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Off-Site Biological Monitoring of Anadromous Salmonid Populations in the Mad River in 2017/18: Fulfillment of Annual Requirements for Mad River Hatchery's Hatchery and Genetic Management Plan

Prepared by

Michael D. Sparkman

CDFW AFRAMP

Northern Region

Anadromous Fisheries Resource Assessment and Monitoring Program

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Table of Contents

List of Figures

List of Tables

List of Appendices

2020 CDFW AFRAMP REPORT

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Abstract

The Hatchery and Genetic Management Plan for winter-run Steelhead Trout at Mad River Hatchery (MRH) requires annual off-site monitoring of anadromous salmonid populations within the Mad River, and determination of the Proportionate Natural Influence (PNI) for the winter-run Steelhead Trout breeding program. We used an ARIS sonar with species apportionment methods to estimate the returns of adult late summer/fall-run Steelhead Trout (natural and hatchery origin), Chinook Salmon (wild origin), Pink Salmon (unknown origin), Coho Salmon (wild origin), and winter-run Steelhead Trout (natural and hatchery origin) from August 28th, 2017 through March 31st, 2018.

The estimated abundance of adult late summer/fall-run Steelhead Trout (TL > 41 cm) returns equaled 2,808 (95% CI = 2,684 – 2,932; CV = 2.2%) and was the highest of record. The percentage of natural-origin Steelhead Trout in the run equaled 77%, and for hatchery-origin Steelhead Trout equaled 23%. The estimated abundance of Chinook Salmon (TL > 41 cm) returns equaled 12,667 (95% CI = 12,010 – 13,324; CV = 2.6%) and was considerably higher than abundances in 2014 – 2016. The abundance of Chinook Salmon adults (TL > 54 cm) equaled 9,906 (95 % CI = 9,390 – 10,423; CV = 2.6%), and for Chinook Salmon jacks (TL 42 – 54 cm) equaled 2,761 (95% CI = 2,551 – 2,966; CV = 3.7%). The estimated abundance of Pink Salmon (TL > 41 cm) returns equaled 750 (95% CI = 694 – 807; CV = 3.8%) and represented potential colonization from areas north of California. The estimated abundance of Coho Salmon (TL > 41 cm) returns equaled 1,575 (95% CI = 1,482 – 1,668; CV = 3.0%). The estimated abundance of winter-run Steelhead Trout equaled 8,224 (95% CI = 7,895 – 8,554; CV = 2.0%), and the month of January 2018 accounted for 54% of the run. The number of natural-origin (NOS) Steelhead Trout equaled 5,270 (95% CI = 5,049 – 5,491; CV = 2.1%) and for hatchery origin (HOS) equaled 2,954 (95% CI = 2,835 – 3,073; CV = 2.0%). The percentage of natural-origin Steelhead Trout (pNOS) equaled 64% and for hatchery-origin Steelhead Trout (pHOS) equaled 36%. Daily run-timing among natural and hatchery-origin winter-run Steelhead Trout from December 1st, 2016 – March 31st, 2017 was similar. Based upon visual identification and occasional scale analyses of NOR broodstock collections, pNOB at MRH equaled 0.50. Thus, PNI equaled 0.58 and was above the minimum goal of 0.50. CDFW initiated changes to the collection of natural-origin brood stock in 2018, which should increase pNOB and the PNI index.

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Introduction

Mad River supports annual runs of California Coastal (CC) Chinook Salmon (*Oncorhynchus tshawytscha*), Northern California (NC) Steelhead Trout (*O. mykiss*) Distinct Population Segment, Southern Oregon/Northern California Coasts (SO/NCC) Coho Salmon (*O. kisutch*), and Southern Oregon/California Coasts Coastal (SO/CC) Cutthroat Trout (*O. clarkii clarkii*) (Fig. 1) (Sparkman, 2003). Mad River also provides an important recreational sport fishery for NC Steelhead Trout, and Mad River Hatchery (Rm 13.3) produces hatchery winter-run Steelhead Trout for angler harvest (Sparkman, 2003; CDFW, 2016; NMFS, 2017). CC Chinook Salmon, NC Steelhead Trout, and SO/NCC Coho Salmon in the Mad River are considered functionally independent populations, and Mad River is considered 'essential' for recovery of the CC Chinook Salmon ESU and NC Steelhead Trout DPS (NMFS 2016).

This paper presents results of off-site biological monitoring in the Mad River (MR) from August 28th, 2017 through March 31st, 2018 with respect to fulfilling several annual requirements of Mad River Hatchery's Hatchery and Genetic Management Plan (MRH HGMP) (NMFS 2017). Annual reporting requirements of MRH HGMP include, but are not limited to:

1. Determine the run size of adult (and jack) Chinook Salmon, late summer/fall-run Steelhead Trout (TL > 41 cm), Coho Salmon (if present in quantifiable numbers), and winter-run Steelhead Trout (TL > 41 cm).

2. Determine the hatchery-origin (HOR) and natural-origin (NOR) component for winter-run Steelhead Trout.

3. Compare run-timing of HOR and NOR Steelhead Trout (winter-run).

4. Calculate the Proportionate Natural Influence (PNI) for the winter-run Steelhead Trout breeding program at Mad River Hatchery.

The PNI is a useful index for assessing a hatchery's influence upon the selective forces acting upon wild or naturally produced population(s) within a given watershed. Generally, a PNI index of > 0.50 means the natural environment is the dominate selective force on the population, and a PNI < 0.50 means the hatchery environment is the dominate selective force (NMFS 2017). Domestication of propagated Steelhead Trout is also less when PNI > 0.50. According to MRH HGMP, one of our requirements is to have a PNI > 0.50 with a long-term goal of PNI equaling or exceeding 0.67 (NMFS 2017).

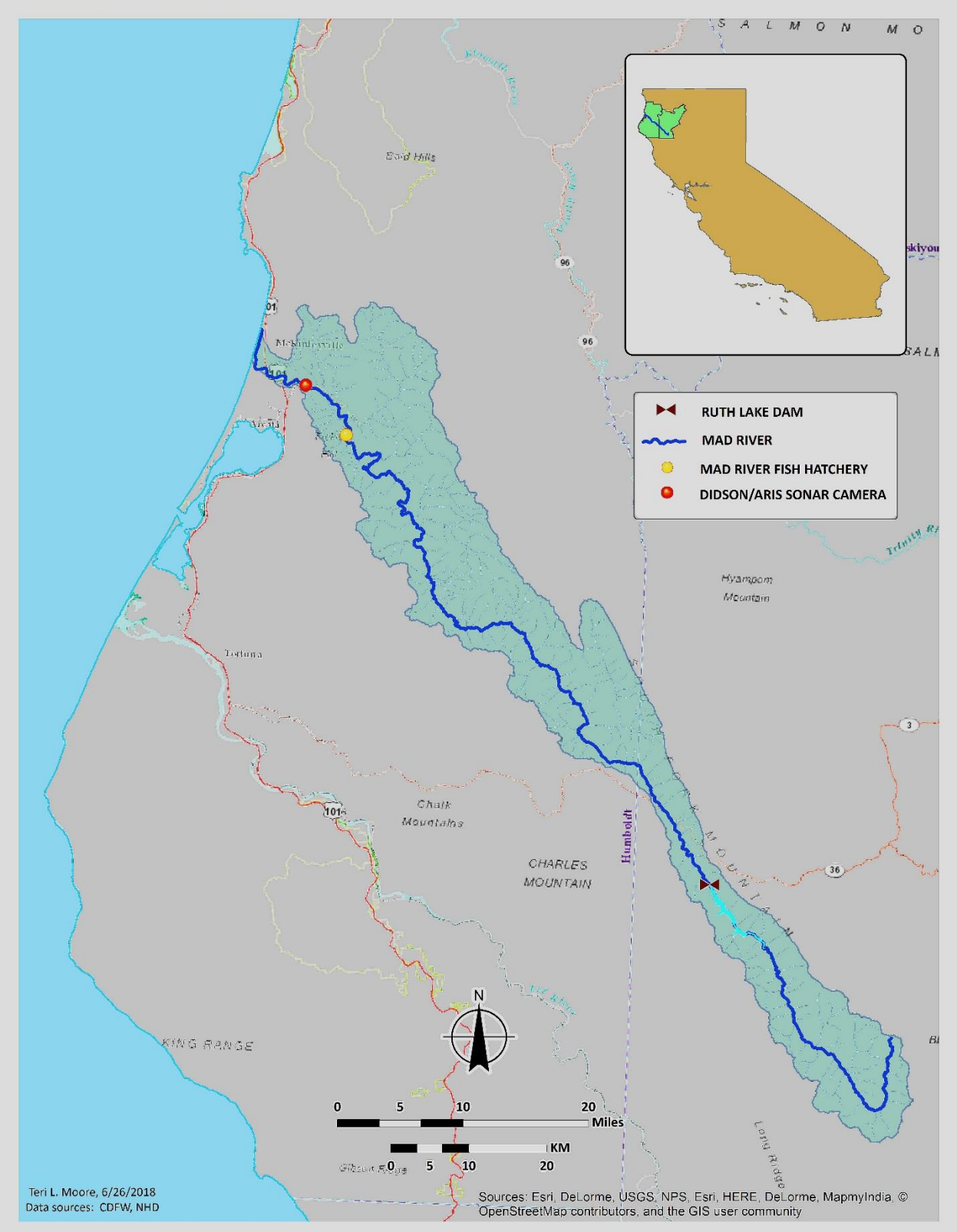

Figure 1. Watershed map of Mad River, Humboldt County, CA., with location of ARIS sonar, Mad River Hatchery, and Ruth Dam (map courtesy of Teri Moore, CDFW Environmental Scientist).

Methods

Sonar Deployment

We used an ARIS long range sonar (model # 1200) at river mile (Rm) 7.0 and species apportionment methods to estimate the abundances of returning Chinook Salmon adults (TL > 54 cm), Chinook Salmon jacks (TL < 55 cm), Coho Salmon (TL > 41), Pink Salmon (TL > 41), late summer/fall-run Steelhead Trout (TL > 41 cm), and winter-run Steelhead Trout (TL > 41 cm) to the Mad River during the 2017/18 season. We first installed and deployed the long-range ARIS in the Mad River (Rm 7.0) on August 27, 2017 (Fig. 1). The sonar operated continuously (24 hrs/d) through March 31st, 2018 with exception for periods of down-time associated with high stream flows which were unsafe to operate the sonar. We missed 42 hours (1.75 d) from 1700 January 24 – 1100 January 26, 2018, and did not estimate missed fish passage due to the severity of the stream rise.

V5 Population and Variance Estimator

We used a non-replicated systematic sample of the first 20 minutes of each hour to estimate adult passage through the sonar beams (Reynolds et al., 2007; Lilja et al., 2008; Xie and Martens, 2014). For each 20-minute file, net movement was defined as the sum of positive upstream movements and negative downstream movements (un-expanded) (Xie et al., 2002). Net movement was multiplied by a factor of three to derive hourly estimates of fish passage (expanded), and net movement of adults per day was simply the sum of hourly net movements. The un-expanded data was then used with the V5 variance estimator to assess error arising from using a 20-minute sample to represent hourly fish passage, and to determine population abundances with 95% confidence intervals (95% CI) and the coefficient of variation (CV) for total and monthly passage (Reynolds et al., 2007; Xie and Martens, 2014; Metheny et al., 2016; Sparkman et al., 2017; Sparkman et al. 2020).

