d (sub-yearling chinook). In year 2, sub-yearling chinook displayed the shortest mean residence time (4.9 d); steelhead displayed the longest (15.8 d). Migration rates tended to increase with increasing fork length in year 1 (R^2 = 0.08), but decreased with increasing fork length in year 2 (R^2 = 0.17; Figure 4).

Migration rates differed between upper (above Ross Island Bridge) and lower (Below Ross Island Bridge) sections of the study area (Table 12). As in year 1, all salmonid groups in year 2 (except sub-yearling chinook salmon) exhibited a tendency to migrate faster in the lower section of the study area, but these differences were not statistically significant ($P > 0.05$).

Habitat Association

Group-specific relocation of juvenile salmonids by river width and section indicated no distinct pattern of distribution across the water column (Figures 5 and 6). Actual percentages of relocations within the nearshore zone (10% of either shore) of the entire study area were 38% for both coho salmon and steelhead, 25% for sub-yearling chinook salmon, and 19% for yearling chinook salmon. In contrast to year 1 radio telemetry, when chinook salmon were more likely to be found close to shore, year 2 data indicated coho salmon and steelhead were more likely to be found in nearshore areas. In the lower section of the study area (below Ross Island Bridge), 37% of all salmonids were relocated in the nearshore area, compared to 30% in the upper section.

Relocations of radio tagged salmonids adjacent to different bank treatments (years 1 and 2 combined) were consistent with the relative availability of each habitat type (Figure 7). Frequencies of recoveries for individual groups adjacent to each bank type varied. Relocations of all salmonid groups except coho salmon were disproportionately high adjacent to rock outcrops, which composed approximately 14% of the available bank habitat. Overall, 65.6% of relocated juvenile salmonids were associated with natural bank habitat types, which composed 59.2% of the available habitat within the study area. Yearling chinook salmon exhibited the highest frequency toward natural bank treatment types at 73.0% followed by 70.9% for sub-yearling chinook salmon, 69.3% for steelhead, and 51.8% for coho salmon. Aerial photographs of juvenile salmonid relocations and bank treatment types are presented in Appendix C.

Task 2.2. Standardized Sampling for Juvenile Salmonids

Catch and Effort

Through June 2002, we caught 2,291 juvenile salmonids in 378 beach seine efforts (6.1 fish per effort) and 7,513 juvenile salmonids in 627 electrofishing runs (12.0 fish per run). Distribution of sampling effort through June 2002 varied among sampling sites (Table 14). Beach seine sites were sampled 65-81 times each, except site 069W, which was sampled 13 times beginning in spring 2002. Electrofishing effort ranged from 12 to 37 runs at standard sampling sites, and 13-15 runs at alcove sites. In 2001, distribution of electrofishing effort

Table 13. Summary of migration parameters for radio tagged juvenile salmonids in the lower Willamette River, April - June 2001. Mean d = mean number of days present in the study area, extrapolated from migration rate data.

Species	N	Number relocations	Mean fork length(mm)	Mean weight (g)	Mean km/d	Range km	Mean d
			Mouth to Willamette Falls (river kilometer 0.0-42.6)				
Chinook sub-yearling	11	72	114	14	7.21	0.76 - 16.42	5.9
Chinook yearling	18	93	139	24	11.01	2.41 - 29.66	3.9
Coho yearling	9	44	143	24	13.83	4.73 - 23.26	3.1
Steelhead yearling	16	82	202	71	15.54	1.36 - 33.79	2.7
			Mouth to Ross Island (river kilometer 0.0-22.5)				
Chinook sub-yearling	3	6	113	15	8.64	0.35 - 14.14	4.9
Chinook yearling	12	42	140	25	11.06	3.71 - 53.06	3.9
Coho yearling	8	18	140	27	16.83	13.28 - 24.30	2.5
Steelhead yearling	13	29	202	72	20.52	9.21 - 36.86	2.1
			Ross Island to Willamette Falls (river kilometer 22.6-42.6)				
Chinook sub-yearling	10	55	114	14	7.53	0.95 - 16.42	5.7
Chinook yearling	17	42	137	24	11.00	0.29 - 30.73	3.9
Coho yearling	3	10	140	27	12.31	5.65 - 27.68	3.5
Steelhead yearling	14	40	202	72	9.03	1.36 - 22.03	4.7

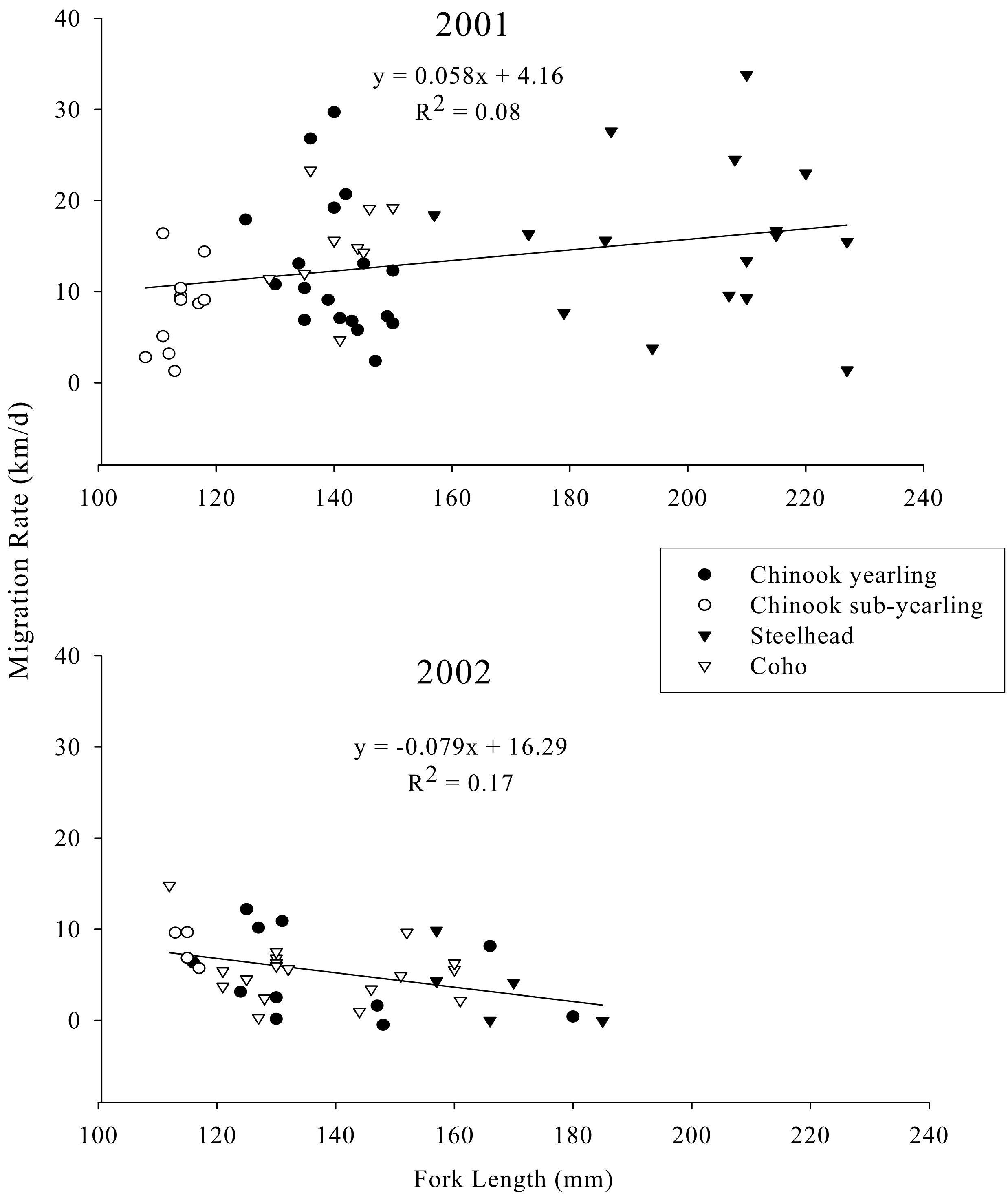

Figure 4. Mean migration rates (km/d) by fork length (mm) of juvenile salmonids in the lower Willamette River, April – June 2001 and May – June 2002.

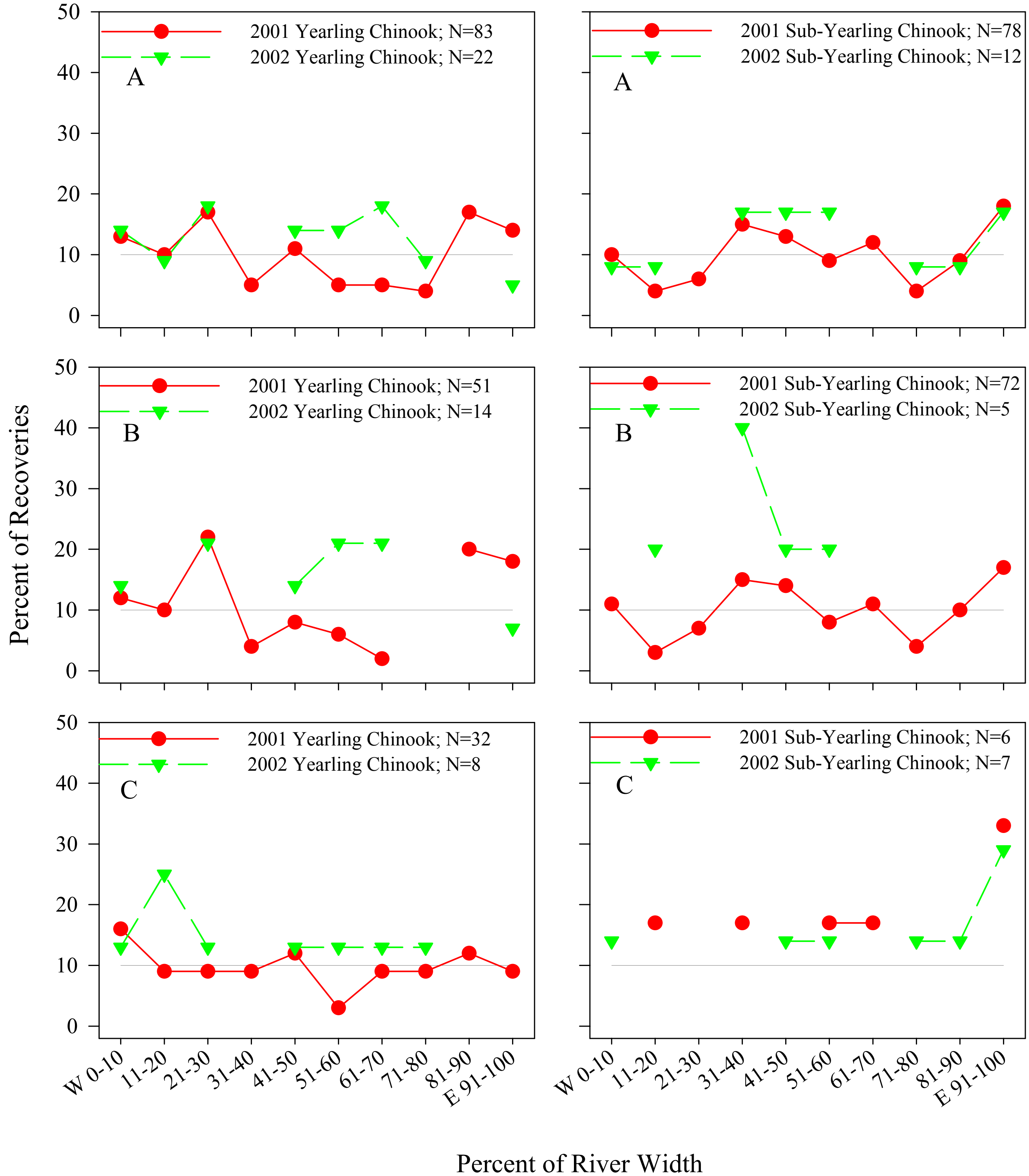

Figure 5. Frequency of recoveries of radio tagged yearling and sub-yearling chinook salmon by percent of river width for A) Willamette Falls to Columbia River, B) Willamette Falls to Ross Island Bridge, and C) Ross Island Bridge to Columbia River, May 2000-June 2002. West bank of river = 0%, east bank of river =100%.

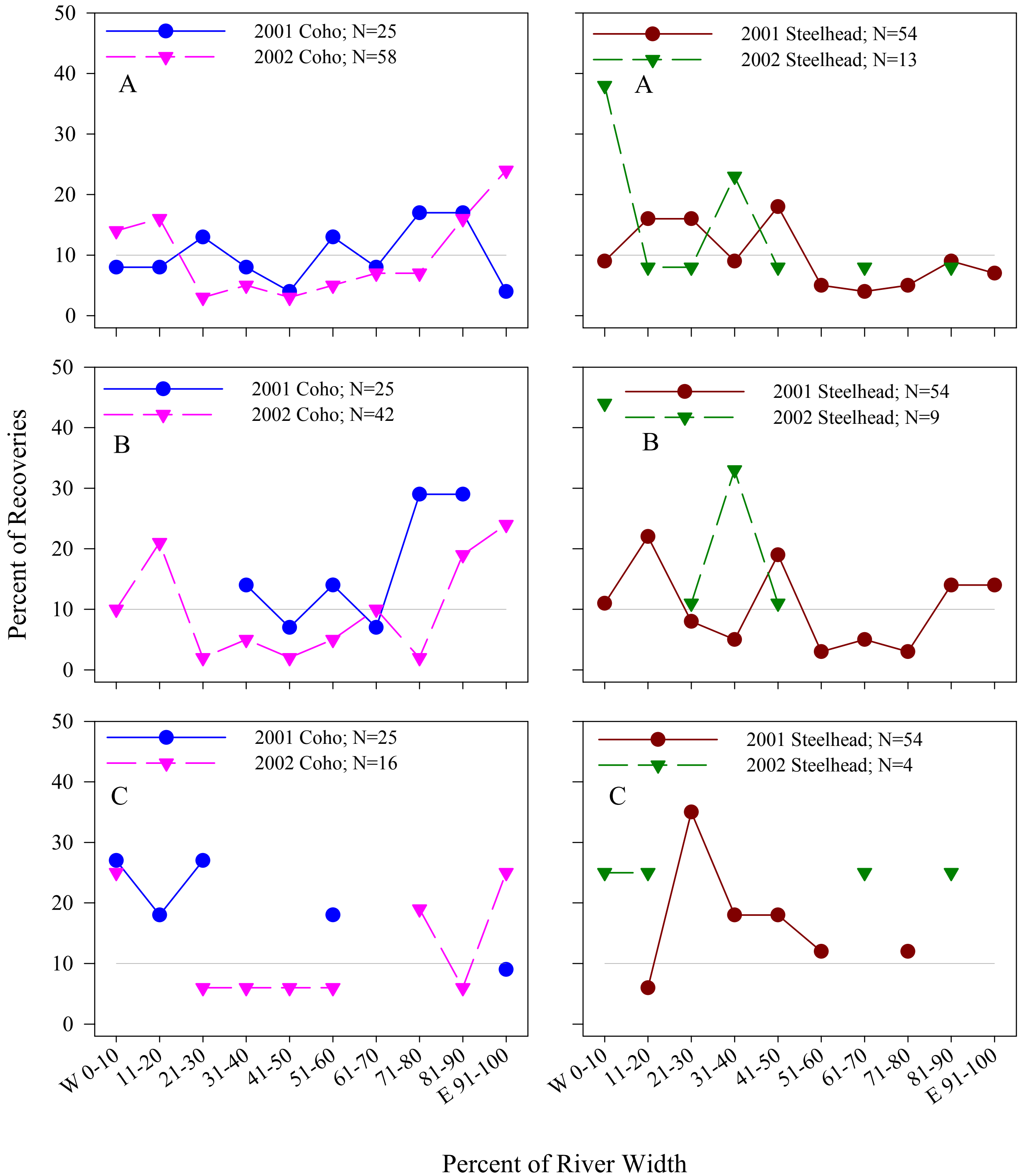

Figure 6. Frequency of recoveries of radio tagged juvenile coho salmon and steelhead by percent of river width for A) Willamette Falls to Columbia River, B) Willamette Falls to Ross Island Bridge, and C) Ross Island Bridge to Columbia River, May 2000-June 2002. West bank of river = 0%, east bank of river =100%.

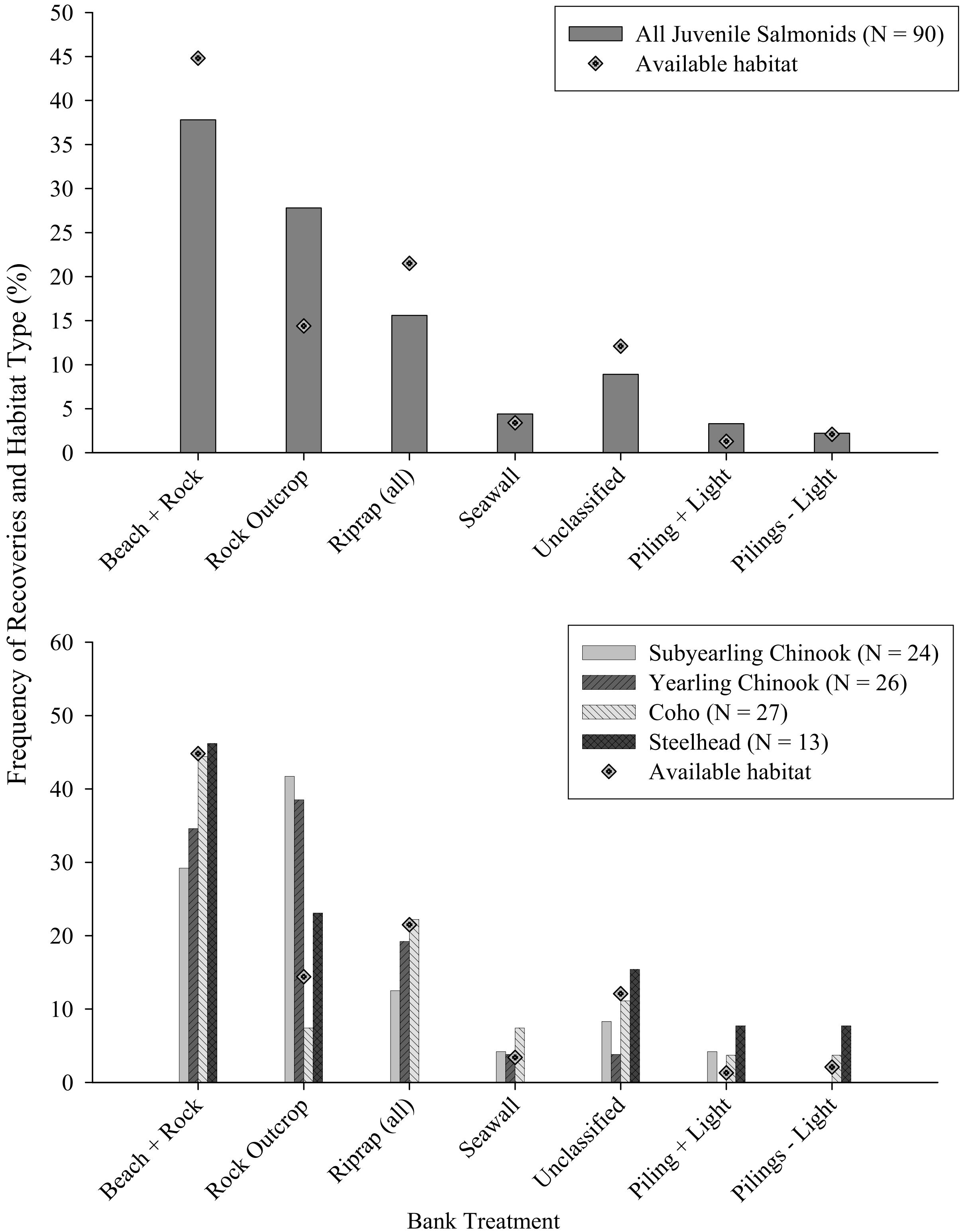

Figure 7. Relocation frequency of radio tagged juvenile salmonids by bank treatment type in the lower Willamette River, May 2000 through June 2002. Data limited to relocations in the nearshore zone equal to 10% of the river width.

Table 14. Sampling effort by gear type and sample site in the lower Willamette River, May 2000 through June 2002.

Sampling sites	Beach Seining	Gillnetting	Electrofishing	
	N (sets)	N (sets)	N (runs)	Mean; range (s)
006E	72	31	34	752; 505-902
010E[a]	--	58	36	771; 341-914
012W	--	29	32	619; 296-900
040W	70	--	--	--
048E[a]	--	31	37	675; 407-902
051E[a]	--	56	35	730; 295-914
064W[a]	--	61	36	801; 231-920
069W	13	--	--	--
079W[a]	--	61	37	604; 208-903
097E	65	--	--	--
100W[a]	--	43	18	296; 81-755
116E	--	8	12	651; 352-777
121W	--	30	35	823; 611-904
133W	--	23	26	474; 270-866
136E[a]	--	57	34	544; 267-902
148E	--	31	33	833; 750-901
167W	81	32	36	793; 271-900
200E	--	31	33	705; 394-925
203W[a]	--	30	33	577; 342-905
219W	--	30	36	712; 333-914
243W	76	--	--	--
Alcoves:				
067EA	--	--	14	700; 461-900
076WA	--	--	15	641; 474-761
107WA	--	--	14	609; 319-764
148WA	--	--	15	407; 145-789
232WA	--	--	15	761; 700-902
239EA	--	--	13	761; 703-901

[a] Includes near shore and mid-shore gill net efforts

among months was unequal; no sampling occurred in April, July, or October. For both beach seining and electrofishing, effort was lowest during autumn (Table 15).

Seasonal Catch Rates and Abundance

Catch rates (CPUE) of juvenile salmonids varied considerably among years, months, and gears (Figure 8). In year 1, we observed peak electrofishing CPUE in November and December. Catch rates in year 2 increased monthly from December to March, peaked in April (64.9 fish/effort), and declined rapidly in May. Unidentified salmonids and chinook salmon composed the majority of salmonids captured by electrofishing. Field observations and beach seining results indicated most unidentified salmonids were probably chinook salmon. Hatchery chinook salmon were generally captured at a higher rate than unmarked chinook salmon, and were present almost every month we conducted electrofishing (Figure 9).

Beach seining catch rates in year 2 were similar to those observed in year 1 (Figure 8). Catches increased monthly beginning in December, and peaked in April (18.5 fish/effort) and May (18.8 fish/effort). June CPUE was less than half of May CPUE, and catch rates declined to near zero in summer and autumn months (we did not conduct sampling in July, August, October, or November of year 2). Most salmonids captured by beach seining were chinook salmon. Unmarked sub-yearling fish composed the largest component of the chinook salmon catch in year 2 (Figure 9), except in April, when hatchery fish and unmarked sub-yearling fish had similar catch rates. Beach seining catch rates for year 2 were highest at sites 006E and 069W in the lower portion of the study area (Table 16).

Cumulatively (year 1 and year 2 combined), CPUE of chinook salmon captured by beach seining was highest in May (Figure 9). Catch rates of hatchery fish were highest in April; catch rates of unmarked fish peaked in May. Total beach seine catches were higher during year 2 than year 1 at all sampling sites, and catch rates varied considerably among sites (Tables 16 and 17).

Fork Length and Length Frequencies

Season-specific length frequencies (electrofishing and beach seining data; both years combined) indicate multiple age classes of unmarked juvenile salmonids are present in the lower Willamette River during winter (January-March) and spring (April-June) (Figure 10). Mean fork length of unmarked chinook salmon was progressively greater from spring through autumn (October-December), though sample sizes in summer (July-September) and autumn were relatively small. Monthly length frequencies of unmarked chinook salmon also indicated the presence of several size classes through May, and the smallest group of fish had progressively greater fork lengths from January through May (Figure 11). In addition, the mean fork length of all unmarked juvenile chinook salmon increased from May through December.

Sample sizes for juvenile hatchery chinook salmon fork lengths were largest during winter and spring, and consisted of one relatively uniform size class (Figure 12). Mean fork length of hatchery fish varied only slightly from February through April, and sample sizes were very small during May-September and December-January (Figure 13). Almost all of the 213 hatchery chinook salmon observed in November were captured during 2001.

Table 15. Monthly effort by gear type and sample site in the lower Willamette River, May 2000 through June 2002.

Season; month	Beach Seining (sets)	Electrofishing (runs)	Gillnetting (sets)
Winter			
January	49	46	44
February	43	90	73
March	26	55	35
Spring			
April	24	46	23
May	43	55	66
June	66	87	126
Summer			
July	28	0	0
August	41	52	69
September	16	74	82
Autumn			
October	0	0	17
November	12	73	70
December	30	49	37

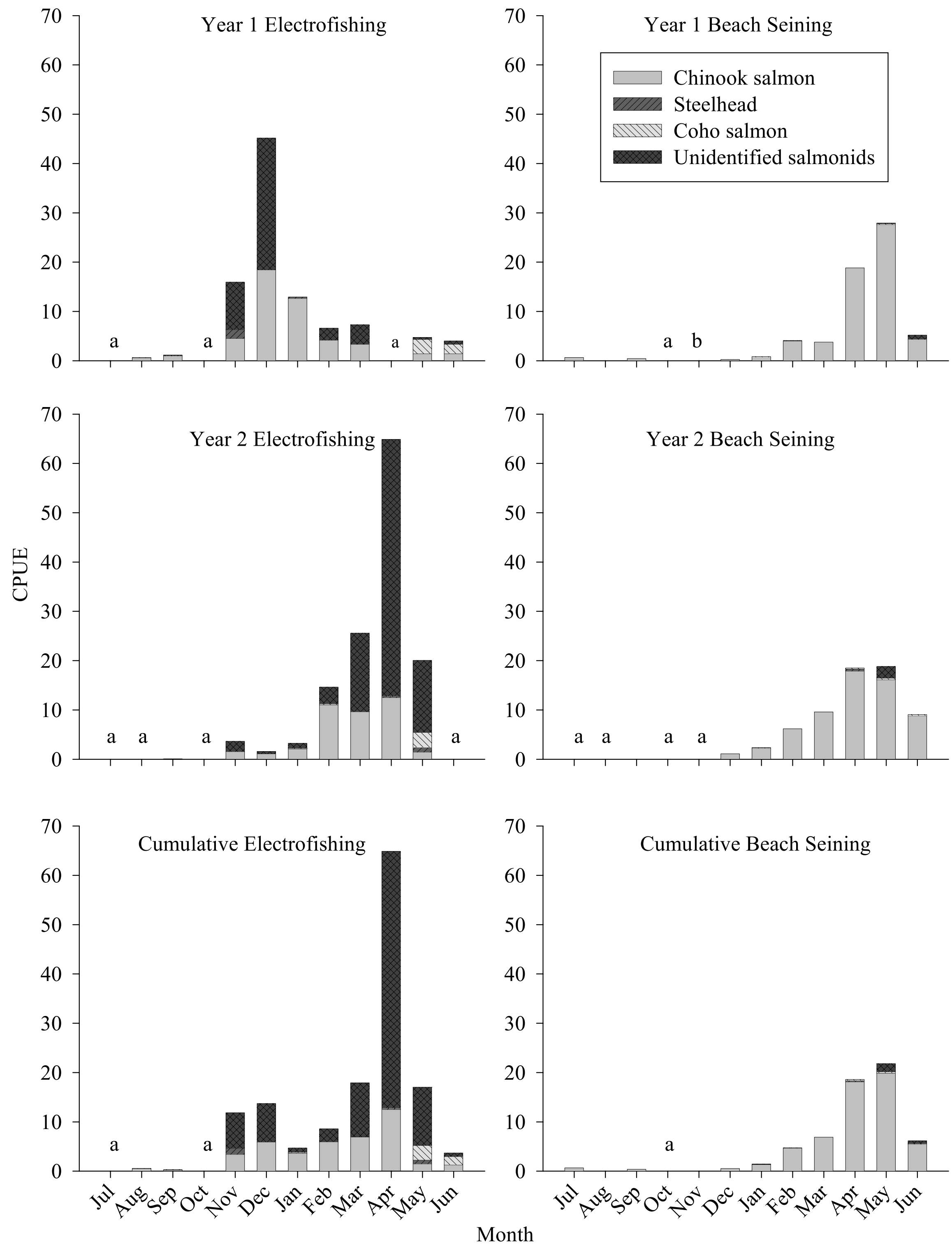

Figure 8. Monthly catch per unit-effort of juvenile salmonids captured by electrofishing and beach seining in the lower Willamette River, July 2000 – June 2001 (year 1) and July 2000 – June 2002 (year 2). a = no sampling conducted; b = three days of sampling.

