State of California
The Resources Agency
DEPARTMENT OF FISH AND WILDLIFE

BUTTE CREEK
JUVENILE CHINOOK SALMON MONITORING
2015-2016 /

By

Clint E. Garman
North Central Region
Chico, Ca.

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ABSTRACT

This report covers the juvenile spring-run Chinook salmon (*Oncorhynchus tshawytscha*) emigration monitoring at Parrot-Phelan Diversion Dam in Butte Creek from November 1, 2015 through June 30, 2016. Of the available 243 trap days, the diversion trap and rotary screw trap fished a total of 217 and 200 days respectively. A total of 7,802 juvenile salmon, including yearlings were captured; a total of 4,998 in the diversion trap and 2,804 in the rotary screw trap. Approximately 97% of the total catch had emigrated past the trap site by the end of February.

[1] California Department of Fish and Wildlife, North Central Regions, 1701 Nimbus Road, Rancho Cordova, CA. 95670. This study was funded in part by the U.S. Fish and Wildlife Service, Grant No. F12AS00084

[2] California Department of Fish and Wildlife, North Central Region, 629 Entler Ave. Suite 12, Chico, CA. 95928

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INTRODUCTION

This is a report summarizing life history characteristics of spring-run Chinook salmon (SRCS), *Oncorhynchus tshawytscha*, in Butte Creek. It is a continuation of past life history investigations which initiated in 1995. However, since 2012, this study has been funded in part by the U.S. Fish and Wildlife Service under Grant No. F12AS00084. Butte Creek is one of several streams that form the basis for population trends for the threatened SRCS in the Central Valley of California. The U.S. Fish and Wildlife Service (USFWS) are proposing to reintroduce Central Valley SRCS to the San Joaquin River (SJR) upstream of the mouth of the Merced River in the Central Valley of California. The overall objective of reintroducing SRCS into the SJR is to collect and reintroduce multiple life stages to develop a naturally reproducing, self-sustaining, genetically distinct and diverse population. This project will provide baseline population information on juvenile out-migrant SRCS essential for the assessment of Butte Creek as a potential donor for the SJR as well as assessing restoration actions on Butte Creek.

The project objectives are:

1) Identify and monitor time of alevin emergence.
2) Monitor and document juvenile size at emigration.
3) Develop a measure of juvenile relative abundance.
4) Document rearing and emigration patterns.

Butte Creek Watershed and Hydrology

Butte Creek is located in Butte and Sutter counties (Figures 1 and 2). The headwaters of Butte Creek originate in the Lassen National Forest, within the Jonesville Basin at an elevation of approximately 2,137 meters (m) (7,000 feet (ft)). The watershed is approximately 2,103 square kilometers (km^2), (809 square miles (mi^2) and has an unimpaired average annual yield of approximately 300,000 cubic decameters (dam^3) (243,000 acre-feet) (Hillaire, 1993). Butte Creek enters the mainstem Sacramento River at two locations, the Butte Slough Outfall gates and the downstream end of the Sutter Bypass near the confluence of the Feather and Sacramento rivers` (Figure 1). When flows in the Sacramento River are greater than approximately 651 cubic meters per second (m^3/s) (23,000 cubic feet per second (cfs)) at Wilkins Slough, part of the Sacramento River flows into lower Butte Creek and the Sutter Bypass through the Tisdale Weir (Figure 1). Moulton and Colusa weirs are upstream of Tisdale Weir and are staged to spill when the flow in the Sacramento River reaches approximately 849 m^3/s (30,000 cfs) and ,1982 m^3/s (70,000 cfs), respectively(DWR 2011). The capacity of the Sacramento River channel downstream of the Tisdale Weir at Wilkins Slough is approximately 850 m^3/s (30,000 cfs). These weirs have a combined capacity to pass approximately 3,766 m^3/s (133,000 cfs) into the Sutter Bypass (Dept. of the Army, 1975). When water is bypassed, outmigrating salmonids from the upper Sacramento River mix with SRCS from Butte Creek.