Species and Origin Apportionment

We used various methods to apportion species to sonar count data, including: snorkeling, past and present angler creel surveys, hook-and-line sampling, and professional judgement. We did not use data collected near MRH due to the bias for hatchery-origin Steelhead Trout. By far the most effective and common method from August 28, 2017 – January 2, 2018 was snorkeling, which occurred nearly every other day. The last survey was conducted on January 2nd, 2018 when we conducted dives at eight locations. We conducted a total of 188 dives over 32 dive days during the sonar deployment period of August 28, 2017 – January 2, 2018, which averaged to 6 different locations each dive day. The term ‘dive’ includes all passes made in a habitat unit. For example, if the snorkeler made seven passes in a pool, that would equal one dive for reporting purposes. After each pass, data was relayed to the field technician.

We interviewed anglers above and below the sonar location when we could not snorkel survey, due to increased streamflows and turbidities. During this study period we primarily used angler creel data from November 19th, 2017 – February 28th, 2018. Angler creel data was collected from simple interviews (Creel), from interviews for anglers who captured fish for radio tagging (Telemetry/Creel) and broodstock collection for MRH (Broodstock/Creel). Nearby anglers were also interviewed. For each interview type, we collected information on species caught and whether any Steelhead Trout captured had an adipose fin clip and fin erosion (i.e. hatchery-origin). If not certain, those fish were not used for discriminating naturally produced Steelhead Trout from hatchery produced Steelhead Trout. For radio tagging and broodstock collections, CDFW staff were able to critically examine if a given Steelhead Trout was hatchery or natural-origin. We collected origin information on a total of 217 Steelhead Trout (TL > 41 cm) from December 1, 2017 – February 28th, 2018 for determining the natural-origin and hatchery-origin component for Winter-run Steelhead Trout (Appendix 1). Since we had no observational data for March, we used professional judgement with respect to origin type for winter-run Steelhead Trout. *Apriori*, we know that winter-run Steelhead Trout return in lower numbers in March (eg N = 698 in 2018, or 8% of total for 2017/18), and that relatively few hatchery-origin may enter MRH in March (eg. n = 165 in 2018). Therefore, we averaged origin data by month (Dec, Jan, and Feb) and applied that value to each sonar count per day for March.

Applying Species Apportionment Data to Sonar Counts

Snorkeling

Species apportionment and hatchery/natural origin data was expressed as a percentage for a given species for each sampling day and applied to daily sonar counts each day per size class: small adults 42 -54 cm TL and larger adults 55^{+} cm TL. If most of the fish were seen below the sonar site (common scenario) we applied those percentages to the day of survey, and to post sampling days when species apportionment was not determined. Usually this equated to two days after the apportionment data was taken on any given day. If most fish were seen upstream of the sonar, we would back-fill days in a similar manner. For time periods that extended beyond the 2 – 3 days from a snorkel survey, we interpolated proportions between apportionment sampling dates (Carroll and McIntosh, 2011; McEwen, 2013), or just simply extended the survey data beyond 2 – 3 days.

Creel, Radio Telemetry/Creel, and Broodstock/Creel

Similar to snorkel derived data, we determined the percent composition of each species for each sampling day and applied those percentages to sonar counts for the day of capture/interview(s), and post days of the capture/interview(s). If the sample size of catches was less than 10, we pooled each day's data until we reached 10 fish. Then we back-filled the percentages to day(s). Once a 10 fish cumulative catch was reached, we started the process over until 10 more fish were captured. This method was adapted from ADFG's use of fish wheels for species apportionment (for sonar count data) when catches are less than 20 fish per

day (Glick and Faulkner, 2019). The Mad River has far fewer fish than most Alaska rivers, therefore we used 10 instead of 20. The anglers captured each species of fish that were present (Chinook Salmon, Coho Salmon, Steelhead Trout Trout), with exception to Pink Salmon since their run ended in October based upon numerous snorkel surveys. We used a similar method for determining the origin composition for Winter-run Steelhead Trout, however, we reduced sample size to five observations. Data on daily counts of winter-run Steelhead Trout and application of origin type (Natural or Hatchery) to daily counts are provided in Appendix 2.

We used the general 'salmon model' for enumerating Chinook Salmon, late summer/fall-run Steelhead Trout, Coho Salmon, and Pink Salmon (Maxwell and Gove, 2004; Maxwell, 2007), and a newly revised model (Salmon Model with Specific Kelt Adjustments) for winter-run Steelhead Trout (Sparkman et al. 2018). The 'salmon model' for sonar requires that fish moving upstream or downstream through the beams are unspawned, which doesn't necessarily apply to Steelhead Trout since they can be iteroparous. Thus, when spawned Steelhead Trout (kelts) move downstream they can't be subtracted from upstream counts. CDFW AFRAMP is currently comparing various models which account for kelts when using sonar (Sparkman et al. 2018). The number of kelts we report is an underestimate since kelting can occur to late May, based upon radio telemetry studies (CDFW, in house data). We used the 'salmon model' for late summer/fall-run Steelhead Trout in the Mad River because they normally kelt and move downstream December – February based upon radio telemetry studies (CDFW, in house data).

Detailed descriptions of sonar use, sonar settings, recording and processing files, and species apportionment methods can be found in Sparkman et al. (2020), which reports sonar data from August 28, 2017 – January 2, 2018.

Collection of NOR Winter-Run Steelhead Trout Brood Stock for MRH

Hatchery-origin winter-run Steelhead Trout can be differentiated from natural origin winter-run Steelhead Trout by the absence of an adipose fin and potentially dorsal fin, pectoral fin, or pelvic fin erosion. Thus, the quality of the adipose fin clip for hatchery origin fish must be high, or confusion between HOR and NOR fish can occur. During the 2018 breeding program at MRH, we primarily relied upon the Mad River Steelhead Trout Stewards Volunteer Program (MRSSVP) to collect natural-origin Steelhead Trout for breeding at MRH. Steelhead Trout were captured with hook and line at various locations in the Mad River and placed in tube(s) in the river. MRSSVP volunteers would then call CDFW AFRAMP personnel to inspect the fish as to origin. If deemed natural origin, CDFW placed the fish in a large water bag and then delivered the fish to a CDFW MRH truck that housed a circulating water system (250 gallons). Natural-origin fish were trucked to MRH, and then placed in the rectangular adult holding pond that drains into the fish ladder. Beginning on 1/30/18, CDFW applied floy tags (with a unique number identifier) to collected NOR Steelhead Trout. CDFW AFRAMP personnel removed scales from any questionable NOR's and analyzed the scales in the office to look for a natural-origin life history.

There were several ways to discern a natural-origin from a hatchery-origin Steelhead Trout based upon scale patterns:

1. *Number of Freshwater Annuli*: Hatchery-origin Steelhead Trout are released as age-1 smolts, whereas most natural-origin Steelhead Trout smolts in Mad River migrate to the ocean as age-2 smolts (CDFW, in house data). Thus, hatchery-origin smolts have one annuli and natural origin smolts usually have two annuli.

2. *Freshwater Growth Patterns*: Hatchery-origin smolts were fed a routine diet every day throughout the juvenile growth period at MRH, and therefore show fairly uniform freshwater growth in the scale patterns. Conversely, natural-origin fish show periods of growth that are not as uniform since they prey upon various food items, and at variable stream temperatures. The spaces between circuli will vary as their growth varies. Additionally, during winter months their growth can be slower (and hence space between circuli becomes less than for hatchery juveniles) due to colder water temperatures and variable availability of food items.

If the natural-origin Steelhead Trout was deemed 'natural-origin', MRH bred that fish with a hatchery-origin fish (1:1). If not natural-origin (discovered post spawning in 2018), then those eggs were culled from production. During the spawning process, CDFW AFRAMP collected tissue samples (fin snips) from each adult used for spawning at MRH as in past years. These fin snips were then stored in coin envelopes (with appropriate information: date, origin, sex, mating pair, floy tag number, etc.) for future genetic analysis.

Proportionate Natural Influence (PNI)

As previously mentioned, PNI is a useful index for assessing a hatchery's influence upon the selective forces acting upon wild or naturally produced population(s) within a given watershed. PNI is a major requirement of any HGMP, and is derived from the following equation:

$$PNI = (pNOB) / (pNOB + pHOS)$$

Where pNOB equals the proportion of natural-origin Steelhead Trout used for breeding at MRH (winter-run Steelhead Trout Program), and pHOS equals the proportion of hatchery-origin winter-run Steelhead Trout present in the entire Mad River basin. Thus, we also need to know the proportion of hatchery-origin Steelhead Trout used for breeding, and the proportion of natural-origin Steelhead Trout returning to MR in a given year. As previously mentioned, hatchery-origin Steelhead Trout are recognized by having an adipose fin clip, dorsal fin erosion to varying degrees, and missing or eroded pelvic/pectoral fins due to abrasion when raised as juveniles in the hatchery environment. More detailed analysis or confirmation included scale reading(s).

Results

Sonar Deployment

The ARIS sonar was first deployed on August 27, 2017 in the same location as in previous study years and operated until April 1, 2018.

Run Timing

For a given run-type per species, sonar deployment encompassed 98.6 – 100% of estimated, specific run timings (Table 1). We did not estimate passage during periods of non-deployment.

Table 1. Run timing of various anadromous salmonids and ARIS sonar down-time from August 28, 2017 – March 31, 2018, Mad River, Humboldt County, CA., 2017-18.

Run Type/Species	Period of Run Timing in 2017/18	Number of Days	Sonar Downtime (%)
Late Summer/Fall-Run Steelhead Trout	August 28, 2017 – November 30, 2017	95	0.0
Chinook Salmon*	August 28, 2017 – December 29, 2017	124	0.0
Pink Salmon	September 13, 2017 – October 31, 2017	49	0.0
Coho Salmon	September 26, 2017 - January 2, 2018	99	0.0
Winter-Run Steelhead Trout	December 1, 2017 – March 31, 2018	121	1.4

* Late summer, fall, early winter-run types.

Late-Summer / Fall-Run Steelhead Trout Abundance

The estimated abundance of Steelhead Trout (TL > 41 cm) returns from August 28th, 2017 – November 30th, 2017 equaled 2,808 (95% CI = 2,684 – 2,932; CV = 2.2%).

Monthly abundances ranged from 103 - 1,063 and peaked in November (Figure 2). Monthly passage rates ranged from 103 – 1,063, with peak migration occurring in October for hatchery-origin Steelhead Trout and November for natural-origin Steelhead Trout (Fig. 3). The percentage of natural-origin Steelhead Trout in the run equaled 77%, and for hatchery-origin Steelhead Trout equaled 23%.

