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RESULTS OF JUVENILE SALMONID DOWNSTREAM MIGRANT TRAPPING CONDUCTED ON FRESHWATER CREEK, 2007

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Table of Contents

LIST OF TABLES ..... **iii**
LIST OF FIGURES ..... **iii**
ABSTRACT ..... **iv**
ACKNOWLEDGEMENTS ..... **v**
INTRODUCTION **1**
Objectives 2
Study Area 2
METHODS **4**
Trap Placement 4
Fish Capture 4
Abundance estimates 5
Age Determination 6
Juvenile Trout Movement 6
RESULTS **7**
Abundance Estimates 7
Migration Timing 9
Juvenile Trout Movement 11
Length of Steelhead and Coho Salmon 13
Steelhead 13
Coho Salmon 15
DISCUSSION **16**
LITERATURE CITED **16**

LIST OF TABLES

Table 1. Abundance estimates (N(hat)), associated error (SD) of the estimate, of smolts and parr by group, age class, and sub-drainage in Freshwater Creek 2007. Bold indicates number of fish captured and is not an estimated total yield. 8
Table 2. Age 0+ (young of the year) catches for the eight downstream migrant traps in Freshwater Creek basin. 9

LIST OF FIGURES

Figure 1. Freshwater Creek Basin, depicting relative location in Humboldt County, California and downstream migrant traps and RFID antenna locations locations. 4
Figure 2. Length-frequency histogram of all steelhead captured. Boxes indicate age classes and arrow depicts fork length used for age class delineation. 9
Figure 3. Timing of steelhead trout emigration at the HFAC weir, LMS, and combined tributary (TRIBS) traps, Freshwater Creek, 2007. 10
Figure 4. Timing of the estimated number of coho salmon emigrants at the juvenile downstream migrant traps, partitioned by six tributary traps combined (TRIBS), the lower mainstem (LMS) and HFAC weir (HFAC), Freshwater Creek spring 2007 10
Figure 5. Distribution of travel times of individually marked coho salmon emigrants from the tributary traps combined to the LMS trap (Tribs → LMS), and from the LMS trap to the HFAC trap (LMS→ HFAC) in Freshwater Creek, 2007. 11
Figure 6. Migration direction and timing of individually PIT tagged trout marked at the tributary DSMT traps (Trib Marks) and recorded at the tributary antennas (A) and at the HHL antenna (B). Negative y-axis values indicate a downstream movement and positive y-axis values indicate an upstream movement. 12
Figure 7. 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, 2007. 13
Figure 8. Comparison of fork lengths of measured steelhead categorized by migrant stage. Box plots depict 25th, 50th, and 75th percentiles, whiskers depict 10th and 90th percentiles, and points indicate outliers, 2007. 14
Figure 9. Number of captured Smolt, Pre-Smolt and Parr steelhead trout by sub-basin, Freshwater Creek 2007. 14
Figure 10. Comparison of fork lengths of 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, 2007. 15
Figure 11. Estimates of the number of coho salmon emigrants from all tributaries combined (TRIBS), the lower main- stem (LMS) from 2001-2007 and the HFAC site for 2007 in Freshwater Creek. 16

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ABSTRACT

Juvenile salmonid downstream migrant trapping was conducted at eight locations in the Freshwater Creek basin between March 15 and June 6, 2007. 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 main stem of Freshwater Creek, and the Humboldt Fish Action Council weir was retrofit to function as a basin-wide juvenile emigrant trap. The multiple traps were fished 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 estimated that 2111, 1574 and 2203 coho salmon (*Oncorhynchus kisutch*) emigrated from the tributaries, main stem below the tributaries and rk 13.9, and lower main-stem between rk 13.9 and rk 8.4 respectively. The total coho salmon age 1+ emigrant yield was estimated to be 5888 (±504 SD). The total Steelhead age 2+ smolt yield was estimated to be 1918 (±382 SD) with the majority, (88%) of captures occurring at the lower HFAC weir basin-wide trap location.

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 Department of Fish and Game Fisheries Restoration Grants.

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 2007 and 2) tag juvenile coho salmon, steelhead (*0. 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. There are approximately 32.8 km of anadromous stream within Freshwater Creek (excluding Ryan Creek). Five main tributaries, Little Freshwater, Graham Gulch, Cloney Gulch, McCready Gulch, and South Fork Freshwater, each provide 2 to 5 km of anadromous fish habitat, and when combined with the upper main-stem above the confluence with the South Fork provide 19.7 km (60%) of the anadromous stream kilometers. The main-stem habitat below the tributaries down stream to the LMS trap site provide 7.6 km (23 %) of the habitat while the remaining space from the LMS trap to the HFAC trap provides and additional 5.5 km (17%) of linear stream habitat.

Levees confine the channel in the lower basin and the surrounding land is primarily used for cattle grazing. The stream continues at low gradient to the confluence of the South Fork and is mainly small parcel residential properties. The remaining 7143 hectares of the watershed encompassing 19.7 km of anadromous fish habitat, is owned and managed for timber production by the Pacific Lumber Company.

The lower grazing land and residential areas support limited riparian development consisting of willow (*Salix spp*.), red alder (*Alnus rubra*), black cottonwood (*Populus trichocarpa*), blackberry (*Rubus ursinus*). Upstream, the riparian community is more developed and is composed of salmonberry (*Rubus spectasbilis*), and other herbaceous plants together with willow, red alder, 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*).

