APPENDIX 3A

DISTRIBUTION AND RELATIVE ABUNDANCE OF TROUT FRY IN THE J.C. BOYLE REACHES OF THE UPPER KLAMATH RIVER

KLAMATH HYDROELECTRIC PROJECT (FERC NO. 2082)

DISTRIBUTION & RELATIVE ABUNDANCE OF TROUT FRY IN THE J.C. BOYLE REACHES OF THE UPPER KLAMATH RIVER

FINAL REPORT

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KLAMATH HYDROELECTRIC PROJECT (FERC NO. 2082)

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ABSTRACT

Single-pass electrofishing surveys were conducted every two weeks from June to September at 26 study sites with 61 margin units distributed throughout the J.C Boyle bypass and peaking reaches; including: 1) the bypass reach (Bypass), 2) the Oregon Peaking reach (OR Peaking), 3) and the California Peaking reach (CA Peaking). Rainbow trout (*Oncorhynchus mykiss*) fry (<50mm FL) occurred at highest index densities (avg 1-3 fry/100ft^2) in the Bypass reach downstream of known spawning areas. Intermediate fry densities (0.2-1 fry/100ft^2) were observed in the CA Peaking reach below Shovel Creek, but none were captured above the spawning tributary. Fry occurred at low index densities (0.1-0.3 fry/100ft^2) in the upper half of the OR Peaking reach (below the Bypass), but fry were rarely captured in the lower portion of that reach. The distribution data suggests little movement of fry upstream of spawning areas, or downstream more than 4 miles from spawning areas. Index densities declined very slowly through the summer months, with evidence of a secondary emergence of fry in late July. Paired comparisons of fry densities in vegetated and non-vegetated margin units showed significantly higher densities in vegetated units in the OR Peaking reach and in combined peaking reaches, but no difference in densities among units in the CA Peaking reach. A similar relationship was observed for speckled dace (*Rhinichthys osculus*) and chubs (*Gila* spp.), but no difference in densities was noted for sculpin (*Cottus* spp.) or for fry and juvenile suckers (mostly *Catostomus rimiculus*). All margin units were non-vegetated during non-peaking flows. A stepwise multiple regression model explained 76% of observed variation in mean fry densities in the peaking reaches. Distance to known spawning area, mean velocity, maximum depth, and dominant substrate type were selected predictor variables. Of 334 fry fin-clipped in the Bypass reach, 14 were recaptured at the same study site and one was recaptured downstream. Nine of 73 marked fry in the CA Peaking reach were recaptured at the same location following one or two peaking flow events. Fry captured in the OR Peaking reach tended to be longer than fry from the Bypass reach, whereas fry from the CA Peaking reach were shorter than fry from Shovel Creek. Although comparative length-weight relationships showed generally inconsistent patterns among reaches, fry in the CA Peaking reach appeared heavier than other fry when small (<35mm FL), but such differences were not evident for larger fry.

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INTRODUCTION

Rainbow trout (*Oncorhynchus mykiss*) are an ecologically and economically valuable component of the aquatic community inhabiting the Upper Klamath River project area. Considerable effort has been allocated to the documentation and study of trout spawning in tributaries to the project area, particularly Shovel Creek (Beyer 1984) and Spencer Creek (various Oregon Department of Fish and Wildlife [ODFW] reports). However, relatively little is known about spawning within the mainstem Klamath River. Fish assessment studies and fish microhabitat studies conducted in 2002, 2003, and cursory redd surveys in 2003 indicated that spawning occurs in the J.C. Boyle Bypass reach, however sampling efforts in the Oregon and California portions of the J.C. Boyle Peaking reach have yielded few observations of trout fry (<5 cm FL). Consequently, PacifiCorp proposed to conduct additional distribution and abundance studies to help identify possible trout spawning areas in the mainstem and to assess fry rearing and movement in Peaking reach. This information will help to gain insights into the potential effects of hydropower peaking operations on fry rearing.

STUDY OBJECTIVES

The primary objective of this proposed study was to assess the relative distribution and abundance of trout fry (<50mm FL) in the J.C. Boyle Peaking reach and the Bypass reach using a repeated series of qualitative electrofishing surveys at index sites. Qualitative electrofishing surveys were conducted at bi-weekly intervals at index locations within the Bypass reach and the Peaking reach in margin areas that contained habitat suitable for early rearing of trout fry (i.e., shallow, low-velocity areas with instream cover). Information regarding the localized distribution of trout fry may help to identify possible spawning areas in the mainstem. Temporal and spatial changes in the relative distribution and abundance of fry in proximity to known spawning locations (i.e., the Bypass reach and Shovel Creek) may also provide insight into the timing of fry emergence in the Bypass reach and the dynamics of fry recruitment into the Peaking reach.

A second objective of this study was to compare index densities of trout fry among different Stream Margin Edge Types (SMET's). The index sites located within the Bypass reach and the Peaking reach included margin areas that contained different types of instream cover. An *index* of relative fry density was calculated in each margin type by comparing the number of trout fry captured with the amount of effort allocated at that location, with effort measured as the physical area surveyed (in ft^2).

A third objective of this study was to compare index densities of fry along specific margin areas immediately before, during, and after an increased flow event. Recapture of marked fry at the marking location or at downstream locations may provide some insight into the lateral or longitudinal movement of fry in relation to increased flows.

Finally, *a fourth objective was to compare growth patterns of fry in different reaches*. Different growth rates could suggest possible effects of peaking operations on early life-stages of trout within the mainstem reaches.

STUDY AREA DESCRIPTION

The Klamath River from John C. Boyle dam downstream to the headwaters of Copco Reservoir was divided into four stream reaches: the J.C. Boyle bypass reach (Bypass) (4.6 mi), the Oregon peaking reach (OR Peaking) (5.9 mi), the Hells Corner peaking reach (5.1 mi), and the California peaking reach (CA Peaking) (5.4 mi) (Figure 1). Except during periods of spill, the Bypass receives approximately 100 cfs from the diversion dam, however several large springs are located approximately one mile below the dam, and combined these springs (and numerous smaller springs) contribute approximately 225 cfs of cold (46-50º F), crystal-clear water. The spring inflow stabilizes seasonal water temperatures, minimizes summer maxima, and also increases water visibility.

In contrast to the cool, low, stable flow regime of the Bypass, the three peaking reaches are subject to near daily flow fluctuations from the J.C. Boyle Powerhouse over most of the year (depending on water year type). During summer and fall months, typical peaking operations at the J.C. Boyle Powerhouse consist of no generation during the night (thus the peaking reach receives the 325 cfs from the bypass reach), upramping in the morning to a peak of ca. 1,500 cfs by late-morning or noon, then downramping to minimum flow from afternoon to early evening. During the spring and at other times of high water availability and electrical demand, maximum daily flows typically reach 2,800-3,000 cfs in the peaking reaches, and generation may occur for extended periods (i.e., flows may not drop to minimum levels). During peaking operations wide fluctuations occur not only in streamflow characteristics, but also in water temperature and other water quality characteristics (e.g., water clarity). Water temperatures during summer peaking operations frequently exceed 70^{o} F.

Physical habitat also differs among the four study reaches (Table 1). The Bypass can be described as a high gradient, highly confined channel containing an abundance of very large (>four ft diameter) boulders, as opposed to the Peaking reach which contains a mixture a of high and lower gradient areas, and more side channel habitat. All reaches in the study area are generally lacking in

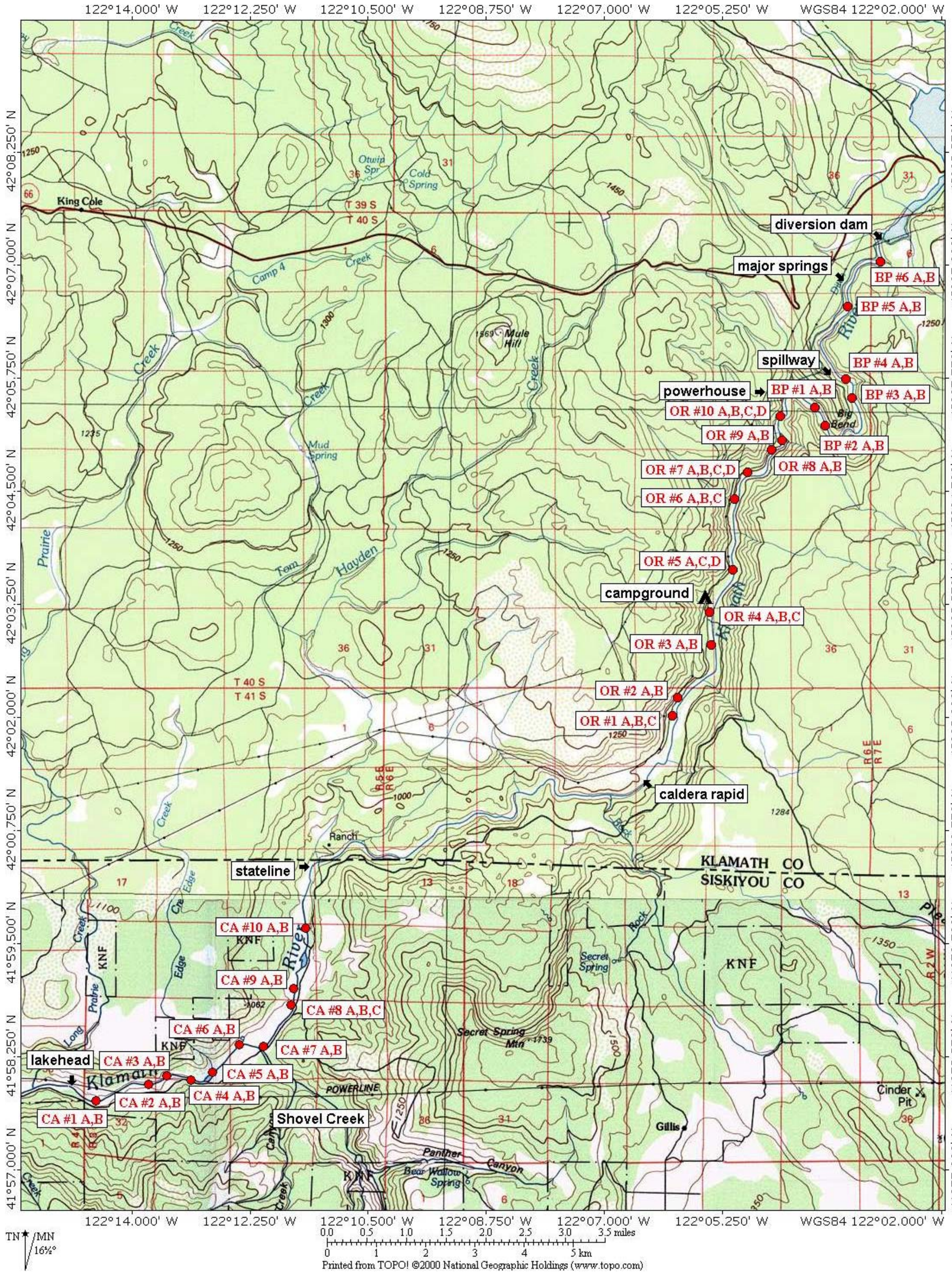


Figure 1. Map of study area showing study sites and number of margin units in the Bypass reach (BP), Oregon Peaking reach (OR), and California Peaking reach (CA). Landmarks are also shown.

gravel and other fine substrate components, however the Bypass does receive some gravel recruitment from an eroded spillway channel approximately midway in the reach. Reed canary grass, a tall (1-3 ft) herbaceous plant, grows along the water's edge in all but the steepest rapids. Larger riparian plants are typically restricted to higher elevations several feet from the water's edge. The upper one-half of the Bypass is bordered on one bank by the power canal and associated road, which occur approximately 100 to 300 ft above the stream elevation.

Table 1. Physical characteristics of the upper Klamath River according to reach and flow.

Reach	Length (mi)	Upper Elevation (msl)	% Slope	Mean Channel Widths @ ~ 350 cfs	1,600 cfs	3,000 cfs
Boyle Bypass	4.57	3,750	1.7	87	115	-
OR Peaking	5.95	3,335	0.7	134	166	181
Hells Corner	5.06	3,125	1.3	-	116	-
CA Peaking	5.41	2,765	0.6	110	142	154

The OR Peaking reach is moderate gradient for the first 2.5 mi below the powerhouse, and then the gradient lessens into the relatively flat area known as Frain Ranch (Figure 1). The wetted channel width and the floodplain width increase in this three-mile stretch, with a decrease in riffle gradients and overall substrate size. Canary grass is the dominant riparian plant where is grows at the water's edge produced by medium flow levels (i.e., 1,000 to 2,000 cfs). Larger riparian plants, including willows and other woody trees, are also abundant along the lower gradient habitats, particularly in the Frain Ranch area. Most of the woody plant species are not flooded except at higher flow levels (i.e., >2,000 cfs). Virtually all stream margins are non-vegetated at low flows, and some large bars are exposed in the Frain Ranch area. This reach is bordered by a gravel road on one bank well offset from the stream channel.

The Hells Corner peaking reach begins at Caldera Rapid at the bottom of the Frain Ranch area (Figure 1). This high gradient, highly confined channel contains numerous class IV whitewater rapids and is renown for whitewater recreation. Fry sampling was not conducted in this reach due to difficult access (it is road-less area) and hazardous working conditions. Below Stateline Falls, in the CA Peaking reach, the gradient lessens and the channel becomes bordered by flat agricultural fields and a well maintained road (mostly distant from the channel). Canary grass, willows, and larger woody plants dominate the riparian community, but stream margins are generally devoid of vegetation except at medium and higher flows. Some large cobble bars are exposed during periods of low flow. Several low diversion dams formed by boulder bars have been constructed to redirect water for agricultural use. Islands and associated side channels are relatively common in this reach, however most of the side channels are not wetted during low flows and thus are periodically dewatered during hydropower peaking operations.

METHODS

Sampling Periodicity

Qualitative surveys were conducted in the Bypass and OR Peaking reaches twice per month in June (beginning the second week) and July 2003, with a single survey in mid-August (Table 2). A repeat survey was conducted in the OR Peaking reach in early June after flows were held constant at 1,500 to 1,700 cfs for three days in order to see if fry densities changed following a prolonged period of higher flows. All other medium flow surveys in the Peaking reaches were conducted during normal peaking operations, typically within 12 hours of low flow conditions. Surveys in the CA Peaking reach were conducted three times in July, with a fourth survey in early September. Shovel Creek was sampled during two of the July surveys and the early September survey. Fry surveys did not occur after September 4, 2003 because most young-of-year trout were expected to have grown from the “fry” size-class into the “juvenile” size class (>50mm FL), and therefore, were assumed to be more widely distributed in non-margin habitats which were not accessible to backpack electrofishing.

Targeted Sampling Flows

Qualitative electrofishing surveys in the OR and CA Peaking reaches were largely conducted during periods of medium flow with power generation through one turbine (1,500 to 1,700 cfs), in order to sample margins containing vegetative cover (Table 2). Lower flows (350-700 cfs) were sampled in the OR Peaking reach during the mid-June maintenance period and in the CA Peaking reach in mid-July and early September during normal peaking operations. In the Bypass reach, sampling efforts were conducted under low flows (100 to 350 cfs, depending upon study site) except during the maintenance period when flows were approximately 520 cfs below the springs.

Comparative surveys were conducted in the Bypass reach immediately before and after the flows were increased (see below for details). Similar comparative surveys (before and during peaking) were also conducted in the OR and CA Peaking reaches at specific sampling locations found to contain sufficient densities of trout fry (Table 2).

Study Site Selection

Twenty-six index study sites were sampled in the Klamath River, with each site containing two or more individual margin units (Figure 1). The Bypass and both Peaking reaches were divided into segments approximately 6,000 feet in length, and one to three index study sites were selected from each segment. Segments located in proximity to known spawning areas contained a higher density of study sites in order to better track the process of recruitment into the Peaking reaches. One additional study site with one sampling unit was placed in Shovel Creek. The Bypass and Shovel Creek sites provided comparative size and growth information for fry from the cooler, non-peaking sources of recruitment.

Table 2. Sampling periodicity for single-pass and multiple electrofishing surveys for rainbow trout fry in the study area.

Time Period	Date 2003	Study Reach	Study Sites	Stream-flow*	Survey Type
late May	5/30,6/3	Bypass	1-6	325	standard single-pass surveys
	5/31-6/2	OR Peaking	1-10	1,600	standard single-pass surveys
	6/2	OR Peaking	1-10	1,600	repeat single-pass surveys after period of constant flow
mid June	6/13	Bypass	1-6	325	standard single-pass surveys
	6/14	OR Peaking	1-10	1,600	standard single-pass surveys
	6/15	Bypass	1-10	520	high flow sampling during powerhouse maintenance
	6/16-6/17	OR Peaking	1-10	520	medium-low flow sampling during powerhouse maintenance
early July	7/2	Bypass	1-6	325	standard single-pass surveys
	7/3	OR Peaking	1-10	1,600	standard single-pass surveys
	7/7	CA Peaking	1-10,Shovel	1,600	standard single-pass surveys
mid July	7/15	CA Peaking	2,5	325	low flow (pre-peaking) single-pass surveys
	7/15	CA Peaking	1-10	1,600	standard single-pass surveys
	7/16-7/17	Bypass	1-6	325	standard single-pass surveys
	7/16-7/17	OR Peaking	1-10	1,600	standard single-pass surveys
late July	7/29	CA Peaking	1-10,Shovel	1,600	standard single-pass surveys
	7/30-7/31	Bypass	1-6	325	standard single-pass surveys
	7/30-7/31	OR Peaking	1-10	1,600	standard single-pass surveys
August	8/12	OR Peaking	1-10	1,600	standard single-pass surveys
	8/12-8/13	Bypass	1-6	325	standard single-pass surveys
September	9/3	Bypass	4a	325	multiple-pass survey
	9/3	OR Peaking	9b	>1,600	multiple-pass survey
	9/4	CA Peaking	3,5	325	low flow (pre-peaking) single-pass surveys
	9/4	CA Peaking	1-10,Shovel	1,600	standard single-pass surveys
	9/5	CA Peaking	3a,6b	325	low flow (pre-peaking) multiple-pass survey
	9/5	CA Peaking	5a,6b	>1,600	multiple-pass surveys
	9/9-9/11	OR Peaking	8a-b,10c-d	1,600	multiple-pass surveys
	9/15	CA Peaking	3a,6a	1,600	multiple-pass surveys
	9/16	OR Peaking	6a	1,600	multiple-pass surveys
	9/18	CA Peaking	3b,4b	1,600	multiple-pass surveys
	9/22-9/23	CA Peaking	1a-b,2b,5b	1,600	multiple-pass surveys
	9/24-9/25	OR Peaking	7d,9a,DP31	1,600	multiple-pass surveys

* peaking flows ranged from 1,500-1,700 cfs, Bypass flows at site 6 above springs were 100 cfs

The Bypass reach contained four 6,000 ft segments, with two study sites in each of the lowest two segments (where the majority of spawning occurs), and one study site in each of the upper two segments, thus yielding a total of six study sites (Figure 1). Five 6,000 ft segments occurred in the OR Peaking reach, with three study sites placed in the upper segment (immediately below the Bypass), two study sites in each of the following three segments, and a single study site in the last segment above Caldera Rapid (for a total of 10 study sites). Similarly, 10 study sites were selected within the four segments in the CA Peaking reach. Three study sites were selected from each of the lowest two segments (below Shovel Creek), and two study sites from each the upper two segments (for a total of 10 study sites). Among the three study reaches, a total of 26 study sites were surveyed during each sampling period. The specific location of these study sites was determined according to the segmentation described above, and the availability of diverse margin types.

Margin Unit Types and Selection

Eleven specific margin types (SMET's) were identified in the lower Klamath River (Hardin-Davis et al. 2002), nine of which contained specific combinations of substrate and/or emergent vegetative cover types (Table 3). Margin types in the Upper Klamath project area differed both in cover components and availability, thus some of the nine cover-related SMET categories were not available or were too rare to include in the fry surveys. For example, almost all margins in the Bypass reach were composed of large substrate with vegetation (canary grass). Locations without vegetation occurred in deep, rapid areas unsuitable for fry rearing, and willows or other vegetation types did not occur at the water's edge except at higher flows. In the Peaking reaches, margin areas containing either large substrate elements alone (mostly deep and fast) or containing large substrate with canary grass were again the predominant margin types and thus were most represented during this study. Margin areas containing either no cover (open areas), herbaceous vegetation with fine substrate, or emergent willows or other shrubs, did occur infrequently in the Peaking reaches and were sampled where available.

Table 3. SMET codes and descriptions. Code from lower Klamath study, Hardin-Davis et al. (2002).

Stream Margin Edge Type (SMET) Code	
1. Trees (diameter @ water surface >4")	
2. Trees and emergent vegetation	
3. Dense aggs of willow / WD / berry	
4. Emergent Shrubs (willow / black berry)	
5. Open Areas	
6. Sparse herbaceous vegetation	
7. Dense herbaceous vegetation	
8. Large sub / Rip-Rap (natural or man made)	
9. Large substrate / Rip Rap with vegetation	
10. Eddy	a. Bank influenced
	b. Substrate influenced
11. Backwater	

Margin units were only included for sampling if depth and velocity characteristics at the middle flow regime (ca. 1,500 cfs) were suitable for rearing small fry (<5 cm). The lower Klamath study (Hardy et al. 2001), the Bypass study conducted in 2002, and numerous other fry microhabitat studies (Moore and Gregory 1988, Bozek and Rahel

1991, Nehring and Anderson 1993, Allen 2000) have shown that fry are restricted to shallow, slow microhabitats. Consequently, this fry study chose to sample only within margin areas that were predominantly less than two feet in depth with velocities less than one fps. These criteria are consistent with data collected in the Bypass for trout fry and in the lower Klamath for chinook fry (Figure 2).

In addition to being consistent with findings from a broad range of fry studies, restricting sampling efforts to shallow/slow margins also served to maximize sampling efficiency by not expending valuable effort in poor fry habitat, it helped to focus the identification and location of suitable margin units, and it minimized bias when comparing index densities among margin types. For example, the majority of margins containing only large substrate were too fast and/or too deep to provide suitable rearing habitat for small fry. In contrast, vegetated margins tended to be slower and shallower due to vegetative requirements for adequate lighting, interstitial fines for root attachment and nutrient uptake, and protection from scouring flows. Thus, if deep/fast substrate margins were compared with shallow/slow vegetation margins, biased conclusions would result. In summary, due to the highly restrictive microhabitat requirements of small fry, depth and velocity must be accounted for in any comparisons of fry among margin types (Lister et al. 1995).

In addition to depth and velocity requirements, many of the studies cited above (including data from the Bypass reach and the lower Klamath) have also indicated that small fry are restricted to areas near the streambank or other form of emergent cover. Consequently, margin units typically did not extend more than three feet away from emergent vegetation or more than six to eight feet from the stream bank where vegetation was absent (Figure 3).

Each of the 26 study sites contained a minimum of two margin units, one unit containing large substrate (dominated by cobbles or boulders) with minimal emergent vegetation, and one unit containing significant area with emergent vegetation (mostly canary grass) with or without large substrate. Margin unit lengths varied according to natural boundaries, but most individual sampling units ranged from 80 ft to 150 ft in length. In some study sites numerous short margin units were sampled due to limited availability of margin types, whereas in other study sites fewer but longer margin units were sampled.

<u>Margin Unit Habitat Measurements</u>

All sampled areas were identified by GPS coordinates and described in terms of sampling area (in ft^2 of surface area), sampling time (time of day and duration of shocking), SMET category, and habitat characteristics. Habitat characteristics were measured along three to (typically) six transects, depending upon margin unit length, placed perpendicular to the bank at systematic intervals (with a random start) along the full length of the margin unit (Figure 4). Mean depths and mean water velocities were measured at three points along each transect (at $^1/_3$, $^2/_3$, and $^3/_3$ of the total width); values were assumed to be zero at the bank margin. Depth and distance to bank was also measured at the far edge of emergent vegetation. The percentage of the sampling area containing instream cover

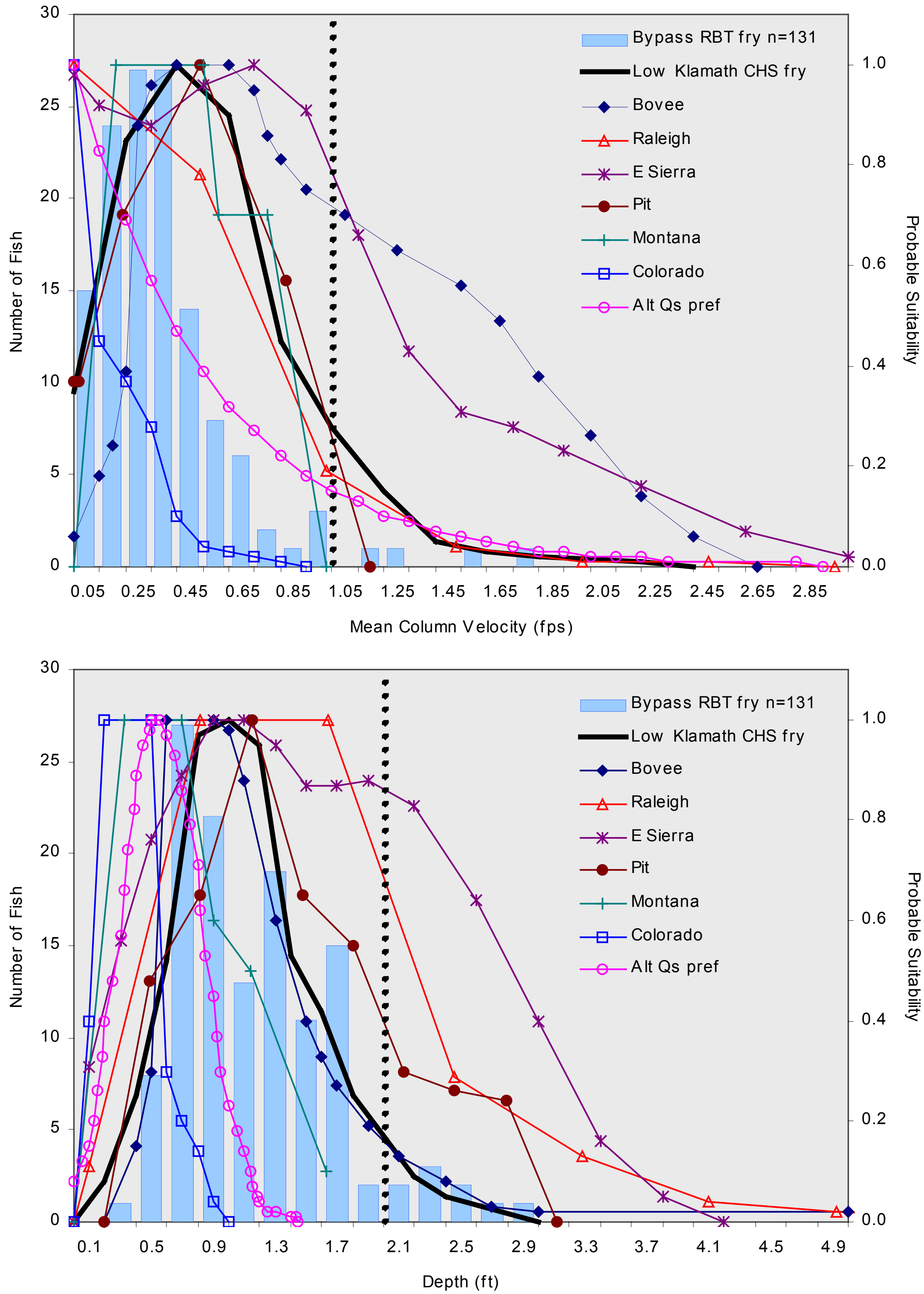


Figure 2. Mean column velocities and depths selected by rainbow trout fry in the Bypass reach in 2002, with HSC from a variety of other studies. Heavy dashed vertical line defines maximum velocity and depth criteria used to select margin units for sampling by electrofishing in the Upper Klamath River.

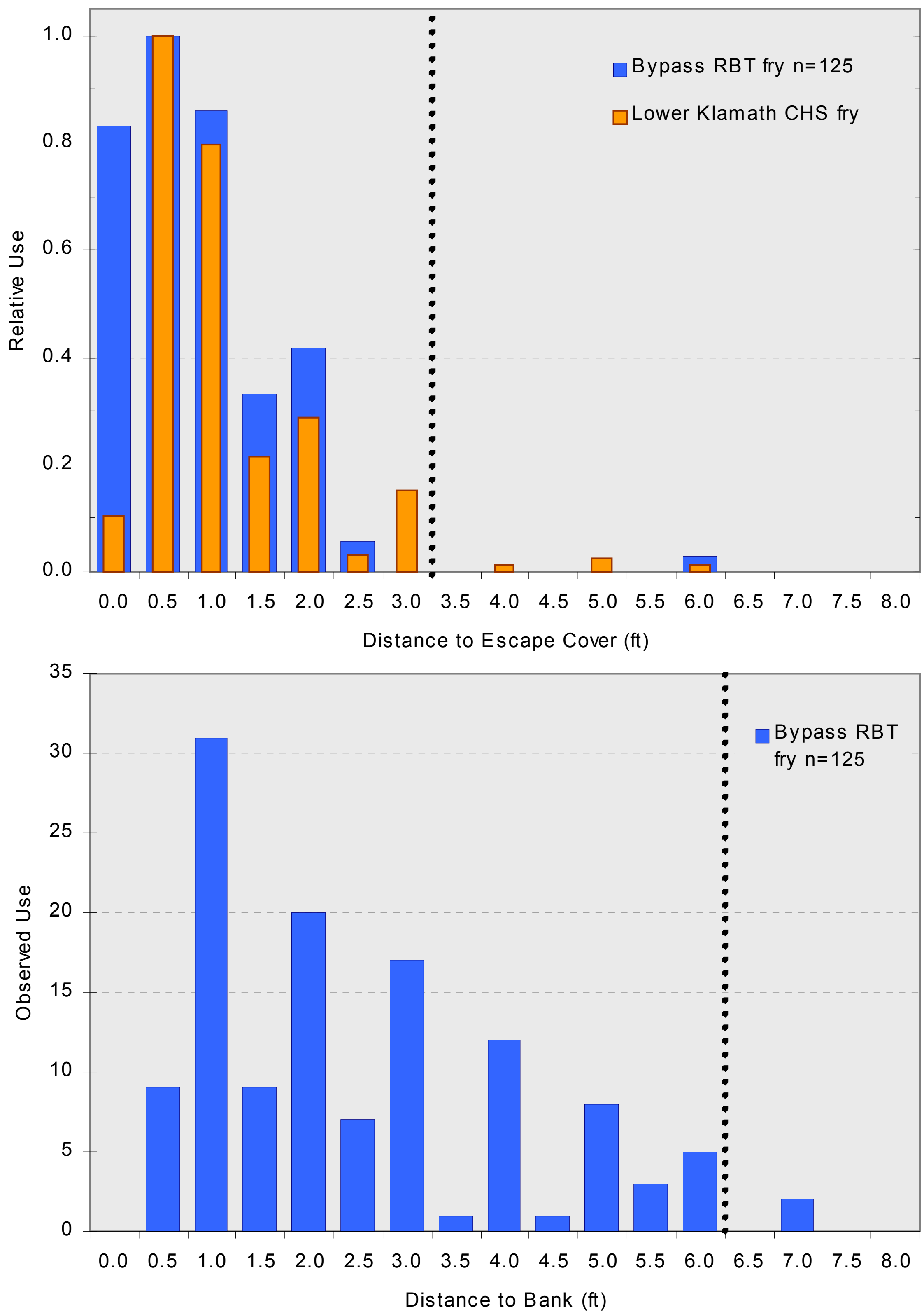


Figure 3. Distance of trout and salmon fry focal positions from instream escape cover in the Bypass reach in 2002 and the lower Klamath River (Hardy et al. 2001) (upper graph), and distance of trout fry from the streambank in the Bypass reach (lower graph). Heavy dashed vertical lines represent distance criteria used to define margin sampling areas.

formed by cobble or boulder substrate, by emergent vegetation, or by aquatic vegetation, was eye-estimated. The specific substrate or vegetative types forming the dominant and subdominant types were also recorded (Table 4). The distance from the medium flow water's edge (at 1,500-1,700 cfs) to the low flow water's edge (at 350 cfs) was measured at each transect. Water temperatures and photographs were taken at each site. Habitat characteristics were re-measured at each site when flow conditions differed between sampling periods.