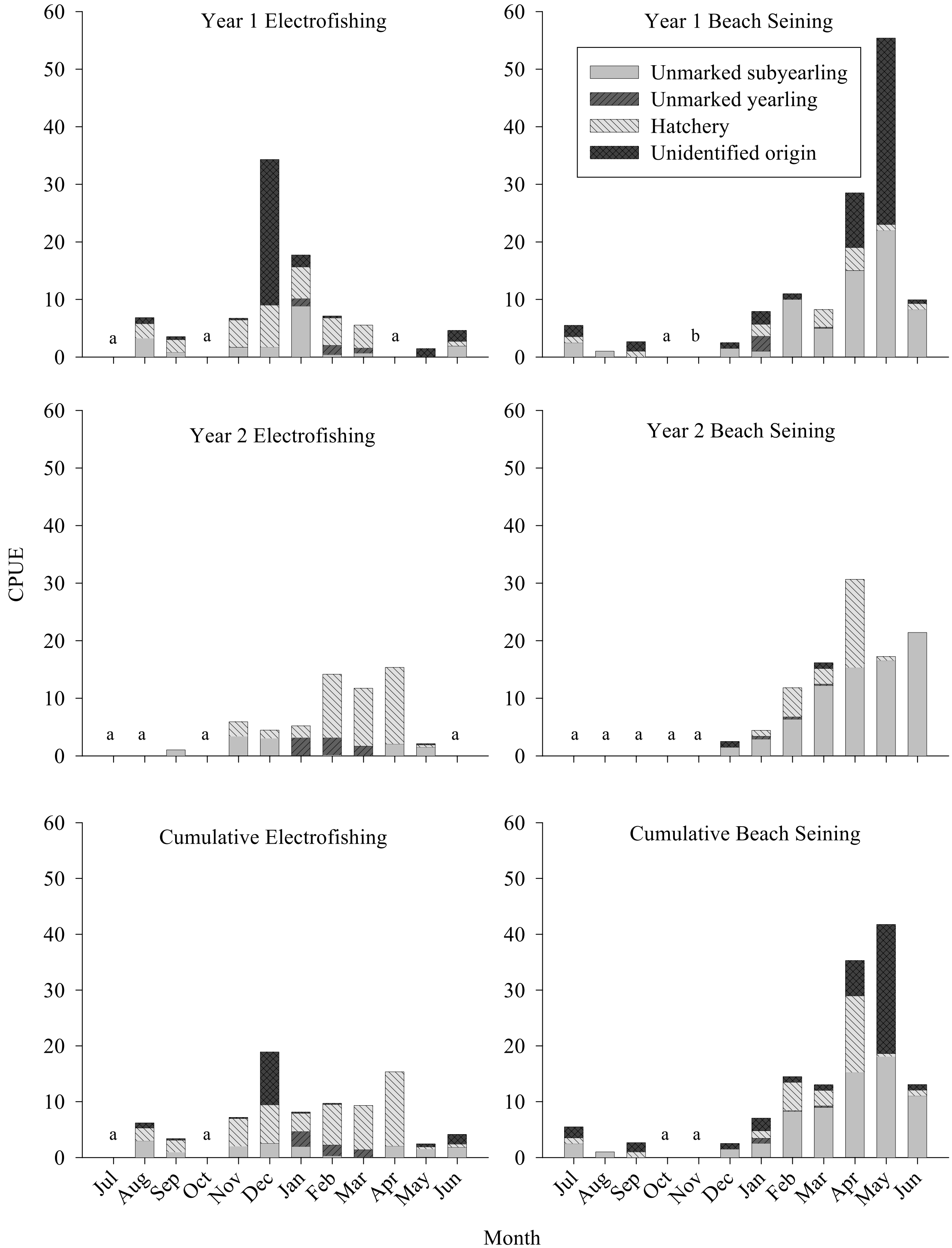

Figure 9. Monthly catch per unit-effort of juvenile chinook salmon captured by electrofishing and beach seining in the lower Willamette River, July 2000 – June 2001 (year 1) and July 2000 – June 2002 (year 2). a = no sampling conducted; b = three days of sampling.

Table 16. Mean beach seining catch rate of juvenile salmonids at sampling sites in the lower Willamette River, July 2001 - June 2002.

Site	Chinook salmon	Coho salmon	Steelhead	Unidentified salmonids	Total
006E	14.54	0.04	0.04	0.67	15.29
040W	5.13	0.13	0.00	0.04	5.29
069W	14.08	0.00	0.08	0.00	14.15
097E	7.20	0.00	0.00	0.07	7.27
167W	11.25	0.25	0.29	0.67	12.46
243W	8.24	0.24	0.10	1.71	10.29

Table 17. Mean beach seining catch rate of juvenile salmonids at sampling sites in the lower Willamette River, May 2000 - June 2002.

Site	Chinook salmon	Coho salmon	Steelhead	Unidentified salmonids	Total
006E	5.42	0.03	0.01	0.44	5.90
040W	2.39	0.04	0.00	0.01	2.44
069W	14.08	0.00	0.08	0.00	14.15
097E	2.63	0.00	0.00	0.05	2.68
167W	8.36	0.12	0.09	0.54	9.11
243W	7.29	0.08	0.03	0.49	7.88

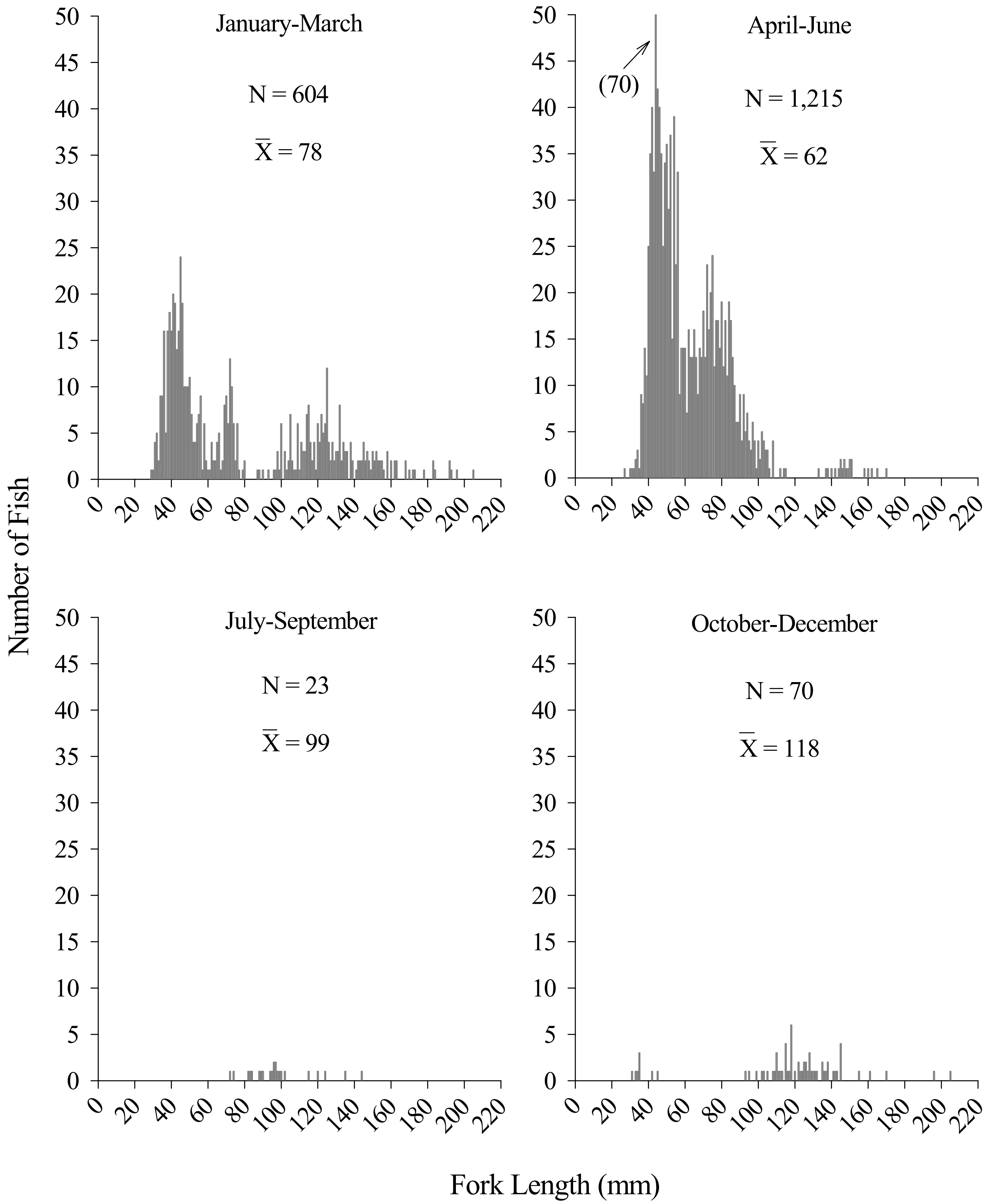

Figure 10. Seasonal length-frequency distributions of unmarked juvenile chinook salmon collected in the lower Willamette River, May 2000 – June 2002. Beach seining was not conducted in October and electrofishing was not conducted in July or August.

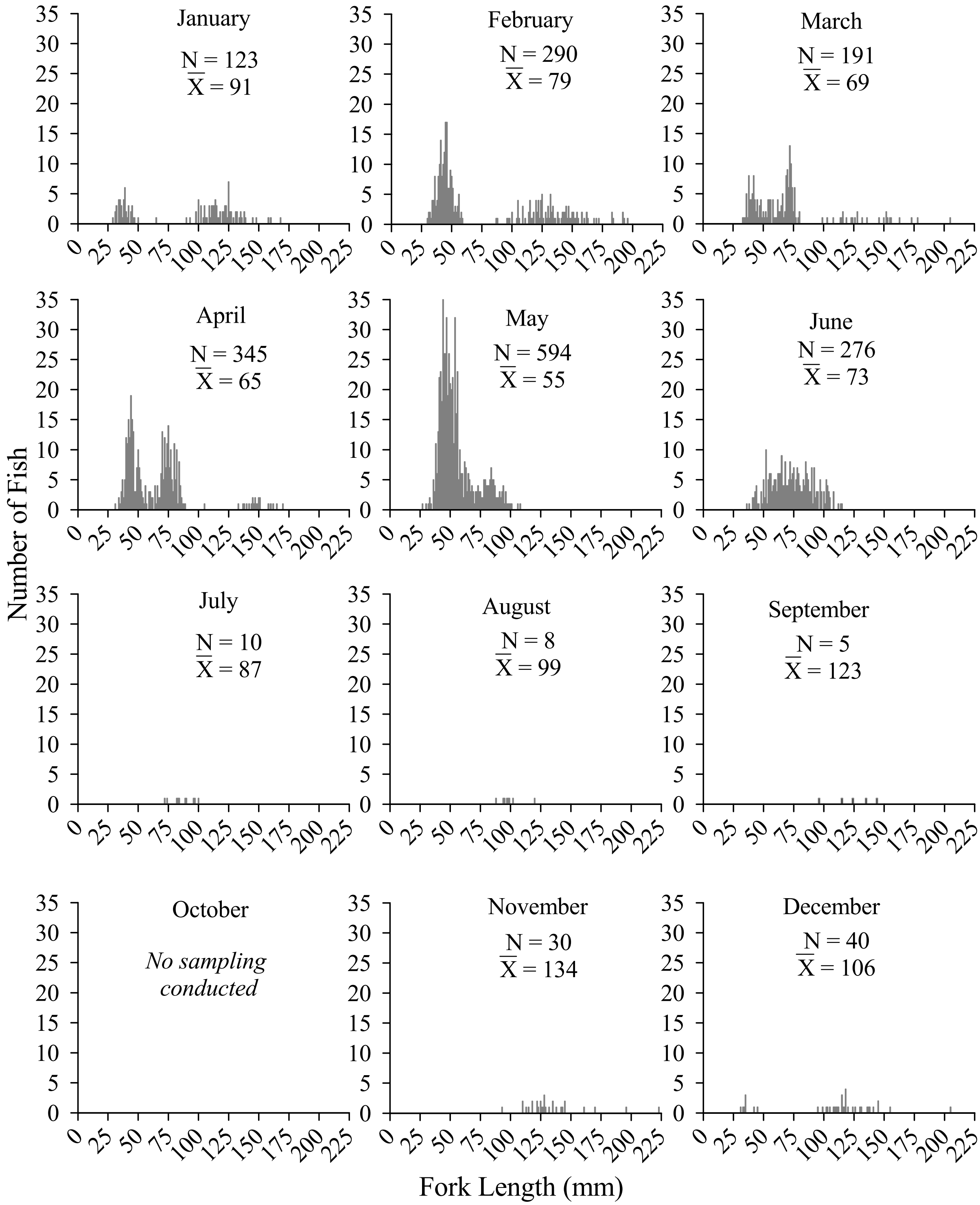

Figure 11. Monthly length-frequency distributions of unmarked juvenile chinook salmon collected in the lower Willamette River, May 2000 – June 2002.

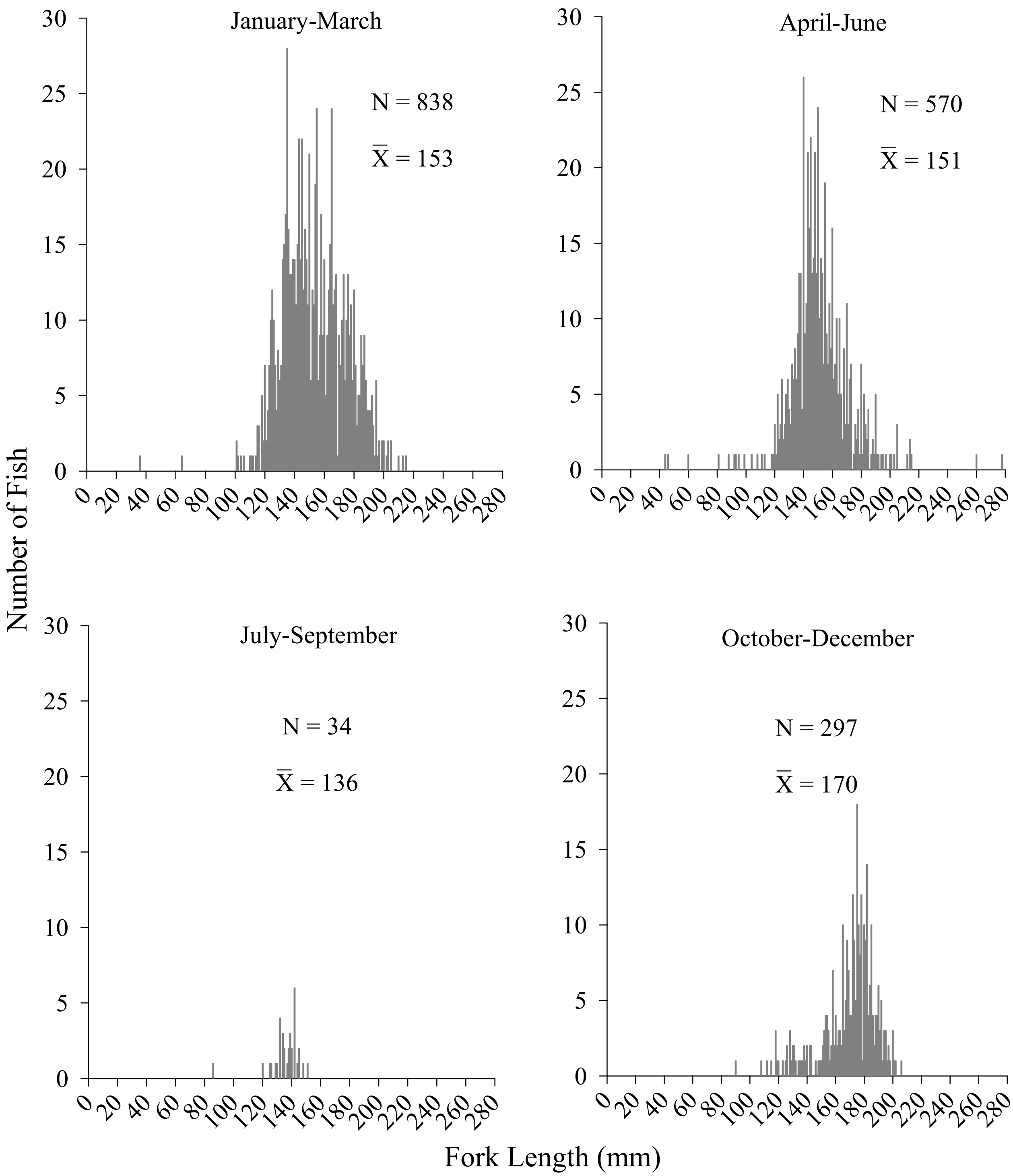

Figure 12. Seasonal length-frequency distributions for hatchery juvenile chinook salmon collected in the lower Willamette River, May 2000 – June 2002.

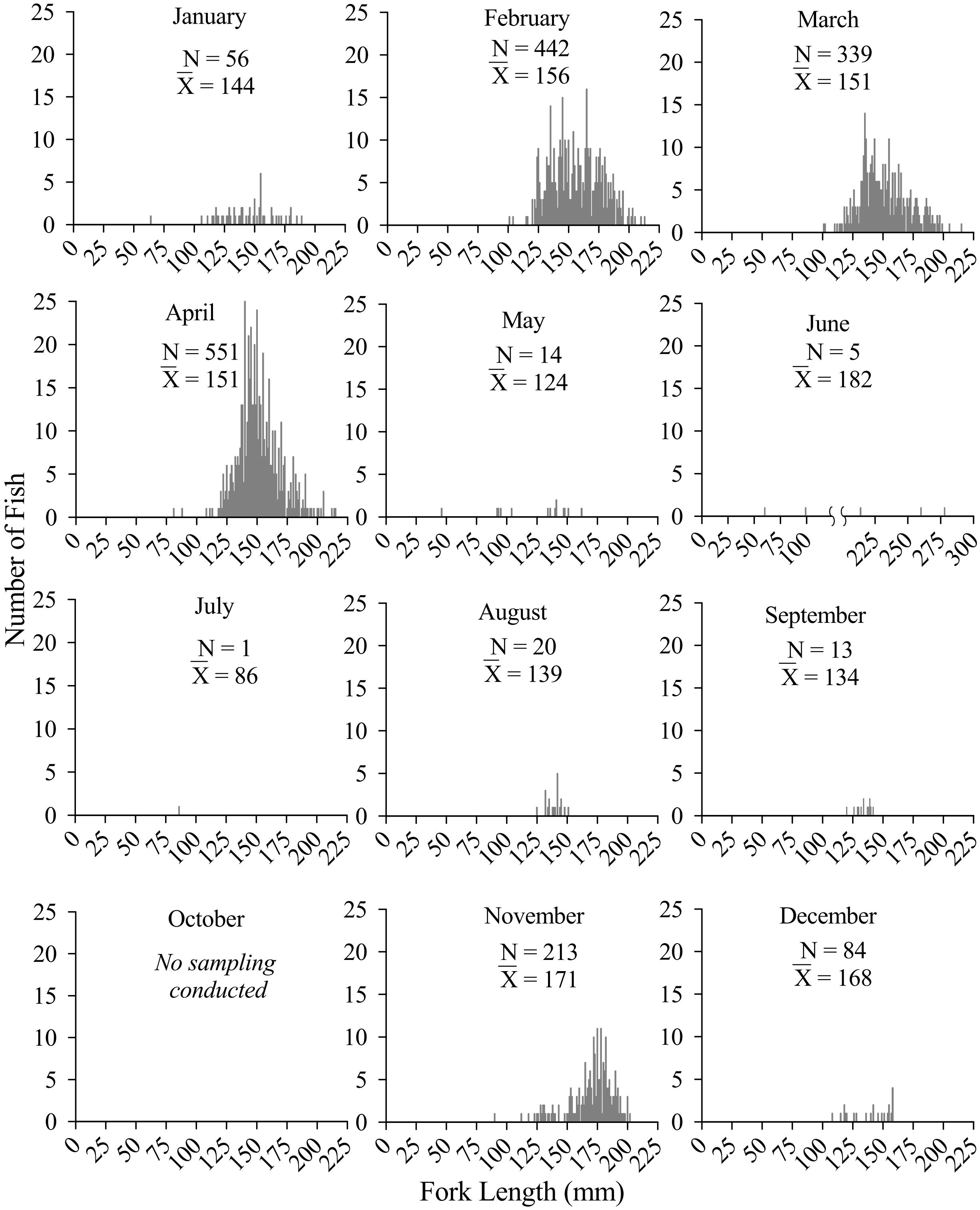

Figure 13. Monthly length-frequency distributions for hatchery juvenile chinook salmon collected in the lower Willamette River, May 2000 – June 2002.

All fork length data we examined approximated normal distributions. Analysis of variance identified many significant differences ($P < 0.05$) in chinook salmon fork lengths among both seasons and years (Figure 14). For example, mean fork length of unmarked chinook salmon in 2000 differed significantly from mean fork length in both 2001 and 2002. Mean fork length of hatchery chinook salmon was not significantly different between winter and spring; this was the only comparison that was not statistically significant. Fork length sample sizes were somewhat disparate among years and seasons.

Through June 2002, we collected a total of 2,895 paired lengths and weights from juvenile salmonids. Length-weight equations for all species are provided in Table 18.

Rearing Potential

Mean fork length of sub-yearling juvenile chinook salmon (< 90 mm FL) was significantly different among lower and upper beach seining sites in February ($P < 0.01$), April ($P < 0.01$), May ($P < 0.01$), and June ($P < 0.01$) (Figure 15). Mean fork length was greater at upper sites than at lower sites for February, May, and June. We observed no significant differences in mean fork length among seasons.

Gear Efficiencies and Selectivity

Changes in electrofisher settings during November 2000 and March 2002 did not appear to affect catch rates of juvenile salmonids (Figure 16). We observed very few mortalities and a low incidence of injury among juvenile salmonids after lowering output to $\leq$ 50% of the low range (30 volts DC) in March 2002. Electrofishing consistently captured larger chinook salmon than beach seining, and trends in fork length over time were similar among gear types (Figure 17). Mean monthly electrofishing CPUE of juvenile chinook salmon increased significantly ($R^2 = 0.561$, $P = 0.02$) with increasing fork length, whereas beach seining catch rate was negatively correlated ($R^2 = -0.556$, $P = 0.01$) with fork length (Figure 18).

Habitat Use

Juvenile salmonid electrofishing CPUE varied greatly among species and sample sites in year 2 (Table 19). The catch rate for all juvenile salmonid species except coho salmon was highest at site 136E; the highest coho salmon catch rate occurred at site 167W. Chinook salmon were by far the most abundant juvenile salmonid species collected at standard sampling sites followed by steelhead and coho salmon. Among standard sites, the highest catch rates for all species generally occurred between rm 13.3 (rkm 21.4) and rm 16.7 (rkm 26.9) in the middle portion of the study area. Alcove sites had a higher mean catch rate (20.2 fish/effort) than standard sampling sites (16.8 fish/effort). Upper river alcove sites (148WA – 239EA), had considerably higher catch rates than lower river alcove sites (067EA – 107WA).

Mean electrofishing catch rates of juvenile salmonids for both years combined were similar to year 2 results (Table 20). As in year 1, CPUE of chinook salmon, steelhead, and unidentified salmonids was highest at sites 133W and 167W. The highest coho salmon catch rates occurred at sites 200E and 219W. In general, catch rates of all species were highest

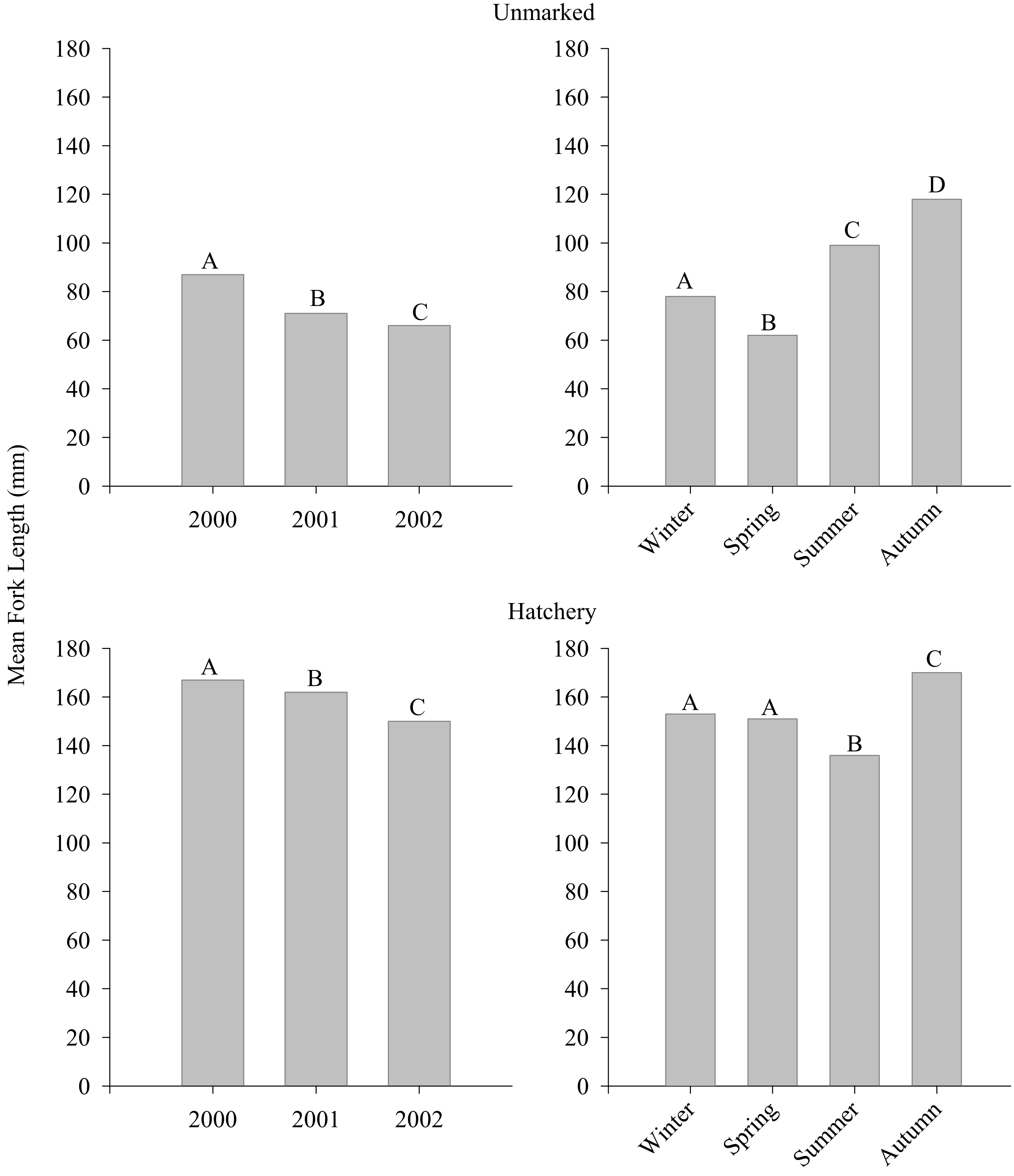

Figure 14. Annual and seasonal mean fork length of unmarked and hatchery chinook salmon collected in the lower Willamette River, May 2000 – June 2002. Within each graph, bars without a letter in common differed significantly ($P<0.05$).

Table 18. Length-weight relationships of juvenile salmonids collected by electrofishing and beach seining in the lower Willamette River, May 2000 - June 2002.

Species	Length-weight equation	r^2	N
Chinook salmon (unmarked)	$W= 8.99x10^{-5} FL^{2.51}$	0.81	1036
Chinook salmon (hatchery)	$W= 1.26x10^{-5} FL^{2.96}$	0.73	1537
Coho salmon (unmarked)	$W= 1.87x10^{-5} FL^{2.88}$	0.93	67
Coho salmon (hatchery)	$W= 4.44x10^{-5} FL^{2.70}$	0.57	131
Steelhead (unmarked)	$W= 8.70x10^{-6} FL^{3.04}$	0.99	11
Steelhead (hatchery)	$W= 8.00x10^{-5} FL^{2.60}$	0.79	113

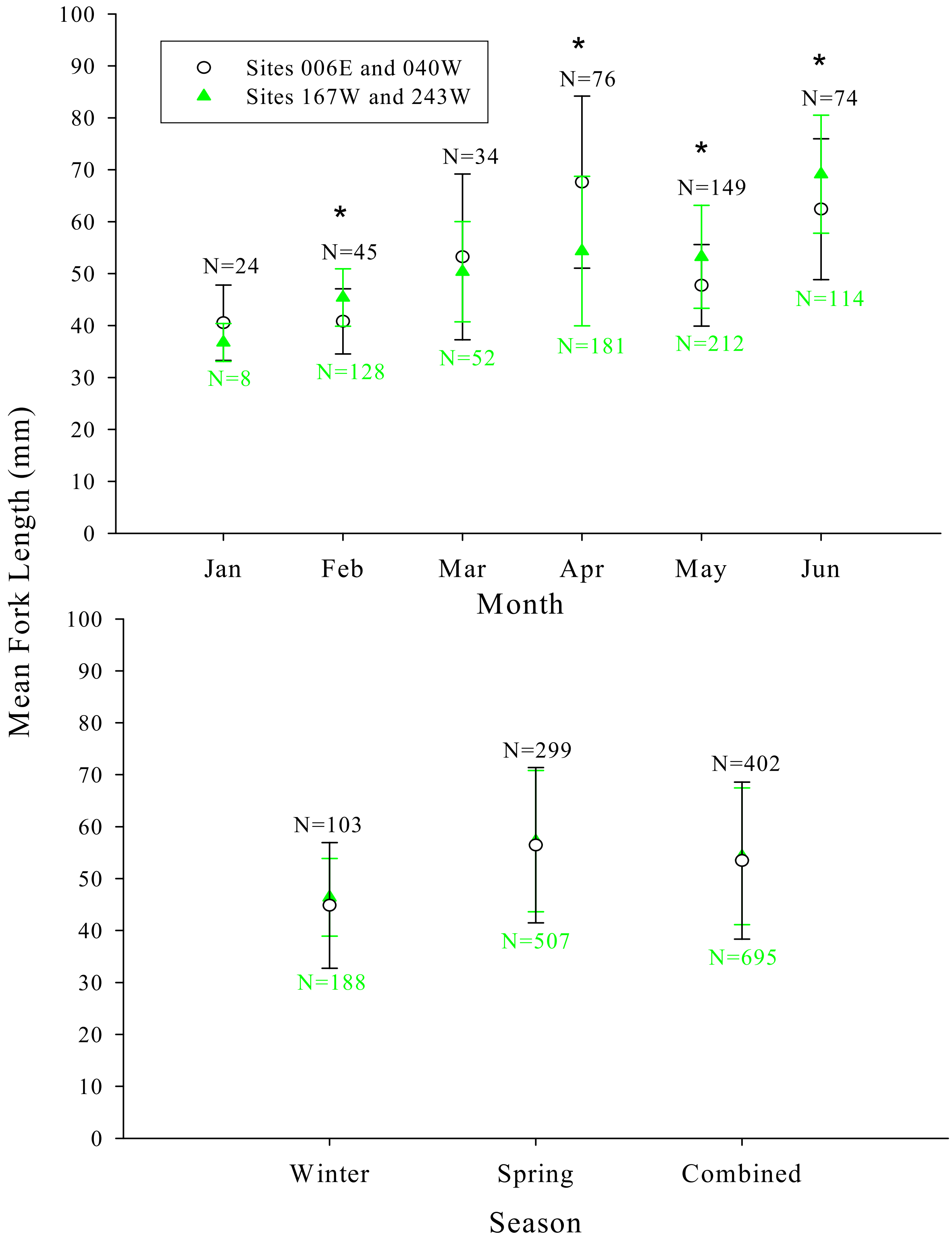

Figure 15. Mean fork length and standard deviations of unmarked sub-yearling chinook salmon at upper and lower beach seining sites in the lower Willamette River, January – June (2001 and 2002 combined). * indicates a significant (*P*<0.05) difference in mean fork length among upper and lower sites.