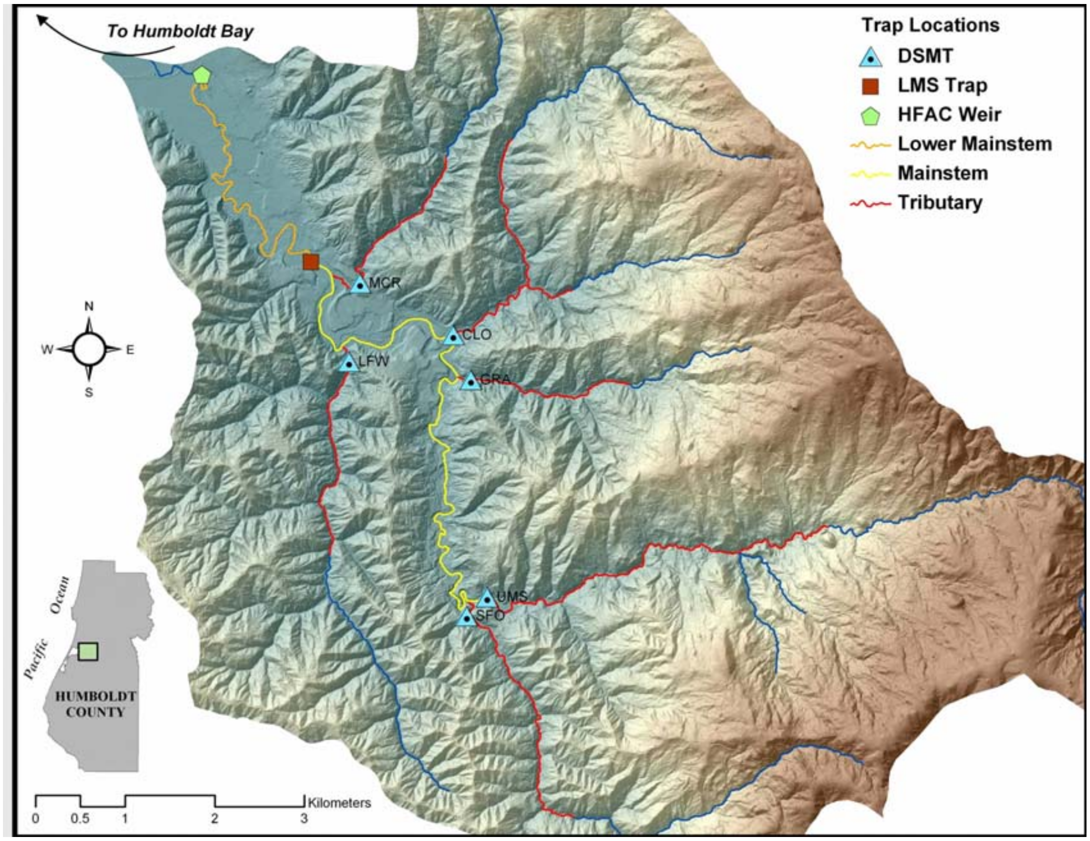

Figure 1. Freshwater Creek Basin, depicting relative location in Humboldt County, California and downstream migrant traps and RFID antenna locations locations.

METHODS

Trap Placement

This study partitioned Freshwater Creek into three major sub-basins components. The first combines the five major tributaries and the upper main-stem above the confluence with the South Fork to form the inclusive tributary sub-basin (TRIBS). The second Mainstem unit includes all stream downstream of the TRIBS to the Lower Main-Stem (LMS) trap site, and the third lower main-stem sub-basin includes the stream from the LMS site to the Humboldt Fish Action Council (HFAC) weir trapping site (Figure 1.)

Fish Capture

Eight downstream migrant traps were installed in the Freshwater Creek basin from March 15 through June 6, 2007. 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 main stem 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 main stem 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 LMS site. 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). Finally, the lower most emigrant trap was located at the Humboldt Fish Action Council weir. The weir was retrofit with a 10" PVC pipe extending from a 4' X 5'X 3' plywood cone at the upstream end, to a 4' X 4' X 8' aluminum live cart at the down stream end. Fish were directed to the cone with a screened fence angled approximately 60 degrees to the direction of flow forcing fish down the pipe and depositing them in the floating live cart.

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). 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. 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 sub-basin, the mark-recapture data was analyzed separately for all age 1+ steelhead and cutthroat trout, age 2+ and older steelhead and cutthroat trout, and age 1+ coho salmon emigrants. The mark-recapture data was analyzed using Darroch Analysis with Ranked Regression (DARRv2) 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 re-migration timing 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.).

Chinook salmon juvenile emigrants were counted each day at all traps. No mark recapture estimate was attempted due to very low abundance, and the desire to reduce handling and marking stress on the population.

Two types of PIT tags were used to mark juvenile salmonids. Small, 11.5 mm long Full Duplex (FDX-B) tags were implanted into fish measuring 70mm 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.

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 $\geq$ 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 and slender body, flaking scales, no visible parr marks, and blackening of the caudal fin tips.

