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RESULTS OF JUVENILE SALMONID DOWNSTREAM MIGRANT TRAPPING CONDUCTED ON FRESHWATER CREEK, 2004

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ABSTRACT

Juvenile salmonid downstream migrant trapping was conducted at seven locations in the Freshwater Creek basin between March 13 and June 6, 2004. Pipe traps were deployed on McCready Gulch, Cloney Gulch, Graham Gulch, the upper mainstem of Freshwater Creek, South Fork Freshwater, and Little Freshwater Creek. An inclined plane trap was fished on the lower mainstem of Freshwater Creek to i) provide basin wide estimate of salmonid migrants and ii) allow partitioning of salmonid production by sub-drainage. Based on trapping results, it was estimate that 3523 (318 SD) coho salmon (*Oncorhynchus kisutch*) emigrated from Freshwater Creek between May 13 and June 6, 2004. We estimate that 872 (72 SD) Chinook salmon (*O. tshawytscha*) smolts emigrated from Freshwater Creek between May 8 and June 6, 2004. Basin wide lower mainstem (LMS) estimates of other species were not possible due to low capture rates.

ACKNOWLEDGEMENTS

We would like to thank the Humboldt Fish Action Council, the landowners of Freshwater Creek who allowed us access to trapping sites, Pacific Lumber Company for their support, the Institute for River Ecosystems for their technical and administrative assistance, and the AmeriCorps Watershed Stewards Project for their help in monitoring traps. This work was made possible by a grant from the California Adaptive Watershed Improvement.

INTRODUCTION

The California Department of Fish and Game and the National Oceanic and Atmospheric Administration ~ Fisheries recognize four key parameters for assessing the long term viability of salmonid populations. These parameters are population size, population growth rate (productivity), population spatial structure, and life history diversity (McElhany et al. 2000). The Freshwater Salmonid Monitoring Project is designed to be a full life cycle monitoring station where the primary goals are to: 1) fill the data needs necessary to estimate these VSP (viable salmonid population) parameters in one small basin, 2) provide the data necessary to interpret patterns in data gathered from less intensive abundance sampling on larger spatial scales, and 3) investigate the relationship between watershed and habitat conditions and abundance and distribution of animals.

The first goal is to estimate the four fundamental parameters used to assess population viability. Primarily, the focus is placed on estimating yearly abundance of adults and juveniles. A time series of this full life cycle abundance monitoring is then used to estimate both freshwater (summer and winter) and marine survival, as well as the ratio of the number of recruits to the number of adults for a given brood year (productivity). Additionally, by following individual animals through space and time, we hope to define life history patterns as well as the spatial and temporal structure of the population(s).

The second goal is to define the relationships and sampling protocols necessary to appropriately gather data and interpret abundance sampling on larger spatial scales. For example, density dependant functions can make the interpretation of population trend from a time series of juvenile abundance unclear. Similarly, evaluating abundance data of adult spawners from carcasses, live fish, or redd counts remains ambiguous when variability in observation probability is unaccounted for between years or sites. By sampling at multiple life stages and using a permanent counting fence to enumerate adults, the dynamics of cohort abundance through time as well as biases associated with adult and juvenile sampling techniques can be fully investigated.

The third goal is to examine habitat-fish productivity relationships and habitat restoration effectiveness. If survival between successive life stages and associated habitat and environmental conditions are monitored, this information can be used to target recovery actions which can be taken to improve survival at specific stages in the salmonid life cycle.

Life cycle monitoring in Freshwater Creek seeks to identify: 1) whether trends in coastal salmonid abundance are due to changes in freshwater and/or marine survival, 2) the spatial and temporal structure of Freshwater Creek salmonid populations (e.g. spawning group distribution and connectivity), 3) whether survival at various life stages and habitat and environmental conditions are correlated, and 4) the life stage or stages which are limiting adult production and are conducive to efforts to improve survival.

This report summarizes Freshwater Salmonid Monitoring Project's efforts to: 1) estimate smolt abundance in Freshwater Creek for the spring of 2004 and 2) tag steelhead (*Oncorhynchus mykiss*) and cutthroat trout (*O. clarki*) for a full life history mark-recapture experiment. The estimates of emigrant abundance are intended to be used in conjunction with annual estimates of adult and juvenile over-summer rearing abundance to achieve project goals.

