ABUNDANCE OF JUVENILE SALMONIDS IN TRIBUTARIES ON THE HOOPA VALLEY RESERVATION, 2015-16

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ABSTRACT

In 2015 and 2016, out-migrating anadromous fish were monitored using fyke traps deployed on six tributaries located on the Hoopa Valley Indian Reservation (Reservation): Tish Tang, Campbell, Supply, Hostler, Mill, and Soctish creeks. The purpose of this study was to analyze data from trapping efforts to quantify juvenile anadromous salmonid abundance and compare results to similar data gathered in previous years. All creeks sampled are tributaries to the Trinity River.

Annual expanded catch estimates of juvenile salmonids across all tributaries ranged from 9 to 70,182 for Chinook salmon, and 8 to 18,270 for steelhead. There were less than 20 Coho salmon were captured in each of three creeks in 2015 and two creeks in 2016.

The largest abundance of Chinook salmon out-migrants were produced in Mill, Supply and Tish Tang Creeks; these creeks represented 98% of the expanded catch of emigrants. Mill, Supply and Tish Tang Creeks were responsible for 86% and 93% of the expanded catch of steelhead emigration in 2015 and 2016 respectively. There were Coho salmon caught in Campbell, Hostler, and Supply Creeks in 2015 and Mill and Supply Creeks in 2016.

TABLE OF CONTENTS

TABLE OF FIGURES

LIST OF TABLES

INTRODUCTION

Background

Salmon and steelhead populations in the western United States have declined in the past century, due to habitat loss (Burgner 1999, Moyle 2002). In order to track decline or recovery of fish populations in response to changing habitat conditions, it is necessary to monitor trends in abundance of fish populations. Fisheries biologists have often assessed the status of anadromous salmonid populations by estimating the abundance of out migrating juvenile salmonids (Everest and Sedell 1984, Reeves et al. 1991). This is perhaps the most direct measure of the influence of freshwater habitat on the spawning and rearing success of anadromous salmonids. To monitor juvenile anadromous salmonid abundance, researchers have typically employed rotary screw traps (Thedinga et al. 1994, Polos 1997), weirs (Dempson and Stansbury 1991, Mullins et al. 1991, Polos 1997), inclined plane traps (Healey 1979, DuBois et al. 1991), and fyke nets (Davis et al. 1980, Milner and Smith 1985).

The outmigration of juvenile salmonids in streams of the Hoopa Valley Indian Reservation (Reservation) has been monitored by Hoopa Valley Tribal Fisheries Department (Department) in 1985, 1986, 1990, and annually from 1992 through 2016, primarily using fyke nets (HVT Fisheries 1997, Logan and Zajanc 2002, Green 2004, Alvarez 2009, Alvarez 2010, Alvarez 2011, Alvarez 2013, Alvarez 2014). Salmonid species inhabiting streams of the Reservation include Chinook salmon (*Oncorhynchus tshawytscha*), Coho salmon (*Oncorhynchus kisutch*), and steelhead (*Oncorhynchus mykiss*). Prior to 1997, streams typically sampled included Mill, Supply, Pine, and Tish-Tang Creeks. From 1997 through 2016, Campbell, Hostler, and Soctish Creeks were sampled in most years in addition to the streams sampled prior to 1997 (Table 1). In 2012 a passage project was constructed on Hostler creek at a diversion. To monitor the effectiveness of this project the trap at Pine creek was moved to Hostler creek above the diversion and this dual sampling continued through 2014. Six of these streams on the Reservation (Tish Tang, Mill, Supply, Campbell, Hostler, and Soctish Creek) are tributaries to the Trinity River while one (Pine Creek) is a tributary to the Klamath River, entering the Klamath approximately one mile below the Trinity River confluence (Figure 1). In 2003, a mark-recapture study of salmonid emigration utilizing fyke nets on streams of the Reservation was initiated to obtain estimates of juvenile salmonid abundance of these streams. This report describes methods used and results obtained during the mark-recapture study conducted during 2015 and 2016. The sampling began in February of 2015 and April of 2016 and ended in early August.

The primary objective of this project is to provide abundance estimates of out-migrating salmonids within seven tributaries located on the Reservation through the use of a mark-recapture study employing fyke nets. A secondary objective is to detect a long-term trend analysis.

Table 1. Creeks fished by year.

		Year						
		1985	1986	1990	1992-1996	1997-2012	2013-2015	2016
Creek	Campbell					X	X	
	Hostler					X	X	X
	Mill	X	X	X	X	X	X	X
	Pine	X	X	X	X	X		
	Soctish					X	X	X
	Supply	X	X	X	X	X	X	X
	Tish Tang	X	X	X	X	X	X	X

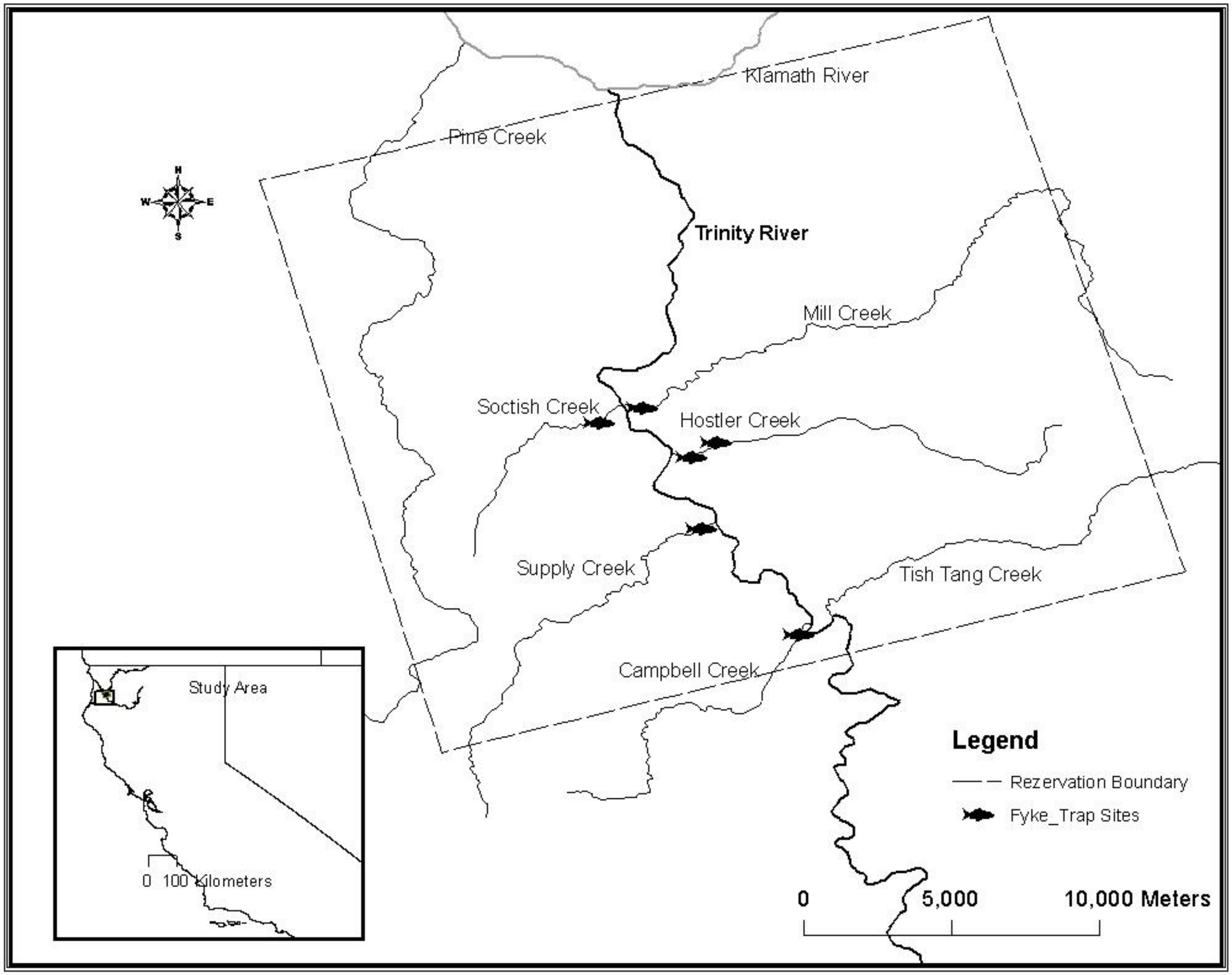

Figure 1. Map of Hoopa Valley Reservation Creeks with locations of fyke traps.