Juvenile Trout Movement

Juvenile trout greater than 100mm in fork length were captured at the juvenile downstream migrant traps were tagged with 23 mm passive integrated transponder (PIT) tags. After tagging, fish were released upstream of the traps to estimate trap efficiency (see Fish Capture). We operated six radio frequency identification (RFID) antenna systems in Freshwater Creek basin to track the movement of juvenile trout throughout the year. RFID antenna arrays were installed near the mouths of the five major sub basins as well as upper main stem (Figure 1). Briefly, the antennas emit an electromagnetic pulse that excites PIT tags located within the antenna's field causing them to transmit the 16 digit tag identification code as a low frequency radio signal which is received by the antenna. The codes are unique to each fish and when transmitted, are read by the antenna and logged into a computer file along with the date and time of logging. The arrays consisted of two stream-width antennas separated by 3-5m at each site. The time of an individual tag detection at the upstream or downstream antenna at each array allows the determination of up and down stream movement (i.e. detection at upstream antenna before detection at downstream antenna at a single array is considered a downstream move). We operated the antennas continually throughout the juvenile spring migration.

Juvenile trout PIT tagged at the tributary DSMT traps with HDX 23mm PITs in 2007 were recorded by the stream-width RFID antennas as they moved within the basin. Raw antenna data was summarized to produce directional movement histograms. Two types of antenna data scenarios were considered directional movements. First, directional movements were considered at individual paired antenna sites. PIT tag codes recorded at the lower antenna previous to being recorded at the upper antenna at a particular site were considered ‘upstream’ directional movement. PIT tag codes detected at an upstream antenna previous to being recorded at a downstream antenna at any particular site were considered ‘downstream’ movements. A single site directional movement was only considered ‘valid’ if the time interval between antenna records at an individual site was less than 10 minutes. If this interval was greater than or equal to 10 minutes, a directional move was not assigned and the record ‘flagged’ as a potential error. Second, PIT tag codes detected at either of the paired antenna at upstream sites previous to detection at either antenna at downstream sites were considered ‘downstream’ movements. PIT tag codes detected at either antenna at downstream sites previous to either antenna at upstream sites were considered ‘upstream’ movements. All consecutive records for site to site movements were considered valid (i.e. no interval timing filter).

RESULTS

Abundance Estimates

All trap abundance estimates or catch data are displayed in Table 1. The number of fish captured was presented if sample sizes precluded reasonable abundance estimation. An estimated 36% of the season’s coho salmon smolts emigrated from the six tributaries, 27% from the mainstem habitat downstream of the tributary traps but upstream of the LMS trap, and 37% emigrated from the lower most reach between the LMS and HFAC weir traps. Although age 2+ steelhead trout could not be estimated at the LMS site with a mark-recapture experiment, only 241 fish were captured, while an estimated 1918 (±382 SD) age 2+ steelhead emigrated past the lower most HFAC trap site. Two thousand and sixty-four Chinook salmon juvenile emigrants were counted at the LMS trap, and only 314 at HFAC. No mark recapture estimate was attempted for Chinook salmon in an effort to reduce handling and eliminate marking stress on a small population. Young of the year (age 0+) captures for all traps and salmonid species are displayed in Table 2.

The 2007 season is the first year coho salmon emigrants were estimated at the HFAC site. This site is located within the tidally influenced area in the estuary of Freshwater Creek and thus captures the vast majority to juvenile coho emigrating from the basin. Emigrants per anadromous kilometer of stream in 2007 are 0.08, 0.28, and 0.40, for the TRIBS, main-stem below TRIBS and above LMS, and lower main-stem below LMS and above HFAC respectively.

Table 1. Abundance estimates (N(hat)), associated error (SD) of the estimate, of smolts and parr by group, age class, and sub-drainage in Freshwater Creek 2007. **Bold** indicates number of fish captured and is not an estimated total yield.

Trap Species / Age class	N(hat)	SD
Lower Mainstem		
Steelhead 1+	3715	±835
Steelhead 2+	**241**	**NA**
Cutthroat 1+	**65**	**NA**
Cutthroat 2+	686	±289
Coho 1+	3685	±266
McCready Gulch		
Steelhead 1+	**18**	**NA**
Steelhead 2+	**0**	**NA**
Cutthroat 1+	140	±38
Cutthroat 2+	152	±24
Coho 1+	73	±17
Cloney Gulch		
Steelhead 1+	**513**	**136**
Steelhead 2+	**5**	**NA**
Cutthroat 1+	**9**	**NA**
Cutthroat 2+	**16**	**NA**
Coho 1+	508	± 15
Graham Gulch		
Steelhead 1+	270	± 68
Steelhead 2+	**11**	**NA**
Cutthroat 1+	**0**	**NA**
Cutthroat 2+	**10**	**NA**
Coho 1+	73	±8
Upper Mainstem		
Steelhead 1+	260	± 16
Steelhead 2+	80	± 14
Cutthroat 1+	42	± 16
Cutthroat 2+	**8**	**NA**
Coho 1+	686	± 8
South Fork		
Steelhead 1+	60	± 21
Steelhead 2+	**9**	**NA**
Cutthroat 1+	80	±20
Cutthroat 2+	89	± 19
Coho 1+	128	± 6
Little Freshwater		
Steelhead 1+	167	± 68
Steelhead 2+	**4**	**NA**
Cutthroat 1+	**27**	**NA**
Cutthroat 2+	**21**	**NA**
Coho 1+	643	± 145
HFAC weir		
Steelhead 1+	3092	±799
Steelhead 2+	1918	±382
Cutthroat 1+	**36**	**NA**
Cutthroat 2+	527	±147
Coho 1+	5888	±504

Table 2. Age 0+ (young of the year) catches for the eight downstream migrant traps in Freshwater Creek basin.