Objectives

The Freshwater Creek downstream migrant program was initiated to: i) determine the yield of coho salmon (*O. kisutch*) and Chinook salmon (*O. tshawytscha*) smolts as well as cutthroat and steelhead parr and smolts from the Freshwater Creek basin, ii) determine the timing of outmigration of salmonids, iii) partition the basin yield of salmonids by tributaries versus mainstem areas, and iv) serve as a tagging/recapture period for a full life history mark-recapture experiment of steelhead and cutthroat.

Study Area

The Freshwater Creek basin is located in Humboldt County, California, between Eureka to the south and Arcata to the north (Figure 1). Freshwater Creek, which drains into Humboldt Bay via the Eureka Slough, is a fourth order stream with a drainage area of approximately 9227 hectares (31 square miles). Elevations in the watershed range from 823 meters at the headwaters to sea level at the mouth. The mainstem of Freshwater Creek is approximately 23 km long, of which 14.5 km is anadromous fish habitat. Five main tributaries, Little Freshwater, Graham Gulch, Cloney Gulch, McCready Gulch, and South Fork Freshwater, each provide 2 to 4 km of anadromous fish habitat.

Annual rainfall is approximately 150 cm in the headwaters and 100 cm near the mouth. Levees confine the channel in the lower 6 km and the surrounding land is primarily used for cattle grazing. This section is characterized by low gradient and limited riparian development. Upstream, the riparian community is more developed and is composed of willow (*Salix spp*.), red alder (*Alnus rubra*), black cottonwood (*Populus trichocarpa*), blackberry (*Rubus ursinus*), salmonberry (*Rubus spectasbilis*), and other herbaceous plants. Bordering the riparian areas are forests of redwood (*Sequoia sempervirens*), Douglas-fir (*Psuedotsuga menziesii*), white fir (*Abies concolor*) and Sitka spruce (*Picea sitchensis*).

The fishery resources of the basin include three species of salmon, Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), and steelhead (*O. mykiss*). Occasionally, chum salmon (*O. keta*) are observed. Other fish present in the basin include Pacific lamprey (*Entosphenus tridentatus*), brook lamprey (*Lampetra pacifica*), cutthroat trout (*O. clarki*), and prickly and coast range sculpin (*Cottus asper, Cottus aleuticus*), and three spine stickleback (*Gasterosteus aculeatus*).

Amphibians and reptiles present include pacific giant salamanders (*Dicamptodon ensatus*), red legged frogs (*Rana boylii*), tailed frogs (*Ascaphus truei*) and western pond turtles (*Clemmys marmorata*).