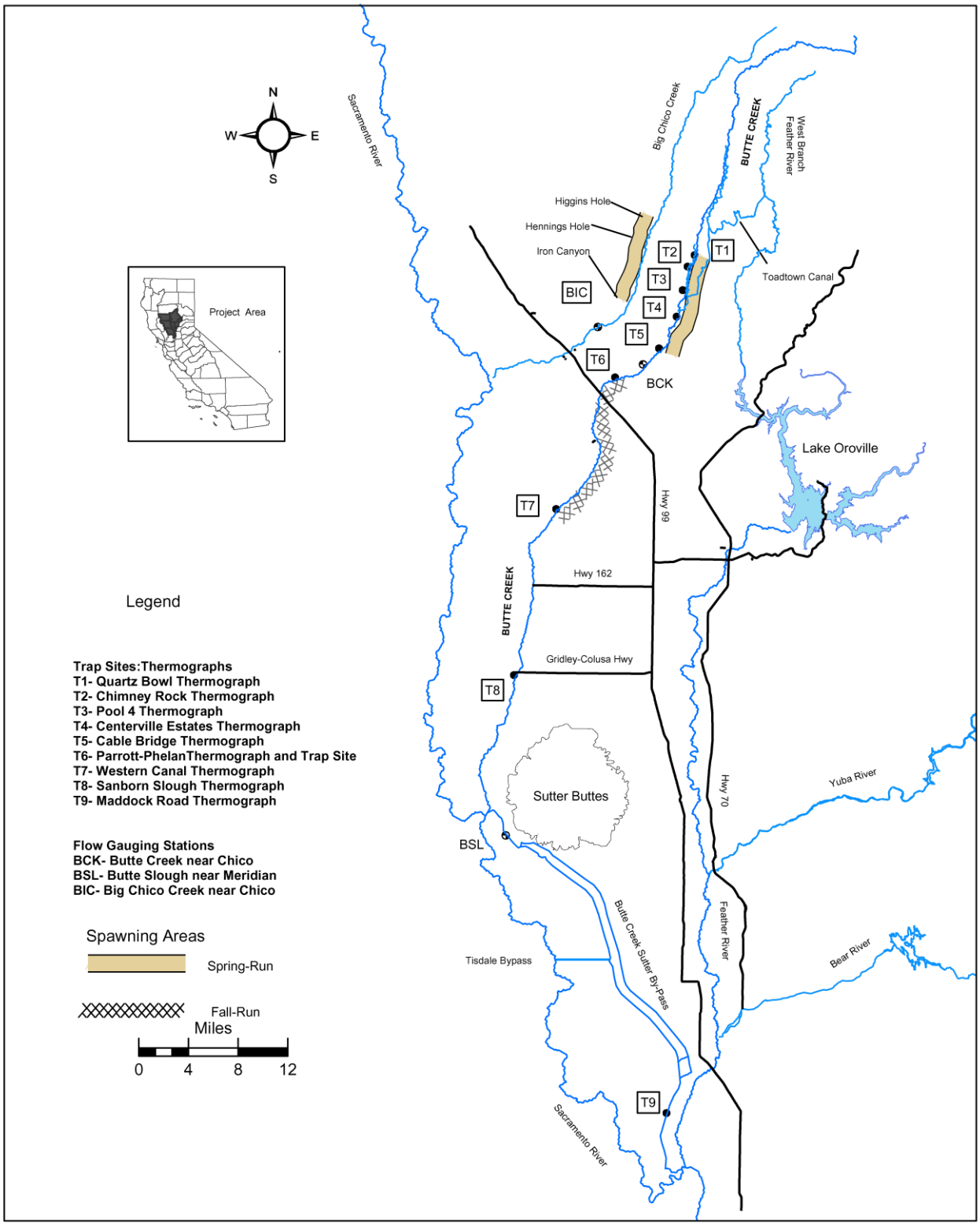
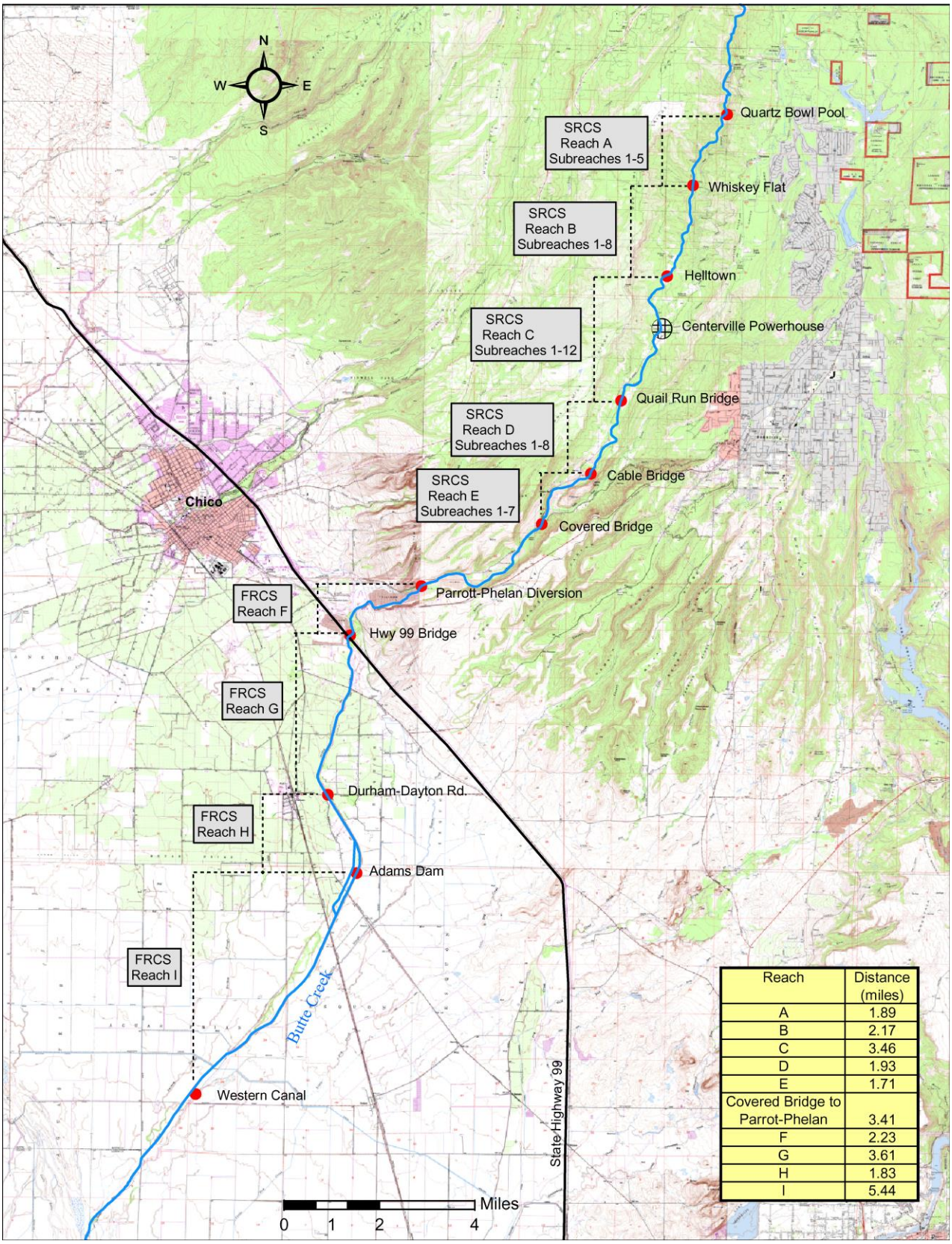


Figure 1. Butte Creek watershed with trap location, gaging stations, and salmon spawning areas indicated.