Age 0+ Young of the Year Captures

	Cloney Gulch	Graham Gulch	HFAC weir	Little Fresh	Lower Main	South Fork	Upper Main
Coho	1571	0	2	1692	1777	2438	2056
Chinook	45	0	314	1081	2064	0	820
Trout	4	32	0	0	278	130	4134

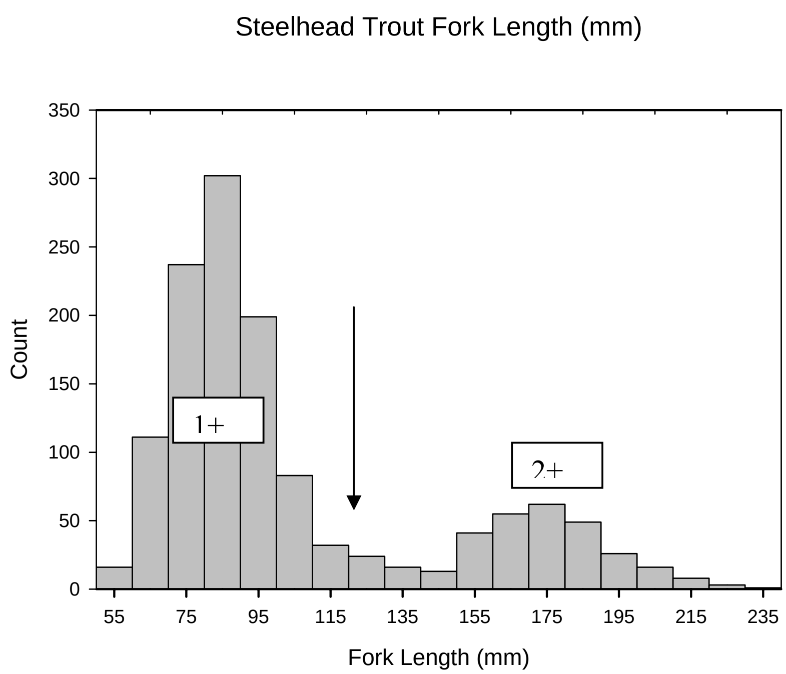

Figure 2. Length-frequency histogram of all steelhead captured. Boxes indicate age classes and arrow depicts fork length used for age class delineation.

Migration Timing

Operation of the HFAC weir juvenile trap commenced on March 16, 2007, 10 days prior to the LMS and all tributary (TRIB) trap locations. Peak catches of steelhead migrants occurred the first week of April at HFAC and TRIB traps, and the week of May 14^{th} at the LMS trap (Figure 3). Coho smolt estimated unmarked captures peaked the third week of March at the tributaries. Peak weekly estimates occurred in mid May for both the LMS and HFAC weir trap site (Figure 4). The median travel time of coho salmon emigrants down the main-stem reach 8 days, and the median travel time down the lower main-stem reach was 3 days (Figure 5).

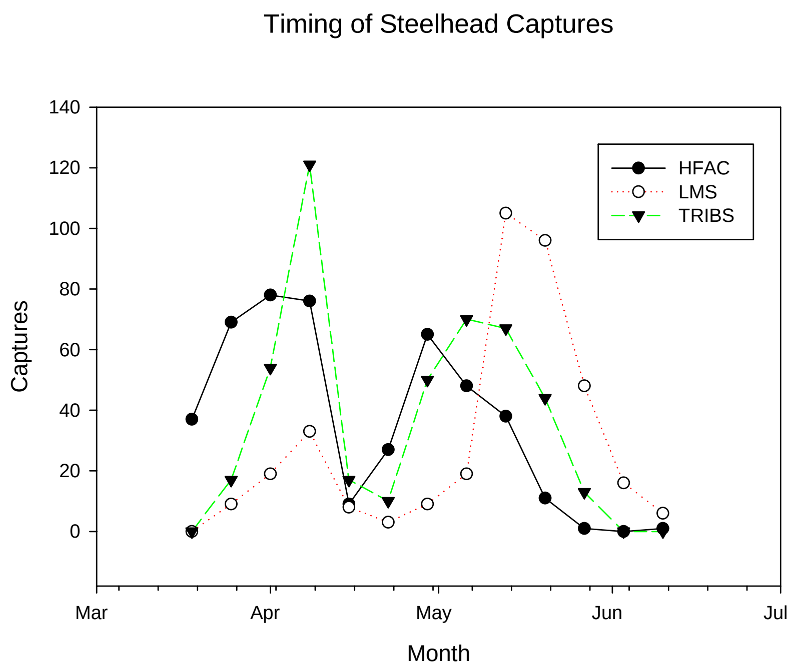

Figure 3. Timing of steelhead trout emigration at the HFAC weir, LMS, and combined tributary (TRIBS) traps, Freshwater Creek, 2007.