Figure 1. Freshwater Creek Survey Locations

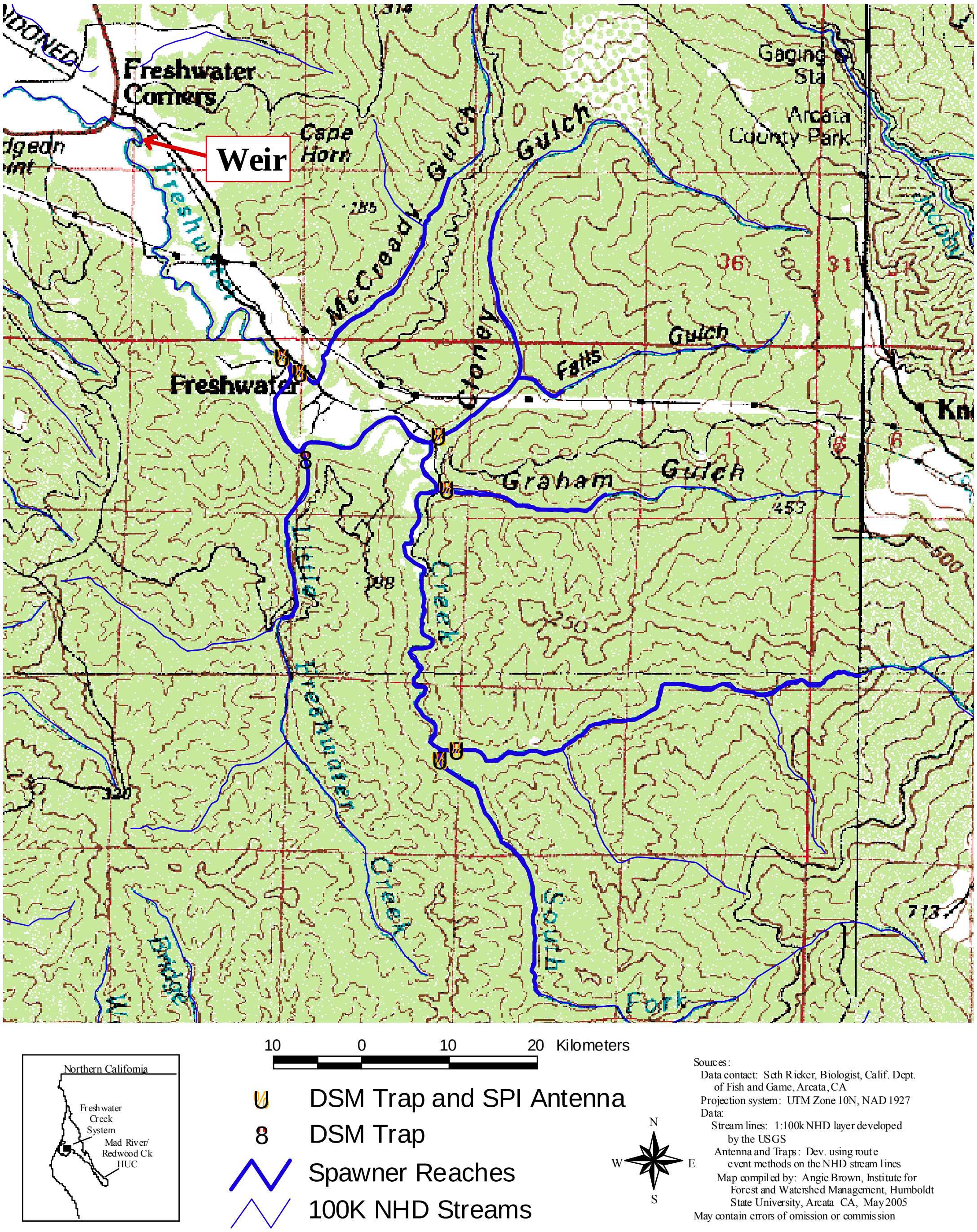

Figure 1. Freshwater Creek Basin, depicting relative location in Humboldt County, California and downstream migrant trap locations.

METHODS

Fish Capture

Seven downstream migrant traps were installed in the Freshwater Creek basin from March 14 through June 11, 2004. Pipe traps were deployed in each of the five major tributaries, Cloney Gulch, McCready Gulch, Graham Gulch, Little Freshwater, and South Fork, as well as on the upper mainstem reach of Freshwater Creek just above the confluence with the South Fork. The pipe traps were placed within 20 – 300 meters upstream of the confluence with the mainstem of Freshwater Creek, at a pool tail-out/riffle crest. Each of the six pipe traps consisted of a downstream "V" shaped rock and wooden pallet weir which concentrated fish and water flow through a 10" diameter PVC pipe. The pipe extended downstream through a low gradient riffle and emptied onto a perforated, inclined plane. This structure allows most of the water to pass through, while depositing any fish into trap boxes attached at the downstream end. A floating inclined plane trap (a.k.a. scoop trap) was deployed at the lower mainstem site (LMS) (Figure1). This floating trap has a 48" X 48" mouth which narrows to a 36" X 8" cod end which then deposits into a live box. Water velocity pushes fish up the plane into the live box. The plane and box are buoyed by two 16' pontoon floats. Design, fabrication, and deployment of this trap follow closely with the plans described by Todd (1994).