Study Area

The Reservation contains a majority of the basin areas of Tish Tang Creek, Mill Creek, Supply Creek, Campbell Creek, Hostler Creek, Soctish Creek, and Pine Creek (Figure 1). The headwaters of Mill, Supply, and Tish-Tang creeks are located within Six Rivers National Forest, while the lower regions are located on the Reservation. The headwaters of Supply Creek are located on privately owned commercial timberland. Although the majority of Pine Creek flows through the Reservation, the lower three miles are located outside the Reservation boundary.

Drainage areas for monitored tributaries range from 6.9 to 49.2 square miles (Table 2). East-side drainages of the Trinity River (e.g. Tish Tang, Hostler, Mill Creek basins) differ from west-side drainages (Campbell, Soctish, and Supply Creek basins) in elevation and geology (Franklin 1995). West-side drainages are typically under 1,000 m in elevation and are composed of fine-grained meta-sedimentary formations, whereas east-side drainages are up to 1,500 m in elevation and are composed of granite and Franciscan mélange. Tish Tang, Mill, Supply, Campbell, Hostler, and Soctish creeks enter the Trinity River from eight to 17 miles upstream of the confluence with the Klamath River. Orographic effects are responsible for a large variability in rainfall, with annual rainfall ranging from an average of 49 inches at lower elevations to 98 inches at higher elevations (Franklin 1995).

The predominant anadromous species utilizing these streams are Chinook salmon and steelhead. Steelhead are common among all seven tributaries, while Chinook salmon are generally more abundant in the larger tributaries (Franklin 1995). Other species inhabiting these streams include three spine stickleback (*Gasterosteus aculeatus*), Pacific lamprey (*Lampetra tridentata*), suckers (*Catastomus spp.*), sculpins (*Cottus spp.*), speckled dace (*Rhinichthys osculus*) and recently German brown trout (*Salmo trutta*).

Table 2. Watershed Areas in square miles.

Creek	Watershed Area (sq. mi.)
Campbell	6.9
Hostler	10.4
Mill	48.0
Pine	49.1
Soctish	9.3
Supply	16.5
Tish Tang	29.9

MATERIALS AND METHODS

Trapping

In 2015 and 2016 traps were monitored from late February or Mid April through August depending on the year and condition of the creek sampled. Generally traps were installed on Monday, and captured fish were processed Tuesday through Friday. Traps were stored on the stream banks for the weekend after the fish were processed on Friday. Some sampling days were missed due to high stream discharge and difficult sampling conditions (e.g. periods in which large volumes of debris enter the traps). A single trapping day encompassed the time from trap deployment in the morning or afternoon to trap check the following day. This sampling period was selected to allow fishing during evening and night hours when most juvenile salmonids migrate (McDonald 1960, Reimers 1973).

One fyke trap was installed per creek with each trap installed within a half-mile of the creek mouth. Each fyke net had a steel 5-foot x 5-foot frame opening with 20 feet of mesh netting (ten feet of 3/8 inch X 5/8 inch mesh followed by ten feet of 1/4 inch mesh) leading to the trap via a 6-5/8 inch diameter PVC pipe (Figure 2). The traps were generally deployed near the edge of the thalweg during higher flows. However, as stream flows decreased throughout the season, traps were re-positioned toward the middle of the thalweg to sample the greatest amount of flow possible. Ropes were used to secure the frame of the fyke net to a rope tied across the channel.

Biological Sampling

Captured juvenile salmonids were transferred from fyke net traps to five-gallon plastic buckets where they were anesthetized with MS-222 to minimize handling stress. Salmonids

Figure 2. Fyke net set up in Campbell Creek.

were identified by species, inspected for marks, and enumerated. If fewer than 30 fish per species per category (new mark, no mark, recapture) were captured, all captured Chinook salmon, Coho salmon, and steelhead trout were measured (fork length). Otherwise a sub-sample of 30 fish per species per category was measured. Marking occurred on alternating weeks with three creeks being marked each week. The creeks were grouped so that Campbell, Mill and Supply creeks were marked on one week and Hostler Soctish, and Tish Tang creeks were marked the following week. The alternating of creeks by week reduced handling of emigrating fry while still allowing population estimates using a Bayesian spline method to interpolate between weeks (Schwarz et al 2009). Steelhead and Chinook were marked by clipping either the upper or lower caudal fin with the marks. These marks were rotated on a two week cycle so that both groups had upper caudal clips and then both groups had lower caudal clips. Egg-sac fry and Coho salmon were not marked. Marked fish were released at least one riffle/pool sequence upstream from the trap, typically within a pool, eddy or backwater habitat. Unmarked fish were released downstream from the trap, typically within an eddy or backwater habitat. For each species, the number of captured fish was recorded. For Chinook and steelhead, the number of marked fish and the number of recaptured fish was recorded.

ANALYSIS

Salmonid Age Class Composition

Age class composition of the catch of each species was determined for each month using length-frequency analysis. For each species, fork length data for all creeks were pooled and ordered from smallest to largest for each month sampled. Length measurements were grouped by length categories (Table 3). Numbers in each category were plotted. Breakpoints between year classes were determined based on low points in the length-frequency histograms (Jearld 1983), and on discontinuities (gaps) in the sequence of lengths from smallest to largest.

Table 3. Fork length categories for age class analysis in mm.

0-30
31-40
41-50
51-60
61-70
71-80
81-90
91-100
101-110
111-120
121-130
131-140
141-150
151-170
171-190

Weekly Expanded Catch

Weekly expanded catch $\hat{C}_{ew}$ was estimated for each week of sampling as:

$$\hat{C}_{ew} = \frac{C}{p} \tag{1}$$

where C is the total weekly catch for a particular species and p is the proportion of days sampled in a particular week. To analyze seasonal trends, the weekly expanded catch was plotted against calendar week for each year and species. Weekly expanded catch was referred to as "weekly abundance index" in a previous report (Logan and Zajanc 2002).

For each field season, seasonal expanded catch $\hat{C}_{es}$ was estimated based on the sum of weekly abundance indices obtained from mid-March to mid-July. This time period was selected so that estimates were comparable across years as the dates for initiation and completion of trapping varied inter-annually. The seasonal expanded catch was estimated as:

$$\hat{C}_{es} = \sum_{i=1}^{W} \hat{C}_{ew} , \tag{2}$$

where W is the total number of weeks sampled for every trapping week within a given year, and $\hat{C}_{ew}$ is the weekly expanded catch for the *i*th week sampled.

<u>Salmonid Abundance</u>

Estimates of abundance were derived using a mark recapture technique on out-migrating salmonids. Population estimates were calculated using a Bayesian Spline method (Schwarz 2009) for creeks that had an adequate sample size to accurately calculate trap efficiency.

For purposes of analysis, numbers of marked steelhead and Chinook were pooled for a common M, and numbers of recaptured steelhead and Chinook were pooled for a common R. This pooled trap efficiency was applied to the estimates so that there were never more recaptured fish than marked fish. A preliminary analysis showed no pattern of consistently greater or lesser trap efficiency (R/M) for Chinook or steelhead; steelhead trap efficiency was equally likely to be equivalent to Chinook trap efficiency. This is expected, as both salmonid species were captured primarily as fry; there is considerable overlap in behavior and habitat preference of steelhead and Chinook fry. By pooling data for the two species, greater sample sizes were derived for calculation of population estimates.

RESULTS

Abundance

Based on the expanded catch of fish in tributaries, Mill, Supply, and Tish Tang Creeks had the greatest numbers of out-migrating Chinook salmon in 2015 and 2016, accounting for at least 97% of Chinook salmon from all sampled streams (Table 4). The majority of steelhead out-migrants came from Mill, Supply, and Tish Tang Creeks, which together accounted for over 90% of the expanded catch (

Table 5). Coho salmon were found in Campbell, Hostler, and Supply Creeks in 2015 and Mill and Supply Creeks in 2016 (Table 6).

Table 4. Expanded catch and population estimates for Chinook salmon emigrants from tributaries on the Hoopa Valley Reservation during 2015 and 2016.

	2015		2016	
Creek	Expanded Catch	% of yearly total	Expanded Catch	% of yearly total
Campbell	101	0.1%		
Hostler	25	0.0%	42	0.6%
Mill	70,182	52.6%	3,358	46.7%
Soctish	2,929	2.2%	9	0.1%
Supply	18,703	14.0%	2,597	36.1%
Tish Tang	41,377	31.0%	1,184	16.5%
Total	133,317	100.0%	7,190	100.0%

Table 5. Expanded net catch for steelhead emigrants from tributaries on the Hoopa Valley Reservation during 2015 and 2016.