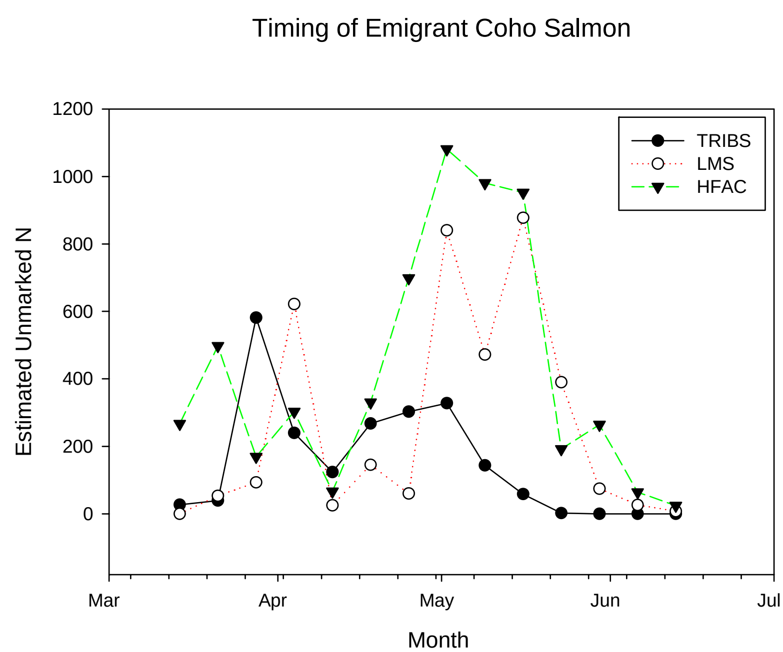

Figure 4. Timing of the estimated number of coho salmon emigrants at the juvenile downstream migrant traps, partitioned by six tributary traps combined (TRIBS), the lower mainstem (LMS) and HFAC weir (HFAC), Freshwater Creek spring 2007 .

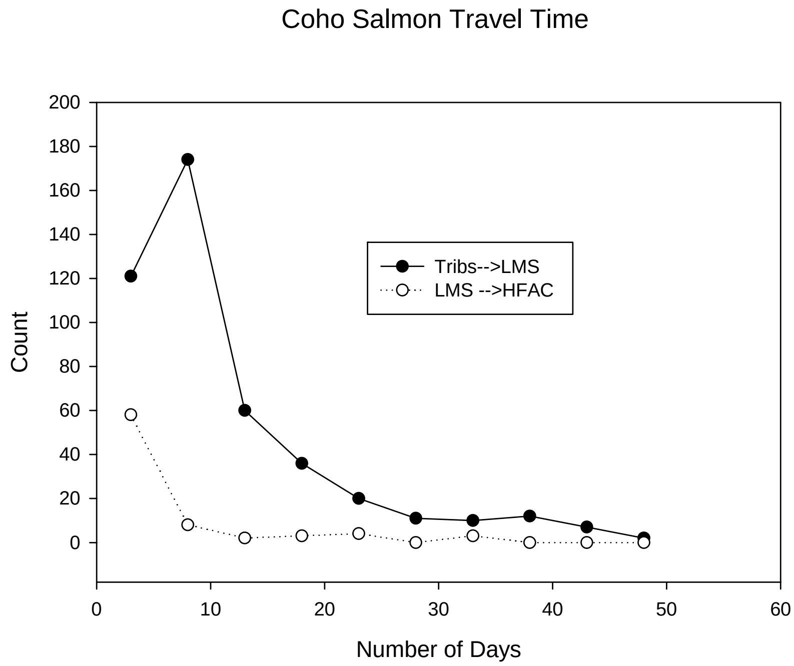

Figure 5. Distribution of travel times of individually marked coho salmon emigrants from the tributary traps combined to the LMS trap (Tribs → LMS), and from the LMS trap to the HFAC trap (LMS→ HFAC) in Freshwater Creek, 2007.

Juvenile Trout Movement

The majority of the downstream movements at the tributary antennas were coincident in time with the release of fish from the tributary DSMTs, followed by two less extensive periods of active movement at the end of June and again in the beginning of December (Figure 6A). Detections of tributary marked trout at the RFID antenna located below the LMS trap (HHL), were similar in time, but substantially fewer in number (Figure 6B).