Reach	Distance (miles)
A	1.89
B	2.17
C	3.46
D	1.93
E	1.71
Covered Bridge to Parrot-Phelan	3.41
F	2.23
G	3.61
H	1.83
I	5.44

Figure 2. Butte Creek watershed showing spring-run spawning area from Quartz Pool to Covered Bridge and of Parrott-Phelan Diversion Dam where trap sites are located.

MATERIALS AND METHODS

Butte Creek Trapping Sites

During the 2015-2016 trapping period, fish were trapped at the Parrott-Phelan Diversion Dam (PPDD) location along Butte Creek (Figure 1, Site T6). This site is directly downstream of the SRCS spawning habitat and upstream of the fall-run Chinook salmon (FRCS) spawning habitat, although periodically some FRCS spawn above this site. The site was sampled with a 2.4 m diameter (8 ft) rotary screw trap (RST) manufactured by EG Solutions (Eugene, Oregon). The RST was connected to an upstream stationary object, dam, weir, or fish ladder by use of steel cable 0.6 centimeter (cm) (0.25 inch (in)) in diameter. Placement was adjusted regularly to allow for safe operation and access as well as to maximize the efficiency of sampling. In addition to the RST at PPDD, the diversion canal has an off-stream diversion fish screen (DST) fitted with a trap box 1.2 m x 0.9 m x 2.1 m (4 ft x 3 ft x 7 ft). The PPDD traps were fished 24 hours a day, seven days a week, except during extraordinarily high flows, periods of excessive debris or when the potential to catch, injure or kill many juveniles was present.

Physical Measurements

Three physical measurements were taken daily. Water velocity in meters per second (m/s) was measured at the mouth of the RST cone with a Marsh-McBirney Flo-Mate, Model 2000. The velocity sensor was attached to a graduated staff and submersed to a depth of 0.61 m (2 ft) directly below the shaft of the screw trap cone. Each velocity reading was based upon a preset 45-second averaging period and recorded as the velocity reading for the entire 24 hour period. Additionally, RST cone revolutions were recorded through the use of a mechanical counter (Reddington Counters Inc., Model 1-2936). Total revolutions for the 24 hour period were recorded and the counter reset each day. Water temperature (Celsius) was measured in the live box of each trap using a hand held Enviro-Safe Thermometer.

Processing Captured Fish

All fish were netted daily from the trap live-boxes and immediately placed into a shallow tub of fresh river water. Juvenile Chinook salmon were sorted from other species and swiftly transferred with small aquarium nets into buckets equipped with portable aerators to be transported to shore for processing. Juvenile Chinook salmon were processed prior to any non-salmonid species. The first 10 of each non-salmonid species were identified to species, measured to the nearest mm fork length (FL), and released. The remainder were counted and released.

A random sub-sample of 50 salmon juveniles was placed into a bucket containing a weak, standardized solution of Tricaine methane sulfonate (MS-222) and anaesthetized. Approximatley10 grams (g) of MS-222 powder was dissolved in 1 liter (L) of fresh distilled water to create a stock solution, which was then used at a dilution of 40 milliliters (ml) stock solution added to 6 L of fresh river water. Upon immobilization, juveniles were individually placed onto a wetted plexiglas measuring board and measured to the nearest mm FL. Salmon not processed within the sub-sample were hand counted to determine the total catch for the 24 hour sample period. When numbers of fish were too high to count individually (>2,000), five 25 g (0.88-ounce (oz)) sub-samples were weighed on an Ohaus electronic scale to the nearest 1.0 g (0.035 oz). The remaining fish were then added to a previously weighed bucket of fresh water and then weighed to the nearest 25 g on a Chatillon hanging scale. The average number of fish

per gram from the five weighed sub-samples was then multiplied by the total grams from the hanging scale to provide an estimate for the total number of fish for the period.

Juvenile Emigration

By examining length frequency distributions of fish captured at PPDD, young-of-the-year (YOY) and yearlings can generally be identified. Yearling SRCS begin emigrating in the fall, approximately one year after egg deposition. These fish are the only salmon to emigrate before salmon from the newly spawned YOY emerge. Emigration of YOY SRCS is analyzed by examining catches of salmon trapped at PPDD.

RESULTS

Trapping Season 2015-2016

The 2015-2016 trapping season began at the PPDD when the DSTR and the RSTR were both set and installed on November 1, 2015 and ended when removed on July 1, 2016. During the trapping season, there were occasions when one or both of the traps were removed due to high stream flows, excessive debris or the potential to harm or kill excessive numbers of juveniles. A total of 7,802 juvenile salmon, including yearlings, was captured in all traps; 4,998 in the DSTR and 2,804 in the RST (Tables 1 & 2).

Table 1. Bi-Weekly catch summary of SRCS caught in the screen trap (DSTR) at Parrott-Phelan Diversion Dam from November 1, 2015 to June 30, 2016; yearling captures are included.

Trapping Period		Mean FL (mm)	Standard Deviation	Range FL (mm)		Total No. Captured	No. Trapping Days
11/1/15	11/15/15	-	-	-	-	0	15
11/16/15	11/30/15	-	-	-	-	0	15
12/01/15	12/15/15	36.2	10.6	30	119	345	15
12/16/15	12/31/15	35.0	3.5	30	88	950	16
1/01/16	1/15/16	35.3	1.8	30	41	2,508	15
1/16/16	1/31/16	35.5	1.6	31	39	108	16
2/01/16	2/15/16	35.7	2.0	30	47	578	15
2/16/16	2/29/16	35.9	2.8	30	63	427	14
3/01/16	3/15/16	35.7	4.3	31	60	40	4
3/16/16	3/31/16	51.9	8.1	43	67	8	1
4/01/16	4/15/16	64.3	10.6	48	80	7	15
4/16/16	4/30/16	70.8	10.8	54	89	20	15
5/01/16	5/15/16	73.3	8.6	60	88	7	15
5/16/16	5/31/16	-	-	-	-	0	16
6/01/16	6/15/16	-	-	-	-	0	15
6/16/16	6/30/16	-	-	-	-	0	15
					TOTAL	4,998	217

Average daily flows for months within the migration period were very low when compared to historical flows with the exception of an above average January and March (Figure 4). Trapping was suspended periodically for both the DST and RST during this survey period between November and June, for a total of 25 and 42 days respectively (Tables 1 & 2 and Appendix A).