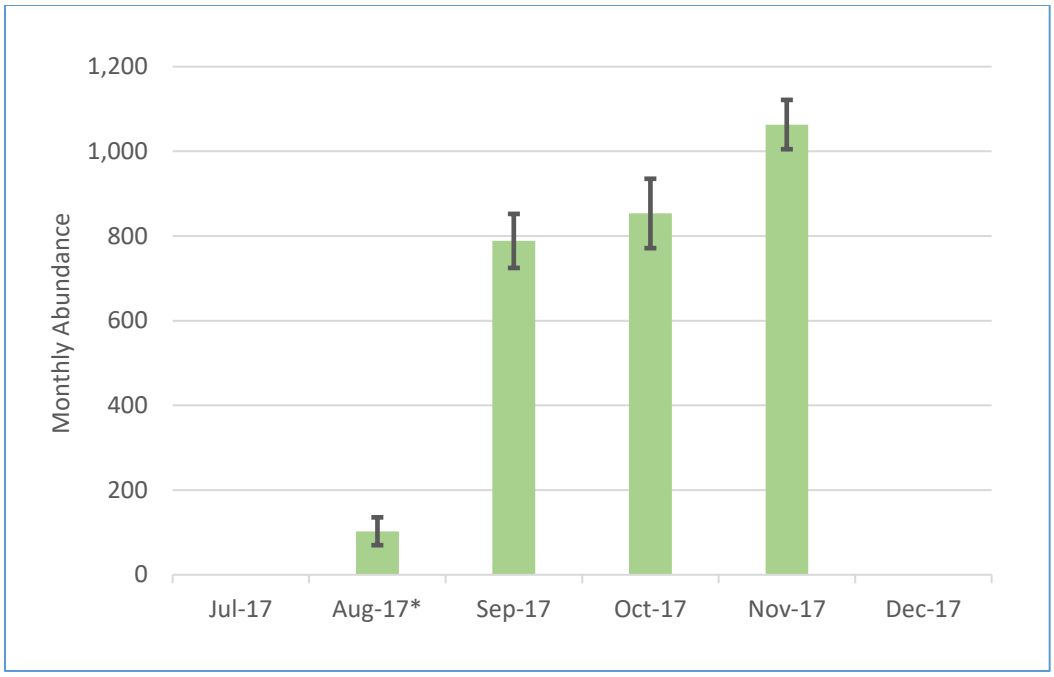

Figure 2. Late summer/fall-run Steelhead Trout (TL > 41 cm) monthly passage in 2017, Mad River, Humboldt County, CA. Error bars represent 95% Confidence Intervals. * Denotes estimate for August 28-31.

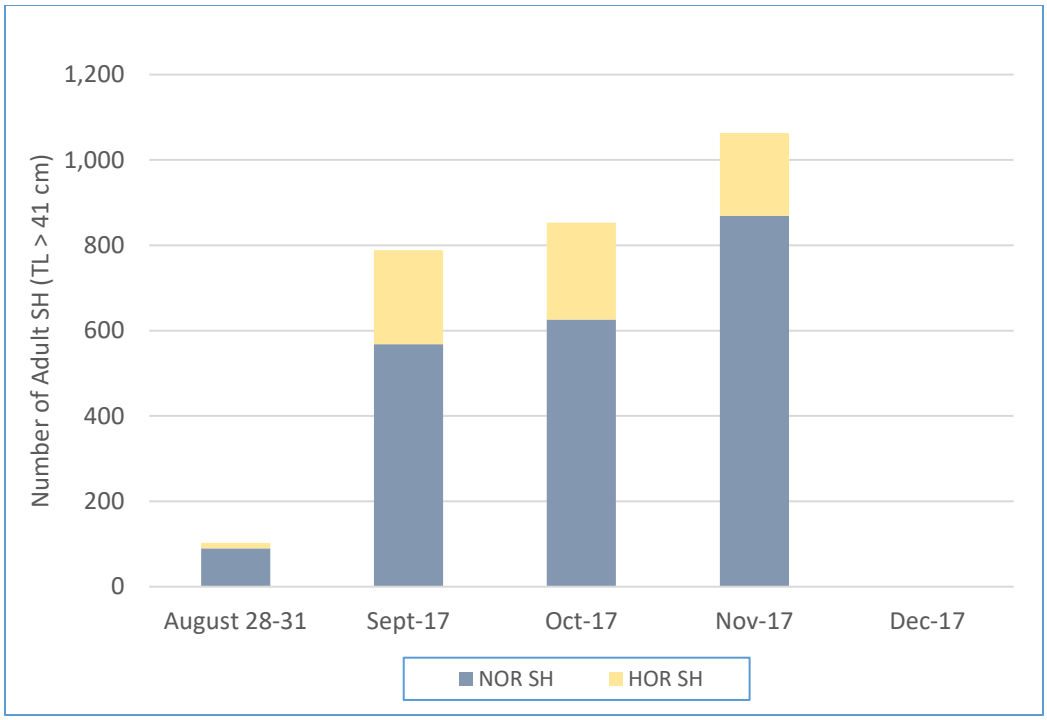

Figure 3. Monthly abundances of late summer/fall-run natural (NOR) and hatchery-origin (HOR) adult Steelhead Trout, Mad River, Humboldt County, CA., 2017.

Late summer/fall-run Steelhead Trout daily passage rates ranged from 3 – 125 per day and averaged 30 fish/day (SEM = 2.3). The peak in abundance (N = 125) occurred during a slight rise in the hydrograph on 10/20/17 (Fig. 4). A total of 1,851 Steelhead Trout (or 66% of total) migrated upstream past the sonar site during the low flow fishing closure (9/1/17 – 11/8/17).

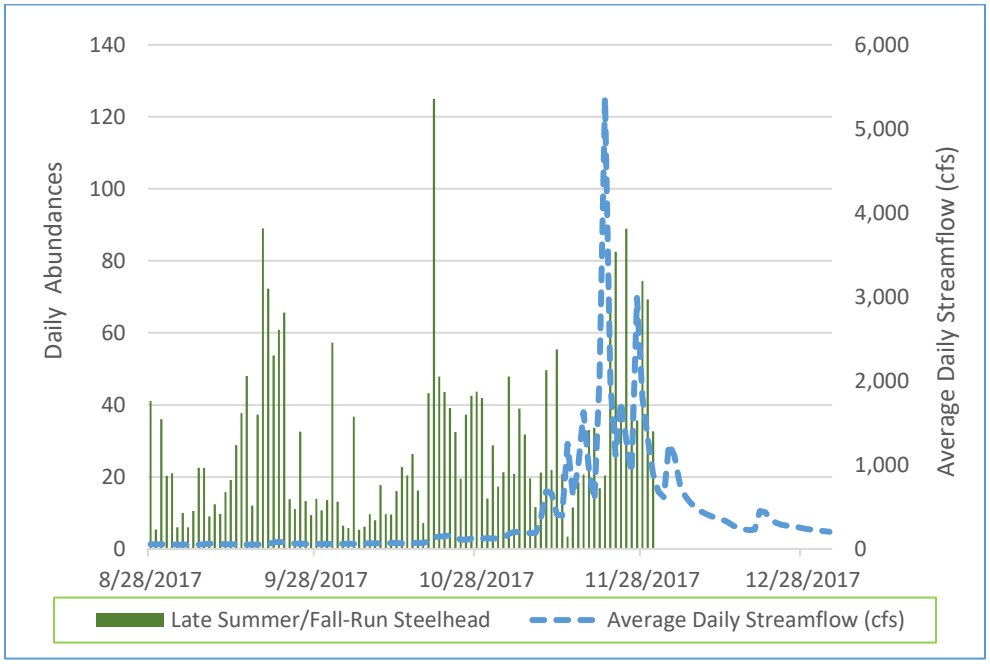

Figure 4. Daily passage estimates for late summer/fall-run Steelhead Trout (TL > 41; NOR + HOR) returns in relation to average daily stream flow (cfs) (USGS/CDWR Arcata Gaging Station, #11481000) in 2017, Mad River, Humboldt County, CA.

Annual abundances of late summer/fall-run Steelhead Trout in YRS 2014 – 2017 ranged from 425 - 2,808 and averaged 1,222 (SEM = 539) (Fig. 5). Annual abundances of natural-origin Steelhead Trout ranged from 300 – 2,142 and averaged 941 (SEM = 413). Abundances for hatchery-origin Steelhead Trout ranged from 125 – 656 and averaged 280 (SEM = 127) (Fig. 6).

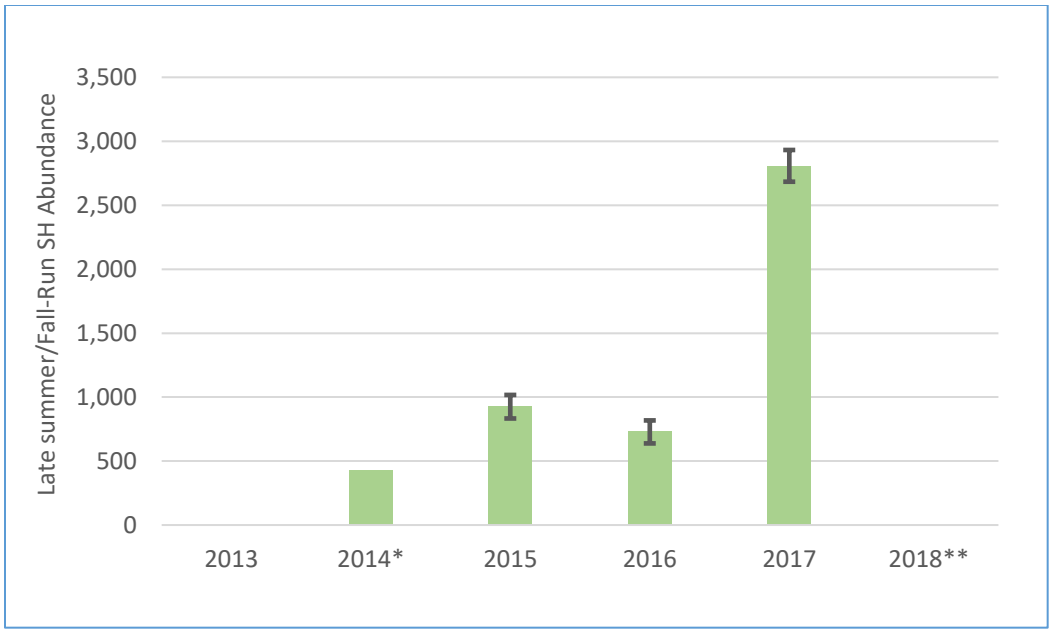

Figure 5. Annual abundances of late summer/fall-run Steelhead Trout returns to Mad River in 2014 – 2017, Humboldt County, CA. Error bars represent 95% Confidence Intervals. * Denotes 95% CI not determined. ** Denotes data in review.