Abundance estimates

Numbers of migrants at each trap were estimated using a single trap mark-recapture method. All age 1+ steelhead, cutthroat, and coho were marked by inserting small, individually numbered Passive Integrated Transponder (PIT) tags directly into the body cavity (Prentice 1990). Chinook salmon smolts were marked with weekly Visual Implant Elastomer (VIE) colors injected into the snout. Seven different elastomer colors were used to represent weekly stratified marking groups. This system allowed estimates of the number of migrants to be separated when trap efficiencies varied. Each day, trapped fish were anaesthetized with MS-222, counted, checked for marks, and recaptures measured for fork length. Once processed, those fish that were recaptured or did not receive marks were allowed to recover from the anesthetic in flow-through live cars. After they were fully recovered, they were released downstream of the trap. Newly marked fish were held in a flow-through live car for up to one hour to check for handling and marking mortalities. If any marked fish experienced mortality prior to release from the live car, the total number of marks released was adjusted accordingly. All marked fish were released one to three pool-riffle sequences upstream of the trap. Releases were rotated among three to five sites, all having adequate cover, in an effort to avoid habituation of predators.

For each drainage, the mark-recapture data was analyzed separately for all age 1+ steelhead, age 2+ and older steelhead, and age 1+ coho salmon emigrants. Numbers of age 0+ Chinook salmon smolts were only estimated at the lower mainstem trap. The mark-recapture data was analyzed using Darroch Analysis with Ranked Regression (DARR) to produce bounded estimates of abundance (Darroch 1961, Bjorkstedt pers. comm.). Briefly, this method is a temporally stratified mark-recapture experiment that estimates capture probability for each period, accounting for the effects of migration on the pool of marked fish susceptible to capture during each period. This method does not require the assumption that all fish resume migration during the period in which they were released. Strata that contain problematic structure for Darroch (1961) analysis are combined to neighboring strata thereby reducing the rank of the data to the least possible extent to produce a dataset amenable to Darroch (1961) analysis (Bjorkstedt pers. Comm.).

Two types of PIT tags were used to mark juvenile salmonids. Small, 11.5 mm long Full Duplex (FDX) tags were implanted into fish measuring 69mm to 100mm in fork length. Fish greater than 100mm in fork length were implanted with 23mm long tags. This larger size and Half-Duplex (HDX) tag platform has the ability to be detected at a much larger range. Table 1 summarizes the number of fish tagged by species and tag type.

Table 1. Numbers and type of PIT tags given to juvenile steelhead and cutthroat trout and coho salmon.

Species	23 mm tag	11.5 mm tag
Steelhead	289	516
Cutthroat	240	64
Coho	NA	1433

Age Determination

Age classes were determined using length frequencies. Two distinct modes of the frequency distribution were identified, and ages were divided at the nadir of the frequency distribution. From the data, it was determined that age 1+ steelhead had fork lengths <120 mm and age 2+ had fork lengths ≥ 120 mm (Figure 3).

The developmental stage of all captured and recaptured fish was determined by visual observation and consisted of three categories: parr, pre-smolt and smolt. Parr were characterized by well defined parr marks; pre-smolts exhibited partial silvering of the body and fading but still visible parr marks; and smolts exhibited total silvering of the body, no visible parr marks, and blackening of the caudal fin tips.

RESULTS

Abundance Estimates

Estimation of fish passing the LMS trapping site was limited to age 1+ coho smolts and Chinook salmon smolts, due to low numbers of captured and subsequent recaptured fish. An estimated 3523 (318 SD) age 1+ coho salmon emigrated past the LMS site. An estimated 872 (72 SD) Chinook smolts emigrated past the LMS site between May 5 and June 18, 2004. Previous to May 5, 1122 Chinook salmon fry were simply enumerated with no estimated trap efficiency. The number of fish captured was presented only if sample sizes precluded reliable (95% C.I. ± > 50% of estimate) abundance estimation. All trap abundance estimates or catch data are displayed in Table 2. Young of the year (age 0+) captures for all traps are displayed in Table 3.

Table 2. Abundance estimates (N(hat)), associated error (SD) of the estimate, of smolts and parr by group, age class, and sub-drainage. **Bold** indicates number of fish captured and is not an estimated total yield. An * indicates estimated number of migrant Chinook smolts (>50mm) after 5/8/2004.