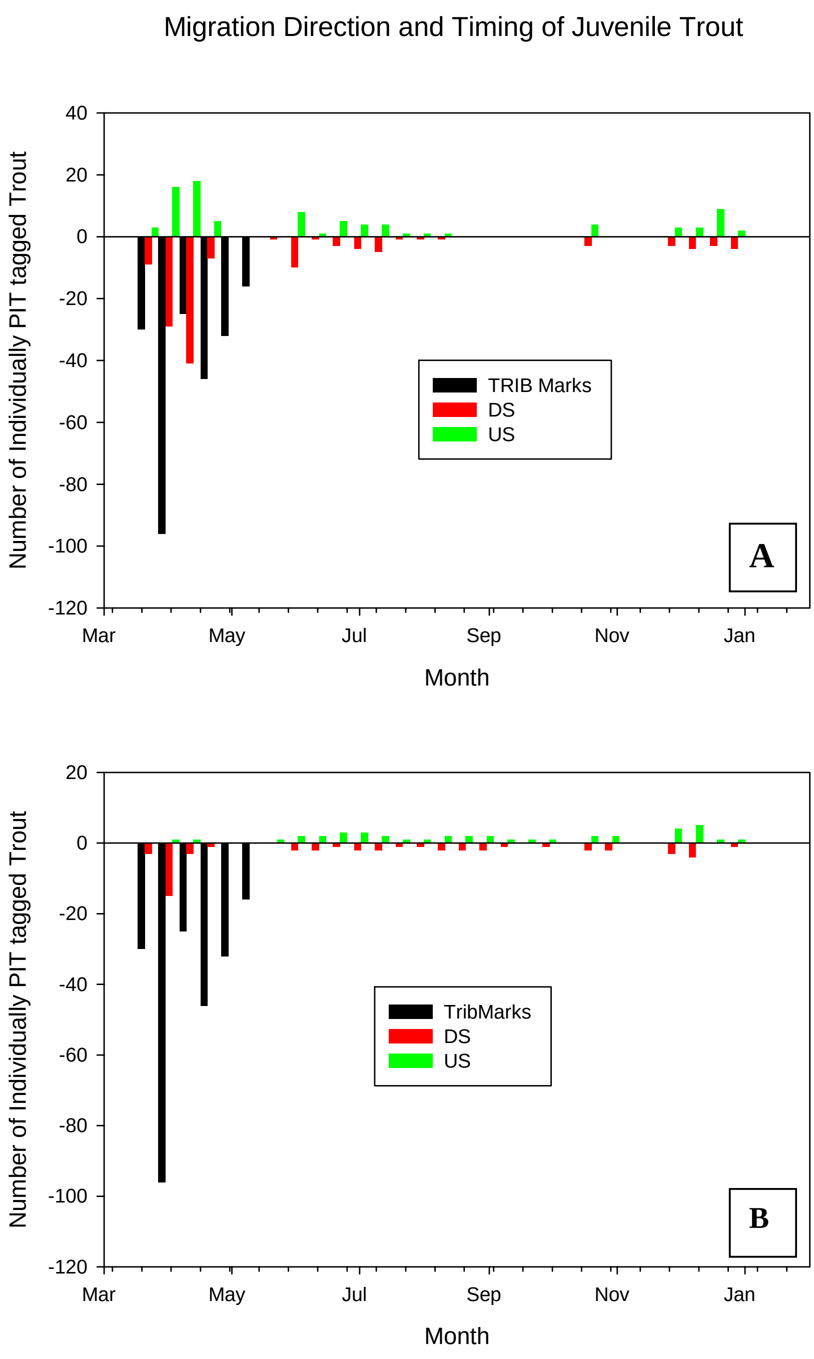

Figure 6. Migration direction and timing of individually PIT tagged trout marked at the tributary DSMT traps (Trib Marks) and recorded at the tributary antennas (A) and at the HHL antenna (B). Negative y-axis values indicate a downstream movement and positive y-axis values indicate an upstream movement.

Length and Migrant Stage of Steelhead and Coho Salmon

Steelhead Fork length of steelhead from tributary creeks ranged from 53 mm from Cloney Gulch to 207mm from the upper main-stem (Figure 5). Steelhead emigrants ranged from 80 mm to 233mm in fork length at the HFAC weir. Steelhead smolt, pre-smolt and parr migrant stages averaged 178 mm, 94 mm and 81 mm in fork length respectively (Figure 7).

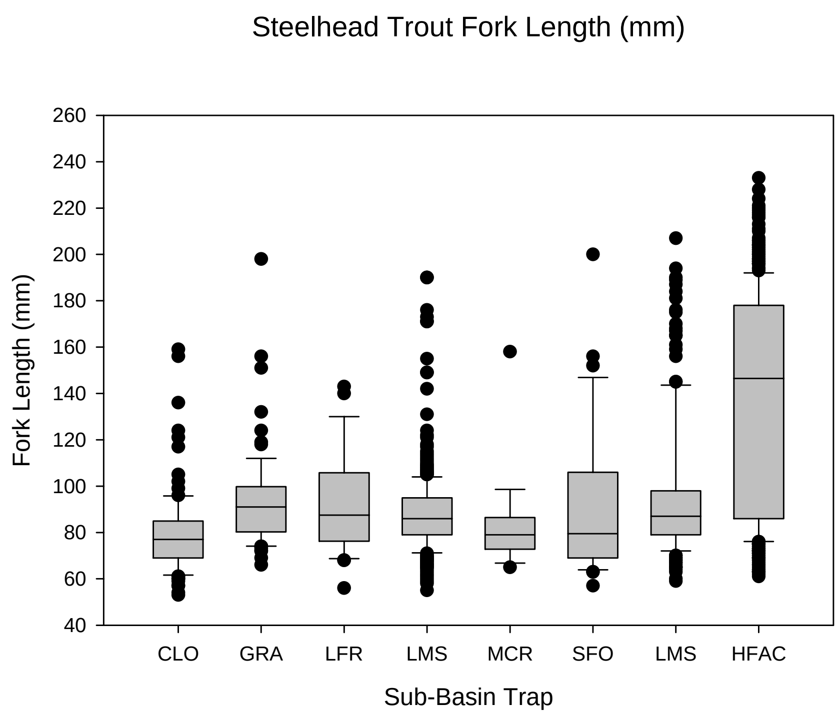

Figure 7. Comparison of fork lengths of measured steelhead from each tributary trap. Box plots depict 25th, 50th, and 75th percentiles, whiskers depict 10th and 90th percentiles, and points indicate outliers, 2007.