Fish Sampling Procedures

Single-Pass Electrofishing

Margin units were identified by GPS coordinates and flagged at the top and bottom boundaries. Sampling area widths remained constant according to the fry rearing criteria listed above, i.e., 6-8 ft from the bank, or 3 ft from the edge of emergent vegetation (which ever was greater). Electrofishing procedures were consistent with guidelines established by NOAA Fisheries for protecting listed species of salmonids (NMFS 2000). Each margin unit was sampled using a single pass with one (rarely two) Smith-Root Type VII and XII backpack electrofishing units. Electroshocking teams consisted of one person carrying a backpack electroshocker and one or two netters.

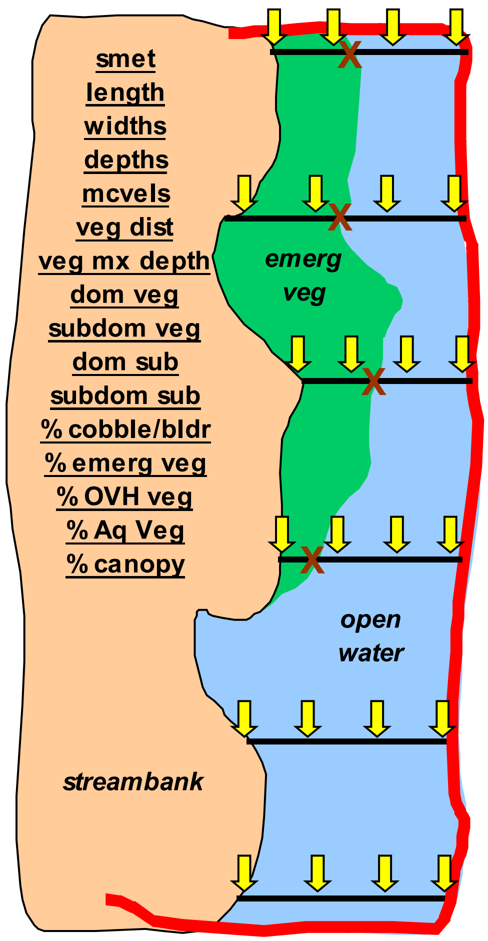


Figure 4. Example of margin unit showing sampling area boundary, transects, depth and velocity measurement points (arrows), and habitat variables. X's represent locations where emergent vegetation distance and max depths are measured.

Captured fish were temporarily held in aerated buckets containing fresh river water until the pass was completed. All fish were identified to species and counted, and all trout fry were measured to the nearest mm fork length and weighed on a digital scale (accuracy ±0.1g) on a portable table with attached windscreen. When necessary, fish were anesthetized with bottled CO^2. Small fry (<30mm FL) were weighed in groups of similar sized fish to calculate an average weight for an average length. Larger trout and non-listed, non-salmonid species were not anesthetized nor measured, but were released back into the capture area following the completion of electrofishing. Shocking seconds and starting and ending times were recorded for each pass.

Because sampling in the lower portion of the California segment in July could have resulted in the capture of endangered sucker species (*Chasmistes brevirostris* and *Deltistes luxatus*), additional precautions were taken to ensure protection of those species according to CDFG MOU permitting conditions.

Multiple-Pass Electrofishing

Single-pass electrofishing is a feasible methodology for use in many margin areas of the Upper Klamath River where depth, velocity, and dense cover prevent the effective use of block-nets and accepted multiple-pass methodologies. However, index data resulting from single-pass electrofishing may not be highly effective for assessing community structure (Meador et al. 2003), nor does it allow the estimation of total fish abundance and associated levels of uncertainty (i.e., variance and confidence intervals). Nevertheless, if carefully applied with diligent attention to fishing effort and sampling areas, single-pass data can be useful in assessing *relative index* densities of trout fry in different margin types, particularly if validation samples are available to compare sampling success in different habitat types.

Table 4. Substrate and cover codes used to describe characteristics in margin units. Code from lower Klamath study, Hardin-Davis et al. (2002).

Code	Substrate / Cover Type	Size (in)
1	Filamentous Algae	-
2	Non Emergent Rooted Aquatic	-
3	Emergent Rooted Aquatic-bull rushes	-
4	Grass	-
5	Sedges-cattails	-
6	Cockle Burrs	-
7	Grape Vines	-
8	Willows	-
9	Berry Vines	-
10	Small Trees	<4 dbh
11	Large Trees	>4 dbh
12	Rootwad	-
13	Aggregates of small veg dom	<4
14	Aggregates of large veg dom	>4
15	Duff, leaf litter, organic debris	-
16	Small Woody Debris	<4 in x12 ft
17	Large Woody Debris	>4 in x12 ft
18	Clay	-
19	Sand and/or Silt	<0.1
20	Coarse Sand	0.1-0.2
21	Small Gravel	0.2-1
22	Medium Gravel	1-2
23	Large Gravel	2-3
24	Very Large Gravel	3-4
25	Small Cobble	4-6
26	Medium Cobble	6-9
27	Large Cobble	9-12
28	Small Boulder	12-24
29	Medium Boulder	24-48
30	Large Boulder	>48
31	Bedrock	-

Validation exercises were thus conducted using accepted multiple-pass methodologies at selected single-pass margin units in order to better assess the reliability of single-pass captures for developing density indices in a variety of margin habitats. Of the 61 total margin units sampled by single-pass electrofishing, 21 units were found to contain trout fry (at least during some surveys) and were also deemed feasible for deployment of block nets. The remaining margin units either occurred where fry were rarely captured or else the units were too deep, too fast, or contained too much cover (i.e., large boulders or dense vegetation) to effectively enclose with block nets. All multiple-pass surveys were conducted in September 2003 following the conclusion of the single-pass surveys.

The multiple-pass electrofishing protocol was fundamentally the same as that used in single-pass surveys, however block nets were first placed to span the full length and width of the stream margin prior to the first pass. One crew member deployed the net in a downstream direction after securing the upper boundary. The net was deployed as slowly and carefully as possible to minimize displacement of fish from the margin unit prior to sampling. A second crew member followed behind (from outside of the sample area to minimize disturbance) to fully secure the net bottom to prevent fish escape during sampling. After the margin unit was fully enclosed, fish were captured using one electroshocker and two netters with a minimum of three passes (one sample was terminated after two passes due to nightfall). Care was taken to conduct each pass in an identical manner in order to meet the equal effort assumptions inherent to removal-depletion estimators. Fish were processed after each pass and held in recovery buckets until the final pass was complete. Fish were released back into the margin unit after the sampling was complete and the block nets were removed.

Fish abundance estimates were generated using MicroFish 3.0 (Van Deventer and Platts 1989). MicroFish calculates bounded population estimates and capture probabilities from electrofishing data obtained by the removal method using a maximum-likelihood estimator. Because conventional removal-depletion estimators perform poorly when the captured organisms are in low abundance, estimates of abundance and the associated capture probabilities and variances could not be calculated for two of the multiple-pass samples. Capture probabilities for those samples were thus calculated from a jack-knife procedure developed by Hankin and Mohr (unpublished manuscript) for sampling rare populations. Estimates of fry abundance in those samples used the total number of fry captured (both instances involved only 1 fry capture).

Fry Residence During High Flow and Peaking Events

Repeat sampling was conducted within many margin units during periods of high, stable flow or during periods of fluctuating flows in order to evaluate if changes in fry densities or fry locations occurred. Some of these evaluations involved fin-clipped fry. For example, in the Bypass reach all fry >25mm in length captured in mid-June or later were marked with fin-clips specific to each of the lower five study sites (Site #1-left pelvic, Site #2-right pelvic, Site #3-left pelvic+adipose, Site #4-right pelvic+adipose, and Site#5-adipose only). Fin clips were made on anesthetized fry using nail clippers or dissecting scissors, and then fry were transferred into fresh water for evaluation of recovery. Fry were released back into the margin unit after recovery appeared complete, however longer-term survival studies were not conducted. All captured fry were inspected for fin clips during each subsequent sampling period, and all newly captured but unmarked fry were fin-clipped according to the code described above. Thus, a fin-clip could be used to identify the location of the fry's original capture, but not the sampling period when it was clipped.

In the Bypass reach, maintenance of the J.C. Boyle Powerhouse occurred over a ten-day period in mid-June, during which time flows released from the J.C. Boyle dam into the Bypass reach increased from 100 cfs (the normal release flow) to approximately 300 cfs. In order to evaluate the potential effects of the flow increase on fry residence and index densities, all Bypass margin units were sampled one day before and again one day after the flow increase. All captured fry were inspected for fin-clips.

Another repeated sampling effort was conducted in the Oregon Peaking reach, where all margin units were sampled twice over a three-day period of sustained medium flows (1,700 cfs) in late-May and early-June. This repeat sample was conducted to determine if fry densities differed from the first sample immediately after flows increased from a base of 350 cfs to 1,700 cfs, to the second sample after 1-2 days of stabilized higher flows with a stable water's edge.

Additional repeated sampling efforts were conducted using fin-clipped fry in the California Peaking reach. In mid-July, four margin units were sampled under low flow conditions prior to peaking, and all captured fry were fin-clipped using a unique clip for each margin unit. The units were resampled later in the afternoon after peaking flows had stabilized, and all captured fry were inspected for clips from the morning surveys. In early September, four margin units were again sampled before and immediately after peaking, using fin clipping to distinguish fry captured during the previous low flow period.

Data Analysis

Comparison of Fry Densities by Margin Cover Type

Because single-pass electrofishing does not provide estimates of true abundance, and because capture probabilities were expected to be lower in vegetated margin units than in non-vegetated units (due to the relative magnitude and density of instream cover), comparisons of fry densities according to margin cover type utilized "expanded" index densities from single-pass electrofishing to correct for differences in capture probabilities. Mean capture probabilities were calculated for both margin cover types, using the multiple-pass capture probability estimates in vegetated units for the vegetated mean, and the multiple-pass estimates in non-vegetated units for the non-vegetated mean. These mean capture probabilities were then used to scale-up (or, expand) the catch of fry in each single-pass sample, by dividing each single-pass catch by the mean capture probability according to the margin unit's cover type. This adjustment procedure was only used for trout fry when comparing fry densities in vegetated versus non-vegetated units and when evaluating the role of habitat characteristics upon fry densities (see below). All other analyses for trout fry and for non-salmonid fish utilized the raw, unadjusted index densities.

Because only a limited number of capture probabilities were estimated for each margin type (4 non-vegetated units and 5 vegetated units contained fry during multiple-pass surveys), the estimated mean probabilities and subsequently expanded estimates of fry density should be viewed with caution. Additional multiple-pass surveys would likely produce more reliable estimates of mean capture probability, especially for vegetated units that showed high variability in capture probabilities.

The Wilcoxon's signed rank test, a non-parametric equivalent to the paired t-test, was used to determine if expanded and raw (i.e., non-adjusted) fry index densities (expressed as number of fry/100 ft^2) were significantly different between vegetated and non-vegetated margin pairs in the Oregon and California Peaking reaches (non-vegetated margins did not occur in the Bypass). The non-parametric test was used due to non-normality in the calculated differences. All tests were two-tailed and P-values <0.05 were considered to be statistically significant.

Where a study site contained more than one margin unit of a specific cover type (i.e., 2 vegetated margin units), paired tests were conducted after calculating a mean index density for the multiple units. This was necessary to produce a single index density to represent the vegetated margins and a single value for the non-vegetated margins in each study site. Independent paired tests were conducted for the CA Peaking and OR Peaking reaches separately and for the entire Peaking reach together, using data from all sample periods (medium flows only, low flow samples did not contain vegetated margins).

Effects of Unit Habitat Characteristics on Fry Densities

Bar charts were developed to illustrate potential differences in margin habitat characteristics between study locations and between paired vegetated and non-vegetated margin units. Paired t-tests were used to determine if habitat parameters differed statistically among the paired units. For most habitat parameters (i.e., mean depth, mean velocity, etc.), a two-tailed test was conducted under the null hypothesis that the parameter was equal in vegetated and non-vegetated units. For those habitat parameters expected to differ (i.e., vegetation parameters), one-tailed tests were conducted using the hypothesis that (for example) the vegetated units contained more vegetative cover than did the non-vegetated units. All differences were considered statistically significant for P-values ≤ 0.05.

Spatial and temporal changes in fry densities were visually evaluated using a series of bar and line plots to identify obvious trends or patterns. In order to help explain the observed variation in fry densities according to index study site and margin unit, a stepwise multiple regression analysis was conducted using physical characteristics of the margin units as predictor variables and mean expanded (i.e., adjusted) fry densities as the response variable. Mean index densities were calculated for each margin unit using all available sampling periods at the targeted flow level (i.e., 325 cfs in the Bypass reach and 1,500-1,700 cfs in the Peaking reaches), which included six sample periods for the Bypass and OR Peaking reaches, and four sample periods for the CA Peaking reach.

Scatterplots of margin habitat characteristics and mean index densities of trout fry were created to identify margin characteristics that appeared to influence observed fry densities. The scatterplots and simple correlation analysis was used to select an initial set of predictor variables for input into the regression model. The observed differences in fry densities among the 26 index locations appeared to be strongly influenced by proximity to known spawning location. Consequently, distance to the nearest upstream spawning area was also evaluated as a predictor variable. The response variable and the distance to spawning area variable were log-transformed in order to stabilize variance and linearize the residuals.

The stepwise procedure (conducted in S-Plus 2000) uses a C_p statistic to repeatedly test whether an added variable significantly reduces the error variance term of the current model, and also tests if any of the previously added variables no longer contribute to variance reduction given the addition of a new variable. The stepwise procedure terminates when no additional variables contribute to the existing model (in terms of error reduction), and not existing variables can be dropped without increasing the error term. The final model was evaluated using the multiple-R^2 term and F-test, and the model aptness was tested by inspecting model residuals against the selected variables and fitted values, as well as normality and outlier plots. In addition, the residuals were compared to non-selected variables to see if additional variability could be explained.

Because of the apparent influence of distance to spawning area on observed fry densities, the analysis was restricted to index locations in the Peaking reaches where fry were commonly observed and where habitat characteristics were thus expected to exert some influence upon local fry densities (i.e., sites 6-10 in the Oregon Peaking reach and sites 1-6 in the California Peaking reach). Although margin units in the Bypass reach were originally included in the analysis, fry densities in that reach showed a negative relationship to unit average velocity whereas densities in the Peaking reaches were positively associated with unit velocities. Because the emphasis of this study was to describe fry distribution and abundance in the Peaking reaches, and because water temperature is a possible factor causing the different responses to unit velocity, the analysis was conducted using data only from the Peaking reaches. Incorporating a temperature variable into the model is a potential alternative to deleting the Bypass data, however that alternative was not attempted.

<u>Analysis of Fry Growth</u>

Fry length data were used to construct length-frequency histograms according to index site location and sampling time period. All captured trout up to 79mm FL were included in order to track growth of young-of-year from the “fry” size class (<50mm FL) to the “juvenile” size class, although all analysis of fry densities (described above) were restricted to the smaller fish(<50mm FL). Length-weight relationships were derived for fry and small juveniles using log-transformed lengths (in mm FL) and log-transformed weights (in grains) according to sampling period and reach (Bypass, OR Peaking, CA Peaking, and Shovel Creek). Fry weights were converted from grams to grains to allow log-transformation (i.e., no fish were <1 grain in weight). Linear regression was used to model growth as: $\log(wt) = a + b \times \log(FL)$. Significance of regressions was tested using the multiple R^2 and the F-test.

It should be noted that errors associated with weighing small fry in the field produced numerous outliers in the length vs. weight data. Although the most extreme outliers were deleted from the analysis, many questionable data points could not be confidently deleted and thus some of the regressions were likely influenced by the outlier observations.

Regression models were compared among reaches for each time period to determine if fry were larger or grew at a faster rate according to reach. The former condition would be detected by differences in the elevation of regression lines (determined by line intercept and slope), whereas the latter condition would be detected by differences solely in the slope of the line. Comparison of overall regression models (both intercept and slope) was performed by comparing the error (unexplained) variance of a "full" model with the error variance in a "reduced" model (Neter and Wasserman 1974, pg 160). The "full" model is equivalent to adding the error variances from the two separate models, whereas the "reduced" model error variance is estimated by pooling the data together and fitting a regression to the common data. An F-test was used to determine significance of the error variance terms.

This test requires the usual assumptions for developing regression models, including constant variance of error terms. Comparison of error terms was made for each pair of regression models using an F-test of the full and reduced mean square errors (Neter and Wasserman 1974, pg 165). Despite the log-transformation of length and weight data, all tests comparing error variances were significant (at $P<0.05$). Consequently, the resulting comparisons of regression models should be evaluated with caution and all reported P values are only approximate.

For those model comparisons that were significantly different, another test was conducted to determine if the difference was due to non-parallel slopes (as opposed to a difference in intercept alone). This comparison also used an F-test and was essentially equivalent to determining if an interaction occurs in the paired data (Neter and Wasserman 1974, pg 702). A lack of interaction indicates that the regression models exhibit the same relationship between length and weight (i.e., similar slopes). Again, the lack of constant error variances among the length vs. weight data suggests that caution should be applied in interpretation of the results.

A new, alternative testing procedure that utilizes a ratio test and a "relative" weight index (Brenden et al. 2003, Murphy et al. 1990) was also considered, however a standardized weight equation (W_s) has not been specifically developed for very small trout fry, and the errors associated with field-weighing the fry in this study could significantly reduce the ability to compare site-specific data with a standardized weight relationship. The ratio test was therefore not recommended for use in this study (Travis Brenden, personal communication).

RESULTS

Fry Densities Among Index Locations

A total of 1,212 fry were captured by single-pass electrofishing at 26 index sites representing 61 individual margin units (Appendix A). Fry were common along margins in the Bypass reach downstream of the spillway, where index densities (based on single-pass electrofishing) were 1-3 fry/100 ft^2 (Figure 5). A major spawning area occurs immediately below the Bypass spillway.

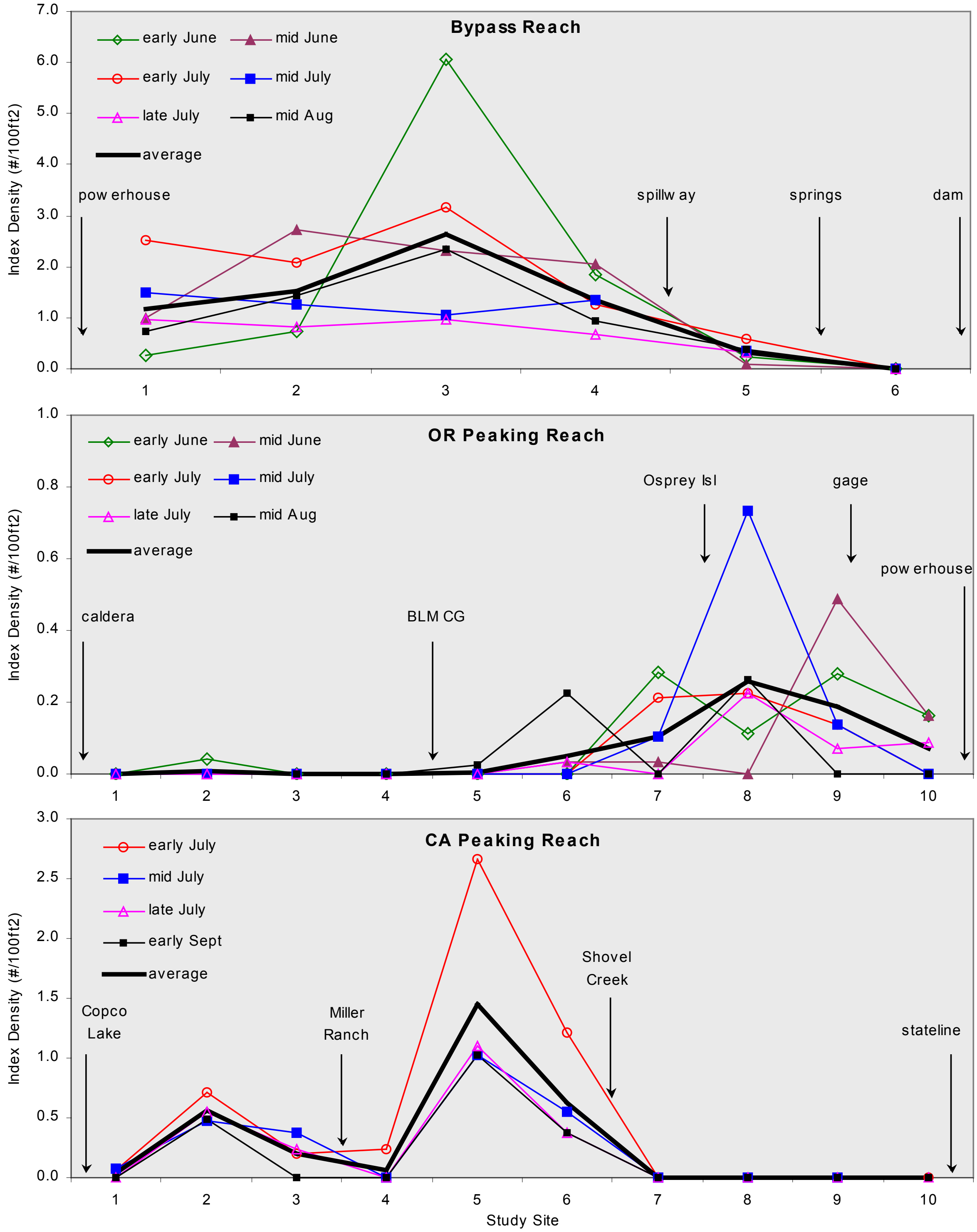


Figure 5. Index densities of rainbow trout fry (<50mm FL) according to reach, index site (margin units combined within sites), and sampling period. Note differences in y-axes. Relative locations of landmarks are also shown.

Some fry were captured at the index site upstream of the spillway but below the springs, but no fry were captured at the uppermost site above the springs. In the OR Peaking reach, fry were captured in low numbers (0.1-0.3 fry/100 ft^2) in the upper five index sites closest to the Bypass reach, but fry were rarely observed in the downstream sites below the BLM campground. In the CA Peaking reach, fry were common at most index sites below Shovel Creek (0.2-1 fry/100 ft^2), but were not observed at sites above the spawning tributary. The averaged fry densities clearly show the spatial trends in each reach.

The relatively consistent relationship of fry densities among sites in the Bypass reach and the CA Peaking reach, when compared to the OR Peaking reach, is evident from the fewer line intersections. That relationship may be related to the stability of fry populations in those reaches, but it is likely to be in part due to the very low densities of fry in the OR Peaking reach where a difference in capture of one or two fry over time may produce fluctuations in relative densities when compared among sites.

Changes in Fry Densities Over Time

Temporal variation in fry index densities was evaluated by comparing densities per location over time, and by calculating an average density among index locations by reach for each sampling period (Figure 6). The mean fry density by sampling period showed a relatively minor decrease through the summer in all three reaches, possibly due to continued recruitment of fry into the mainstem reaches. Length-frequency data from captured fry showed a prominent recruitment of very small fry in late July in each reach (see below). Trout spawning observations in the Bypass reach revealed a protracted spawning period of over two months in duration with at least two peaks in activity. Although an extended spawning period is not known to occur in Shovel Creek, fry do emigrate from that spawning tributary into the CA Peaking reach throughout the late summer months (Beyer 1984). The minor decrease in fry index densities despite growth of fry into the next size class ("juveniles" at >50mm FL) may thus be attributable in part to the continued recruitment of small fry into the peaking reaches throughout the summer.

Habitat Characteristics in Margin Units

An important design aspect of this fry study was an attempt to select margin units that were highly consistent in habitat characteristics with the exception of dominant cover type (Appendix B). Margin units were selected to largely contain shallow depths and slow velocities, which are important habitat requirements for small trout fry (Figure 2). A paired comparison of margin units was thus conducted to determine if units differed in habitat characteristics, which could potentially explain the observed differences in fry densities among study sites and margin units (Appendix C).

Unit mean velocities and mean depths fell well within the desired criteria of 1 fps and 3 ft, although many units contained maximum velocities well in excess of the criteria (Figure 7). In general, mean velocities in the Bypass units were very similar to velocities in the OR Peaking units (overall mean velocities were <0.3 fps), but were less than velocities in the CA Peaking units (means were 0.4-0.5 fps). Overall mean depths ranged from 0.7 ft to 0.9 ft in all reaches. Paired t-tests showed that there were no significant differences in mean or maximum velocities in vegetated and non-vegetated margin units in either of the Peaking reaches (Table 5). Mean depths were likewise similar among vegetated and non-vegetated units in the OR Peaking reach, but mean depth was significantly greater in CA vegetated units than in CA non-vegetated units

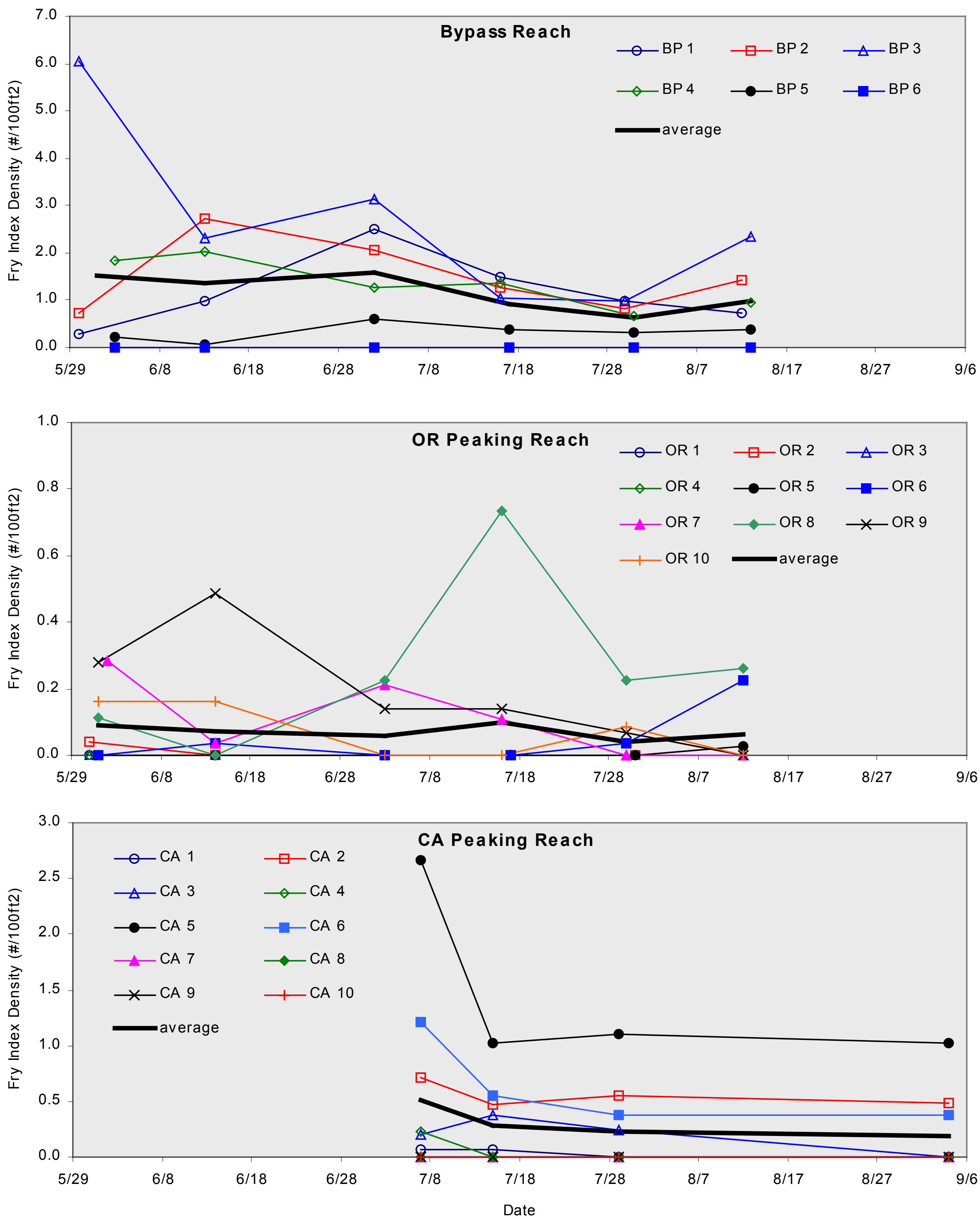


Figure 6. Temporal changes in index densities of rainbow trout fry (<50mm FL) according to reach and index site (margin units combined within sites). Note differences in y-axes.