Trap Group / Age class	N(hat)	SD
Lower Mainstem		
Steelhead 1+	**301**	**NA**
Steelhead 2+	**53**	**NA**
Cutthroat 1+	**37**	**NA**
Cutthroat 2+	**56**	**NA**
Coho 1+	3523	± 318
Chinook	872*	± 72
McCready Gulch		
Steelhead 1+	**1**	**NA**
Steelhead 2+	**1**	**NA**
Cutthroat 1+	**1**	**NA**
Cutthroat 2+	**12**	**NA**
Coho 1+	**53**	**NA**
Cloney Gulch		
Steelhead 1+	**9**	**NA**
Steelhead 2+	**20**	**NA**
Cutthroat 1+	**5**	**NA**
Cutthroat 2+	82	± 27
Coho 1+	619	± 80
Graham Gulch		
Steelhead 1+	12	± 3
Steelhead 2+	**7**	**NA**
Cutthroat 1+	**0**	**NA**
Cutthroat 2+	**0**	**NA**
Coho 1+	51	± 5
Upper Mainstem		
Steelhead 1+	340	± 41
Steelhead 2+	12	± 3
Cutthroat 1+	**8**	**NA**
Cutthroat 2+	**18**	**NA**
Coho 1+	319	± 11
South Fork		
Steelhead 1+	**17**	**NA**
Steelhead 2+	**12**	**NA**
Cutthroat 1+	**9**	**NA**
Cutthroat 2+	33	± 10
Coho 1+	132	± 38
Little Freshwater		
Steelhead 1+	225	± 31
Steelhead 2+	**13**	**NA**
Cutthroat 1+	**26**	**NA**
Cutthroat 2+	**25**	**NA**
Coho 1+	446	± 55

Table 3. Age 0+ (young of the year) catches for the seven downstream migrant traps in Freshwater Creek basin.

Age 0+ catches

	McCready	Cloney	Graham	Upper Main	South Fork	Little Fresh	Lower Main
Coho	218	5680	385	13833	20061	702	15582
Steelhead	21	1654	4451	1374	259	144	3920
Chinook	0	0	0	4	0	0	1681

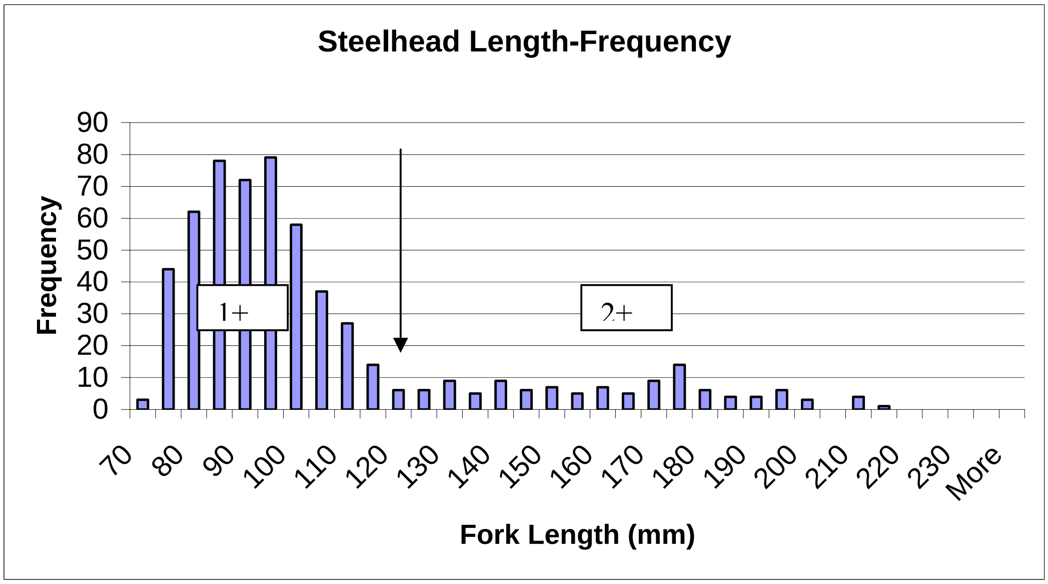

Figure 2. Length-frequency histogram of all steelhead captured at the LMS trap. Boxes indicate age classes and arrow depicts fork length used for age class delineation.