The first juvenile YOY capture occurred on December 11, 2015. Fifty-six were captured in the RST and 120 were captured in the DST. The last salmon captured in both the DST and RST was May 6th and May 25th, 2016 respectively. During this study trapping period, the majority of Butte Creek SRCS that were captured migrated as fry. The first yearling SRCS was captured on December 1, 2015 and the last on December 16, 2015 (Tabled 1 and 2; Appendix B). Peak daily catch for the RST was 356 and peak DST daily catch was 616, both occurring on January 14, 2016. The largest percentage of fry was captured during the mid- December through mid-January time frame (Figure3).

Figure 3. Cumulative percent catch of juvenile salmon in both diversion and rotary screw traps at Parrott-Phelan Diversion Dam from 2012-2016.

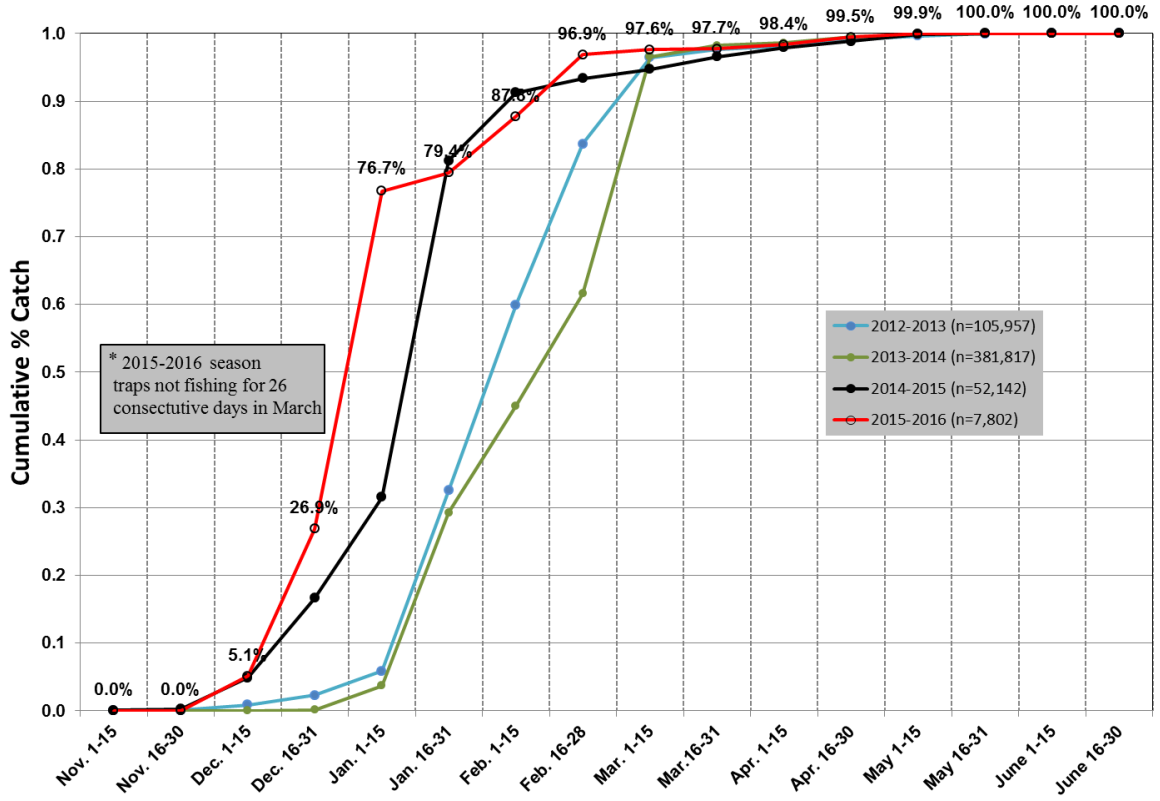


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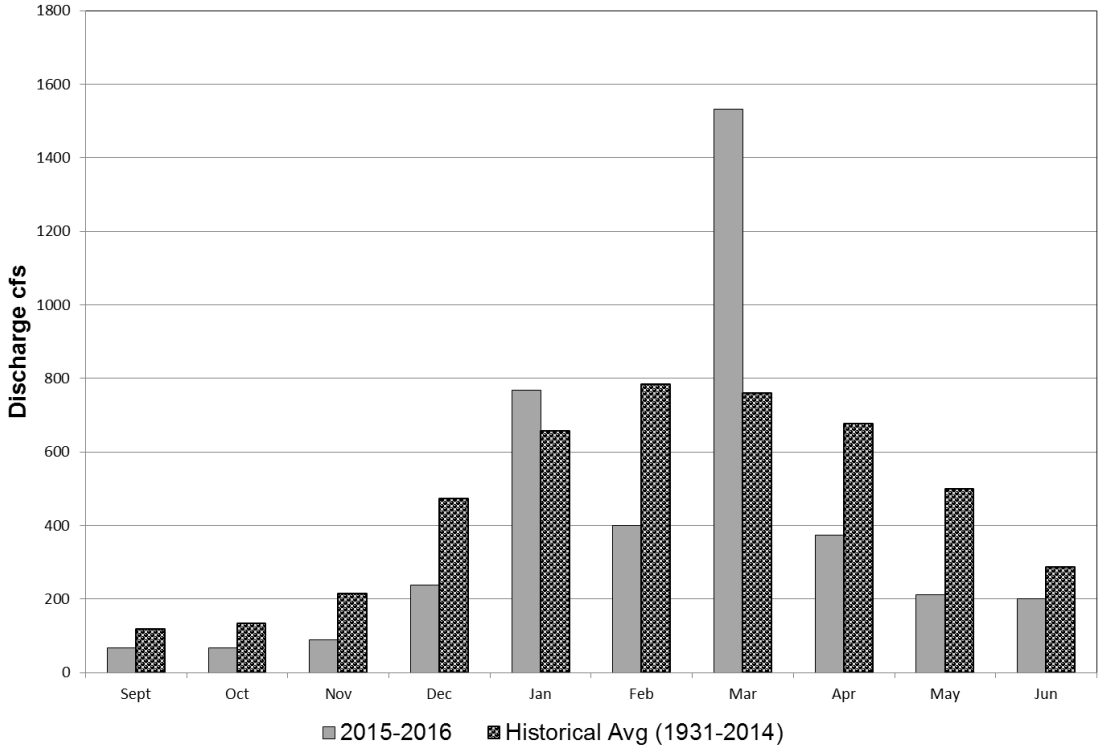
Table 2. Semi-monthly catch summary of SRCS caught in the rotary-screw trap at Parrott-Phelan Diversion Dam from November 1, 2015 to June 30, 2016; yearling captures are included.

Trapping Period		Mean FL (mm)	Standard Deviation	Range FL (mm)		Total No. Captured	No. Trapping Days
11/1/15	11/15/15	-	-	-	-	0	15
11/16/15	11/30/15	-	-	-	-	0	15
12/01/15	12/15/15	35.4	3.4	32	40	56	15
12/16/15	12/31/15	34.9	1.8	30	39	744	16
1/01/16	1/15/16	35.5	1.7	31	41	1,384	14
1/16/16	1/31/16	36.3	1.5	33	39	101	4
2/01/16	2/15/16	36.0	1.8	32	44	74	10
2/16/16	2/29/16	36.3	3.1	30	54	282	14
3/01/16	3/15/16	37.7	7.5	33	67	18	5
3/16/16	3/31/16	65.3	6.4	58	70	3	1
4/01/16	4/15/16	73.6	11.0	47	97	41	15
4/16/16	4/30/16	75.0	14.9	52	115	66	15
5/01/16	5/15/16	86.7	16.8	59	121	31	15
5/16/16	5/31/16	91.3	29.6	62	121	4	16
6/01/16	6/15/16	-	-	-	-	0	15
6/16/16	6/30/16	-	-	-	-	0	15
					Total	2,804	200

Figure 4. Comparison of Butte Creek average flows as measured at Butte Creek near Chico gauge (USGS #11390000) during 2015-2016 with average flows during 1931-2014 (CDWR, 2016)



DISCUSSION

The 2015-2016 trapping period began during the fifth year of an unprecedented drought in California. First emerging fry are typically captured from mid to late November. However, during this trapping season the first fry was not caught until December 11th. The low background flows in Butte Creek in the fall months of September through November may have stalled emigration until the first substantial flow increase seen in mid-December. (Appendix A, Figure1).