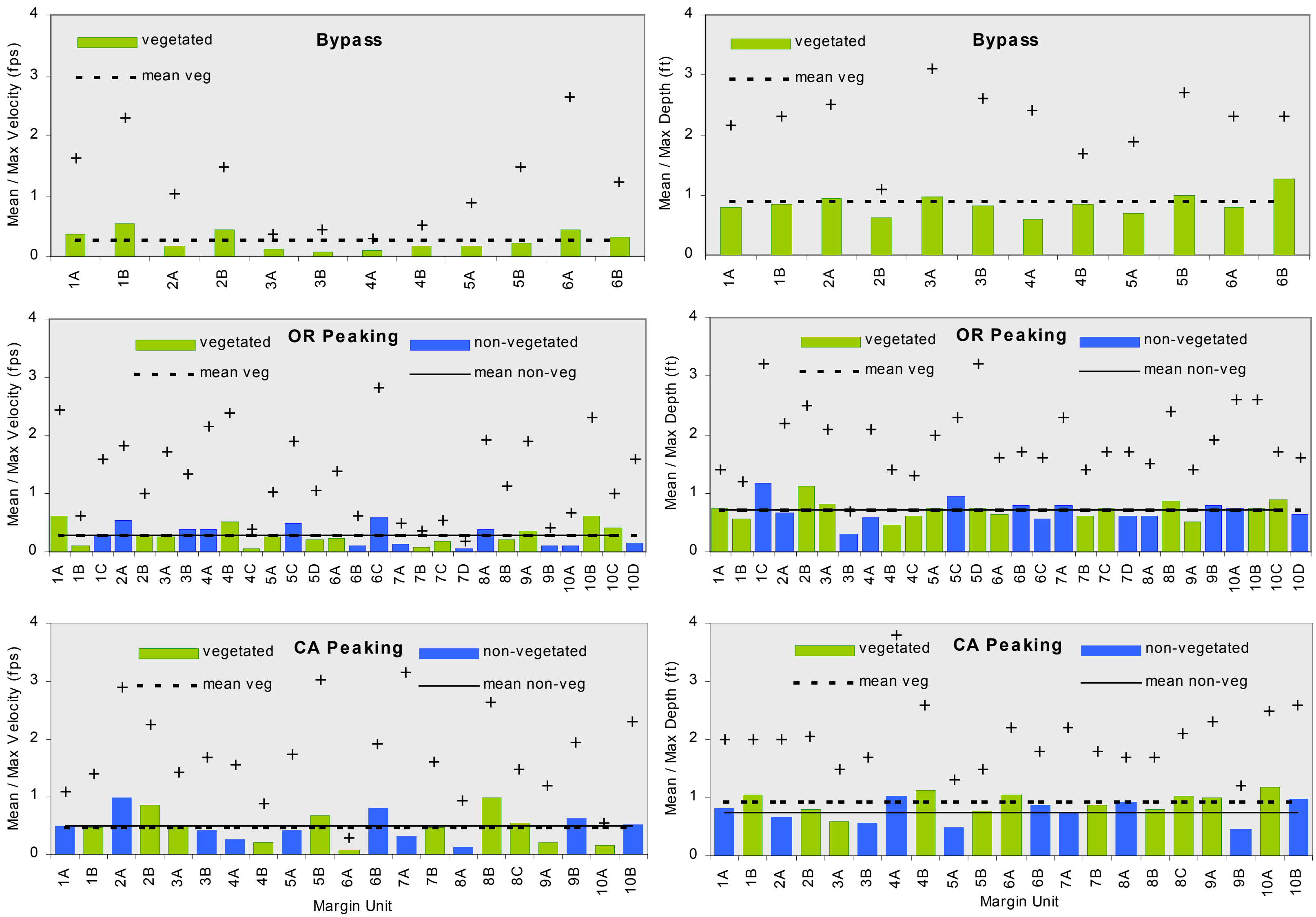


Figure 7. Mean velocities (left graphs) and mean depths (right graphs) in margin units according to reach and dominant cover type (vegetated vs. non-vegetated). Overall means are shown by horizontal lines, unit maximum values are shown by pluses.

(P=0.003, paired t-test). However, mean depth in the CA vegetated units was less than 1 ft (0.93 ft), which was well within the suitable range for trout fry (Figure 2).

Table 5. Paired t-test statistics comparing habitat characteristics in vegetated and non-vegetated margin units according to reach.

	Dom	# *	Unit Depth		Unit MCVel		Emerg Veg		Substrate		% of Unit Containing:					Δ
Reach	Cover	Units	Avg	Max	Avg	Max	Dist	MxDep	Dom	SubD	Cob+	EmVeg	OVH	AQV	Canopy	WE
Bypass	veg	9	0.90	2.30	0.26	1.19	0.8	0.40	28	27	67	9	10	n/a	0	n/a
OR Peaking	sub	13	0.70	2.00	0.28	1.35	0.1	0.03	27	27	85	2	4	n/a	18	13.7
	veg	15	0.72	1.86	0.29	1.29	2.3	0.47	26	26	78	15	24	n/a	8	16.2
difference in means			-0.02	0.14	-0.01	0.06	-2.2	-0.44	1	1	7	-13	-20	n/a	10	-2.5
paired t statistic			-0.19	0.07	0.32	-0.24	-4.32	-5.53	2.51	2.56	1.82	-3.02	-2.68	n/a	1.26	-0.44
***P value*			0.85	0.95	0.75	0.82	0.001	0.000	0.03	0.03	0.10	0.01	0.01	n/a	0.24	0.67
CA Peaking	sub	10	0.75	2.03	0.49	1.91	0.4	0.13	26	26	81	6	20	1	16	11.9
	veg	11	0.93	2.02	0.46	1.52	3.8	0.76	24	24	54	39	44	9	12	9.4
difference in means			-0.19	-0.03	0.06	0.39	-3.7	-0.70	3	2	24	-36	-26	-9	7.8	2.1
paired t statistic			-4.01	-0.14	0.48	1.03	-4.73	-7.97	2.25	2.20	3.22	-4.70	-2.87	-1.67	1.22	0.78
***P value*			0.003	0.89	0.64	0.32	0.001	0.000	0.05	0.06	0.01	0.001	0.01	0.13	0.26	0.45

*paired comparisons in OR and CA Peaking reaches were based on 10 pairs each (ie multiple units/cover type w/in a site were combined prior to testing)

**all emergent vegetation and overhead vegetation tests were one-tailed, tests for all other variables were two-tailed

Comparison of substrate characteristics shows that in most margin units 70-80% of the sample area contained instream cover composed of cobble and/or boulder substrate, except for vegetated units in the CA Peaking reach where on average only 54% of the sampling area contained cobble/boulder cover (Table 5). The difference in vegetated and non-vegetated units in the CA Peaking reach was statistically significant (P=0.01, paired t-test). This result was not unexpected because most of the non-vegetated units were selected on the basis of having substrate-formed cover, whereas the requirement for selecting vegetated units included the presence of vegetated cover with or without substrate cover. Consequently, some of the vegetated units (particularly in the CA Peaking reach) contained relatively small amounts of cobble or boulder cover. In general, the average size of substrate elements decreased from the Bypass reach downstream to the CA Peaking reach. Substrate in the majority of margin units in the Bypass and OR Peaking reaches were dominated by large cobbles or boulders >9in in diameter (see Table 4 for substrate types and sizes), with many units in the Bypass containing boulders >48in (Figure 8). In contrast, margin units in CA Peaking reach were typically dominated by substrates <9in in size, with several vegetated units dominated by gravel or sand.

The percentage of margin sampling area containing emergent vegetative cover was, as expected, significantly greater in vegetated units than in non-vegetated units in both Peaking reaches (P's<0.01, paired t-test, Table 5). Among reaches, the percentage of vegetated cover was greatest in the CA Peaking reach and least in the Bypass reach (Figure 9), where Canary grass grows only along the edge of the waters surface. In the Peaking reaches, the emergent vegetation (again mostly canary grass) is frequently flooded and extends farther into the water column. The distance from the streambank to the edge of emergent vegetation averaged only 0.8 ft in the Bypass reach, but was 2.3 ft in the OR Peaking reach and 3.8 ft in the CA Peaking reach (vegetated units only). The mean distance to bank estimates were significantly greater in vegetated units than in non-vegetated units in both Peaking reaches (P's $\leq$0.001, paired t-tests). The maximum depth of emergent vegetation was also significantly greater in vegetated than in non-vegetated units in both reaches (P's<0.001, paired t-test), with a greater overall mean in the CA Peaking reach (vegetated mean = 0.76 ft) than in the OR Peaking reach (mean = 0.47 ft).

The percentage of overhead cover within a margin unit was closely related to the amount of emergent vegetation, because only vegetation within 18in of the water surface was considered to

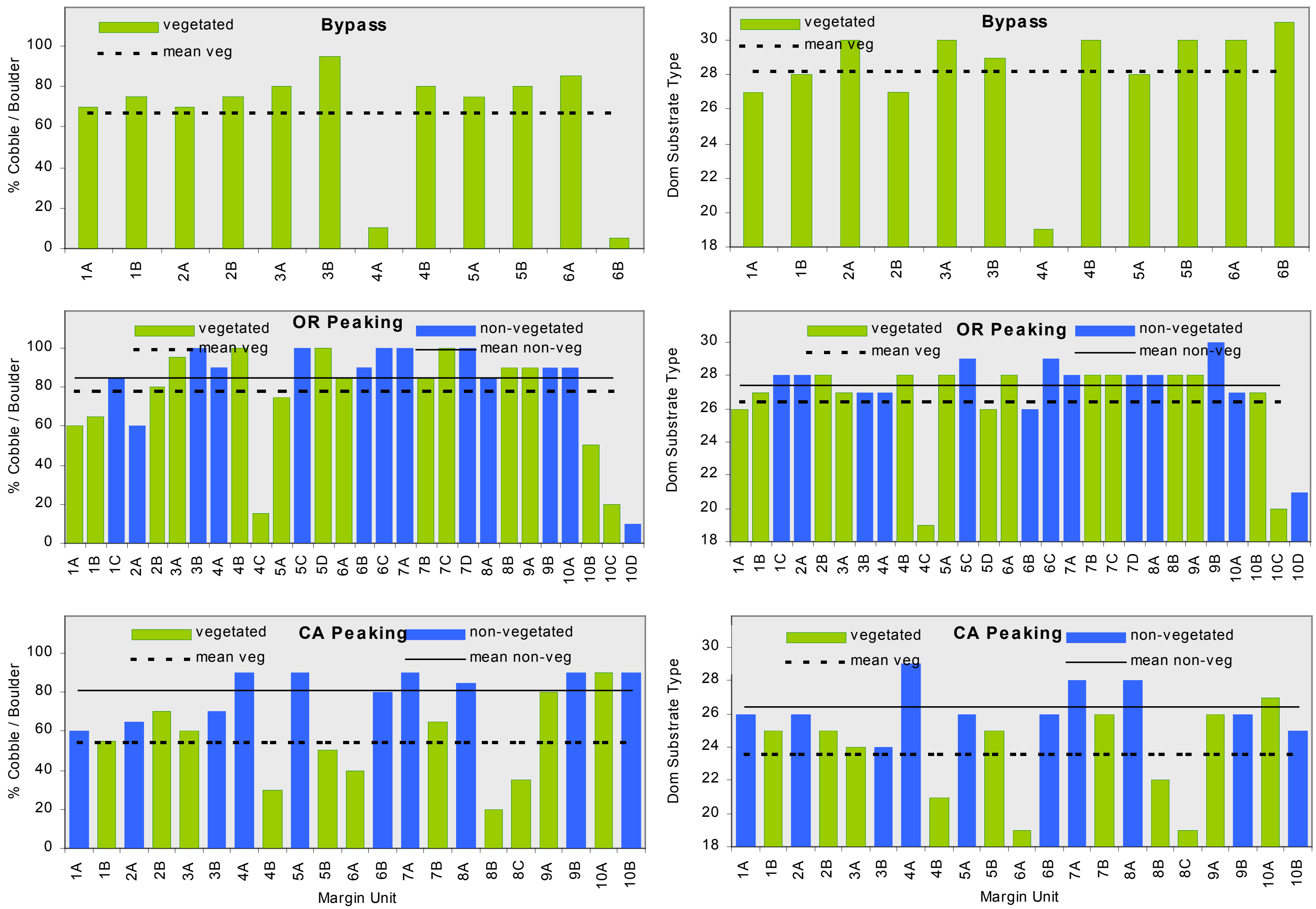


Figure 8. Percent cobble/boulder cover (left graphs) and dominant substrate type (right graphs) in margin units according to reach and dominant cover type (vegetated vs. non-vegetated). Overall means are shown by horizontal lines. See Table 4 for substrate code.

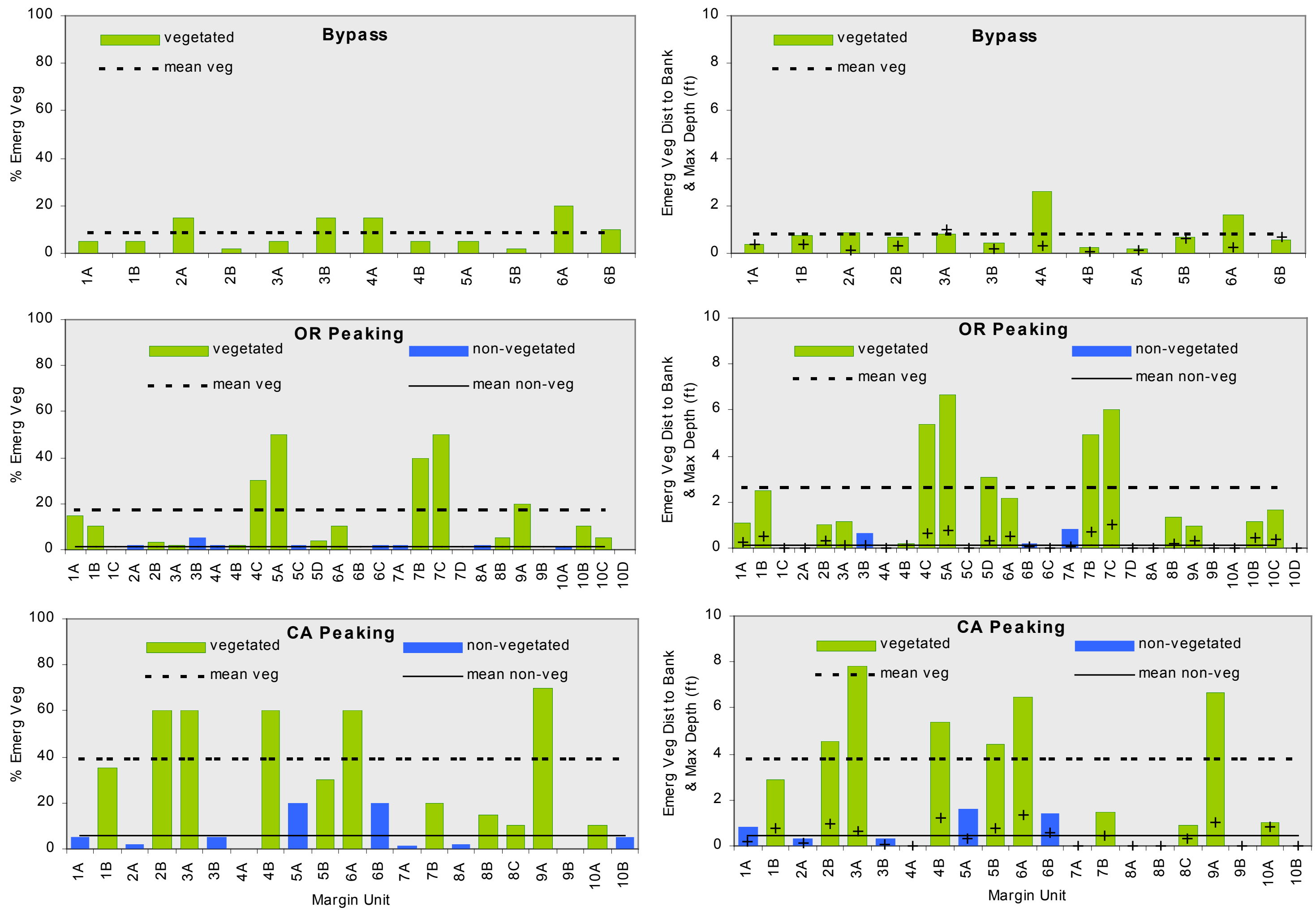


Figure 9. Percent emergent vegetation cover (left graphs) and mean distance to bank from vegetation edge (right graphs) in margin units according to reach and dominant cover type (vegetated vs. non-vegetated). Overall means are shown by horizontal lines, mean maximum depth of vegetation edge is shown by pluses.

provide direct cover for trout fry. Consequently, the overall mean percentage increased from the Bypass reach downstream to the CA Peaking reach (Figure 10), with highly significant differences between vegetated and non-vegetated units (P's = 0.01, paired t-test, Table 5). Overhead canopy coverage, which included vegetation >18in above the water surface, was largely absent in the Bypass reach, but encompassed 8 to 18% of unit sampling areas in both Peaking reaches. Canopy cover tended to be higher in non-vegetated units than in vegetated units, perhaps through competitive effects, but the differences were not statistically significant.

The final habitat variable tested was the distance of movement of the water's edge from low flow conditions (325 cfs) to medium flow conditions (1,500-1,700 cfs); also known as the varial zone. Shallow, gently sloping units would be expected to show more lateral movement of the waters edge than would deeper, steeper units, and might thus require trout fry to migrate over larger distances to remain along the stream margin. On average, the waters edge moved between 10 ft and 16 ft along margin units in the Peaking reaches, with no detectable difference among vegetated and non-vegetated units (P's >0.4, paired t-test, Table 5). Particularly large movements (>25 ft) occurred at 4 margin units in the OR Peaking reach and at 1 unit in the CA Peaking reach (Figure 10), however most of those units were located downstream of the BLM campground and upstream of Shovel Creek where fry were rarely observed. Only units 10C and 10D in the OR Peaking reach were near a source of recruitment of fry (the Bypass reach is upstream, Figure 1) and had a large varial zone, however; unit 10D was an open gravel bank (the raft put-in site) that was devoid of cover and rarely held trout fry.

Comparison of Fry Densities in Vegetated and Non-Vegetated Margin Units

The paired comparisons of margin habitat characteristics showed that, in general, paired units only differed in the form of instream cover, i.e. whether a unit was dominated by emergent vegetation cover or by substrate (cobble or boulder) cover (Table 5). Because the comparisons of fry densities were also paired by study site, the effects of distance to spawning areas on local fry densities was also accounted for. However, multiple-pass surveys indicated that capture of small fry from margin units differed according to vegetation type, which could lead to a bias in paired comparisons of fry densities.

Comparison of first-pass catches in netted margin units with population estimates based on two or more additional passes (with estimates calculated in MicroFish, Table 6) showed a strong linear relationship for both vegetated and non-vegetated units, however the regression slopes appeared to be substantially different (Figure 11). Looking at the estimated capture probabilities according to margin cover type revealed that electrofishing was more efficient in non-vegetated units than in vegetated units, likely because of the difficulty in observing stunned fry in areas of dense cover. Consequently, a paired comparison of fry densities in vegetated and non-vegetated units based on unadjusted single-pass estimates would underemphasize fry densities in vegetated units.

To allow for a more plausible comparison of fry densities in vegetated and non-vegetated units, fry densities were first "expanded" by the mean capture probabilities for each of the two cover types. Of the 21 margin units blocked-off with nets and subjected to multiple-pass electrofishing, five vegetated units and four non-vegetated units (with substrate cover) contained fry (Table 6). One additional unit (OR Peaking 10D) contained fry but did not contain any instream cover, therefore that data was not used to calculate mean capture probability. Mean capture probabilities based on the nine units were 0.76 for non-vegetated units and 0.44 for vegetated units (Figure 11). Because of the small sample sizes, the low capture probabilities, and the high standard errors associated with many of these estimates (particularly for the vegetated units), the mean capture

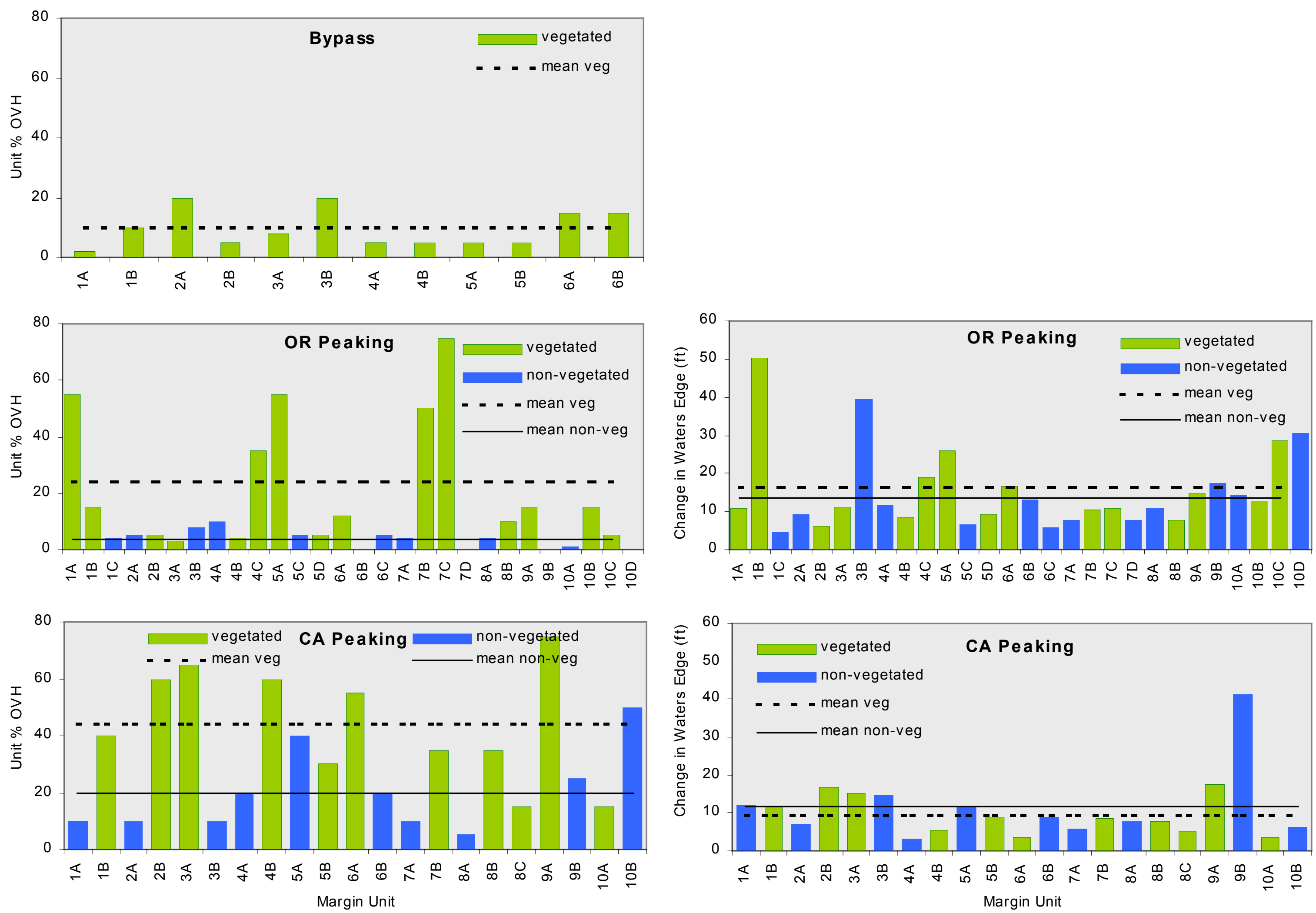


Figure 10. Percent overhead cover (left graphs) and mean change in waters edge from low flow to medium flow (right graphs) in margin units according to reach and dominant cover type (vegetated vs. non-vegetated). Overall means are shown by horizontal lines.

probabilities are highly uncertain. Consequently, the expanded fry index densities and paired test results should be viewed with caution.

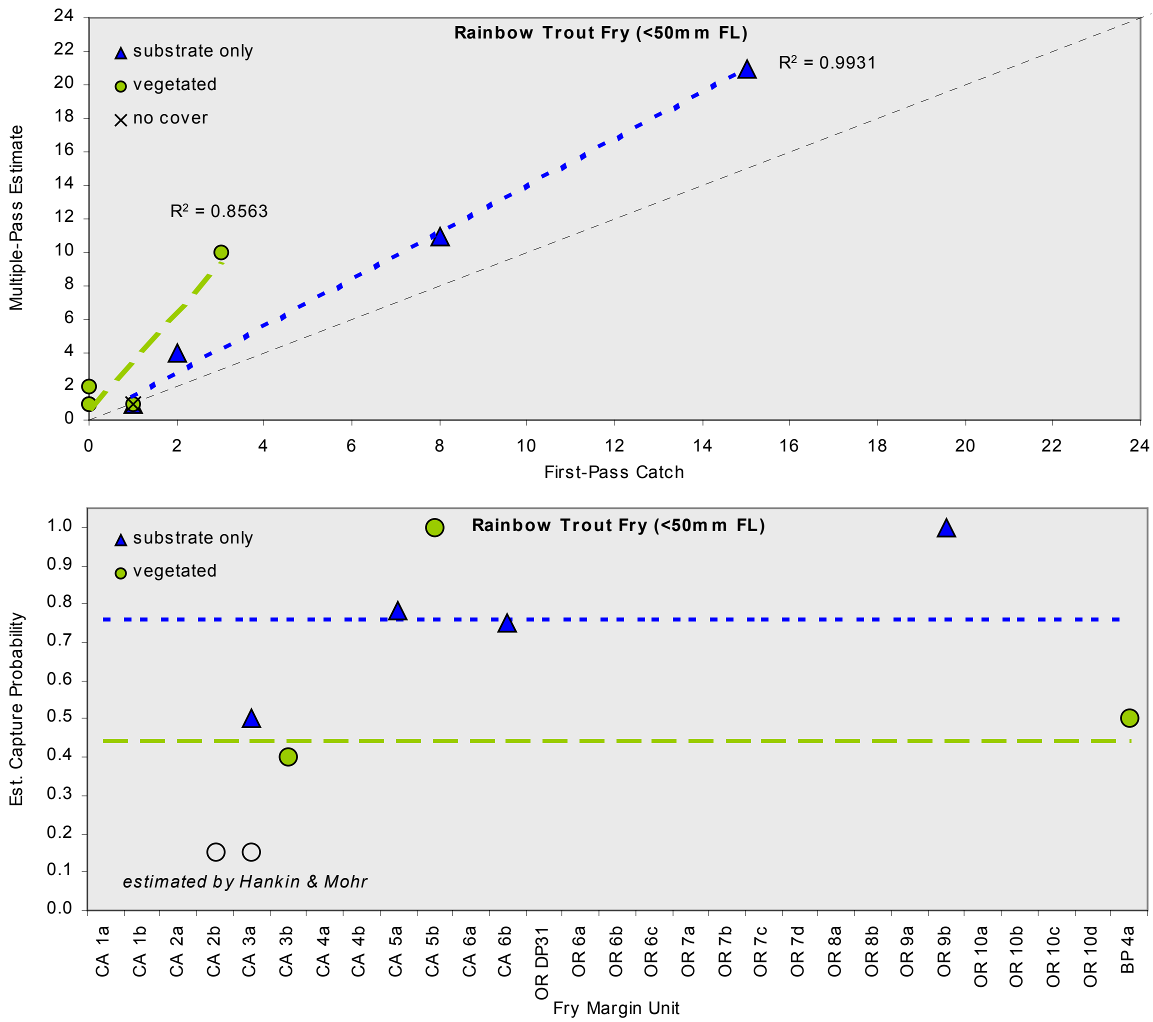


Figure 11. Relationship between first-pass catch and multiple-pass population estimates (upper figure), and comparison of estimated capture probabilities (lower graph), in vegetated and non-vegetated (substrate only) margin units. Diagonal line in upper graph is a 1:1 ratio, horizontal lines in lower graph show mean values. Note that most margin units did not receive multiple-pass samples or did not contain fry.

Paired tests were performed using both unexpanded (original) and expanded fry densities from the margin units that regularly contained fry (CA Peaking sites 1-6, OR Peaking sites 6-10), but did not include units far from spawning areas where margin habitat features were less likely to influence local fry densities (above Shovel Creek and below the BLM campground). The expanded fry densities were calculated by dividing the single-pass fry captures (Appendix A) from the repeated summer surveys by the respective capture probability based on the multiple-pass surveys (0.44 for vegetated units and 0.76 for non-vegetated units). The division thus expanded the fry catch in vegetated units more than the fry catch in non-vegetated units. Expanded and original, non-expanded fry index densities were then calculated by dividing the fry catch by the sampling area (in ft^2) of each margin unit, then multiplying by 100 (resulting in density estimates of fry per 100 ft^2). Regression was not used to estimate total fry abundance because most multiple-pass data contained captures less than five fish (Table 6), whereas single-pass samples (conducted earlier in the summer) frequently contained 10 to 20 fry, which would require extrapolation well beyond the range of the regression data.

Table 6. Catch and population estimation statistics from multiple-pass electrofishing units.

	Margin	Dom	Shocking Seconds				Catch of Fry (<50mm)					Est Abundance			Capture Probability		
Reach	Unit	Cover	Pass1	Pass2	Pass3	Pass4	Pass1	Pass2	Pass3	Pass4	Sum	Est	Std Err	95%CI	Est	Std Err	95%CI
BP	4A	veg	877	910	768	736	3	4	3	0	10	10	1.244	2.813	0.500	0.176	0.398
OR	6A	veg	491	282	150	0	0	0	0	-	0	0	-	-	-	-	-
OR	7D	sub	214	221	217	0	0	0	0	-	0	0	-	-	-	-	-
OR	8A	sub	269	329	272	0	0	0	0	-	0	0	-	-	-	-	-
OR	8B	veg	441	387	304	0	0	0	0	-	0	0	-	-	-	-	-
OR	9A	veg	746	585	629	0	0	0	0	-	0	0	-	-	-	-	-
OR	9B	sub	329	316	269	0	1	0	0	-	1	1	0	0	1.000	0	0
OR	10C	veg	94	67	86	0	0	0	0	-	0	0	-	-	-	-	-
OR	10D	none	223	201	164	0	1	0	0	-	1	1	0	0	1.000	0	0
OR	DP31	veg	795	622	429	0	0	0	0	-	0	0	-	-	-	-	-
CA	1A	sub	338	264	313	0	0	0	0	-	0	0	-	-	-	-	-
CA	1B	veg	802	700	692	0	0	0	0	-	0	0	-	-	-	-	-
CA	*2B	veg	479	351	278	0	0	1	0	-	1	1	-	-	0.154	-	-
CA	3A	sub	486	522	455	405	2	0	2	0	4	4	0.786	2.503	0.500	0.278	0.885
CA	*3A	veg	381	359	345	0	0	0	1	-	1	1	-	-	0.154	-	-
CA	3B	veg	496	378	410	0	0	1	1	-	2	2	1.876	23.834	0.400	0.4	7.945
CA	4B	veg	269	269	337	0	0	0	0	-	0	0	-	-	-	-	-
CA	5A	sub	989	952	0	0	8	3	-	-	11	11	1.124	2.505	0.784	0.174	0.387
CA	5B	veg	696	559	575	0	1	0	0	-	1	1	0	0	1.000	0	0
CA	6A	veg	494	584	466	0	0	0	0	-	0	0	-	-	-	-	-
CA	6B	sub	408	323	272	0	15	5	1	-	21	21	0.704	1.468	0.750	0.101	0.21

* abundance estimate set equal to total capture (I.e., 1 fry); capture probabilities calculated by Hankin and Mohr (unpublished ms)

A visual comparison of fry densities in vegetated and non-vegetated margin units using unadjusted index densities shows the greater fry densities found in the CA Peaking reach than in the OR Peaking reach (Figure 12). In the CA Peaking reach, the generally greater densities in the non-vegetated units than in the vegetated units is also evident, although the relationship is not highly consistent. In the OR Peaking reach, fry index densities were typically greater in vegetated units than in non-vegetated units. When the fry catches were expanded according to mean capture probabilities, the differences in densities by margin type were enhanced in the OR Peaking reach, with densities in vegetated units clearly exceeding densities in non-vegetated units (Figure 13). In the CA Peaking reach, differences were less consistent, with generally similar densities among margin types during the early and late July surveys, but generally higher densities in vegetated sites during the late July and early September surveys.