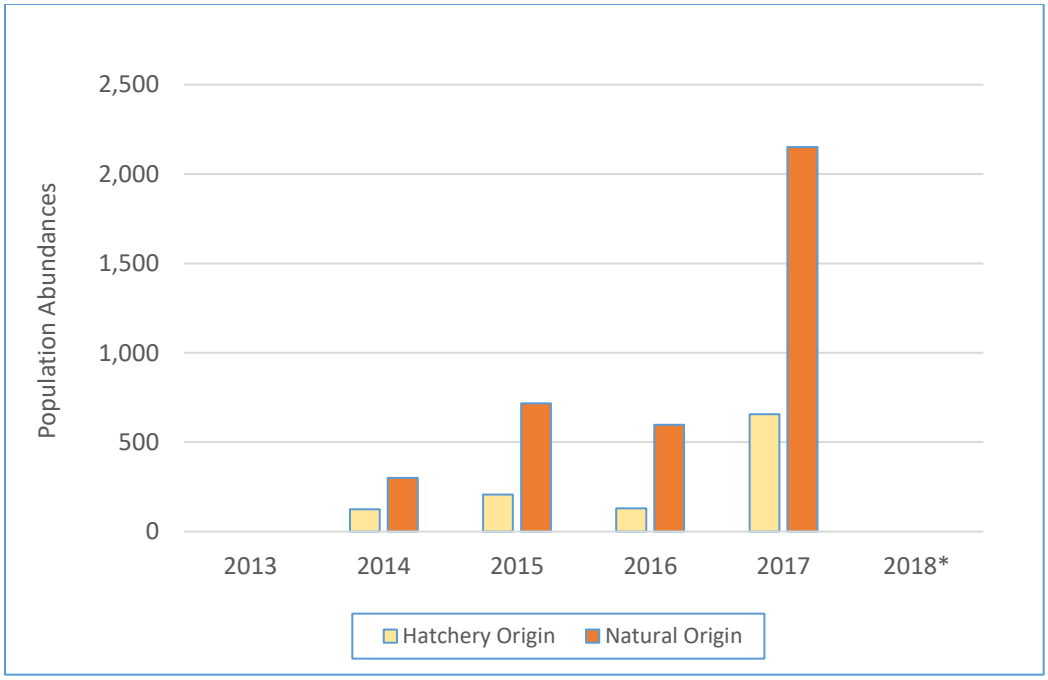

Figure 6. Annual abundances of late summer/fall-run natural (NOR) and hatchery-origin (HOR) Steelhead Trout returns in Years 2014 – 2017, Mad River, Humboldt County, CA. * Denotes data in review.

Chinook Salmon Abundance

The estimated abundance of Chinook Salmon (adults + jacks) returns from August 28th, 2017 to December 29th, 2017 equaled 12,667 (95% CI = 12,010 – 13,324; CV = 2.6%). The number of Chinook Salmon adults (TL > 54 cm) equaled 9,906 (95 % CI = 9,390 – 10,423; CV = 2.6%), and for Chinook Salmon jacks (TL 42 – 54 cm) equaled 2,761 (95% CI = 2,551 – 2,966; CV = 3.7%).

Monthly abundances of Chinook Salmon (adults + jacks) ranged from 32 – 5,546 (Fig. 5). Peak passage occurred in October (N = 5,546), and the months of October and November accounted for 87% of the run. Passage in September (N = 1,391) accounted for 11% of the total run. Monthly passage for Chinook Salmon adults ranged from 9 – 5,073 and for Chinook Salmon jacks ranged from 15 – 1,694 (Table 2). Passage for Chinook Salmon adults peaked in November, and for Chinook Salmon jacks peaked in October (Table 2).

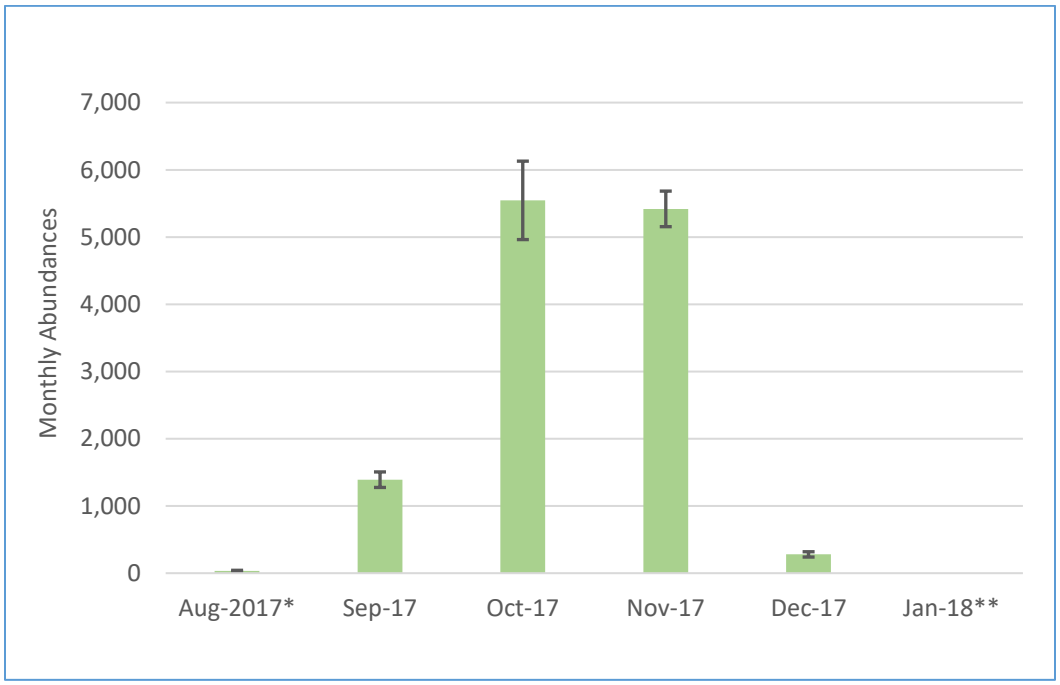

Figure 7. Chinook Salmon (adults + jacks) monthly passage in 2017/18, Mad River, Humboldt County, CA. Error bars represent 95% Confidence Intervals. * Denotes estimate for August 28 - 31. ** Denotes estimate for January 1 - 2, 2018 (N = 0).

Table 2. Monthly passage estimates of Chinook Salmon adults (TL > 54 cm) and Chinook Salmon jacks (TL 42 – 54 cm) in 2017/18, Mad River, Humboldt County, CA.

	Chinook Salmon Abundance (95% CI)	
Month	Adults (TL > 54 cm)	Jacks (TL 42 - 54 cm)
August	9 (6 – 12)	23 (14 – 33)
September	708 (612 – 804)	683 (620 – 746)
October	3,851 (3,422 – 4,282)	1,694 (1,505 – 1,883)
November	5,073 (4,809 – 5,337)	346 (314 – 378)
December	265 (226 – 303)	15 (9 – 20)
January	0	0
TOTAL:	9,906 (9,390 – 10,423)	2,761 (2,555 – 2,996)

Daily passage rates in 2017 ranged from -9 to 1,507 and averaged 102 fish/d (SE = 16.4) (Fig 8). Peaks in daily migration occurred in October and November, with smaller peaks in September. The peaks on 10/01/17 (N = 408) and 10/05/17 (N = 334) occurred during a stable hydrograph. The largest peak occurred on 10/20/17 (N = 1,507), when average daily streamflow increased from 89 cfs to 140 cfs. The second largest peak occurred on 11/10/17 (N = 794), when average daily streamflow increased from 367 cfs to 688 cfs. A total of 7,182 Chinook Salmon (or 62% of total) migrated upstream past the sonar site during the low flow fishing closure (cfs < 200; 9/1/17 – 11/8/17) (Fig. 8).

Annual abundances of Chinook Salmon (adult + jack) returns in Years 2014/15 – 2017/18 ranged from 5,645 – 12,667 and averaged 8,247 (SEM = 1,528) (Fig. 9).

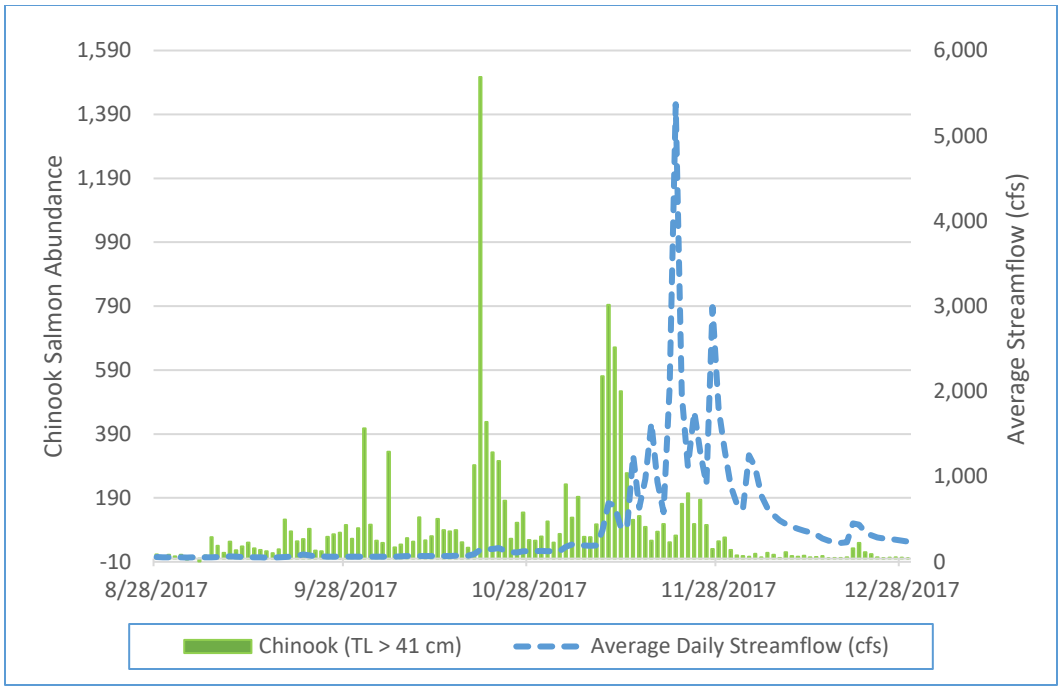

Figure 8. Daily passage estimates for Chinook Salmon (adult and jack) returns in relation to average daily stream discharge (USGS/CDWR Arcata Gaging Station, #11481000) in 2017, Mad River, Humboldt County, CA.

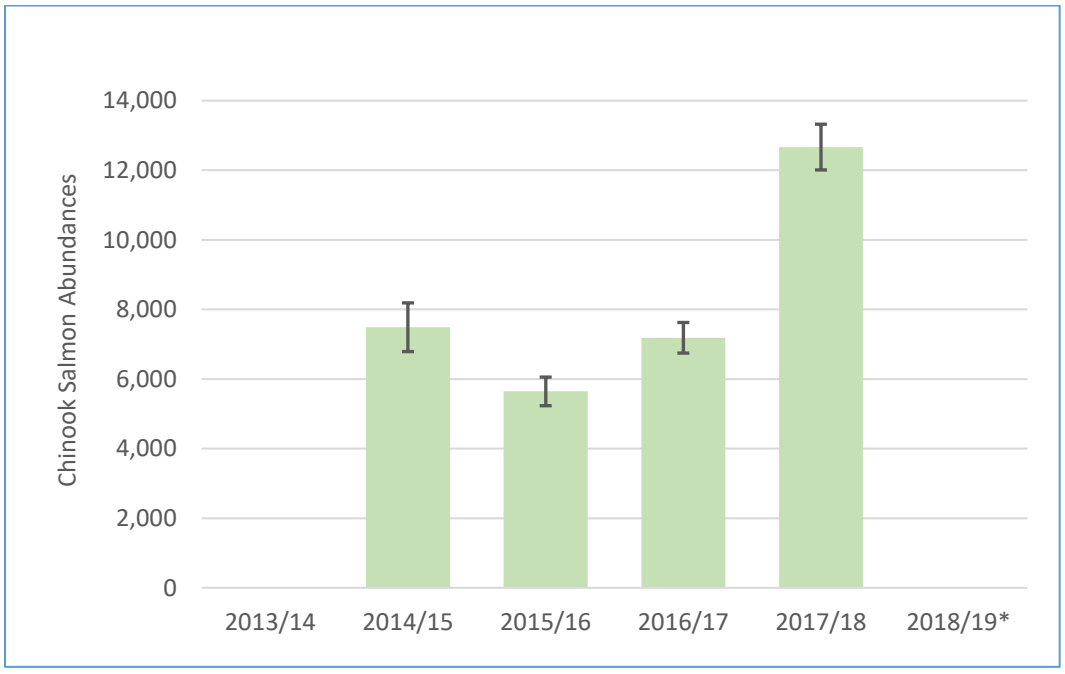

Figure 9. Chinook Salmon (adults + jack) annual returns to Mad River in years 2014/15 - 2017/18, Humboldt County, CA. Error bars represent 95% Confidence Intervals. * Denotes data in review.

