Habitat Selection :

The effects of flow and size-class on habitat use by rainbow trout within the Kings River downstream of the Pine Flat Dam

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Habitat Selection

ABSTRACT

We quantified the amount of availability for seven habitat types (pools, runs, riffles, boulder projects, glides, weirs, and side channels) across three different flows (100-249cfs, 250-999cfs, and ≥ 1,000cfs) for a 9.4 mile reach of the Kings River below Pine Flat Dam. Use of habitat types by rainbow trout *Oncorhynchus mykiss* was quantified using relocation data collected from trout implanted with radio transmitters. The effects of flow and trout size-class were tested on the use of available habitat across the three flow stages. Use varied from strong avoidance to strong preference depending on habitat type, size-class, and flow. In general, trout avoided boulder projects and side channels at low flow. Weirs and side channels were avoided at intermediate flows and runs and side channels were avoided at high flows. We also found that roughly half of the trout in our study chose a single habitat type and location for the duration of their residency while the other half chose multiple habitat types and locations.

1.0 Introduction

Characteristics of habitats preferred by rainbow trout have been well documented (Bugert *et al.* 1991; Matthews 1996; Muhlfeld *et al.* 2001; Dare *et al.* 2002; Tatara *et al.* 2009). Habitat preferences vary by life-stage with juvenile trout preferring shallow edge habitat and riffles, and mature trout preferring the deeper pools (Moyle 2002). The proportion of available habitat types within a stream or river varies in response to a number of factors that include instream flow and water temperature. Factors such as available overhead cover, velocity, and temperature may be affecting habitat selection (Moyle & Baltz 1985; Bugert *et al.* 1991), all of which may be affected by discharge (Dare *et al.*, 2002).

The Kings River below Pine Flat Dam receives an annual stocking allotment of approximately 18,000 pounds of catchable sized trout (two trout/pound) from the California Department of Fish and Game (CDFG) or approximately 36,000 trout. Additionally, the river is planted with approximately 3,000 pounds of trophy trout that average 4-6 pounds each between December and March each year. Lastly, about 25,000 fingerling trout are also released into the river each year. Little is known about how these trout are utilizing the available habitat found in the tailwater fishery. Of particular interest are the effects of flow and size-class on habitat selection. The objectives of this study were to 1) quantify the proportion of available habitat at various flow rates, 2) determine the proportion of use of the available habitat 3) determine the effects of flow on the proportion of habitat use, and 4) determine the effects of size-class on the proportion of use of the available habitat.

2.0 Methods

Two hundred and fifty-nine rainbow trout implanted with radio transmitters were released into the Kings River (Kings River Fisheries Management Program 2010; unpublished) between October 2005 and January 2008. Release locations were stratified across the regulatory management zones and release timing corresponded with seasonal changes in stream flow conditions (Kings River Fisheries Management Program, 2005, unpublished). Seven release groups were utilized for this study. Approximately 40 trout comprised each group; twenty of

which were classified as small (227g to 907g) and twenty were classified as large (907g or greater). The number of trout actually released in each group varied due to mortality during the post-surgery observation period. Study fish were relocated approximately twice per seven day period and their positions within the river were recorded. Trout location and available habitat at the location site were recorded on standardized field data sheets (Appendix 1). A detailed description of the relocation process can be found in the *Residence Time of Rainbow Trout* report (Kings River Fisheries Management Program 2011, unpublished).

The quality and availability of habitat for rainbow trout downstream of Pine Flat Dam varies with instream flow. For the purposes of this study, three flow regimes were chosen. The 100 - 249 cubic feet per second (cfs) discharge rate represents the range of minimum flows released from Pine Flat Dam during the non-demand period (September – March). Instream flows within the range 250 - 999cfs represent low-level demand use. These flows are generally experienced during the fall and winter months. Discharge of 1,000cfs or greater generally begins in March or April, depending on the type of Water Year and irrigation demand and can extend into September or October. Average peak discharge occurs during the summer months and is in the range of 5,000 to 6,000cfs. Habitat availability and utilization by rainbow trout was assessed for each of these flow ranges.

Polygons of the wetted width of the Kings River were drawn for each of the management zones (Put & Take, Catch & Release) using ESRI® ArcMap™ 9.3 software. This process was repeated for each of the three stated flow regimes. Hi-resolution aerial photographs of the Kings River at each of the chosen discharge rates were used to delineate habitat types and to determine total surface area of available habitat. Habitat use and site fidelity were calculated for each of these discharge rates.

Total wetted surface area in hectares was quantified using ESRI® ArcMap™ 9.3. Habitat types within each management zone were also delineated using ESRI® ArcMap™ 9.3 and the habitat polygons were used to determine total available habitat by type as a percentage of the total wetted area (Table 1). The proportion of available habitat within each management zone is summarized in Appendix 2.

Table 1: - Comparison of available habitat types by flow. Availability is recorded in percentage of total available habitat at each given flow.

Proportion of Available Habitat

Flow	Pool	Run	Riffle	Boulder Project	Glide	Weir	Side Channel
100 - 249	16.0%	20.5%	5.2%	17.5%	36.1%	0.2%	4.5%
250 - 999	13.6%	37.3%	4.9%	8.6%	30.1%	0.2%	5.3%
> 1,000	11.9%	47.3%	0.8%	8.8%	22.9%	0.1%	8.2%

Habitat types were categorized as pool, riffle, run, boulder project, glide, Weir (including the skirt and rip rap), and side channels. Pools were characterized by depth, generally deeper than surrounding areas, slow water velocity, and varied substrate. Riffles were characterized by shallow depth and swiftly flowing water. Substrate was rough causing waves and eddies. Runs were characterized by wide reaches of swift water with little or no surface agitation. Boulder projects were characterized by fields of large boulders (≥ 3 cubic yards in size) placed by the FMP. Glides were characterized by shallow, low velocity reaches with no surface disturbance. Side channels were characterized as lateral channels originating from the main channel that may be dry during low flow periods.

Relocation data corresponding with each of the three selected flow regimes was overlaid on the habitat maps to determine habitat usage. Relocations within specific habitat types were enumerated and usage was calculated as percent of total observations. Site fidelity was calculated for each size-class and flow regime as well. Site fidelity was exhibited if a study fish selected for a single habitat type and location (i.e. pool 1) for the duration of its residency within the river. To account for transition zones, a distance of 10 meters was set as the minimum travel distance for selection of an alternate habitat type.

2.1 Analytical Procedures

Less than five observations within a given habitat type was common, rendering Chi square results suspect (Zar, 1999) therefore, Jacobs' D statistic (Jacobs, 1974) was used to test for electivity of habitat types by size-class and management zone. Electivity (D) of habitat type was tested using the equation;

$$D = r – p / (r + p) – 2rp$$

where r is the proportion of use of the available habitat and p is the proportion of habitat available in the environment. A value of ≥0.50 represented a strong preference, >0.25 but <0.50 represented a moderate preference, ±0.25 represented no preference, <-0.25 but >-0.50 represented a moderate avoidance, and ≤-0.50 represented a strong avoidance (Moyle & Baltz 1985). All statistical tests were performed using Microsoft Excel®. Due to its non-representative nature (discussed in the Residence Time report, Kings River Fisheries Management Program 2011, unpublished), data collected from the Exclusion Zone were not included in the Habitat Selection analysis.

3.0 Results

a. *100cfs – 249cfs* (low flow)

Total surface area of the wetted streambed from Pine Flat Dam to the Fresno Weir was approximately 80ha. Approximately 36% of the available habitat was classified as glide habitat (29 ha), approximately 21% was run habitat (16 ha), approximately 17% was boulder project (14 ha), approximately 16% was pool habitat (13 ha), approximately 5% was riffle habitat (4 ha), approximately 5% was side channel (4 ha), and less than 1% was weir habitat (0.13 ha). The Exclusion Zone was approximately 5 ha, the Put & Take Zone was approximately 37 ha, and the Catch & Release Zone was approximately 37 ha. A comparison of the proportion of habitat availability to use is summarized in Figure 1.

From October 24, 2005 to July 7, 2008 (the study period), discharge from the Pine Flat Dam was between 100cfs and 249cfs for 146 days. One hundred and sixteen observations were made during this time. Approximately 61% of the observations (71) were small trout (0.5 – 2 pounds). The remaining 39% (45) were large trout (> 2 pounds). These observations are summarized in Appendix 4.