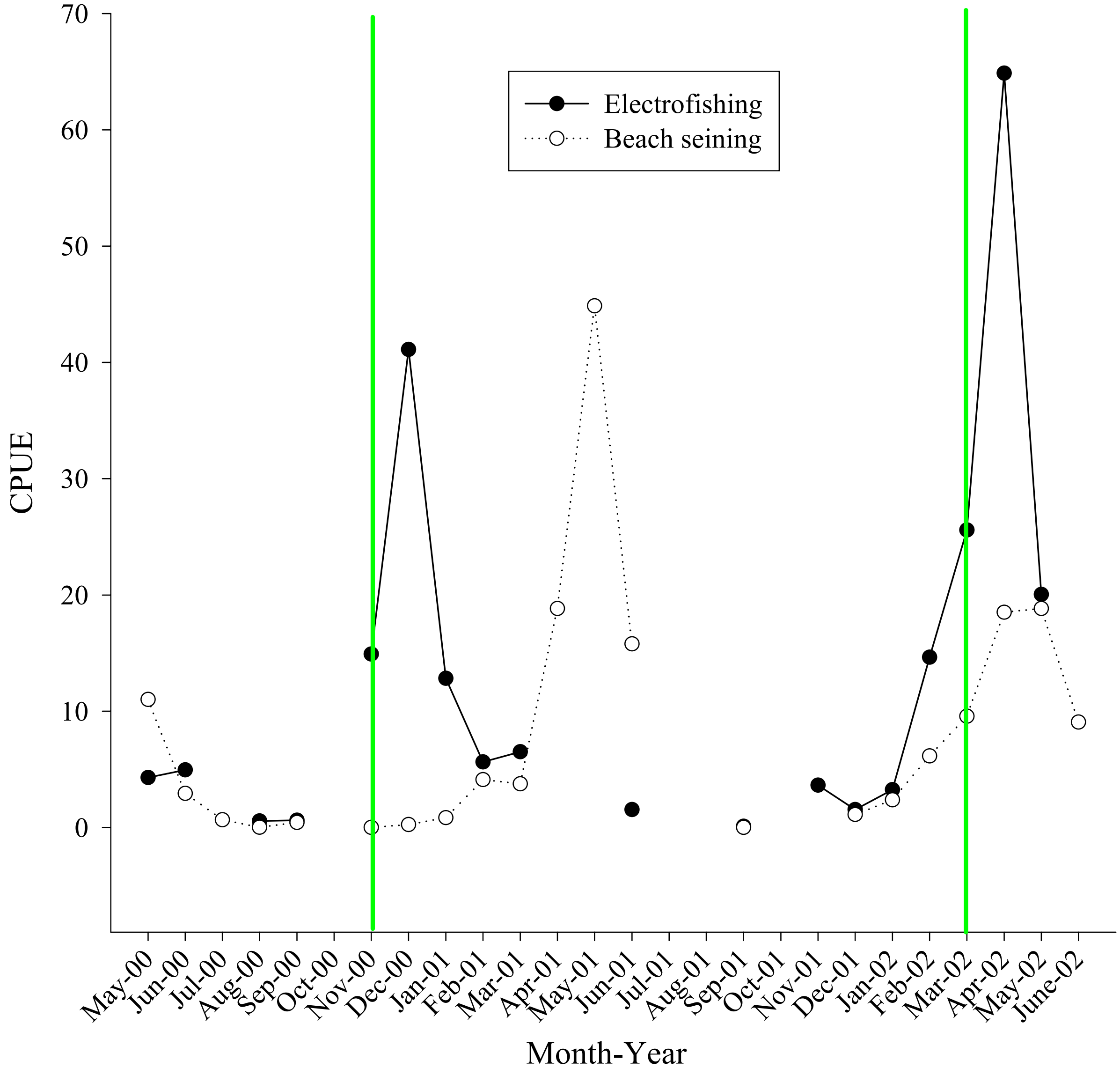

Figure 16. Electrofishing and beach seining catch per unit effort of juvenile salmonids by month in the lower Willamette River, May 2000 – June 2002. Gaps in trend lines indicate non-sampling periods; vertical lines indicate changes in electrofisher settings.

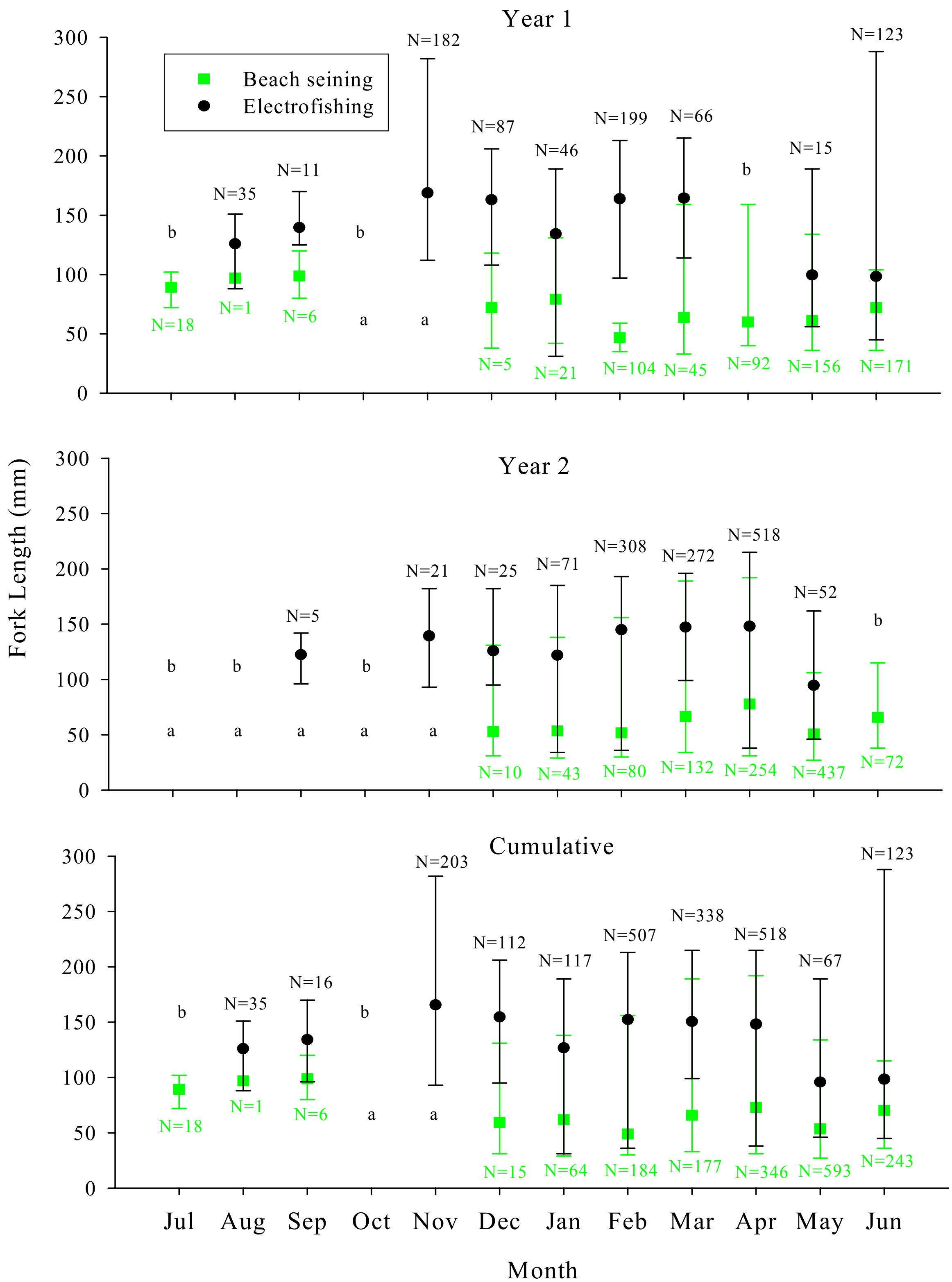

Figure 17. Mean, minimum, and maximum monthly fork lengths (mm) of juvenile chinook salmon captured by electrofishing and beach seining in the lower Willamette River. a = no beach seining conducted; b = no electrofishing conducted.

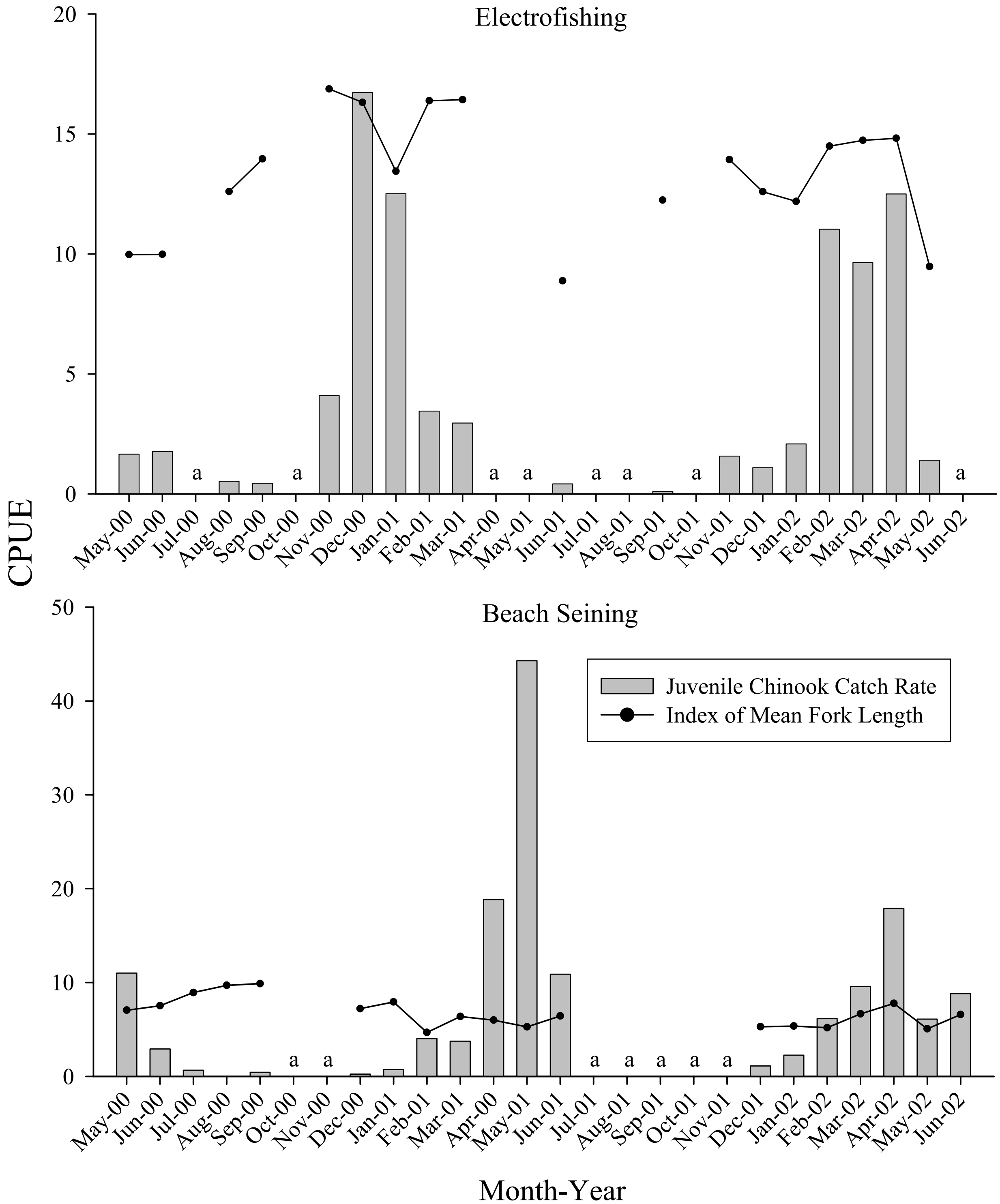

Figure 18. Monthly catch per unit effort and relative fork length of juvenile chinook salmon captured by electrofishing and beach seining in the lower Willamette River, May 2000 – June 2002. a = no sampling conducted.

Table 19. Mean standardized electrofishing catch rate of juvenile salmonids at sampling sites in the lower Willamette River, July 2001 - June 2002.

Site	Chinook	Coho	Steelhead	Unidentified salmonids	All
Standard sites:					
006E	3.97	0.38	0.00	8.68	13.03
010E	5.30	0.30	0.08	18.05	23.72
012W	0.60	0.00	0.00	2.28	2.88
048E	0.08	0.00	0.00	0.22	0.30
051E	6.68	0.23	0.38	11.21	18.51
064W	2.29	0.08	0.24	6.29	8.89
079W	5.43	0.00	0.07	7.36	12.86
100W	2.33	0.14	0.00	7.46	9.93
116E	3.96	0.08	0.23	7.67	11.93
121W	0.45	0.19	0.00	1.88	2.53
133W	10.99	0.47	0.26	25.66	37.38
136E	15.15	0.13	1.42	44.67	60.36
148E	8.42	0.45	0.19	17.81	26.86
167W	7.58	1.19	0.63	20.82	30.23
200E	2.84	0.69	0.55	10.77	14.86
203W	0.97	0.00	0.25	1.72	2.95
219W	2.34	0.37	0.63	5.59	8.93
Alcoves:					
067EA	1.58	0.00	0.00	3.54	5.12
076WA	0.99	0.00	0.00	2.66	3.65
107WA	2.11	0.00	0.00	2.69	4.80
148WA	9.36	0.75	0.26	24.20	34.57
232WA	4.64	1.94	0.13	18.33	25.04
239EA	11.33	4.02	0.00	32.91	48.27

Table 20. Mean standardized electrofishing catch rate of juvenile salmonids at sampling sites in the lower Willamette River, May 2000 - June 2002.

Site	Chinook	Coho	Steelhead	Unidentified salmonids	All
Standard sites:					
006E	2.35	0.27	0.00	3.77	6.39
010E	2.83	0.39	0.03	6.55	9.80
012W	0.66	0.00	0.00	1.49	2.16
048E	0.61	0.16	0.00	0.13	0.91
051E	3.29	0.23	0.19	4.16	7.87
064W	1.31	0.30	0.16	2.36	4.12
079W	3.28	0.27	0.02	3.17	6.74
100W	3.30	0.25	0.00	3.69	7.25
116E	3.96	0.08	0.23	7.67	11.93
121W	0.76	0.36	0.19	0.98	2.29
133W	11.47	0.27	0.38	30.62	42.74
136E	7.43	0.21	0.27	18.72	26.62
148E	5.80	0.26	0.19	8.27	14.51
167W	14.14	0.55	2.05	24.54	41.27
200E	1.96	2.03	0.32	5.24	9.56
203W	1.53	0.07	0.25	0.87	2.73
219W	2.27	1.42	0.46	3.67	7.82
Alcoves:					
067EA	1.45	0.00	0.00	3.42	4.87
076WA	0.86	0.00	0.00	2.46	3.31
107WA	2.11	0.00	0.00	2.69	4.80
148WA	8.74	0.70	0.24	22.59	32.27
232WA	4.38	1.81	0.12	17.11	23.42
239EA	10.69	3.71	0.00	30.38	44.79

between river mile 13.3 (rkm 21.4) and river mile 16.7 (rkm 26.9). Chinook salmon were the most abundant species, followed by coho salmon and steelhead. Steelhead were not found at 4 of 17 standard sampling sites. Alcove sites exhibited considerably higher mean catch rates (18.9 fish/effort) than standard sampling sites (12.0 fish/effort), and catch rates at upstream alcove sites (148WA-239EA) were 4.8-13.5 times higher than catch rates at downstream alcove sites (067EA-107WA).

Mean catch rates of juvenile salmonids were higher in year 2 than year 1 for almost all bank treatment and bank habitat types (Figures 19 and 20). We identified several significant differences among bank habitat types at $\alpha = 0.05$ (both years combined): CPUE at alcove sites was significantly ($P < 0.01$) higher than CPUE at seawall sites and sites with structures and no riprap (Table 21). Catch rate at seawall sites was also significantly lower than catch rate at sites lacking structures. Results for $\alpha = 0.10$ were similar, except CPUE at sites having structures and no riprap was significantly lower than sites lacking both structures and riprap. Fewer differences were present among bank treatment types. Seawall bank treatment sites had a significantly ($P < 0.01$) lower mean catch rate than alcove, beach, and rip rap sites at $\alpha = 0.05$, and a significantly lower mean catch rate than alcove, beach, rip rap, and rock outcrop treatment sites at $\alpha = 0.10$. Sites comprised primarily of natural habitat had significantly ($P < 0.01$) higher mean catch rates of juvenile salmonids than those consisting of artificial habitat (Figure 21).

Mean electrofishing CPUE for juvenile salmonids during year 2 was slightly higher for piling structures allowing light penetration (12.9 fish/effort) compared to light-limited sites (9.9 fish/effort) (Figure 22). Differences in juvenile salmonid catch rate among lighted and light limited sites for years 1 and 2 combined were negligible.

Task 3.2: Standardized Sampling for Resident Fish

Catch and Effort

In year 2 we caught 8,711 resident fish, including 6,748 captured by electrofishing. A total of 1,617 resident fish were collected while beach seining for juvenile salmonids with suckers composing the majority of the catch. We captured an additional 346 resident fish with gillnets, primarily minnows and suckers (165 and 85 respectively). A total of 72 resident predator fish were collected. Effort in year 2 ranged from 8 to 21 gillnet sets and 8 to 16 eletrofishing runs at standard sampling sites, and 12 to 14 electrofishing runs at alcove sites (Table 22). Effort was lowest during summer and autumn of year 2; we did not conduct any sampling in July, August, or October 2001 (Table 23). Sampling effort was similar among other months.

For both years combined, we collected 2,739 suckers, 915 sunfish, 835 minnows, and 97 predators in 627 electrofishing runs at 23 sites. Gillnetting produced another 698 suckers, 527 minnows, 66 sunfish, and 148 predators in 642 net sets. We captured 151 suckers, 651 minnows, 164 sunfish, and one predator while beach seining for juvenile salmonids. Distribution of sampling effort varied from 8 to 61 gillnet sets per sampling site, though more than 30 sets were conducted at most sites (Table 14). Electrofishing effort ranged from 12 to 37 runs at standard

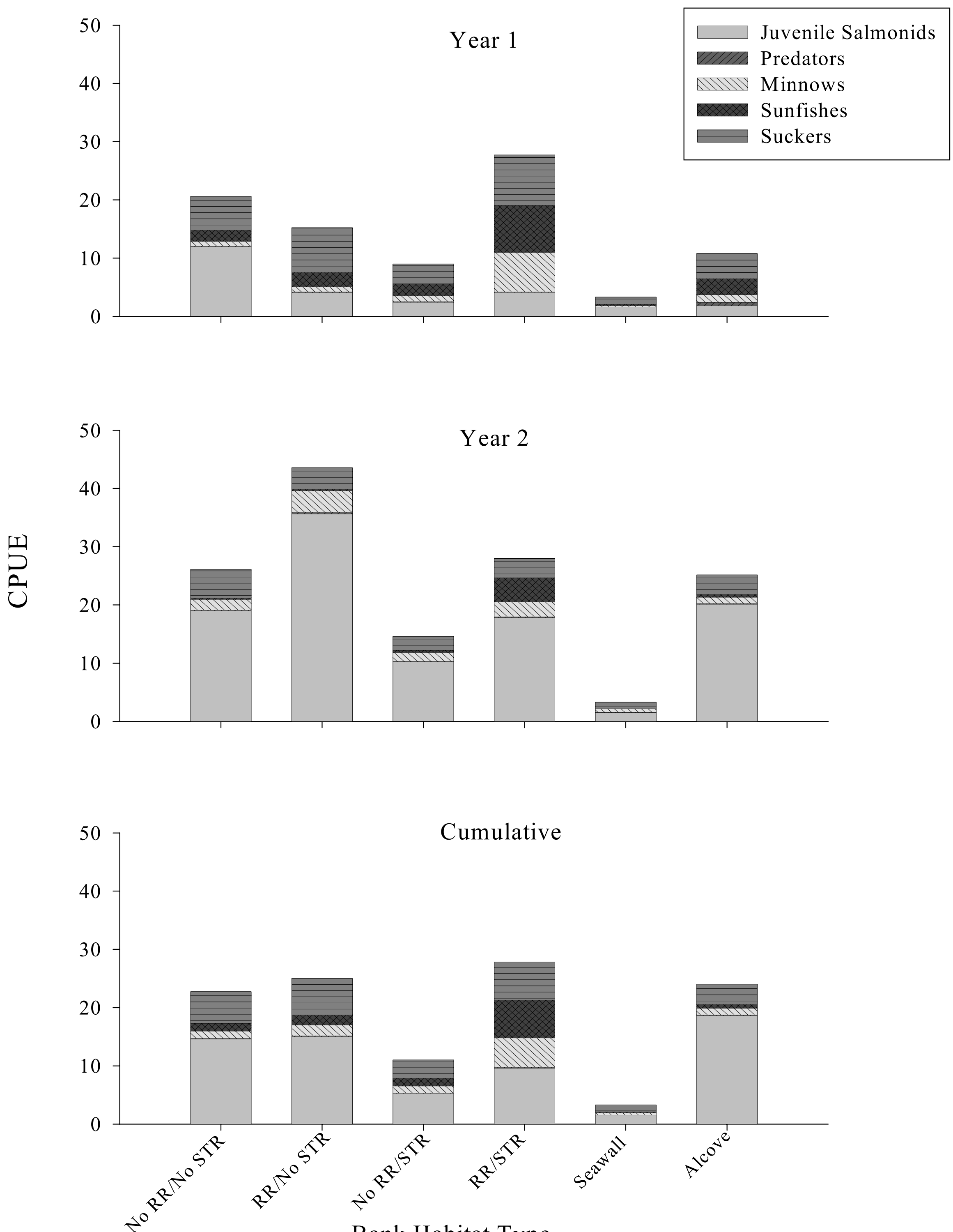

Figure 19. Electrofishing catch per unit effort of juvenile salmonids, potential predator fishes, and other resident family groups by habitat type in the lower Willamette River, May 2000 – June 2002. RR=Riprap; STR=Structure.

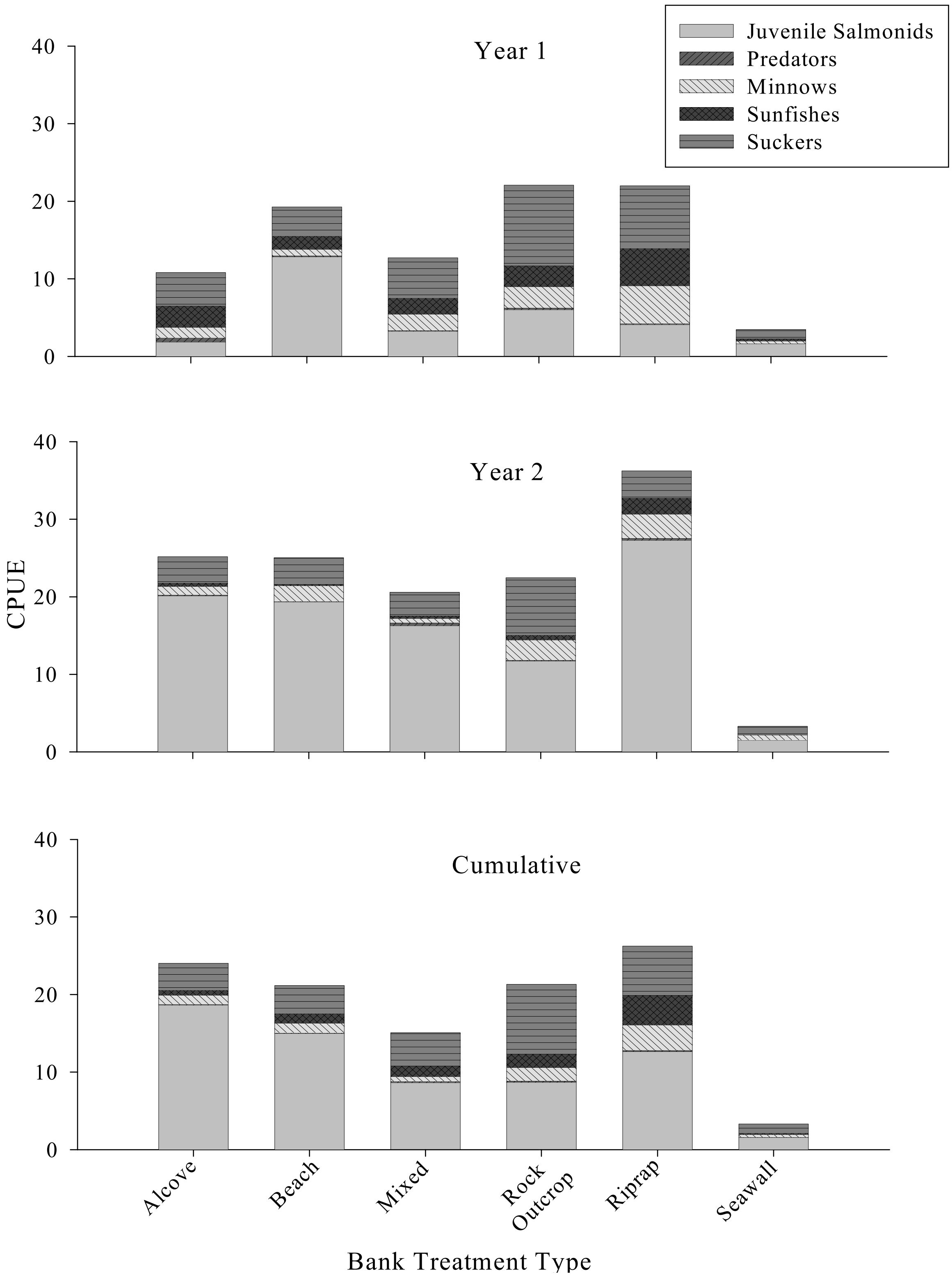

Figure 20. Electrofishing catch per unit effort of juvenile salmonids, potential predator fishes, and other resident family groups by bank treatment type in the lower Willamette River, May 2000 – June 2002.

Table 21. Probability (*P*) and significance of mean electrofishing catch per unit effort (CPUE) among habitat categories in the lower Willamette River, May 2000 - June 2002. Within each fish group and α value, variables without a letter in common differed significantly at the indicated level.

	CPUE (dependent variable)									
	All Juvenile Salmonids		Predator fishes		Minnows		Sunfishes		Suckers	
Independent Variable	α=0.05	α=0.10	α=0.05	α=0.10	α=0.05	α=0.10	α=0.05	α=0.10	α=0.05	α=0.10
Habitat Type	P<0.01		P=0.49		P=0.06		P<0.01		P<0.01	
No Riprap/No Structure	ac	a	a	a	ab	ab	bc	bc	ac	a
Riprap/No Structure	ac	ac	a	a	ab	ab	b	b	a	a
No Riprap/Structure	ab	bc	a	a	ab	ab	bc	bc	b	b
Riprap/Structure	abc	abc	a	a	a	a	a	a	ac	ac
Seawall	b	b	a	a	b	b	c	c	d	d
Alcove	c	a	a	a	ab	ab	bc	bc	bc	bc
Bank Treatment Type	P<0.01		P=0.35		P=0.04		P<0.01		P<0.01	
Beach	a	a	a	a	a	ab	b	bc	b	b
Riprap	a	a	a	a	a	a	a	a	c	c
Mixed	ab	ab	a	a	a	b	b	bc	b	b
Rock outcrop	ab	a	a	a	a	ab	ab	ab	a	a
Seawall	b	b	a	a	a	b	b	c	d	d
Alcove	a	a	a	a	a	ab	b	bc	b	b
Natural vs Artificial	P<0.01		P=0.27		P=0.45		P=0.02		P<0.01	

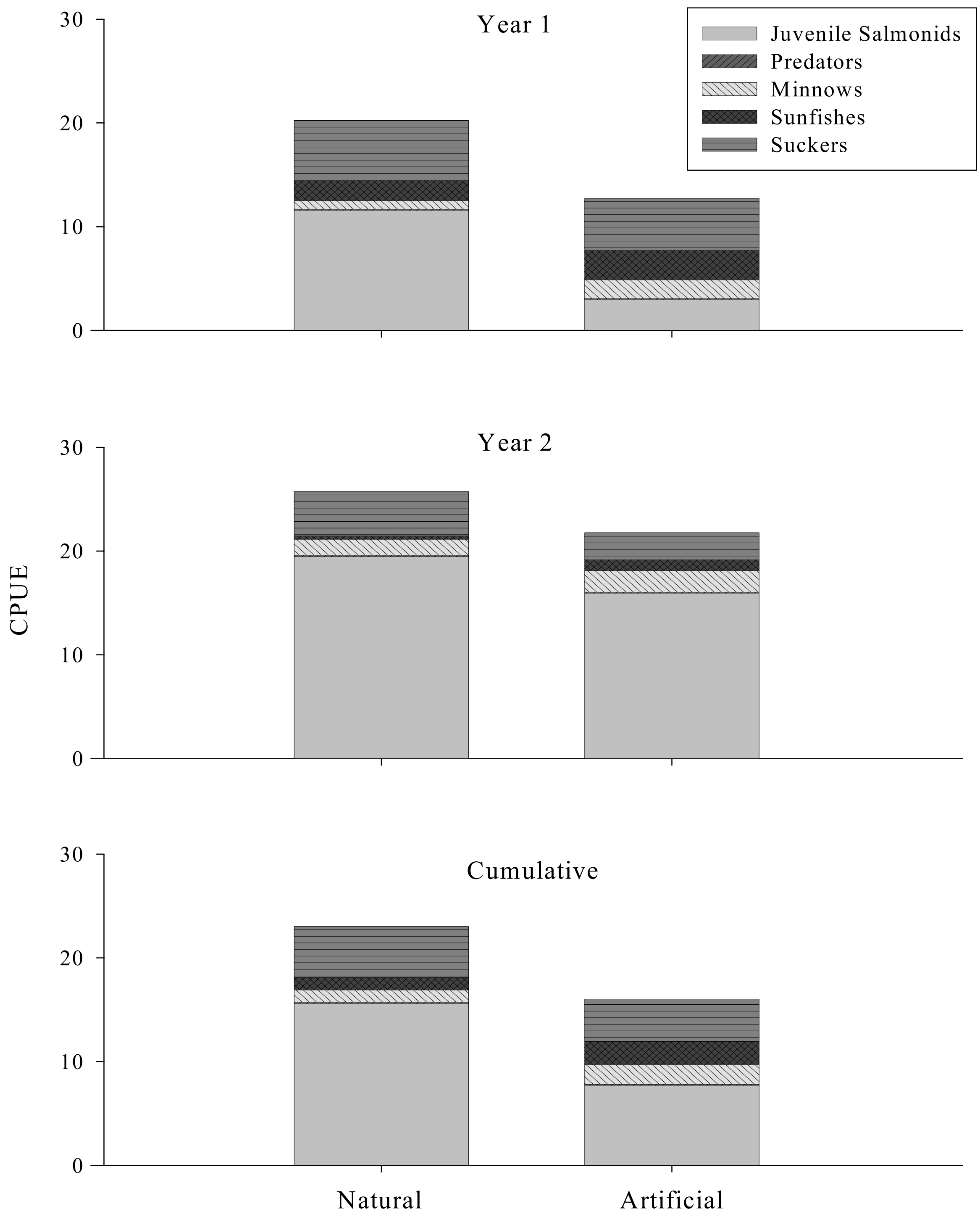

Figure 21. Electrofishing catch per unit effort of juvenile salmonids, potential predator fishes, and other resident family groups by habitat category in the lower Willamette River, May 2000 – June 2002. The artificial category includes sites containing artificial structures (e.g. seawall, riprap, pilings).