Coho Salmon Abundance

The estimated abundance of Coho Salmon (adult + jack) returns from September 26th, 2017 – January 2nd, 2018 equaled 1,575 (95% CI = 1,482 – 1,668; CV = 3.0%).

Monthly abundances ranged from 2 - 1,099 and peaked in November (Fig 10). The run in November accounted for 70% of total abundance (Fig. 10).

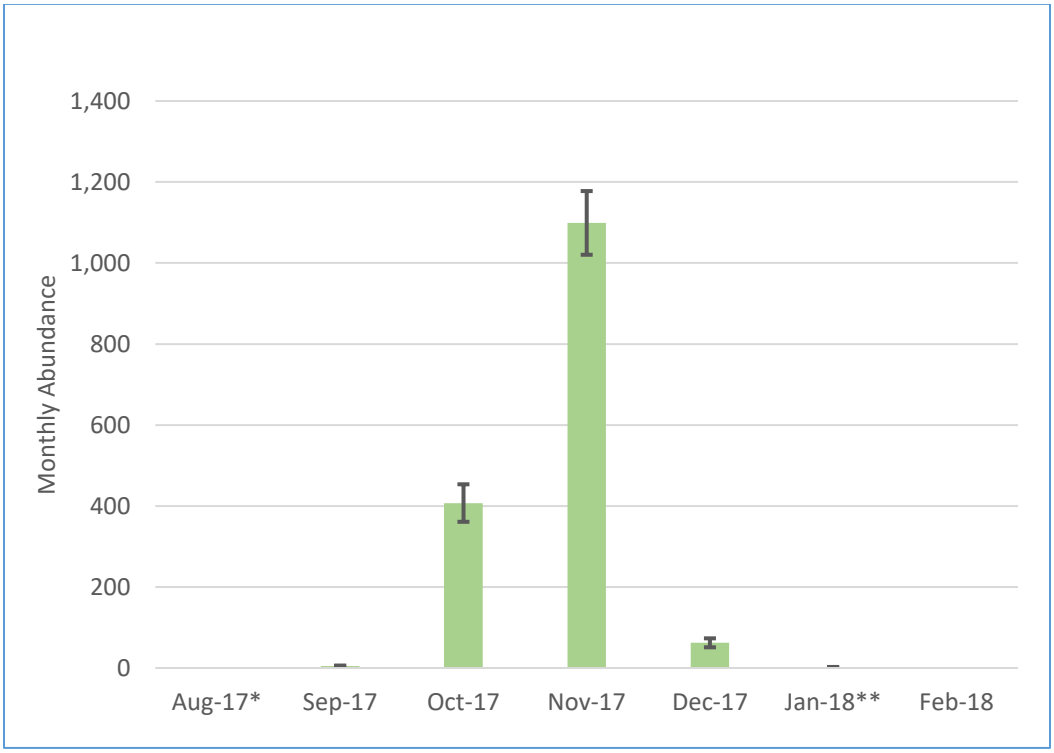

Figure 10. Coho Salmon (adults + jacks) monthly passage in 2017, Mad River, Humboldt County, CA. Error bars represent 95% Confidence Intervals. * Denotes estimate for August 28-31. ** Denotes estimate for January 1 – 2, 2018.

Coho Salmon daily passage rates ranged from 0 – 130 per day and averaged 16 fish/day (SEM = 2.9). The peak in abundance (N = 130) on 11/03/17 occurred during a slight rise in the hydrograph when average daily streamflow rose from 127 cfs to 178 cfs (Fig. 11). A total of 1,054 Coho Salmon (or 67% of total) migrated upstream past the sonar site during the low flow fishing closure (9/1/17 – 11/8/17) (Fig. 11).

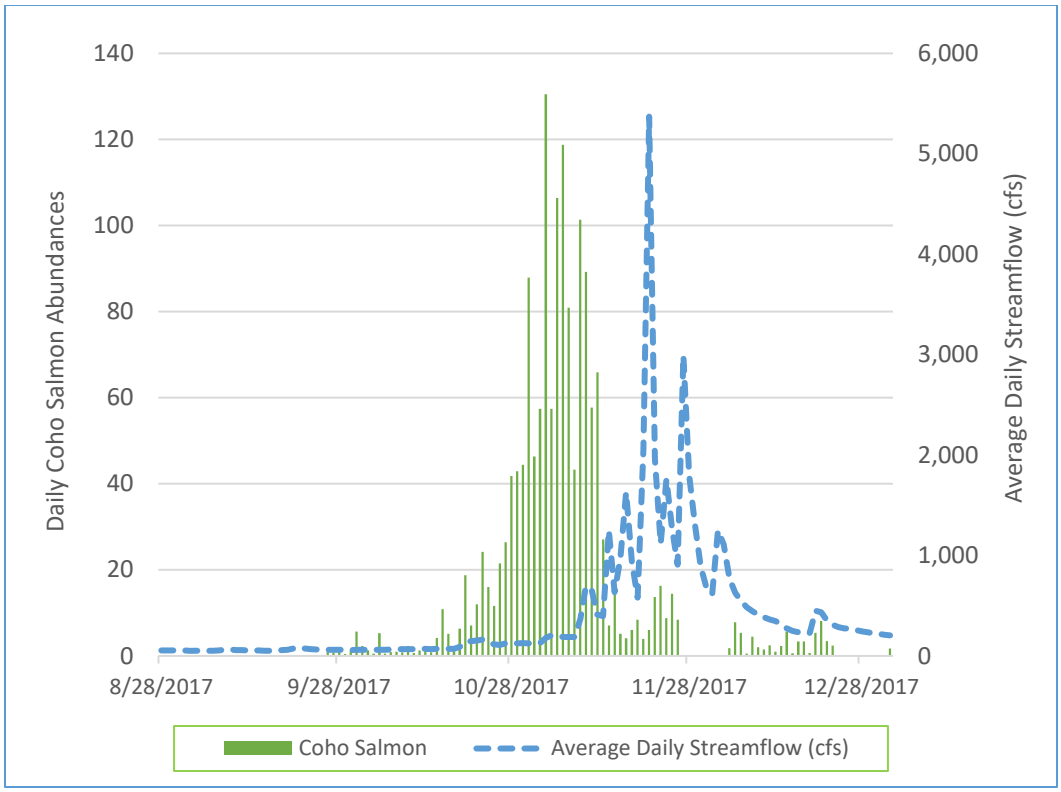

Figure 11. Daily passage estimates for Coho Salmon (adults + jacks) returns in relation to average daily stream flow (cfs) (USGS/CDWR Arcata Gaging Station, #11481000) in 2017, Mad River, Humboldt County, CA.

Pink Salmon Abundance

The estimated abundance of Pink Salmon (TL > 41 cm) returns from September 13, 2017 – October 31, 2017 equaled 750 (95% CI = 694 – 807; CV = 3.8%).

Pink Salmon returned in September and October 2017, with October accounting for slightly more returns than September (Figure 12).

Pink Salmon daily passage rates ranged from 0 – 74 per day and averaged 15 fish/day (SEM = 2.5). The peak in abundance (N = 75) occurred on 10/05/17 during a stable hydrograph (Fig. 13). Pink Salmon (N = 750) migrated upstream past the sonar site during the low flow fishing closure (9/1/17 – 11/8/17) (Fig. 13).

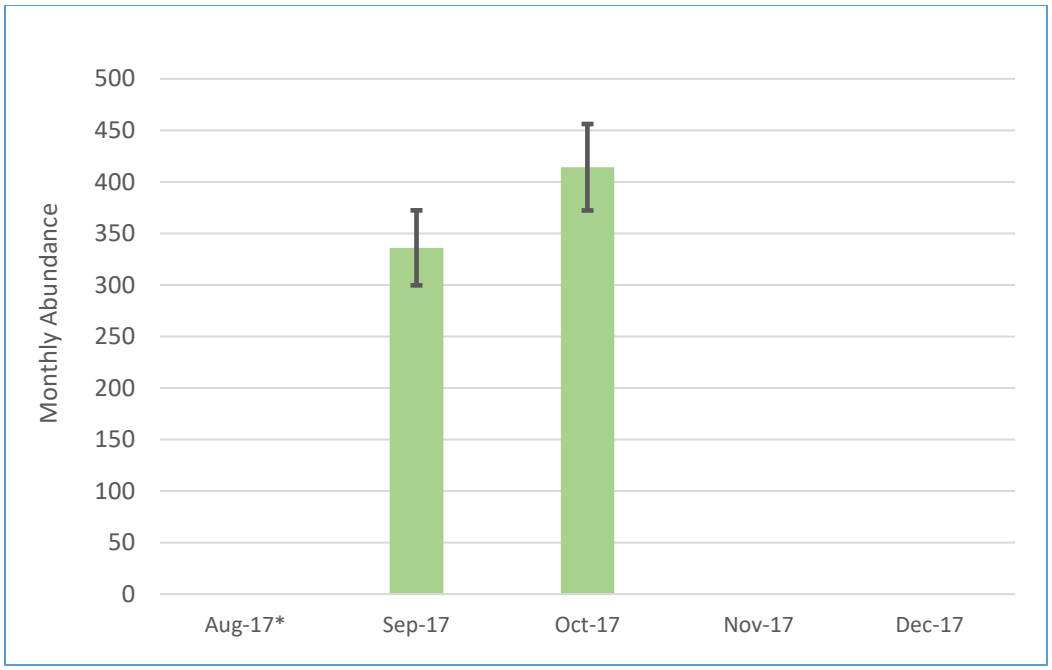

Figure 12. Pink Salmon (TL > 41 cm) monthly passage in the Mad River, Humboldt County, CA. Error bars represent 95% Confidence Intervals. * Denotes estimate for August 28-31.