In general, trout exhibited strong preference for riffles (D= 0.56) and weirs (D= 0.68), and no preference for glides (D= 0.20), pools (D= -0.02), and runs (D= -0.08). Trout also

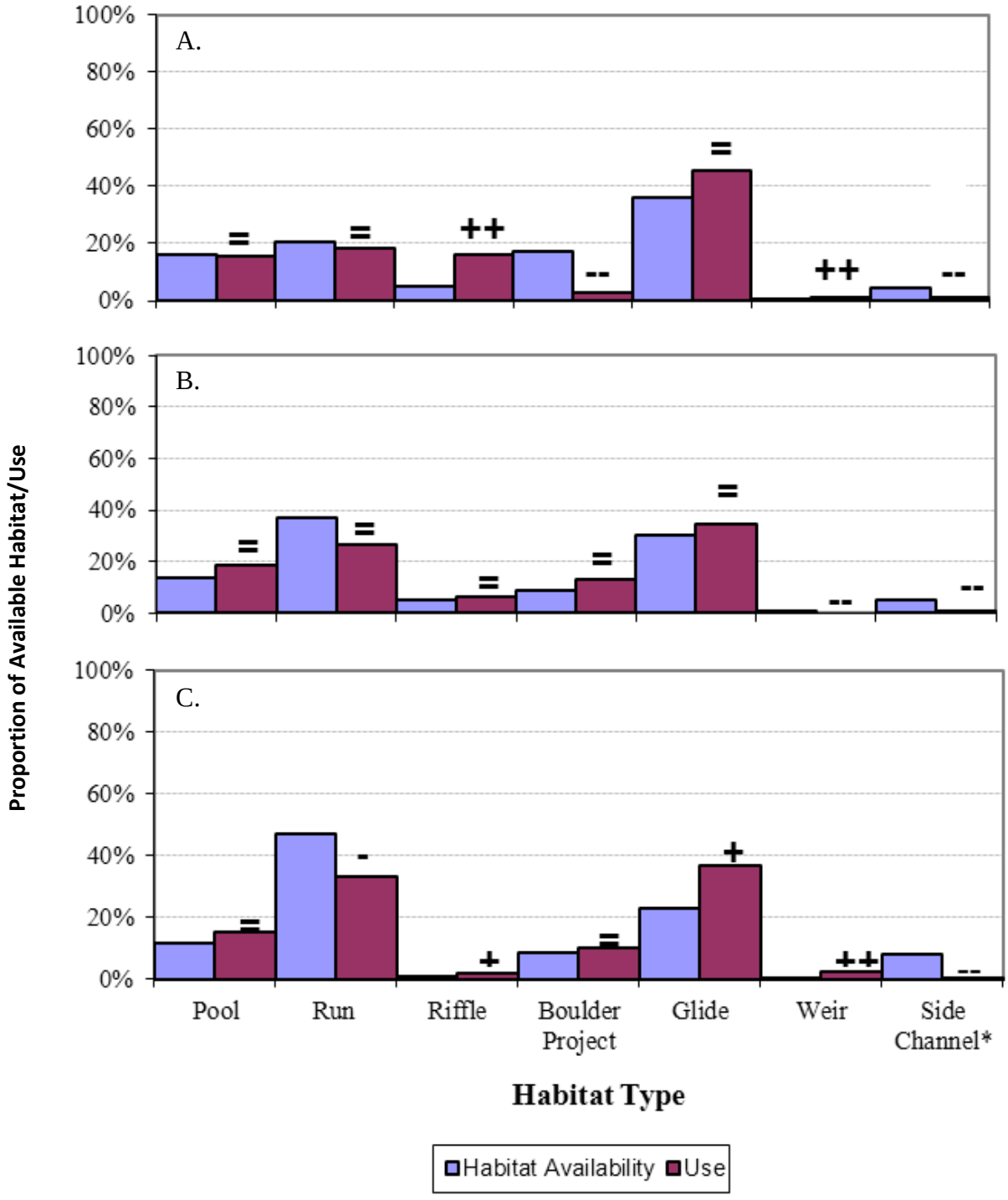

Figure 1: - Comparison of Electivity (D) of habitat types reach wide. A). 100cfs to 249cfs B.) 250cfs to 999cfs, C.) 1,000cfs or greater. Strong preference ++ (≥0.50), Moderate preference + (≥0.25 but < 0.50), No preference = (± 0.25), Moderate avoidance – (> 0.50 but < -0.25), Strong avoidance -- (≤ - 0.50).

exhibited a strong avoidance of boulder projects (D= -0.78), and side channels (D= -0.69). The proportion of habitat use as it compares to the proportion of availability by flow, management zone and size-class is summarized in Appendix 3.

Within the Put & Take zone, trout exhibited a strong preference for riffles (D= 0.81) and a moderate preference for runs (D= 0.34). They exhibited a strong avoidance of glides (D= -0.52), boulder projects (D= -1.00, no observations), and side channels (D= -1.00, no observations). No preference was shown for pools (D= -0.02). In the Catch & Release zone, strong preference was shown for glides (D= 0.50) and weirs (D= 0.51), and only a moderate preference was shown for riffles (D= 0.47). Moderate avoidance was shown for runs (D= -0.31) while strong avoidance was shown for boulder projects (D= -0.72), and side channels (D= -0.76). No preference was shown for pools (D= -0.06).

Analysis of habitat use by small trout revealed only a moderate preference for glides (D= 0.44) and strong avoidance of boulder projects, weirs, and side channels (D= -1.00; no observations). Small trout exhibited no preference for pools (D= 0.08), runs (D= -0.17), or riffles (D= 0.16). In contrast, large trout exhibited a strong preference for riffles (D= 0.78), and weir (D= 0.86). They exhibited a moderate avoidance of glides (D= -0.27) and side channels (D= -0.35) and a strong avoidance of boulder projects (D= -0.50). No preference was shown for pools (D= -0.21) or runs (D= 0.05).

Small trout within the Put & Take zone exhibited a strong preference for runs (D= 0.52) and a moderate preference for glides (D= 0.36). They exhibited a strong avoidance of all other habitat types. Small trout within the Catch & Release zone exhibited a strong preference for glides (D= 0.59) and a moderate preference for riffles (D= 0.37). Small trout also exhibited a strong avoidance of boulder projects, weir, and side channels (D= -1.00, no observations), and a moderate avoidance of runs (D= -0.41). No preference was shown for pools (D= 0.08).

Large trout within the Put & Take zone exhibited a strong preference for riffles (D= 0.91). They exhibited a strong avoidance of boulder projects, glides, and side channels (D= -1.00, no observations). No preference was shown for pools (D= 0.20), or runs (D= 0.23). Within the Catch & Release zone, large trout exhibited a strong preference for riffles (D= 0.62), and

weirs (D= 0.82) and a moderate preference for glides (D= 0.27). They exhibited a moderate avoidance of pools (D= -0.49), boulder projects (D= -0.27), and side channels (D= -0.38). No preference was shown for runs (D= -0.12).

b. *250cfs – 999cfs* (intermediate flow)

Total surface area of the wetted streambed from Pine Flat Dam to the Fresno Weir was approximately 94 ha. Approximately 37% of the available habitat was classified as run habitat (35 ha), approximately 30% was glide habitat (28 ha), approximately 14% was pool habitat (13 ha), approximately 9% was boulder projects (8 ha), approximately 5% was riffle habitat (5 ha), and approximately 5% was side channel (5 ha). Less than 1% was Weir habitat (0.17 ha). The Exclusion Zone was approximately 6 ha, the Put & Take Zone was approximately 45 ha, and the Catch & Release Zone was approximately 44 ha. A comparison of the proportion of habitat availability to use is summarized in Figure 2.

During the study period, discharge from Pine Flat Dam was between 250cfs and 999cfs for 356 days. Three hundred and fifty-five observations were made during this time. Approximately 31% of the observations (110) were small trout (0.5 – 2 pounds). The remaining 69% (245) were of large trout (> 2 pounds). These observations are summarized in Appendix 4.