Paired tests showed that fry index densities in vegetated margin units in the OR Peaking reach were significantly greater than densities in non-vegetated units, using both original and expanded density estimates (Table 7). Both estimates produced non-significant differences in fry densities in vegetated and non-vegetated margins in the CA Peaking reach, where fry were more evenly distributed according to margin cover type (particularly in the earlier surveys). When both reaches were combined, densities were similar according to the unadjusted density estimates, but fry densities were significantly greater in vegetated units than in non-vegetated units using the expanded density estimates.

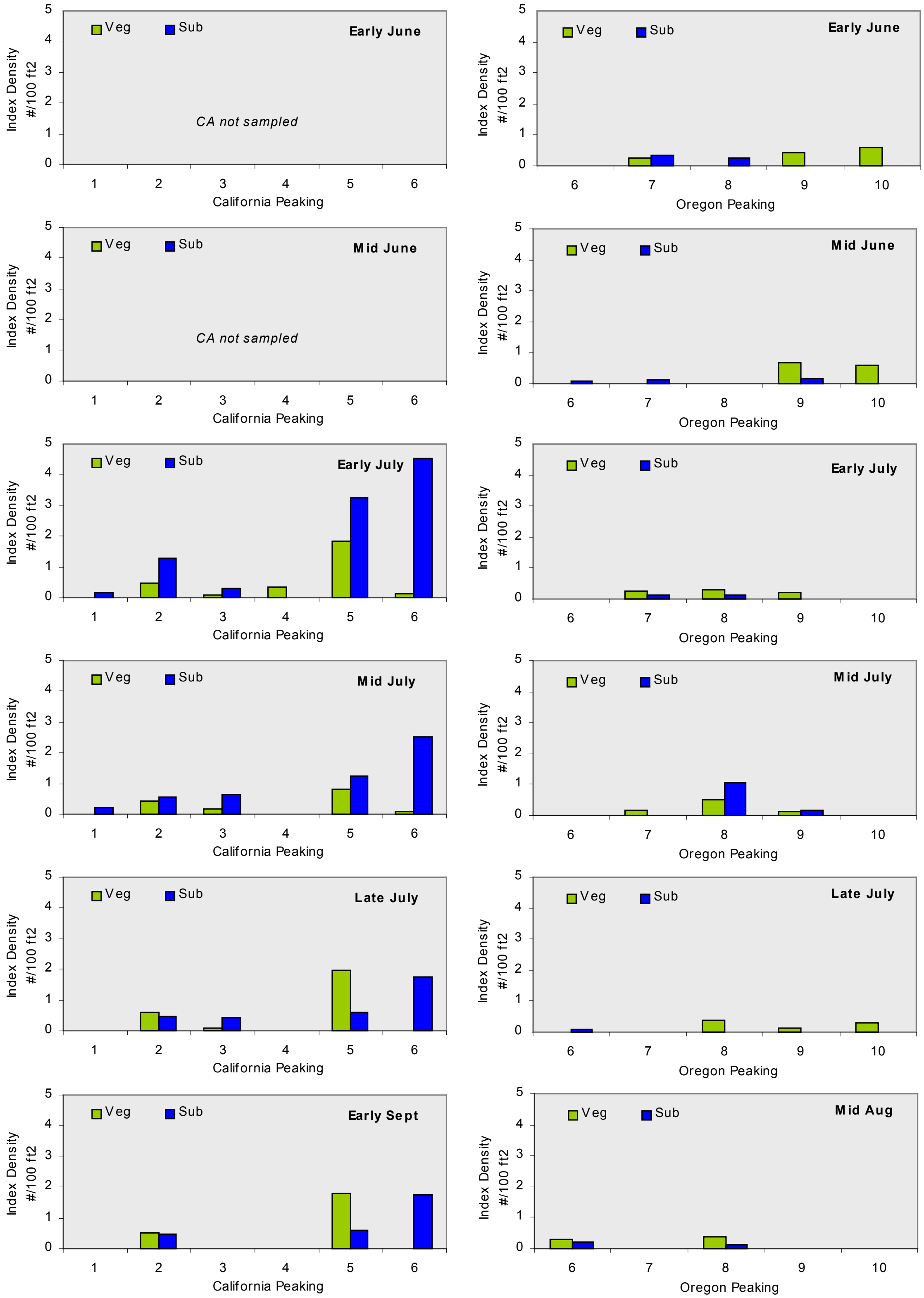


Figure 12. Unadjusted index densities (#/100ft^2) of rainbow trout fry in vegetated and non-vegetated (substrate only) margin units according to reach and sampling period.

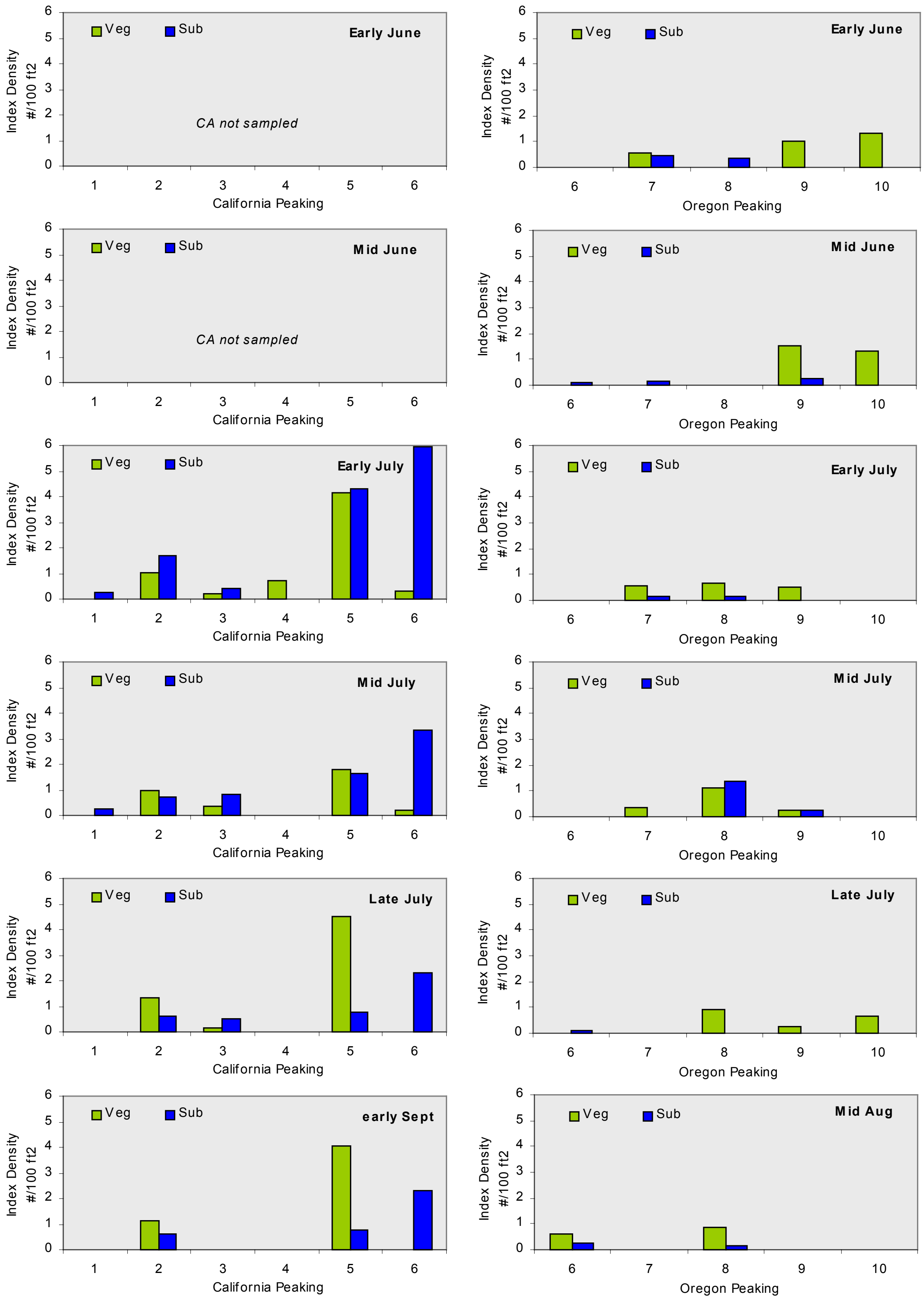


Figure 13. Expanded index densities (#/100ft^2) of rainbow trout fry in vegetated and non-vegetated (substrate only) margin units according to reach and sampling period.

Table 7. Wilcoxon's signed rank test results for paired index densities (#/100ft^2) of trout fry in vegetated and non-vegetated margin units, using unadjusted and expanded density estimates by reach.

Species	Study Sites	Mean Densities Veg	Mean Densities Non-Veg	Std. Deviations Veg	Std. Deviations Non-Veg	Mean Difference	Signed Rank Test Z	Signed Rank Test approx P
RAINBOW	OR 6-10	1.80	0.77	2.02	1.57	1.03	2.27	0.02
original	CA 1-6	3.12	5.21	4.09	7.37	-2.08	-1.66	0.10
density	Combined	2.39	2.74	3.15	5.46	-0.35	0.21	0.83
RAINBOW	OR 6-10	4.09	1.01	4.60	2.06	3.08	3.04	0.002
expanded	CA 1-6	7.10	6.85	9.29	9.69	0.25	-0.35	0.73
density	Combined	5.43	3.61	7.17	7.19	1.82	1.80	0.07

Effects of Margin Habitat Characteristics on Fry Index Densities

Another way of assessing the relative importance of instream cover type and other margin unit habitat variables on fry densities is through a multivariate analysis. One factor that appeared to exhibit a strong influence on local fry densities, but was not a component of a margin unit's microhabitat, is the distance to the nearest known spawning area. Data previously presented clearly showed that margin units well downstream of known spawning areas (e.g., the Bypass reach and Shovel Creek) contained few trout fry through the summer months (Figure 5). A more direct comparison of mean fry densities (averaged across survey periods) by margin unit with distance to upstream spawning areas showed an inverse, curvilinear relationship (Figure 14, top graph). The data shows that margin units greater than approximately four miles from an upstream spawning area was unlikely to contain fry, hence the multivariate analysis, like the paired analysis just described, was restricted to OR Peaking site 6-10 and CA Peaking sites 1-6. The curvilinear relationship was linearized by log-transforming the expanded fry densities and the distance to spawning area values (Figure 14, bottom graph). Although CA Peaking unit 6A was deleted from the lower graph to more clearly show the linear relationship, data from unit 6A was retained in the subsequent regression analysis.

Additional scatterplots of margin unit habitat characteristics and mean fry densities were evaluated to identify potential variables for input into a multiple regression model. Besides distance to spawning area, unit mean velocity was the only habitat variable that showed a clearly visible relationship to fry densities, but only after data from the Bypass reach was removed (Figure 15). A moderate, positive relationship was evident between expanded fry densities and mean velocities in the Peaking reach margin units (particularly in CA), but a weak, negative relationship occurred in the Bypass reach. Although not specifically tested, differences in water temperatures (the Bypass being colder) or fry densities may in part explain the contrasting relationship. Because of the contrasting relationship with velocity and because the multivariate analysis was primarily directed towards describing variables affected fry densities in the Peaking reaches, the Bypass reach data was not used in the subsequent regression analysis.

A correlation table (Table 8) was constructed to further identify potential predictor variables and to eliminate redundant (auto-correlated) variables (i.e., % vegetation and veg distance to bank, mean depth and max depth, etc.). Based on the correlation table and the above scatterplots, the following margin characteristics were input into a multiple regression as predictor variables using a stepwise selection procedure: log (distance to spawning area), unit mean velocity, maximum depth, % emergent vegetation cover, max depth of emergent vegetation, dominant vegetation type, dominant substrate type, and change in waters edge.

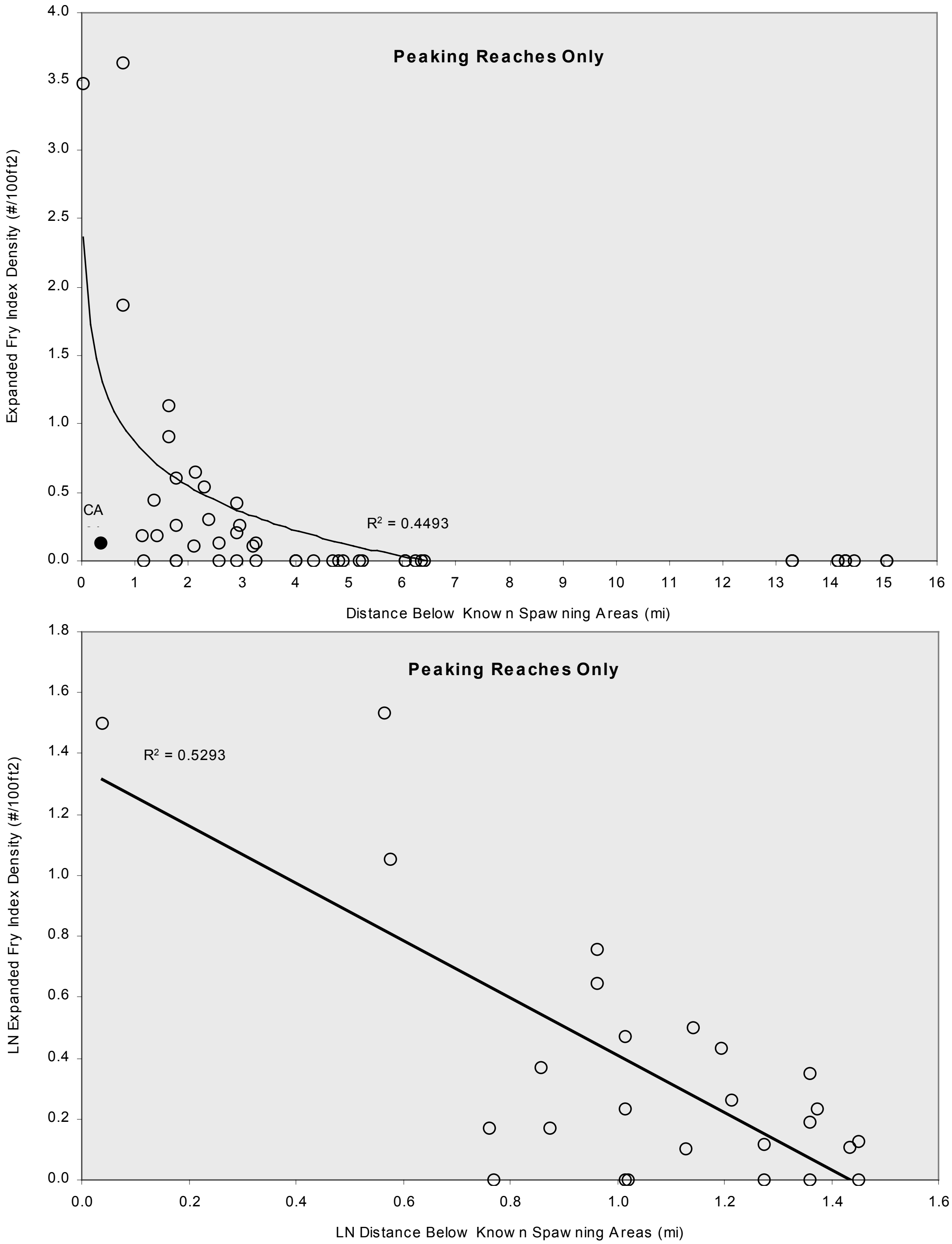


Figure 14. Relationship between expanded trout fry densities (#/100 ft^2) versus distance below known spawning areas for margin units in the Peaking reaches (top graph), and the same data ln-transformed (lower graph) excluding margin units >4mi from spawning areas, and without CA unit 6A (labeled as “CA”).

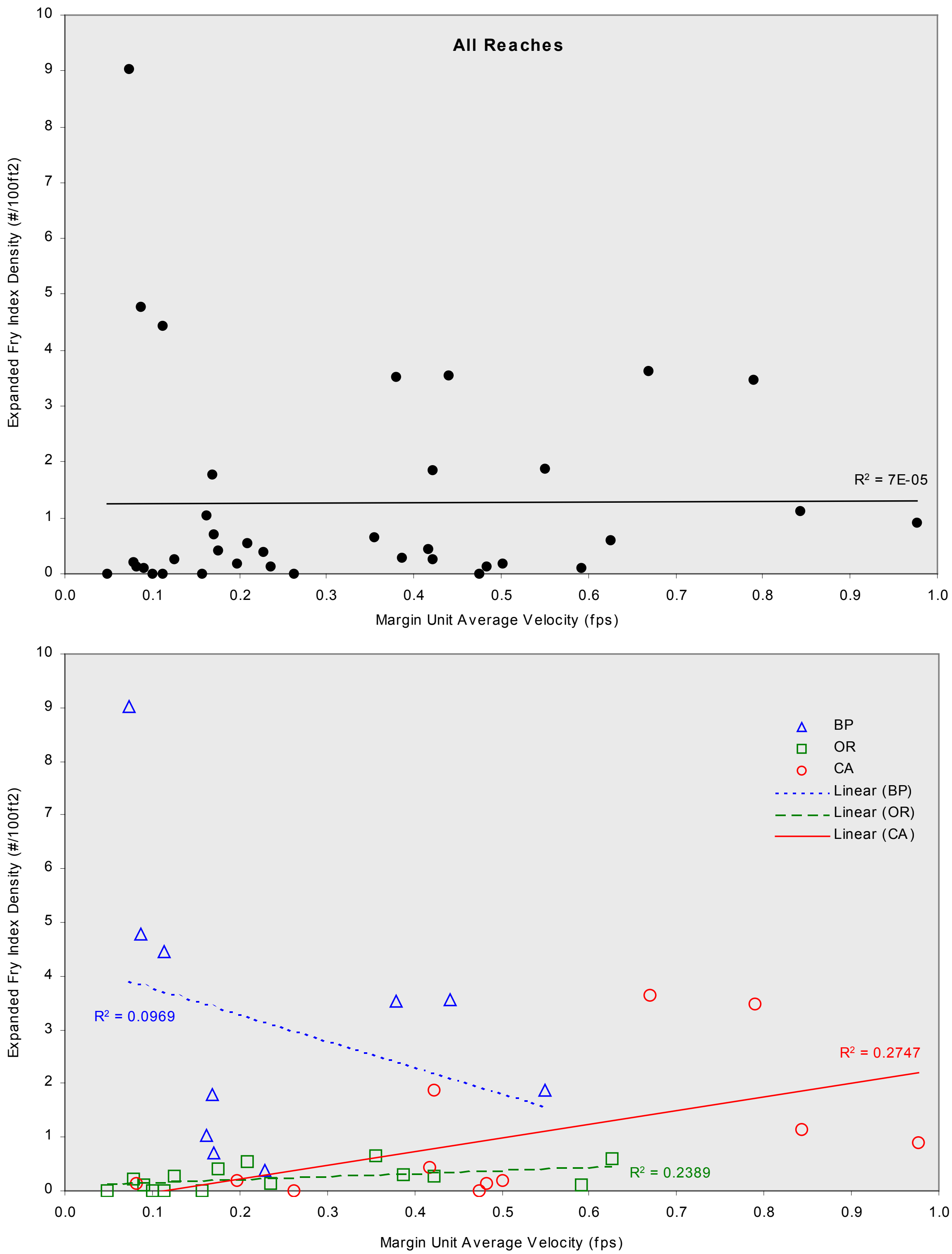


Figure 15. Relationship between expanded trout fry densities (#/100 ft^2) versus margin unit mean velocity for all margin units combined (top graph), and by reach (lower graph). Lines are linear regressions showing R^2 values.

Table 8. Correlation table for margin unit fry densities (expanded and log-transformed) and habitat variables.

	ln (Dist Spwn Area)	Max Depth	Mean Veloc	Mean Depth	Max Veloc	Em Veg Dist to Bank	Em Veg Max Depth	Dom Substr Cover	SubDom Substr Cover	Dom Veg Cover	SubDom Veg Cover	% Em Veg Cover	% Over-head Cover	Change Waters Edge	% Cob/ Bldr Cover
ln (exp Fry Dens)	-0.6168	-0.2520	0.6319	-0.1296	0.5663	0.1377	0.2418	-0.0110	-0.0980	0.1519	0.6411	0.1766	0.1809	-0.1295	0.0057
ln (Dist Spwn Area)		-0.1542	-0.3451	-0.2957	-0.2462	-0.2617	-0.3659	0.4796	0.2533	0.0403	-0.6740	-0.3291	-0.2872	0.1619	0.3739
Max Depth			-0.0981	0.6524	-0.1121	-0.1302	-0.0327	0.0578	0.0564	-0.1986	-0.0567	-0.0899	-0.0333	-0.3813	0.0223
Mean Veloc				-0.1026	0.8481	0.0210	0.0963	-0.0560	-0.1939	0.0827	0.2542	0.0962	0.0934	-0.0372	-0.1510
Mean Depth					-0.2813	0.2656	0.4663	-0.3775	-0.2751	-0.0030	0.2684	0.3059	0.2548	-0.2697	-0.3807
Max Veloc						-0.1407	-0.0841	0.0489	-0.2019	-0.0696	0.1402	-0.0800	-0.0737	-0.0258	-0.1100
Em Veg Dist to Bank							0.8890	-0.4133	-0.3011	0.2732	0.2587	0.9476	0.9186	-0.1370	-0.3011
Em Veg Max Depth								-0.4758	-0.3945	0.2982	0.4224	0.9246	0.8657	-0.1922	-0.3661
Dom Substr Cover									0.5649	-0.0646	-0.2838	-0.4197	-0.2944	-0.3165	0.8960
SubDom Substr Cover										-0.1267	-0.3177	-0.3599	-0.3183	-0.1003	0.6992
Dom Veg Cover											0.3328	0.2637	0.3195	-0.0781	0.0313
SubDom Veg Cover												0.3112	0.2929	-0.2644	-0.2093
% Em Veg Cover													0.9526	-0.1730	-0.2873
% Over-head Cover														-0.2287	-0.1692
Change Waters Edge															-0.4484
% Cob/ Bldr Cover															

Change in water edge was included among the variable list due to it's perceived importance in affecting fry densities, despite the low correlation coefficient (-0.1295). Dominant substrate was added because initial regression models showed a relationship between that variable and the residual pattern. Subdominant vegetation was not included despite a high correlation (0.6411) because that correlation was a function of a single, outlying observation, rather than due to an overall trend.

The response variable was log-transformed expanded fry densities. The stepwise procedure selected four predictor variables in the following order of inclusion: average velocity, log(distance to spawning area), maximum depth, and dominant substrate type. Overall the regression model was highly significant (P<0.001) and explained 76% of the observed variation in fry densities among the included margin units (Table 9, Figure 16).

Application of this model to other locations or even to other studies within the upper Klamath study area is limited by the design of this fry study, which attempted to minimize the range and variability in both depth and velocity among the selected margin units. Consequently, the model may not perform well with a more randomized selection of margin units that may include faster velocities, because in some units velocities will likely exceed tolerances for trout fry, but the model will continue to assume that increasing velocities will produce increasing densities, by virtue of it's positive regression coefficient (Table 9).

Table 9. Stepwise multiple regression statistics and ANOVA table.

	Regression Coefficients and Statistics			
	Value	Std. Error	t value	Prob
Intercept	0.1063	0.4325	0.2459	0.8081
AvVel	0.6038	0.1858	3.2502	0.0037
lnDist	-0.8607	0.1561	-5.5140	0.0000
MxDep	-0.2765	0.0855	-3.2323	0.0038
DSub	0.0556	0.0179	3.1139	0.0051

	ANOVA Table				
	DF	Sum Sq.	Mean Sq.	F-value	Prob
AvVel	1	1.8581	1.8581	37.1515	0.0000
lnDist	1	0.8401	0.8401	16.7970	0.0005
MxDep	1	0.3707	0.3707	7.4119	0.0124
DSub	1	0.4850	0.4850	9.6965	0.0051
Residuals	22	1.1003	0.0500		

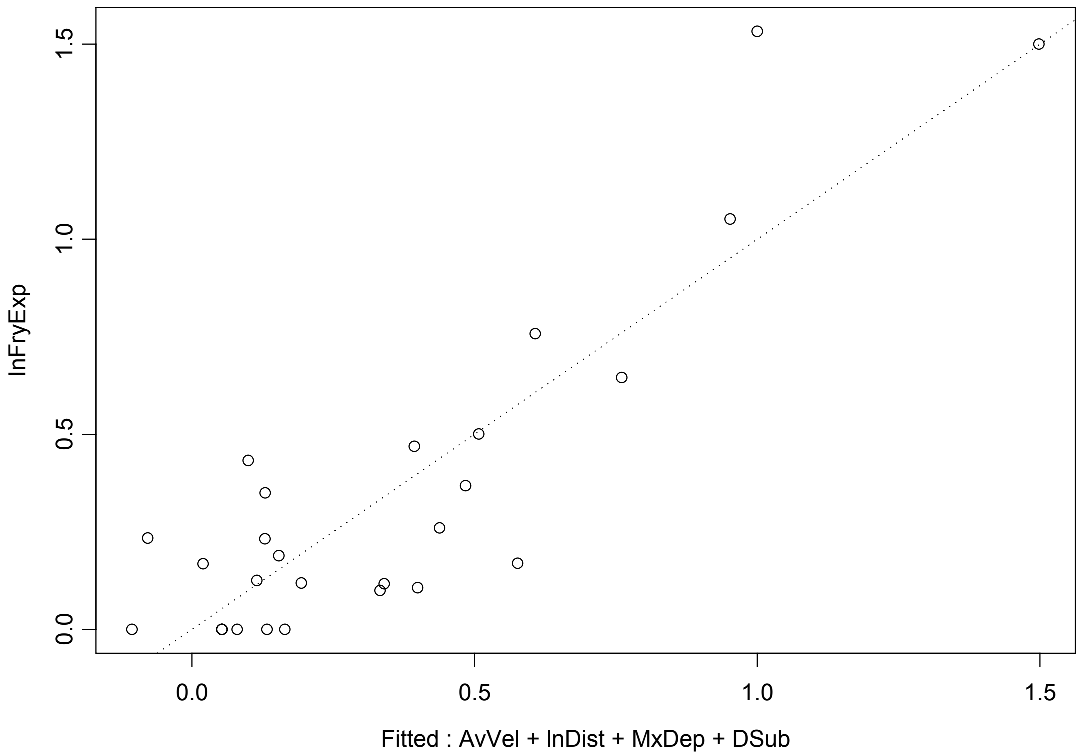


Figure 16. Observed (y-axis) versus predicted (x-axis) fry densities (expanded and ln transformed) in margin units in the Oregon Peaking reach (index sites 6-10) and the California Peaking reach (sites 1-6).

The stepwise regression procedure did not select a vegetation variable even though paired comparisons showed that expanded fry densities were significantly greater in vegetated margin units than in non-vegetated units in the OR Peaking reach and combined reaches datasets. This may be due in part to the relative dominance of the CA Peaking reach, where fry densities were typically much higher than in the OR Peaking reach, and where fry densities appeared to be more evenly distributed among margin cover types (Figure 13). Other factors related to margin cover type (but not including vegetation) may also be responsible for the observed differences in fry densities, such as dominant substrate. In the OR Peaking reach where fry densities were lower in non-vegetated units than in vegetated units, the non-vegetated units typically contained larger substrate elements than did the equivalent units in the CA Peaking reach (Figure 8). In contrast, vegetated units in CA Peaking reach typically contained smaller substrate elements than did vegetated units in the OR Peaking reach.

In order to look more closely at the potential effects of the non-selected variables on the fitted model, the model residuals were plotted against several of the non-selected variables. A weak, positive pattern was evident between vegetated cover variables and fry densities, but the forced addition of such variables to the fitted model failed to produce a decrease in the models unexplained variation or a significant increase in overall fit, consequently the model described above was not further modified.

<u>Recapture of Marked Fry</u>

Most of the trout fry captured in the Bypass reach and some fry captured in the CA Peaking reach were fin-clipped according to index site. Of approximately 400 fin-clipped fry, 23 were recaptured in the same location and one was recaptured at another site farther downstream in the Bypass. In the Bypass, seven clipped fry were recaptured immediately after flows increased from

325 cfs to 520 cfs, two days after marking. Although the change in water's edge was not measured in the Bypass units, casual observations suggested that movement of the water's edge was typically minor (<5 ft) due to the relatively steep banks. Eight additional fry recaptures were made in the Bypass following an interval of at least two weeks. No Bypass-clipped fry were recaptured in the OR Peaking reach. In the CA Peaking reach, 73 fry were marked during low flow (325 cfs) and nine were recaptured in the same locations either later the same day or on the following day after flows were peaked to 1,500 cfs to >2,000 cfs. Margin units where the fry were recaptured in the CA Peaking reach averaged a change in water's edge of 9-11 ft.

Size and Growth of Trout Fry

Length-frequency histograms were created for fry (<50mm FL) and small juvenile trout (50-79mm FL) captured in single-pass electrofishing surveys according to reach and survey period (Figure 17). Because aging data was not available for these fry, it is unclear how many of the smaller juvenile trout were young-of-year versus yearling fish, hence this analysis relies on frequency modes and overall shape rather than on mean values.

The histograms show that by late-May, emergence of trout fry had begun prior to the first sample (Figure 17). However, extensive snorkeling during a redd survey in the Bypass reach in mid-May yielded the observation of only a few trout fry, thereby suggesting that most fry had not yet emerged. The progressive increase in length of trout fry is evident in the histograms for all three reaches and in Shovel Creek, at least until the late June survey when the smallest size class (20-29mm FL) again becomes the dominant class in the Bypass and CA Peaking reaches. Despite the very small sample sizes for the OR Peaking reach, this trend is also evident in both the late-July and mid August sample period. This apparently second emergence of trout fry is not inconsistent with spawning observations conducting in the Bypass, where at least two peaks in spawning activity were noted and where trout were observed actively spawning from late April (when the first survey occurred) to early July. Although late recruitment of small fry was not observed in the Shovel Creek sample (where trout are not know to spawn over such a long interval), the proportion of small fry did increase in the CA Peaking reach downstream of Shovel Creek, which could be the result of mainstem spawning in that reach.