As observed in previous years, some YOY remained to rear in Butte Creek above PPDD, emigrating later in the spring. During this trapping period, only 3 yearling SRCS were captured compared to 152 from the 2014-2015 trapping period. During the 2015-2016 trapping period, 95% of Chinook salmon emigrated past the PPDD trap site by the February 16-29 period. This is similar to the emigration pattern of juveniles during the 2014-2015 trapping period (Figure 3). This is once again in contrast to past trapping data under more normal hydrographs, which support previous project conclusions that Butte Creek SRCS primarily emigrate as fry; where observations found that >95% of the total catch occurred by the end of January (Hill and Webber, 1999; Ward and McReynolds, 2004). This later pattern of emigration may be a result of low creek flows and drought conditions within the watershed.
Past study reports (McReynolds, et al. 2006) have shown that increased flows in Butte Creek during peak juvenile emigration (January-February), result in increased juvenile salmon numbers passing PPDD.

As with previous studies, short periods of elevated uncontrolled flows and heavy debris required cessation of trapping to protect personnel and gear. Traps were also pulled when rainfall was forecasted and creek flows were anticipated to rise suddenly because of the potential to injure or kill juvenile salmon. On March 4th 2016, daily average flows in Butte Creek increased from approximately 370 cfs to 2,085 cfs on March 5th and peaked at 4,906 cfs on March 6th. Consequently, the cone of the RST was raised and the back screen of the live box pulled. During the high flow event, substantial woody debris flowing down the creek ripped and damaged the pontoons of the RST beyond repair and the trap was inoperable for a 26 day period from March 5th – March 30, 2016. Additionally, the RST was only sampling for a short four day period during the historical peak of emigration in mid to late January. This may have skewed the proportion of fish available for capture and pushed the cumulative catch percentage earlier into the trapping season. Therefore, the results from this year's sampling effort may be somewhat biased when compared across different years.

The total season catch for 2015-2016 was 7,802 which is substantially lower than the 2014-2015, 2013-2014 and 2012-2013 periods with a catch of 52,142, 105,957 and 381,817 respectively. This is the fewest number of fry captured since juvenile monitoring began at PPDD in the late 1990's. The cessation of trapping for 12 days during January (peak emigration month) and the 2015 adult escapement estimate of 413 adults may explain the relatively few number of fry captured during the 2015-216 trapping season.