In general, trout exhibited a strong avoidance of side channels (D= -0.74) and weir (D= -1.00, no observations). No preference was shown for pools (D= 0.19), runs (D= -0.24), riffles (D= 0.12), boulder projects (D= 0.22), or glides (D= 0.10). The proportion of habitat use as it compares to the proportion of availability is illustrated in Figure 2.

Within the Put & Take zone, trout exhibited only a moderate preference for boulder projects (D= 0.44). They exhibited a moderate avoidance of runs (D= -0.30) and a strong avoidance of side channels (D= -1.00, no observations). No preference was shown for pools (D= -0.06), riffles (D= 0.21), or glides (D= 0.02). In the Catch & Release zone, trout exhibited only a moderate preference for glides (D= 0.32). They exhibited a strong avoidance of weir (D= -1.00, no observations), and side channels (D= -0.79), and a moderate avoidance of runs (D= -0.33). No preference was shown for pools (D= 0.24), riffles (D= 0.05), or boulder projects (D= 0.13).

Analysis of habitat use by small trout revealed only a moderate preference for riffles (D= 0.32). They exhibited a moderate avoidance of runs (D= -0.43) and a strong avoidance of weirs (D= -1.00, no observations), and side channels (D= -0.50). No preference was shown for pools (D= 0.04), boulder projects (D= 0.25), or glides (D= 0.25).

Within the Put & Take zone, small trout exhibited only a moderate preference for glides (D= 0.40). They exhibited a moderate avoidance of pools (D= -0.29) and a strong avoidance of boulder projects and side channels (D= -1.00, no observations). No preference was shown for runs or riffles. In the Catch & Release zone, small trout exhibited a moderate preference for riffles (D= 0.30), boulder projects (D= 0.32), and glides (D= 0.43). They exhibited a strong avoidance of runs (D= -0.56), side channels (D= -0.61), and weir (D= -1.00, no observations). No preference was shown for pools.

Large trout exhibited a strong avoidance of side channels (D= -0.86), and weir (D= -1.00, no observations). No preference was shown for pools, runs, riffles, boulder projects, or glides.

Within the Put & Take zone, large trout exhibited a strong preference for boulder projects (D= 0.57). They exhibited a moderate avoidance of runs (D= -0.35) and a strong avoidance of side channels (D= -1.00, no observations). No preference was shown for pools, riffles, or glides. In the Catch & Release zone, large trout exhibited only a moderate preference for glides (D= 0.26), and a strong avoidance of side channels (D= -0.89), and weir (D= -1.00, no observations). No preference was shown for pools, runs, riffles, or boulder projects.

c. *1,000cfs or Greater* (high flow)

Total surface area of the wetted streambed from Pine Flat Dam to the Fresno Weir was approximately 137 ha. Approximately 47% of the available habitat was classified as run habitat (65 ha), 23% was glide habitat (31 ha), approximately 12% was pool habitat (16 ha), approximately 9% was boulder project (12 ha), approximately 8% was side channel (11 ha), approximately 1% was riffle habitat (1 ha) and less than 1% was Weir habitat (0.13 ha). A comparison of the proportion of habitat availability to use is summarized in Appendix 2. The Exclusion zone was approximately 9 ha, the Put & Take zone was approximately 68 ha, and the

Catch & Release zone was approximately 60 ha. A comparison of the proportion of habitat availability to use is summarized in Figure 2.

During the study period, discharge from Pine Flat Dam was 1,000cfs or greater for 485 days. Eight hundred and seventy-one observations were made during this time (Appendix 3). Approximately 46% of the observations (400) were small trout (0.5 – 2 pounds). The remaining 54% (471) were large trout (> 2 pounds). These observations are summarized in Appendix 4.

In general, trout exhibited strong preference for weir (D= 0.92) and moderate preference for riffles (D= 0.39), and glides (D= 0.32). They exhibited a moderate avoidance of runs (D= -0.29) and a strong avoidance of side channels (D= -0.90). No preference was shown for pools or boulder projects.

Within the Put & Take zone, trout exhibited only a moderate preference for glides (D= 0.29). They exhibited a moderate avoidance of boulder projects (D= -0.44) and a strong avoidance of riffles and side channels (D= -1.00, no observations). No preference was shown for pools or runs. In the Catch & Release zone, trout exhibited a strong preference for weir (D= 0.86) and a moderate preference for glides (D= 0.39). They exhibited a strong avoidance of side channels (D= -0.95). No preference was shown for pools, runs, riffles, or boulder projects.

Analysis of habitat use by small trout revealed only a moderate preference for glides (D= 0.44), and weir (D= 0.45). Small trout exhibited a strong avoidance of side channels (D= -1.00, no observations). No preference was shown for pools, runs, riffles, and boulder projects.

Within the Put & Take zone, small trout exhibited a moderate avoidance of pools (D= -0.32) and a strong avoidance of boulder projects (D= -0.61). No preference was shown for runs or glides. In the Catch & Release zone, small trout exhibited a strong preference for glides (D= 0.56). They exhibited a moderate avoidance of riffles (D= -0.34) and a strong avoidance of side channels (D= -1.00, no observations). No preference was shown for pools, runs, boulder projects, or weir.

Large trout exhibited a strong preference for riffles (D= 0.55), and weir (D= 0.96). They exhibited only a moderate preference for pools (D= 0.30). They also exhibited a moderate

avoidance of runs (D= -0.33) and a strong avoidance of side channels (D= -0.82). No preference was shown for boulder projects or glides. Within the Put & Take zone, large trout exhibited only a moderate preference for glides (D= 0.48), and a moderate avoidance of runs (D= -0.32), and boulder projects (D= -0.28). No preference was shown for pools. In the Catch & Release zone, large trout exhibited a strong preference for weir (D= 0.92), and moderate preference for pools (D= 0.31), and riffles (D= 0.27). They exhibited a strong avoidance of side channels (D= -0.91). No preference was shown for runs, boulder projects, or glides.

3.1 Site Fidelity

If a study trout selected a single habitat type and location for the duration of its life, it was considered to have exhibited site fidelity. The following analysis addresses site fidelity using the same discharge rates used in the habitat selection analysis. These data are summarized in Figure 2. The proportion of trout exhibiting site fidelity by size-class is summarized in Table 2.

Sixty-two percent (23) of the thirty-seven trout tracked (20 small, 17 large) at low flow exhibited site fidelity. Among those, thirteen were small trout and ten were large trout representing 65% and 59% of their respective populations. Fifty-two percent (50) of the ninety-six trout (40 small, 56 large) chose only a single habitat site at intermediate flow. Twenty-five of those were small trout and 25 were large trout representing 63% and 45% of their respective populations. Lastly, fifty percent (68) of the one hundred and thirty-nine trout (64 small, 72 large) tracked at high flow exhibited site fidelity. Thirty-five of those were small trout and 31 were large trout representing 55% and 43% of their respective populations.

4.0 Discussion

Habitat Selection

Dare et al. (2002) showed that as discharge from a dam decreases, so too does the amount of available habitat. Until now, the change in available habitat had not been quantified below the Pine Flat Dam. In this study, the amount of available pool habitat decreased by approximately 4% as flow increased to the average summer flow stage. Conversely, the proportion of available run habitat increased by over 27% under the same conditions. The only other habitat type to

increase with flows was side channels. Use of most habitat types was variable across the range of variables considered in this study.

In general, use of pools was proportional to their availability across all flows and management zones. When considering size-class, small trout used pools proportionally across all flows reach wide while large trout exhibited a moderate preference of pools at high flow. Size-class and management zone most affected use of pools. Small trout in the Put & Take zone strongly avoided pools at low flow and moderately avoided them at intermediate and high flow. Large trout in the Catch & Release zone exhibited a moderate avoidance at low flow and a moderate preference at high flow. Studies have shown that trout prefer deeper water such as pools as they mature (Moyle & Baltz 1985, Muhlfeld et al. 2001, Cantrell et al. 2005). Pert and Erman (1994) found that trout preferred deeper water at both low and high flow. In our study, preference for pools was only shown by large trout at high flow. Moyle and Baltz (1985) also found that as trout grow in size, so too does their preference for deep water. This may explain why the small trout in our study showed some avoidance of pools or used it in proportion to its availability. Perhaps as these fish continue to grow, so too will their use of pool habitat.