When comparing the length-frequency histograms from each Peaking reach with its associated spawning area (OR Peaking with Bypass reaches, and CA Peaking with Shovel Creek), other differences are noted. In general, fry captured in the OR Peaking reach were larger than fry captured in the Bypass reach, according to sampling period, although the small sample sizes for the OR Peaking data limit confidence in these conclusions (Figure 17). The difference in fry sizes remained evident until the last survey in mid-August. In contrast, fry captured in the CA Peaking reach in early and late-July tended to be smaller than fry captured in Shovel Creek, whereas fry sizes in early September were slightly larger in Shovel Creek. A re-arrangement of the data again clearly shows the increase in size of fry as the summer progressed (Figure 18). The differences in relative proportions of fry by size class among paired reaches (i.e., peaking reach vs. spawning reach) are also evident.

Length-weight relationships were also developed for captured fish for each sampling period and reach. Errors associated with weighing very small fish under field conditions resulted in many outlier observations, some of which could not be confidently identified and eliminated. Small sample sizes from the Oregon Peaking reach also limited interpretation of growth trends. Overall, regressions of log (FL) x log (wt) were highly significant for most datasets (P's<0.001, ANOVA),

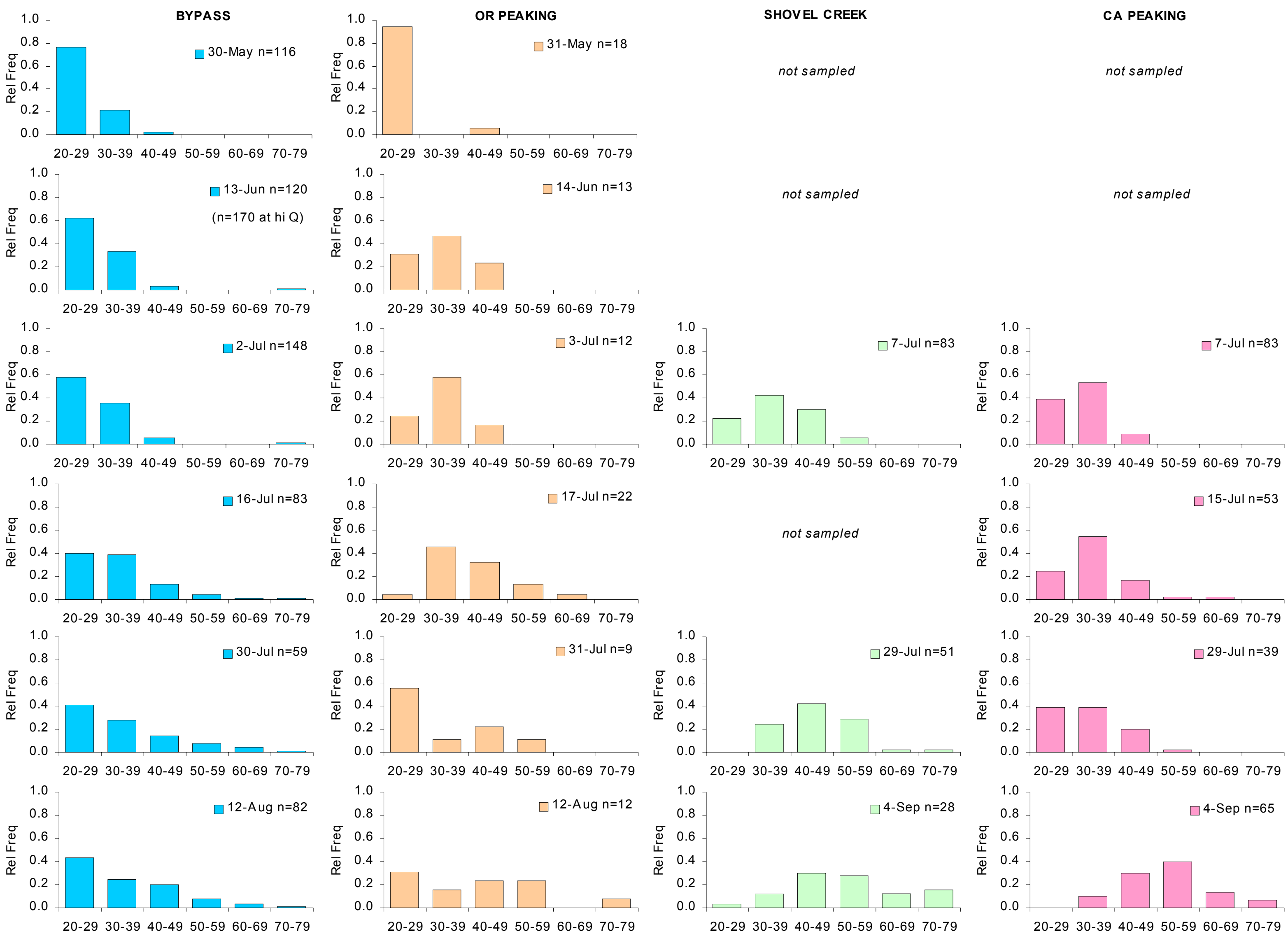


Figure 17. Relative length-frequency distributions for trout fry (<50mm FL) and small juveniles (50-79mm FL) captured in margin units during single-pass electrofishing surveys, by reach and sample period.

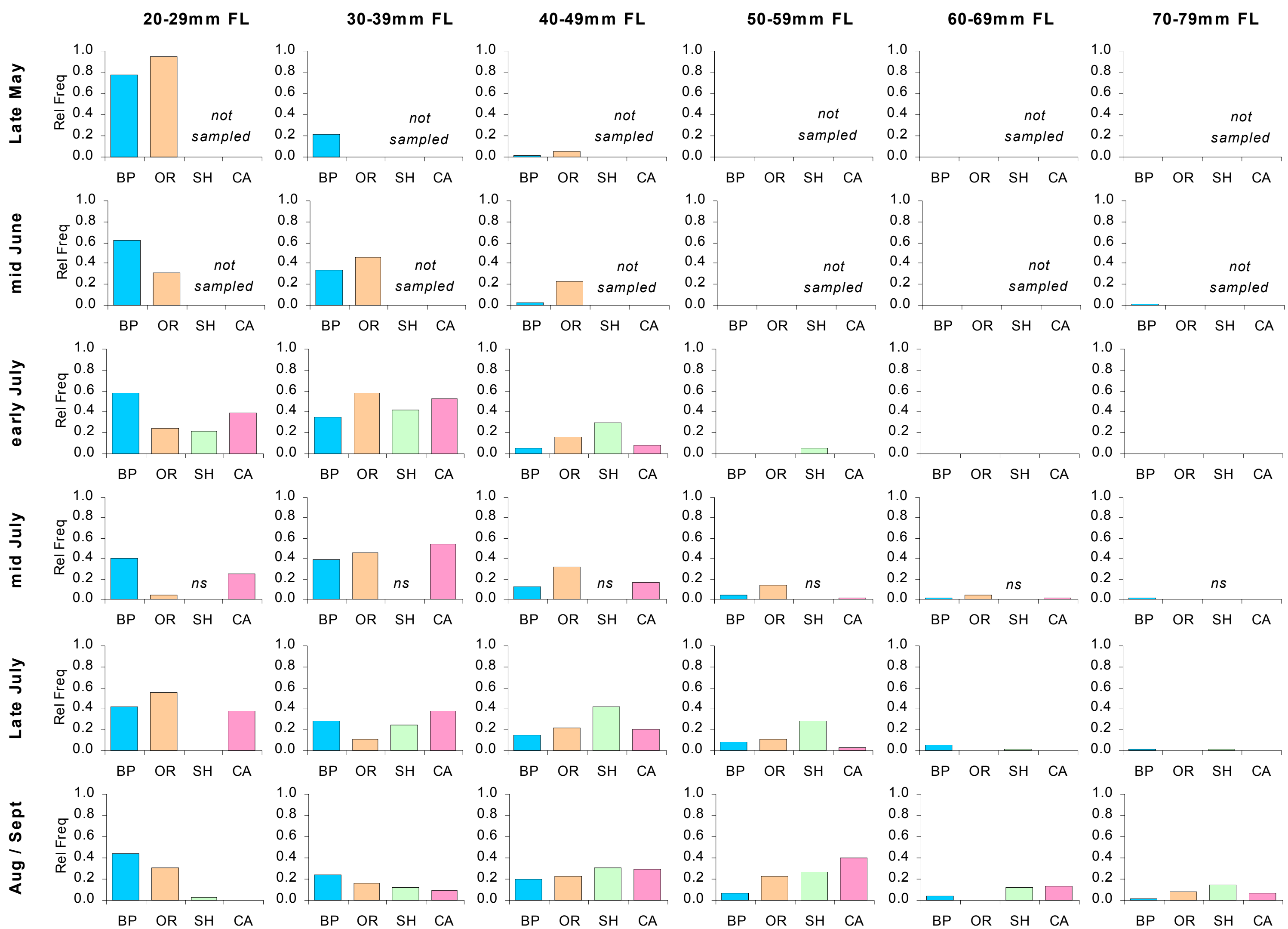


Figure 18. Relative length-frequency distributions for trout fry (<50mm FL) and small juveniles (50-79mm FL) captured in margin units during single-pass electrofishing surveys, re-arranged by sample period.

however slopes varied widely in response to outlier observations (Table 10). The regression equations are of the form:

$$\log(\text{wt in grains}) = a + b \times \log(\text{mm FL}), \text{ where 1 grain} = 0.065 \text{ grams}$$

Table 10. Regression statistics for trout length vs. weight data from single-pass electrofishing in margin units, by time period and reach.

Time Period	Reach	n	R^2	ANOVA F	Prob (F)	Intercept	Coefficient
mid June	Bypass	42	0.55	50	<0.001	-2.389	2.053
	OR Peaking	4	0.93	27	0.04	-3.207	2.579
	BP + OR Peaking	46	0.57	59	<0.001	-2.446	2.089
early July	Bypass	17	0.81	64	<0.001	-3.728	2.997
	OR Peaking	4	0.85	11	0.08	-3.441	2.793
	Shovel Crk	80	0.84	409	<0.001	-4.197	3.309
	CA Peaking	20	0.68	38	<0.001	-3.392	2.782
	All Reaches	121	0.83	589	<0.001	-4.023	3.197
mid July	Bypass	52	0.83	248	<0.001	-4.905	3.735
	OR Peaking	15	0.89	102	<0.001	-6.277	4.531
	CA Peaking	22	0.59	29	<0.001	-3.023	2.587
	BP + OR Peaking	67	0.84	331	<0.001	-5.070	3.827
	BP + OR + CA	89	0.78	316	<0.001	-4.687	3.604
late July	Bypass	40	0.93	477	<0.001	-4.171	3.251
	OR Peaking	5	0.98	127	0.001	-4.644	3.592
	Shovel Crk	49	0.93	621	<0.001	-4.030	3.144
	CA Peaking	35	0.73	88	<0.001	-3.970	3.104
	All Reaches	129	0.91	1239	<0.001	-4.100	3.195
Aug/Sept	Bypass	64	0.92	677	<0.001	-4.773	3.595
	OR Peaking	9	0.78	25	0.002	-2.388	2.232
	Shovel Crk	34	0.90	301	<0.001	-4.379	3.320
	CA Peaking	84	0.91	850	<0.001	-3.467	2.869
	BP + OR Peaking	73	0.90	610	<0.001	-4.638	3.519
	Shovel + CA	118	0.87	763	<0.001	-3.881	3.087
	OR + CA Peaking	93	0.89	742	<0.001	-3.272	2.756
	BP + Shovel	98	0.92	1111	<0.001	-4.505	3.414
	All Reaches	191	0.91	1838	<0.001	-4.417	3.394

Statistical comparison of regression models among reaches within sampling periods was hindered by non-constant error variances. Consequently, the following results should be viewed with caution and all reported significance values are approximate (Table 11). The comparison of regression models from the OR Peaking reach and the Bypass reach in mid-June was not statistically significant, despite visually apparent differences in the length vs. weight plot (Figure 19). The extremely low sample size from the OR Peaking reach (only four weights were measured) effectively prevented a rigorous test of differences. Despite another low sample size from the OR Peaking reach in early July, the other three datasets contained adequate samples and all four reaches showed high similarity in both regression elevations and slopes (Figure 20, Table 11). Despite pre-filtering of the weight data, several obvious outliers remained (likely due to weighing errors), especially in the Shovel Creek dataset. As previously mentioned, the presence of such outliers would be expected to exert large effects on estimated regression parameters and could confound subsequent comparisons among models.

In the mid-July sample, length and weight data from the Bypass reach and both Peaking reaches produced significantly different regression models, both in terms of intercept and slope (Figure 20, Table 11). The differences in the OR Peaking reach and the Bypass reach were only just significant (P = 0.04, F-test), however both datasets contained several outliers among smaller fry. In spite of the outliers, the plot suggests that smaller fry (<35mm FL) in the CA Peaking reach were heavier than similar-sized fry in the OR Peaking and Bypass reaches, but comparative weights of larger fry were similar. By late July, regression models from all four reaches were again very similar and were not statistically different (Figure 21, Table 11). The weight data from the CA Peaking reach appeared to contain more scatter than did the data from the other reaches, particularly for smaller fry.

Table 11. Statistics for comparing overall regression models and estimated slopes of length vs. weight relationships for trout fry according to time period and reach. All probability values are approximate.

Time Period	Reach Comparisons	Regr F	Prob	Slope F	Prob	Action
mid June	all: OR v BP	0.25	0.75	-	-	no further tests
early July	all: OR,BP,CA,SH	0.56	0.70	-	-	no further tests
mid July	all: OR,BP,CA	8.24	<0.001	18.72	<0.001	pairwise tests (see below)
	OR,BP	3.51	0.035	39.19	<0.001	OR peaking/spawning comparison
	OR,CA	-	-	-	-	models not tested, but clearly different
late July	all: OR,BP,CA,SH	1.34	0.25	-	-	no further tests
Aug/Sept	all: OR,BP,CA,SH	20.37	<0.001	44.92	<0.001	pairwise tests (see below)
	OR,BP	8.75	<0.001	-	-	slopes not tested, but clearly different
	CA,SH	28.98	<0.001	-	-	slopes not tested, but clearly different
	OR,CA	2.92	0.06	-	-	no further tests
	BP,SH	2.54	0.08	-	-	no further tests

The final samples were conducted in mid-August for the OR Peaking reach and the Bypass reach, but were not conducted in the CA Peaking reach and Shovel Creek until early September two weeks later (Figure 21). Consequently, the statistically significant difference among models is somewhat confounded by the time difference (Table 11). Despite the time difference, the length-weight relationships were most similar between the two peaking reaches and between the two spawning reaches. Both paired comparisons were not significantly different, although comparisons of paired California reaches and paired Oregon reaches were different. Again, most similarity in length-weight relationships is seen among the larger fry, with greater differences (but also with greater measurement errors) seen among the smaller fry.

Overall, visual comparisons of the length vs. weight data is confounded by measurement errors associated with field sampling small fish, and statistical comparisons are similarly hindered by outlier observations as well as non-constant error variances. Nevertheless, the fry growth data does suggest a pattern that some differences in length-weight relationships may occur among reaches for smaller fry, but for larger fry (>35mm FL) relative weights appear to be very similar among reaches.

Distribution and Abundance of Non-Salmonid Species

Relative abundance data was collected for suckers, dace, chubs, and sculpins during single-pass electrofishing surveys, however the visual identification and capture of small benthic fish (i.e., suckers, dace, and sculpin) was extremely difficult due to the poor water visibility that occurred in the Peaking reaches during medium flow levels. The representativeness of single-pass electrofishing surveys to characterize index densities for these species is therefore questionable. Because multiple-pass surveys did not target these species, expansion factors could not be developed to estimate true abundance of non-salmonids in margin units, nor to correct for differences in capture probabilities in vegetated and non-vegetated units.

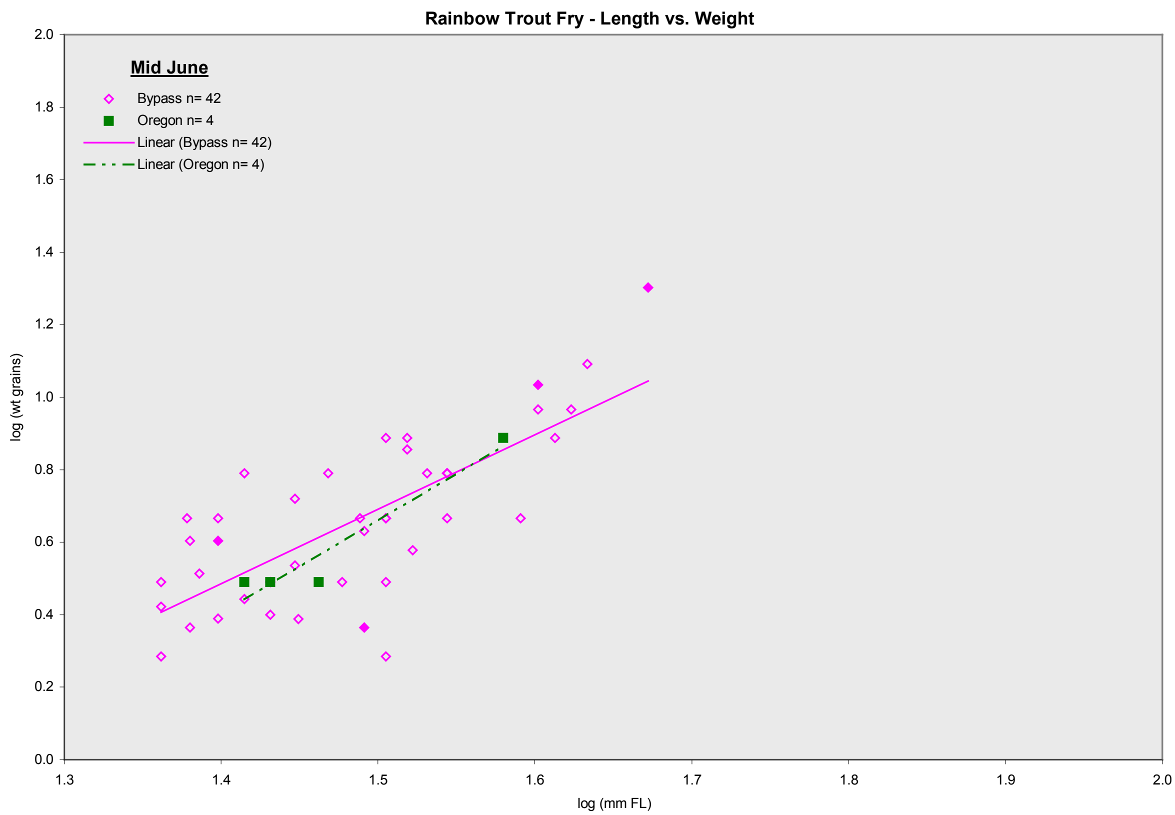


Figure 19. Length vs. weight relationship for trout fry in mid-June, according to reach.

Lengths and weights were not measured for non-salmonid species, and non-salmonid fry smaller than 20-25mm in length were typically classified as "non-game" fry, without further identification. Some electrofishing crews tended to separate small sucker fry from non-game fry whereas other crews did not. Consequently, the analysis of sucker fry and juvenile data is confounded by differences in field identification. None of the suckers >20mm could be accurately identified to species.

In the OR Peaking reach, non-salmonid species were more abundant and more evenly distributed among study sites during the early summer surveys than during the late summer surveys (Figure 22). Like the trout fry, most of the captured non-salmonid species were small (i.e., <80mm in length). Unlike the trout fry, the non-salmonids were not restricted to study sites in close proximity to the Bypass reach or Shovel Creek, but were typically found in all study sites. Dace appeared to be somewhat more abundant along margin units in the lower half of the OR Peaking reach than in the upper half, whereas fry and juvenile suckers were more commonly captured in the upper half of the reach. Chubs were relatively rare and, like the more abundant sculpin, were found throughout the length of the OR Peking reach.

In the CA Peaking reach, dace occurred at higher densities than in the OR Peaking reach, at least during early July and early September when their index densities were highest (Figure 23). Dace were also distributed fairly evenly throughout the CA Peaking reach. Other non-salmonid species

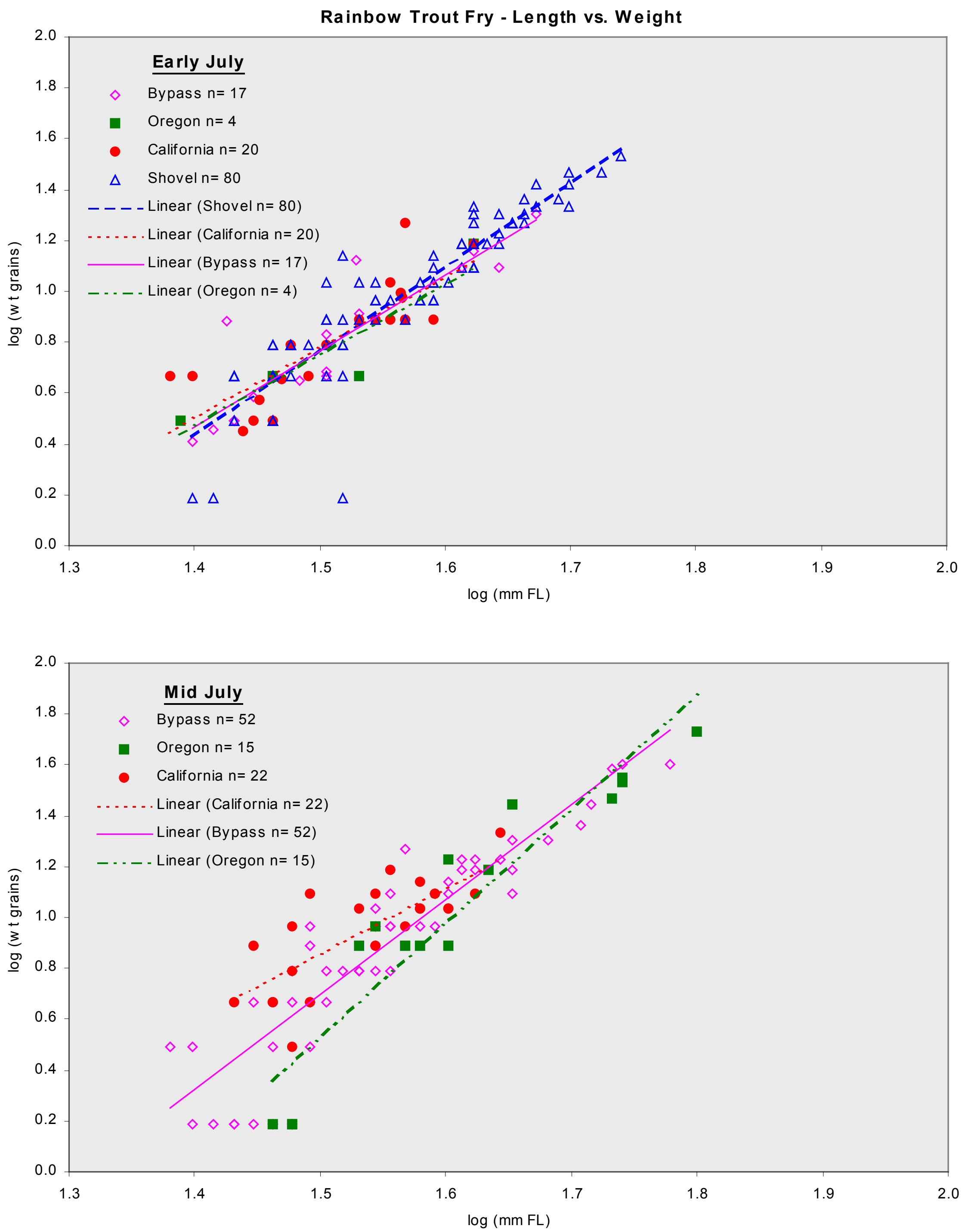
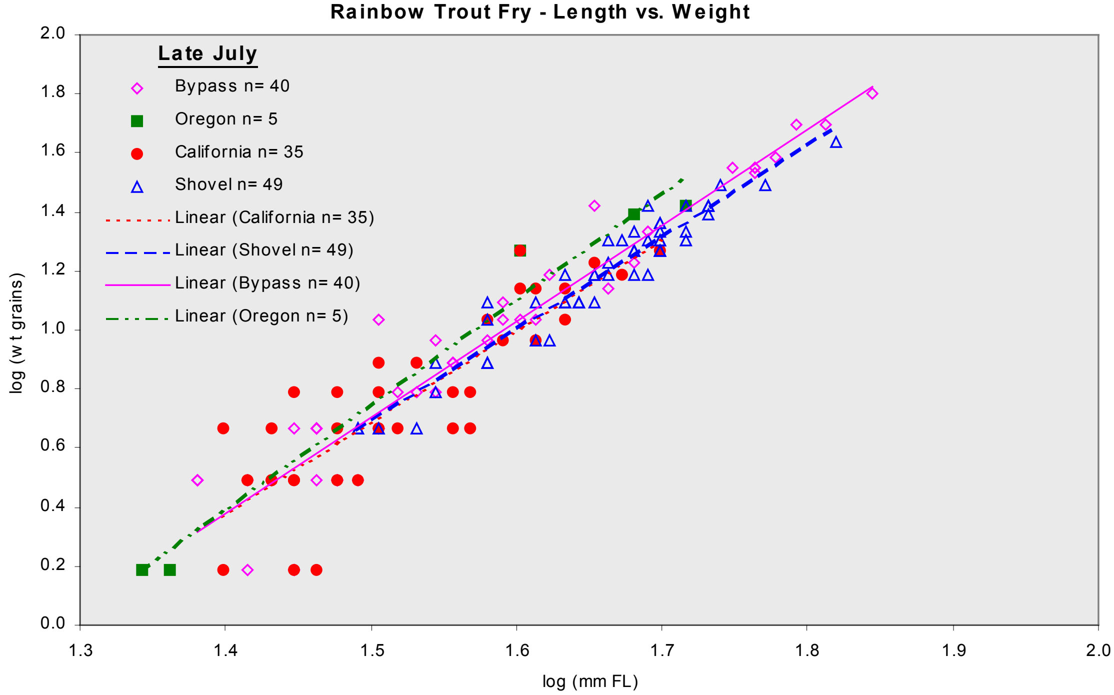


Figure 20. Length vs. weight relationship for trout fry in early July (upper graph) and mid-July (lower graph) according to reach.



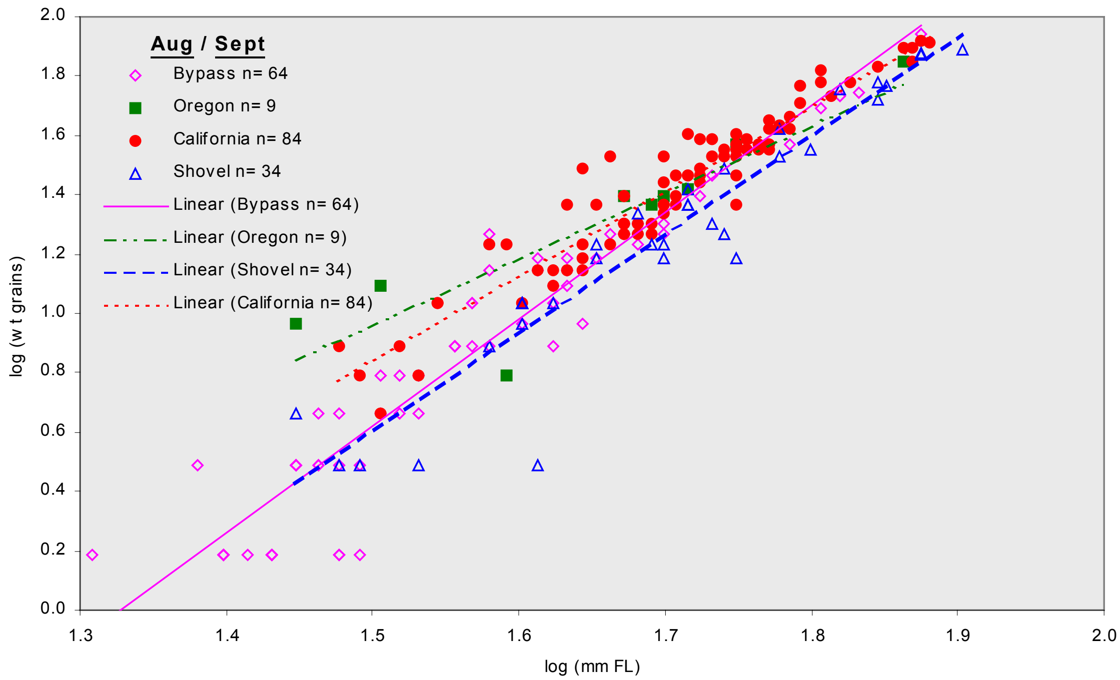


Figure 21. Length vs. weight relationship for trout fry in late July (upper graph) and August/September (lower graph) according to reach.

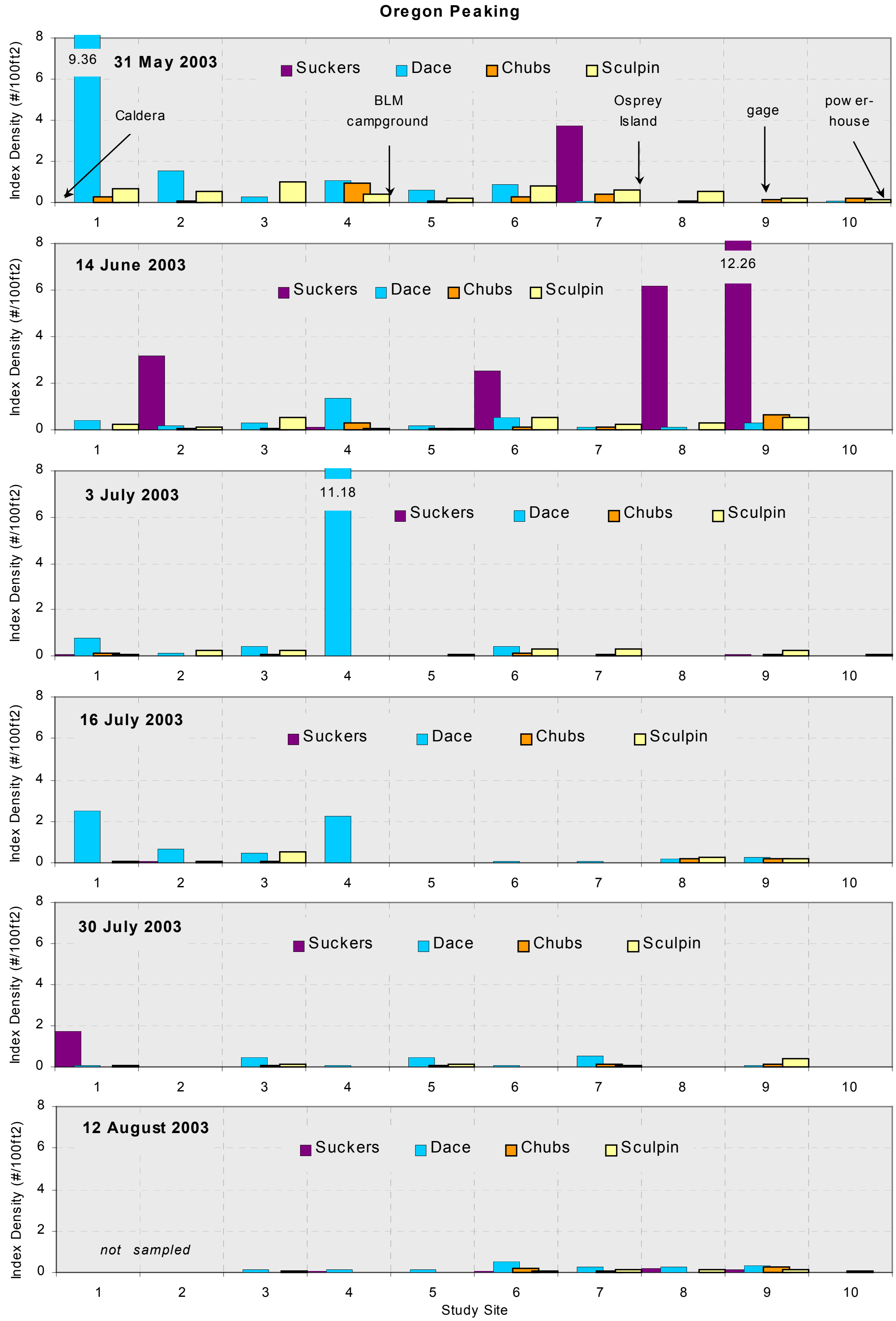


Figure 22. Index density (#/100ft^2) of non-salmonid species in the OR Peaking reach according to time period and study site.