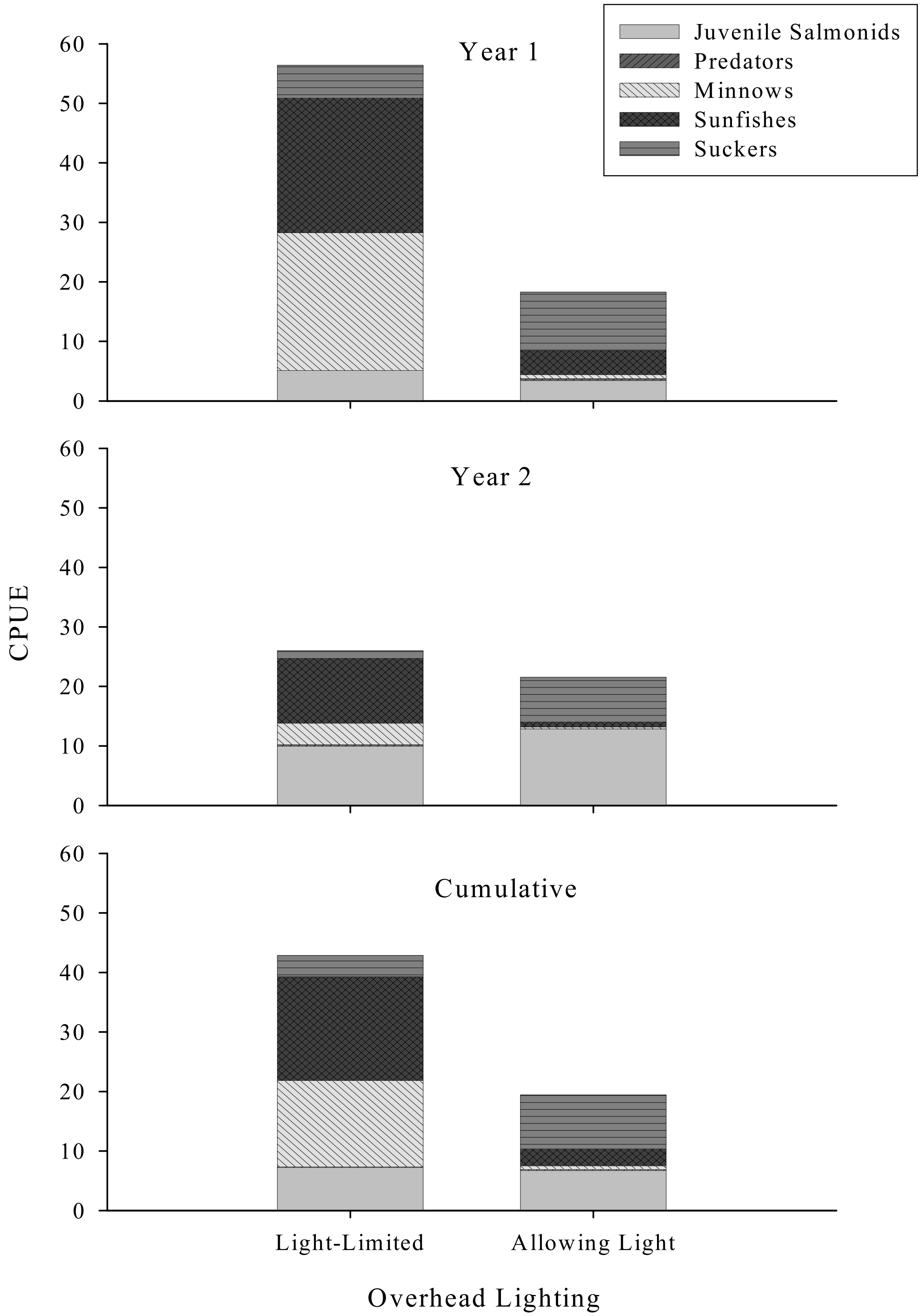

Figure 22. Electrofishing catch per unit effort (CPUE) of juvenile salmonids, potential predator fishes, and other resident family groups by nearshore piling-structure type in the lower Willamette River, May 2000 through June 2002.

Table 22. Sampling effort by gear type for sampling sites in the lower Willamette River, July 2001- June 2002.

Sampling sites	Beach Seining	Gillnetting	Electrofishing	
	N (sets)	N (sets)	N (runs)	Mean (s); Range (s)
006E	24	10	12	679; 505-751
010E[a]	--	20	12	675; 341-751
012W	--	11	13	500; 296-757
040W	24	--	--	--
048E[a]	--	11	12	550; 407-755
051E[a]	--	20	12	657; 295-754
064W[a]	--	21	11	707; 231-781
069W	13	--	--	--
079W[a]	--	20	13	493; 208-755
097E	15	--	--	--
100W[a]	--	17	8	430; 166-755
116E	--	8	12	651; 352-777
121W	--	9	14	750; 742-753
133W	--	10	15	449; 270-750
136E[a]	--	20	14	415; 267-627
148E	--	10	14	755; 750-805
167W	24	10	16	730; 271-840
200E	--	11	15	606; 394-750
203W[a]	--	9	14	531; 362-726
219W	--	9	14	632; 426-770
243W	21	--	--	--
Alcoves:				
067EA	--	--	12	700; 461 -775
076WA	--	--	13	647; 474-761
107WA	--	--	14	609; 319-764
148WA	--	--	14	411; 145-789
232WA	--	--	14	751; 700-783
239EA	--	--	12	749; 703-770

[a] Includes near shore and mid-shore gill net efforts

Table 23. Seasonal and monthly effort by gear type for sampling sites in the lower Willamette River, July 2001 - June 2002.

Season; month	Beach Seining (sets)	Electrofishing (runs)	Gillnetting (sets)
Summer 2001			
July	0	0	0
August	0	0	0
September	2	47	51
Autumn 2001			
October	0	0	0
November	0	21	20
December	9	35	18
Winter 2002			
January	19	40	22
February	13	32	23
March	14	34	23
Spring 2002			
April	18	46	23
May	29	45	23
June	17	0	23

sites, and 13 to 15 runs at alcove sites. Electrofishing has not been conducted in July or October, and gillnetting has not been conducted in July (Table 15).

In total, we captured 37 fish species from 15 families with all gears combined (Table 24). Fishes exotic to Oregon included 17 species from 7 families. Unidentified salmon and trout composed the greatest proportion of the catch (22.4%), followed by American shad (15.6%), chinook salmon (14.6%), unidentified suckers (13.1%), threespine stickleback (8.2%) and peamouth chub (7.2%). Species rarely encountered included cutthroat trout (n = 3), western mosquitofish (n = 3), sockeye salmon (n = 3), grass carp (n = 2), and warmouth (n = 1).

Seasonal Catch Rates and Abundance

We captured resident fish with both electrofishing and gillnetting during all months sampled; minnows and suckers dominated the catch of both gear types (Figure 23; Tables 25-28). Mean electrofishing catch rates were highest for suckers (3.5 fish/effort); minnow species had the highest gillnetting catch rate (1.0 fish/effort). For both years combined, minnows were caught at higher rates from November to May, catch of suckers was relatively consistent throughout the year, and predators were not common in any month. Resident fish were also captured by beach seining during every month sampling occurred, but catch rates were highest during summer months (July-September). Minnows dominated the beach seining catch; sunfishes and suckers were captured less frequently. Catch rates among years were generally similar for gillnetting and beach seining; however, electrofishing catch rates in year 1 were higher during May-December, and lower during December-January than year 2. Minnows were captured by electrofishing at very high rates in May of year 1.

Catch of individual species among sample sites varied considerably. For both year 2 (Table 25) and years 1 and 2 combined (Table 26), peamouth chub and suckers (not identified to species) were captured by electrofishing more frequently than other species. Electrofishing catch rates were very low for redside shiners, largemouth bass < 250 mm fork length, and walleye < 250 mm fork length; in addition, those species were captured at a small number of sites. Species distribution and electrofishing catch rates for resident fish were similar among standard and alcove sites. Catch rate patterns were similar for gillnetting (Tables 27 and 28). Unidentified suckers, peamouth chub, and northern pikeminnow > 250 mm fork length were captured by gillnets at much higher rates than other species. The highest species-specific gillnet catch rate was 10.35 fish/effort for peamouth chub at site 051E. Among large (> 250 mm fork length) predator species, northern pikeminnow were collected by at least one gear type at 78% of the sampling sites, followed by smallmouth bass (43%), walleye (13%), and largemouth bass (9%).

Gear Efficiencies

Changes in electrofisher output did not affect catch rates of predators, minnows, suckers, or sunfishes (Figure 24). Electrofishing CPUE did not change substantially for any fish group after output changes were made. In addition, trends in gillnet CPUE often followed trends in electrofishing CPUE both before and after output changes; differences in catch rate over time did not appear to be related to electrofisher output.

Table 24. Fish species collected by electrofishing, gillnetting, and beach seining in the lower Willamette River, May 2000 - June 2002. An asterisk (*) denotes species exotic to Oregon.

Family	Species	Common name	Percent of catch
Petromyzontidae	*Lampetra tridentata*	Pacific lamprey	<0.1
	Unidentified Petromyzontidae		0.3
Acipenseridae	*Acipenser transmontanus*	white sturgeon	1.6
Clupeidae	*Alosa sapidissima*	American shad*	15.6
Salmonidae	*Oncorhynchus tshawytscha*	chinook salmon	14.6
	Oncorhynchus kisutch	coho salmon	1.6
	Oncorhynchus nerka	sockeye salmon	<0.1
	Oncorhynchus mykiss	steelhead, rainbow trout	0.9
	Oncorhynchus clarki	cutthroat trout	<0.1
	Prosopium williamsoni	mountain whitefish	0.1
	Unidentified Salmonidae		22.4
Cyprinidae	*Ptychocheilus oregonensis*	northern pikeminnow	1.3
	Mylocheilus caurinus	peamouth	7.2
	Acrocheilus alutaceus	chiselmouth	2.4
	Cyprinus carpio	common carp*	1.8
	Ctenopharyngodon idella	grass carp*	<0.1
	Carassius auratus	goldfish*	<0.1
	Richardsonius balteatus	redside shiner	0.2
	Rhinichthys cataractae	longnose dace	<0.1
	Rhinichthys osculus	speckled dace	<0.1
Catostomidae	*Catostomus macrocheilus*	largescale sucker	0.9
	Catostomus commersoni	bridgelip sucker	<0.1
	Unidentified Catostomidae		13.1
Ictaluridae	*Ameiurus natalis*	yellow bullhead*	<0.1
	Ameiurus nebulosus	brown bullhead*	<0.1
	Ictalurus punctatus	channel catfish*	<0.1
	Unidentified Ictaluridae		<0.1
Gasterosteidae	*Gasterosteus aculeatus*	threespine stickleback	8.2
Percopsidae	*Percopsis transmontana*	sand roller	<0.1
Poeciliidae	*Gambusia affinis*	western mosquitofish*	<0.1
Cyprinodontidae	*Fundulus diaphanus*	banded killifish*	0.1
Centrarchidae	*Pomoxis annularis*	white crappie*	0.4
	Pomoxis nigromaculatus	black crappie*	0.4
	Micropterus dolomieu	smallmouth bass*	1.6
	Micropterus salmoides	largemouth bass*	0.2
	Lepomis macrochirus	bluegill*	0.2
	Lepomis gibbosus	pumpkinseed*	0.3
	Lepomis gulosus	warmouth*	<0.1
	Unidentified Centrarchidae		<0.1
Percidae	*Stizostedion vitreum*	walleye*	0.2
	Perca flavescens	yellow perch*	1.6
Cottidae	*Cottus asper*	prickly sculpin	<0.1
	Unidentified Cottidae		1.8
Plueuronectidae	*Platichthys stellatus*	starry flounder	0.7

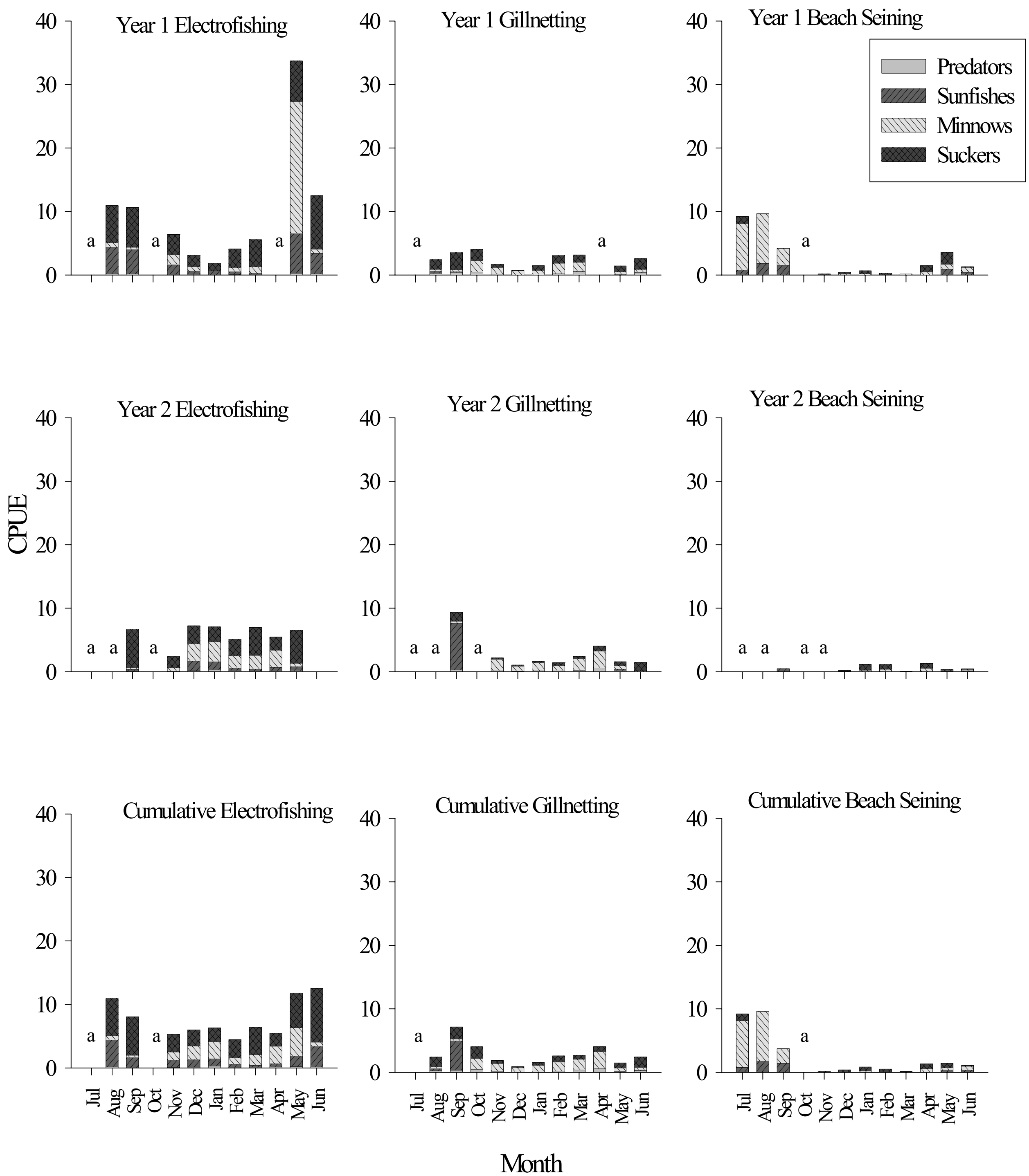

Figure 23. Monthly catch per unit effort (CPUE) of potential predator fishes and other resident family groups captured by electrofishing, gillnetting, and beach seining in the lower Willamette River, July 2000 through June 2002. a = no sampling conducted. Units of effort are not comparable among different gear types.

Table 25. Mean standardized electrofishing catch rate of select species[a] at sampling sites in the lower Willamette River, July 2001 - June 2002.

	≥250 mm				<250 mm				All sizes								
Site	NPM	SMB	LMB	WAL	NPM	SMB	LMB	WAL	YLP	PMC	BLG	BCP	WCP	PMK	TSS	RSS	SUC
Standard sampling sites:																	
006E	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	4.85	0.00	0.00	0.00	0.00	0.08	0.00	1.44
010E	0.00	0.00	0.00	0.00	0.19	0.00	0.08	0.00	0.38	4.09	0.00	0.00	0.00	0.00	10.10	0.00	1.61
012W	0.11	0.07	0.00	0.12	0.49	0.00	0.00	0.00	0.12	4.64	0.00	0.00	0.00	0.00	0.24	0.00	3.66
048E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00
051E	0.08	0.08	0.00	0.00	0.40	0.16	0.49	0.00	0.08	2.28	0.00	0.00	0.00	0.00	0.08	0.00	2.95
064W	0.25	0.08	0.00	1.06	0.00	0.08	0.00	0.08	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00	3.16
079W	0.00	0.07	0.00	0.00	0.00	0.28	0.22	0.00	0.20	0.26	0.00	0.22	0.00	0.00	0.00	0.00	7.44
100W	0.31	0.00	0.00	0.00	0.67	2.23	3.06	0.00	0.11	2.89	1.49	0.64	1.43	1.97	0.00	0.00	1.25
116E	0.22	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	2.22	0.08	0.00	0.00	0.29	0.19	0.00	5.18
121W	0.07	0.00	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.78	0.00	0.00	0.00	0.00	0.26	0.00	2.02
133W	0.00	0.11	0.00	0.00	0.08	0.10	0.08	0.00	0.20	0.98	0.00	0.00	0.00	0.00	0.00	0.00	5.88
136E	0.09	0.15	0.00	0.16	0.08	0.25	0.00	0.00	0.11	2.13	0.00	0.00	0.12	0.09	0.00	0.00	5.48
148E	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.65	0.07	0.00	0.00	0.00	0.26	0.00	4.39
167W	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.85	0.00	0.06	0.06	0.00	1.07	0.00	1.10
200E	0.00	0.00	0.00	0.00	0.64	0.19	0.00	0.00	0.00	3.33	0.14	0.00	0.00	0.27	1.09	0.00	8.37
203W	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.37	0.00	0.16
219W	0.11	0.11	0.00	0.00	0.05	0.62	0.00	0.00	0.00	1.38	0.00	0.00	0.06	0.00	0.00	0.00	6.50
067EA	0.15	0.00	0.00	0.00	0.30	0.00	0.08	0.07	0.00	2.91	0.15	0.22	0.15	0.07	0.00	0.00	4.96
076WA	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.07	0.00	1.42
107WA	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.70	0.14	0.00	0.00	0.07	0.07	0.00	0.55
148WA	0.19	0.08	0.00	0.00	0.00	0.24	0.11	0.00	0.06	1.40	0.19	0.00	0.00	0.00	0.00	0.00	3.62
232WA	0.00	0.26	0.07	0.00	0.00	0.07	0.00	0.00	0.19	0.90	0.19	0.07	0.07	0.00	0.00	0.00	4.22
239EA	0.00	0.00	0.08	0.00	0.00	0.31	0.15	0.00	0.23	0.08	0.00	0.00	0.00	0.00	0.00	0.08	6.00

[a] BCP=black crappie, BLG=bluegill, LMB=largemouth bass, NPM=northern pikeminnow, PMC=peamouth chub, PMK=pumpkinseed, RSS=redside shiner, SMB=smallmouth bass, SUC=sucker spp., TSS=threespine stickleback, WAL=walleye, WCP=white crappie,YLP=yellow perch.

Table 26. Mean standardized electrofishing catch rate of select species[a] at sampling sites in the lower Willamette River, May 2000 - June 2002.

	≥250 mm				<250 mm				All sizes								
Site	NPM	SMB	LMB	WAL	NPM	SMB	LMB	WAL	YLP	PMC	BLG	BCP	WCP	PMK	TSS	RSS	SUC
Standard sampling sites:																	
006E	0.00	0.00	0.00	0.05	0.08	0.02	0.00	0.05	0.43	2.60	0.00	0.00	0.08	0.00	0.58	0.00	1.66
010E	0.00	0.05	0.03	0.00	0.15	0.05	0.05	0.04	1.18	2.11	0.00	0.08	0.09	0.04	33.20	0.02	2.78
012W	0.10	0.03	0.00	0.05	0.22	0.03	0.02	0.00	0.61	2.46	0.00	0.12	0.05	0.00	0.43	0.00	3.01
048E	0.00	0.00	0.00	0.00	0.05	0.02	0.00	0.02	0.27	0.20	0.00	0.02	0.04	0.00	4.36	0.00	0.55
051E	0.08	0.08	0.00	0.00	0.19	0.31	0.19	0.00	0.94	1.38	0.03	0.14	0.00	0.00	0.40	0.00	5.48
064W	0.10	0.03	0.00	0.38	0.04	0.21	0.00	0.05	0.66	0.30	0.00	0.36	0.17	0.06	0.11	0.00	5.12
079W	0.09	0.15	0.00	0.00	0.00	0.50	0.12	0.00	1.75	0.52	0.05	0.23	0.09	0.19	1.61	0.02	9.01
100W	0.14	0.00	0.00	0.00	0.67	3.25	1.74	0.00	1.00	13.77	2.93	1.23	1.58	5.74	0.19	0.00	3.58
116E	0.22	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.00	2.22	0.08	0.00	0.00	0.29	0.19	0.00	5.18
121W	0.05	0.00	0.00	0.00	0.26	0.05	0.00	0.00	0.02	0.42	0.00	0.00	0.00	0.00	1.91	0.00	1.79
133W	0.04	0.06	0.00	0.00	0.05	0.13	0.05	0.00	0.30	0.88	0.00	0.00	0.00	0.00	0.20	0.00	5.10
136E	0.04	0.14	0.00	0.12	0.08	0.88	0.00	0.03	1.63	1.41	0.00	0.00	0.09	0.13	0.19	0.00	8.05
148E	0.02	0.05	0.00	0.00	0.02	0.02	0.00	0.00	0.39	0.50	0.05	0.46	0.42	0.07	1.32	0.00	3.59
167W	0.05	0.02	0.00	0.00	0.04	0.02	0.00	0.00	0.32	0.90	0.00	0.07	0.17	0.02	0.51	0.00	2.45
200E	0.02	0.05	0.00	0.00	0.45	1.20	0.00	0.00	0.03	1.89	0.07	0.00	0.05	0.16	0.50	0.00	8.78
203W	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.02	0.04	0.00	0.00	0.00	0.00	0.17	0.00	0.09
219W	0.07	0.17	0.03	0.00	0.16	1.68	0.00	0.00	0.03	1.05	0.10	0.00	0.06	0.14	0.00	0.00	9.16
Alcoves and refugia:																	
067EA	0.13	0.00	0.00	0.00	0.26	0.00	0.07	0.06	0.00	2.49	0.13	0.19	0.13	0.06	0.00	0.00	4.41
076WA	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.06	0.00	1.23
107WA	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.70	0.14	0.00	0.00	0.07	0.07	0.00	0.55
148WA	0.18	0.08	0.00	0.00	0.00	0.48	0.11	0.00	0.06	1.43	0.18	0.00	0.00	0.00	0.00	0.00	3.76
232WA	0.00	0.29	0.06	0.00	0.00	0.06	0.00	0.00	0.53	1.29	0.18	0.06	0.06	0.00	0.00	0.05	4.24
239EA	0.00	0.23	0.07	0.00	0.06	0.75	0.14	0.00	0.50	0.07	0.00	0.00	0.00	0.06	0.00	0.42	6.88

[a] BCP=black crappie, BLG=bluegill, LMB=largemouth bass, NPM=northern pikeminnow, PMC=peamouth chub, PMK=pumpkinseed, RSS=redside shiner, SMB=smallmouth bass, SUC=sucker spp., TSS=threespine stickleback, WAL=walleye, WCP=white crappie,YLP=yellow perch.

Table 27. Mean gillnetting catch rate of select species[a] by sampling site in the lower Willamette River, July 2001 - June 2002.

	≥250mm				<250mm				All sizes								
Site	NPM	SMB	LMB	WAL	NPM	SMB	LMB	WAL	YLP	PMC	BLG	BCP	WCP	PMK	TSS	RSS	SUC
006EN	0.50	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	3.60	0.00	0.10	0.20	0.00	0.00	0.00	1.50
010EN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.00	0.23	0.00	0.00	0.00	0.00	0.39
010EO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012WN	0.25	0.17	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	1.42
048EN	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.10	0.00	0.00	0.00	0.00
048EO	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
051EN	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	1.22
051EO	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.09
064WN	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.80
064WO	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.09	0.00	0.00	0.00	0.27
079WN	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10	0.00	0.10	0.00	0.00	0.00	0.00	1.50
079WO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
100WN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.13	0.00	0.13	0.00	0.00	0.25
100WO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
116EN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.00	0.00	0.00	0.00	0.00	0.00	1.50
121WN	0.11	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
133WN	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.30	0.00	0.00	0.00	0.80
136EN	0.10	0.10	0.00	0.10	0.00	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	2.40
136EO	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.70
148EN	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.60
167WN	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	1.00
200EN	0.91	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	2.73	0.00	0.00	0.00	0.00	0.00	0.00	0.27
203WN	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
203WO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
219WN	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.67

[a] BCP=black crappie, BLG=bluegill, LMB=largemouth bass, NPM=northern pikeminnow, PMC=peamouth chub, PMK=pumpkinseed, RSS=redside shiner, SMB=smallmouth bass, SUC=sucker, TSS=threespine stickleback, WAL=Walleye, WCP=white crappie, YLP=yellow perch.

Table 28. Mean gillnetting catch rate of select species[a] by sampling site in the lower Willamette River, May 2000 - June 2002.

	≥250mm				<250mm				All sizes								
Site	NPM	SMB	LMB	WAL	NPM	SMB	LMB	WAL	YLP	PMC	BLG	BCP	WCP	PMK	TSS	RSS	SUC
006EN	0.39	0.00	0.00	0.03	0.13	0.00	0.00	0.03	0.00	3.48	0.00	0.07	0.07	0.00	0.00	0.00	3.13
010EN	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.03	0.18	0.00	0.00	0.00	0.00	1.00
010EO	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.08	0.00	0.04	0.04	0.00	0.00	0.00	0.17
012WN	0.24	0.07	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.24	0.00	0.17	0.00	0.00	0.00	0.00	2.14
048EN	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.03	0.00	0.00	0.00	0.13
048EO	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
051EN	0.10	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.20	0.00	0.07	0.07	0.00	0.00	0.00	1.10
051EO	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.35	0.00	0.04	0.12	0.00	0.00	0.00	0.27
064WN	0.19	0.00	0.00	0.06	0.09	0.00	0.00	0.00	0.00	0.19	0.00	0.06	0.03	0.00	0.00	0.00	0.78
064WO	0.14	0.00	0.00	0.07	0.03	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.03	0.00	0.00	0.00	0.24
079WN	0.21	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.06	0.15	0.00	0.00	0.44	2.03
079WO	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.41
100WN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.05	0.05	0.05	0.00	0.00	0.32
100WO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.04	0.00	0.00	0.00	0.13
116EN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.00	0.00	0.00	0.00	0.00	0.00	1.50
121WN	0.17	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	1.87	0.00	0.03	0.03	0.00	0.00	0.00	1.48
133WN	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.13	0.00	0.00	0.00	1.26
136EN	0.22	0.03	0.00	0.03	0.03	0.00	0.00	0.00	0.00	1.06	0.00	0.00	0.03	0.00	0.00	0.00	2.63
136EO	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.08	0.00	0.08	0.04	0.00	0.00	0.00	1.40
148EN	0.10	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.10	0.00	0.00	0.00	1.42
167WN	0.50	0.00	0.00	0.06	0.03	0.00	0.00	0.03	0.00	0.81	0.00	0.03	0.09	0.00	0.00	0.00	1.28
200EN	0.55	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	1.36	0.00	0.00	0.00	0.00	0.00	0.00	0.55
203WN	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.17	0.07	0.00	0.00	0.00	0.24
203WO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
219WN	0.40	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.77	0.00	0.00	0.03	0.00	0.00	0.00	0.87

[a] BCP=black crappie, BLG=bluegill, LMB=largemouth bass, NPM=northern pikeminnow, PMC=peamouth chub, PMK=pumpkinseed, RSS=redside shiner, SMB=smallmouth bass, SUC=sucker, TSS=threespine stickleback, WAL=Walleye, WCP=white crappie, YLP=yellow perch.