Use of runs and glides was proportionate to their availability at low and intermediate flows but changed at high flow. Trout exhibited a moderate avoidance of runs and a moderate preference for glides at high flow. These results may be explained by changing conditions as flow increases, particularly when considering that use of runs changed from random to a moderate avoidance while use of glides changed from random to moderate preference. The water velocity and turbulence experienced in runs may have become too great as river flows increase (Dare et al. 2002), reducing the amount of usable area within the run to a level significant enough to cause some trout to select for more suitable habitat (Pert & Erman 1994) such as glides.

Moyle and Baltz (1985) reported that adult trout preferred a higher mean water column velocity as their size increased. Our results showed that trout used riffles at a level equal to or greater than their availability across all flows; thus supporting the findings from Moyle and Baltz (1985). We found that small trout moderately avoided riffles in the Catch & Release zone at high flow and strongly avoided them in the Put & Take zone at low flow. In both cases, large trout

showed a preference for riffles suggesting that competition among size-classes may be affecting habitat selection. Unfortunately, very few observations of small trout were made in the Put & Take zone under low flow conditions, just eight; therefore, these results may be uncertain.

Moyle and Baltz (1985) also reported that boulder substrates, as well as bedrock substrates, were generally avoided by trout. Our results indicate that boulder projects are strongly avoided at low flow with the exception of large trout in the Catch & Release zone which moderately avoided such projects. In contrast to Moyle and Baltz, Cantrell *et al.* (2005) reported that cover in the form of boulders, as well as overhanging vegetation and debris, were predictor variables for locating Apache trout *O. gilae apache* in central Arizona streams. Pert and Erman (1994) reported that adult trout in their study used boulders approximately 70% of the time at all discharge levels although this was likely due to the predominance of boulders in the river. We found that use of boulder projects at intermediate and high flow was generally proportional to availability. Our results indicate that as flow and thus water velocity increases, so too does the importance of such boulder projects.

Weirs were strongly preferred at low and high flow. While these findings were statistically significant, it is doubtful that they were biologically significant. Weirs comprise no more than 0.2% of the available habitat reach wide across all flows and no more than 0.4% within the Catch & Release zone. The relatively low proportion of availability results in a significant finding with a small number of observations. For example, at low flow, just a single observation resulted in the finding of a strong preference for weirs. Unexpectedly, 13 observations were made of trout (1 small, 12 large) around weirs at high flow, accounting for the finding of a strong preference for weirs. It is plausible that these fish were taking advantage of the bubble curtain created by the weir or perhaps using an undercut section of the skirt for cover. It is also possible that a slight error in locating the fish may have resulted in the trout being triangulated closer to the weir than it actually was. Conditions downstream of the weir, particularly at high flow, do not outwardly appear hospitable to trout given the extreme turbulence and high water velocities, which leads us to believe that while these results were statistically significant, weirs do not represent an important habitat feature. Further strengthening this argument is the fact that the 13 observations around weirs at high flow represent just 1.5% of

the total observations at these flows indicating that other habitat features are much more widely used.

Surprisingly, side channels were seldom used in our study. Just eight observations were made (one small, seven large) in the available side channels across all flows. These results may be explained by the size-class being studied, as side channel habitats may be more suitable to juvenile trout as rearing habitat. This could not be confirmed however, as many of the side channels were inaccessible due to private property boundaries, or dense vegetation and thus, habitat quality could not be assessed.

4.1 Site Fidelity

The definition of site fidelity varies from study to study. Generally, it has been defined as the return of trout to within a certain distance of a release point or point of origin (Bridcut & Giller 1993, Hilderbrand & Kershner 2000, Berrell et al. 2000, Bridger et al. 2001). For the purposes of our study, site fidelity was defined as the use of a single habitat type and location (i.e. pool 10) by an individual trout for the duration of its residency. We found that site fidelity ranged from 50% to 62% of the population. This is similar to rates reported by other investigators however; our definition of site fidelity was different. Hilderbrand and Kershner (2000) reported 61% of the cutthroat trout (O. clarki) they studied returned to within 300 m of their release point after one year. Bridger et al. (2001) reported 75% of simulated escapees from grow-out cages remained within 500 m of the farm site in May Cove in Bay d'Espoir, Newfoundland, Canada, and as much as 65% of the escapees from the off-site scenario returned to the farm site.

Our results indicate that roughly half of the trout population we studied is sedentary, exhibiting strong site fidelity. This characteristic can be advantageous in stable systems (Jenkins 1969) such as the Kings River below Pine Flat Dam. These results also indicate that roughly half of the trout population is mobile, which also has its advantages; allowing trout to migrate to any available habitat (Heggenes et al. 1991) as needed.

5.0 Summary

The quality and availability of habitat for rainbow trout downstream of Pine Flat Dam varies with instream flow. So too does the manner in which trout utilize the available habitat. This study has helped shed light on the response of rainbow trout to changes in discharge from the Pine Flat Dam. These findings confirm that trout were indeed utilizing FMP constructed boulder fields during periods of increased flow. They also indicate that side channels may not play an important role in the life history of adult rainbow trout in the Kings River. Further investigation of the use of side channels by juvenile trout is warranted and needed. As the Program continues to develop future habitat enhancement projects, the information gathered from this study will help guide their development.

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Appendix A

Date _____

LOCATION DATA

Frequency – Code:

_____

Time – Bearing:

1) _____

2) _____

3) _____

Photograph Number:

_____

NOTES:

HABITAT

☐ Pool

☐ Riffle

☐ Run

☐ Tailout

☐ Boulder Project

SHELTER

☐ Bubble Curtain

☐ Depth

☐ Terrestrial Veg.

☐ Aquatic Veg.

☐ Root Mass

☐ Cut Bank

☐ Boulder

☐ Woody Debris

☐ Other:

_____

_____

Appendix B

Comparison of the available habitat by flow for each management zone.

Proportion of Available Habitat Within the Put & Take Zone

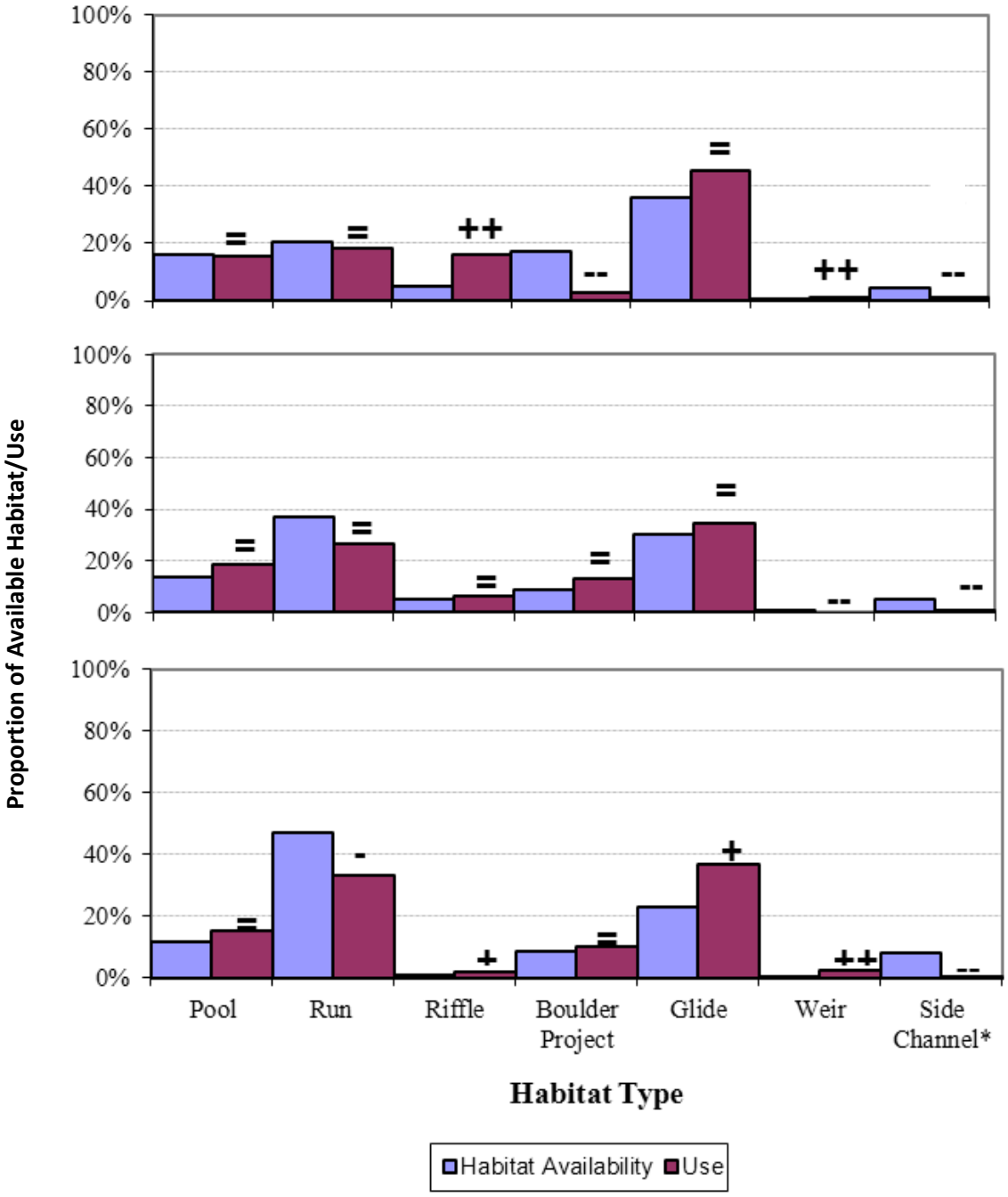
Flow	Pool	Run	Riffle	Boulder Project	Glide	Weir	Side Channel
100 - 249	12.4%	16.1%	6.6%	20.0%	44.0%	0.0%	0.9%
250 - 999	12.2%	34.0%	5.3%	9.7%	36.5%	0.0%	2.2%
> 1,000	9.8%	56.4%	0.0%	10.0%	23.9%	0.0%	0.0%