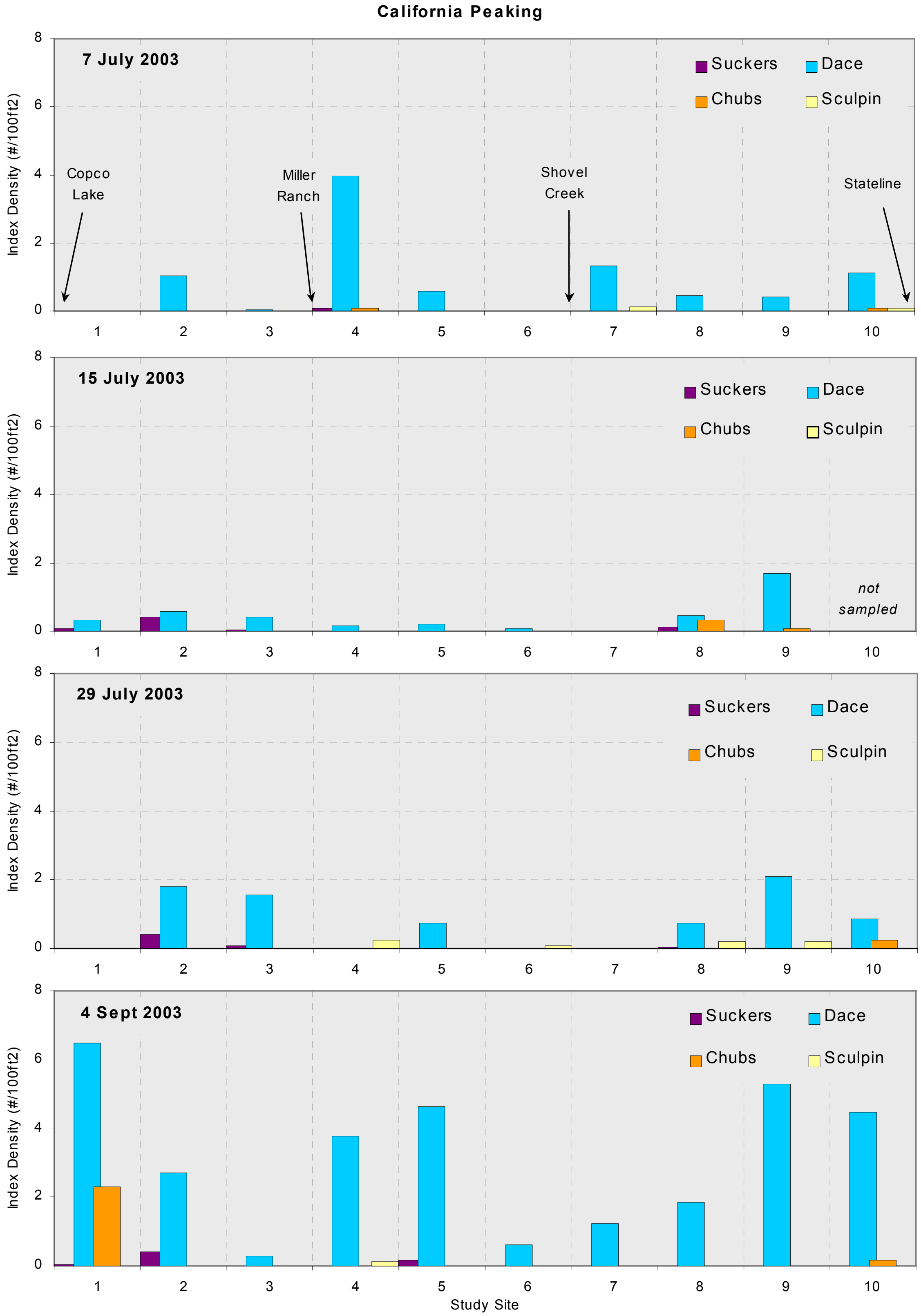


Figure 23. Index density (#/100ft^2) of non-salmonid species in the CA Peaking reach according to time period and study site.

were relatively uncommon in the CA Peaking reach, although chubs were somewhat abundant at the lowest study site during the final survey in early September.

Statistical comparison of non-salmonid densities in vegetated and non-vegetated margin units is complicated by a lack of calibration data and expected low capture probabilities, however a casual interpretation may be informative (Table 12). Index densities of fry and juvenile suckers were not different among margin types in either reach, although that comparison is confounded by the identification limitations previously described. Comparative abundance of dace and chubs appeared similar to trout fry with higher densities in vegetated units than in non-vegetated units in the OR Peaking reach, but with the opposite trend in the CA Peaking reach. Some of the reach-specific differences were statistically significant, and the combined data for both species showed significance values of <0.10 with higher overall densities in non-vegetated units. Estimated densities of sculpin were very similar in both margin types in all comparisons.

Table 12. Wilcoxon's signed rank test statistics comparing non-salmonid index densities (#/100ft^2) in vegetated and non-vegetated margin units, according to reach.

	Study	Mean Densities		Std. Deviations		Mean	Signed Rank Test	
Species	Sites	Veg	Non-Veg	Veg	Non-Veg	Difference	Z	*approx P*
SUCKER	OR 1-10	0.42	0.45	1.60	2.17	-0.03	1.23	0.22
original	CA 1-10	0.06	0.03	0.16	0.09	0.04	0.95	0.35
density	Combined	0.29	0.29	1.29	1.74	-0.004	1.55	0.12
DACE	OR 1-10	0.71	0.40	2.13	0.72	0.312	-0.39	0.70
original	CA 1-10	0.81	2.22	1.23	3.85	-1.41	-3.02	0.003
density	Combined	0.75	1.06	1.85	2.53	-0.32	-2.29	0.02
CHUB	OR 1-10	0.12	0.07	0.22	0.14	0.05	2.09	0.04
original	CA 1-10	0.03	0.19	0.08	1.03	-0.16	-0.37	0.71
density	Combined	0.09	0.11	0.18	0.63	-0.03	1.88	0.06
SCULPIN	OR 1-10	0.23	0.22	0.23	0.35	0.01	1.36	0.17
original	CA 1-10	0.01	0.05	0.04	0.15	-0.05	-1.90	0.06
density	Combined	0.15	0.16	0.22	0.30	-0.01	0.87	0.39

CONCLUSIONS

Single-pass electrofishing surveys were conducted every two weeks from June to September in 61 margin units distributed throughout the Bypass, OR Peaking, and CA Peaking reaches. Rainbow trout fry (<50mm FL) were common in margin units in the lower portion of the Bypass reach downstream of the main spawning areas (below the spillway). Some fry were observed at site 5 above the spillway, which suggests that limited spawning may be occurring in isolated gravel patches below the springs (Figure 1). No fry were captured at site 6 above the springs. In the Oregon Peaking reach, some fry were captured in the upstream half of the reach closest to the Bypass, however fry abundance was much lower than in the Bypass or in the CA Peaking reach. Very few fry were captured in the Frain Ranch portion of the OR Peaking reach, or in any other study sites more than 4 miles from a known spawning area. In the CA Peaking reach, fry were abundant in several study sites below Shovel Creek, but fry were not captured above Shovel Creek, which suggests little upstream movement of small fry.

The relative numbers of fry showed a generally minor decline in most margin units throughout the summer. Declines associated with growth into the next size class (juveniles >50mm FL), movement away from the stream margin into non-sampleable habitat, and emigration or mortality, appeared to be somewhat offset by extended recruitment of new fry from upstream spawning areas (i.e., from the Bypass reach into the OR Peaking reach, and from Shovel Creek into the CA Peaking reach). A secondary peak in small fry (<30mm FL) occurred in the Bypass and the two peaking reaches in late July, possibly due to a later peak in spawning activity.

Paired margin units were similar in habitat characteristics except for instream cover type, which intentionally differed in order to compare fry densities between vegetated and non-vegetated margins. Among reaches, the diameter of substrate-associated cover was greatest in the Bypass reach and smallest in the CA Peaking reach. In contrast, the width and depth of emergent vegetation was greatest in the CA Peaking reach and least in the Bypass reach. All margin units in the Bypass were vegetated, and no margin units in the Peaking reaches were vegetated at low flows (e.g., when the river was not peaking).

A limited number of multiple-pass electrofishing surveys suggested that capture probabilities of fry were lower in vegetated margin units than in non-vegetated units. Consequently, the estimated index densities of fry from single-pass electrofishing were expanded by the mean capture probabilities according to margin cover type. Paired comparisons of expanded fry densities in vegetated and non-vegetated units showed significantly higher index densities in vegetated units than in non-vegetated units in the OR Peaking reach, but similar densities in the CA Peaking reach. When combined, significantly more fry occurred in vegetated units than in non-vegetated units.

A multiple regression model was developed using distance to spawning area, margin mean velocity, maximum depth, and dominant substrate type, to predict fry density in margin units. The model predicted 76% of the observed variation in mean fry densities in the OR and CA Peaking reaches. This model is limited by the relatively narrow range of depths and velocities sampled, and by the effects of peaking where margin characteristics changed according to flow.

Over 300 fry were fin-clipped in the Bypass reach and 73 were clipped in the CA Peaking reach. All but one of the 15 recaptured fry from the Bypass were found in the study site where it was originally clipped, even after flows were increased from 325 cfs to 520 cfs. No marked fry were recovered in the OR Peaking reach. In the CA Peaking reach, nine of the marked fry were recaptured in the same margin unit after one or two peaking events, indicating some ability to maintain their location and migrate with the changing waters edge under peaking flows.

Trout fry captured in the Bypass reach tended to be shorter than fry captured in the OR Peaking reach (although OR Peaking n's were small). In contrast, fry captured in Shovel Creek were typically longer than fry captured in the CA Peaking reach. Length-weight relationships contained high scatter and numerous outliers (due in part to errors associated with weighing small fry in field conditions). Regression models constructed for data from mid June, early July, and late July suggested little difference in growth among reaches (including Shovel Creek). In contrast, models developed from mid July and August / September data suggested different growth patterns, with CA Peaking fry being heaviest when small (<35mm FL). Length-weight distributions for larger fry appeared similar in all reaches and time periods.

Analysis of catch data for non-salmonid fish (suckers, dace, chubs, and sculpins) showed a much more even distribution of fish within reaches (i.e., no distance to recruitment area effect). In the OR Peaking reach, index densities (not expanded by capture probabilities) declined through the summer months, whereas in the CA Peaking reach the highest densities (for dace and chubs) occurred in late summer. Paired comparisons of index densities among vegetated and non-vegetated margin units showed similar densities for suckers and sculpins. For dace and chubs, highest densities occurred in vegetated units in the OR Peaking reach, whereas lowest densities occurred in vegetated units in the CA Peaking reach. That pattern was similar to the relationship observed for trout fry. Most paired comparisons of non-salmonid densities were not statistically significant.

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Appendix A. Catch data for single-pass electrofishing surveys in the upper Klamath River project area. Reaches are BP=Bypass, OR=Oregon Peaking, CA=California Peaking. Flows are 325 cfs for BP low and CA low, 520 cfs for BP high and OR low, 1,500-1,700 for OR and CA medium. See Table 3 for SMET code. Units are in ft or sq ft. Fish sizes in mm FL. "n/a" means data not applicable. Non-Game fry and sucker fry were not consistently distinguished in field data.

				Margin	Margin Unit				Shock	# Rainbow Trout Captured							#	#	ReCapt	NGame	Fry/Juv	All	All	All	
Date	Reach	Flow	Site	Unit	SMET	Length	Width	Area	Effort	<20	20-29	30-39	40-49	50-59	60-69	70+	Marked	ReCapt	Site	Fry	Suckers	Dace	Chubs	Sculpin	Notes
5/30	BP	low	1	A	9	130	7.3	949	625	0	1	3	0	0	0	0	3	n/a	n/a	-	0	0	0	0	
5/30	BP	low	1	B	9	101	8.7	879	566	0	0	1	0	0	0	0	0	n/a	n/a	-	0	0	0	0	
5/30	BP	low	2	A	9	100	10.3	1,030	621	0	2	0	0	0	0	0	0	n/a	n/a	-	0	0	0	0	
5/30	BP	low	2	B	9	126	6.9	869	724	0	12	0	0	0	0	0	8	n/a	n/a	-	0	0	0	0	
5/30	BP	low	3	A	9	88	5.2	458	392	0	13	2	0	0	0	0	0	n/a	n/a	-	0	0	0	0	incl 2 unmeasured (eye-est) fry
5/30	BP	low	3	B	9	109	7.3	796	397	0	45	14	2	0	0	1	1	n/a	n/a	-	0	0	0	0	incl 6 unmeasured (eye-est) fry
6/3	BP	low	4	A	9	78	6.0	468	352	0	11	5	0	0	0	0	0	n/a	n/a	-	0	0	0	0	incl 2 unmeasured (eye-est) fry
6/3	BP	low	4	B	9	87	5.9	513	270	0	2	0	0	0	0	1	0	n/a	n/a	-	0	0	0	0	
6/3	BP	low	5	A	9	75	5.4	405	370	0	3	0	0	0	0	0	2	n/a	n/a	-	0	0	0	0	incl 1 unmeasured (eye-est) fry
6/3	BP	low	5	B	9	140	6.7	938	715	0	0	0	0	0	0	1	0	n/a	n/a	-	0	0	0	0	
6/3	BP	low	6	A	9	83	6.3	523	248	0	0	0	0	0	0	0	0	n/a	n/a	-	0	0	0	0	
6/3	BP	low	6	B	7	55	6.0	330	248	0	0	0	0	0	0	0	0	n/a	n/a	-	0	0	0	0	
6/13	BP	low	1	A	9	130	7.3	949	468	0	15	1	0	0	0	0	0	0	-	-	0	0	0	0	incl 7 unmeasured (eye-est) fry
6/13	BP	low	1	B	9	101	8.7	879	436	0	0	2	0	0	0	2	1	0	-	-	0	0	0	0	
6/13	BP	low	2	A	9	100	10.3	1,030	391	0	7	5	0	0	0	0	6	0	-	-	0	0	0	0	NOT incl 14 uncaptured fry
6/13	BP	low	2	B	9	126	6.9	869	429	0	25	14	1	0	0	0	26	0	-	-	0	0	0	0	NOT incl 5 uncaptured fry
6/13	BP	low	3	A	9	88	5.2	458	276	0	6	4	0	0	0	0	6	0	-	-	0	0	0	0	NOT incl 2 uncaptured fry
6/13	BP	low	3	B	9	109	7.3	796	402	0	11	7	1	0	0	0	10	0	-	-	0	0	0	0	NOT incl 8 uncaptured fry
6/13	BP	low	4	A	9	78	6.0	468	493	0	7	6	2	0	0	0	3	0	-	-	0	0	0	0	
6/13	BP	low	4	B	9	87	5.9	513	214	0	4	1	0	0	0	0	1	0	-	-	0	0	0	0	
6/13	BP	low	5	A	9	75	5.4	405	414	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/13	BP	low	5	B	9	140	6.7	938	660	0	0	1	0	0	0	1	0	0	-	-	0	0	0	0	
6/13	BP	low	6	A	9	83	6.3	523	720	0	0	0	0	0	0	3	0	0	-	-	0	0	0	0	
6/13	BP	low	6	B	7	55	6.0	330	428	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/15	BP	high	1	A	9	130	5.3	689	526	0	11	3	0	0	0	0	6	0	-	-	0	0	0	0	
6/15	BP	high	1	B	9	101	7.2	727	376	0	4	1	0	0	0	0	4	0	-	-	0	0	0	0	NOT incl 4 uncaptured fry
6/15	BP	high	2	A	9	110	14.8	1,628	473	0	12	11	0	0	0	0	14	2	2	-	0	0	0	0	NOT incl 2 uncaptured fry
6/15	BP	high	2	B	9	130	5.7	741	456	0	22	8	3	0	0	0	18	4	2	-	0	0	0	0	
6/15	BP	high	3	A	9	85	4.9	417	497	0	5	4	0	0	1	0	2	1	?	-	0	0	0	0	only one AD-only fry prev clipped
6/15	BP	high	3	B	9	109	6.7	730	310	0	39	26	1	0	0	0	43	0	-	-	0	0	0	0	_ larger than this recapt
6/15	BP	high	4	A	7	85	7.7	655	500	3	12	4	0	0	0	0	1	0	-	-	0	0	0	0	
6/15	BP	high	4	B	9	88	4.9	431	196	0	2	0	1	0	0	0	1	0	-	-	0	0	0	0	
6/15	BP	high	5	A	9	75	11.0	825	447	0	0	0	0	0	0	1	0	0	-	-	0	0	0	0	
6/15	BP	high	5	B	9	140	5.6	784	462	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/15	BP	high	6	A	9	83	11.7	971	483	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/15	BP	high	6	B	7	55	6.3	347	274	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/2	BP	low	1	A	9	130	7.3	949	479	0	18	8	0	0	0	0	15	0	-	-	0	0	0	0	incl 2 RBT not captured (no leng
7/2	BP	low	1	B	9	101	8.7	879	288	0	12	6	2	0	0	0	17	0	-	-	0	0	0	0	_ est, put in 30-39)
7/2	BP	low	2	A	9	110	10.3	1,133	419	0	5	10	0	0	0	0	13	0	-	-	0	0	0	0	
7/2	BP	low	2	B	9	130	6.9	897	397	0	15	11	1	0	0	1	20	1	2	-	0	0	0	0	incl 1 RBT not captured (eye-est)
7/2	BP	low	3	A	9	85	5.2	442	355	0	12	3	0	0	0	0	7	0	-	-	0	0	0	0	
7/2	BP	low	3	B	9	109	7.3	796	551	0	14	7	3	0	0	0	18	1	3	-	0	0	0	0	
7/2	BP	low	4	A	9	85	6.0	510	506	0	5	2	1	0	0	0	7	0	-	-	0	0	0	0	
7/2	BP	low	4	B	9	88	5.9	519	264	0	1	3	1	0	0	0	3	0	-	-	0	0	0	0	
7/2	BP	low	5	A	9	75	5.4	405	442	0	4	3	1	0	0	1	6	0	-	-	0	0	0	0	incl 2 RBT not captured (eye-est)
7/2	BP	low	5	B	9	140	6.7	938	807	0	0	0	0	0	0	3	0	0	-	-	0	0	0	0	
7/2	BP	low	6	A	9	83	6.3	523	723	0	0	0	0	0	0	1	0	0	-	-	0	0	0	0	

Appendix A (continued)

Date	Reach	Flow	Site	Margin Unit	SMET	Margin Unit Length	Margin Unit Width	Margin Unit Area	Shock Effort	# Rainbow Trout Captured <20	20-29	30-39	40-49	50-59	60-69	70+	# Marked	# ReCapt	ReCapt Site	NGame Fry	Fry/Juv Suckers	All Dace	All Chubs	All Sculpin	Notes
7/2	BP	low	6	B	7	55	6.0	330	363	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/16	BP	low	1	A	9	130	6.7	871	328	0	7	12	2	1	0	0	13	1	1	-	0	0	0	0	
7/16	BP	low	1	B	9	101	8.7	879	-	0	2	3	0	0	0	0	0	0	-	-	0	0	0	0	incl 2 RBT not captured (eye-est)
7/16	BP	low	2	A	9	110	7.1	781	650	0	0	0	1	0	0	0	0	1	2	-	0	0	0	0	
7/16	BP	low	2	B	9	130	6.8	884	949	0	11	6	3	2	0	1	17	1	2	-	0	0	0	0	
7/16	BP	low	3	A	9	85	5.2	442	247	0	4	2	0	0	0	0	2	0	-	-	0	0	0	0	
7/16	BP	low	3	B	9	109	7.3	796	381	0	2	5	0	0	0	0	3	0	-	-	0	0	0	0	incl 3 RBT not captured (eye-est)
7/16	BP	low	4	A	9	85	6.0	510	636	1	4	1	0	0	0	0	4	0	-	-	0	0	0	0	
7/16	BP	low	4	B	9	88	5.9	519	349	0	2	2	4	1	0	0	5	0	-	-	0	0	0	0	
7/17	BP	low	5	A	9	75	6.1	458	303	0	1	1	1	0	1	0	2	1	5	-	0	0	0	0	
7/17	BP	low	5	B	9	140	6.5	910	303	0	1	1	0	0	0	0	0	0	-	-	0	0	0	0	
7/17	BP	low	6	A	9	83	7.6	631	238	0	0	0	0	0	0	2	0	0	-	-	0	0	0	0	
7/17	BP	low	6	B	7	55	4.3	237	185	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/30	BP	low	1	A	9	130	7.4	962	392	0	5	0	2	0	0	0	2	0	-	-	0	0	0	0	
7/30	BP	low	1	B	9	101	6.8	687	212	0	7	1	1	1	0	0	2	0	-	-	0	0	0	0	
7/30	BP	low	2	A	9	110	7.1	781	377	0	1	1	0	0	0	0	0	0	-	-	0	0	0	0	
7/30	BP	low	2	B	9	130	6.1	793	430	0	5	4	2	1	0	0	9	0	-	-	0	0	0	0	
7/30	BP	low	3	A	9	85	5.2	442	258	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/30	BP	low	3	B	9	109	7.3	796	530	1	3	5	3	1	1	0	4	1	5	-	0	0	0	0	
7/31	BP	low	4	A	9	85	6.0	510	581	0	2	2	0	0	0	0	2	0	-	-	0	0	0	0	
7/31	BP	low	4	B	9	88	5.9	519	429	0	1	1	1	2	2	1	7	0	-	-	0	0	0	0	
7/31	BP	low	5	A	9	75	6.1	458	164	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/31	BP	low	5	B	9	140	5.9	826	263	0	1	3	0	0	0	0	0	0	-	-	0	0	0	0	incl 1 RBT not captured (eye-est)
7/31	BP	low	6	A	9	83	7.6	631	341	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/31	BP	low	6	B	7	55	4.3	237	143	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
8/12	BP	low	1	A	9	130	6.2	806	381	1	2	3	1	0	0	0	0	0	-	-	0	0	0	0	
8/12	BP	low	1	B	9	101	6.7	677	273	0	2	1	1	0	0	0	0	0	-	-	0	0	0	0	
8/12	BP	low	2	A	9	110	7.2	792	736	0	1	4	3	2	2	0	0	0	-	-	0	0	0	0	
8/12	BP	low	2	B	9	130	6.2	806	583	0	6	3	6	0	0	0	0	0	-	-	0	0	0	0	
8/13	BP	low	3	A	9	85	6.2	527	279	0	6	1	0	1	0	0	0	0	-	-	0	0	0	0	
8/13	BP	low	3	B	9	109	5.3	578	313	0	14	3	2	2	0	0	0	1	3	-	0	0	0	0	
8/13	BP	low	4	A	9	85	5.0	425	405	0	3	2	2	0	0	0	0	0	-	-	0	0	0	0	
8/13	BP	low	4	B	9	88	6.0	528	319	0	0	0	2	1	1	2	0	0	-	-	0	0	0	0	
8/13	BP	low	5	A	9	75	6.1	458	-	0	1	1	0	0	0	0	0	0	-	-	0	0	0	0	
8/13	BP	low	5	B	9	140	5.9	826	219	0	1	2	0	0	0	0	0	0	-	-	0	0	0	0	
8/13	BP	low	6	A	9	83	6.3	523	495	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
8/13	BP	low	6	B	7	55	7.6	418	248	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
5/31	OR	med	1	A	3	122	8.7	1,061	690	0	0	0	0	0	0	0	0	0	-	-	0	11	3	6	
5/31	OR	med	1	B	9	122	11.8	1,440	498	0	0	0	0	0	0	0	0	0	-	-	0	250	5	9	
5/31	OR	med	1	C	8	79	5.0	395	432	0	0	0	0	0	0	0	0	0	-	-	0	10	0	5	
5/31	OR	med	2	A	8	110	7.6	836	622	0	0	0	1	0	0	0	0	0	-	-	0	21	1	4	
5/31	OR	med	2	B	9	230	6.7	1,541	1,136	0	0	0	0	0	0	0	0	0	-	-	0	15	0	8	
5/31	OR	med	3	A	9	228	5.7	1,300	685	0	0	0	0	0	0	0	0	0	-	-	0	3	0	12	
5/31	OR	med	3	B	8/9	74	6.0	444	284	0	0	0	0	0	0	0	0	0	-	-	0	2	0	6	
5/31	OR	med	4	A	8	139	6.5	904	714	0	0	0	0	0	0	0	0	0	-	-	0	2	0	1	
5/31	OR	med	4	B	9	155	4.0	620	449	0	0	0	0	0	0	0	0	0	-	-	0	4	0	4	
5/31	OR	med	4	C	7	204	14.5	2,958	787	0	0	0	0	0	0	0	0	0	-	-	0	42	42	12	
6/1	OR	med	5	A	4/9	160	16.2	2,592	1,253	0	0	0	0	0	0	0	0	0	-	-	0	15	1	5	
6/1	OR	med	5	C	8	110	5.7	627	639	0	0	0	0	0	0	0	0	0	-	-	0	5	2	0	
6/1	OR	med	5	D	9	87	9.2	800	545	0	0	0	0	0	0	2	0	0	-	-	0	4	0	2	incl 1 RBT not captured (eye-est)
6/1	OR	med	6	A	9	161	9.2	1,481	983	0	0	0	0	0	0	0	0	0	-	-	0	15	5	9	

Appendix A (continued)

				Margin		Margin Unit			Shock	# Rainbow Trout Captured							#	#	ReCapt	NGame	Fry/Juv	All	All	All	
Date	Reach	Flow	Site	Unit	SMET	Length	Width	Area	Effort	<20	20-29	30-39	40-49	50-59	60-69	70+	Marked	ReCapt	Site	Fry	Suckers	Dace	Chubs	Sculpin	Notes
6/1	OR	med	6	B	8	107	5.5	589	425	0	0	0	0	0	0	0	0	0	-	-	0	6	3	2	
6/1	OR	med	6	C	8	117	7.0	819	549	0	0	0	0	0	0	0	0	0	-	-	0	4	0	12	
6/2	OR	med	7	A	8/9	114	5.0	570	719	0	3	0	0	0	0	0	0	0	-	-	25	0	2	3	
6/2	OR	med	7	B	9	187	9.2	1,720	896	1	4	0	0	0	0	0	0	0	-	-	41	2	9	14	incl 3 RBT not captured (eye-est)
6/2	OR	med	7	C	8/3	28	8.3	232	181	0	0	0	0	0	0	0	0	0	-	-	40	0	0	0	
6/2	OR	med	7	D	8	49	6.3	309	185	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/1	OR	med	8	A	8	133	5.7	758	718	0	2	0	0	0	0	0	0	0	-	-	0	0	1	2	
6/1	OR	med	8	B	9	154	6.6	1,016	721	0	0	0	0	0	0	0	0	0	-	-	0	0	0	7	
6/1	OR	med	9	A	9	125	7.2	900	601	0	4	0	0	0	0	0	0	0	-	-	0	0	2	3	
6/1	OR	med	9	B	8	101	5.3	535	484	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/1	OR	med	10	A	8	70	7.2	504	469	0	0	0	0	0	0	0	0	0	-	-	0	0	0	1	
6/1	OR	med	10	B	9	69	6.3	435	534	0	3	0	0	0	0	0	0	0	-	-	0	1	3	2	
6/1	OR	med	10	C	6/7	34	7.3	248	764	0	1	0	0	0	0	0	0	0	-	-	0	0	2	0	
6/1	OR	med	10	D	5	126	10.0	1,260	427	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/2	OR	med	1	A	3	122	8.7	1,061	521	0	0	0	0	0	0	0	0	0	-	-	1	7	0	8	
6/2	OR	med	1	B	9	122	11.8	1,440	591	0	0	0	0	0	0	0	0	0	-	100	1	61	0	0	
6/2	OR	med	1	C	8	79	5.0	395	266	0	0	0	0	0	0	0	0	0	-	-	0	1	0	5	
6/2	OR	med	2	A	8	110	7.6	836	311	0	0	0	0	0	0	0	0	0	-	-	0	4	0	4	
6/2	OR	med	2	B	9	230	6.7	1,541	704	0	0	0	0	0	0	0	0	0	-	-	0	3	0	6	
6/2	OR	med	3	A	9	228	5.7	1,300	586	0	0	0	0	0	0	0	0	0	-	-	0	2	1	0	
6/2	OR	med	3	B	8/9	74	6.0	444	477	0	0	0	0	0	0	0	0	0	-	-	0	1	0	5	
6/2	OR	med	4	A	8	139	6.5	904	529	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/2	OR	med	4	B	9	155	4.0	620	658	0	0	0	0	0	0	0	0	0	-	-	0	1	0	0	
6/2	OR	med	4	C	7	204	14.5	2,958	1,226	0	0	0	0	0	0	0	0	0	-	-	0	14	10	6	
6/2	OR	med	5	A	4/9	160	16.2	2,592	1,098	0	0	0	0	0	0	0	0	0	-	10	0	1	0	4	
6/2	OR	med	5	C	8	110	5.7	627	454	0	0	0	0	0	0	0	0	0	-	-	0	2	1	0	
6/2	OR	med	5	D	9	87	9.2	800	426	0	0	0	0	0	0	0	0	0	-	-	0	2	0	0	
6/2	OR	med	6	A	9	161	9.2	1,481	937	0	2	0	0	0	0	0	0	0	-	-	0	17	2	4	incl 2 RBT not captured (eye-est)
6/2	OR	med	6	B	8	107	5.5	589	363	0	0	0	0	0	0	0	0	0	-	-	0	2	1	2	
6/2	OR	med	6	C	8	117	7.0	819	442	0	0	0	0	0	0	0	0	0	-	-	0	3	0	5	
6/2	OR	med	7	A	8/9	114	5.0	570	327	0	2	1	0	0	0	0	0	0	-	15	0	0	0	3	
6/2	OR	med	7	B	9	187	9.2	1,720	782	0	1	0	0	0	0	0	0	0	-	-	0	1	5	14	
6/2	OR	med	7	C	8/3	28	8.3	232	165	0	0	0	0	0	0	0	0	0	-	20	0	0	0	1	
6/2	OR	med	7	D	8	49	6.3	309	143	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/2	OR	med	8	A	8	133	5.7	758	691	0	0	0	0	0	0	0	0	0	-	-	0	1	4	1	
6/2	OR	med	8	B	9	154	6.6	1,016	649	0	1	0	0	0	0	0	0	0	-	-	0	0	0	2	
6/2	OR	med	9	A	9	125	7.2	900	555	0	3	1	0	0	2	0	0	0	-	-	0	0	6	6	
6/2	OR	med	9	B	8	101	5.3	535	371	0	1	0	0	0	0	1	0	0	-	-	0	0	2	2	other fry observed between units
6/2	OR	med	10	A	8	70	7.2	504	390	0	0	0	0	0	0	0	0	0	-	-	0	0	0	2	
6/2	OR	med	10	B	9	69	6.3	435	416	0	0	0	0	0	0	0	0	0	-	-	0	0	0	1	
6/2	OR	med	10	C	6/7	34	7.3	248	247	0	0	0	0	0	0	0	0	0	-	-	0	0	1	0	
6/2	OR	med	10	D	5	126	10.0	1,260	434	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/14	OR	med	1	A	3	122	8.7	1,061	397	0	0	0	0	0	0	0	0	0	-	-	0	2	0	3	
6/14	OR	med	1	B	9	122	11.8	1,440	892	0	0	0	0	0	0	0	0	0	-	-	0	9	0	1	
6/14	OR	med	1	C	8	79	5.0	395	235	0	0	0	0	0	0	0	0	0	-	-	0	1	0	2	
6/14	OR	med	2	A	8	110	7.6	836	385	0	0	0	0	0	0	0	0	0	-	-	0	3	2	2	
6/14	OR	med	2	B	9	230	6.7	1,541	870	0	0	0	0	0	0	0	0	0	-	-	75	1	0	1	
6/14	OR	med	3	A	9	228	5.7	1,300	780	0	0	0	0	0	0	0	0	0	-	50	0	1	1	5	
6/14	OR	med	3	B	8/9	74	6.0	444	420	0	0	0	0	0	0	0	0	0	-	-	0	4	0	4	
6/14	OR	med	4	A	8	139	6.5	904	423	0	0	0	0	0	0	0	0	0	-	-	0	2	0	0	
6/14	OR	med	4	B	9	155	4.0	620	803	0	0	0	0	0	0	0	0	0	-	-	5	2	0	0	