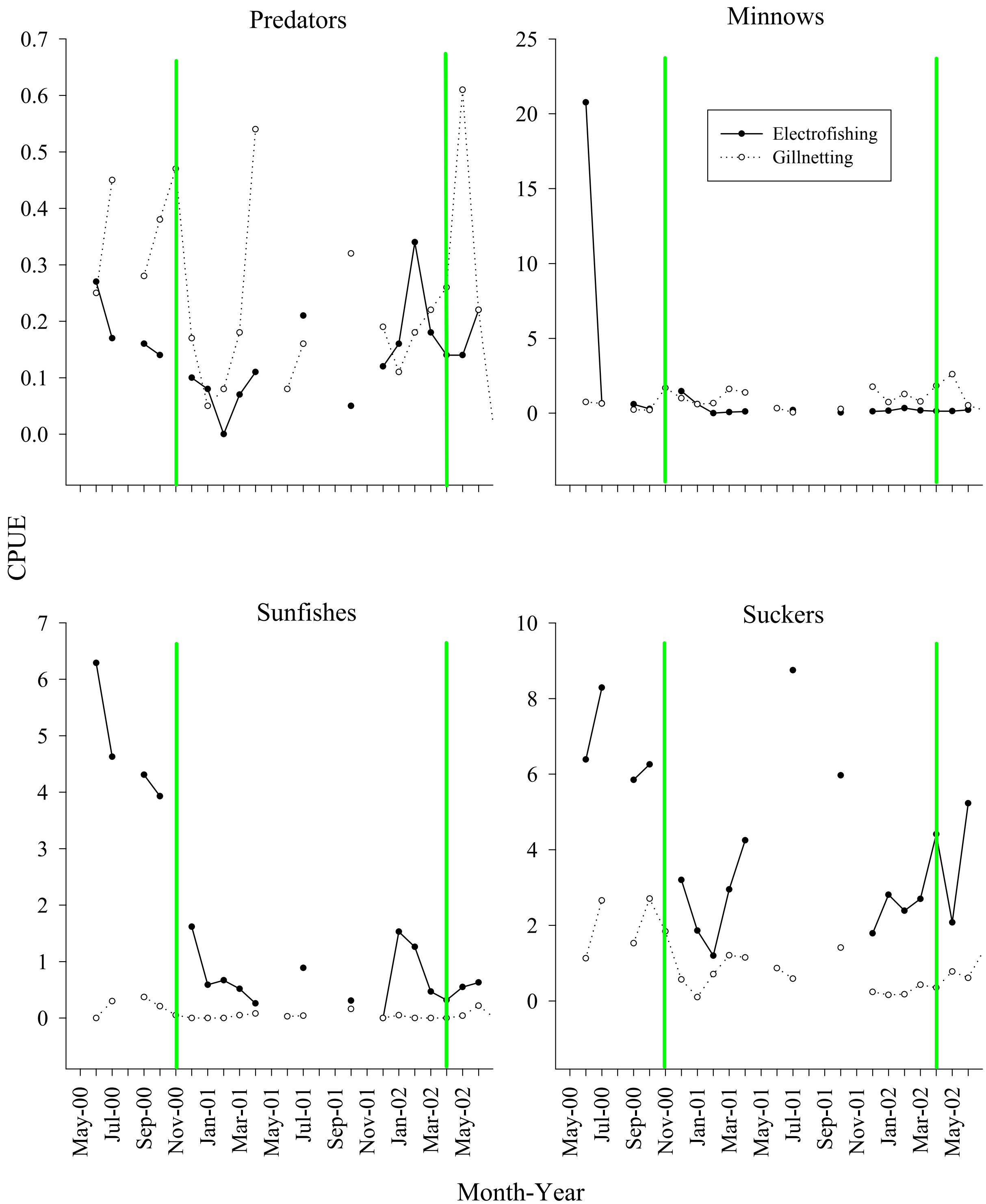

Figure 24. Electrofishing and gillnetting catch-per-unit-effort (CPUE) of potential predator fish, minnows, suckers, and sunfish by month and year in the lower Willamette River, May 2000 through June 2002. Gaps in trend lines indicate non-sampling periods. Vertical lines indicate changes in electrofisher settings.

Habitat Use

Mean electrofishing CPUE varied widely among individual sample sites in year 2 (Table 29). Suckers were generally captured at the highest rates, followed by minnows, sunfishes, and predator fishes. Unusually high catch rates were observed for predator fishes at site 064W (1.39 fish/effort) and sunfishes at site 100W (10.94 fish/effort). Electrofishing catch rates at alcove sites were similar to catch rates at standard sites for all resident fish groups. Patterns were similar for years 1 and 2 combined (Table 30), except catch rates for both minnows and sunfishes were unusually high at site 100W. Specimens from all four resident fish groups have been captured by electrofishing at every sampling site, except predator species were not found at two standard sites (048E and 203W) and two alcove sites (076W and 107W).

Gillnet catch rates were relatively low (0.0-3.8 fish/effort) among individual sample sites in year 2 (Table 31). Individual fish groups, especially predator fish and sunfish, were not represented in the catch at many sites. Two sites (006E and 010E) had high catch rates of minnows relative to other sites. Patterns for year 1 and year 2 combined were similar, except zero catches for individual fish groups were less common (Table 32). The mean catch rate was highest for suckers followed by minnows, predator fishes, and sunfishes. No minnows, sunfishes, or suckers were collected at site 048E, but CPUE of predator fishes was higher than any other site (1.0 fish/effort).

Significant differences in mean electrofishing catch rate of resident fish among bank treatment and bank habitat types were rare (Table 21). We observed no significant differences in predator fish catch rates for any comparison. Results for minnow species indicate significantly higher catch rates at habitats with riprap and structure compared to seawall habitats ($P = 0.06$) and higher catch rates at riprap bank treatment sites compared to mixed habitat and seawall sites ($P = 0.04$) (Table 21). Among sunfish and suckers, seawall sites often had significantly lower catch rates than other habitat and bank treatment types. At $\alpha = 0.10$, mean CPUE of sunfish at riprap bank treatment sites was significantly higher ($P < 0.01$) than CPUE at beach, mixed habitat, seawall, and alcove sites. Sunfish catch rates were also significantly higher at sites with both riprap and structure than all other habitat types ($P < 0.01$). Catch rate of suckers was significantly ($P < 0.01$) higher at riprap sites than at all other bank treatment sites. Mean CPUE for predators ($P = 0.27$) and minnows ($P = 0.45$) was not significantly different among natural and artificial habitats (Table 21, Figure 25); however, sunfish ($P = 0.02$) were caught at significantly higher rates near artificial habitat. Suckers had significantly ($P < 0.01$) higher collection rates at sites comprised of natural habitat.

Gillnetting CPUE for all fish groups was relatively low (<3.7 fish per effort). Catch rates of mid-shore gillnets were consistently lower than catch rates of near shore gillnets; however, catch rates for minnows were similar for both types (Figure 26). Predator fishes and suckers were captured at higher rates in areas without structure for both nearshore and mid-shore gillnet sets, whereas sunfishes and minnows were equally abundant in areas with and without structure (Figures 27 and 28). In areas with structure, we found minnows more frequently where pilings were present (Figure 29). We observed higher catch rates for predators and sunfishes in areas without pilings; suckers were equally abundant in both areas. Overall gillnetting catch rates were much higher at piling structures allowing light than at light-limited piling structures, and

Table 29. Mean standardized electrofishing catch rates of predator[a], minnow[b], sunfish[c], and sucker[d] species by sampling site in the lower Willamette River, July 2001 - June 2002.

Site	Predators	Minnows	Sunfishes	Suckers
006E	0.00	4.92	0.00	1.44
010E	0.00	4.27	0.45	1.61
012W	0.30	5.13	0.12	3.66
048E	0.00	0.42	0.00	0.00
051E	0.16	2.68	0.72	2.95
064W	1.39	0.41	0.08	3.16
079W	0.07	0.26	0.91	7.44
100W	0.31	3.56	10.94	1.25
116E	0.22	2.22	0.62	5.18
121W	0.06	0.84	0.06	2.02
133W	0.11	1.07	0.37	5.88
136E	0.40	2.21	0.57	5.48
148E	0.06	0.65	0.13	4.39
167W	0.00	0.85	0.17	1.10
200E	0.00	3.97	0.61	8.37
203W	0.00	0.09	0.00	0.16
219W	0.21	1.43	0.68	6.49
Alcoves:				
067EA	0.15	3.21	0.67	4.96
076WA	0.00	0.21	0.08	1.42
107WA	0.00	0.70	0.28	0.55
148WA	0.27	1.40	0.61	3.62
232WA	0.32	0.90	0.58	4.22
239EA	0.08	0.08	0.68	6.00

[a] Smallmouth bass, largemouth bass, northern pikeminnow, and walleye ≥ 250mm fork length.

[b] Peamouth chub of all sizes and northern pikeminnow < 250mm.

[c] Black crappie, bluegill, pumpkinseed, white crappie, and yellow perch of all sizes. Smallmouth and largemouth bass < 250mm.

[d] Largescale suckers and unidentified suckers of all sizes.

Table 30. Mean standardized electrofishing catch rates of predator[a], minnow[b], sunfish[c], and sucker[d] species by sampling site in the lower Willamette River, May 2000 - June 2002.

Site	Predators	Minnows	Sunfishes	Suckers
006E	0.04	2.68	0.53	1.66
010E	0.08	2.26	1.49	2.78
012W	0.18	2.68	0.82	3.00
048E	0.00	0.26	0.35	0.55
051E	0.15	1.58	1.61	5.48
064W	0.50	0.35	1.45	5.12
079W	0.24	0.52	2.93	9.01
100W	0.14	14.44	17.47	3.58
116E	0.22	2.22	0.62	5.18
121W	0.05	0.45	0.07	1.79
133W	0.10	0.93	0.47	5.10
136E	0.30	1.49	2.73	8.05
148E	0.07	0.53	1.41	3.59
167W	0.07	0.95	0.60	2.45
200E	0.07	2.34	1.50	8.78
203W	0.00	0.04	0.06	0.09
219W	0.28	1.21	2.01	9.16
Alcoves:				
067EA	0.13	2.75	0.57	4.41
076WA	0.00	0.18	0.07	1.23
107WA	0.00	0.70	0.28	0.55
148WA	0.26	1.43	0.82	3.76
232WA	0.35	1.29	0.89	4.24
239EA	0.30	0.13	1.45	6.88

[a] Smallmouth bass, largemouth bass, northern pikeminnow, and walleye ≥ 250mm fork length.

[b] Peamouth chub of all sizes and northern pikeminnow < 250mm.

[c] Black crappie, bluegill, pumpkinseed, white crappie, and yellow perch of all sizes; smallmouth and largemouth bass < 250mm.

[d] Largescale suckers and unidentified suckers of all sizes.

Table 31. Mean gillnet catch rates of predator[a], minnow[b], sunfish[c], and sucker[d] species by sampling site in the lower Willamette River, July 2001 - June 2002.

Site	Predators	Minnows	Sunfishes	Suckers
006EN	0.50	3.80	0.30	1.50
010EN	0.00	0.77	0.23	0.38
010EO	0.00	3.43	0.00	0.00
012WN	0.42	0.42	0.00	1.42
048EN	0.10	0.10	0.10	0.00
048EO	1.00	0.00	0.00	0.00
051EN	0.11	0.56	0.00	1.22
051EO	0.55	0.45	0.00	0.09
064WN	0.10	0.30	0.00	0.80
064WO	0.09	0.27	0.09	0.27
079WN	0.30	1.10	0.10	1.50
079WO	0.00	1.00	0.00	0.50
100WN	0.00	0.13	0.25	0.25
100WO	0.00	0.11	0.00	0.00
116EN	0.00	2.25	0.00	1.50
121WN	0.11	0.44	0.00	0.00
133WN	0.10	0.30	0.30	0.80
136EN	0.30	1.60	0.00	2.40
136EO	0.20	0.90	0.00	0.70
148EN	0.20	0.40	0.00	0.60
167WN	0.30	1.50	0.00	1.00
200EN	0.91	2.82	0.00	0.27
203WN	0.38	1.00	0.00	0.00
203WO	0.00	0.00	0.00	0.00
219WN	0.56	0.67	0.00	0.67

[a] Smallmouth bass, largemouth bass, northern pikeminnow, and walleye ≥ 250mm fork length.

[b] Peamouth chub of all sizes and northern pikeminnow < 250mm.

[c] Black crappie, bluegill, pumpkinseed, white crappie, and yellow perch of all sizes. Smallmouth and largemouth bass < 250mm.

[d] Largescale suckers and unidentified suckers of all sizes.

Table 32. Mean gillnet catch rates of predator[a], minnow[b], sunfish[c], and sucker[d] species by sampling site in the lower Willamette River, May 2000 - June 2002.

Site	Predators	Minnows	Sunfishes	Suckers
006EN	0.42	3.61	0.13	3.13
010EN	0.12	0.44	0.21	1.00
010EO	0.04	2.08	0.08	0.17
012WN	0.31	0.31	0.17	2.14
048EN	0.13	0.17	0.03	0.13
048EO	1.00	0.00	0.00	0.00
051EN	0.10	0.23	0.13	1.10
051EO	0.23	0.35	0.15	0.27
064WN	0.25	0.28	0.09	0.78
064WO	0.21	0.21	0.03	0.24
079WN	0.24	0.35	0.21	2.03
079WO	0.04	0.89	0.00	0.41
100WN	0.00	0.05	0.16	0.32
100WO	0.00	0.38	0.04	0.13
116EN	0.00	2.25	0.00	1.50
121WN	0.17	1.97	0.07	1.48
133WN	0.04	0.17	0.13	1.26
136EN	0.28	1.09	0.03	2.63
136EO	0.24	1.08	0.12	1.40
148EN	0.16	0.32	0.10	1.42
167WN	0.56	0.84	0.13	1.28
200EN	0.55	1.39	0.00	0.55
203WN	0.38	0.38	0.24	0.24
203WO	0.00	0.00	0.00	0.00
219WN	0.40	0.80	0.03	0.87

[a] Smallmouth bass, largemouth bass, northern pikeminnow, and walleye ≥ 250mm fork length.

[b] Peamouth chub of all sizes and northern pikeminnow < 250mm.

[c] Black crappie, bluegill, pumpkinseed, white crappie, and yellow perch of all sizes; smallmouth and largemouth bass < 250mm.

[d] Largescale suckers and unidentified suckers of all sizes.

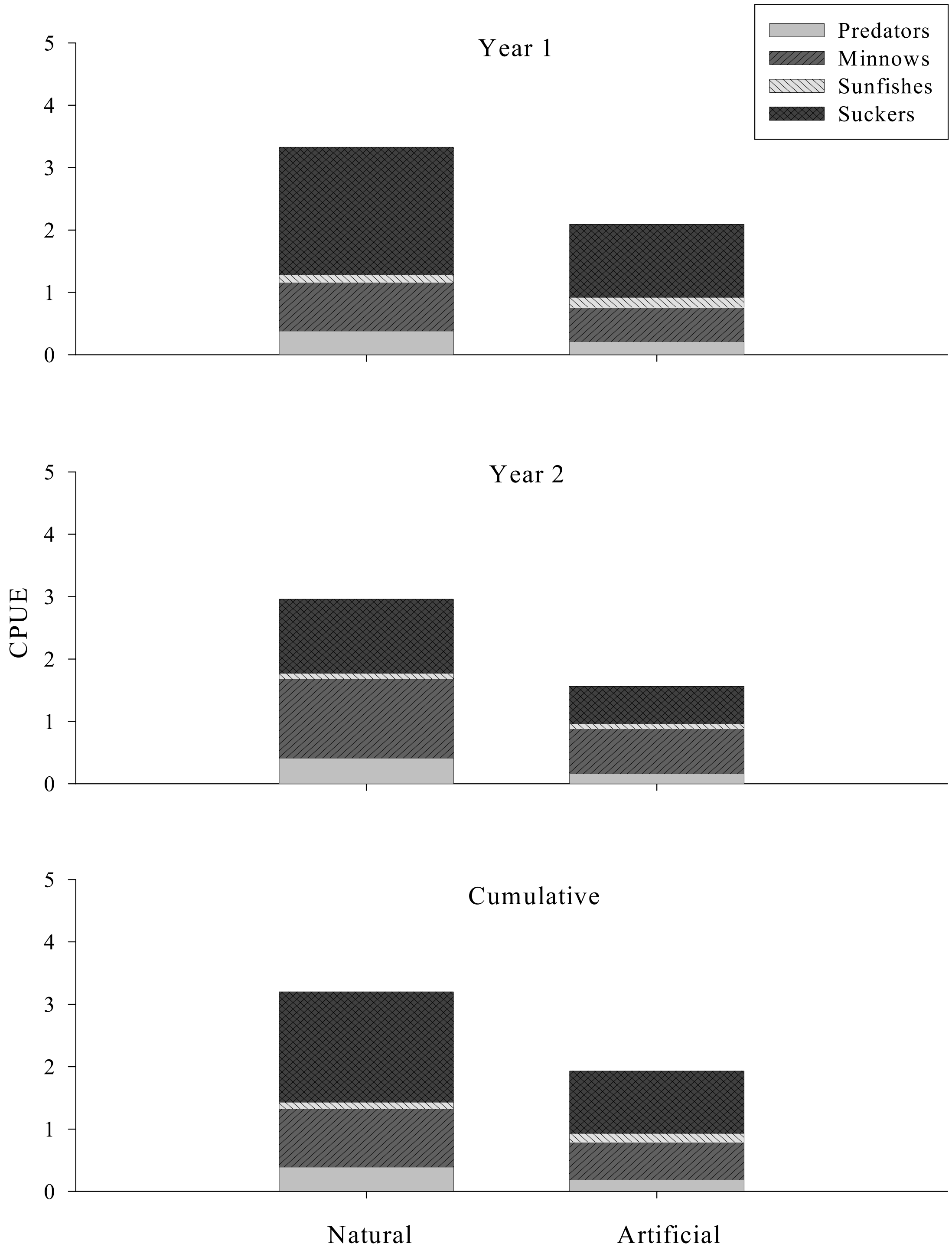

Figure 25. Electrofishing catch per unit effort of potential predator fishes and other resident family groups among natural and artificial habitat categories in the lower Willamette River, May 2000 – June 2002. The artificial category includes sites containing artificial structures (e.g. seawall, riprap, pilings).

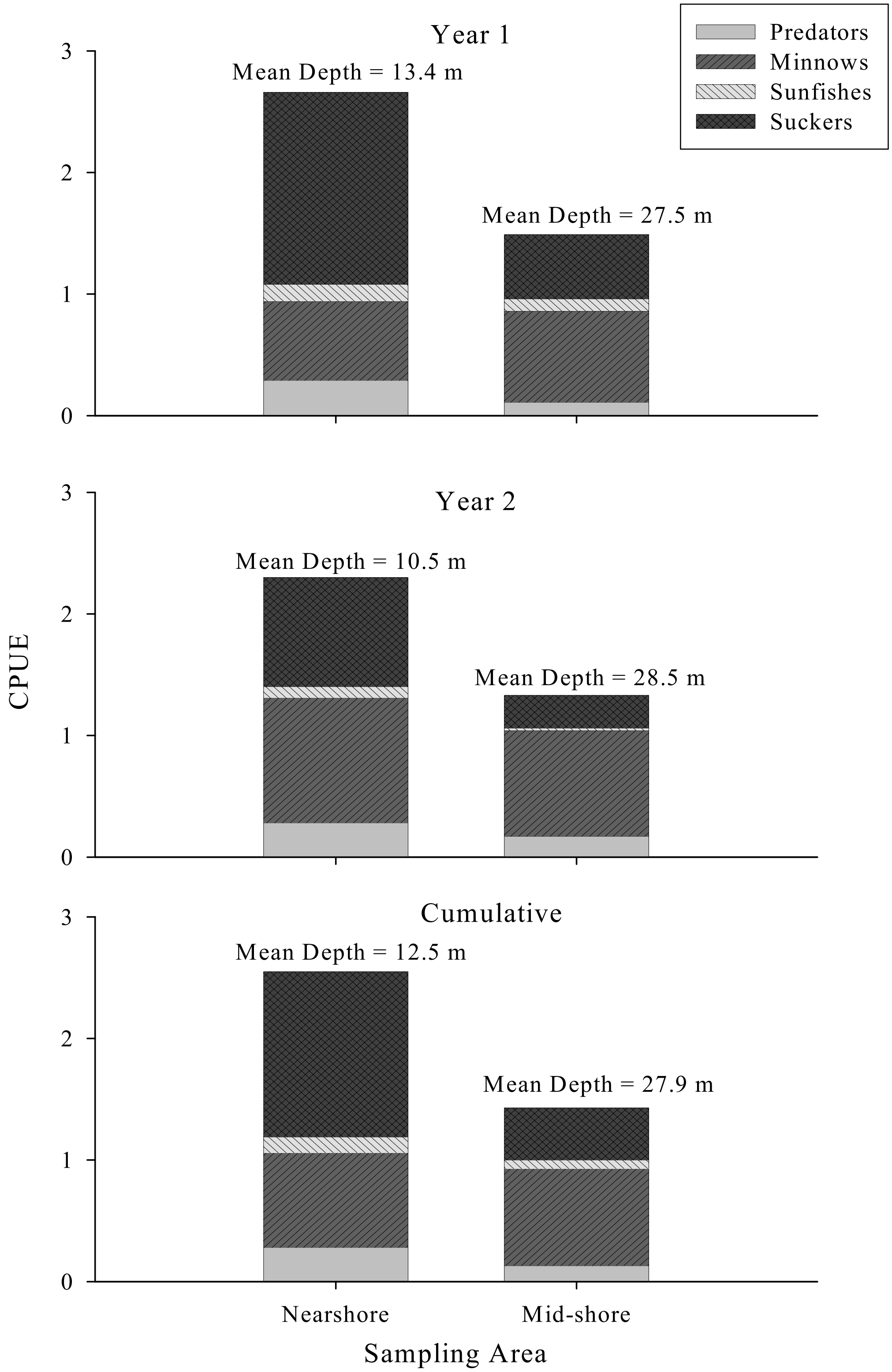

Figure 26. Gillnetting catch per unit effort (CPUE) of potential predator fishes and other resident family groups by proximity to shore in the lower Willamette River, May 2000 through June 2002.

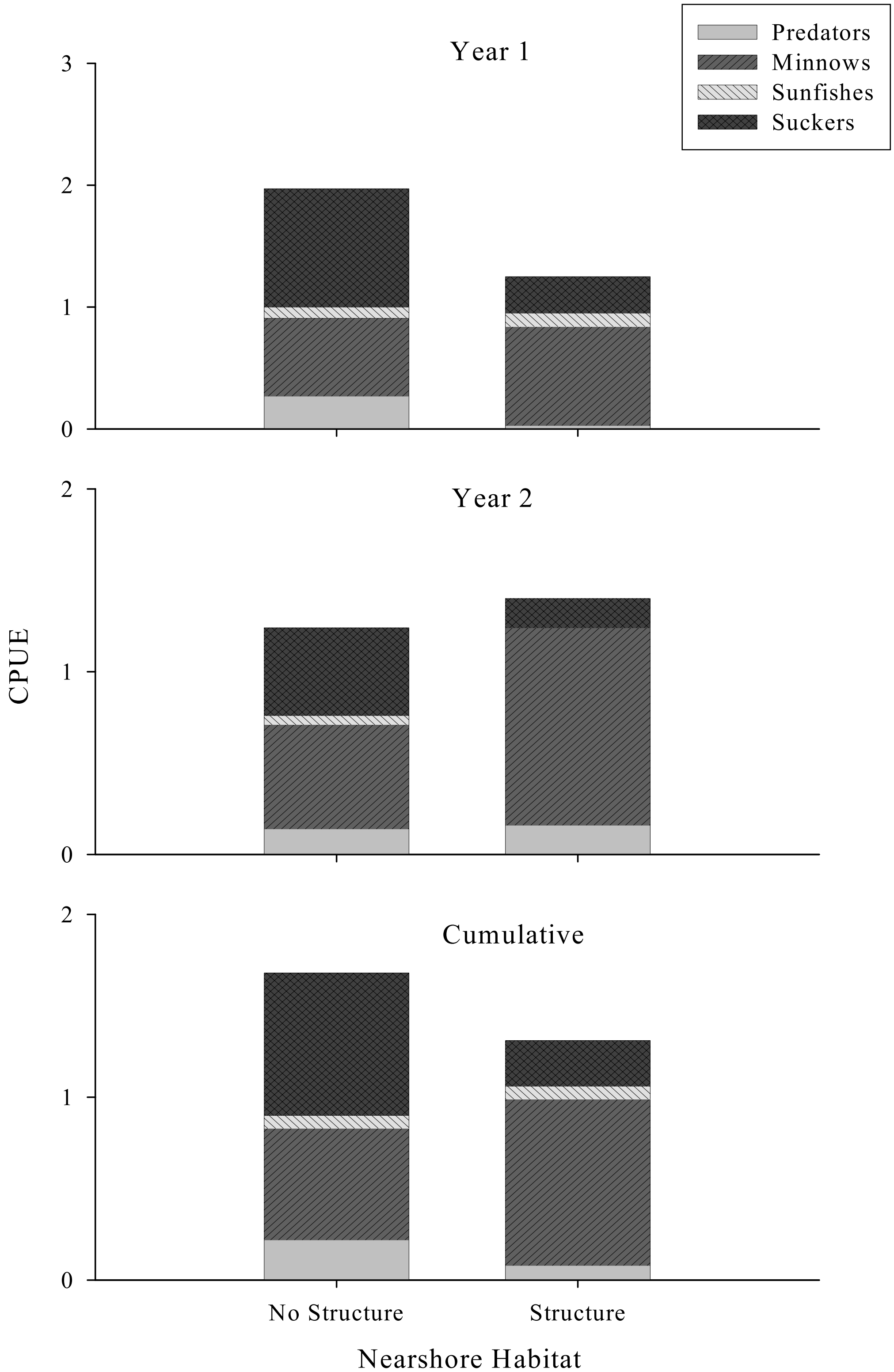

Figure 27. Gillnetting catch per unit effort (CPUE) of potential predator fishes and other resident family groups by presence/absence of nearshore structure in the lower Willamette River, May 2000 through June 2002.

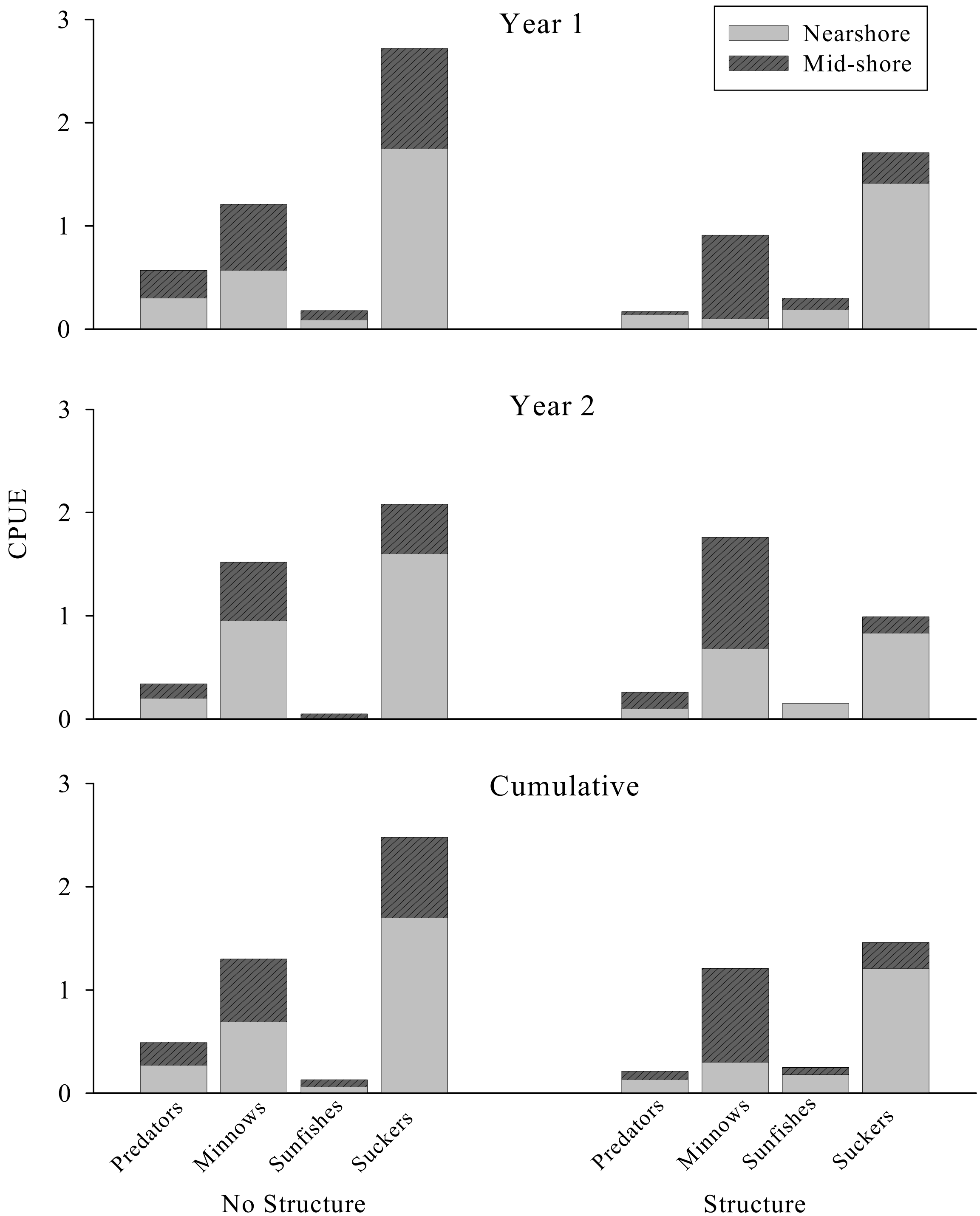

Figure 28. Gillnetting catch-per-unit-effort (CPUE) of potential predator fishes and other resident family groups by presence/absence of nearshore structure in the lower Willamette River, May 2000 through June 2002.