Newly emerged fry were captured at PPDD from December 11, 2015 through May 25, 2016. No adult fall-run Chinook salmon (FRCS) were observed spawning upstream of PPDD in late October. A carcass survey, Vaki Riverwatcher and anecdotal visual sightings resulted in an estimate of 82 adult FRCS. In previous years (McReynolds et al., 2005), recently emerged fry captured at PPDD beginning in early April were assumed to be FRCS. During the 2015-2016 trapping season, fry captured appear to delineate a FRCS presence at PPDD during the mid-

February timeframe and continuing through the mid-March timeframe (Appendix B). This would suggest that adult FRCS ascended the ladder at PPDD and successfully spawned upstream of PPDD. This is in contrast with other trapping years when YOY captured at the site from November through March were assumed to be SRCS. The earlier emergence of apparent FRCS may be attributed to the low water flows and relatively warmer temperatures than in past years and expedited thermal unit egg maturation. However, length-frequency distributions for the entire period (Appendix B) continue to show a bi-modal, and sometimes tri-modal distribution that generally appear to delineate YOY and yearling SRCS and also occasionally late fall-run Chinook salmon (LFRCS).

The 2015-2016 trapping period captured 3 yearling SRCS the entire season, compared to 151 in the 2014-2015 season. Typically, most yearling fish in low flow conditions can avoid capture into the RST and are not a large representative proportion of catch at PPDD. All three yearlings were captured in the DSTR. Two were caught on December 11 and the other on December 16th, 2015.

ACKNOWLEDGMENTS

This project was supported by funding provided by the United States Fish and Wildlife Service through grant No. F12AS00084 administered by the CSU Chico Research Foundation, in partnership with the California Department of Fish and Wildlife. Additionally, we wish to acknowledge the field crew members that participated during the 2015-2016 season to include Andrew Huneycutt, Brad Underwood, Alyssa Caldwell, Matt Rogers, Grant Henley, Justin Fairchild, Andrew Coloma and Kevin Moncrief.

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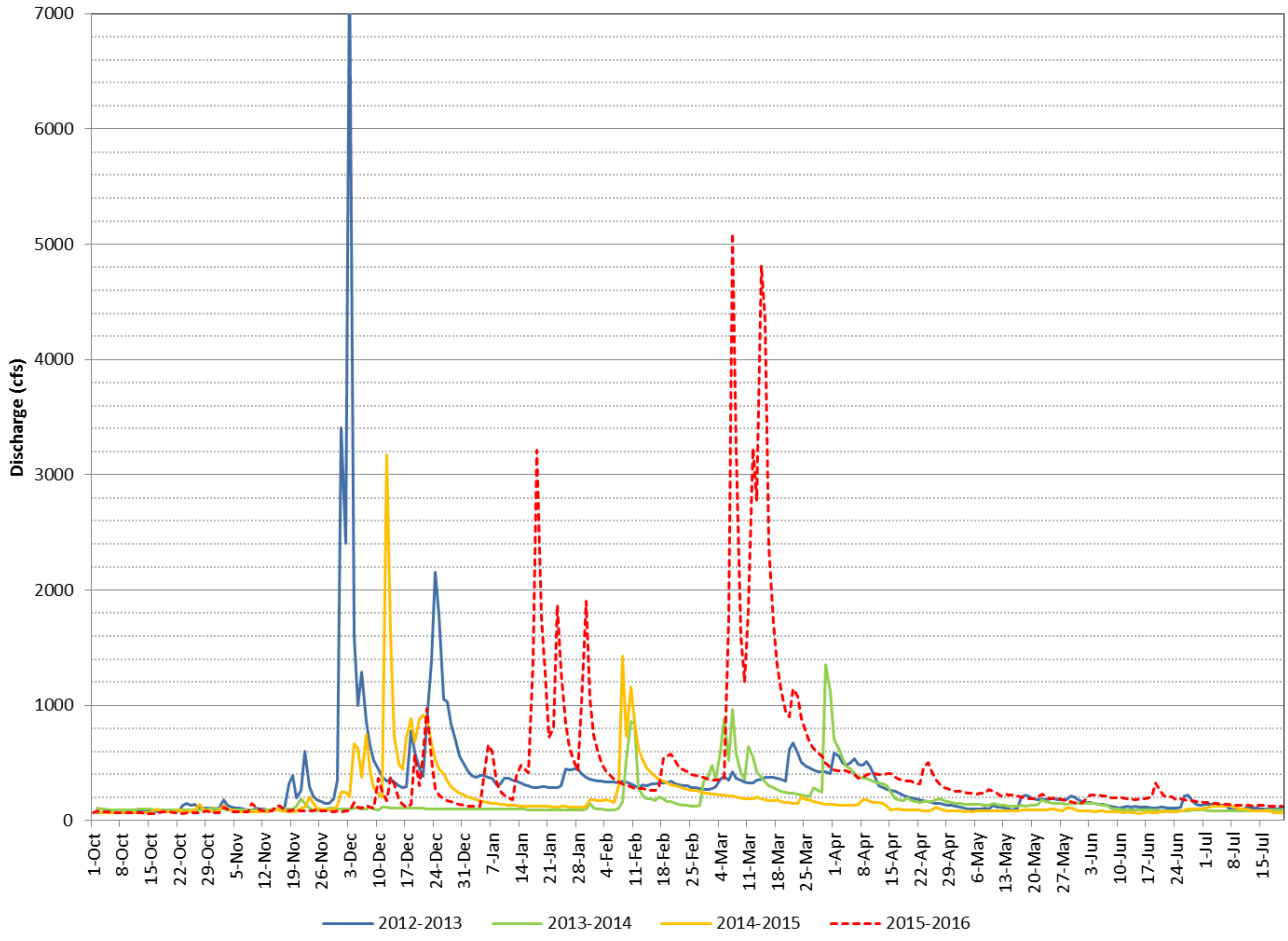
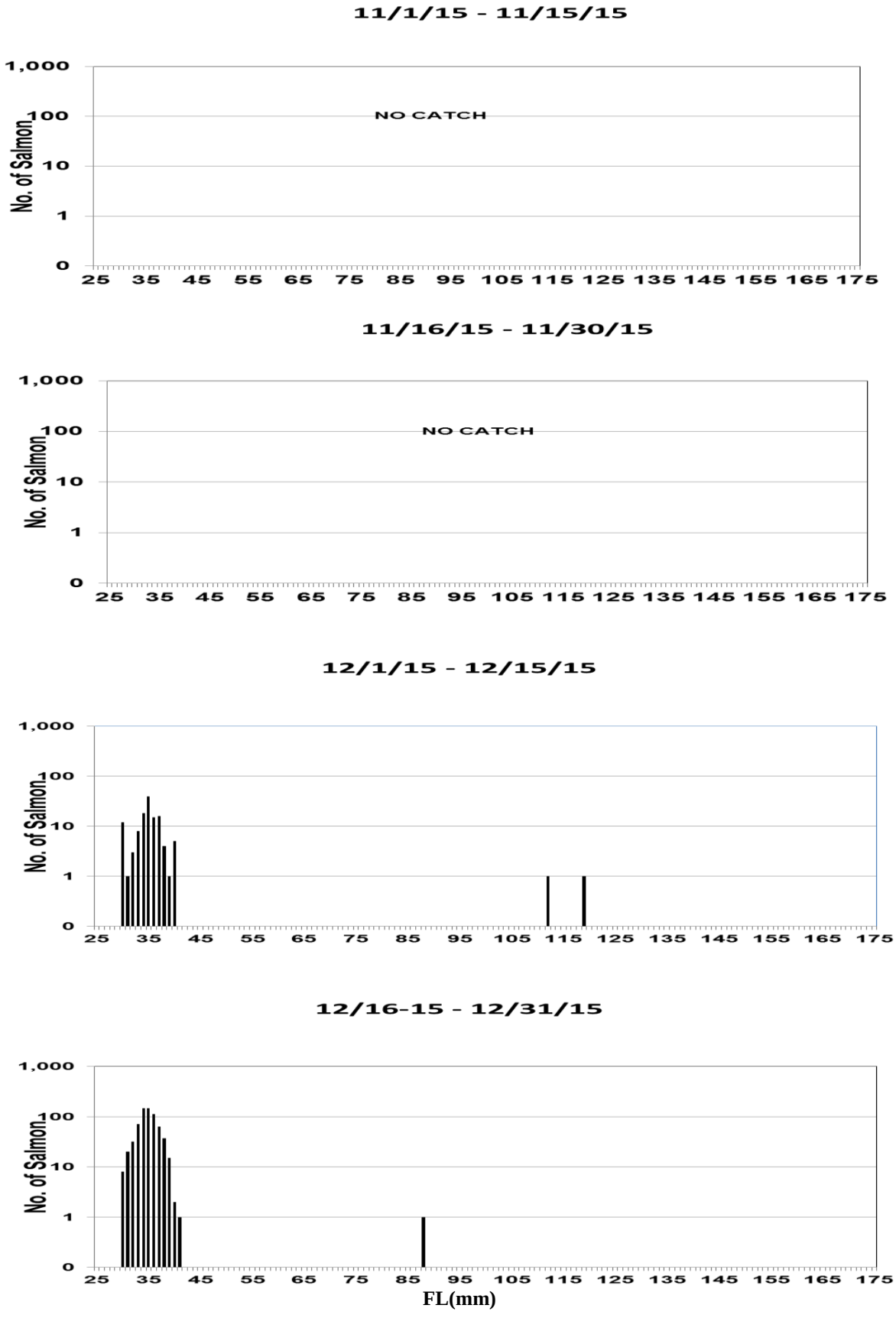
APPENDIX A, Figure 1. Butte Creek flow at Butte Creek near Chico Gage (USGS - #11390000), water year's 2012-2016, with trapping period shown. Flow data are provisional and subject to revision.