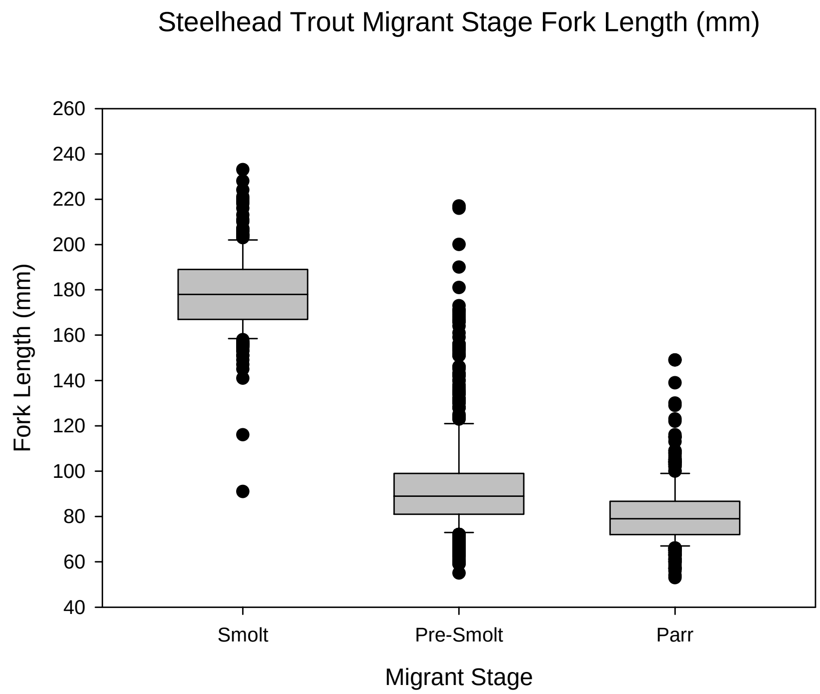

Figure 8. Comparison of fork lengths of measured steelhead categorized by migrant stage. Box plots depict 25th, 50th, and 75th percentiles, whiskers depict 10th and 90th percentiles, and points indicate outliers, 2007.

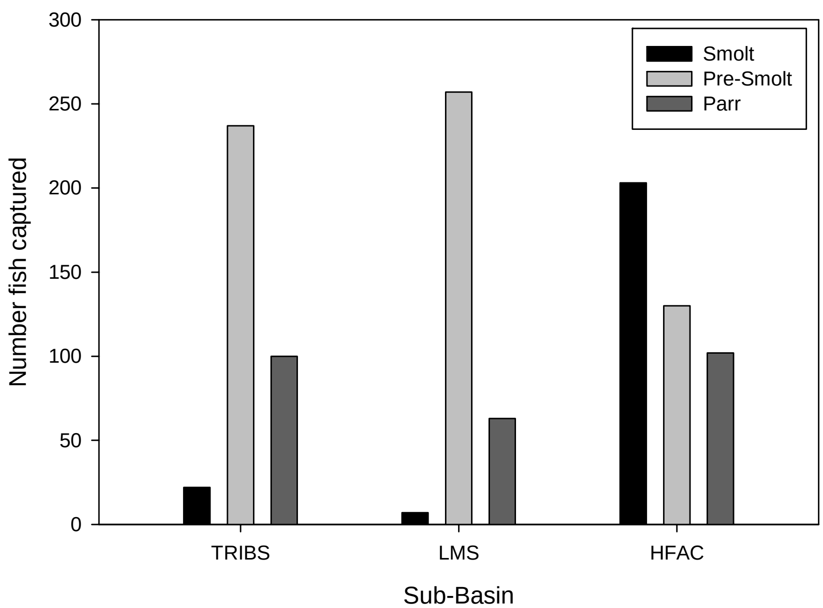

Figure 9. Number of captured Smolt, Pre-Smolt and Parr steelhead trout by sub-basin, Freshwater Creek 2007.

Coho Salmon: Fork lengths of coho salmon captured at the tributary traps ranged from 54 mm to 137 mm with a mean of 95 mm. Fork lengths of coho salmon captured in the Lower Main-Stem (LMS) ranged from 60mm to 126mm with an average of 98 mm. Fork lengths of coho salmon captured in the HFAC weir trap (HFAC) ranged from 49 mm to 145 mm with an average of 105 mm (Figure 10).