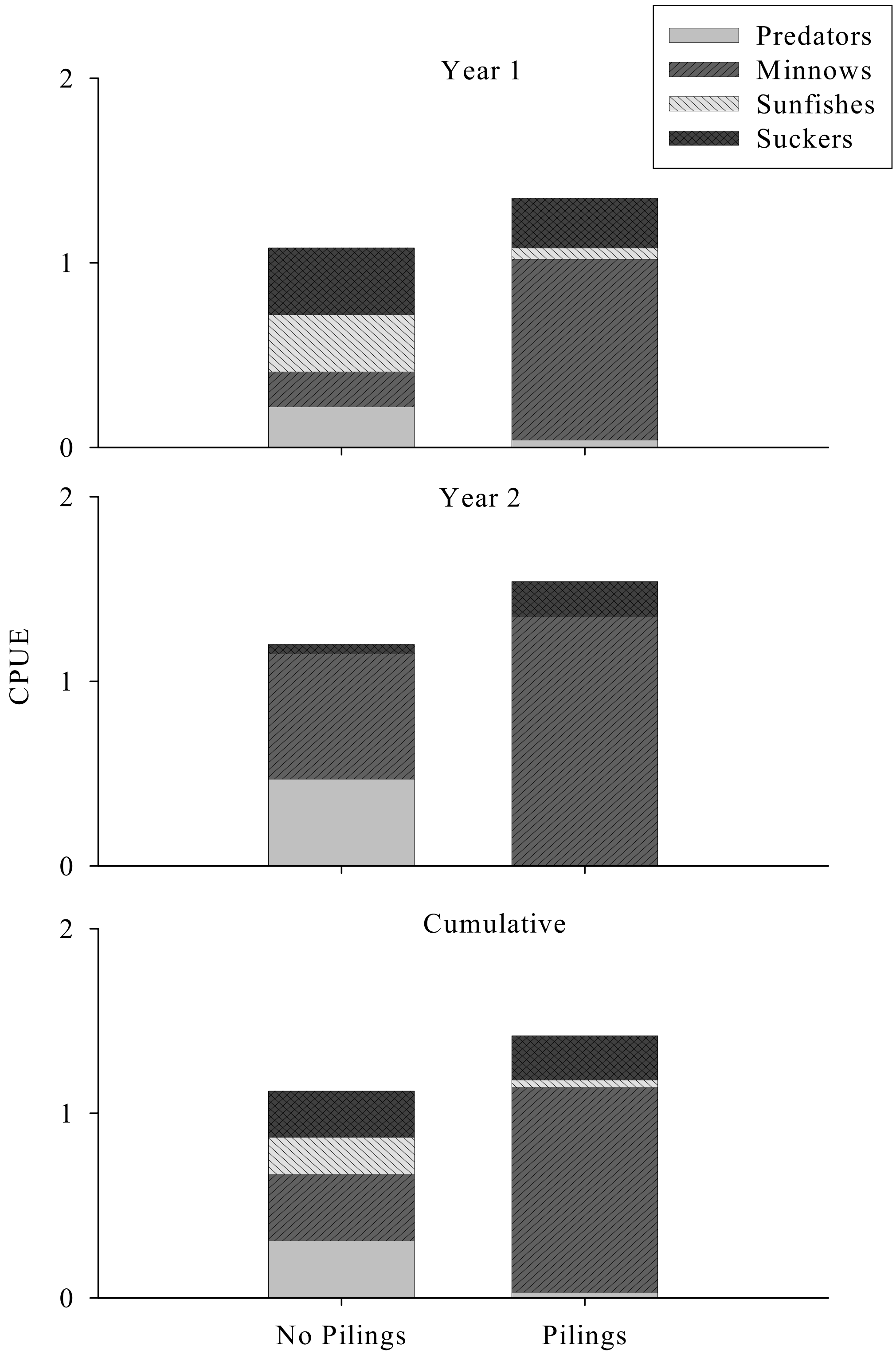

Figure 29. Gillnetting catch per unit effort (CPUE) of potential predator fishes and other resident family groups by presence/absence of pilings in the lower Willamette River, May 2000 through June 2002.

patterns of abundance at these sites were similar between year 1 and year 2 (Figure 30). Suckers in particular were more abundant at piling sites allowing light than at light-limited piling sites (2.03 fish/effort vs. 0.32 fish/effort). No predator fish were captured with gillnets at light-limited piling structures.

We found few significant differences in gillnet catch rates of resident fish species among bank treatment and bank habitat types (Figures 31 and 32; Table 33). The mean CPUE for resident predators was significantly ($P < 0.01$) higher at no riprap/no structure bank habitat sites in comparison to no riprap/structure, riprap/structure, and seawall sites. Among bank treatment types, rock outcrop sites had significantly higher predator catch rates than riprap or seawall sites ($P = 0.01$). We found no significant differences in gillnet catch rates for minnows among bank habitat types, but minnows were captured at significantly ($P = 0.03$) higher rates at beach and rock outcrop bank treatment sites than at mixed habitat sites. Gillnet catch rates for sunfishes did not vary significantly among habitat types or bank treatment types. The CPUE for suckers was significantly ($P < 0.01$) higher at no riprap/no structure habitat types compared to no riprap/structure or seawall sites. In addition, gillnet CPUE for suckers was significantly ($P < 0.01$) higher at beach sites than mixed habitat, rock outcrop, or seawall bank treatments .

TASK 3.3. PREDATION AND RESIDENT FISH DIETS

Through August 2002, we collected 71 stomach content samples: 53 from northern pikeminnow, 14 from smallmouth bass, 2 from walleye, and 2 from largemouth bass (Table 34). Most (69%) stomach samples contained no food; however, empty stomachs were considerably more common for northern pikeminnow (77%) than the other three species (44%). Prey fish remains were observed in both walleye stomach samples, 29% of smallmouth bass samples, and 8% of northern pikeminnow samples. Of the ten samples containing prey fish remains, only one possessed diagnostic bones necessary for species identification (a sculpin from a smallmouth bass stomach). Crayfish were the most common food item, occurring in 11 of the 22 samples containing food. One northern pikeminnow stomach contained 3.9 g of yellow corn. Because of the relatively small number of samples and low incidence of predation on fishes, we did not attempt to identify statistical differences in predation among habitat or bank treatment types.

DISCUSSION

The primary objective of this study is to evaluate and describe the nature of relationships between fish communities and riverbank habitat. A number of factors make this a challenging task, including the number and variety of species and habitat parameters present, frequently changing conditions (e.g. river flow), and confounding factors such as sampling effectiveness. Relationships are likely to be weak because many fish, especially migrating salmonids, move often and may not always be associated with their preferred habitat. Habitat preferences by individual species are likely driven by a number of related variables (especially in a large river). Despite these difficulties, in year 2 we identified several relationships between bank habitat and fish use, and broadened our knowledge of lower Willamette River fish community dynamics.

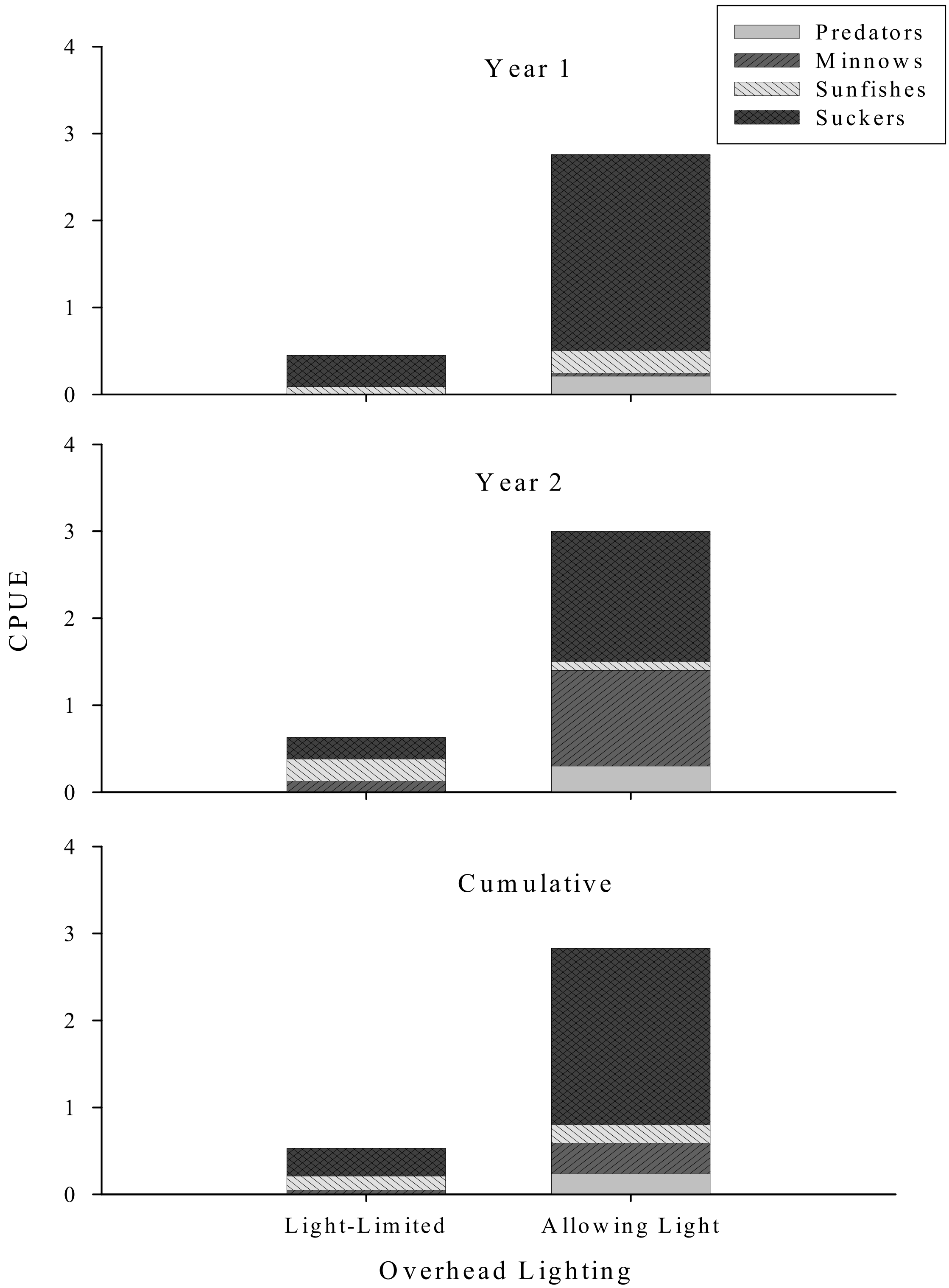

Figure 30. Gillnetting catch per unit effort (CPUE) of potential predator fishes and other resident family groups by lighting type of nearshore piling structures in the lower Willamette River, May 2000 through June 2002.

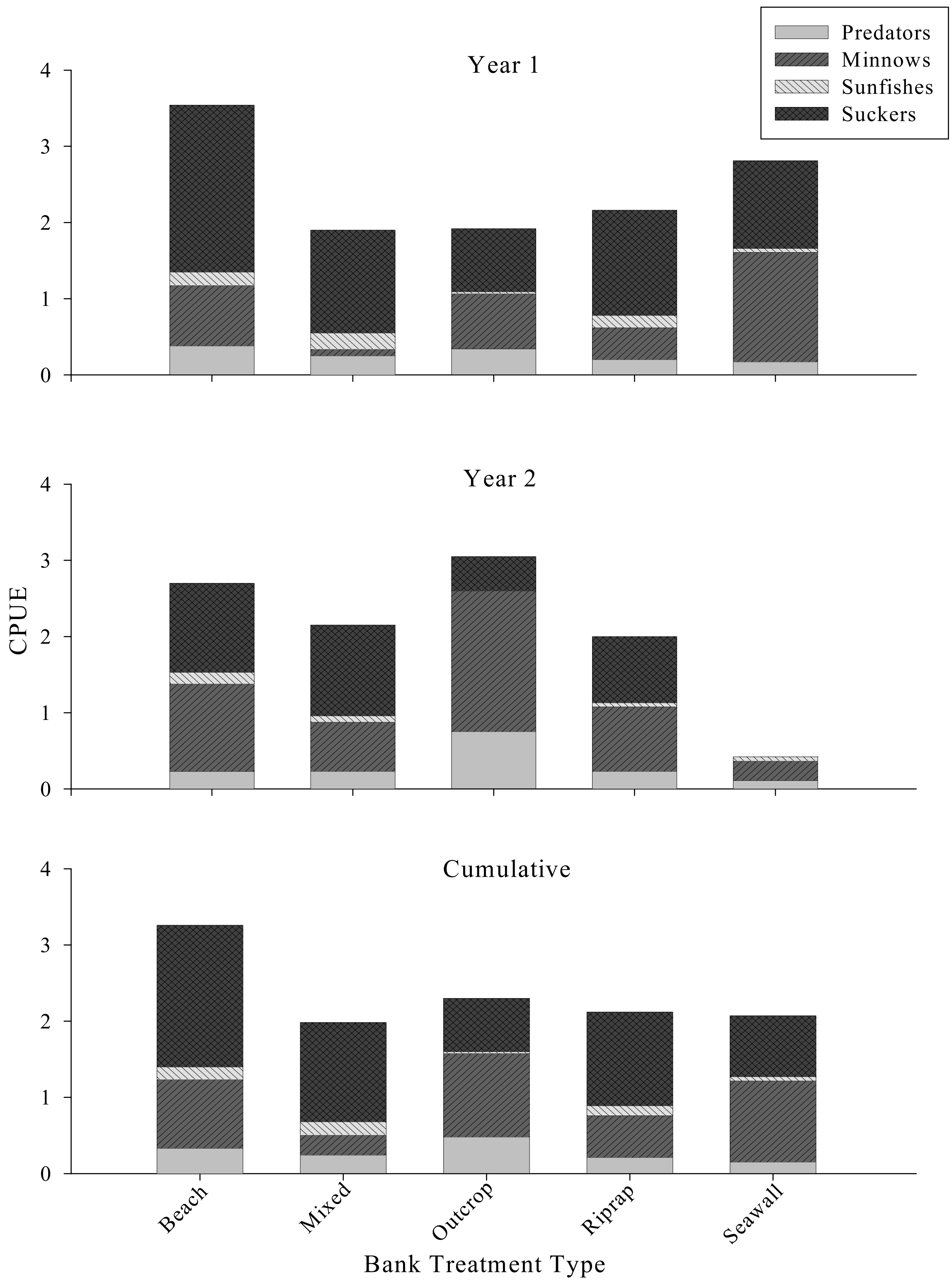

Figure 31. Gillnetting catch per unit effort (CPUE) of potential predator fishes and other resident family groups by bank treatment type in the lower Willamette River, May 2000 through June 2002.

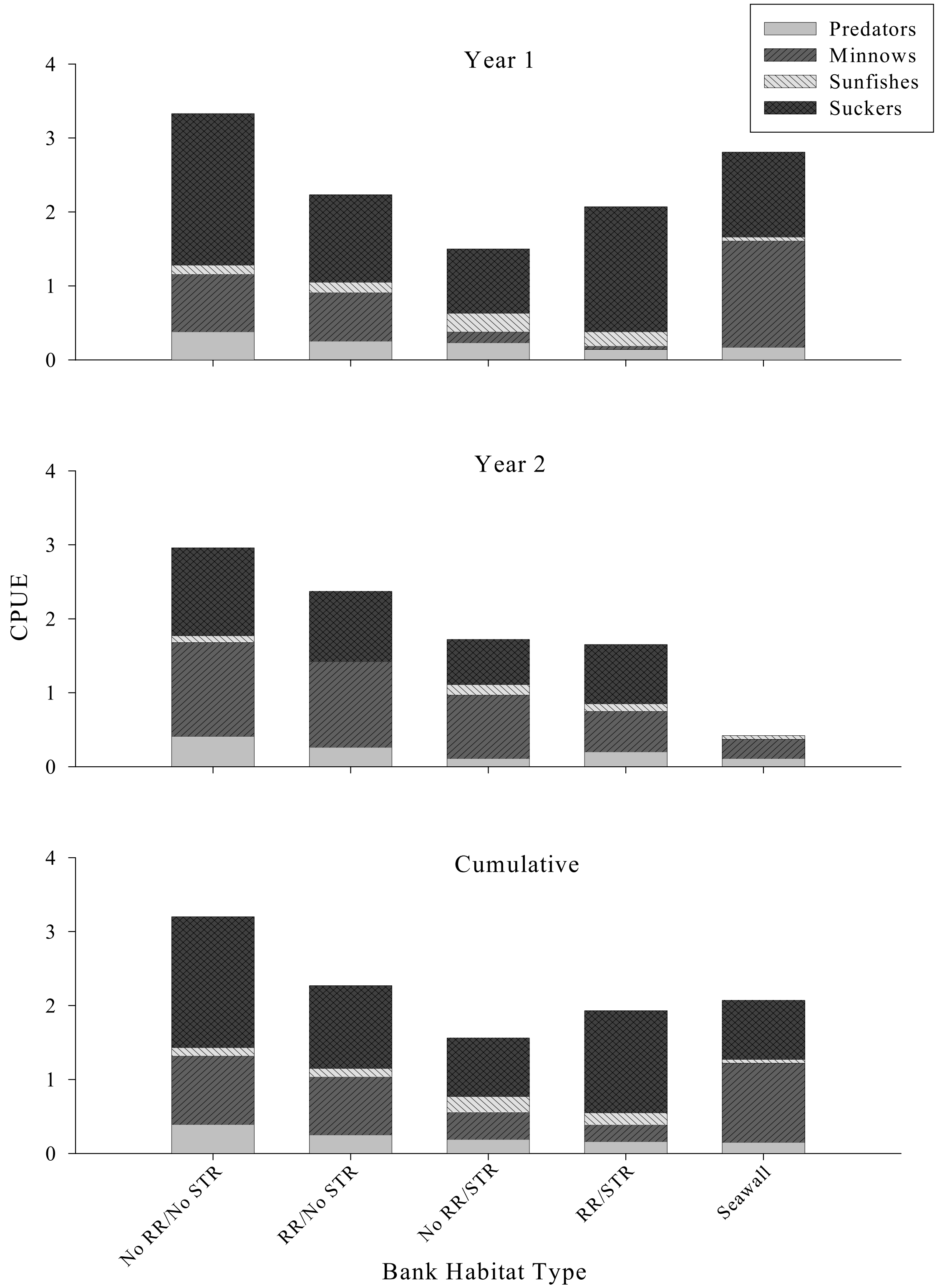

Figure 32. Gillnetting catch per unit effort (CPUE) of potential predator fishes and other resident family groups by habitat type in the lower Willamette River, May 2000 through June 2002. RR=Riprap; STR=Structure.

Table 33. Probability (*P*) and significance of mean gillnetting catch per unit effort (CPUE) among habitat categories in the lower Willamette River, May 2000 through June 2002. Within each fish group and α value, variables without a letter in common differed significantly at the indicated level.

	CPUE (Dependent variable)							
	Predator Fishes		Minnows		Sunfishes		Suckers	
Independent Variable	α=0.05	α=0.10	α=0.05	α=0.10	α=0.05	α=0.10	α=0.05	α=0.10
Habitat Type	*P*<0.01		*P*=0.03		*P*=0.21		*P*<0.01	
No Riprap/No Structure	a	a	a	a	a	a	a	a
Riprap/No Structure	ab	ab	a	a	a	a	ab	ab
No Riprap/Structure	ab	b	a	a	a	a	b	b
Riprap/Structure	ab	b	a	a	a	a	ab	ab
Seawall	b	b	a	a	a	a	b	b
Bank Treatment Type	*P*=0.01		*P*=0.03		*P*=0.11		*P*<0.01	
Beach	ab	ab	a	b	a	a	a	a
Mixed	ab	ab	a	a	a	a	b	b
Rock Outcrop	a	a	a	b	a	a	b	b
Riprap	b	b	a	ab	a	a	ab	ab
Seawall	b	b	a	ab	a	a	b	b
Natural vs. Artificial	*P*<0.01		*P*=0.06		*P*=0.47		*P*<0.01	

Table 34. Summary of stomach samples collected from resident predator fishes in the lower Willamette River, January – August, 2002.

Species	Number of Samples	Samples containing food	Samples containing fish	Other contents (number of samples)
Northern pikeminnow	53	12	4	crayfish (7); corn (1)
Smallmouth bass	14	6	4	crayfish (2)
Largemouth bass	2	2	0	crayfish (2)
Walleye	2	2	2	none

The nature of habitat use by juvenile salmonids remains somewhat unclear; however, the additional data collected in year 2 has allowed us to identify some differences in juvenile salmonid density among habitat and bank treatment types (few differences were apparent in year 1; North et al. 2002). The strong statistical significance of these relationships (i.e., low *P* values) suggests juvenile salmonids do exhibit preferences for some habitat types, especially alcoves and natural habitat types. Our findings must be interpreted with some caution, as differential sampling efficiency may render catch rates for some habitat types incomparable. For example, CPUE of juvenile salmonids at seawall sites was consistently and significantly lower than CPUE for other habitat types. Seawall sites are characterized by very deep water (30-60 feet) close to the shoreline. As boat electrofishing is effective only to a depth of approximately 10 feet, we did not sample the entire water column; therefore, catch rates from seawall sites are probably not comparable to catch rates from shallower sites. We will consider adjusting catch rates according to depth or eliminating problematic sites from future analyses. In addition, our analyses to date are limited to a relatively small number of general categories. Future work will include multivariate analyses and a wider range of specific variables. For example, we will analyze salmonid species separately instead of grouping them into one category; analyses addressing life stage and origin (hatchery vs. naturally produced) may also be appropriate for habitat comparisons. North et al. (2002) found no specific habitat parameters that predicted juvenile salmonid density. We plan to resurvey and collect habitat data from each site during year 3, effectively doubling our sample size to better address this topic.

Radio telemetry results provided additional insight into juvenile salmonid habitat use, though these results did not always support the relationships suggested by CPUE comparisons. As in year 1, a disproportionately high number of nearshore telemetry recoveries occurred at natural rock outcrop sites, suggesting juvenile salmonids may select rock outcrops as a preferred habitat. However, electrofishing catch rates at rock outcrop sites were not significantly different from other bank treatment types. In addition, telemetry recoveries did not indicate a strong affinity among juvenile salmonids for nearshore areas.

Resident fish exhibited similar habitat use patterns. Predator fish appeared to overutilize riprap during year 1 radio telemetry (North et al. 2002), but CPUE of predators was not significantly different among any of the habitat and bank treatment types through year 2. Northern pikeminnow, walleye, smallmouth bass, and largemouth bass grow to large sizes and are active predators (Vigg et al. 1991); their behavior is probably not predicted entirely by bank habitat type. This is supported by other data. Gillnets select for larger fish, and gillnet catches of resident fish were not significantly different among most habitat types. Smaller fish, requiring complex habitat for cover and feeding, may be more closely associated with specific bank types. Sunfish (including largemouth bass and smallmouth bass <250 mm fork length) were captured at significantly higher rates at sites containing both riprap and structures. This is an important observation, as these artificial habitat types may encourage colonization by introduced species (no sunfish are native to Oregon) and enhance the recruitment of juvenile salmonid predators.

We have collected a great deal of data on timing, species composition, size, and origin of juvenile salmonid outmigrations in the lower Willamette River, all of which may be pertinent to future development issues and the protection of ESA-listed species. Beach seining and electrofishing surveys were relatively consistent among years: juvenile salmonids were present during every month surveyed, with catches increasing from November through March, peaking in April, and tapering to near zero by July. High November-December catch rates observed in year 1 were not apparent in year 2. Variations in the timing of outmigrations may be explained by differences in river flow; 2000-2001 (year 1) was characterized by late rains and periods of extremely low water in the lower Willamette River, whereas 2001-2002 (year 2) river levels were relatively normal. A third year of data (currently being collected) may help clarify variations in migration timing. Our field observations indicate most unidentified salmonids were chinook salmon; therefore, this species composes the vast majority of all juvenile salmonids utilizing the lower Willamette River. Steelhead were rarely observed, and coho salmon were observed in relatively high numbers only during May and June.

Because ESA restrictions prevented us from collecting tissue or scale samples from listed species, the identification of individual salmonid races must be inferred from length-frequency data. Fall chinook salmon typically outmigrate as sub-yearlings (age 0+), whereas spring chinook remain in fresh water for approximately one year (age 1+; Wydoski and Whitney 1979). Considerable rearing may occur well away from the Willamette River (e.g. the Columbia River estuary); therefore, many sub-yearling fish we observed may have been spring chinook that would eventually rear elsewhere. Additionally, fish originating from streams in the upper watershed may grow significantly before reaching the study area. Three distinct groups of juvenile chinook salmon were evident in length frequency analyses. We speculate these represent (1) small sub-yearling fall and spring chinook salmon from lower Willamette River tributaries, (2) larger sub-yearling fall and spring chinook salmon from upper Willamette River tributaries and the mainstem Willamette River, and (3) a small number of spring chinook salmon that have reared to age 1+ in the Willamette River. Mean fork lengths of unmarked spring chinook captured in summer and autumn were larger and significantly different from those captured in winter and spring, providing some support for this observation.

Juvenile salmonids spending extended amounts of time (i.e. rearing) in the lower Willamette River would be expected to grow as they move downstream. Comparisons of mean fork length among upstream and downstream beach seining sites did not indicate unmarked sub-yearling chinook salmon increase in length during this portion of their migration. To the contrary, fish captured at upstream sites were significantly larger than fish captured at downstream sites during some months. This is probably an artifact of relatively small monthly sample sizes (mean n=91); seasonal comparisons with larger sample sizes (mean n=365) indicated virtually no difference in fork length among upper and lower sites during any season. Radio telemetry results suggested some fish do spend extended amounts of time in the study area. Four steelhead and one yearling chinook salmon captured in Clackamette Cove apparently returned to the cove after their release approximately 1.0 mile downstream, and were not subsequently relocated elsewhere (these fish were not included in migration rate analyses). In addition, a juvenile steelhead was relocated several times in the lower reach of Tryon Creek, and each successive relocation was further upstream within the creek. In both of these instances, fish were using off-channel habitat and were not actively migrating downstream, suggesting some incidence of rearing.

Because we collected relatively few stomach samples from resident fish, and many samples contained no food, we did not attempt to relate predation to bank habitat or individual habitat parameters. This small sample size, and the relatively low densities of predators observed, indicates predation is not a major factor influencing juvenile salmonid mortality in the lower Willamette River. Ward et al. (1994) reported somewhat higher predation by northern pikeminnow in this area; the proportion of stomach samples containing salmonids ranged from 0.07 to 0.29 at nine sampling sites. Another ODFW study documented very low levels of predation on juvenile salmonids by northern pikeminnow at other locations in the Willamette basin; principle food items included insects, crayfish, and sculpins, and only 2.0% of stomachs examined contained salmonids (Buchanan et al. 1981). Smallmouth bass can be important predators on juvenile salmonids, but consume a greater number of sculpins, minnows, and crayfish, even when salmonids are abundant (Zimmerman 1999). We observed very few largemouth bass, walleye, or other potential predators; their contribution to salmonid predation is probably negligible. Assuming we continue to collect a modest number of predator stomach samples, we will likely be able to calculate some basic statistical comparisons, for example, differences in predation rates among natural and artificial habitat types.

PLANS FOR 2003

Task 1.1: Selection of Sampling Sites

We do not anticipate any sampling site changes for 2003.

Task 1.2: Habitat Evaluation

We have completed the task of mapping and inventorying available bank habitat types and nearshore structures above mean low water. Data on individual habitat parameters has been collected twice, in October 2000 and March 2001. Because of increasing interest in specific factors driving habitat utilization, we plan to repeat detailed habitat surveys once per season for four seasons, beginning in autumn 2002. The additional data collected from these surveys will provide larger sample sizes for comparisons of fish abundance versus habitat characteristics.

Task 2.1: Juvenile Salmonid Radio Telemetry

Juvenile salmonid telemetry methods during 2002 were similar to those in 2001, except we reduced the number of fixed sites to four. This work will be replicated for the third consecutive year in spring 2003. We intend to eliminate all fixed site receivers in 2003, concentrating our efforts on mobile tracking. The fixed sites are expensive, prone to data errors because of interference, and do not provide any information on habitat use.

Task 2.2: Standardized Sampling for Juvenile Salmonids

We plan to continue beach seining weekly through the end of 2002 to address whether juvenile salmonids rear in the study area. Sampling of standard and alcove sites will continue at least until July 2003. Assuming the appropriate permits are obtained, we will continue collecting length and weight information on juvenile salmonids caught incidentally while boat electrofishing. This is a valuable tool for several tasks because of the number and variety of salmonids that can be collected.

Task 2.3: Juvenile Salmonid Diets

Using non-lethal techniques (lavage), we began collecting juvenile salmonid stomach samples in September 2002. Stomach contents will be analyzed and compared with samples from select resident fish to address competition. Assuming adequate sample sizes, we will compare diets of juvenile salmonids among habitat types and bank treatments.

Task 3.2: Standardized Sampling for Resident Fish

As with juvenile salmonids, we plan to continue standardized sampling of resident fish through July 2003. Gillnet effort may be reduced to facilitate new tasks. Indices of community structure will be developed and used to compare biotic integrity among habitat types. We will also apply more robust statistical tests to better analyze differences in fish communities among habitat types.

Task 3.3: Resident Fish Diets

We will continue to collect stomach samples from resident predator fish in 2003. These samples will be analyzed to evaluate predation on salmonids in relation to habitat type. Diets of other select resident fish (collection of samples began in August 2002) will be analyzed to determine the dietary overlap of introduced species with juvenile salmonids.

Task 4.1: Macroinvertebrate Sampling

In 2003, we will begin to collect benthic invertebrate samples with substrate grabs to classify community structures among habitat types. We intend to collect eight grab samples per site per season. Surface and/or mid-water samples will also be collected to evaluate terrestrial and other invertebrate communities. Where possible, we will relate invertebrate surveys to juvenile salmonid and resident fish diets.

Task 4.2: Sediment Sampling

Sediment samples will be collected concurrent with Task 4.1 to describe riverbed composition among habitat types and seasons.

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The use of trade names does not imply endorsement by the Oregon Department of Fish and Wildlife.

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APPENDIX A

Electrofishing Protocols

Appendix A. Electrofishing protocols incorporated to reduce impacts on juvenile salmonids in the lower Willamette River, May 2000 through June 2002.

- Reduced average range of electrical output from 3.0-3.5 to 1.0-2.0 amperes.
- Electrofishing procedures followed the National Marine Fisheries Service protocols (Guidelines for electrofishing waters containing salmonids listed under the endangered species act, June 2000).
- Project personnel obtained and reviewed "Principles and techniques of electrofishing" training course offered by the U. S. Fish and Wildlife Service-National Conservation Training Center.
- Obtained personal on-the-water training by staff of Smith-Root.
- Reduced voltage output to minimize injury to adult and juvenile salmonids.
- Changed pulse width and wave form to maximize taxis of juvenile salmonids.
- Eliminated sampling at a few areas where juvenile salmonid densities were highest.
- Adult salmonids were not handled.
- Limited electrical-field exposure of juvenile salmonids to 10 seconds.
- Collection of juvenile salmonids for length and weight measurements was limited to fish that could be collected within the 10-second exposure time limit and any remaining stunned fish. Remaining individuals were enumerated rather than handled.
- Avoided reintroduction of dipped fish to the energized field.
- Large concentrations of juvenile salmonids were bypassed after initial detection to avoid repeated exposure to the energized field.
- Stunned fish nearest the anodes were dipped first to avoid contact.
- Used a designated boom configuration for even distribution of the energized field.

APPENDIX B

Habitat Parameter Data

Appendix B; Table 1. Water column[a] velocities (cm/s) of sampling sites in the lower Willamette River, October 2000 and March 2001.