Proportion of Available Habitat Within the Catch & Release Zone

Flow	Pool	Run	Riffle	Boulder Project	Glide	Weir	Side Channel
100 - 249	18.2%	25.7%	3.8%	17.4%	27.0%	0.4%	7.6%
250 - 999	13.7%	43.4%	5.3%	8.7%	20.6%	0.4%	8.0%
> 1,000	12.9%	38.7%	1.9%	8.6%	20.4%	0.2%	17.3%

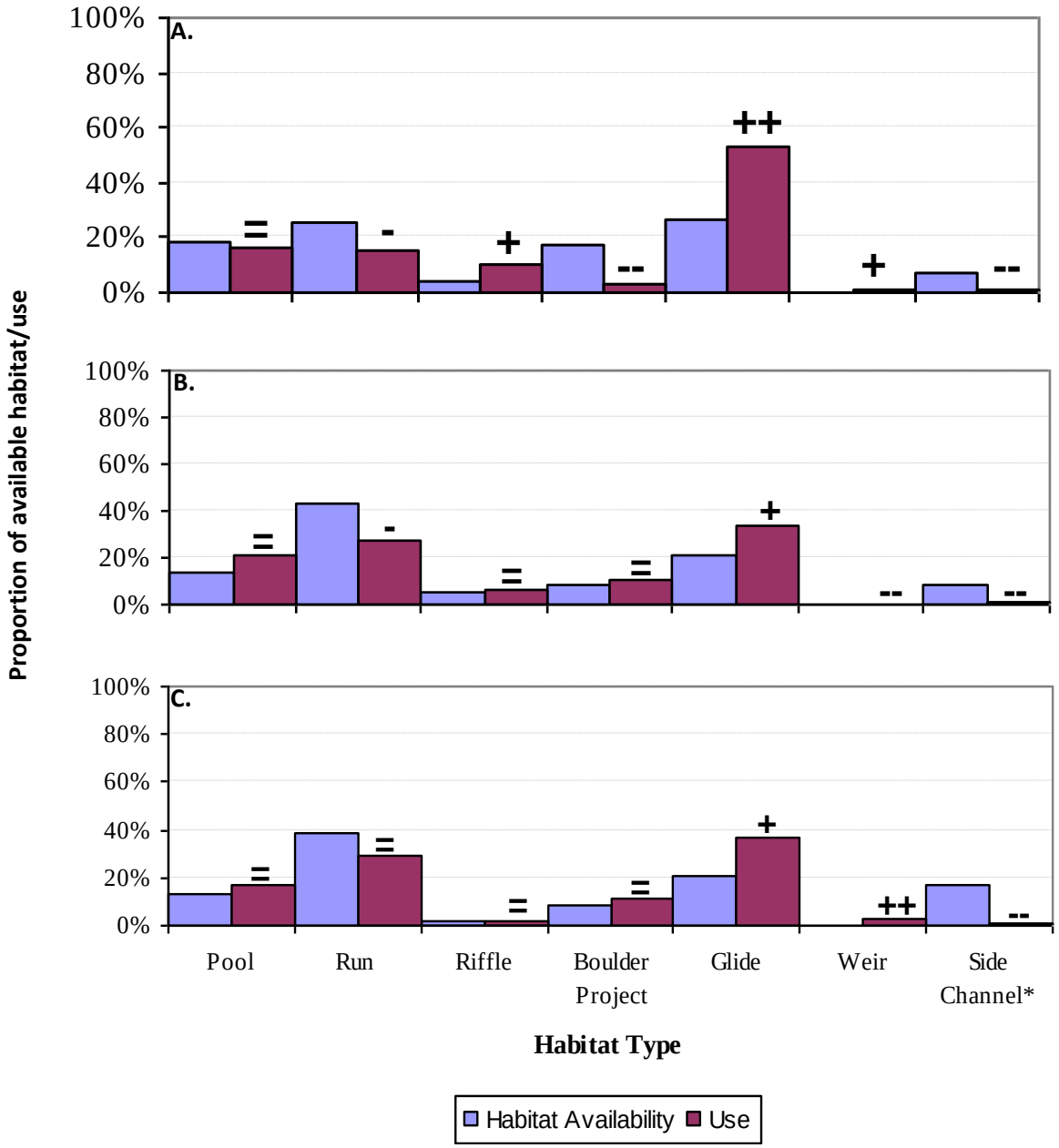
Appendix C

Put & Take Management Zone



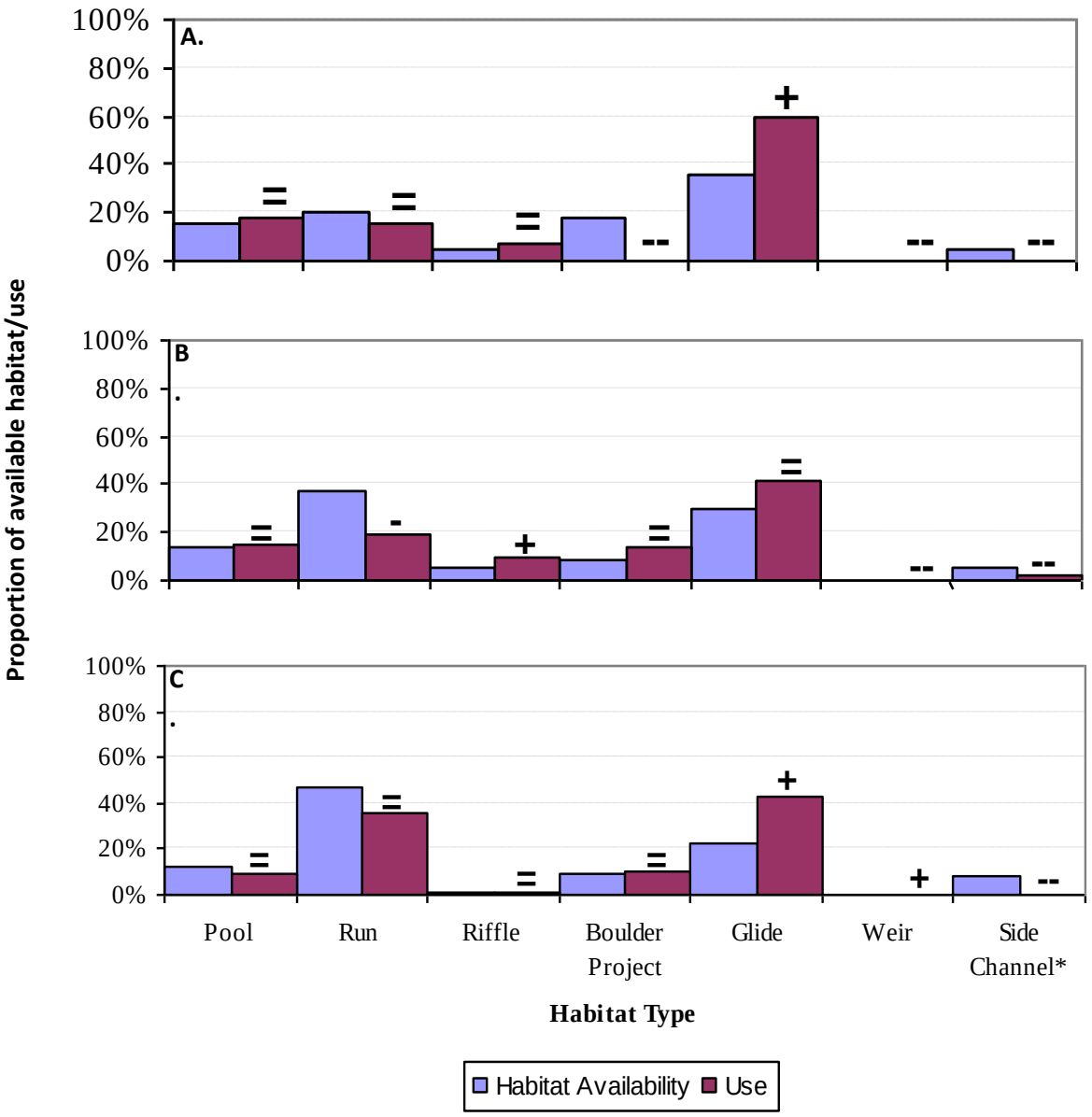
Comparison of Electivity (D) of habitat types reach wide. A). 