Appendix A (continued)

Date	Reach	Flow	Site	Margin Unit	SMET	Margin Unit Length	Width	Area	Shock Effort	# Rainbow Trout Captured <20	20-29	30-39	40-49	50-59	60-69	70+	# Marked	# ReCapt	ReCapt Site	NGame Fry	Fry/Juv Suckers	All Dace	All Chubs	All Sculpin	Notes
6/14	OR	med	4	C	7	204	14.5	2,958	709	0	0	0	0	0	0	0	0	0	-	-	0	57	14	2	
6/14	OR	med	5	A	4/9	160	16.2	2,592	784	0	0	0	0	0	0	0	0	0	-	-	0	5	2	1	
6/14	OR	med	5	C	8	110	5.7	627	292	0	0	0	0	0	0	0	0	0	-	-	0	1	0	1	
6/14	OR	med	5	D	9	87	9.2	800	254	0	0	0	0	0	0	0	0	0	-	-	0	1	0	1	
6/14	OR	med	6	A	9	161	9.2	1,481	657	0	0	0	0	0	0	1	0	0	-	-	35	6	0	6	
6/14	OR	med	6	B	8	107	5.5	589	244	0	0	0	0	0	0	0	0	0	-	-	35	7	3	2	
6/14	OR	med	6	C	8	117	7.0	819	364	0	0	1	0	0	0	0	0	0	-	-	3	2	0	8	
6/14	OR	med	7	A	8/9	114	5.0	570	338	0	0	1	0	0	0	0	0	0	-	-	0	2	1	0	
6/14	OR	med	7	B	9	187	9.2	1,720	681	0	0	0	0	0	0	0	0	0	-	200	0	2	3	6	
6/14	OR	med	7	C	8/3	28	8.3	232	120	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/14	OR	med	7	D	8	49	6.3	309	162	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/14	OR	med	8	A	8	133	5.7	758	429	0	0	0	0	0	0	0	0	0	-	-	80	0	0	2	
6/14	OR	med	8	B	9	154	6.6	1,016	420	0	0	0	0	0	0	0	0	0	-	-	30	2	0	3	
6/14	OR	med	9	A	9	125	7.2	900	518	0	1	3	2	0	0	0	0	0	-	-	100	2	6	4	
6/14	OR	med	9	B	8	101	5.3	535	418	0	0	0	1	0	0	0	0	0	-	-	76	2	3	4	
6/14	OR	med	10	A	8	70	7.2	504	275	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/14	OR	med	10	B	9	69	6.3	435	224	0	3	1	0	0	0	0	0	0	-	-	0	0	0	0	
6/14	OR	med	10	C	6/7	34	7.3	248	166	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/14	OR	med	10	D	5	126	10.0	1,260	378	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/16	OR	low	1	A	8	122	16.6	2,025	413	0	0	0	0	0	0	0	0	0	-	5	0	20	0	7	
6/16	OR	low	1	B	7	122	2.4	293	97	0	0	0	0	0	0	0	0	0	-	200	0	0	0	2	
6/16	OR	low	1	C	8	79	4.3	340	156	0	0	1	0	0	0	0	0	0	-	30	0	0	0	4	incl 1 RBT not captured (eye-est)
6/16	OR	low	2	A	8	110	4.8	528	237	0	0	0	0	0	0	0	0	0	-	25	0	0	0	18	
6/16	OR	low	2	B	8	230	5.6	1,288	424	0	0	0	0	0	0	0	0	0	-	40	0	10	0	11	
6/16	OR	low	3	A	8	228	7.3	1,664	729	0	0	0	0	0	0	0	0	0	-	10	0	1	0	13	
6/16	OR	low	3	B	8	74	5.7	422	268	0	0	0	0	0	0	0	0	0	-	-	0	0	0	2	
6/16	OR	low	4	A	8	139	6.2	862	312	0	0	0	0	0	0	0	0	0	-	-	0	1	0	0	
6/16	OR	low	4	B	8	155	4.3	667	352	0	0	0	0	0	0	0	0	0	-	-	0	3	0	7	
6/16	OR	low	4	C	9	204	18.2	3,713	495	0	0	0	0	0	0	0	0	0	-	25	0	100	0	7	1 turtle
6/16	OR	low	5	A	8	151	9.2	1,389	894	0	0	0	0	0	0	0	0	0	-	-	0	2	0	10	
6/16	OR	low	5	C	8	110	8.8	968	337	0	0	0	0	0	0	0	0	0	-	-	0	1	0	0	
6/16	OR	low	5	D	8	87	5.8	505	283	0	1	1	0	0	0	0	0	0	-	-	0	0	0	2	
6/17	OR	low	6	A	8	161	8.6	1,385	526	0	0	0	0	0	0	0	0	0	-	-	0	0	6	2	
6/17	OR	low	6	B	8	107	5.7	610	338	0	0	0	0	0	0	0	0	0	-	-	0	1	1	2	
6/17	OR	low	6	C	8	117	6.3	737	290	0	0	0	0	0	0	0	0	0	-	70	0	2	1	4	
6/17	OR	low	7	A	8	114	4.8	547	378	0	0	0	0	0	0	0	0	0	-	75	0	0	0	3	
6/17	OR	low	7	B	8	187	10.8	2,020	827	0	1	1	0	0	0	0	0	0	-	127	0	0	7	12	
6/17	OR	low	7	C	8	28	4.0	112	107	0	0	0	0	0	0	0	0	0	-	-	0	0	0	3	
6/17	OR	low	7	D	8	49	4.3	211	135	0	0	0	0	0	0	0	0	0	-	-	0	0	0	1	
6/17	OR	low	8	A	8	133	6.8	904	356	0	0	1	0	0	0	0	0	0	-	75	0	0	0	2	
6/17	OR	low	8	B	8	154	5.7	878	318	0	0	0	1	0	0	0	0	0	-	30	0	0	3	4	
6/17	OR	low	9	A	8	125	15.5	1,938	262	0	2	8	2	0	0	0	0	0	-	105	0	0	1	4	all 12 RBT not captured (eye-est)
6/17	OR	low	9	B	8	101	6.2	626	184	0	3	2	0	0	0	0	0	0	-	65	0	0	1	0	
6/16	OR	low	10	A	8	70	7.5	525	343	0	0	0	0	0	0	0	0	0	-	-	0	0	3	1	
6/16	OR	low	10	B	8	69	7.2	497	294	0	2	4	0	0	0	0	0	0	-	-	0	0	0	1	incl 4 RBT not captured (eye-est)
6/16	OR	low	10	C	5	34	12.5	425	415	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
6/16	OR	low	10	D	5	126	16.6	2,092	1,310	0	0	0	0	0	0	0	0	0	-	-	0	0	0	2	
7/3	OR	med	1	A	3	122	8.7	1,061	333	0	0	0	0	0	0	0	0	0	-	20	0	0	0	1	
7/3	OR	med	1	B	9	122	11.8	1,440	691	0	0	0	0	0	0	0	0	0	-	-	1	23	3	0	
7/3	OR	med	1	C	8	79	5.0	395	181	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/3	OR	med	2	A	8	110	7.6	836	229	0	0	0	0	0	0	0	0	0	-	-	0	3	0	1	

Appendix A (continued)

Date	Reach	Flow	Site	Margin Unit	SMET	Margin Unit Length	Width	Area	Shock Effort	# Rainbow Trout Captured <20	20-29	30-39	40-49	50-59	60-69	70+	# Marked	# ReCapt	ReCapt Site	NGame Fry	Fry/Juv Suckers	All Dace	All Chubs	All Sculpin	Notes
7/3	OR	med	2	B	9	230	6.7	1,541	726	0	0	0	0	0	0	0	0	0	-	-	0	0	0	4	
7/3	OR	med	3	A	9	228	5.7	1,300	601	0	0	0	0	0	0	0	0	0	-	15	0	0	1	2	
7/3	OR	med	3	B	8/9	74	6.0	444	243	0	0	0	0	0	0	0	0	0	-	-	0	7	0	2	
7/3	OR	med	4	A	8	139	6.5	904	273	0	0	0	0	0	0	0	0	0	-	15	0	0	0	0	
7/3	OR	med	4	B	9	155	4.0	620	359	0	0	0	0	0	0	0	0	0	-	7	0	1	0	0	
7/3	OR	med	4	C	7	204	14.5	2,958	616	0	0	0	0	0	0	0	0	0	-	10	0	500	0	0	
7/3	OR	med	5	A	4/9	160	16.2	2,592	594	0	0	0	0	0	0	0	0	0	-	-	0	0	1	1	
7/3	OR	med	5	C	8	110	5.7	627	245	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/3	OR	med	5	D	9	87	9.2	800	244	0	0	0	0	0	0	0	0	0	-	-	0	0	0	1	
7/3	OR	med	6	A	9	161	9.2	1,481	545	0	0	0	0	0	0	0	0	0	-	-	0	8	2	7	
7/3	OR	med	6	B	8	107	5.5	589	241	0	0	0	0	0	0	0	0	0	-	200	0	4	2	2	
7/3	OR	med	6	C	8	117	7.0	819	342	0	0	0	0	0	0	1	0	0	-	20	0	0	0	0	
7/3	OR	med	7	A	8/9	114	5.0	570	388	0	0	0	1	0	0	0	0	0	-	3	0	0	0	0	
7/3	OR	med	7	B	9	187	9.2	1,720	583	0	2	2	0	0	0	0	0	0	-	100	0	0	1	8	incl 2 RBT not captured (no leng
7/3	OR	med	7	C	8/3	28	8.3	232	116	0	0	1	0	0	0	0	0	0	-	10	0	0	0	0	_ est, put in 30-39)
7/3	OR	med	7	D	8	49	6.3	309	-	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/3	OR	med	8	A	8	133	5.7	758	427	0	1	0	0	0	0	0	0	0	-	350	0	0	0	0	1 PGS
7/3	OR	med	8	B	9	154	6.6	1,016	378	0	0	3	0	0	0	0	0	0	-	225	0	0	0	0	incl 1 RBT not captured (eye-est)
7/3	OR	med	9	A	9	125	7.2	900	356	0	0	1	1	0	0	0	0	0	-	275	1	0	1	3	incl 1 RBT not captured (eye-est)
7/3	OR	med	9	B	8	101	5.3	535	211	0	0	0	0	0	0	0	0	0	-	450	0	0	0	0	
7/3	OR	med	10	A	8	70	7.2	504	315	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/3	OR	med	10	B	9	69	6.3	435	435	0	0	0	0	0	0	0	0	0	-	-	0	0	0	2	
7/3	OR	med	10	C	6/7	34	7.3	248	161	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/3	OR	med	10	D	5	126	10.0	1,260	381	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/17	OR	med	1	A	3	122	8.7	1,061	406	0	0	0	0	0	0	0	0	0	-	-	0	6	0	0	
7/17	OR	med	1	B	9	122	11.8	1,440	486	0	0	0	0	0	0	0	0	0	-	-	0	50	0	0	
7/17	OR	med	1	C	8	79	5.0	395	261	0	0	0	0	0	0	0	0	0	-	-	0	17	0	1	
7/17	OR	med	2	A	8	110	7.6	836	378	0	0	0	0	0	0	0	0	0	-	-	0	7	0	0	
7/17	OR	med	2	B	9	230	6.7	1,541	782	0	0	0	0	0	0	0	0	0	-	110	1	8	0	2	
7/17	OR	med	3	A	9	228	4.5	1,026	656	0	0	0	0	0	0	0	0	0	-	-	0	4	0	8	
7/17	OR	med	3	B	8/9	74	6.0	444	243	0	0	0	0	0	0	0	0	0	-	-	0	3	1	0	
7/17	OR	med	4	A	8	139	6.5	904	382	0	0	0	0	0	0	0	0	0	-	-	0	1	0	1	
7/17	OR	med	4	B	9	155	4.0	620	399	0	0	0	0	0	0	0	0	0	-	1	0	0	0	0	
7/17	OR	med	4	C	7	204	14.5	2,958	822	0	0	0	0	0	0	0	0	0	-	200	0	100	0	0	
7/17	OR	med	5	A	4/9	160	16.2	2,592	418	0	0	0	0	0	0	0	0	0	-	8	0	1	0	0	
7/17	OR	med	5	C	8	110	5.7	627	303	0	0	0	0	0	0	0	0	0	-	1	0	0	0	0	
7/17	OR	med	5	D	9	87	9.2	800	215	0	0	0	0	0	0	0	0	0	-	5	0	0	0	1	
7/17	OR	med	6	A	9	161	9.2	1,481	639	0	0	0	0	0	0	0	0	0	-	40	0	0	0	0	
7/17	OR	med	6	B	8	107	5.5	589	282	0	0	0	0	0	0	0	0	0	-	45	0	1	0	0	
7/17	OR	med	6	C	8	117	7.0	819	332	0	0	0	0	0	0	0	0	0	-	40	0	0	0	0	
7/16	OR	med	7	A	8/9	114	5.0	570	299	0	0	0	0	0	0	0	0	0	-	15	0	1	0	0	
7/16	OR	med	7	B	9	187	9.2	1,720	435	0	0	1	0	0	0	0	0	0	-	60	0	1	0	0	
7/16	OR	med	7	C	8/3	28	8.3	232	95	0	0	2	0	0	0	0	0	0	-	-	0	0	0	0	incl 1 RBT not captured (eye-est)
7/16	OR	med	7	D	8	49	6.3	309	114	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/16	OR	med	8	A	8	133	5.7	758	623	0	1	3	4	0	1	0	0	0	-	100	0	2	0	2	
7/16	OR	med	8	B	9	154	6.6	1,016	592	0	0	3	2	3	0	0	0	0	-	35	0	1	3	3	
7/16	OR	med	9	A	9	125	7.2	900	508	0	0	0	1	0	0	0	0	0	-	40	0	0	2	3	
7/16	OR	med	9	B	8	101	5.3	535	372	0	0	1	0	0	0	0	0	0	-	100	0	4	1	0	
7/16	OR	med	10	A	8	70	7.2	504	141	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/16	OR	med	10	B	9	69	6.3	435	148	0	0	0	0	0	0	0	0	0	-	10	0	0	0	0	
7/16	OR	med	10	C	6/7	34	7.3	248	75	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	

Appendix A (continued)

Date	Reach	Flow	Site	Margin Unit	SMET	Margin Unit Length	Width	Area	Shock Effort	# Rainbow Trout Captured <20	20-29	30-39	40-49	50-59	60-69	70+	# Marked	# ReCapt	ReCapt Site	NGame Fry	Fry/Juv Suckers	All Dace	All Chubs	All Sculpin	Notes
7/16	OR	med	10	D	5	126	10.0	1,260	380	0	0	0	0	0	0	0	0	0	-	35	0	0	0	0	
7/31	OR	med	1	A	3	122	8.7	1,061	286	0	0	0	0	1	0	0	0	0	-	-	50	1	0	1	suckers or NGF ?
7/31	OR	med	1	B	9	122	11.8	1,440	394	0	0	0	0	0	0	0	0	0	-	150	0	0	0	0	
7/31	OR	med	1	C	8	79	5.0	395	-	0	0	0	0	0	0	0	0	0	-	7	0	1	0	0	
7/31	OR	med	2	A	8	110	7.6	836	271	0	0	0	0	0	0	0	0	0	-	10	0	0	0	0	
7/31	OR	med	2	B	9	230	6.7	1,541	442	0	0	0	0	0	0	0	0	0	-	75	0	0	0	0	
7/30	OR	med	3	A	9	228	4.5	1,026	584	0	0	0	0	0	0	0	0	0	-	-	0	0	1	2	
7/30	OR	med	3	B	8/9	74	6.0	444	280	0	0	0	0	0	0	0	0	0	-	-	0	7	0	0	
7/31	OR	med	4	A	8	139	6.5	904	365	0	0	0	0	0	0	0	0	0	-	-	0	1	0	1	
7/31	OR	med	4	B	9	155	4.0	620	396	0	0	0	0	0	0	0	0	0	-	-	0	1	0	0	
7/31	OR	med	4	C	7	204	14.5	2,958	630	0	0	0	0	0	0	0	0	0	-	100	0	0	0	0	
7/31	OR	med	5	A	4/9	160	16.2	2,592	664	0	0	0	0	0	0	0	0	0	-	-	0	10	1	5	
7/31	OR	med	5	C	8	110	5.7	627	348	0	0	0	0	0	0	0	0	0	-	-	0	9	2	0	
7/31	OR	med	5	D	9	87	9.2	800	283	0	0	0	0	0	0	0	0	0	-	-	0	1	0	0	
7/30	OR	med	6	A	9	161	9.2	1,481	461	0	0	0	0	0	0	0	0	0	-	1	0	2	0	0	
7/30	OR	med	6	B	8	107	5.5	589	189	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/30	OR	med	6	C	8	117	7.0	819	301	0	0	1	0	0	0	0	0	0	-	-	0	0	0	0	
7/30	OR	med	7	A	8/9	114	4.7	536	303	0	0	0	0	0	0	0	0	0	-	15	0	0	0	0	
7/30	OR	med	7	B	9	187	9.2	1,720	449	0	0	0	0	0	0	0	0	0	-	15	0	15	3	2	
7/30	OR	med	7	C	8/3	28	8.3	232	76	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/30	OR	med	7	D	8	49	6.3	309	95	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/30	OR	med	8	A	8	133	5.7	758	391	0	0	0	0	0	0	0	0	0	-	1	0	0	0	0	
7/30	OR	med	8	B	9	154	6.6	1,016	431	0	2	0	2	0	0	0	0	0	-	-	0	0	0	0	
7/30	OR	med	9	A	9	125	7.2	900	591	0	1	0	0	0	0	0	0	0	-	25	0	0	0	5	
7/30	OR	med	9	B	8	101	5.3	535	315	0	0	0	0	0	0	0	0	0	-	4	0	1	2	1	
7/30	OR	med	10	A	8	70	5.4	378	205	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/30	OR	med	10	B	9	69	6.2	428	207	0	1	0	0	0	0	0	0	0	-	15	0	0	0	0	
7/30	OR	med	10	C	6/7	34	7.3	248	87	0	1	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/30	OR	med	10	D	5	126	10.0	1,260	323	0	0	0	0	0	0	0	0	0	-	100	0	0	0	0	
8/12	OR	med	1	A	3	*not sampled*				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
8/12	OR	med	1	B	9	*not sampled*				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
8/12	OR	med	1	C	8	*not sampled*				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
8/12	OR	med	2	A	8	*not sampled*				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
8/12	OR	med	2	B	9	*not sampled*				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
8/12	OR	med	3	A	9	228	4.5	1,026	362	0	0	0	0	0	0	0	0	0	-	2	0	1	0	1	
8/12	OR	med	3	B	8/9	74	6.0	444	190	0	0	0	0	0	0	0	0	0	-	2	0	1	0	0	
8/12	OR	med	4	A	8	139	6.5	904	480	0	0	0	0	0	0	1	0	0	-	20	1	3	0	0	
8/12	OR	med	4	B	9	155	4.0	620	436	0	0	0	0	0	0	0	0	0	-	1	1	3	0	0	
8/12	OR	med	4	C	7	204	14.5	2,958	689	0	0	0	0	0	0	0	0	0	-	3	0	0	0	0	
8/12	OR	med	5	A	4/9	160	14.9	2,384	465	0	0	0	0	0	0	0	0	0	-	-	0	1	0	0	
8/12	OR	med	5	C	8	110	5.7	627	328	0	0	0	0	0	0	0	0	0	-	-	0	5	0	0	
8/12	OR	med	5	D	9	87	9.2	800	325	0	1	0	0	0	0	0	0	0	-	-	0	0	0	0	
8/12	OR	med	6	A	9	161	4.5	725	591	0	1	1	0	0	0	0	0	0	-	-	0	7	3	1	
8/12	OR	med	6	B	8	107	4.5	482	251	0	0	0	0	0	0	0	0	0	-	2	0	1	0	0	
8/12	OR	med	6	C	8	117	4.8	562	350	0	1	0	1	0	0	0	0	0	-	2	1	1	0	0	
8/12	OR	med	7	A	8/9	114	4.7	536	390	0	0	0	0	0	0	0	0	0	-	-	0	2	1	0	
8/12	OR	med	7	B	9	187	9.2	1,720	787	0	0	0	0	0	0	0	0	0	-	2	0	6	1	4	
8/12	OR	med	7	C	8/3	28	8.3	232	105	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
8/12	OR	med	7	D	8	49	6.3	309	91	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
8/12	OR	med	8	A	8	133	5.7	758	513	0	0	0	1	1	0	1	0	0	-	-	0	0	0	1	
8/12	OR	med	8	B	9	154	5.0	770	567	0	1	1	1	2	0	0	0	0	-	15	3	4	0	1	

Appendix A (continued)

				Margin		Margin Unit			Shock	# Rainbow Trout Captured							#	#	ReCapt	NGame	Fry/Juv	All	All	All	
Date	Reach	Flow	Site	Unit	SMET	Length	Width	Area	Effort	<20	20-29	30-39	40-49	50-59	60-69	70+	Marked	ReCapt	Site	Fry	Suckers	Dace	Chubs	Sculpin	Notes
8/12	OR	med	9	A	9	125	7.2	900	562	0	0	0	0	0	0	1	0	0	-	10	2	4	2	1	
8/12	OR	med	9	B	8	101	5.3	535	375	0	0	0	0	0	0	0	0	0	-	4	0	1	2	1	
8/12	OR	med	10	A	8	70	7.2	504	185	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
8/12	OR	med	10	B	9	69	6.2	428	181	0	0	0	0	0	0	0	0	0	-	1	0	0	1	0	
8/12	OR	med	10	C	6/7	34	7.3	248	95	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
8/12	OR	med	10	D	5	126	10.0	1,260	322	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/7	CA	med	1	A	8	88	6.0	528	305	0	0	1	0	0	0	0	0	0	-	28	0	0	0	0	
7/7	CA	med	1	B	7	130	7.2	936	282	0	0	0	0	0	0	0	0	0	-	1	0	0	0	0	
7/7	CA	med	2	A	8	102	6.1	622	608	0	5	3	0	0	0	0	0	0	-	-	0	10	0	0	
7/7	CA	med	2	B	9	130	10.2	1,326	910	0	4	2	0	0	0	0	0	0	-	6	0	10	0	0	
7/7	CA	med	3	A	7	91	11.6	1,056	526	0	1	0	0	0	0	0	0	0	-	30	0	0	0	0	
7/7	CA	med	3	B	8	117	8.1	948	689	0	1	1	1	0	0	0	0	0	-	70	0	1	0	0	
7/7	CA	med	4	A	8	78	4.5	351	488	0	0	0	0	0	0	0	0	0	-	3	0	48	0	0	
7/7	CA	med	4	B	7	101	9.2	929	712	0	1	2	0	0	0	0	0	0	-	100	1	3	1	0	
7/7	CA	med	5	A	8	151	7.1	1,072	487	0	8	22	5	0	0	0	0	0	-	-	0	5	0	0	
7/7	CA	med	5	B	7	105	7.3	767	513	0	6	7	1	0	0	0	0	0	-	20	0	6	0	0	
7/7	CA	med	6	A	7	115	6.5	748	359	0	0	1	0	0	0	0	0	0	-	500	0	0	0	0	
7/7	CA	med	6	B	8	53	4.6	244	222	0	6	5	0	0	0	0	0	0	-	-	0	0	0	0	
7/7	CA	med	7	A	8	50	5.9	295	117	0	0	0	0	0	0	0	0	0	-	-	0	1	0	0	
7/7	CA	med	7	B	9	106	5.8	615	348	0	0	0	0	0	0	0	0	0	-	-	0	11	0	1	
7/7	CA	med	8	A	8	102	7.1	724	598	0	0	0	0	0	0	1	0	0	-	2	0	6	0	0	incl 1 RBT not captured (eye-est)
7/7	CA	med	8	B	9	59	8.6	507	443	0	0	0	0	0	0	0	0	0	-	5	0	2	0	0	
7/7	CA	med	8	C	8	82	6.4	525	443	0	0	0	0	0	0	0	0	0	-	2	0	0	0	0	
7/7	CA	med	9	A	9	85	15.7	1,335	387	0	0	0	0	0	0	0	0	0	-	-	0	5	0	0	
7/7	CA	med	9	B	8	68	12.0	816	159	0	0	0	0	0	0	0	0	0	-	-	0	4	0	0	
7/7	CA	med	10	A	9	105	7.3	767	569	0	0	0	0	0	0	0	0	0	-	4	0	4	0	0	1 fathead minnow
7/7	CA	med	10	B	8	120	6.3	756	221	0	0	0	0	0	0	0	0	0	-	-	0	13	1	1	
7/7	CA	-	Shovel	-	-	-	-	-	1,782	0	18	35	25	5	0	0	0	0	-	-	0	0	0	0	
7/15	CA	low	2	A	8	102	8.1	826	491	0	0	3	1	0	0	0	0	0	-	-	0	17	0	2	
7/15	CA	low	2	B	5	130	10.8	1,404	745	0	0	0	0	0	0	0	0	0	-	8	3	25	0	0	
7/15	CA	low	5	A	8	151	7.3	1,102	1,286	0	4	7	5	1	1	0	13	0	-	-	1	54	0	10	incl 1 RBT not captured (eye-est)
7/15	CA	low	5	B	5	105	18.6	1,953	1,360	0	6	9	5	2	0	0	18	0	-	10	2	58	0	0	3 fathead minnow & 5 lamprey
7/15	CA	med	1	A	8	88	11.7	1,030	605	0	1	1	0	0	0	0	0	0	-	33	2	8	0	0	1 fathead minnow
7/15	CA	med	1	B	7	130	13.8	1,794	558	0	0	0	0	0	0	0	0	0	-	22	0	1	0	0	
7/15	CA	med	2	A	8	102	7.3	745	537	0	0	3	1	0	1	0	0	0	-	-	0	3	0	0	
7/15	CA	med	2	B	9	130	10.5	1,365	701	0	1	4	1	0	0	0	0	0	-	3	9	9	0	0	
7/15	CA	med	3	A	7	91	14.3	1,301	401	0	1	1	0	0	0	0	0	0	-	1	1	5	0	0	
7/15	CA	med	3	B	8	117	9.5	1,112	650	0	2	2	3	1	0	0	0	0	-	18	0	5	0	0	
7/15	CA	med	4	A	8	78	4.7	367	157	0	0	0	0	0	0	0	0	0	-	1	0	2	0	0	
7/15	CA	med	4	B	7	101	7.5	758	458	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/15	CA	med	5	A	8	151	7.5	1,133	482	0	4	8	2	0	0	0	0	0	-	3	0	3	0	0	incl 1 RBT not captured (eye-est)
7/15	CA	med	5	B	7	105	9.6	1,008	436	0	2	6	0	0	0	0	0	0	-	5	0	1	0	0	
7/15	CA	med	6	A	7	115	10.3	1,185	327	0	0	0	1	0	0	0	0	0	-	66	0	1	0	0	
7/15	CA	med	6	B	8	53	5.2	276	210	0	2	4	1	0	0	0	0	0	-	-	0	0	0	0	
7/15	CA	med	7	A	8	50	5.8	290	185	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/15	CA	med	7	B	9	106	6.1	647	504	0	0	0	0	0	0	0	0	0	-	4	0	0	0	0	
7/15	CA	med	8	A	8	102	7.1	724	333	0	0	0	0	0	0	0	0	0	-	-	0	6	2	0	
7/15	CA	med	8	B	9	59	8.6	507	267	0	0	0	0	0	0	0	0	0	-	5	1	0	4	0	
7/15	CA	med	8	C	8	82	6.4	525	373	0	0	0	0	0	0	0	0	0	-	5	1	2	0	0	
7/15	CA	med	9	A	9	85	9.1	774	575	0	0	0	0	0	0	0	0	0	-	35	0	11	1	0	
7/15	CA	med	9	B	8	68	7.1	483	281	0	0	0	0	0	0	0	0	0	-	-	0	10	0	0	

Appendix A (continued)