	October 2000											March 2001										
	Shore zone (0-25m)					Shore zone (26-50 m)						Shore zone (0-25m)					Shore zone (26-50 m)					
	Site Quartile[b]					Site Quartile[b]						Site Quartile[b]					Site Quartile[b]					
	2		4			1		3			Site	2		4			1		3			Site
Site	S	B	S	B	Mean	S	B	S	B	Mean	mean	S	B	S	B	Mean	S	B	S	B	Mean	mean
006E	*	*	0.9	1.2	1.0	6.3	3.1	3.7	13.3	6.6	4.7	*	*	16.9	*	16.9	*	*	19.8	9.0	14.4	15.2
010E	3.0	6.5	9.7	8.9	7.0	0.8	1.5	10.2	13.0	6.4	6.7											
012W	11.4	3.0	3.0	3.0	5.1	13.0	13.9	1.4	2.2	7.6	6.3											
031W	*	*	*	*	0.0	8.6	*	24.2	*	16.4	16.4											
040W[c]	*	*	*	*	0.0	5.2	2.9	*	*	4.1	4.1											
048E	0.4	0.4	0.8	5.2	1.7	0.4	5.4	5.3	4.9	4.0	2.8	5.5	6.6	4.8	1.0	4.5	20.1	19.3	10.3	23.4	18.2	11.4
051E	13.1	10.3	1.9	1.3	6.6	*	*	6.7	4.0	5.3	6.2	0.8	*	0.7	*	0.7	*	*	6.7	3.6	5.1	2.9
064W	2.6	0.9	0.8	1.5	1.5	3.9	3.1	8.3	1.6	4.2	2.8	1.1	*	0.5	0.1	0.6	20.3	16.1	12.4	17.7	16.6	9.7
079W	3.2	0.8	1.3	*	1.8	0.7	2.9	0.9	2.1	1.6	1.7	0.0	2.0	1.6	0.3	1.0	3.4	*	0.1	1.9	1.8	1.3
097E	*	*	*	*	0.0	16.1	8.6	10.9	*	11.9	11.9											
100W	2.7	3.1	0.4	0.8	1.7	0.0	0.6	2.2	1.8	1.1	1.4											
112E	0.4	0.1	0.0	0.5	0.2	7.5	4.5	1.5	0.0	3.4	1.8											
118W	0.6	1.7	1.1	9.6	3.2	1.4	11.2	5.5	9.6	6.9	5.1											
121W	18.7	12.1	0.6	1.2	8.1	10.9	7.6	17.2	10.7	11.6	9.9											
133W	*	*	0.2	0.9	0.5	2.0	*	5.9	2.3	3.4	2.3	*	*	*	*	*	*	*	13.2	*	13.2	13.2
136E	*	*	0.2	0.8	0.5	5.7	5.1	5.8	1.7	4.5	3.2	*	*	*	*	*	8.6	8.6	5.9	1.7	6.2	6.2
148E	1.7	2.7	4.3	*	2.9	1.8	1.7	7.0	5.5	4.0	3.5											
167W	0.0	*	0.1	0.5	0.2	0.2	0.5	0.2	0.5	0.4	0.3	4.6	*	*	*	4.6	3.0	0.7	7.9	5.8	4.3	4.4
200E	2.4	1.5	21.0	9.2	8.5	24.1	17.4	28.9	12.0	20.6	14.6											
203W	0.1	1.1	0.1	0.4	0.4	5.7	13.8	1.3	9.7	7.6	4.0	1.8	5.8	3.4	5.9	4.2	20.8	13.9	8.4	2.9	11.5	7.9
219W	15.4	10.8	6.5	4.5	9.3	20.1	16.4	5.3	10.7	13.1	11.2	10.7	22.9	3.9	26.0	15.9	*	*	88.9	27.7	58.3	30.0
243W	0.3	0.7	0.2	1.0	0.6	0.1	2.6	0.1	0.2	0.7	0.7											

[a] Velocities collected 1 m below surface (S) and 1 m above river bed (B) at random points within each site quartile.
[b] Site quartiles are: 1=0-25%; 2=26-50%; 3=51-75%; and 4=76-100% of site length.
[c] Short transect; data collected in quartiles 1-2 (0-50% of site length) and quartiles 3-4 (51-100% of site length).
An asterisk (*) indicates velocities could not be measured due to shallow water.

Appendix B; Table 2. Depth profiles (m) of sampling sites in the lower Willamette River, October 2000 and March 2001.

	October 2000								March 2001							
	Distance from shore (m)							Site Mean	Distance from shore (m)							Site Mean
Site	5	10	15	20	30	40	50		5	10	15	20	30	40	50	
006E	0.4	0.8	1.6	3.0	5.2	7.5	10.4	4.1	0.4	0.5	1.2	2.2	3.7	6.1	7.9	3.2
010E	0.4	1.0	2.9	5.1	6.2	7.2	8.7	4.4								
012W	0.6	0.8	1.5	3.9	6.6	8.5	9.2	4.4								
031W	0.4	0.6	0.7	0.9	1.4	2.4	3.2	1.4								
040W[a]	0.5	0.5	0.7	1.1	1.7	3.5	7.7	2.2								
048E	14.8	14.7	15.0	15.6	16.3	18.0	19.6	16.3	13.7	13.7	13.6	13.6	14.4	15.1	16.5	14.4
051E	1.9	2.8	4.0	6.1	8.9	11.1	13.0	6.4	1.1	3.1	4.6	5.9	9.1	11.2	13.1	6.6
064W	0.7	2.5	6.2	9.0	12.1	14.5	15.1	8.6	0.9	1.7	3.3	4.8	7.9	10.9	12.1	5.9
079W	0.6	1.8	3.0	6.2	9.1	11.2	12.8	6.4	0.9	1.8	2.8	4.3	6.4	8.6	9.9	4.7
097E	0.6	0.8	1.3	1.5	2.5	3.8	5.1	2.2								
100W	3.3	4.9	6.3	7.1	7.4	8.3	8.9	6.6								
112E	2.2	4.1	6.4	10.9	12.4	13.4	14.8	9.2								
118W	3.0	6.1	8.9	12.6	15.6	17.3	17.7	12.0								
121W	11.1	11.0	12.3	14.9	16.8	16.9	17.5	14.4								
133W	0.5	1.0	1.3	1.6	2.0	2.3	2.5	1.6	0.8	1.5	1.8	2.0	2.6	2.9	3.2	2.1
136E	0.8	2.6	3.7	4.7	7.7	10.1	10.8	5.7	0.8	3.1	4.0	5.0	7.5	9.3	10.6	5.8
148E	0.5	1.4	2.7	3.7	4.8	6.0	6.9	3.7								
167W	0.2	1.3	3.1	4.9	8.2	9.7	12.9	5.8	0.4	1.1	1.6	3.3	4.9	7.5	9.8	4.1
200E	4.5	9.2	11.8	16.2	19.2	20.9	21.1	14.7								
203W	1.9	5.8	6.6	10.5	13.3	16.1	19.0	13.3	1.2	4.1	9.0	11.3	13.4	16.9	19.6	13.5
219W	12.3	18.5	19.0	21.8	20.0	17.9	21.9	18.8	4.5	8.8	13.4	14.4	18.6	20.2	17.1	13.9
243W	1.2	2.8	5.1	6.2	6.2	6.5	6.5	4.9								

[a] Short site; data collected at 0, 50, and 100% of length.

Appendix B; Table 3. Percent[a] overhead cover (natural and artificial) of sampling sites in the lower Willamette River, October 2000 and March 2001.

	October 2000						March 2001					
	Site Percentile (0=upstream)						Site Percentile (0=upstream)					
Site	0	25	50	75	100	Site mean	0	25	50	75	100	Site mean
006E	0	0	0	0	0	0	0	0	0	0	0	0
010E	0	25	25	12	0	12						
012W	0	0	0	0	0	0						
031W	0	0	0	0	0	0						
040W	0		0		0	0						
048E	0	0	0	0	0	0	0	0	0	0	0	0
051E	50	0	12	25	12	20	25	0	12	12	12	12
064W	0	0	0	0	0	0						
079W	12	12	88	12	0	25						
097E	0	0	0	0	0	0						
100W	75	88	100	25	25	63						
112E	0	12	50	25	12	20						
118W	0	0	25	0	0	5						
121W	0	0	0	0	0	0						
133W	0	0	0	0	0	0						
136E	0	0	0	0	0	0						
148E	0	0	0	0	0	0						
167W	0	0	0	0	0	0						
200E	0	0	0	0	0	0						
203W	12	0	25	12	0	10	0	0	25	0	0	5
219W	0	0	0	0	0	0						
243W	0	0	0	0	0	0						

[a] Mean percentage of overhead cover measured at seven points (0, 5, 10, 20, 30, 40, and 50 m from shore) at 0, 25, 50, 75,and 100 percentiles of the site length.

Appendix B; Table 4. Mean[a] temperatures (°C) of sampling sites in the lower Willamette River, October 2000 and March 2001.

	October 2000											March 2001										
	Shore zone (0-25 m)					Shore zone (26-50 m)						Shore zone (0-25 m)					Shore zone (26-50 m)					
	Site Quartile[b]					Site Quartile[b]					Site	Site Quartile[b]					Site Quartile[b]					Site
Site	1	2	3	4	Mean	1	2	3	4	Mean	mean	1	2	3	4	Mean	1	2	3	4	Mean	mean
006E	6.9	6.6	6.5	6.8	6.7	6.8	6.6	6.6	6.5	6.6	6.7	7.0		7.0	7.8	7.3	7.0	7.1	7.8	7.5	7.4	7.3
010E	6.6	6.5	6.6	6.6	6.6	6.5	6.5	6.5	6.5	6.5	6.5											
012W	6.5	6.5	6.5	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.5											
031W	6.6	6.6	6.6	6.7	6.6	6.6	6.6	6.6	6.5	6.5	6.6											
040W	6.6	6.7	6.5	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6											
048E	6.5	6.6	6.6	6.6	6.5	6.6	6.6	6.6	6.6	6.6	6.6	9.1	9.1	9.1	9.2	9.1	9.1	9.1	9.1	9.1	9.1	9.1
051E	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	9.3	9.3	9.3	9.3	9.3		9.2	9.2	9.2	9.2	9.3
064W	7.4	7.4	7.5	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	10.0	10.0	9.9	10.0	10.0	9.8	9.8	9.9	9.9	9.9	9.9
079W	7.3	7.4	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	9.9	9.8	10.0	10.0	9.9	9.8	9.9	10.0	9.9	9.9	9.9
097E	7.0				7.0	6.9	7.0		7.0	7.0	7.0											
100W	6.8	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9											
112E	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4											
118W	6.8	6.8	6.8	6.7	6.8	6.8	6.8	6.8	6.8	6.8	6.8											
121W	6.8	6.8	6.8	6.8	6.8	6.7	6.8	6.8	6.7	6.7	6.8											
133W				6.9	6.9		6.8	6.8	6.8	6.8	6.8						10.0	10.0	10.0	9.9	10.0	10.0
136E	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	10.3	10.4	10.2	10.2	10.3	10.1	10.1	10.1	10.1	10.1	10.2
148E	7.4	7.4	7.3	7.3	7.4	7.4	7.4	7.3	7.4	7.4	7.4											
167W	7.4	7.4		7.5	7.5	7.4	7.5	7.5	7.5	7.5	7.5	10.2	10.3	10.4		10.3	10.2	10.2	10.2	10.2	10.2	10.2
200E	7.3	7.3	7.3	7.4	7.3	7.3	7.3	7.3	7.3	7.3	7.3											
203W	7.3	7.4	7.4	7.4	7.4	7.3	7.4	7.4	7.4	7.4	7.4	9.3	9.2	9.4	9.4	9.3	9.4	9.3	9.3	9.3	9.3	9.3
219W	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
243W	7.4	7.5	7.5	7.5	7.4	7.4	7.5	7.5	7.5	7.5	7.4											

[a] Mean of measurements at 1 m below surface, mid-column, and 1 m above river bed at random points in each site quartile.

[b] Site quartiles are: 1=0-25%; 2=26-50%; 3=51-75%; and 4=76-100% of site length.

Appendix B; Table 5. Mean[a] conductivities (micro seimens) of sampling sites in the lower Willamette River, October 2000 and March 2001.

	October 2000											March 2001										
	Shore zone (0-25 m)					Shore zone (26-50 m)						Shore zone (0-25 m)					Shore zone (26-50 m)					
	Site Quartile[b]					Site Quartile[b]					Site	Site Quartile[b]					Site Quartile[b]					Site
Site	1	2	3	4	Mean	1	2	3	4	Mean	mean	1	2	3	4	Mean	1	2	3	4	Mean	mean
006E	0.12	0.11	0.11	0.12	0.11	0.12	0.11	0.11	0.11	0.11	0.11	0.15		0.14	0.13	0.14	0.14	0.14	0.12	0.13	0.13	0.14
010E	0.11	0.10	0.10	0.10	0.10	0.11	0.10	0.10	0.10	0.10	0.10											
012W	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10											
031W	0.09	0.10	0.09	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09											
040W	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09											
048E	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.09	0.09	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09
051E	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09		0.09	0.09	0.09	0.09	0.09
064W	0.11	0.11	0.13	0.12	0.12	0.11	0.11	0.12	0.12	0.12	0.12		0.09	0.08	0.09	0.09	0.08	0.07	0.07	0.07	0.07	0.08
079W	0.10	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.07	0.07	0.07	0.07	0.07	0.06	0.07	0.06	0.07	0.07	0.07
097E	0.07				0.07	0.07	0.08		0.08	0.07	0.07											
100W	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08											
112E	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08											
118W	0.08	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08											
121W	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07											
133W				0.08	0.08		0.08	0.07	0.07	0.07	0.08						0.06	0.06	0.06	0.06	0.06	0.06
136E	0.07	0.07	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.07	0.06		0.06	0.06	0.06	0.06	0.06	0.06	0.06
148E	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08											
167W	0.08	0.08		0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.06	0.06	0.06		0.06	0.06	0.06	0.06	0.06	0.06	0.06
200E	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08											
203W	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
219W	0.08	0.08	0.07	0.08	0.07	0.08	0.08	0.08	0.08	0.08	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
243W	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08											

[a] Mean of measurements at 1 m below surface, mid-column, and 1 m above river bed at random points within each site quartile.
[b] Site quartiles are: 1=0-25%; 2=26-50%; 3=51-75%; and 4=76-100% of site length.

Appendix B; Table 6. Mean[a] dissolved oxygen (ppm) of sampling sites in the lower Willamette River, October 2000 and March 2001.

	October 2000											March 2001										
	Shore zone (0-25 m)					Shore zone (26-50 m)						Shore zone (0-25 m)					Shore zone (26-50 m)					
	Site Quartile[b]					Site Quartile[b]					Site	Site Quartile[b]					Site Quartile[b]					Site
Site	1	2	3	4	Mean	1	2	3	4	Mean	mean	1	2	3	4	Mean	1	2	3	4	Mean	mean
006E	13.4	10.7	10.7	11.0	11.5	11.3	11.0	10.9	10.8	11.0	11.2	10.8		10.4	10.2	10.5	10.3	10.8	10.0	10.2	10.3	10.4
010E	10.7	11.0	11.1	11.0	10.9	10.8	10.9	10.9	11.0	10.9	10.9											
012W	10.9	10.9	11.0	10.9	10.9	10.6	11.0	10.9	10.9	10.8	10.9											
031W	11.2	11.1	11.1	11.5	11.2	11.2	11.2	11.1	11.1	11.1	11.2											
040W	11.1	11.1	11.0	11.0	11.1	11.0	11.1	11.0	11.1	11.0	11.1											
048E	11.1	12.0	11.1	11.0	11.3	11.0	11.1	11.1	11.0	11.1	11.2	9.0	8.9	8.9	8.9	8.9	8.9	8.8	8.9	8.9	8.9	8.9
051E	11.2	11.1	11.1	11.0	11.1	11.1	11.0	11.0	11.1	11.0	11.1	8.9	8.6	8.7	8.7	8.7		9.0	8.8	9.1	9.0	8.8
064W	11.6	11.4	11.3	11.3	11.4	11.4	11.4	11.3	11.3	11.4	11.4	8.8	8.8	8.8	8.9	8.8	8.8	8.8	8.8	9.0	8.9	8.8
079W	11.0	11.3	11.2	11.1	11.1	11.1	11.2	11.2	11.2	11.2	11.2	9.0	8.8	8.8	8.6	8.8	8.8	8.7	8.8	8.8	8.8	8.8
097E	11.1				11.1	11.0	11.1		11.0	11.0	11.1											
100W	11.0	11.0	11.0	10.9	11.0	11.0	11.0	11.0	11.3	11.0	11.0											
112E	11.5	11.6	11.8	11.3	11.5	11.4	11.5	11.4	11.5	11.4	11.5											
118W	11.2	11.2	11.1	11.1	11.1	11.1	11.2	11.1	11.4	11.2	11.2											
121W	11.4	11.3	11.2	11.4	11.3	11.3	11.2	11.2	11.2	11.2	11.3											
133W				11.2	11.2		13.4	11.2	11.2	11.9	11.8				8.8	8.8	8.8	8.6	8.9	8.8	8.8	8.8
136E	11.6	11.2	11.5	11.3	11.4	11.6	11.2	11.4	11.3	11.4	11.4	8.7	8.8	8.7	8.6	8.7	9.0	8.9	8.8	8.7	8.9	8.8
148E	10.4	10.3	10.3	10.2	10.3	10.4	10.4	10.2	10.3	10.3	10.3											
167W	10.5	10.4		10.3	10.4	10.5	11.4	11.4	11.3	11.2	10.8	8.7	8.7	9.2		8.9	8.7	8.7	8.7	8.7	8.7	8.8
200E	10.6	10.4	10.5	10.4	10.4	10.5	10.4	10.5	10.5	10.5	10.4											
203W	10.6	10.4	10.4	10.4	10.5	10.5	10.4	10.4	10.4	10.4	10.5	9.3	9.2	9.4	9.4	9.3	9.4	9.3	9.3	9.3	9.3	9.3
219W	10.7	10.5	10.5	10.7	10.6	10.6	10.4	10.6	10.6	10.5	10.6	9.2	9.2	9.0	9.0	9.1	9.0	9.1	9.3	9.0	9.1	9.1
243W	10.9	10.7	10.6	10.6	10.7	10.6	10.6	10.6	10.4	10.5	10.6											

[a] Mean of measurements at 1 m below surface, mid-column, and 1 m above river bed at random points within each site quartile.

[b] Site quartiles are: 1=0-25%; 2=26-50%; 3=51-75%; and 4=76-100% of site length.

Appendix B; Table 7. Mean[a] water column clarity (cm) of sampling sites in the lower Willamette River, October 2000 and March 2001.

	October 2000											March 2001										
	Shore zone (<15 m)					Shore zone (>15 m)						Shore zone (<15 m)					Shore zone (>15 m)					
	Site Quartile[b]					Site Quartile[b]					Site	Site Quartile[b]					Site Quartile[b]					Site
Site	1	2	3	4	Mean	1	2	3	4	Mean	mean	1	2	3	4	Mean	1	2	3	4	Mean	mean
006E	*	*	*	85	85	96	108	115	119	110	105	*	*	*	120	120	125	100	*	114	113	115
010E	*	*	*	*	150	131	142	170	158	150	150											0
012W	*	*	*	*	110	120	107	106	107	110	110											0
031W	*	*	*	*	131	127	137	118	142	131	131											0
040W	*	*			159	161	156			159	159											0
048E	142	147	145	162	149	158	155	148	155	154	151	168	165	148	154	159	153	154	114	150	143	151
051E	*	162	168	141	157		172	175	169	172	165	113	*	117	120	117		156	114	162	144	130
064W	149	150	155	151	151	171	159	175	165	168	159	*	*	*	*		107	120	112	102	110	110
079W	181		151	145	159	154	147	144	178	156	157	*	*	*	*		112	111	95	132	113	113
097E	*	*	*		162	162	160	164	163	162	162											
100W	110	138	178	149	144	185	163	152	187	172	158											
112E	158	152	160	154	156	123	165	144	141	143	150											
118W	169	153	169	131	156	103	143	146	155	137	146											
121W	*	*	*	*	161	174	179	137	152	161	161											
133W	*	*	*	100	100	110	140	115	129	124	119	*	*	*	*		112	119	112	131	119	119
136E	154	146	160	165	156	173	165	156	161	164	160	*	*	*	*		108	111	101	117	109	109
148E	*	173	*	*	173	170	178	166	194	177	176											
167W	188	217	215	180	200	241	276	242	270	257	229	*	*	*	*		97	107	90	*	98	98
200E	173	160	159	174	167	153	165	166	162	162	164											
203W	148	138	154	142	146	170	158	157	157	161	153	116	103	99	*	106	96	97	95	114	101	103
219W	217	201	199	140	189	236	199	210	201	212	200	95	124	125	131	119				127	127	120
243W	181	175	197	201	189	176	172	222	195	191	190											

[a] Average depth of a 20.0 cm secchi disk appearance and reappearance measured in shade at random points within each site quartile.

[b] Site quartiles are: 1=0-25%; 2=26-50%; 3=51-75%; and 4=76-100% of site length.

* Water clarity exceeded depth; data not recorded.

Appendix B; Table 8. Mean shoreline substrate composition (%) of sampling sites in the lower Willamette River, November 2001.

Site	Sand and gravel (<64 mm)	Natural rock (>64 mm)	Small riprap (65-256 mm)	Large riprap (257-512 mm)	Boulders (>513 mm)	Bedrock	Seawall	Artificial fill (concrete, etc.)	% "Natural"
006E[a]	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
010E[a]	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
012W[a]	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0
031W	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
040W	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
048E[a]	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0
051E	0.0	0.0	12.5	87.5	0.0	0.0	0.0	0.0	0
064W[a]	37.5	0.0	25.0	37.5	0.0	0.0	0.0	0.0	38
079W[a]	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0
097E	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
100W	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0
112E	0.0	0.0	31.3	56.3	0.0	0.0	0.0	12.5	0
118W	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0
121W[a]	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0
133W[a]	75.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	75
136E[a]	0.0	0.0	25.0	75.0	0.0	0.0	0.0	0.0	0
148E[a]	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
167W[a]	83.3	0.0	8.3	8.5	0.0	0.0	0.0	0.0	83
200E	0.0	12.5	0.0	0.0	0.0	87.5	0.0	0.0	100
203W	25.0	0.0	0.0	0.0	0.0	75.0	0.0	0.0	100
219W[a]	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	100
243W	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100

Appendix B; Table 9. Estimated percent of shoreline vegetation types of sampling sites in the Lower Willamette River, October 2000.

	No vegetation					Grasses					Forbes					Shrubs					Trees					
	Site Percentile[a]					Site Percentile[a]					Site Percentile[a]					Site Percentile[a]					Site Percentile[a]					
Site	0	25	50	75	100	0	25	50	75	100	0	25	50	75	100	0	25	50	75	100	0	25	50	75	100	Score[b]
006E	100	100	100	100	100																					0.0
010E	100	100	100	100	50										50											2.5
012W	90	80	85	75	95	5	10	5	10	5		5	10	10			5				5			5		3.8
031W	100	100	90	90	100			10	10																	1.0
040W	100		100		100																					0.0
048E	100	100	100	100	100																					0.0
051E	75	90	100	80	90	5			5	10		10		15		20										3.3
064W	100	100	100	100	100																					0.0
079W	94	98	99	100	95						5	1				1	1	1		5						0.7
097E	70	100	100	100	99											30				1						1.6
100W	100	100	100	100	100																					0.0
112E	90	95	90	60	60	5						5	10			5			40	40						5.3
118W	95	75	100	50	95	5	5					20							50	5						4.3
121W	100	100	100	100	100																					0.0
133W	100	100	100	100	100																					0.0
136E	99	90	80	80	90						1		20	20			10			10						3.1
148E	100	100	100	100	99										1											0.1
167W	99	99	100	100	100	1						1														0.1
200E	100	90	80	100	95		10	10		5			10													1.8
203W	75	70	70	90	99	20		10			5	20	20	10	1		10									4.8
219W	99	99	99	98	99				1		1	1	1	1	1											0.3
243W	95	100	100	100	100						5															0.3

[a] 0=Upstream, 100=Downstream.

[b] Vegetation score is the sum of vegetation percentages (excluding no-vegetation) divided by 20.

Appendix B; Table 10. Bank slope[a] (degrees) of sampling sites in the lower Willamette River, October 2000 and March 2001.

	October 2000						March 2001					
	Site Percentile (0=upstream)						Site Percentile (0=upstream)					
Site	0	25	50	75	100	Site mean	0	25	50	75	100	Site mean
006E	4	5	6	6	6	5	3	6	8	7	7	6
010E	7	14	6	6	3	7						
012W	12	10	12	12	2	10						
031W	4	4	4	7	7	5						
040W[b]	6		6		6	6						
048E	90	90	90	90	90	90	90	90	90	90	90	90
051E	23	23	23	23	23	23	21	17	18	26	21	21
064W	15	18	5	8	14	12						
079W	13	15	15	18	22	17						
097E	7	7	7	8	8	7						
100W	28	28	24	24	24	26						
112E	29	31	27	31	37	31						
118W	14	16	22	14	22	18						
121W	90	90	90	90	90	90						
133W	4	13	8	18	22	13						
136E	12	16	22	32	33	23						
148E	5	6	9	5	8	7						
167W	12	6	3	5	3	6						
200E	42	33	9	25	28	27						
203W	32	26	26	23	10	23						
219W	14	14	25	32	18	21						
243W	12	16	9	8	6	10						

a Angle of river bank measured 10 m upslope from waterline.

b Short site; data collected at 0, 50, and 100th percentiles.

Appendix B; Table 11. Number of pilings within sampling sites in the lower Willamette River, October 2000 and March 2001.

Site	October 2000											March 2001										
	Shore zone (0-25 m)					Shore zone (26-50 m)						Shore zone (0-25 m)					Shore zone (26-50 m)					
	Site Quartile[a]					Site Quartile[a]						Site Quartile[a]					Site Quartile[a]					
	1	2	3	4	Sum	1	2	3	4	Sum	Site Sum	1	2	3	4	Sum	1	2	3	4	Sum	Site Sum
006E	0	0	0	0	0	5	0	0	0	5	5	0	0	0	0	0	5	0	0	0	5	5
010E	0	4	20	263	287	59	49	75	66	249	536											
012W	0	0	4	0	4	0	0	0	0	0	4											
031W	8	5	0	0	13	0	0	0	0	0	13											
040W	0	0	0	0	0	0	7	0	0	7	7											
048E	36	45	36	39	156	0	0	0	0	0	156	35	42	36	39	152	0	0	0	0	0	152
051E	4	6	14	14	38	1	27	20	0	48	86	6	4	15	15	40	0	29	14	0	43	83
064W	0	0	0	0	0	0	0	0	0	0	0											
079W	19	6	24	0	49	0	53	66	8	127	176											
097E	0	0	0	0	0	0	0	0	0	0	0											
100W	40	17	27	49	133	25	19	46	0	90	223											
112E	0	31	0	25	56	28	10	36	39	113	169											
118W	3	10	12	5	30	0	0	2	0	2	32											
121W	3	0	0	0	3	0	0	0	0	0	3											
133W	0	5	0	0	5	0	0	0	0	0	5											
136E	0	0	0	0	0	0	0	0	0	0	0											
148E	2	22	0	0	24	0	0	0	0	0	24											
167W	0	0	0	0	0	0	0	0	0	0	0											
200E	0	3	0	0	3	0	0	0	0	0	3											
203W	20	16	16	20	72	0	0	0	0	0	72											
219W	0	0	0	0	0	0	0	0	0	0	0											
243W	0	0	0	0	0	0	0	0	0	0	0											

[a] Site quartiles are: 1=0-25%; 2=26-50%; 3=51-75%; and 4=76-100% of site length.

Appendix B; Table 12. Number of outfalls (pipes) entering sampling sites in the lower Willamette River, October 2000 and March 2001.

	October 2000											March 2001										
	Active					Inactive						Active					Inactive					
	Site Quartile[a]					Site Quartile[a]					Site	Site Quartile[a]					Site Quartile[a]					Site
Site	1	2	3	4	Sum	1	2	3	4	Sum	sum	1	2	3	4	Sum	1	2	3	4	Sum	sum
006E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
010E	0	0	0	0	0	0	1	0	2	3	3											
012W	0	0	0	0	0	0	0	0	0	0	0											
031W	0	0	0	0	0	0	0	0	0	0	0											
040W	0	0	0		0	0	0	0		0	0											
048E[b]	0	0	0	0	0	24	27	35	33	119	119	9	9	12	8	38	15	18	23	25	81	119
051E	0	0	0	0	0	0	2	4	7	13	13		0	0	0	0		3	5	5	13	13
064W	0	0	0	0	0	0	0	0	0	0	0											
079W	0	0	0	0	0	0	0	0	0	0	0											
097E	0	0	0	0	0	0	0	0	0	0	0											
100W	0	0	0	1	1	0	0	0	0	0	1											
112E	0	0	0	0	0	1	0	1	0	2	2											
118W	0	0	0	0	0	1	1	0	0	2	2											
121W	0	0	0	1	1	23	28	19	23	93	94											
133W	0	0	0	0	0	0	0	0	0	0	0											
136E	0	0	0	0	0	0	0	0	0	0	0											
148E	0	0	0	0	0	0	0	0	0	0	0											
167W	0	0	0	0	0	0	0	0	0	0	0											
200E	0	0	0	0	0	0	0	1	0	1	1											
203W	0	0	0	0	0	0	0	0	0	0	0											
219W	0	0	0	0	0	0	0	0	0	0	0											
243W	0	0	0	0	0	0	0	0	0	0	0											

[a] Site quartiles are: 1=0-25%; 2=26-50%; 3=51-75%; and 4=76-100% of site length.

[b] Overhead parking lot drainage pipes.

Appendix B; Table 13. Minimum distance (m) to nearest impervious surface adjacent to sampling sites in the lower Willamette River, October 2000 and March 2001.

	October 2000						March 2001					
	Site Percentile (0=upstream)						Site Percentile (0=upstream)					
Site	0	25	50	75	100	Site mean	0	25	50	75	100	Site mean
006E	250	250	250	150	131	206	250	250	250	150	60	192
010E	34	28	46	28	28	33						
012W	250	250	250	250	250	250						
031W	250	250	250	250	250	250						
040W[a]	250		250		250	250						
048E	0	0	0	0	0	0	0	0	0	0	0	0
051E	22	18	18	18	19	19	16	16	16	16	16	16
064W	23	23	23	23	23	23						
079W	27	27	24	28	20	25						
097E	22	38	37	29	35	32						
100W	12	12	12	12	12	12						
112E	24	15	15	15	15	17						
118W	20	15	5	10	5	11						
121W	0	0	0	0	0	0						
133W	80	53	24	29	33	44						
136E	45	45	39	30	30	38						
148E	250	250	98	250	250	220						
167W	70	76	68	88	114	83						
200E	65	67	61	86	250	106						
203W	30	10	10	15	27	18						
219W	250	250	250	250	250	250						
243W	250	250	250	250	124	225						

[a] Short transect; data collected at 0, 50, and 100th percentiles.