100cfs to 249cfs B.) 250cfs to 999cfs, C.) 1,000cfs or greater. Strong preference ++ (≥0.50), Moderate preference + (≥0.25 but < 0.50), No preference = (± 0.25), Moderate avoidance – (> 0.50 but < -0.25), Strong avoidance -- (≤ - 0.50).

Catch & Release Management Zone



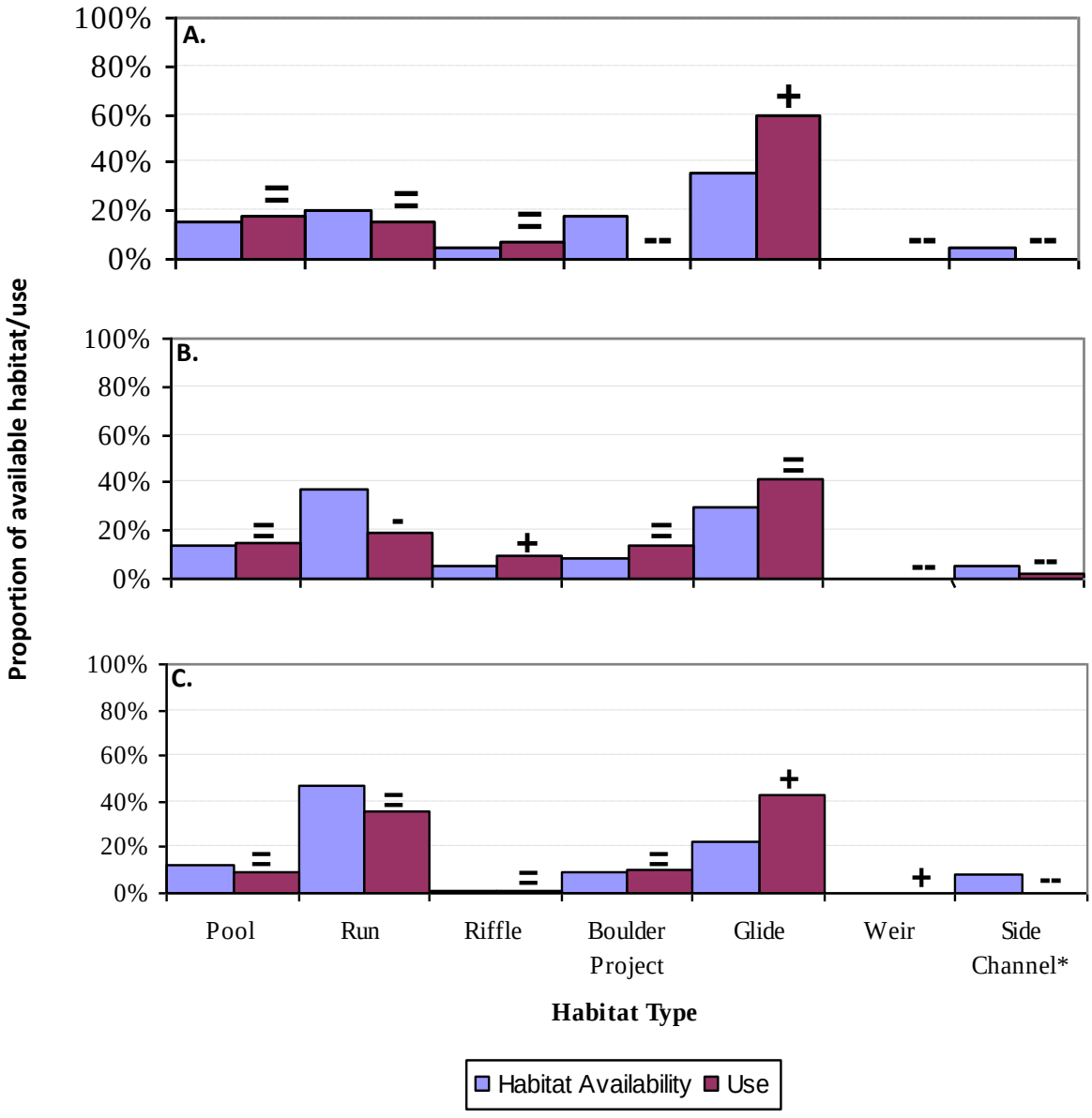
Comparison of Electivity (D) of habitat types reach wide. A.) 100cfs to 249cfs B.) 250cfs to 999cfs, C.) 1,000cfs or greater. Strong preference ++ (≥0.50), Moderate preference + (>0.25 but <0.50), No preference = (±0.25), Moderate avoidance – (> -0.50 but < -0.25), Strong avoidance -- (≤ -0.50).