	2015		2016	
Creek	Expanded Catch	% of yearly total	Expanded Catch	% of yearly total
Campbell	2,409	8.3%		
Hostler	8	0.0%	22	0.1%
Mill	12,806	44.2%	18,270	53.5%
Soctish	372	1.3%	763	2.2%
Supply	1,503	5.2%	1,775	5.2%
Tish Tang	11,875	41.0%	13,331	39.0%
Total	28,973	100.0%	34,161	100.0%

Table 6. Expanded net catch for Coho emigrants from tributaries on the Hoopa Valley Reservation during 2015 and 2016.

	2015		2016	
Creek	Expanded Catch	% of yearly total	Expanded Catch	% of yearly total
Campbell	2	14.3%		
Hostler	8	57.1%		0.0%
Mill		0.0%	5	34.2%
Soctish		0.0%		0.0%
Supply	4	28.6%	10	65.8%
Tish Tang		0.0%		0.0%
Total	14	100.0%	15	100.0%

Abundance results from 2015 and 2016 were compared with results from earlier out-migrant trapping reports authored by the Hoopa Valley Tribe Fisheries Department (Alvarez 2009, Green 2004, Logan and Zajanc 2002). Chinook abundance has been highly variable over the last five years with alternating high and low abundances every other year. The recent years of low abundance are similar to low years across the long term sampling period, but the recent high abundance years are much higher than any year since 1999 in large creeks and are of similar magnitude in small creeks (Figure 3, Figure 4).

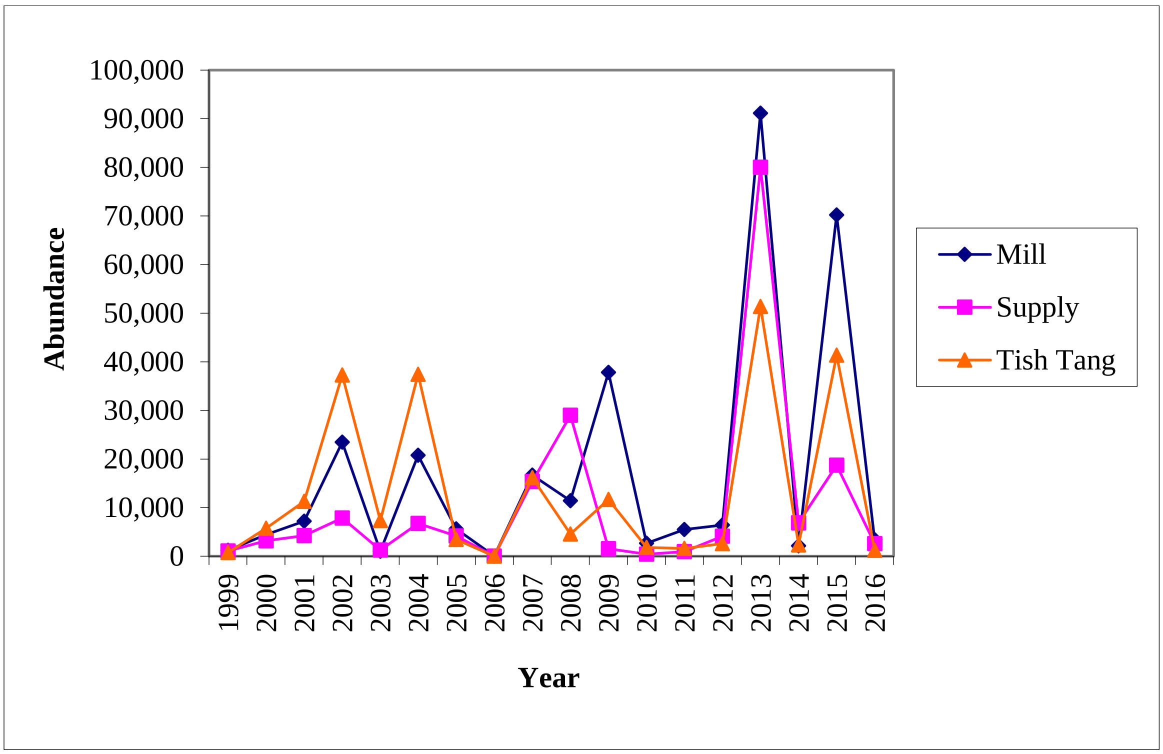

Figure 3. Chinook salmon abundance in Mill, Supply, and Tish Tang Creeks, 1999-2016.

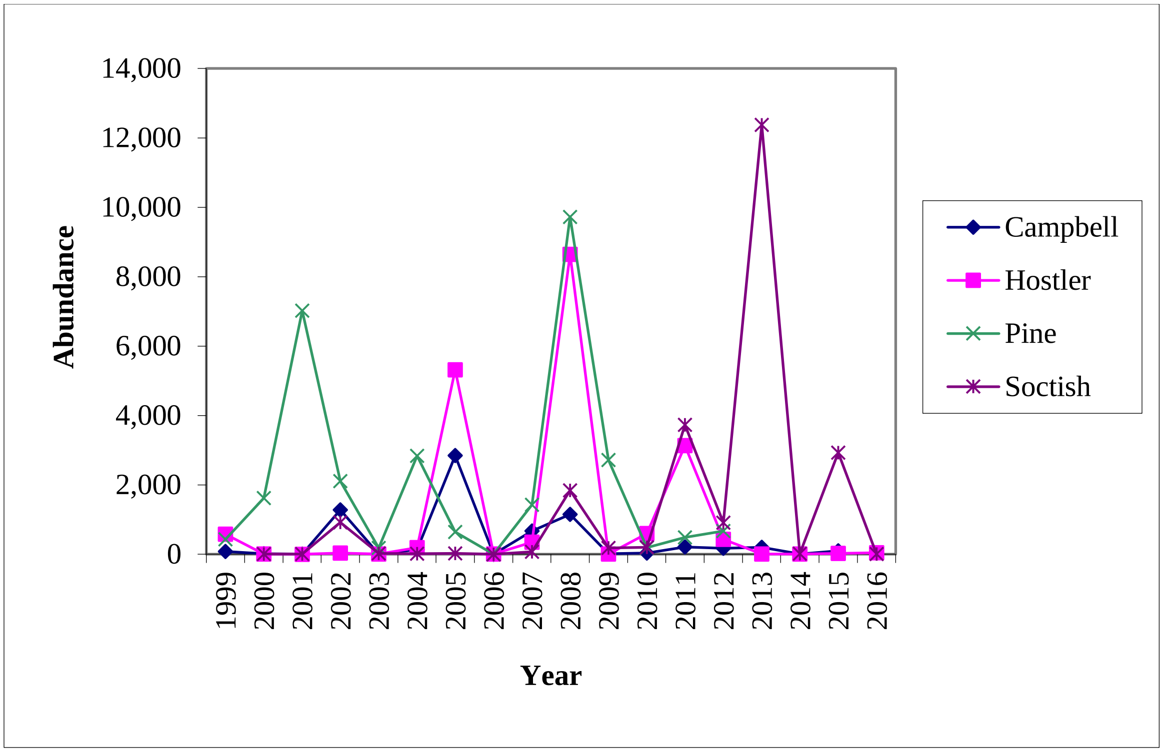

Figure 4. Chinook salmon abundance in Campbell, Pine, Soctish, and Hostler Creeks, 1999-2016.

Steelhead abundance has been climbing slowly in almost all creeks (Figure 5, Figure 6) since a four year low from 2009 to 2012. Abundance estimates still vary between years but the number of steelhead originating in creeks seems to be rebounding to levels more similar to that seen before 2008.

In general, Coho salmon are substantially less abundant in monitored streams, compared to abundance levels of Chinook salmon and steelhead trout. Coho abundance in most creeks peaked in 2002 and 2005 (Figure 7, Figure 8). Coho salmon were absent from many creeks but the creeks they are detected in change each year. In 2015 and 2016 Supply Creek was the only creek to have Coho Salmon both years.