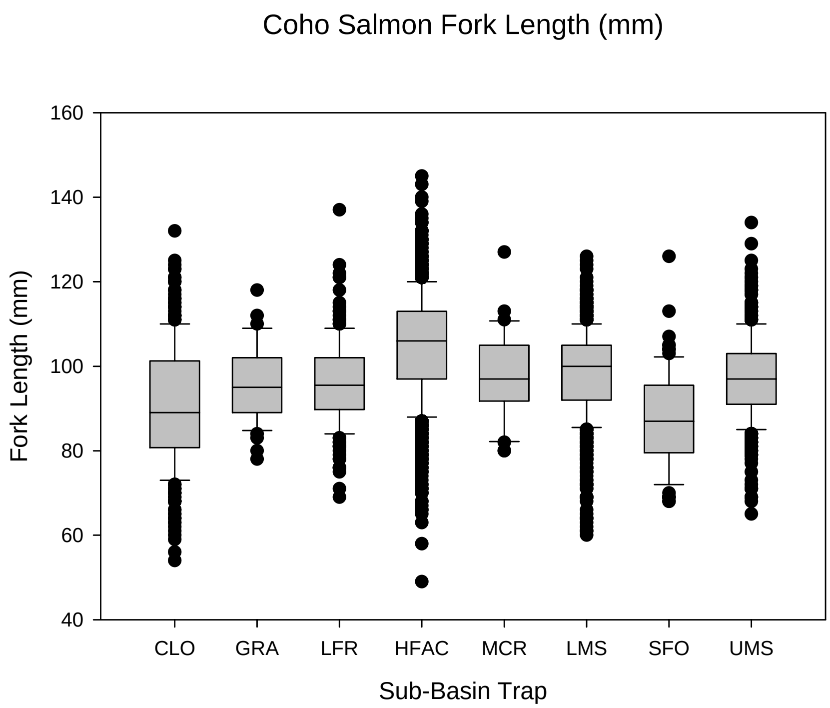

Figure 10. Comparison of fork lengths of measured coho salmon smolts captured at each trap. Box plots depict 25th, 50th, and 75th percentiles, whiskers depict 10th and 90th percentiles, and points indicate outliers, 2007.

DISCUSSION

Estimates of juvenile coho salmon spring emigrants have remained relatively consistent over 7 years about 3000 fish (range 2376-3685) at the LMS site. Study year 2001 is an exception to this consistent yield where nearly double the number (6080) of fish were estimated (Figure 11). The number of coho salmon emigrating from the tributaries is a relatively consistent fraction (46%-63%) of the fish estimated emigrating from the main-stem with the exception of 2003 when the TRIBS estimate was only10% of the LMS estimate (Figure 11).

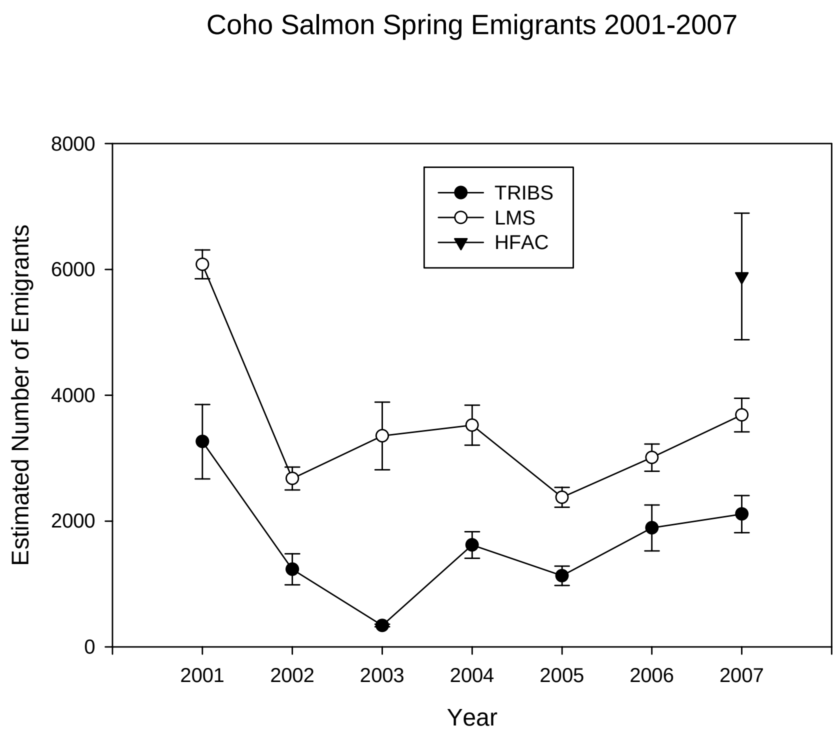

Figure 11. Estimates of the number of coho salmon emigrants from all tributaries combined (TRIBS), the lower main- stem (LMS) from 2001-2007 and the HFAC site for 2007 in Freshwater Creek.

The number of age 1+ coho salmon emigrating from the lower main-stem constituted 37% of the entire basin yield with 44%, and 400% greater density of emigrants per km than the main-stem and tributary sub-basins respectively. The size of coho salmon emigrating from this section of Freshwater Creek was larger and the first peak in emigration timing was earlier, than those fish emigrating from upstream areas. The average size of steelhead trout emigrating from the lower main-stem habitat was larger than the two upstream sub-basins, and comprised nearly 88% of the smolts captured in all traps.

These data suggest the lower main-stem habitat comprising only 16.7% of the anadromous freshwater habitat surveyed by the study is very important to both the quality and quantity of both steelhead trout and coho salmon smolts in Freshwater Creek.

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