Use of habitat by small trout



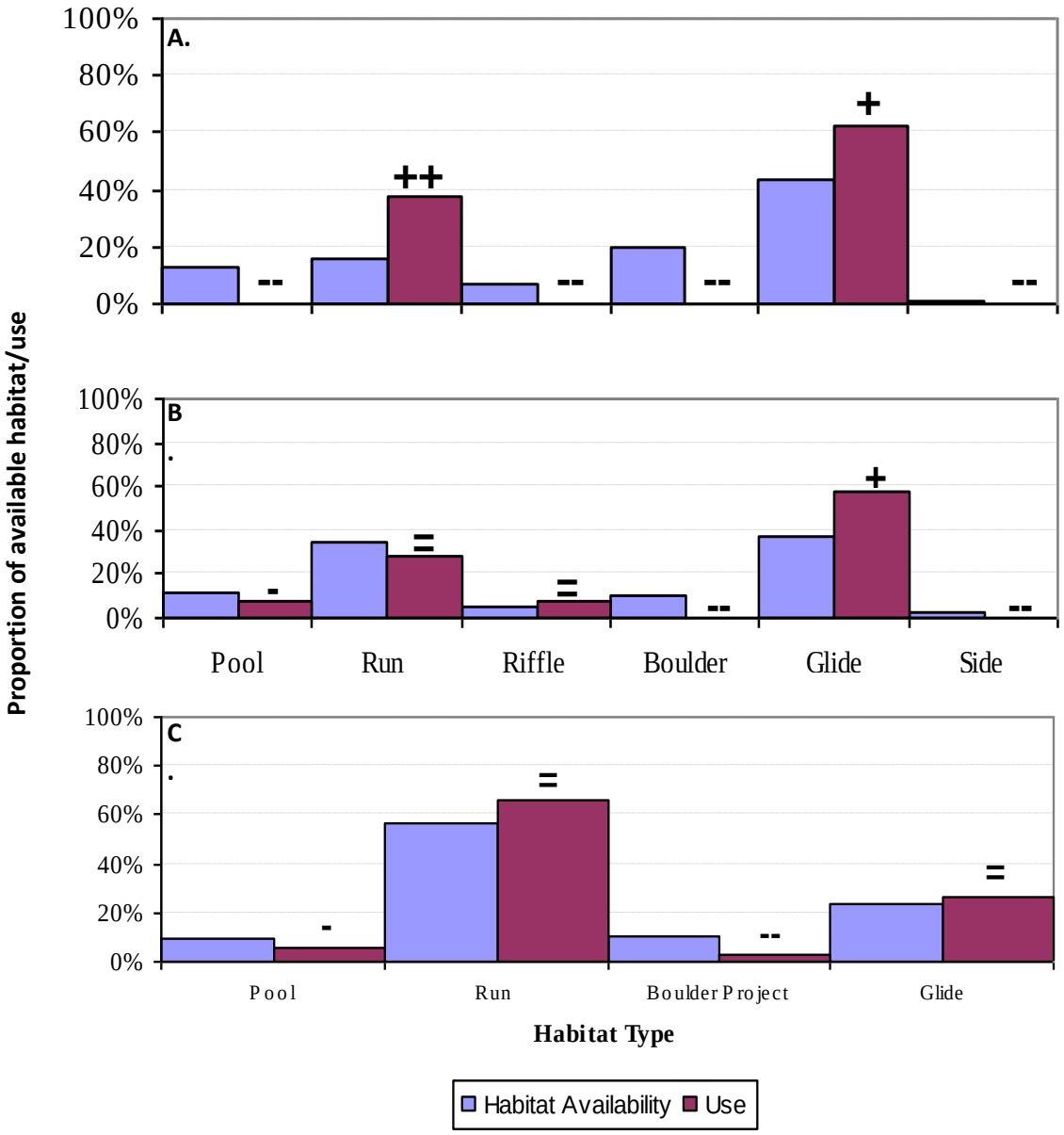
Comparison of Electivity (D) of habitat types reach wide. A.) 100cfs to 249cfs B.) 250cfs to 999cfs, C.) 1,000cfs or greater. Strong preference ++ (≥0.50), Moderate preference + (>0.25 but <0.50), No preference = (±0.25), Moderate avoidance – (> -0.50 but < -0.25), Strong avoidance -- (≤ -0.50).

Use of habitat by large trout



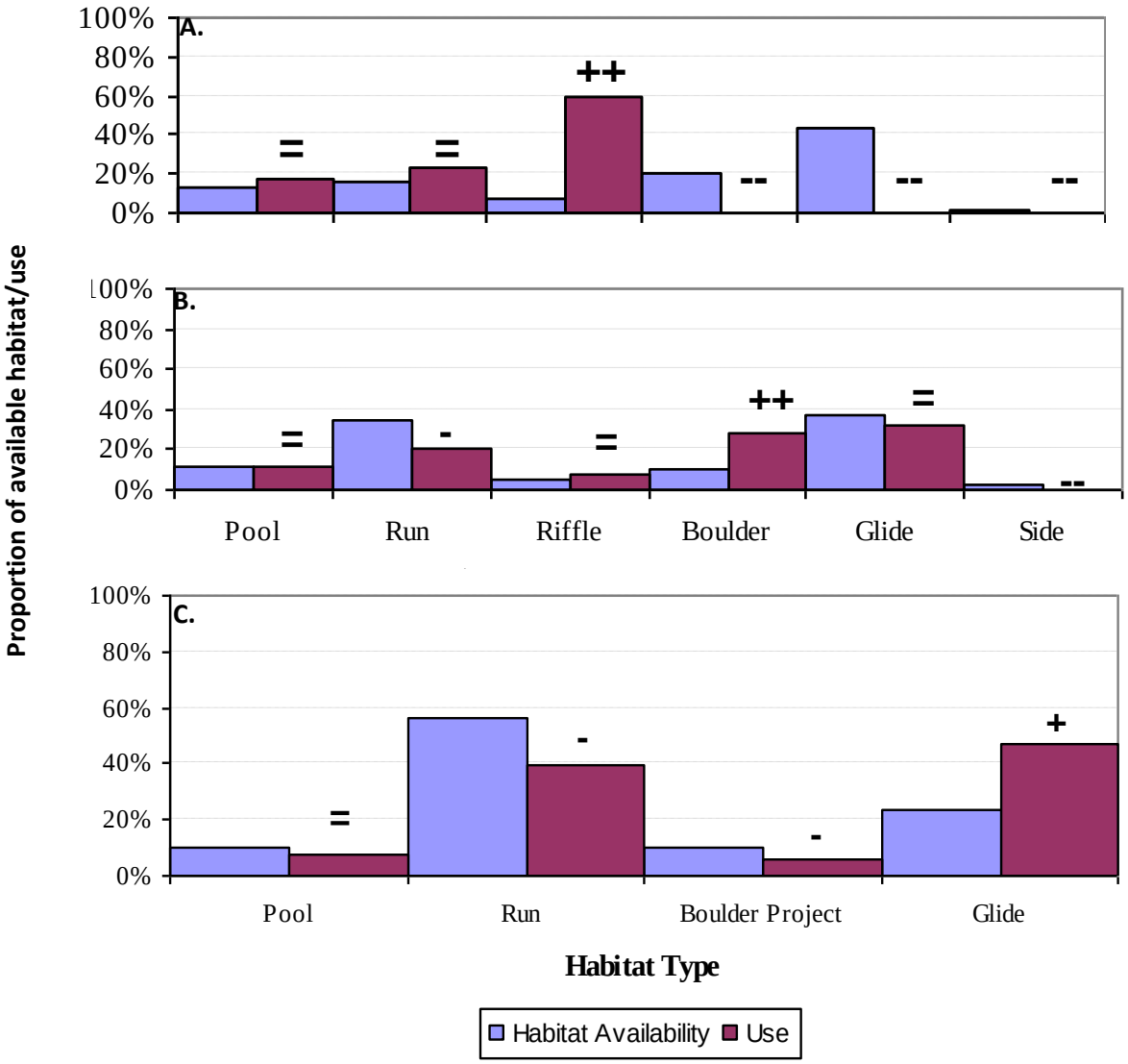
Comparison of Electivity (D) of habitat types reach wide. A.) 100cfs to 249cfs B.) 250cfs to 999cfs, C.) 1,000cfs or greater. Strong preference ++ (≥0.50), Moderate preference + (>0.25 but <0.50), No preference = (±0.25), Moderate avoidance – (> -0.50 but < -0.25), Strong avoidance -- (≤ -0.50).