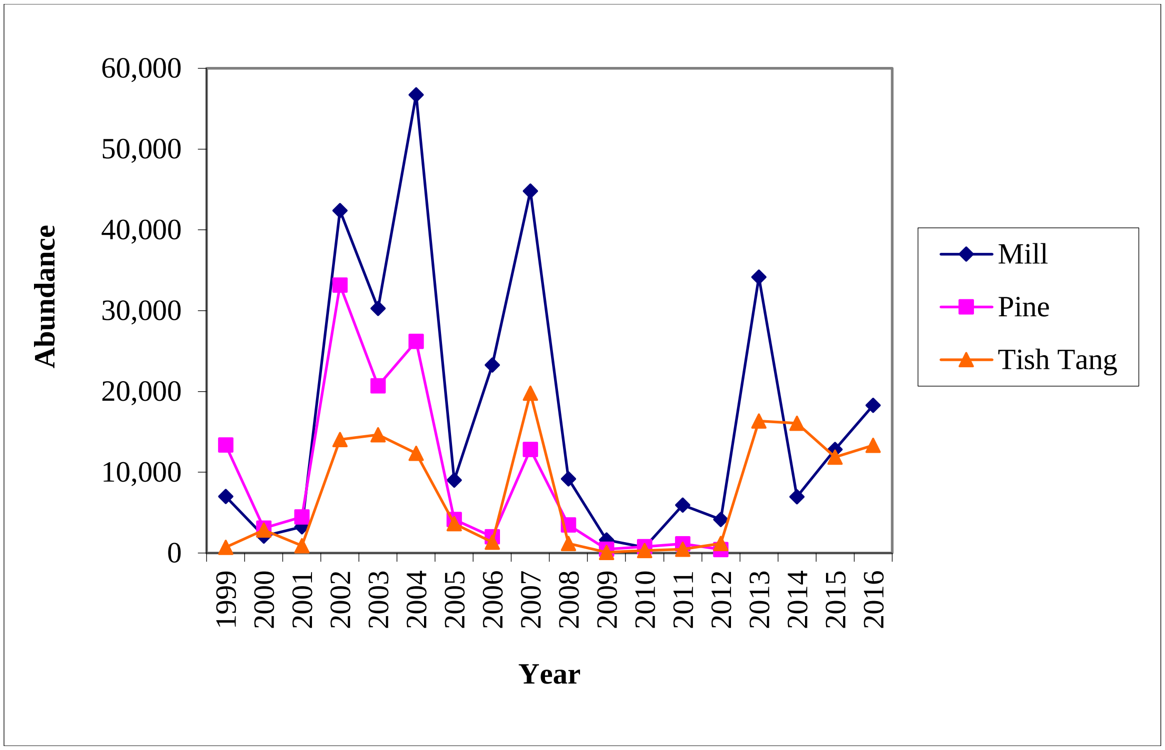

Figure 5. Steelhead abundance in Mill, Pine, and Tish Tang Creeks, 1999-2016.

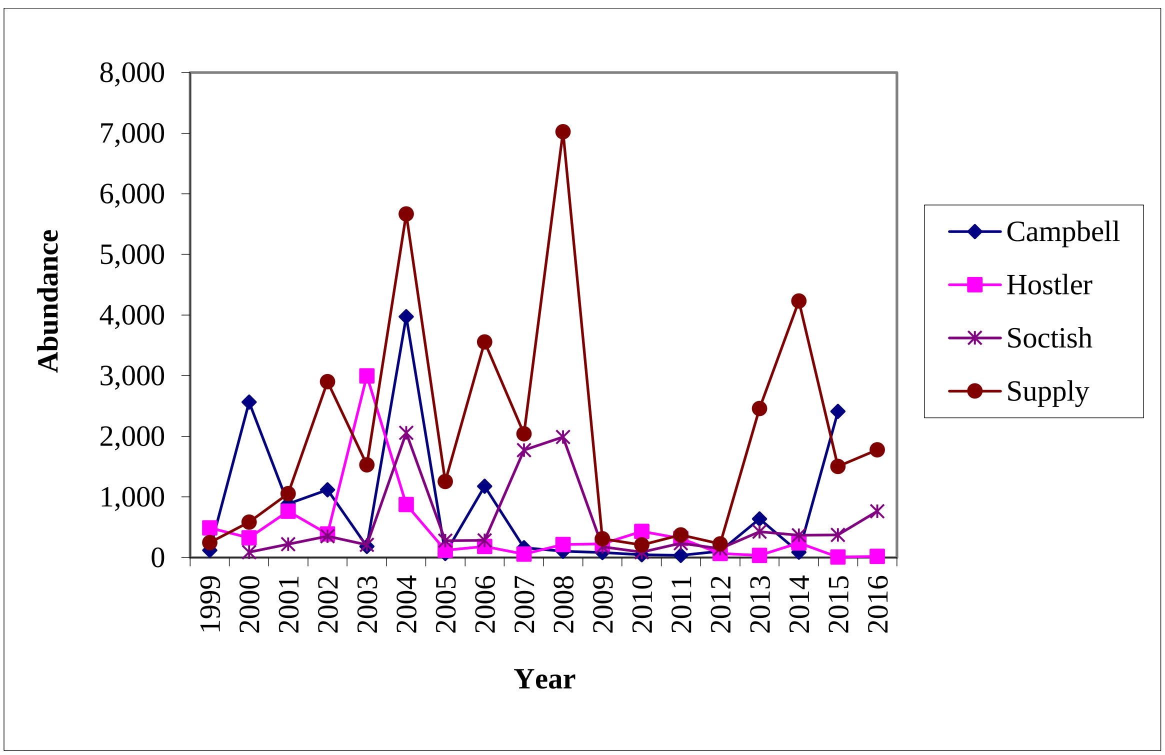

Figure 6. Steelhead abundance in Campbell, Hostler, Soctish, and Supply Creeks, 1999-2016.

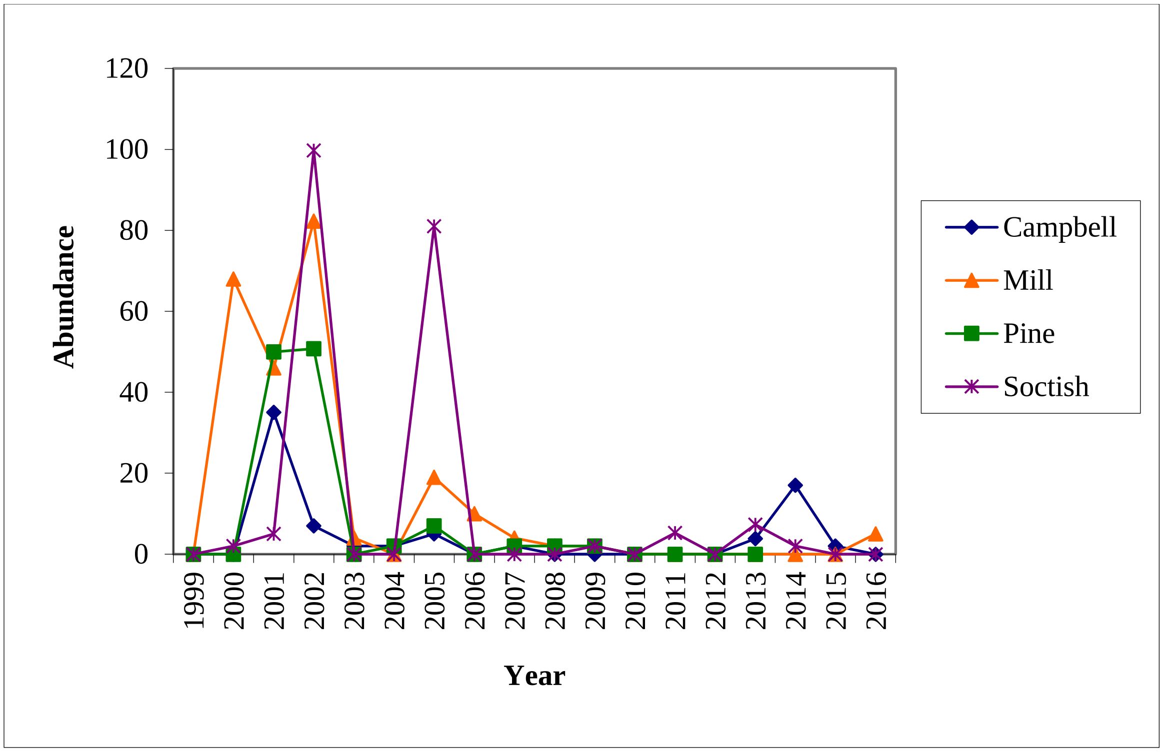

Figure 7. Coho abundance in Campbell, Mill, Pine and Soctish Creeks, 1999-2016.