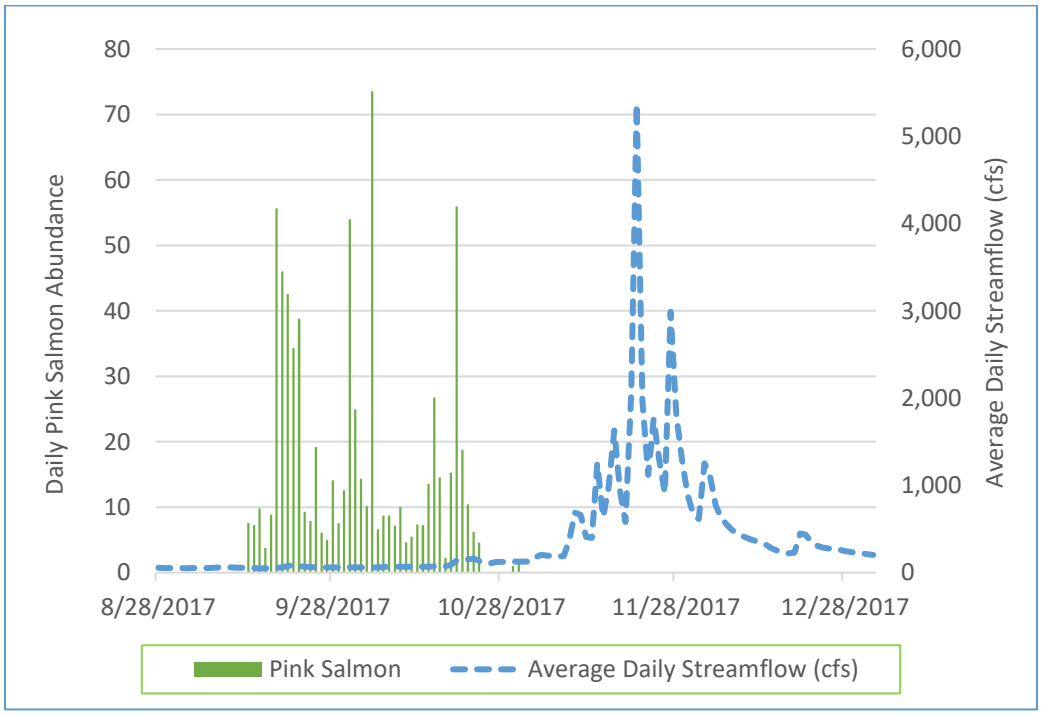

Figure 13. Daily passage estimates for Pink Salmon (TL > 41) returns in relation to average daily stream flow (cfs) (USGS/CDWR Arcata Gaging Station, #11481000) in 2017, Mad River, Humboldt County, CA.

Winter-Run Steelhead Trout Abundance

The estimated abundance (using salmon model with specific kelt adjustments) of adult winter-run Steelhead Trout (TL > 41 cm) returns in 2017/18 equaled 8,224 (95% CI = 7,895 – 8,554; CV = 2.0%). Depending upon model choice, abundances in 2017/18 ranged from 7,410 – 9,329 and averaged 8,284 (SEM = 236) (Fig. 14).

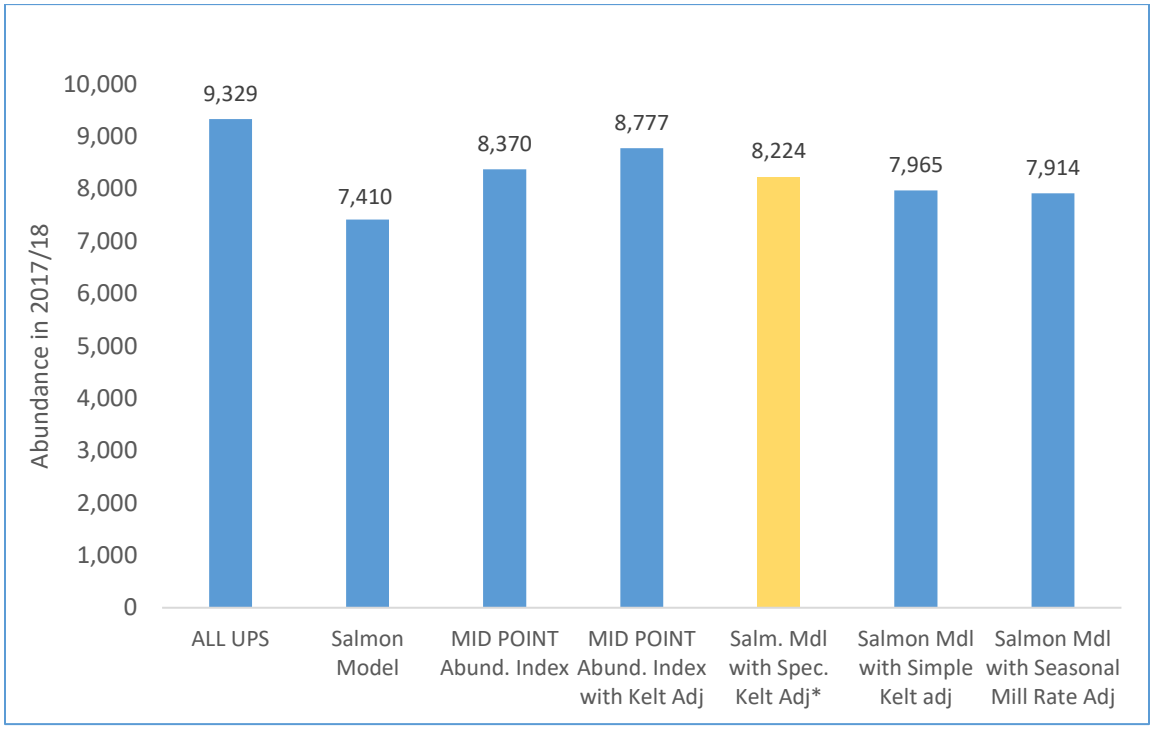

Figure 14. Comparison of various sonar models used to estimate winter-run Steelhead Trout returns to Mad River in 2017/18, Humboldt County, CA. * Denotes preferred model for Mad River winter-run Steelhead Trout returns.

Monthly passage of winter-run Steelhead Trout (NOR and HOR combined) ranged from 689 – 4,406 (Fig. 15).

Winter-run Steelhead Trout daily passage rates ranged from 0 – 471 per day and averaged 69 fish/day (SEM = 7.5) (Fig. 16). The peak in abundance (N = 471) occurred on 1/09/18 when average daily streamflow increased from 313 to 1,070 cfs (Fig. 16). Most (98%) of the winter-run Steelhead Trout migrated upstream at average daily streamflows less than 4,000 cfs, 82% migrated upstream at average daily streamflows less than 2,000 cfs, and 0.1% migrated upstream at flows greater than 5,000 cfs.

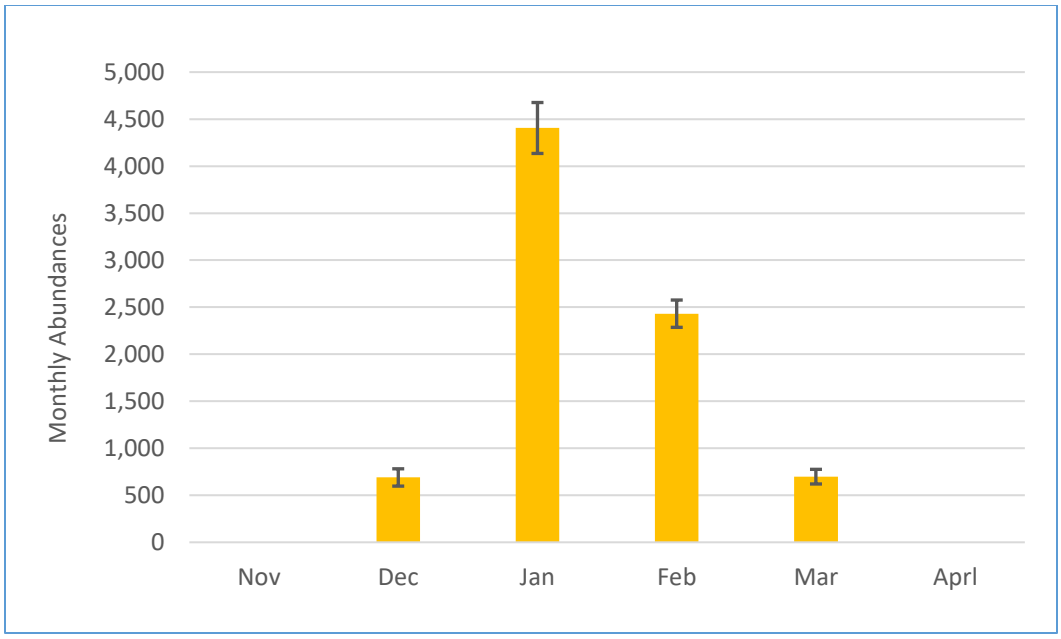

Figure 15. Monthly passage estimates of winter-run Steelhead Trout (N = 8,224; TL > 41 cm) returns to the Mad River in 2017/18, Humboldt County, CA. Error bars represent 95% Confidence Intervals.

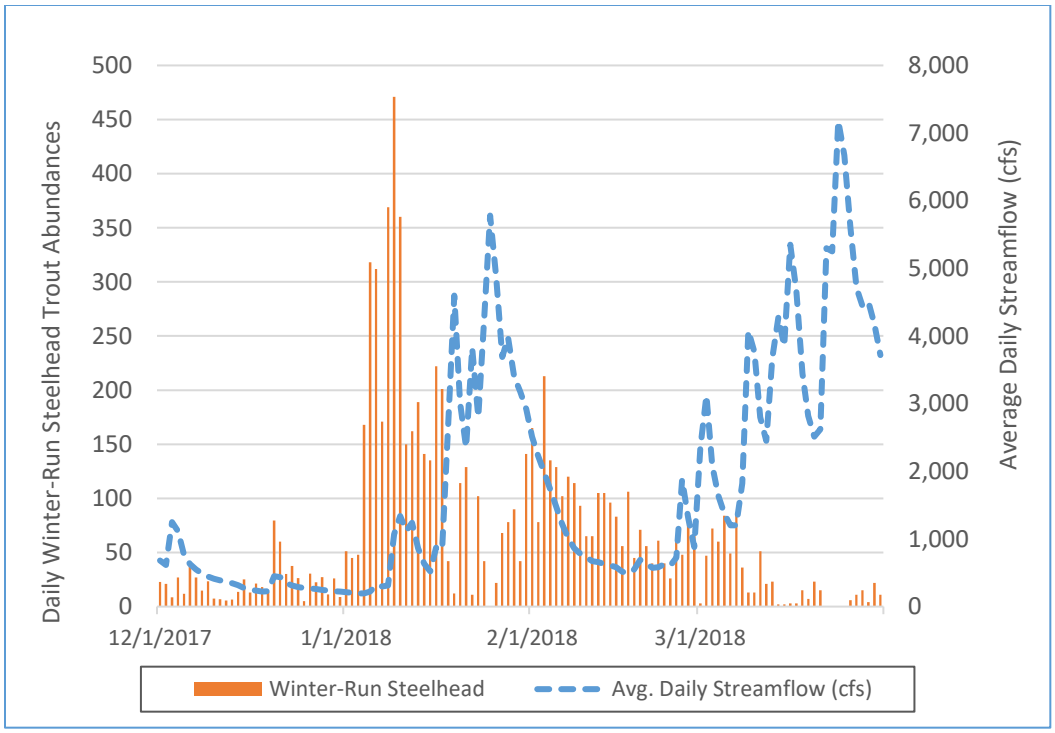

Figure 16. Daily passage estimates for winter-run Steelhead Trout (TL > 41) returns to Mad River in relation to average daily stream flow (cfs) (USGS/CDWR Arcata Gaging Station, #11481000) in 2017/18, Humboldt County, CA.