APPENDIX B, Figure 1. Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from November 1, 2015 through June 30, 2016.



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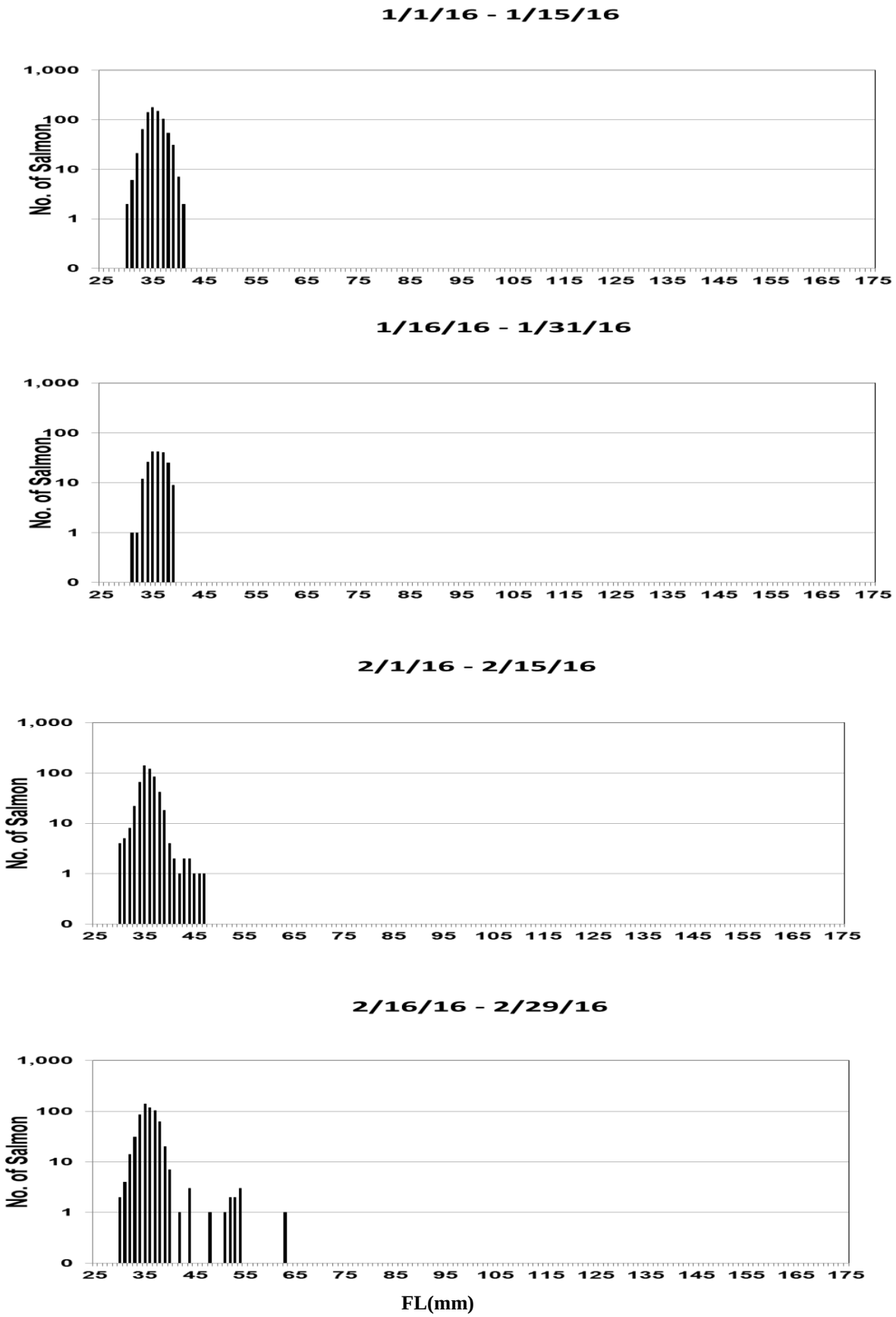

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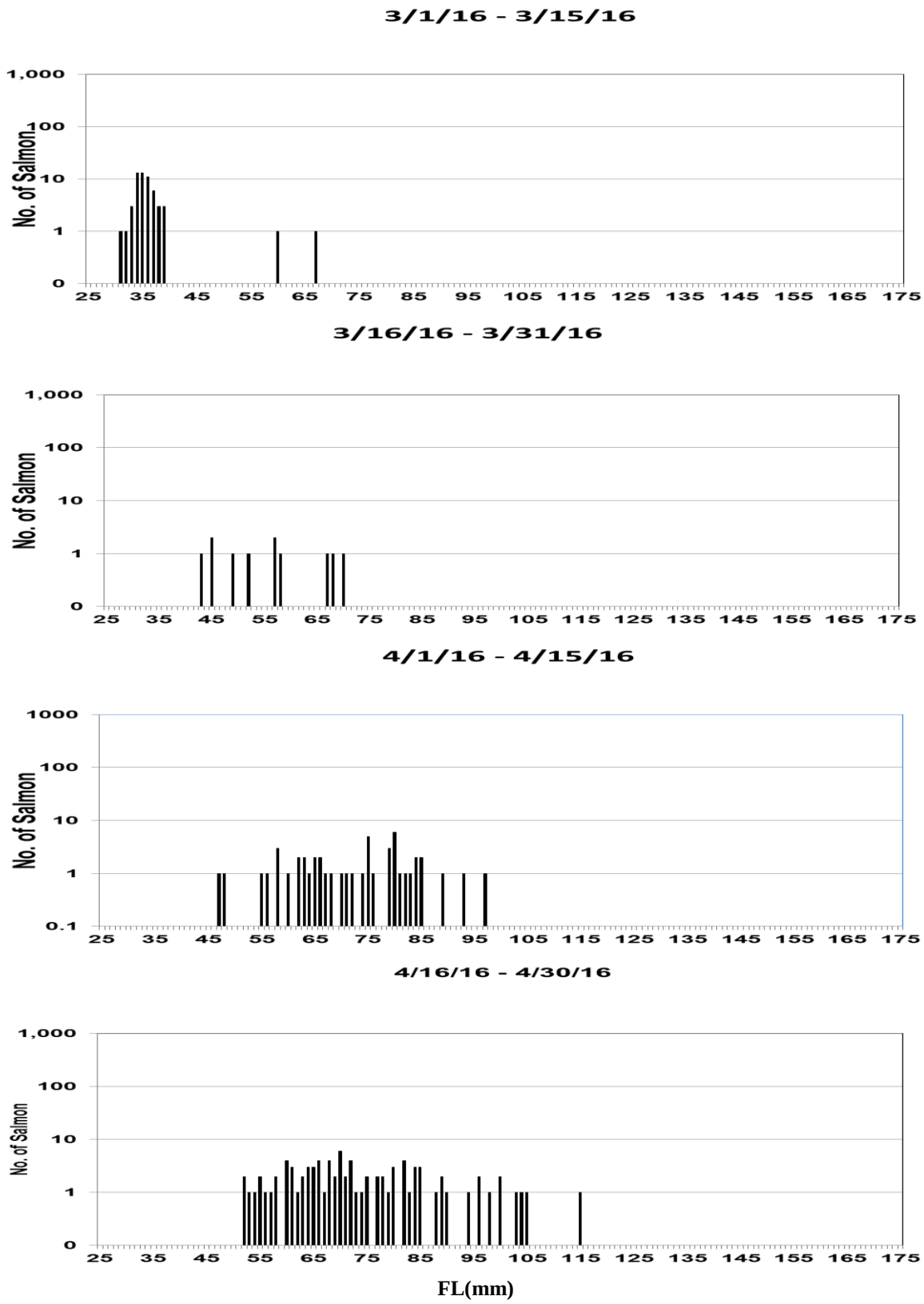

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