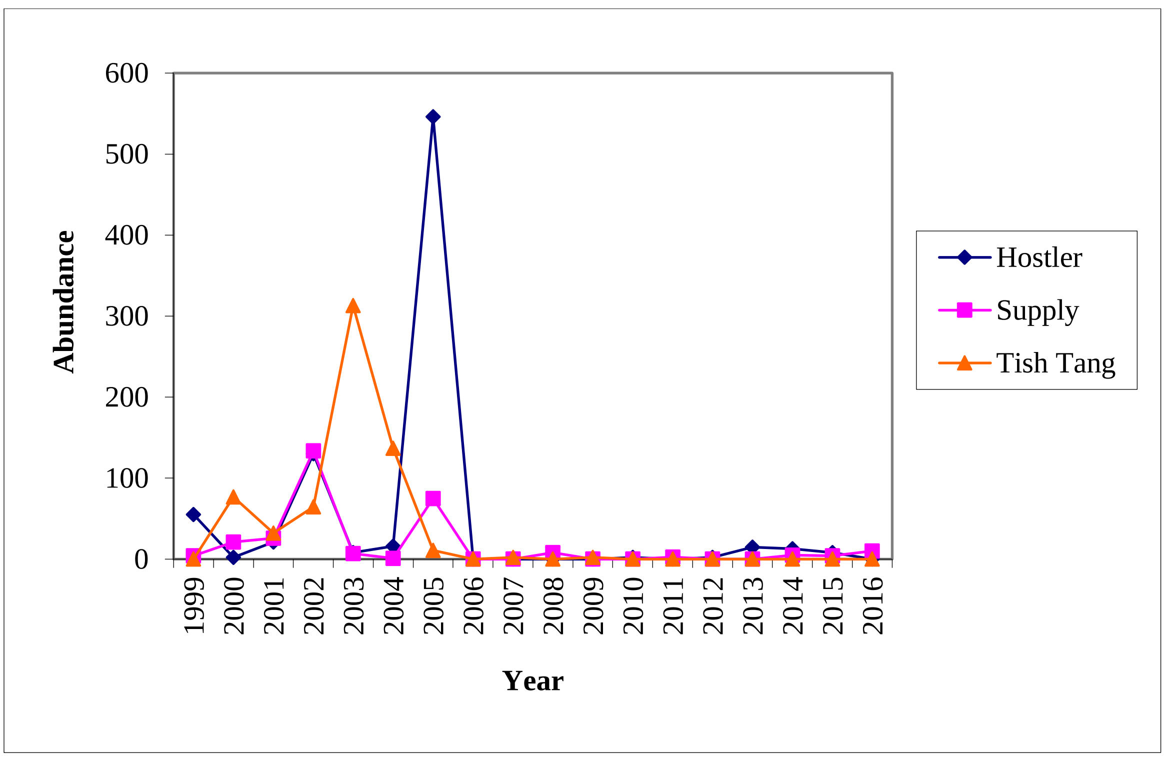

Figure 8. Coho abundance in Hostler, Supply and Tish Tang Creeks, 1999-2016.

Fork Lengths

During 2015 and 2016, fork lengths of Chinook salmon ranged from 28- 101 and 24 to 81 mm respectively (Table 8). Weekly mean fork lengths increased steadily throughout the season, as fry grew and matured. Fork length of steelhead ranged from 24 - 226 mm during 2015 and 24 to 190 mm in 2016 (Table 8). Out-migrant steelhead from these smaller streams tended to be larger when compared to steelhead from the larger tributaries.

The Coho salmon which were measured ranged from 36 – 102 mm in 2015 and 2016.

Table 7. Range of fork lengths by creek in 2015.

	Chinook		Coho		Steelhead	
Campbell	33	-65	94		24	-164
Hostler	36	-40	97	-102	74	-118
Mill	31	-92	77		24	-147
SocTish	32	-89			26	-173
Supply	30	-91	85		24	-187
TishTang	28	-101			24	-226

Table 8. Range of fork lengths by creek in 2016.

	Chinook		Coho		Steelhead	
Hostler	24	-27			26	-35
Mill	29	-84	44	-56	24	-190
SocTish	27	-45			26	-141
Supply	30	-87	36	-76	23	-160
TishTang	30	-87			21	-160

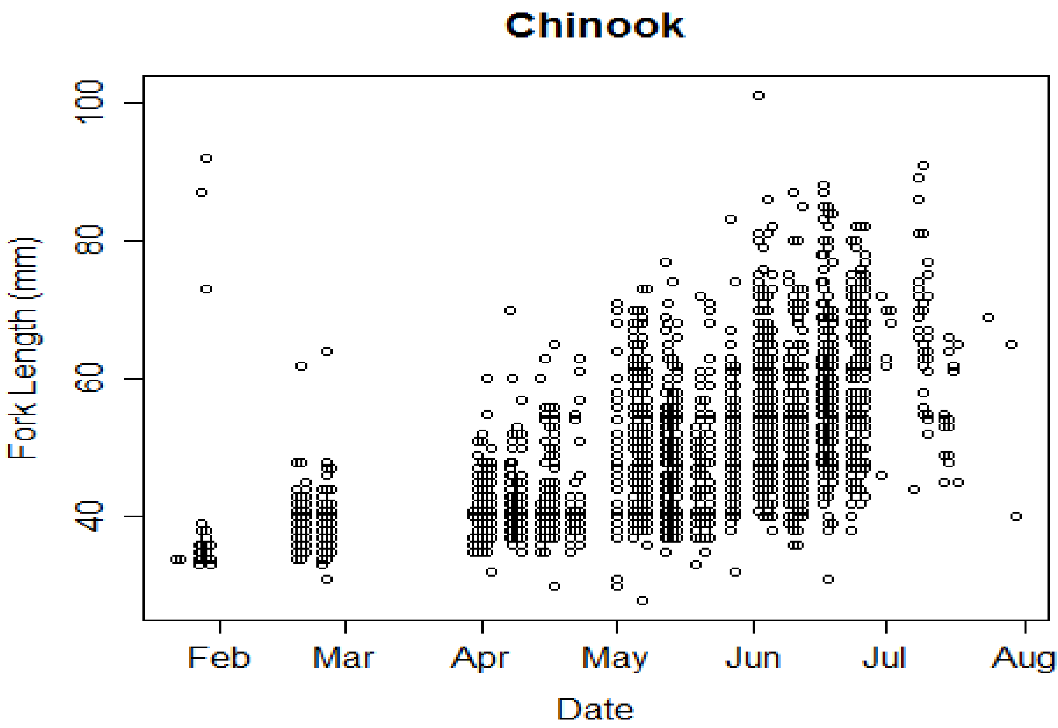

Figure 9. Fork lengths of Chinook salmon from all creeks through the 2015 trap season.

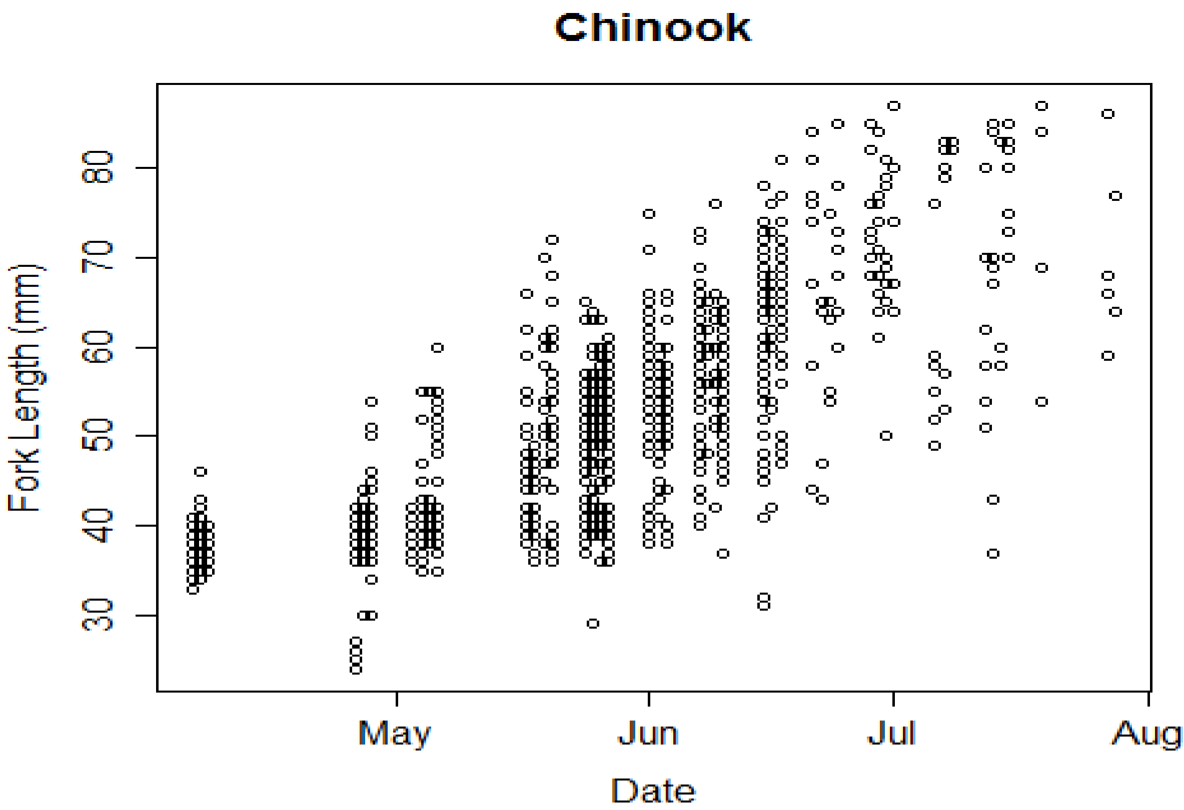

Figure 10. Fork lengths of Chinook salmon from all creeks through the 2016 trap season.