Post spawn (kelt) Steelhead Trout (n = 832) migrated downstream past the sonar from December – March, with March accounting for 51% of the kelt abundance (Fig. 17).

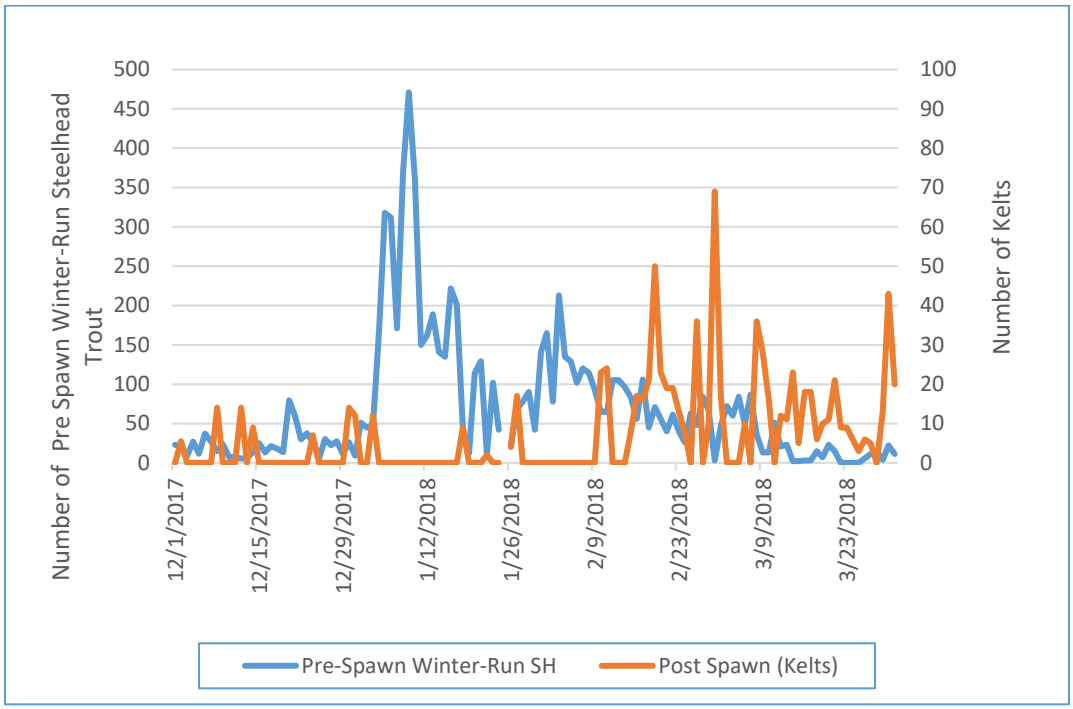

Figure 17. Daily abundances of pre-spawn (first Y axis) and post spawn (kelts) (second Y axis) winter-run Steelhead Trout in the Mad River in 2017/18, Humboldt County, CA.

Winter-run Steelhead Trout abundances in years 2013/14 to 2017/18 ranged from 5,655 – 8,224 and averaged 7,110 (SEM = 441) (Fig. 18).

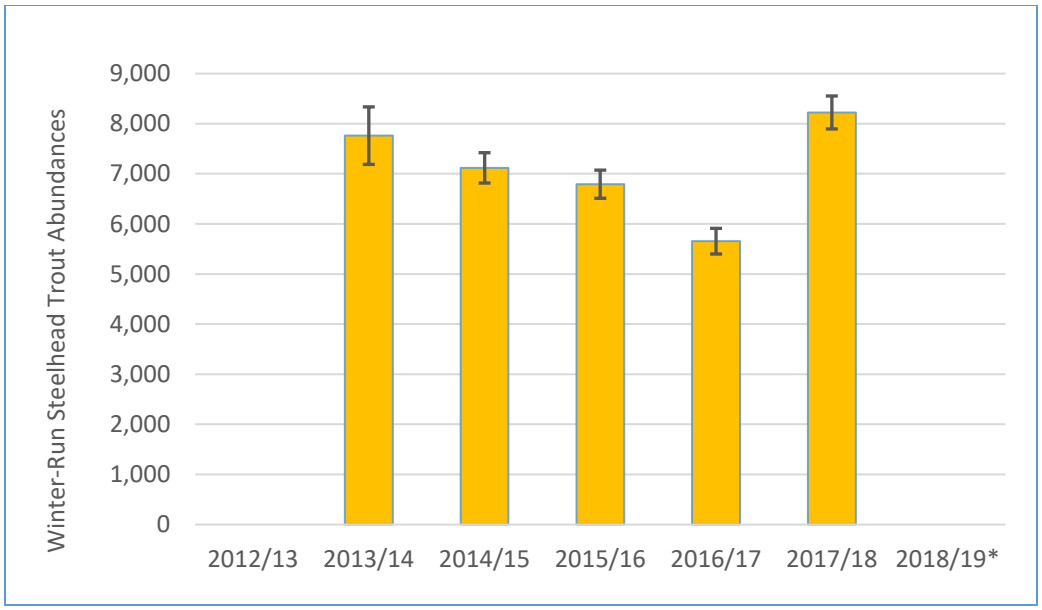

Figure 18. Winter-run Steelhead Trout annual abundance estimates in the Mad River in 2013/14 to 2017/18, Humboldt County, CA. Error bars represent 95% Confidence Intervals. * Denotes data in review.

Natural-Origin and Hatchery-Origin Winter-Run Steelhead Trout

We estimate 5,270 natural-origin Steelhead Trout (95% CI = 5,049 – 5,491; CV = 2.1%) and 2,954 hatchery-origin Steelhead Trout (95% CI = 2,835 – 3,073; CV = 2.0%) returned to Mad River in the 2017/18 season. The percentage of natural-origin fish (pNOS) equaled 64.1% and the percentage of hatchery-origin fish (pHOS) equaled 35.9%.

The peak month of migration occurred in January for both natural-origin and hatchery-origin Steelhead Trout (Fig. 19).

The pattern in the daily run timing of natural origin and hatchery origin winter-run Steelhead Trout was similar (Fig. 20).

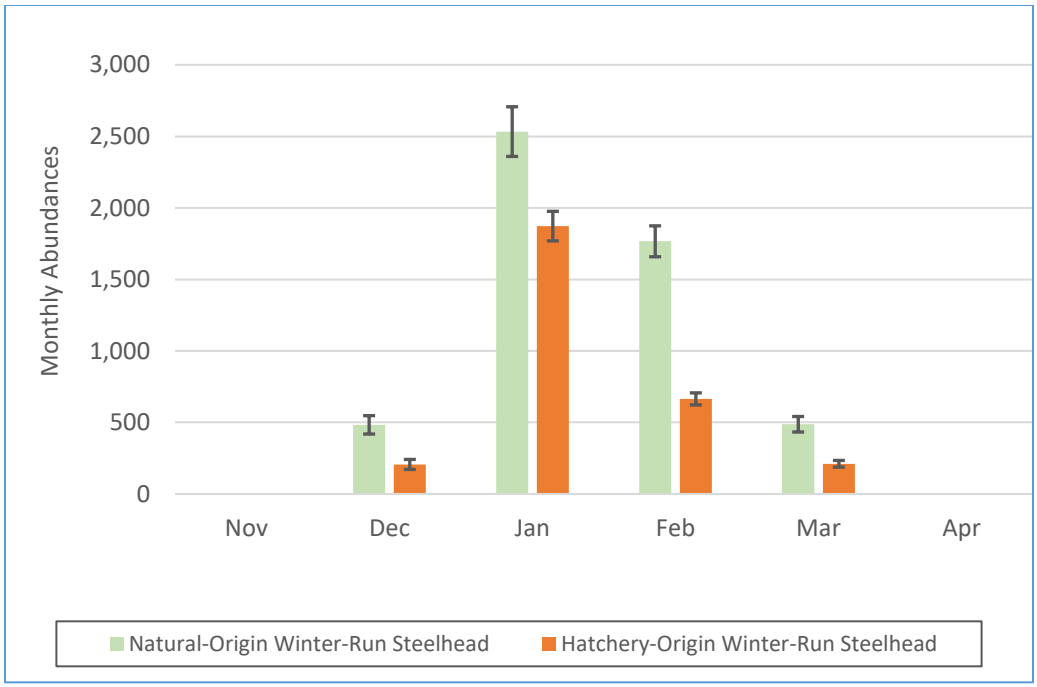

Figure 19. Monthly passage rates of natural-origin and hatchery-origin winter-run Steelhead Trout returns to the Mad River in 2017/18, Humboldt County, CA.

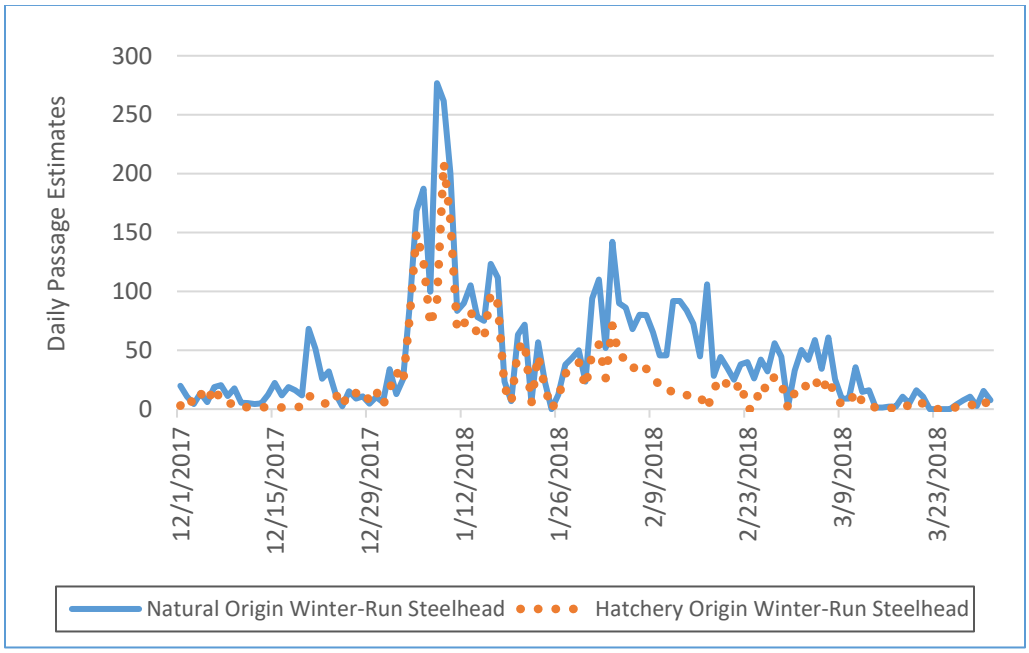

Figure 20. Daily passage estimates of natural-origin and hatchery-origin winter-run Steelhead Trout returns to the Mad River in 2017/18, Humboldt County, CA

Calculation of PNI for MRH Winter-Run Steelhead Trout Program

The goal for MRH breeding program is to have at least 50% of the spawners be of natural origin (CDFW 2016; NMFS 2017). Beginning in 2018, we analyzed scale patterns of NOR Steelhead Trout that were questionable. We collected 61 NOR's for breeding with 61 (HOR's) in 2018, however 6 of the NOR's were actually HOR's based upon scale analysis. MRH staff were informed of the six breedings the day after spawning and culled those lots. Thus, 55 NOR's were bred with 55 HOR's (1:1 ratio). For calculating PNI, the pNOB (apparent) equaled 0.5, and pHOS equaled 0.36. The corresponding PNI value (apparent) for 2018 equaled 0.58 and was above the minimum target of 0.5 (CDFW 2016; NMFS 2017).