Migration Timing

Operation of the traps commenced on March 13, 2004. Peak catches of steelhead parr and smolt migrants occurred the week of April 24th, while coho smolt and Chinook parr and smolt peak catches occurred two weeks later during the week of May 8th. (See Figures 3, 4, and 5)

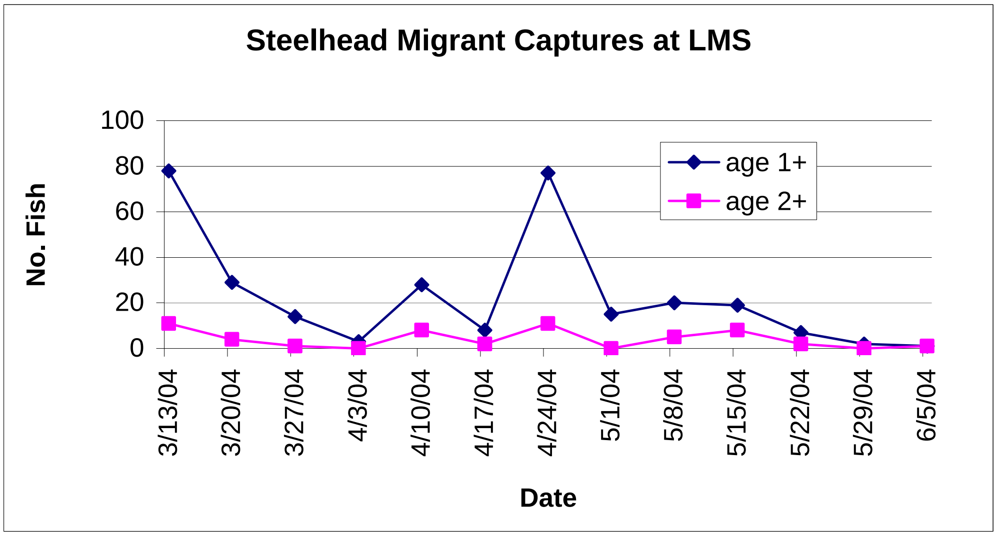

Figure 3. Timing of age 1 and 2+ steelhead trout emigration at the LMS trap.

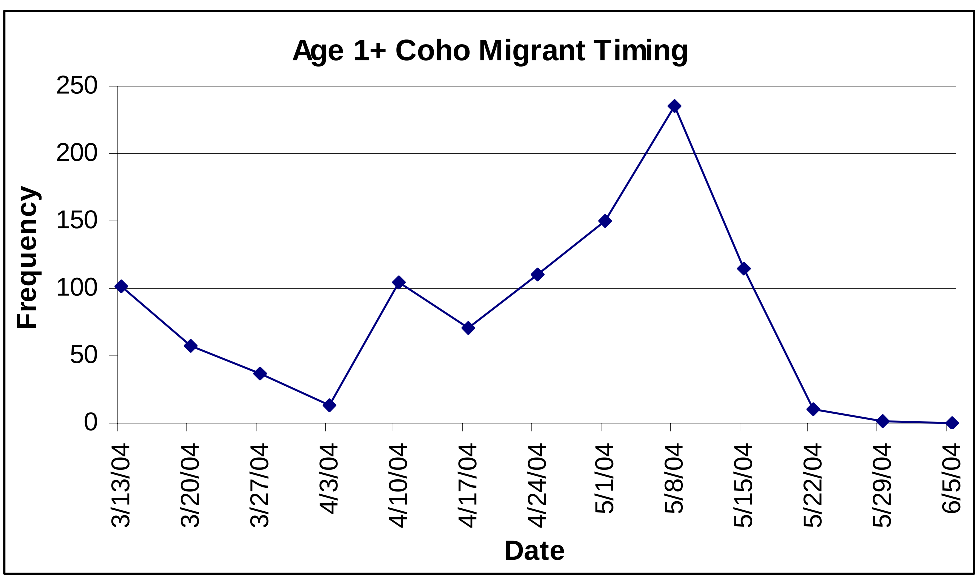

Figure 4. Timing of coho salmon captures at the LMS trap.