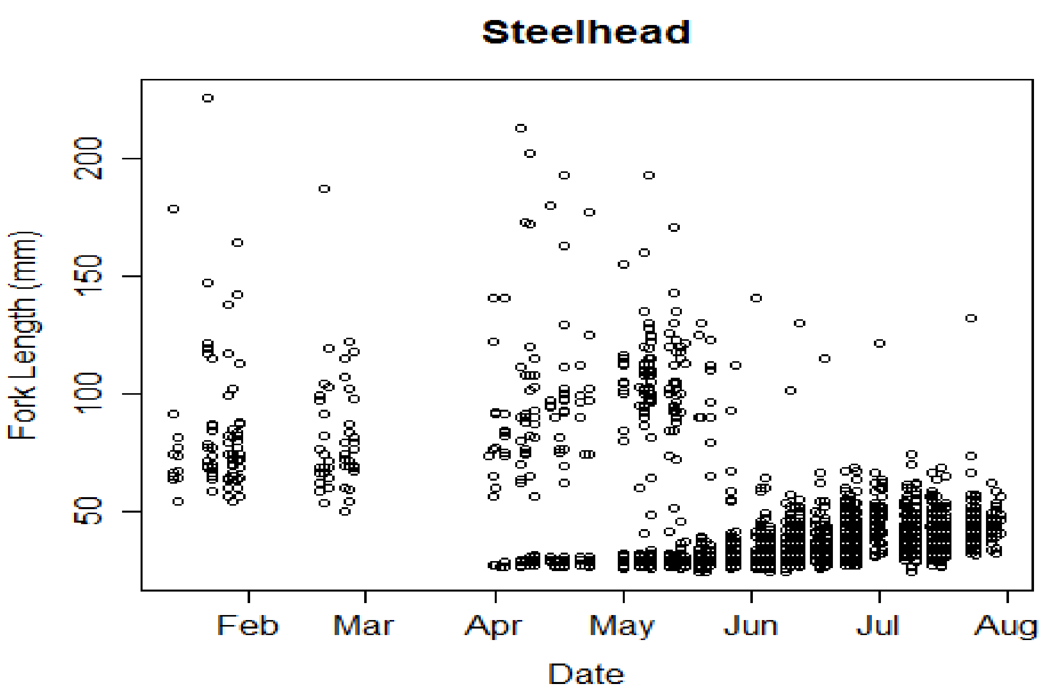

Figure 11. Fork lengths of steelhead trout through the 2015 trap season.

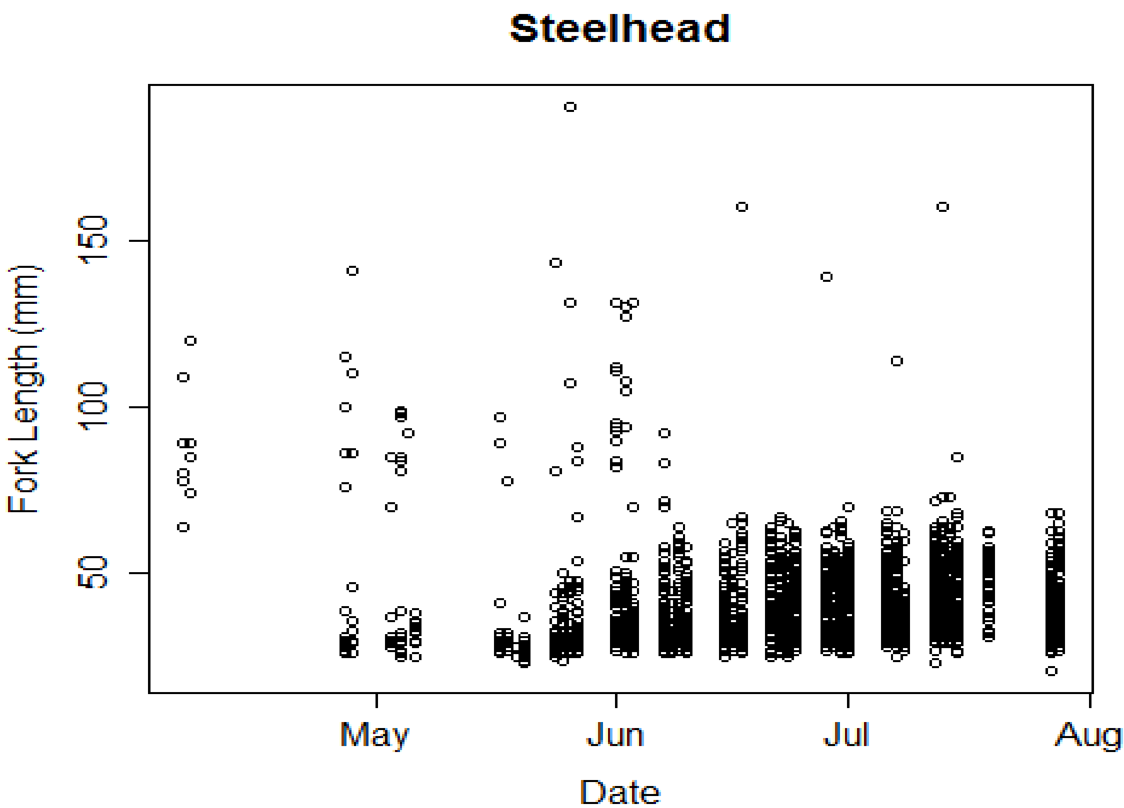

Figure 12.Fork lengths of steelhead trout from all creeks through the 2016 trap season.

Age Class Distribution

Based on an analysis of fork length data, there were three distinguishable age classes of steelhead: age 0+, age 1+, and age 2+ (APPENDIX A). However, the division between age 1+ and age 2+ steelhead by fork length was ambiguous in some months, due to insufficient sample size. Therefore, we combine two categories; the category age 1++ includes both 1+ and 2+ steelhead. Age class cut-off fork lengths dividing age 0+ from age 1++ steelhead based on examination of length-frequency plots are given in Appendix A (Table 9). The range in size of age 0+ steelhead expanded during the season due to growth of early emergent steelhead fry, but newly emerged steelhead continued to appear in the samples in large numbers through July (Appendix A). In 2014, age 1++ steelhead outmigration occurred mainly in May, then dropped off in June (Table 11). Age 0+ steelhead were present in the sampled catch during April through June, but the great majority of age 0+ steelhead out migrated from sampled streams during May, and June (Table 11).

Table 9. Age class fork length breaks for steelhead in the six creeks sampled on the Hoopa Valley Reservation in 2016.

Month	Age Class	
	Age 0+	Age 1++
February	<=40	>40
March	<=40	>40
April	<=45	>45
May	<=50	>50
June	<=70	>70

Table 10. Total number of captured steelhead in each age class for the six creeks sampled on the Hoopa Valley Reservation combined in 2015.

	0+	1++	% 0+	% 1+ +
January	0	84	0.0	100.0
February	0	49	100.0	0.0
March	1	6	85.7	14.3
April	184	77	29.5	70.5
May	830	125	13.1	86.9
June	1173	4	0.3	99.7
July	734	0	0	100

Table 11. Total number of captured steelhead in each age class for the five creeks sampled on the Hoopa Valley reservation combined by month in 2016.

	0+	1++	% 0+	% 1+ +
April	23	18	56.1	43.9
May	469	22	95.5	4.5
June	1734	20	98.9	1.1
July	1135	3	99.7	0.3

DISCUSSION

Abundance

Abundance indices were minimum estimates of out-migrants. It was assumed that fish were not captured in the fyke trap more than once. This was a reasonable assumption as unmarked and recaptured fish were typically released at least one riffle downstream of the trap. Further, as fish capture occurred in the first week of trapping, we assumed that some fish may have migrated prior to trap deployment and likely continued after trap removal.

An initial objective to estimate abundance by volumetric expansion of trap catch was terminated, due to previous research. Polos (1997) found that the relationship between trap efficiency and the proportion of stream discharge sampled can change during a particular field season, across seasons, and among different trap sites. He cautioned against using discharge-based estimates unless a relationship between trap efficiency and discharge could be verified at the trap site at varying flows and between years. Although Polos determined that the relationship of discharge to trap efficiency was not consistent, the relationship was typically found to be significant (Polos 1997). Generally, trap efficiency increased as discharge decreased.