Appendix B; Table 14. Nighttime artificial light intensities (Lux[a]) at sampling sites in the lower Willamette River, October 2000.

	Shore zone (0-25 m)					Shore zone (26-50 m)					
	Site Quartile[b]					Site Quartile[b]					
Site	1	2	3	4	Mean	1	2	3	4	Mean	Site mean
006E	3	2	3	3	2.8	3	3	3	3	3.0	2.9
010E	7	8	7	4	6.5	7	10	5	3	6.3	6.4
012W	3	3	3	3	3.0	3	3	3	3	3.0	3.0
031W				4	4.0	3	3	4	3	3.3	3.4
040W	3				3.0	3		3		3.0	3.0
048E	7	8	7	14	9.0	7	6	7	8	7.0	8.0
051E	4	5	4	25	9.5	3	4			3.5	7.5
064W	3	3	4	4	3.5	3	2	5	3	3.3	3.4
079W	4		10	6	6.7	4	48	6	4	15.5	11.7
097E	2	2	2	2	2.0	3	1	2	1	1.8	1.9
100W	3	3	3	3	3.0	4	3	2	3	3.0	3.0
112E	3	1	2	1	1.8	3	2	2	3	2.5	2.1
118W	3	3	3	5	3.5	2	2	3	3	2.5	3.0
121W	9	4	4	14	7.8	3	4	4	5	4.0	5.9
133W	3	4	3	5	3.8	3	3	2	4	3.0	3.4
136E	3	4	4	3	3.5	2	4	3	3	3.0	3.3
148E	3	3	3	2	2.8	3	3	3	1	2.5	2.6
167W	3	3	3	3	3.0	3	3	3	3	3.0	3.0
200E	3	3	3	3	3.0	3	3	3	3	3.0	3.0
203W	4			4	4.0	3	4	12	4	5.8	5.2
219W	3	3	3	4	3.3	3	3	3	4	3.3	3.3
243W	3	3	3	3	3.0	3	3	3	3	3.0	3.0

[a] Lux: equals one lumen/m^2 or illumination on a surface one meter from a point source of one candle intensity.

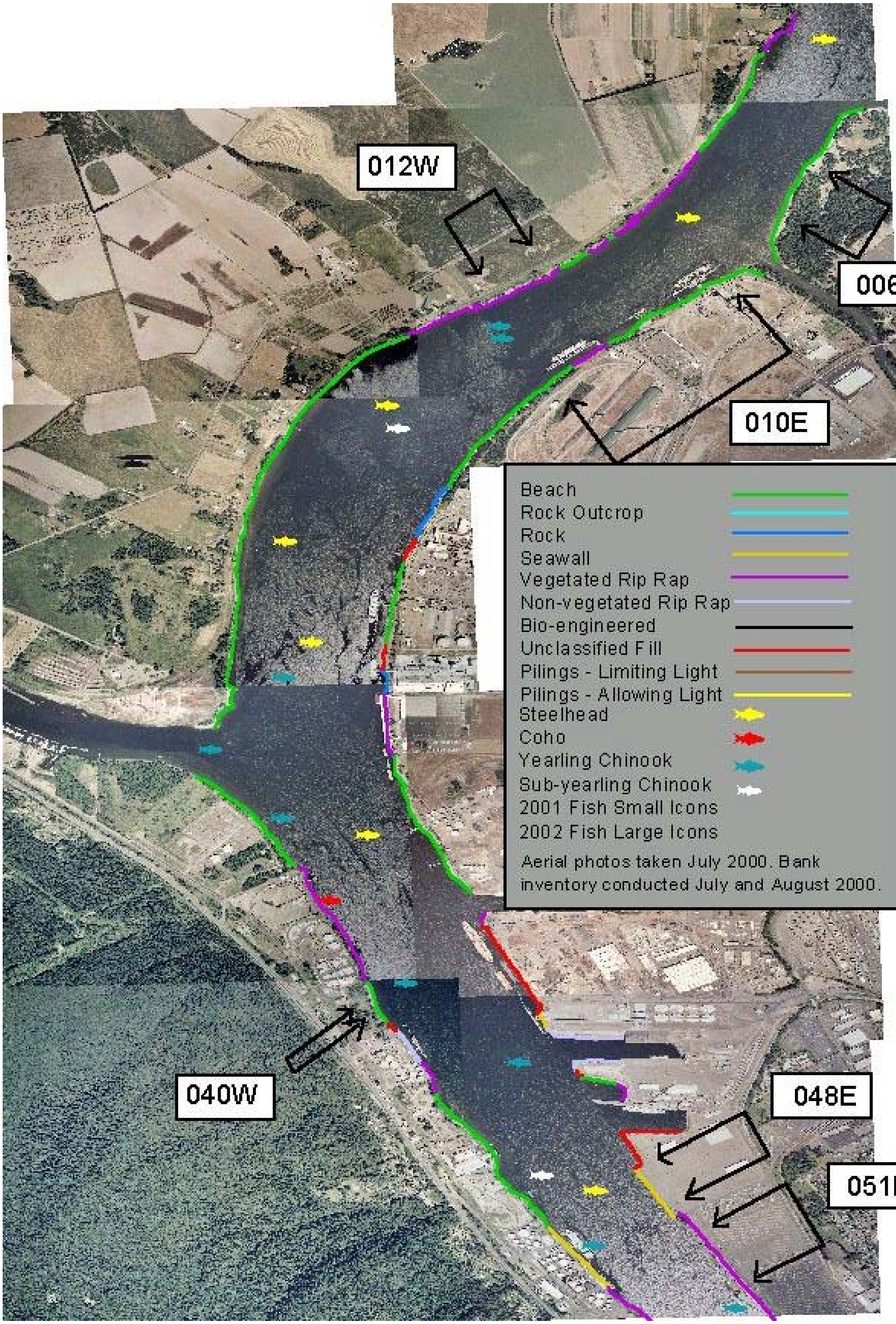
[b] Site quartiles are: 1=0-25%; 2=26-50%; 3=51-75%; and 4=76-100% of site length.

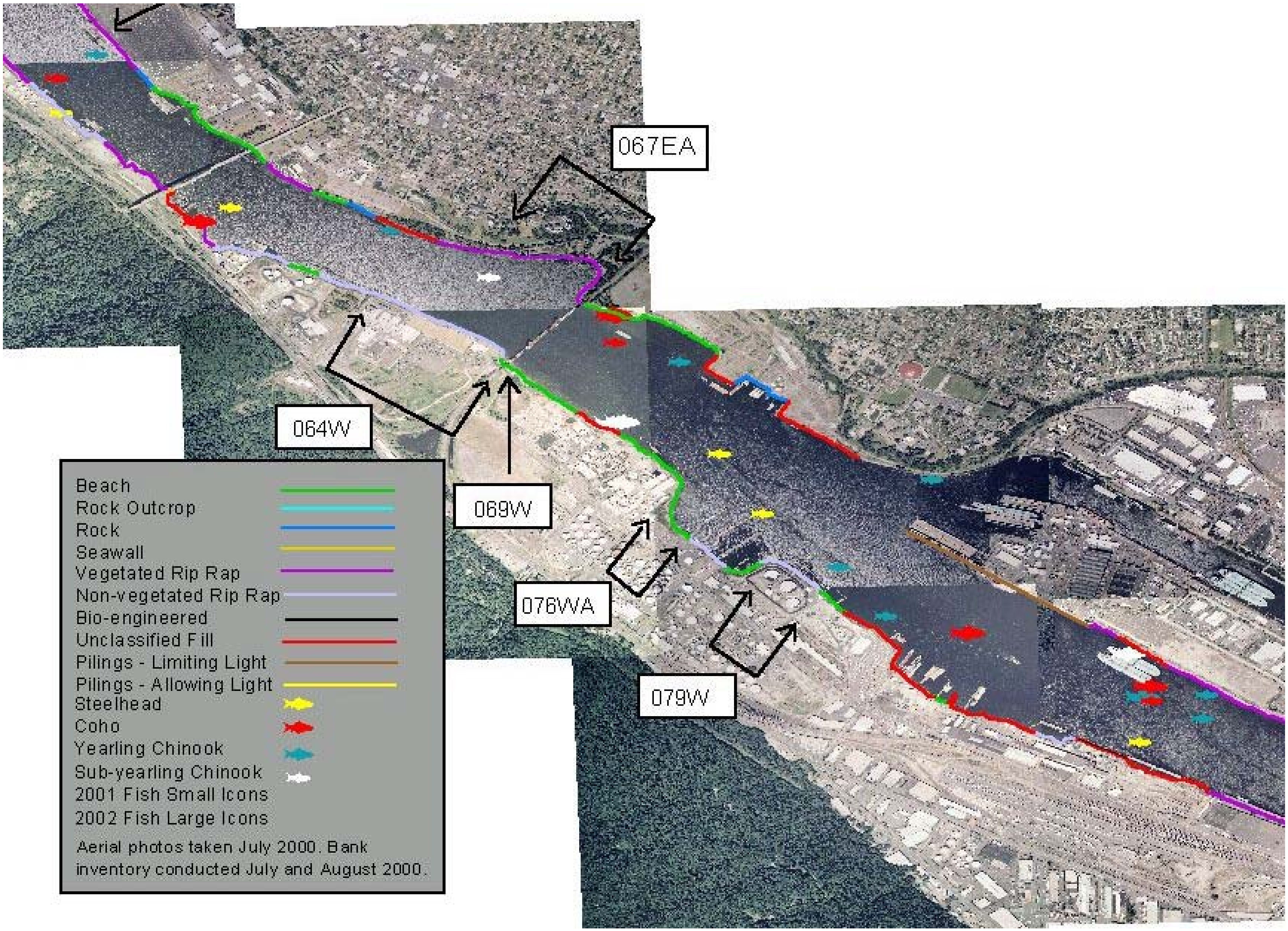
Appendix B; Table 15. Mean habitat parameter values of sampling sites in the lower Willamette River, October-November 2000.

Site	Velocity (cm/s)	Depth (m)	Overhead cover (%)	Temperature (C)	Conductivity (microseimens)	Dissolved oxygen (ppm)	Transparency (cm)	Shoreline substrate (% natural)	Vegetative score	Bank slope (degrees)	Pilings (#)	Outfalls (#)	Buffer width (m)	Artificial light (Lux)
006E	4.7	4.1	0.0	6.7	0.11	11.2	105	100	0.0	5	5	0	206	2.9
010E	6.7	4.4	12.4	6.5	0.10	10.9	150	100	2.5	7	536	3	33	6.4
012W	6.3	4.4	0.0	6.5	0.10	10.9	110	0	3.8	10	4	0	250	3.0
031W	16.4	1.4	0.0	6.6	0.09	11.2	131	100	1.0	5	13	0	250	3.4
048E	2.8	16.3	0.0	6.6	0.09	11.2	151	0	0.0	90	156	119	0	8.0
051E	6.2	6.4	19.8	6.6	0.09	11.1	165	0	3.3	23	86	13	19	7.5
064W	2.8	8.6	0.0	7.4	0.12	11.4	159	38	0.0	12	0	0	23	3.4
079W	1.7	6.4	24.7	7.3	0.10	11.2	157	0	0.7	17	176	0	25	11.7
100W	1.4	6.6	62.5	6.9	0.08	11.0	158	0	0.0	26	223	1	12	3.0
112E	1.8	9.2	19.8	7.4	0.08	11.5	150	0	5.3	31	169	2	17	2.1
118W	5.1	12.0	5.0	6.8	0.08	11.2	146	0	4.3	18	32	2	11	3.0
121W	9.9	14.4	0.0	6.8	0.07	11.3	161	0	0.0	90	3	94	0	5.9
133W	2.3	1.6	0.0	6.8	0.08	11.8	119	75	0.0	13	5	0	44	3.4
136E	3.2	5.7	0.0	6.8	0.07	11.4	160	0	3.1	23	0	0	38	3.3
148E	3.5	3.7	0.0	7.4	0.08	10.3	176	100	0.1	7	24	0	220	2.6
167W	0.3	5.8	0.0	7.5	0.08	10.8	229	83	0.1	6	0	0	83	3.0
200E	14.6	14.7	0.0	7.3	0.08	10.4	164	100	1.8	27	3	1	106	3.0
203W	4.0	13.3	9.8	7.4	0.08	10.5	153	100	4.8	23	72	0	18	5.2
219W	11.2	18.8	0.0	7.3	0.07	10.6	200	100	0.3	21	0	0	250	3.3

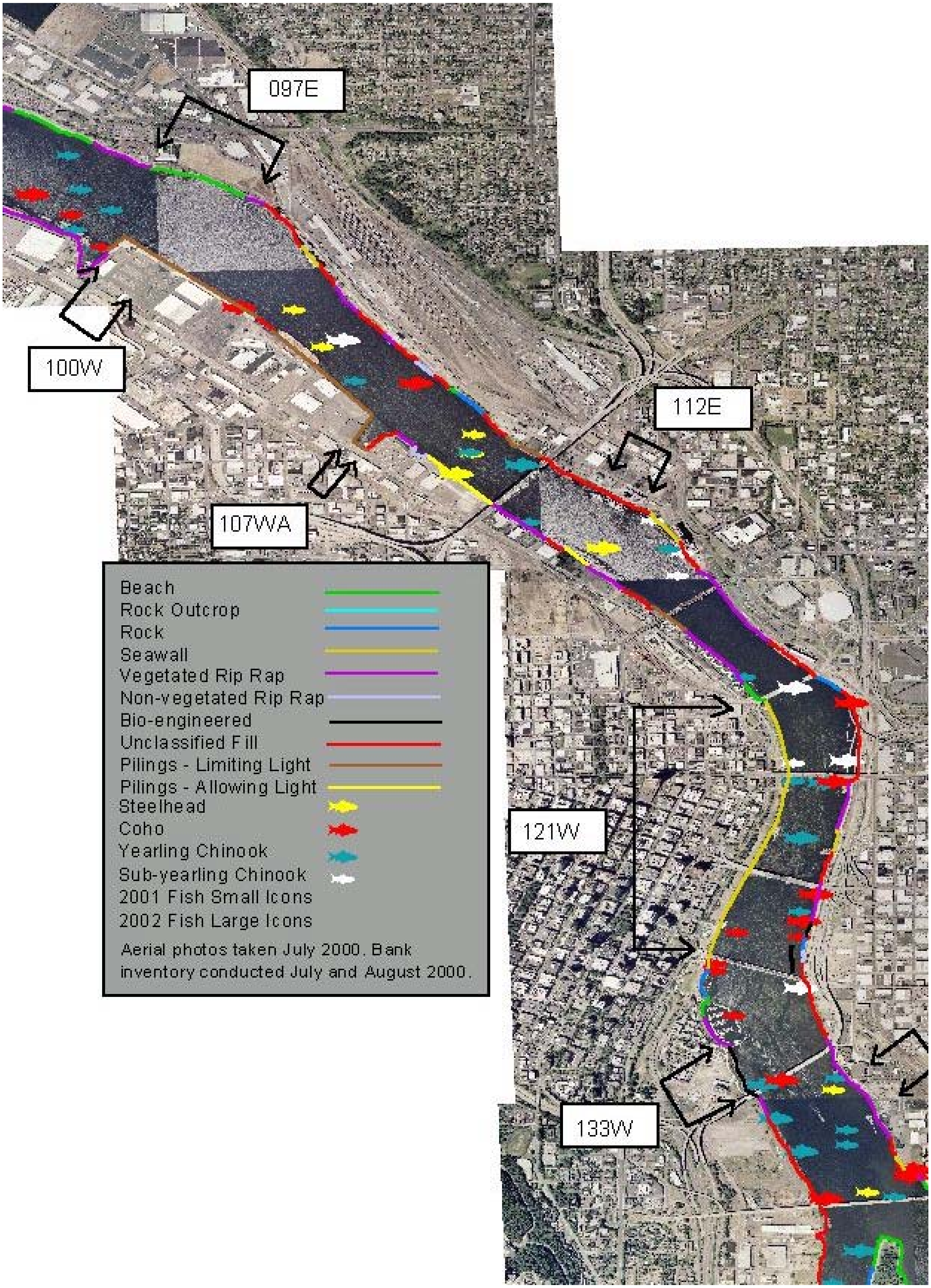
APPENDIX C

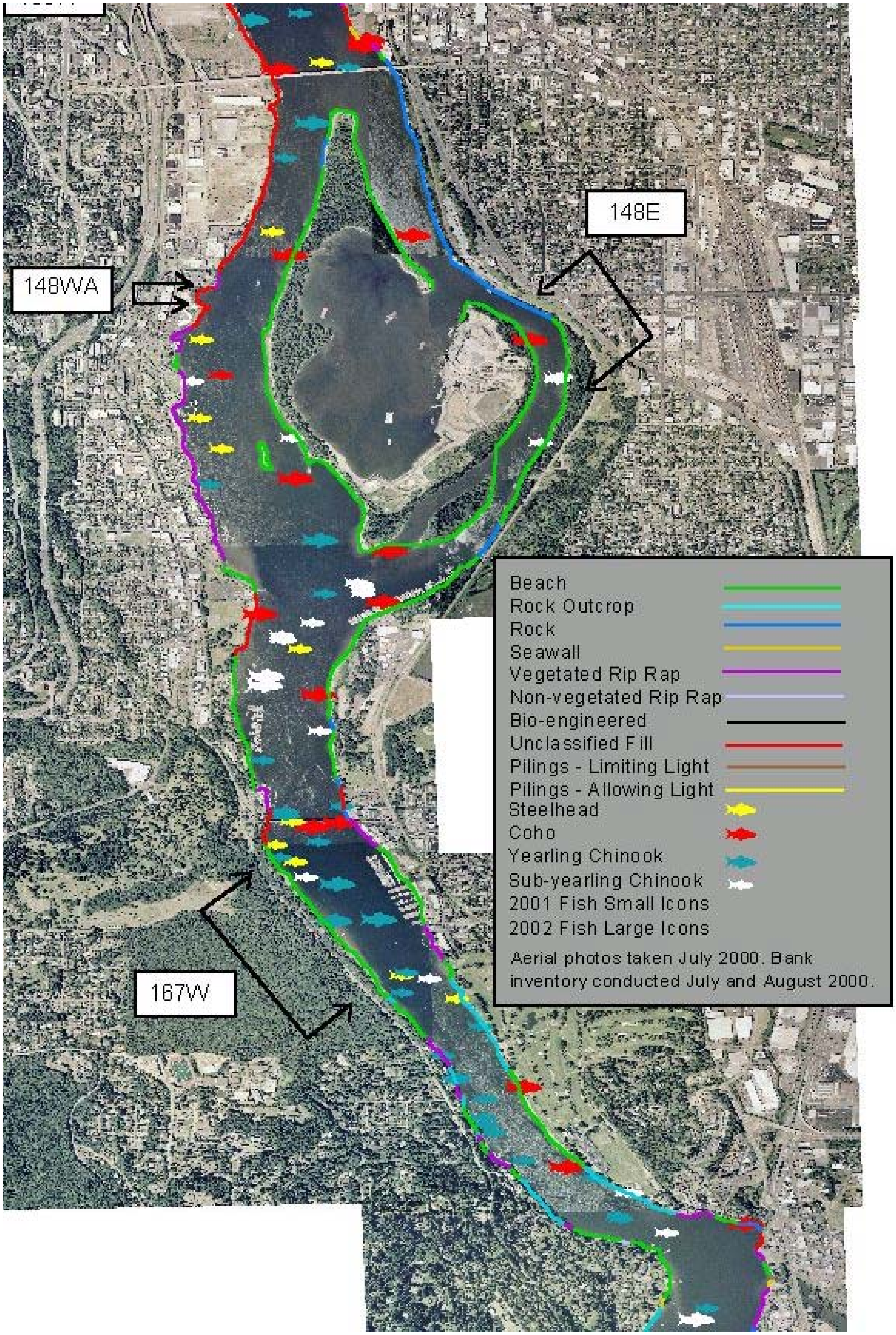
Aerial Photographs of Sampling Sites, Bank Treatment Types, and Relocations of Radio tagged Juvenile Salmonids


012W
006E
010E
040W
048E
051E
Beach
Rock Outcrop
Rock
Seawall
Vegetated Rip Rap
Non-vegetated Rip Rap
Bio-engineered
Unclassified Fill
Pilings - Limiting Light
Pilings - Allowing Light
Steelhead
Coho
Yearling Chinook
Sub-yearling Chinook
2001 Fish Small Icons
2002 Fish Large Icons
Aerial photos taken July 2000. Bank inventory conducted July and August 2000.



067EA
064W
069W
076WA
079W
Beach
Rock Outcrop
Rock
Seawall
Vegetated Rip Rap
Non-vegetated Rip Rap
Bio-engineered
Unclassified Fill
Pilings - Limiting Light
Pilings - Allowing Light
Steelhead
Coho
Yearling Chinook
Sub-yearling Chinook
2001 Fish Small Icons
2002 Fish Large Icons
Aerial photos taken July 2000. Bank inventory conducted July and August 2000.


097E
100W
112E
107WA
121W
133W
Beach
Rock Outcrop
Rock
Seawall
Vegetated Rip Rap
Non-vegetated Rip Rap
Bio-engineered
Unclassified Fill
Pilings - Limiting Light
Pilings - Allowing Light
Steelhead
Coho
Yearling Chinook
Sub-yearling Chinook
2001 Fish Small Icons
2002 Fish Large Icons
Aerial photos taken July 2000. Bank inventory conducted July and August 2000.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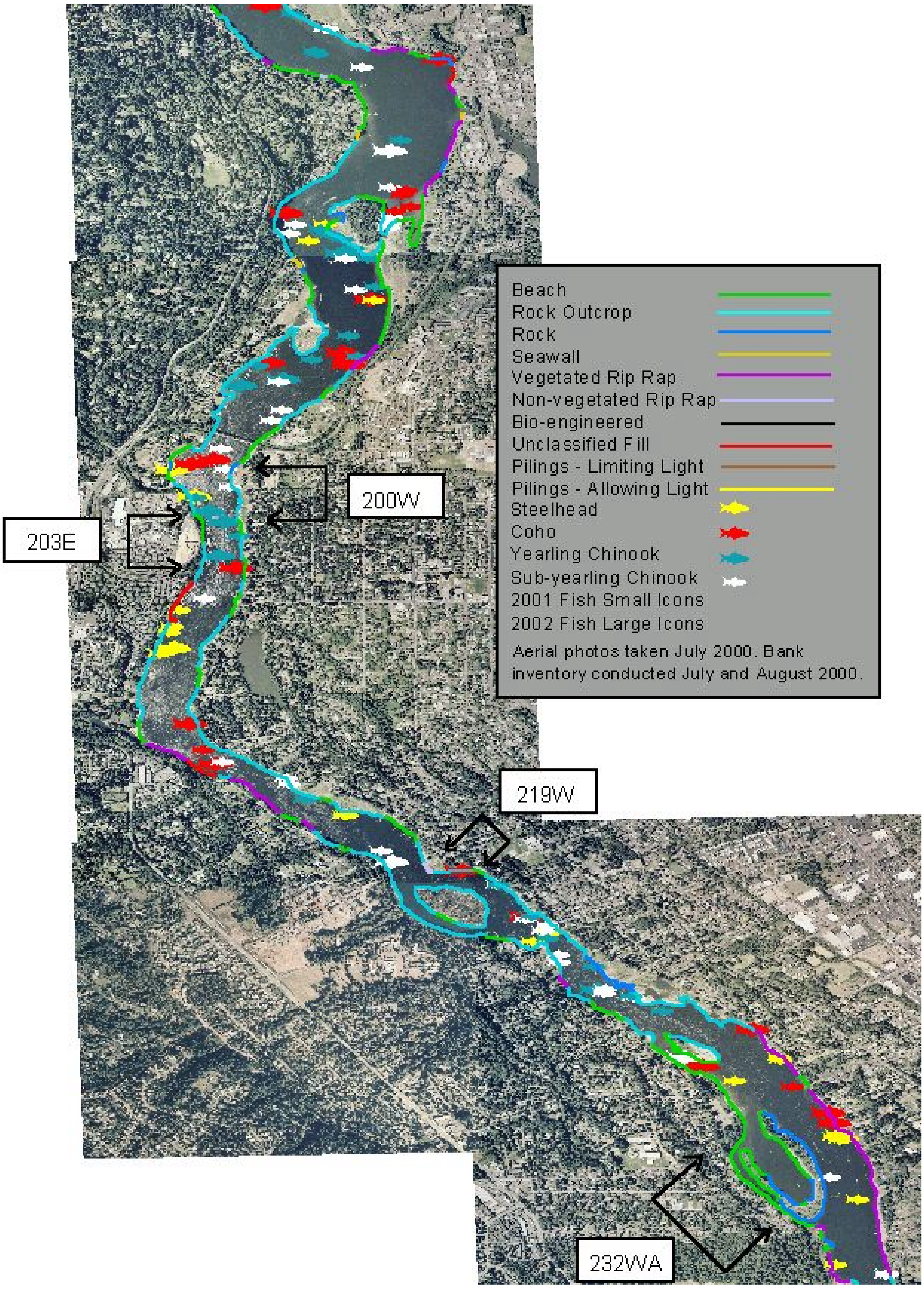
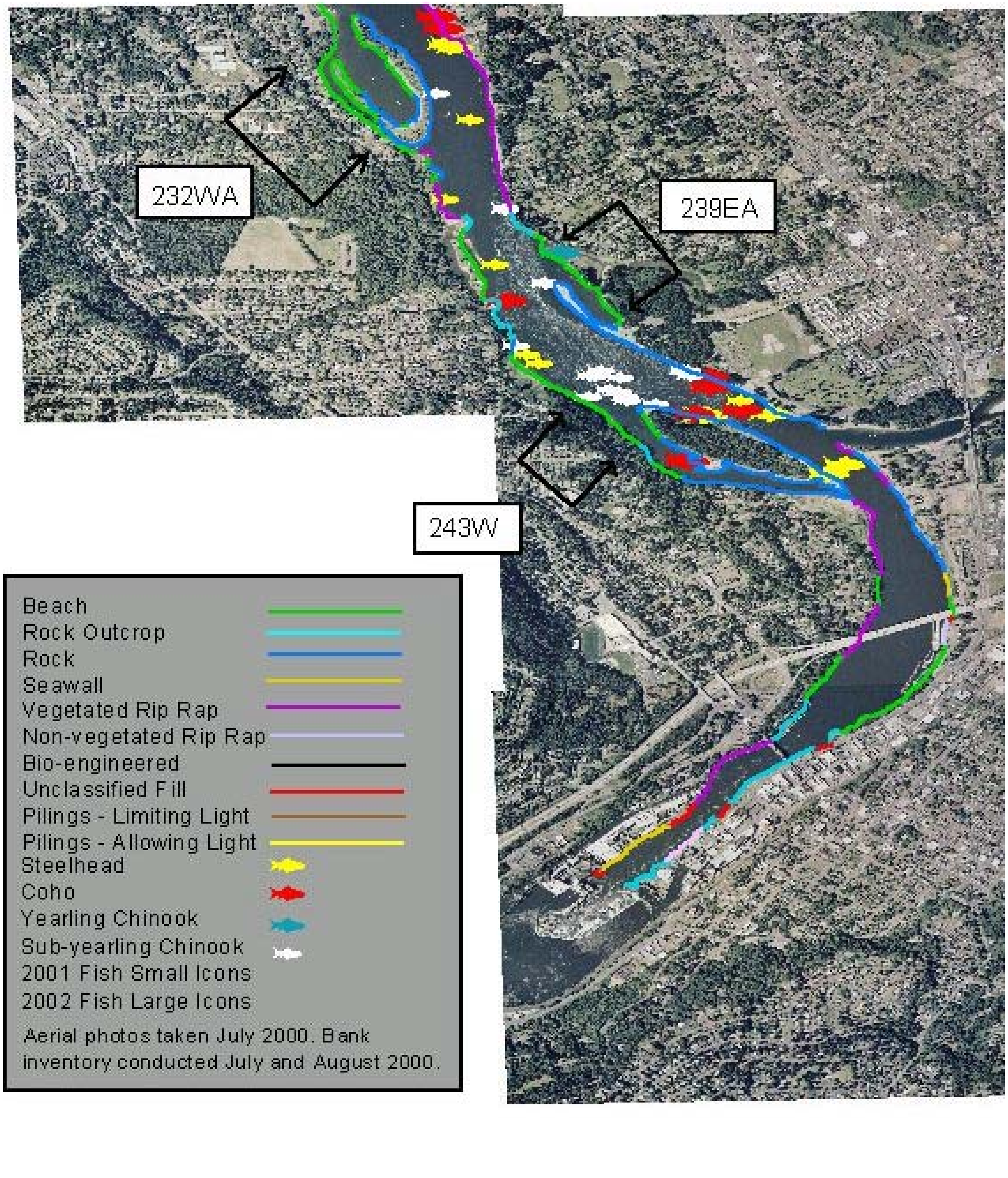
148WA
167W
Beach
Rock Outcrop
Rock
Seawall
Vegetated Rip Rap
Non-vegetated Rip Rap
Bio-engineered
Unclassified Fill
Pilings - Limiting Light
Pilings - Allowing Light
Steelhead
Coho
Yearling Chinook
Sub-yearling Chinook
2001 Fish Small Icons
2002 Fish Large Icons
Aerial photos taken July 2000. Bank inventory conducted July and August 2000.



Beach
Rock Outcrop
Rock
Seawall
Vegetated Rip Rap
Non-vegetated Rip Rap
Bio-engineered
Unclassified Fill
Pilings - Limiting Light
Pilings - Allowing Light
Steelhead
Coho
Yearling Chinook
Sub-yearling Chinook
2001 Fish Small Icons
2002 Fish Large Icons
Aerial photos taken July 2000. Bank inventory conducted July and August 2000.
200W
203E
219W
232WA



232WA
239EA
243W
Beach
Rock Outcrop
Rock
Seawall
Vegetated Rip Rap
Non-vegetated Rip Rap
Bio-engineered
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Pilings - Limiting Light
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