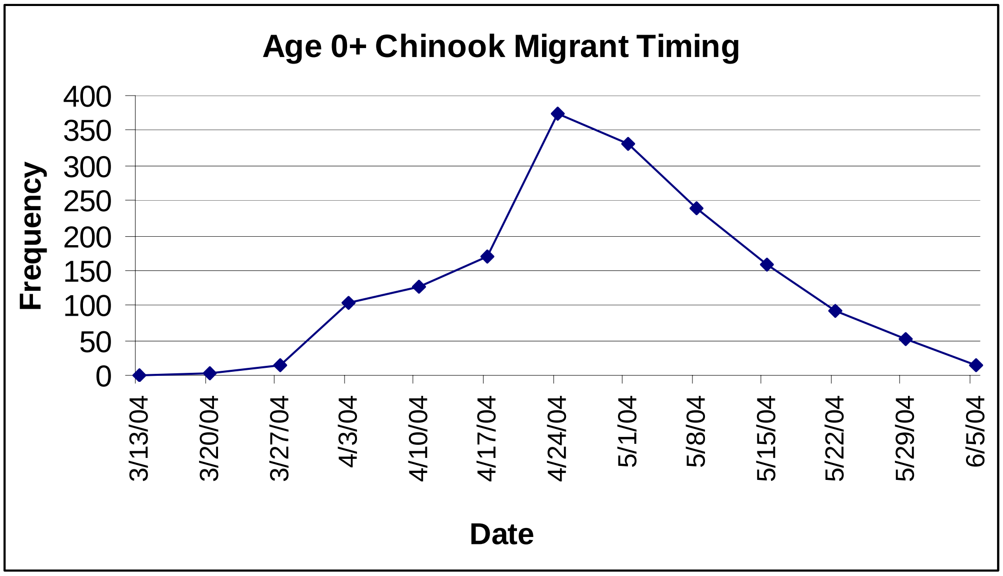

Figure 5. Timing of Chinook salmon captures at the LMS trap.

Length of Steelhead and Coho Salmon

Steelhead The median fork length of steelhead from tributary creeks ranged from 81 mm for the South Fork to 146mm for McCready Gulch (Figure 6).

Coho Salmon: Mean sizes of coho salmon captured at the tributary traps ranged from 88mm for the South Fork to 101mm for Graham Gulch (Figure 7).

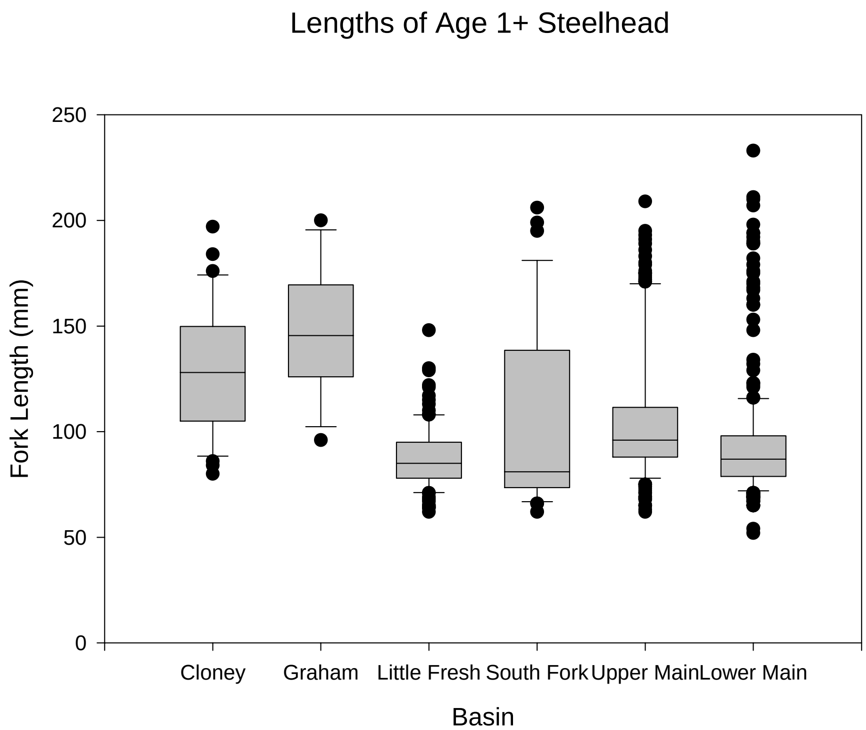

Figure 6. Comparison of fork lengths of measured steelhead from each tributary trap. Box plots depict 25th, 50th, and 75th percentiles, whiskers depict 10th and 90th percentiles, and points indicate outliers.