Coho salmon are so rare during the sampling season, especially in Reservation tributaries, that population trends are untenable. When summer snorkeling has occurred in these same tributaries many more Coho salmon are detected than during the spring fyke trapping. Many of these Coho may be swimming up from the main stem Trinity River but some of them may have held over within the creek for a year. During one such dive on Supply Creek over 100 Coho salmon were counted in one pool. Despite higher numbers of juvenile Coho in 2005, which may have been an artifact of erroneous identification, than other years, data reflects little or no change in spawning effort over the years evaluated in this report. Coho were similar to most previous years in 2015 and 2016.

Chinook salmon have been fluctuating on an every other year basis for the last five years. The abundance estimates have been high on odd years and low in even years. In Mill, Supply, and Soctish Creeks the number of Chinook have hit highs unseen prior to 2012 within the period of sampling.

Steelhead trout are still generally improving over the extremely low abundances that occurred from 2009 to 2012. The number of fish is still fluctuating each year but the trend is in a positive direction in almost all surveyed creeks.

The effects of the rehabilitation on Supply Creek will likely take time to reveal itself but hopefully starting next year we will begin to see marked improvement of all salmonid species.

Salmonid Species Composition

From 2008 to 2014 there have been more Chinook in the creeks than steelhead. In these years the low was 64% in 2011 and the high was 95% in 2009. In 2015 the sampled creeks produced 83% Chinook salmon and in 2016 Chinook only made up 17%. Only Campbell Creek had more steelhead than Chinook salmon in 2015. In 2016 all creeks except Hostler Creek had more steelhead than Chinook. The relative species abundance shifts between Chinook salmon and steelhead every few years, with approximately half the years dominated by each species respectively since 1999. The percent composition ranged from 0% to 95% and 5% to 99% for Chinook and steelhead respectively. When steelhead were the more abundant species, they were abundant by a greater percentage than the Chinook. In years with more steelhead than Chinook, the relative abundance of steelhead averaged 75% of juveniles. In years with more Chinook than steelhead, Chinook relative abundance averaged 70%. When each species had a low relative abundance, steelhead had a higher average abundance then Chinook -- 29% versus 25% respectively.

Age Structure of Steelhead Juveniles

In 2015 1++ steelhead made up 10% of the total steelhead run. If sampling hadn't started until February then it would have matched 2014 with 8% of the run being holdover steelhead. In 2016 1++ steelhead only made up 1.8% of the steelhead run but sampling started later than most years so likely we missed the majority of the holdover steelhead. This is similar to most years since 2005 with two exceptions. 2009 had the highest percent of 1++ steelhead trapped at 49% and the next highest was in 2007, with 14% of steelhead a year or more old. This difference could have been due to variations in over-wintering habitat or discharge among creeks. The overall low numbers of fish in 2009 make the percentage of overwintering fish seem unusually high. The actual numbers of 2009 are only slightly higher than 2007. The lowest proportion of age 1++ steelhead prior to 2016 are in 2006 and 2011 which both only had 3% (Alvarez 2009, Alvarez 2012).

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APPENDIX A

Fork length frequency histograms by month with the seven creeks

sampled on the Hoopa Valley Reservation combined

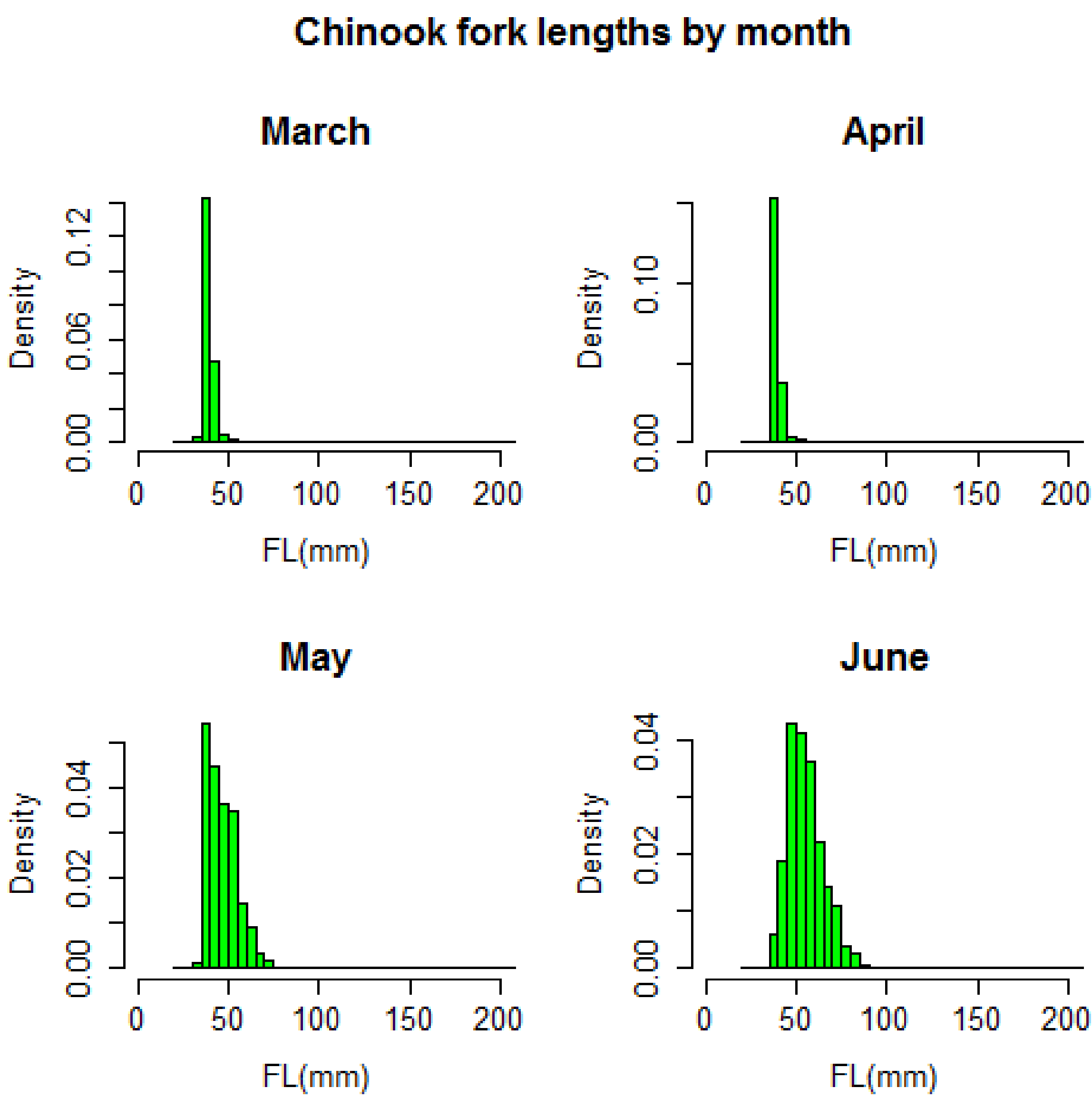

Figure 13. 2015 Chinook salmon fork length frequency histograms.