				Margin		Margin Unit			Shock	# Rainbow Trout Captured							#	#	ReCapt	NGame	Fry/Juv	All	All	All	
Date	Reach	Flow	Site	Unit	SMET	Length	Width	Area	Effort	<20	20-29	30-39	40-49	50-59	60-69	70+	Marked	ReCapt	Site	Fry	Suckers	Dace	Chubs	Sculpin	Notes
7/15	CA	med	10	A	9	*not sampled*				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
7/15	CA	med	10	B	8	*not sampled*				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
7/15	CA	-	Shovel	-	-	*not sampled*				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
7/29	CA	med	1	A	8	88	6.9	607	366	0	0	0	0	0	0	0	0	0	-	9	0	0	0	0	
7/29	CA	med	1	B	7	130	8.7	1,131	417	0	0	0	0	0	0	0	0	0	-	7	0	0	0	0	
7/29	CA	med	2	A	8	102	6.3	643	472	0	0	2	1	0	0	0	0	0	-	0	0	16	0	0	
7/29	CA	med	2	B	9	130	10.3	1,339	770	0	2	4	2	1	0	0	0	0	-	2	8	20	0	0	
7/29	CA	med	3	A	7	91	14.4	1,310	424	0	0	0	1	0	0	0	0	0	-	2	0	5	0	0	
7/29	CA	med	3	B	8	117	10.5	1,229	570	0	2	2	1	0	0	0	0	0	-	11	2	35	0	0	
7/29	CA	med	4	A	8	78	4.3	335	269	0	0	0	0	0	0	0	0	0	-	2	0	0	0	2	
7/29	CA	med	4	B	7	101	5.3	535	383	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	
7/29	CA	med	5	A	8	151	5.7	861	365	0	4	1	0	0	0	0	0	0	-	11	0	8	0	0	
7/29	CA	med	5	B	7	105	4.8	504	488	0	4	3	3	0	0	0	0	0	-	1	0	2	0	0	
7/29	CA	med	6	A	7	115	10.9	1,254	434	0	0	0	0	0	0	0	0	0	-	12	0	0	0	0	
7/29	CA	med	6	B	8	53	6.4	339	298	0	3	3	0	0	0	0	0	0	-	-	0	0	0	1	
7/29	CA	med	7	A	8	50	5.8	290	186	0	0	0	0	0	0	0	0	0	-	1	0	0	0	0	
7/29	CA	med	7	B	9	106	6.3	668	409	0	0	0	0	0	0	0	0	0	-	4	0	0	0	0	
7/29	CA	med	8	A	8	102	9.9	1,010	391	0	0	0	0	0	0	0	0	0	-	-	0	8	0	6	
7/29	CA	med	8	B	9	59	14.1	832	297	0	0	0	0	0	0	0	0	0	-	-	1	12	0	0	
7/29	CA	med	8	C	8	82	10.4	853	344	0	0	0	0	0	0	0	0	0	-	11	0	0	0	0	
7/29	CA	med	9	A	9	85	11.8	1,003	326	0	0	0	0	0	0	0	0	0	-	7	0	5	0	2	
7/29	CA	med	9	B	8	68	13.5	918	326	0	0	0	0	0	0	0	0	0	-	-	0	35	0	2	
7/29	CA	med	10	A	9	105	9.3	977	275	0	0	0	0	0	0	0	0	0	-	-	0	3	2	0	
7/29	CA	med	10	B	8	120	6.2	744	427	0	0	0	0	0	0	0	0	0	-	-	0	12	2	0	
7/29	CA	-	Shovel	-	-	-	-	-	1,276	0	0	13	22	15	1	6	0	0	-	-	0	0	0	0	
9/4	CA	low	3	A	7	91	8.0	728	382	0	0	0	1	2	0	0	3	0	-	-	0	5	0	0	
9/4	CA	low	3	B	8	117	7.0	819	314	0	0	0	0	1	0	0	1	0	-	3	0	17	0	0	
9/4	CA	low	5	A	8	151	5.8	876	573	0	0	2	3	3	1	2	11	0	-	-	0	50	0	2	
9/4	CA	med	1	A	8	88	6.9	607	787	0	0	0	0	0	0	0	0	0	-	5	1	113	39	0	
9/4	CA	med	1	B	7	130	8.7	1,131	582	0	0	0	0	0	0	0	0	0	-	-	0	0	1	0	
9/4	CA	med	2	A	8	102	6.3	643	393	0	0	1	2	3	3	1	0	0	-	-	3	14	0	0	
9/4	CA	med	2	B	9	130	7.6	988	850	0	0	1	4	2	1	0	0	0	-	1	4	30	0	0	
9/4	CA	med	3	A	7	91	9.7	883	391	0	0	0	0	0	0	0	0	0	-	-	0	2	0	0	
9/4	CA	med	3	B	8	117	8.3	971	375	0	0	0	0	0	0	0	0	0	-	-	0	3	0	0	
9/4	CA	med	4	A	8	78	4.3	335	250	0	0	0	0	0	0	0	0	0	-	-	0	28	0	1	
9/4	CA	med	4	B	7	101	5.3	535	383	0	0	0	0	0	0	0	0	0	-	-	0	5	0	0	
9/4	CA	med	5	A	8	151	5.7	861	519	0	0	0	5	4	2	0	0	0	-	-	0	37	0	0	
9/4	CA	med	5	B	7	105	4.8	504	497	0	0	1	8	8	1	3	0	0	-	-	2	26	0	0	
9/4	CA	med	6	A	7	115	10.9	1,254	404	0	0	0	0	0	0	0	0	0	-	-	0	5	0	0	
9/4	CA	med	6	B	8	53	6.4	339	-	0	0	4	2	10	2	0	0	0	-	-	0	5	0	0	
9/4	CA	med	7	A	8	50	6.0	300	185	0	0	0	0	0	0	0	0	0	-	5	0	4	0	0	
9/4	CA	med	7	B	9	106	6.3	668	418	0	0	0	0	0	0	0	0	0	-	24	0	8	0	0	
9/4	CA	med	8	A	8	102	6.0	612	315	0	0	0	0	0	0	0	0	0	-	32	0	3	0	0	
9/4	CA	med	8	B	9	59	14.1	832	250	0	0	0	0	1	0	0	0	0	-	-	0	35	0	0	
9/4	CA	med	8	C	8	82	10.4	853	306	0	0	0	0	0	0	0	0	0	-	-	0	4	0	0	
9/4	CA	med	9	A	9	85	8.0	680	476	0	0	0	0	0	0	0	0	0	-	6	0	33	0	0	
9/4	CA	med	9	B	8	68	9.2	626	308	0	0	0	0	0	0	0	0	0	-	2	0	36	0	0	
9/4	CA	med	10	A	9	105	6.0	630	339	0	0	0	0	0	0	0	0	0	-	2	0	14	1	0	
9/4	CA	med	10	B	8	120	5.0	600	377	0	0	0	0	0	0	0	0	0	-	-	0	41	1	0	
9/4	CA	-	Shovel	-	-	-	-	-	564	0	1	4	10	9	4	8	0	0	-	-	0	0	0	0	also 6 browns 70-154mm

Appendix B. Habitat characteristics of margin units sampled by electrofishing in the upper Klamath River project area. Reaches are BP=Bypass, OR=Oregon Peaking, CA=California Peaking. Flows are 325 cfs for BP low and CA low, 520 cfs for BP high and OR low, 1,500-1,700 for OR and CA medium. See Table 3 for SMET code, Table 4 for substrate and emergent vegetation codes. Measurement units are in ft. Blanks indicate missing data.

				Habitat			Margin Unit				River	Dist to	Unit Depth		Unit MCVel		Em Veg Max:		Substrate		Emerg Veg		% of Unit Containing:					Chng
Date	Reach	Margin Unit		Type	SMET	Flow	Length	Width	S.A.	Vol	Mile	Spwn	Avg	Max	Avg	Max	Dist	Depth	Dom	SubD	Dom	SubD	Cob+	EVeg	OVH	AQV	Canop	WE
5/30	BP	1	A	PW	9	low	130	7.3	949	750	220.50	1.05	0.8	2.2	0.38	1.64	0.4	0.4	27	29	4	2	70	5	2		0	
5/30	BP	1	B	PL	9	low	101	8.7	875	746	220.55	1.00	0.9	2.3	0.55	2.29	0.8	0.4	28	30	4	2	75	5	10		0	
5/30	BP	2	A	RN	9	low	100	10.3	1,030	984	220.80	0.75	1.0	2.5	0.17	1.03	0.9	0.1	30	29	4	0	70	15	20		0	
5/30	BP	2	B	RF/RN	9	low	126	6.9	872	552	220.85	0.70	0.6	1.1	0.44	1.49	0.7	0.3	27	25	4	2	75	2	5		0	
6/3	BP	3	A	PW	9	low	88	5.3	462	442	221.80	0.40	1.0	3.1	0.11	0.38	0.8	1.0	30	29	4	0	80	5	8		0	
6/3	BP	3	B	RN	9	low	109	7.3	790	649	221.90	0.30	0.8	2.6	0.07	0.45	0.4	0.2	29	30	4	2	95	15	20		0	
6/3	BP	4	A	PL	7	low	78	6.0	468	278	222.05	0.15	0.6	2.4	0.09	0.30	2.6	0.3	19	22	4	0	10	15	5		0	
6/3	BP	4	B	RF	9	low	87	5.9	515	433	222.20	0.00	0.8	1.7	0.16	0.51	0.3	0.1	30	22	4	0	80	5	5		0	
6/3	BP	5	A	PL	9	low	75	5.4	406	282	223.35	4.15	0.7	1.9	0.17	0.88	0.2	0.1	28	29	4	0	75	5	5		0	
6/3	BP	5	B	PL	9	low	140	6.7	933	937	223.35	4.15	1.0	2.7	0.23	1.48	0.7	0.6	30	27	4	0	80	2	5		0	
6/3	BP	6	A	PL	9	low	83	6.3	526	421	224.25	3.25	0.8	2.3	0.45	2.65	1.6	0.3	30	27	4	0	85	20	15		0	
6/3	BP	6	B	PL	7	low	55	6.0	330	417	224.25	3.25	1.3	2.3	0.31	1.23	0.5	0.7	31	19	4	8	5	10	15		0	
6/15	BP	1	A	PW	9	high	130	5.3	693	741	220.50	1.05	1.1	2.4	0.19	1.05	1.9	1.0						25	30		0	
6/15	BP	1	B	PL	9	high	101	7.3	732	654	220.55	1.00	0.9	2.5	0.39	2.87	5.0	1.6						40	50		0	
6/15	BP	2	A	RN	9	high	110	14.8	1,632	1,842	220.80	0.75	1.1	3.2	0.35	1.15	3.8	1.2									0	
6/15	BP	2	B	RF/RN	9	high	130	5.7	737	614	220.85	0.70	0.8	1.6	0.60	1.63	1.3	0.5									0	
6/15	BP	3	A	PW	9	high	85	4.9	418	443	221.80	0.40	1.1	3.1	0.25	1.04	2.1	1.0	30	30	4	3	80	30	40		0	
6/15	BP	3	B	RN	9	high	109	6.7	727	663	221.90	0.30	0.9	1.9	0.41	1.27	3.4	0.8									0	
6/15	BP	4	A	PL	9	high	85	7.7	652	698	222.05	0.15	1.1	3.3	0.20	1.25	3.9	0.9	30	19	4		55	70	60		0	
6/15	BP	4	B	RF	9	high	88	4.9	433	262	222.20	0.00	0.6	1.9	0.62	1.74	1.1	0.5	30	21	4	0	70	40	50		0	
6/15	BP	5	A	PL	9	high	75	11.0	825	636	223.35	4.15	0.8	2.6	0.18	0.99	4.8	0.9	30	29	4		80	50	50		0	
6/15	BP	5	B	PL	9	high	140	5.6	782	845	223.35	4.15	1.1	3.2	0.11	1.38	1.8	0.5	30	28	4		90	70	50		0	
6/15	BP	6	A	PL	9	high	83	11.7	968	1,053	224.25	3.25	1.1	2.5	0.30	1.77	6.8	1.7	30	27	4	8	60	80	50		0	
6/15	BP	6	B	PL	7	high	55	6.3	347	451	224.25	3.25	1.3	3.2	0.23	1.31	4.5	2.3	19	28	4	3	20	80	80		0	
5/31	OR	1	A	RF/RN	3	med	122	8.7	1,057	793	215.15	6.40	0.8	1.4	0.62	2.44	1.1	0.2	26	24	8	4	60	15	55		70	11.0
5/31	OR	1	B	GL	9	med	122	11.8	1,444	800	215.20	6.35	0.6	1.2	0.10	0.61	2.5	0.5	27	19	4	5	65	10	15		1	50.2
5/31	OR	1	C	GL	8	med	79	5.0	395	461	215.30	6.25	1.2	3.2	0.27	1.58	0.0	0.0	28	27	0	0	85	0	4		2	4.8
5/31	OR	2	A	PL	8	med	110	7.6	834	542	215.50	6.05	0.7	2.2	0.53	1.83	0.0	0.0	28	27	4	0	60	2	5		80	9.1
5/31	OR	2	B	PL	9	med	230	6.7	1,533	1,731	215.50	6.05	1.1	2.5	0.28	1.00	1.0	0.4	28	26	4	0	80	3	5		2	6.3
5/31	OR	3	A	RN	9	med	228	5.7	1,292	1,050	216.30	5.25	0.8	2.1	0.27	1.73	1.2	0.1	27	28	4	0	95	2	3		1	11.3
5/31	OR	3	B	RF	8	med	74	6.0	444	133	216.35	5.20	0.3	0.7	0.40	1.33	0.6	0.1	27	28	4	0	100	5	8		10	39.4
5/31	OR	4	A	RN	8	med	139	6.5	904	538	216.65	4.90	0.6	2.1	0.39	2.15	0.0	0.0	27	28	4	0	90	2	10		5	11.8
5/31	OR	4	B	RF/RN	9	med	155	4.0	620	286	216.75	4.80	0.5	1.4	0.51	2.39	0.2	0.1	28	27	4	0	100	2	4		0	8.5
5/31	OR	4	C	RN	7	med	204	14.5	2,958	1,826	216.85	4.70	0.6	1.3	0.06	0.39	5.4	0.6	19	28	5	4	15	30	35		0	19.1
6/1	OR	5	A	PL	4,9	med	160	16.2	2,587	1,886	217.20	4.35	0.7	2.0	0.26	1.03	6.7	0.8	28	27	4	8	75	50	55		40	26.1
6/1	OR	5	C	RN	8	med	110	5.8	633	590	217.55	4.00	0.9	2.3	0.48	1.91	0.0	0.0	29	30	4	0	100	2	5		0	6.5
6/1	OR	5	D	RN	9	med	87	9.2	798	584	217.55	4.00	0.7	3.2	0.20	1.05	3.1	0.4	26	29	4	0	100	4	5		2	9.2
6/1	OR	6	A	RN/PL	9	med	161	9.2	1,476	929	218.25	3.30	0.6	1.6	0.24	1.39	2.2	0.5	28	27	4	0	85	10	12		0	16.7
6/1	OR	6	B	PL	8	med	107	5.5	589	459	218.30	3.25	0.8	1.7	0.10	0.62	0.2	0.1	26	28	4	0	90	0	0		0	13.0
6/1	OR	6	C	RF	8	med	117	7.3	858	477	218.40	3.15	0.6	1.6	0.59	2.82	0.0	0.0	29	30	4	0	100	2	5		65	5.7
6/2	OR	7	A	GL	8	med	114	5.0	570	446	218.65	2.90	0.8	2.3	0.13	0.48	0.8	0.1	28	29	4	0	100	2	4		45	7.8
6/2	OR	7	B	PL	9	med	187	9.2	1,714	1,029	218.70	2.85	0.6	1.4	0.08	0.37	4.9	0.7	28	27	4	0	85	40	50		0	10.6
6/2	OR	7	C	PL	8,3	med	28	8.3	231	173	218.75	2.80	0.8	1.7	0.18	0.54	6.0	1.0	28	27	8	4	100	50	75		1	11.0
6/2	OR	7	D	PL	8	med	49	6.3	310	192	218.75	2.80	0.6	1.7	0.05	0.18	0.0	0.0	28	27	0	0	100	0	0		0	7.8
6/1	OR	8	A	RF	8	med	133	5.7	754	459	219.25	2.30	0.6	1.5	0.39	1.93	0.0	0.0	28	26	4	0	85	2	4		5	10.7
6/1	OR	8	B	PL	9	med	154	6.6	1,014	869	219.25	2.30	0.9	2.4	0.21	1.14	1.3	0.2	28	27	4	0	90	5	10		0	7.6

Appendix B. (continued)

				Habitat			Margin Unit				River	Dist to	Unit Depth		Unit MCVel		Em Veg Max:		Substrate		Emerg Veg		% of Unit Containing:					Chng
Date	Reach	Margin Unit		Type	SMET	Flow	Length	Width	S.A.	Vol	Mile	Spwn	Avg	Max	Avg	Max	Dist	Depth	Dom	SubD	Dom	SubD	Cob+	EVeg	OVH	AQV	Canop	WE
6/1	OR	9	A	RF	9	med	125	7.2	896	463	219.45	2.10	0.5	1.4	0.35	1.90	1.0	0.3	28	27	4	0	90	20	15		0	14.7
6/1	OR	9	B	RN	8	med	101	5.3	539	431	219.50	2.05	0.8	1.9	0.09	0.42	0.0	0.0	30	29	0	0	90	0	0		25	17.4
6/1	OR	10	A	RF	8	med	70	7.3	508	372	219.80	1.75	0.7	2.6	0.11	0.66	0.0	0.0	27	28	4	0	90	1	1		0	14.2
6/1	OR	10	B	PL	9	med	69	6.3	437	321	219.85	1.70	0.7	2.6	0.63	2.31	1.2	0.4	27	26	4	0	50	10	15		0	12.6
6/1	OR	10	C	PL	7	med	34	7.3	249	220	219.85	1.70	0.9	1.7	0.42	1.00	1.7	0.4	20	28	4	0	20	5	5		0	28.5
6/1	OR	10	D	PL	5	med	126	10.0	1,260	798	219.85	1.70	0.6	1.6	0.16	1.60	0.0	0.0	21	20	0	0	10	0	0		0	30.4
6/16	OR	1	A	RF/RN	8	low	130	16.6	2,158	620	215.15	6.40	0.3	1.0	0.33	1.59	0.0	0.0	26	27	2	0	100	0	10		0	11.0
6/16	OR	1	B	GL	7	low	122	2.4	295	8	215.20	6.35	0.0	0.1	0.00	0.00	0.0	0.0	26	18	2	0	50	0	5		2	50.2
6/16	OR	1	C	GL	8	low	79	4.3	342	244	215.30	6.25	0.7	2.6	0.33	1.18	0.0	0.0	28	27	0	0	100	0	0		1	4.8
6/16	OR	2	A	PL	8	low	110	4.8	532	327	215.50	6.05	0.6	1.9	0.22	0.91	0.0	0.0	28	27	0	0	95	0	1		3	9.1
6/16	OR	2	B	PL	8	low	230	5.6	1,284	902	215.50	6.05	0.7	2.2	0.08	0.65	0.0	0.0	27	25	0	0	70	0	1		0.5	6.3
6/16	OR	3	A	RN	8	low	228	7.3	1,653	1,207	216.30	5.25	0.7	2.1	0.28	1.12	0.0	0.0	26	27	0	0	80	0	0		0	11.3
6/16	OR	3	B	RF	8	low	74	5.7	421	237	216.35	5.20	0.6	1.5	0.32	1.93	0.0	0.0	28	27	0	0		0	0		0	39.4
6/16	OR	4	A	RN	8	low	139	6.2	857	454	216.65	4.90	0.5	2.0	0.08	0.43	0.0	0.0	27	28	0	0	100	0	1		5	11.8
6/16	OR	4	B	RF/RN	8	low	155	4.3	672	288	216.75	4.80	0.4	1.1	0.27	1.09	0.0	0.0	28	27	0	0	100	0	0		0	8.5
6/16	OR	4	C	RN	8	low	201	18.2	3,652	4,435	216.85	4.70	1.2	2.5	0.07	0.35	0.0	0.0	28	19	2	5	50	0.5	5		0	19.1
6/16	OR	5	A	PL	8	low	151	8.3	1,246	600	217.20	4.35	0.5	1.2	0.10	0.45	0.0	0.0	28	27	0	0	90	0	0		0	26.1
6/16	OR	5	D	RN	8	low	87	5.8	508	240	217.55	4.00	0.5	1.5	0.36	1.31	0.0	0.0	28	27	0	0	95	0	2		0	6.5
6/16	OR	5	C	RN	8	low	110	8.8	972	748	217.55	4.00	0.8	2.6	0.27	0.77	0.0	0.0	29	30	0	0	100	0	15		0	9.2
6/17	OR	6	A	RN/PL	8	low	161	8.6	1,382	685	218.25	3.30	0.5	1.3	0.24	1.85	0.0	0.0	25	28	0	0	70	0	0		0	16.7
6/17	OR	6	B	PL	8	low	107	5.7	606	498	218.30	3.25	0.8	2.1	0.04	0.30	0.0	0.0	26	29	0	0	75	0	2		0	13.0
6/17	OR	6	C	RF	8	low	117	6.3	741	346	218.40	3.15	0.5	1.3	0.43	3.11	0.0	0.0	26	28	0	0	70	0	0		0	5.7
6/17	OR	7	A	GL	8	low	114	4.8	551	395	218.65	2.90	0.7	2.5	0.36	1.39	0.0	0.0	28	30	0	0	99	0	1		10	7.8
6/17	OR	7	B	PL	8	low	187	10.8	2,026	1,134	218.70	2.85	0.6	1.5	0.12	0.48	0.0	0.0	28	27	0	0	95	0	0		0	10.6
6/17	OR	7	C	PL	8	low	28	4.0	112	55	218.75	2.80	0.5	1.1	0.24	0.88	0.0	0.0	26	27	0	0	95	0	0		0	11.0
6/17	OR	7	D	PL	8	low	49	4.3	211	114	218.75	2.80	0.5	1.7	0.05	0.22	0.0	0.0	27	26	0	0	100	0	0		0	7.8
6/17	OR	8	A	RF	8	low	133	6.8	909	686	219.25	2.30	0.8	2.5	0.20	1.43	0.0	0.0	28	27	0	0	80	0	0		10	10.7
6/17	OR	8	B	PL	8	low	154	5.7	873	433	219.25	2.30	0.5	1.6	0.17	1.14	0.0	0.0	28	27	0	0	95	0	0		0	7.6
6/17	OR	9	A	RF	8	low	125	15.5	1,938	908	219.45	2.10	0.5	1.4	0.31	1.75	0.0	0.0	28	26	0	0	80	0	5		0	14.7
6/17	OR	9	B	RN	8	low	101	6.2	623	551	219.50	2.05	0.9	2.4	0.10	0.37	0.0	0.0	29	28	0	0	100	0	0		0	17.4
6/16	OR	10	A	RF	8	low	70	7.5	525	274	219.80	1.75	0.5	1.7	0.22	1.57	0.0	0.0	25	28	0	0	70	0	0		0	14.2
6/16	OR	10	B	PL	8	low	69	7.2	497	332	219.85	1.70	0.7	2.3	0.32	1.16	0.0	0.0	27	28	0	0		0	0		0	12.6
6/16	OR	10	C	PL	5	low	34	12.5	425	313	219.85	1.70	0.7	1.9	0.03	0.09	0.0	0.0	19	28	0	0	15	0	0		0	28.5
6/16	OR	10	D	PL	5	low	126	16.6	2,090	2,007	219.85	1.70	1.0	2.3	0.05	0.30	0.0	0.0	19	26	0	0	50	0	0		0	30.4
8/19	CA	1	A	PL	8	med	88	9.9	873	713	204.10	2.30	0.8	2.0	0.48	1.08	0.8	0.2	26	23	13	4	60	5	10	5	5	11.9
8/19	CA	1	B	PL	6	med	130	12.5	1,625	1,693	204.10	2.30	1.0	2.0	0.47	1.40	2.9	0.8	25	19	4	0	55	35	40	5	5	11.5
8/19	CA	2	A	RN	8	med	102	5.6	570	377	204.80	1.60	0.7	2.0	0.98	2.89	0.3	0.1	26	24	0	0	65	2	10	0	0	7.1
8/19	CA	2	B	RN	9	med	130	9.5	1,235	996	204.85	1.55	0.8	2.1	0.84	2.25	4.6	1.0	25	26	4	0	70	60	60	0	0	16.8
8/19	CA	3	A	RN	7	med	91	12.5	1,136	679	205.05	1.35	0.6	1.5	0.50	1.42	7.9	0.6	24	25	4	0	60	60	65	0	0	15.1
8/19	CA	3	B	RN	8	med	117	7.6	885	496	205.10	1.30	0.6	1.7	0.42	1.69	0.3	0.0	24	25	4	5	70	5	10	0	5	14.9
8/19	CA	4	A	SC	8	med	78	4.4	345	350	205.40	1.00	1.0	3.8	0.26	1.54	0.0	0.0	29	28	0	0	90	0	20		20	3.0
8/19	CA	4	B	RN/GL	7	med	107	9.7	1,034	1,172	205.45	0.95	1.1	2.6	0.20	0.89	5.4	1.2	21	20	5	9	30	60	60		0	5.3
8/19	CA	5	A	RN	8	med	151	7.0	1,057	502	205.70	0.70	0.5	1.3	0.42	1.73	1.6	0.3	26	25	8	4	90	20	40	0	10	11.7
8/19	CA	5	B	RN	7	med	105	9.3	980	745	205.80	0.60	0.8	1.5	0.67	3.02	4.4	0.8	25	22	4	8	50	30	30	10		8.8
8/18	CA	6	A	RN	7	med	115	11.2	1,284	1,362	206.10	0.30	1.1	2.2	0.08	0.29	6.5	1.3	19	25	4	3	40	60	55	25	0	3.5
8/18	CA	6	B	RN	8	med	53	6.0	318	275	206.35	0.05	0.9	1.8	0.79	1.90	1.4	0.6	26	27	4	13	80	20	20	0	5	8.8
8/18	CA	7	A	RF	8	med	50	6.6	329	244	206.50	15.05	0.7	2.2	0.31	3.15	0.0	0.0	28	29	4	0	90	1	10	0	80	5.8
8/18	CA	7	B	RN	9	med	106	7.8	822	719	206.50	15.05	0.9	1.8	0.47	1.60	1.5	0.4	26	28	4	5	65	20	35	0	30	8.4
8/18	CA	8	A	PL	8	med	102	7.5	765	701	207.10	14.45	0.9	1.7	0.13	0.92	0.0	0.0	28	27	4	0	85	2	5	0	20	7.6
8/18	CA	8	B	PL	4	med	59	8.4	497	389	207.25	14.30	0.8	1.7	0.97	2.63	0.0	0.0	22	26	8	4	20	15	35	0	60	7.9
8/18	CA	8	C	PL	4	med	82	7.4	608	630	207.25	14.30	1.0	2.1	0.55	1.46	0.9	0.4	19	26	4	8	35	10	15	0	20	4.9

Appendix B. (continued)

				Habitat			Margin Unit				River	Dist to	Unit Depth		Unit MCVel		Em Veg Max:		Substrate		Emerg Veg		% of Unit Containing:					Chng
Date	Reach	Margin Unit		Type	SMET	Flow	Length	Width	S.A.	Vol	Mile	Spwn	Avg	Max	Avg	Max	Dist	Depth	Dom	SubD	Dom	SubD	Cob+	EVeg	OVH	AQV	Canop	WE
8/18	CA	9	A	RN	9	med	85	15.8	1,339	1,322	207.40	14.15	1.0	2.3	0.21	1.18	6.7	1.1	26	25	3	4	80	70	75	45	0	17.7
8/18	CA	9	B	RN	8	med	68	9.4	636	297	207.40	14.15	0.5	1.2	0.62	1.93	0.0	0.0	26	25	4	0	90	0	25	0	0	41.4
8/18	CA	10	A	PL	9	med	105	8.7	910	1,084	208.25	13.30	1.2	2.5	0.16	0.53	1.0	0.9	27	26	4	0	90	10	15	0	0	3.7
8/18	CA	10	B	PL	8	med	105	7.0	735	725	208.25	13.30	1.0	2.6	0.51	2.29	0.0	0.0	25	28	8	4	90	5	50	0	10	6.3
6/15	CA	1	A	PL		low	88	9.9	873		204.10	2.30							27	28	0	0	90	0	0	0	0	11.9
6/15	CA	1	B	PL		low	130	12.5	1,625		204.10	2.30							23	26	0	0	95	0	0	0	2	11.5
6/15	CA	2	A	RN		low	102	5.6	570		204.80	1.60							28	27	0	0	85	0	0	0	15	7.1
6/15	CA	2	B	RN		low	130	9.5	1,235		204.85	1.55							26	25	0	0	70	0	0	2	0	16.8
6/15	CA	3	A	RN		low	91	12.5	1,136		205.05	1.35							26	23	0	0	40	0	0	0	5	15.1
6/15	CA	3	B	RN		low	117	7.6	885		205.10	1.30							27	28	0	0	80	0	0	0	5	14.9
6/15	CA	4	A	SC		low	78	4.4	345		205.40	1.00							28	30	0	0	90	0	0	0	40	3.0
6/15	CA	4	B	RN/GL		low	107	9.7	1,034		205.45	0.95							23	22	3	5	20	50	40	0	5	5.3
6/15	CA	5	A	RN		low	151	7.0	1,057		205.70	0.70							28	27	0	0	90	0	0	0	0	11.7
6/15	CA	5	B	RN		low	105	9.3	980		205.80	0.60							24	25	0	0	30	0	2	60	5	8.8
6/15	CA	6	A	RN		low	115	11.2	1,284		206.10	0.30							28	27	0	0	80	0	0	0	5	3.5
6/15	CA	6	B	RN		low	53	6.0	318		206.35	0.05							22	28	3	0	40	5	0	0	0	8.8
6/15	CA	7	A	RF		low	50	6.6	329		206.50	15.05							28	29	0	0	90	0	0	0	15	5.8
6/15	CA	7	B	RN		low	106	7.8	822		206.50	15.05							27	28	0	0	80	0	0	0	10	8.4
6/15	CA	8	A	PL		low	102	7.5	765		207.10	14.45							27	29	0	0	95	0	0	0	5	7.6
6/15	CA	8	B	PL		low	59	8.4	497		207.25	14.30							25	27	0	0	35	0	20	0	50	7.9
6/15	CA	8	C	PL		low	82	7.4	608		207.25	14.30							23	22	3	0	25	2	5	0	10	4.9
6/15	CA	9	A	RN		low	85	15.8	1,339		207.40	14.15							28	27	3	0	95	0	2	1		17.7
6/15	CA	9	B	RN		low	68	9.4	636		207.40	14.15							27	28	0	0	90	0	0	0	0	41.4
6/15	CA	10	A	PL		low	105	8.7	910		208.25	13.30							27	29	3	0	85	2	5	0	5	3.7
6/15	CA	10	B	PL		low	105	7.0	735		208.25	13.30							28	29	0	0	90	0	0	0	5	6.3

Appendix C. Photographs, fry density data, and habitat characteristics for each margin unit arranged by reach and study site (*this appendix is available on CD*).