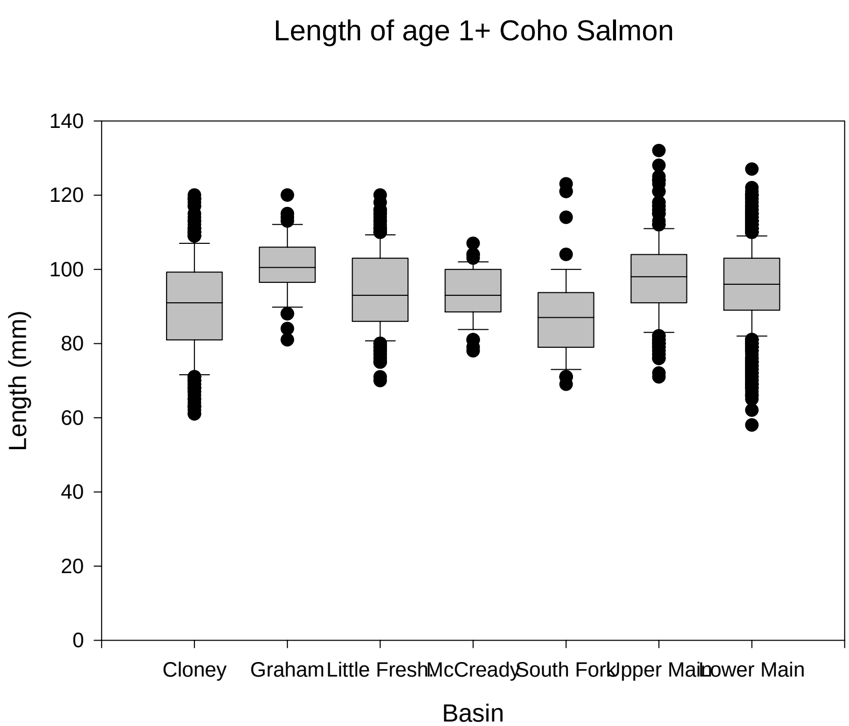

Figure 7. Comparison of fork lengths of systematically measured coho salmon smolts captured at each trap. Box plots depict 25th, 50th, and 75th percentiles, whiskers depict 10th and 90th percentiles, and points indicate outliers.

DISCUSSION

Yield of Smolts and Parr

The appropriate estimation of migrant abundance from mark-recapture trapping data relies not only upon meeting mark-recapture model assumptions, but also on sufficient sample sizes of captured, marked, and subsequently recaptured fish to produce adequately precise estimates. In many cases this sampling year, the study did not capture enough fish, nor have an efficient enough trap to produce estimates with the appropriate precision to adequately address population parameters (e.g. abundance, survival). This situation can be an artifact of low population sizes, which cannot be remedied by changes to the trapping protocol. It appears, however, in some sub-basins, that a large enough migrant population were present, but that trap efficiency was too low to produce reliable estimates. Rainfall, the magnitude and pattern of stream discharge, and floating debris can all affect the ability and efficiency of salmonid outmigrant traps. There were sufficiently long periods of either trap in-operation, or very low trapping efficiencies this season. These "holes" in abundance data may make inference into population trends inferred from trapping data difficult.

Age 0+ Captures

The occurrence of young-of-the-year (YOY) coho salmon fry in all of the tributaries indicates successful adult spawning presence in all anadromous reaches. The high and variable number of YOY captures over the four year duration of this study clearly accounts for a large portion of the attrition of fish from egg deposition to summer rearing abundance. Separating the number of spring YOY outmigrants from egg to summer mortality will add significant biologic inference to estimates of survival for this life stage. It is recommended that YOY trap efficiency estimates be made for the tributary traps in order to estimate the numbers of YOY migrants from each sub-basin.

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