Small trout – Put & Take Management Zone



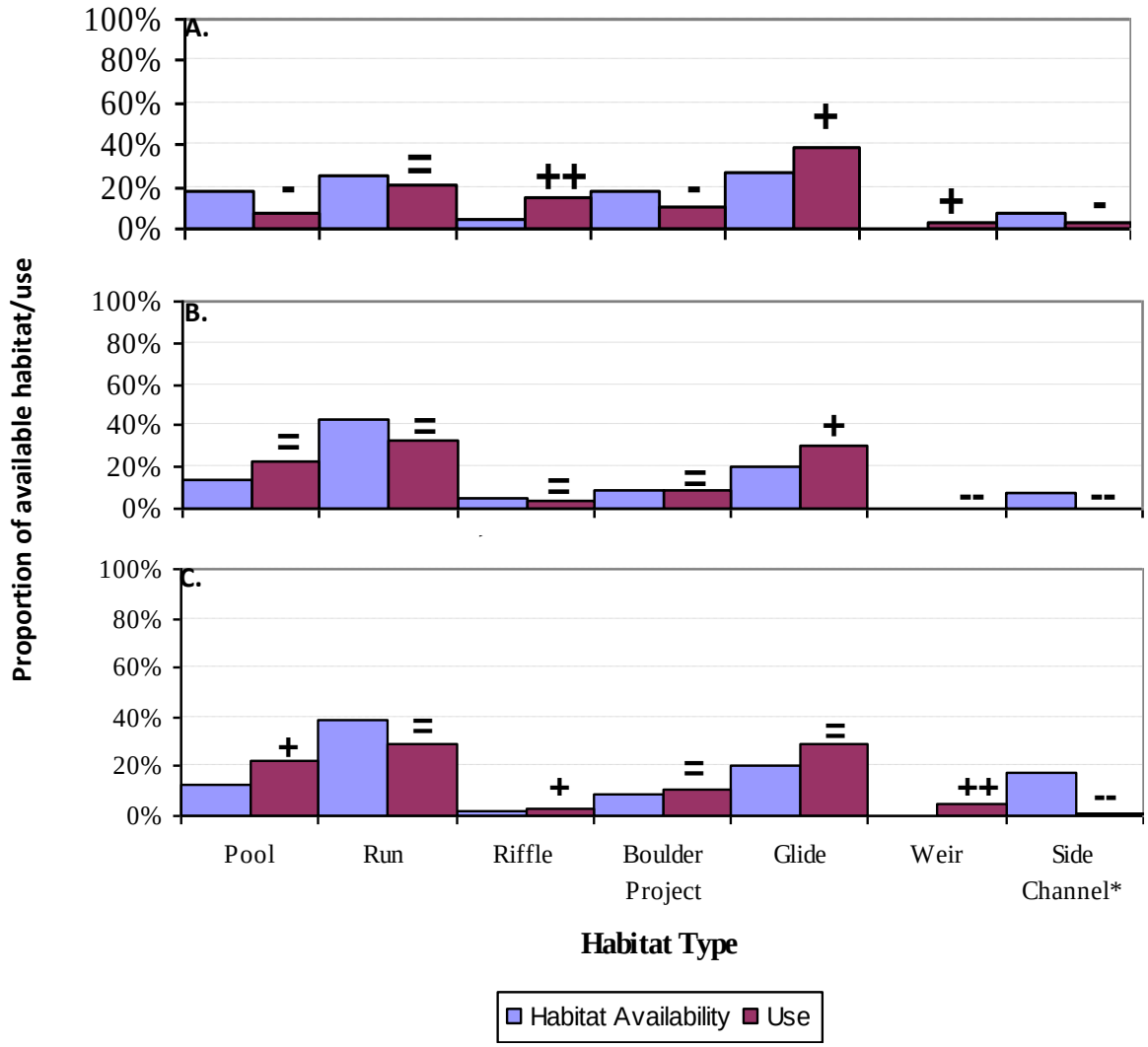
Comparison of Electivity (D) of habitat types reach wide. A.) 100cfs to 249cfs B.) 250cfs to 999cfs, C.) 1,000cfs or greater. Strong preference ++ (≥0.50), Moderate preference + (>0.25 but <0.50), No preference = (±0.25), Moderate avoidance – (> -0.50 but < -0.25), Strong avoidance -- (≤ -0.50).

Large trout – Put & Take Management Zone



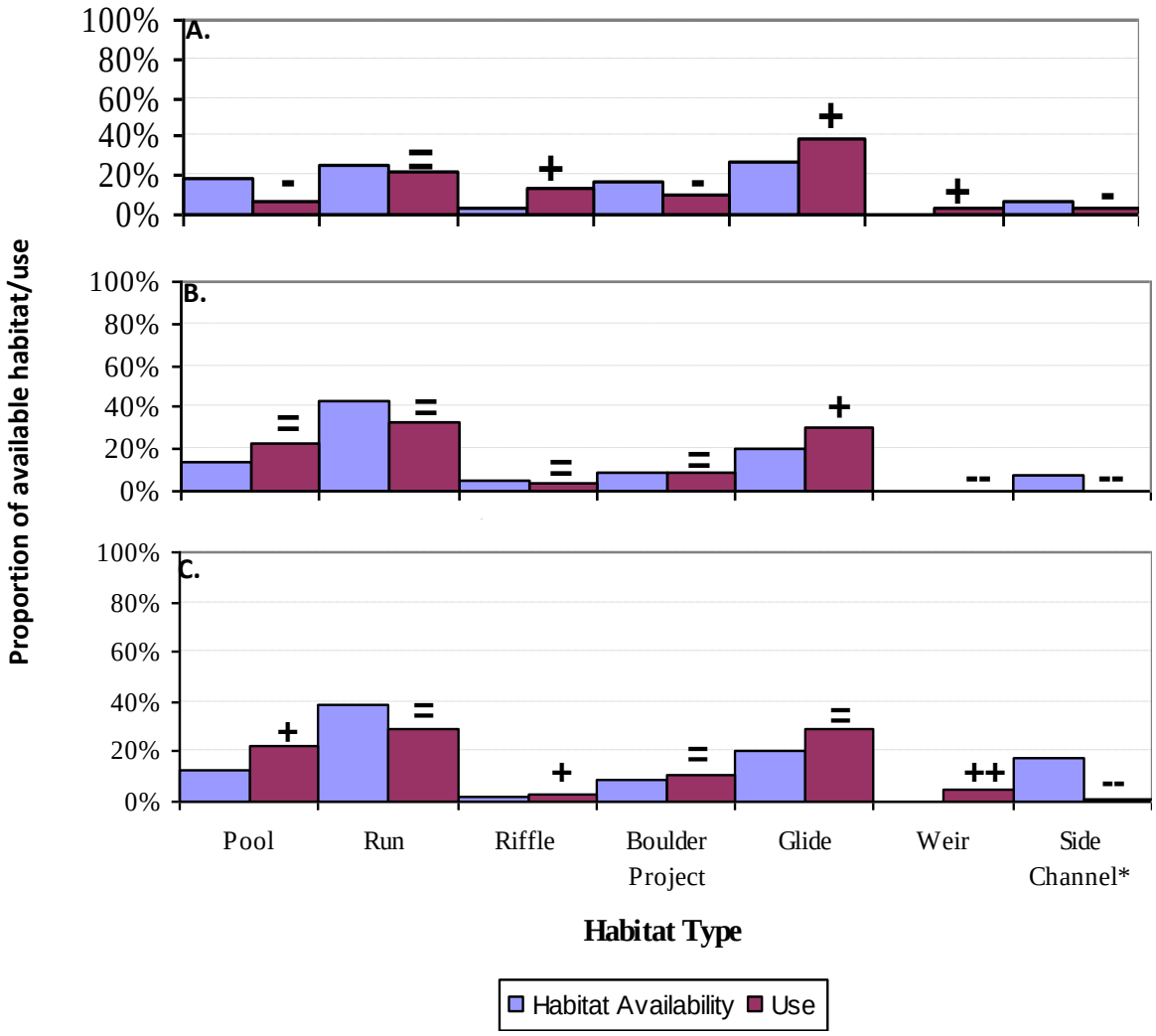
Comparison of Electivity (D) of habitat types reach wide. A.) 100cfs to 249cfs B.) 250cfs to 999cfs, C.) 1,000cfs or greater. Strong preference ++ (≥0.50), Moderate preference + (>0.25 but <0.50), No preference = (±0.25), Moderate avoidance – (> -0.50 but < -0.25), Strong avoidance -- (≤ -0.50).

Small trout – Catch & Release Management Zone



Comparison of Electivity (D) of habitat types reach wide. A.) 100cfs to 249cfs B.) 250cfs to 999cfs, C.) 1,000cfs or greater. Strong preference ++ (≥0.50), Moderate preference + (>0.25 but <0.50), No preference = (±0.25), Moderate avoidance – (> -0.50 but < -0.25), Strong avoidance -- (≤ -0.50).

Large trout – Catch & Release Management Zone



Comparison of Electivity (D) of habitat types reach wide. A.) 100cfs to 249cfs B.) 250cfs to 999cfs, C.) 1,000cfs or greater. Strong preference ++ (≥0.50), Moderate preference + (>0.25 but <0.50), No preference = (±0.25), Moderate avoidance – (> -0.50 but < -0.25), Strong avoidance -- (≤ -0.50).