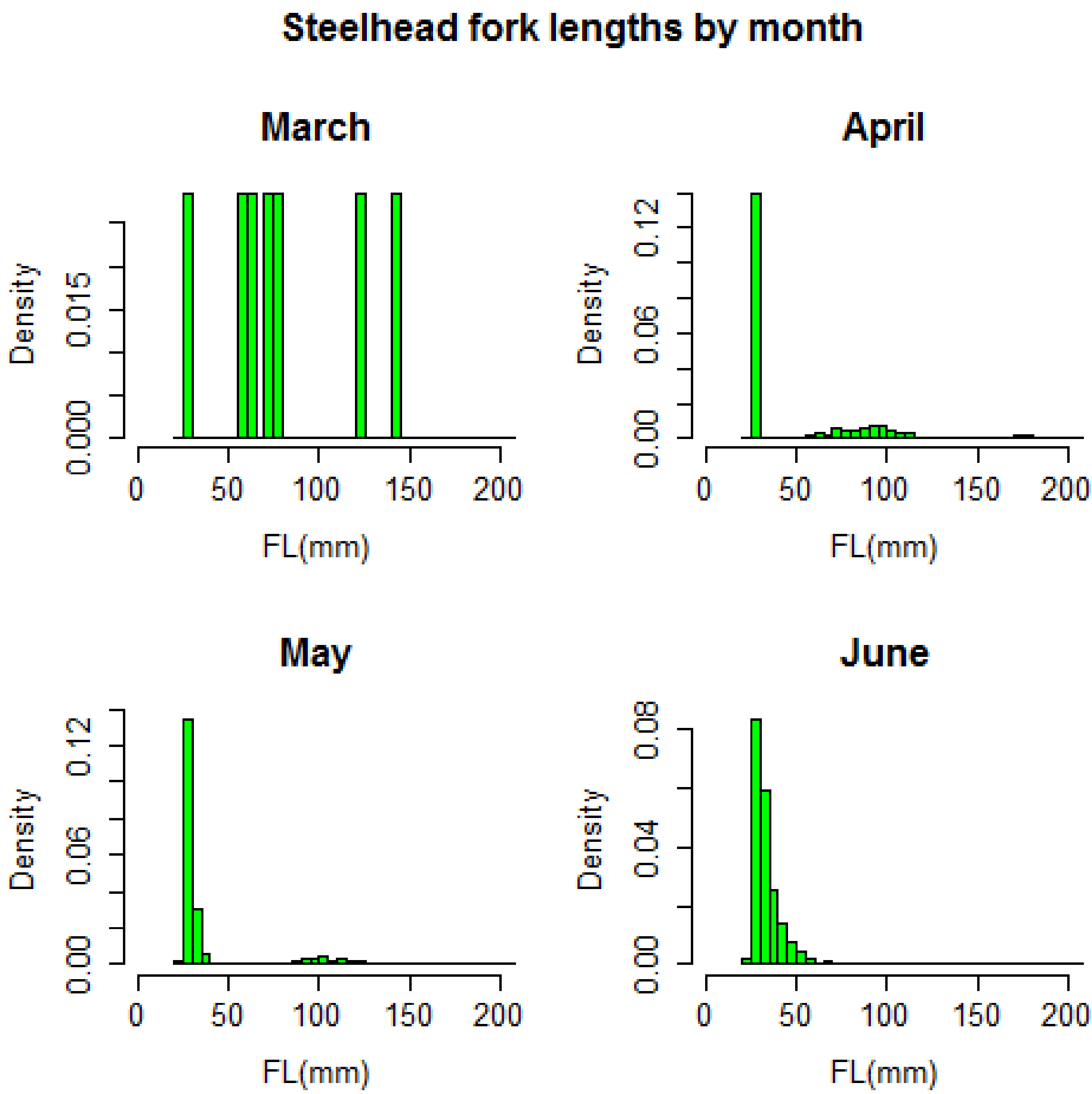

Figure 14. 2015 steelhead fork length frequency histograms.

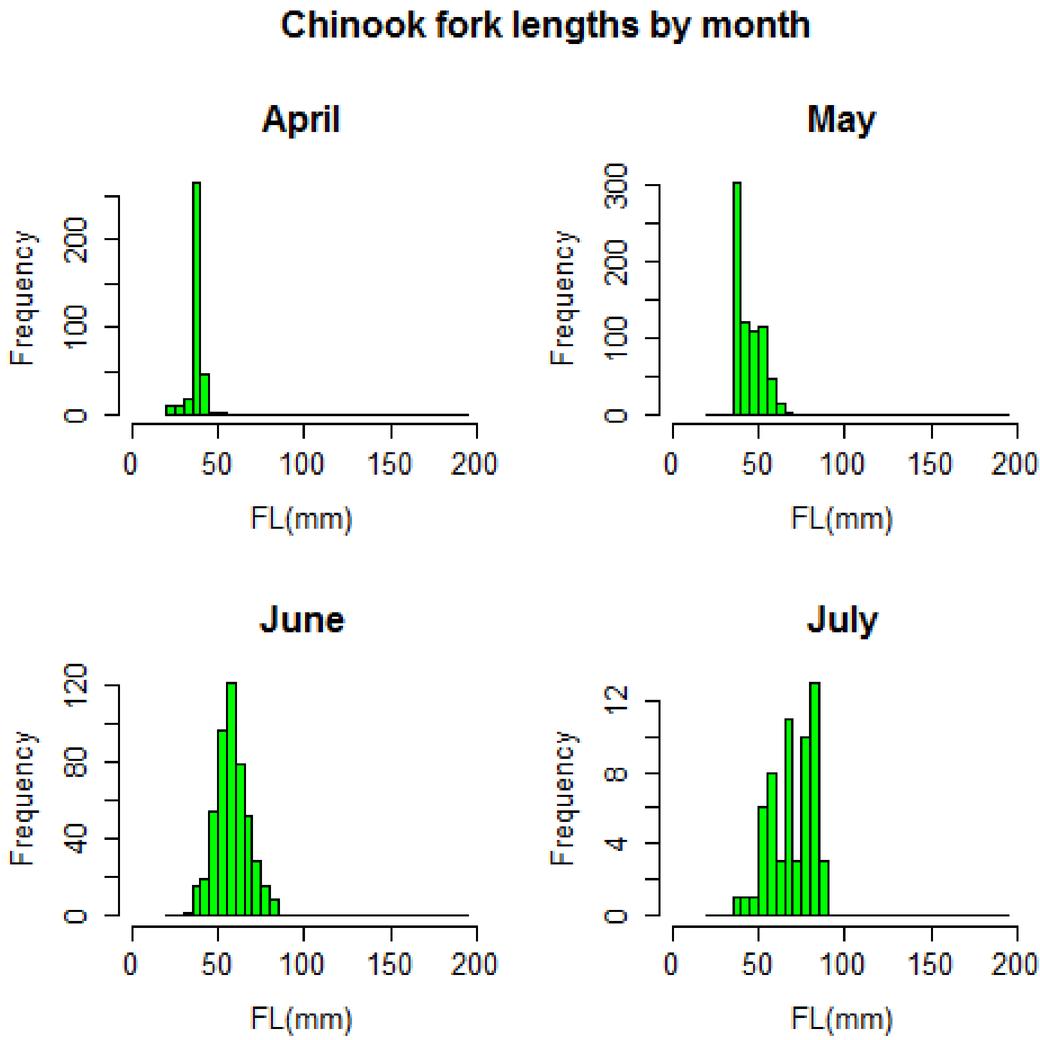

Figure 15. 2016 Chinook salmon fork length frequency histograms.

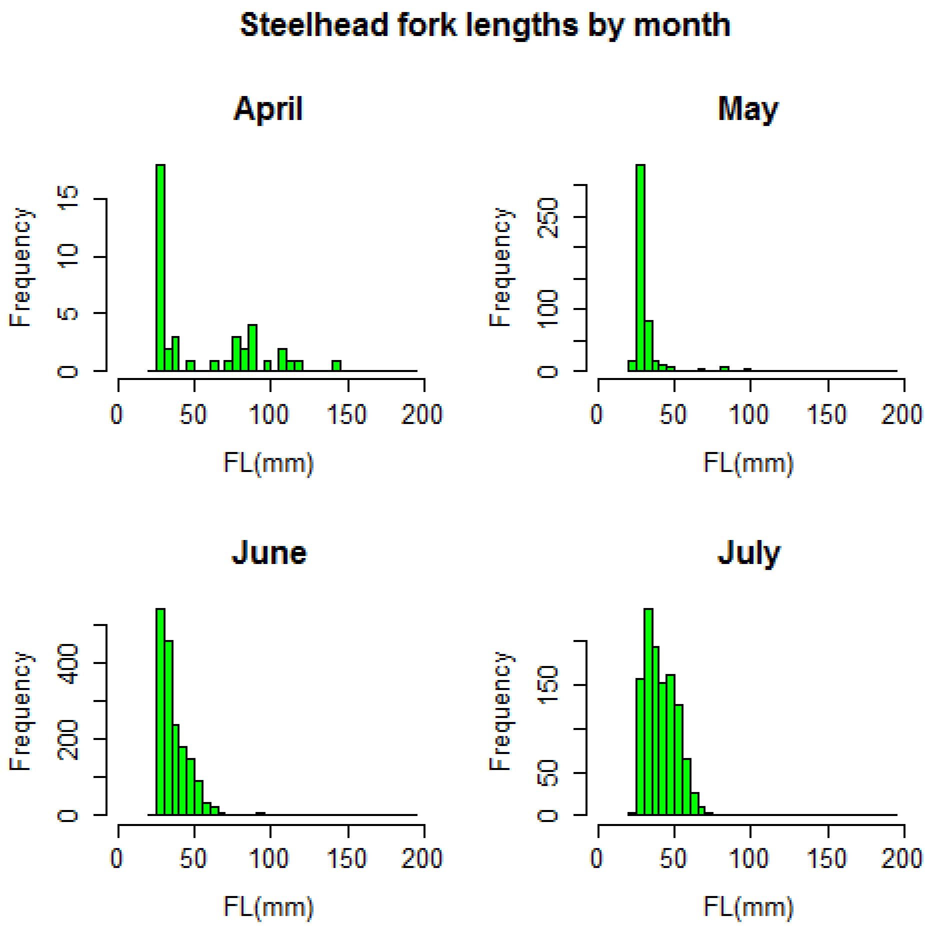

Figure 16. 2016 steelhead trout fork length frequency histograms.