Table 3. Proportionate natural influence (PNI) index for MRH Winter-Run Steelhead Trout Program in 2017 and 2018, Mad River, Humboldt County, CA.

	Proportionate Natural Influence (PNI)	
Year	Apparent	True Value*
2017	0.61	0.30
2018	0.58	-

*Based upon parental based tagging and pedigree analysis (Kinziger et al. 2018), will occur at least every 5 years.

Discussion / Recommendations

Mad River supports several anadromous salmonid species, run types, and is an important river for recreational fishing. All anadromous species, with exception to Coastal Cutthroat Trout, are listed as 'threatened' under the Federal Endangered Species Act, and populations are considered below historic levels. However, Mad River makes important contributions to the CC Chinook Salmon ESU and Northern Coast Steelhead Trout DPS as evidenced by our sonar derived abundance estimates. The total number of (adult and jack) anadromous salmonids returning to Mad River during sonar deployment in 2017/18 equaled 26,204. The Mad River also supports an intense recreational fishery for winter-run Steelhead Trout, supported by Mad River Hatchery's winter-run Steelhead Trout Program. The over-all goal of MRH's HGMP is to raise winter-run Steelhead Trout that can be harvested by sport anglers, without jeopardizing the abundance, genetic diversity and survival of wild Chinook Salmon, wild Coho Salmon, and

naturally produced Steelhead Trout. The Fishery Management and Evaluation Plan for Mad River will specifically address these issues (CDFW, in progress). MRH HGMP also requires integrating natural origin winter-run Steelhead Trout into the breeding program at MRH at a 1:1 ratio with hatchery-origin Steelhead Trout.

In 2017, we found that pNOB using visual identification methods and adult collections that primarily relied upon Puter Creek and the fish ladder at MRH equaled 0.16 based upon PBT and pedigree reconstruction (Kinziger et al. 2018). The pNOB of 0.50 was not met, and the resulting PNI (0.30) was below 0.50. There were several reasons why this occurred:

1. CDFW Volunteers were not aware that many HOR Steelhead Trout had poor adipose fin clips.

2. Adult collections primarily occurred in Puter Cr, which is too close to the hatchery ladder, and HOR Steelhead Trout strayed there.

3. Few natural origin Steelhead Trout will enter the ladder at MRH in most years.

Fulfilling requirements of MRH's HGMP is a learning process, and in 2018 (prior to Kinziger et al. 2018 report) CDFW initiated changes associated with adult collection of NOR Steelhead Trout for breeding at MRH. For example, all NOR Steelhead Trout collected off-site of MRH in 2018 were inspected by experienced CDFW staff prior to transportation to MRH. Additionally, all questionable NOR's (collected off-site or via ladder to MRH) had scales removed to determine a natural or hatchery-origin juvenile life history, and no fish were taken from Puter Creek.

The following recommendations should improve pNOB and the PNI index.

1. CDFW volunteers and MRSSVP personnel are notified of potentially poor fin clips and are instructed to critically examine all fins for fin erosion.

2. MRH will increase the percentage of HOR fish that have a complete (100%) and nearly complete (75%) adipose fin clip. The goal is 98%$^{+}$ of the HOR fish will have an easily recognizable fin clip.

3. NOR fish will not be collected from Puter Cr (tributary about 0.3 miles upstream of MRH. In 2018, a very high percentage of NOR fish were collected in areas far from MRH.

4. All NOR fish will be visually inspected by CDFW staff when collected in the field, and a floy tag is then applied (by CDFW staff) to all NOR Steelhead Trout potentially used for breeding.

5. Beginning in 2019, *all* potential NOR fish will not be bred unless the analysis of scale samples shows a NOR life history (irregular spacing of circuli, possible age-2 smolting).

6. An angler creel survey should be conducted to report the harvest of unspawned, HOR Steelhead Trout. Harvesting HOR Steelhead Trout will decrease pHOS (and increase pNOS) and increase the PNI.

Acknowledgements

I am thankful to CDFW AFRAMP for funding this project in 2017/18, and Humboldt Bay Municipal Water District for access to their property for sonar deployment and use of their electricity. Steven Holt (CDFW Scientific Aide) and Benjamin Sheppard (CDFW Scientific Aide) were instrumental in assisting this study, as were the Mad River Steelhead Trout Stewards Volunteer Program for obtaining natural Steelhead Trout for MRH, and origin information. Steve Sanchez (CDFW) and Sergio da Costa (Sound Metrics) provided technical support, and Teri Moore (CDFW) provided the site location map.

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Appendices

Appendix 1. Origin apportionment data for winter-run Steelhead Trout returns in 2017/18, Mad River, Humboldt County, CA.

Winter SH Run in Mad R, 2017_18 (Origin Apportionment Data)								
* pool if less than 5 fish for the day.				Numer of		217	Percent*	
Rec #	DATE	METHOD	LOCATION	NOR>41	HOR>41	Total	nor	hor
1	12/1/2017	CR, drift boat	blue lk br to sonar	5	1	6	0.875	0.125
2	12/1/2017	Creel	sunbergs	2		2		
3	12/2/2017	Creel	HBMWD	1		1		
4	12/5/2017	telemetry/creel	below bl bridge 3hor		3	3		
5	12/6/2017	Creel	HBMWD	2	0	2	0.5	0.5
6	12/7/2017	Creel	glendale	1		1	0.75	0.25
7	12/7/2017	telemetry/Creel	pepes	1	1	2		
8	12/8/2017					0		
9	12/9/2017	Creel	3gs	1		1		
10	12/13/2017	Creel	kadle	2		2		
58	12/13/2017	Snorkel	run below sonar	1	1	2		
59	12/18/2017	Snorkel	run above aris pool	6	0	6	0.888889	0.1111111
60	12/18/2017	Snorkel	warerfall pool below aris	2	1	3		
11	12/20/2017	Creel	?	1		1	0.857143	0.1428571
63	12/21/2017	telemetry/creel	waldons paving	1		1		
64	12/22/2017	telemetry/creel	pepes	1		1		
12	12/23/2017	Creel	sewer pond	1		1		
13	12/23/2017	Creel	below sonar	2	1	3		
66	12/24/2017	telemetry/creel	anni mary bridge		1	1	0.5	0.5
14	12/25/2017	creel	below sonar/	2		2		
15	12/25/2017	creel	hor at pepes		1	1		
16	12/26/2017	creel	pepes	1		1		
17	12/26/2017	creel	pepes		1	1		
68	12/26/2017	telemetry/creel	pepes	1		1		
18	12/27/2017	creel	101 bridge		1	1	0.4	0.6
71	12/27/2017	telemetry/creel	sewer pond	1		1		
70	12/29/2017	telemetry/creel	3gs	1		1		
19	12/30/2017	creel	wall below sonar		1	1		
20	12/30/2017	creel	sewer pond		1	1		
21	1/1/2018	creel	wall below sonar	1		1	0.666667	0.33333333
22	1/1/2018	creel	upstream hall cr	3	3	6		
23	1/1/2018	creel	below sonar	7	3	10		
26	1/1/2018	creel				0		
73	1/1/2018	telemetry/creel	above essex	1		1		
74	1/1/2018	telemetry/creel	above essex		1	1		
75	1/1/2018	telemetry/creel	above essex	1		1		
76	1/1/2018	telemetry/creel	above essex	1		1		
24	1/2/2018	creel	below sonar	1		1	0.285714	0.7142857
25	1/2/2018	creel	waren cr		1	1		
61	1/2/2018	snorkel	run below wall below sonar	1	2	3		
77	1/2/2018	telemetry/creel	below warren creek		1	1		
27	1/3/2018	Creel	below sonar		1	1	0.529412	0.4705882
28	1/4/2018	Creel	us 299 bridge	1		1		
29	1/4/2018	Creel	by 3g's	1		1		
30	1/4/2018	Creel	wall below sonar		1	1		
31	1/5/2018	Creel	below sonar	5	3	8		
32	1/5/2018	Creel	3gs	1	3	4		
97	1/5/2018	broodstock/creel	sewer pond	1		1		
33	1/6/2018	Creel	below sonar	3	1	4	0.6	0.4
34	1/6/2018	Creel	299 bridge area	2	3	5		
80	1/6/2018	telemetry/creel	below sonar	4	2	6		
82	1/6/2018	telemetry/creel	3gs	1		1		
98	1/6/2018	broodstock/creel	sewer pond	1		1		
100	1/6/2018	broodstock/creel	3gs	2		2		
101	1/6/2018	broodstock/creel	below blue lake br	1		1		
102	1/6/2018	broodstock/creel	3gs	1	4	5		
35	1/7/2018	Creel	below sonar	3	4	7	0.583333	0.4166667
83	1/7/2018	telemetry/creel	just upstream of 3gs	1		1		
103	1/7/2018	broodstock/creel	below sonar	3	1	4		
36	1/8/2018	Creel	3gs	4	3	7	0.75	0.25
84	1/8/2018	telemetry/creel	3gs	1		1		
104	1/8/2018	broodstock/creel	below aris at wall	4		4		
37	1/10/2018	Creel	below sonar	2	1	3	0.555556	0.4444444
105	1/13/2018	broodstock/creel	below blue lake br	1		1		
39	1/30/2018	Creel	glendale, add nor	2	3	5		
40	1/31/2018	Creel	glendale	2	1	3	0.666667	0.3333333
91	2/1/2018	telemetry/creel	summer bridge	1		1		
41	2/2/2018	Creel	sonar	2	1	3		
43	2/7/2018	Creel	below sonar	2	1	3		
44	2/7/2018	Creel	pump4	1		1		
94	2/7/2018	telemetry/creel	3gs	1		1		
95	2/7/2018	telemetry/creel	waldons paving		1	1		
45	2/8/2018	Creel	pepes	2	1	3	0.7	0.3
46	2/8/2018	Creel	3gs	1		1		
47	2/11/2018	Creel	3gs	4	2	6		
48	2/14/2018	Creel	us299	2	0	2	0.875	0.125
106	2/14/2018	broodstock/creel	us299 bridge	1		1		
49	2/15/2018	Creel	pepes	3	1	4		
107	2/15/2018	broodstock/creel	below blue lake br	1		1		
50	2/16/2018	Creel	below sonar	2	1	3	0.8	0.2
108	2/16/2018	broodstock/creel	pepe's	1		1		
109	2/16/2018	broodstock/creel	sewer pond	1		1		
51	2/17/2018	Creel	anni mary bridge	2	0	2	1	0
92	2/17/2018	telemetry/creel	anni mary bridge	1		1		
96	2/17/2018	telemetry/creel	anni mary bridge	1		1		
110	2/17/2018	broodstock/creel	pepes	1		1		
111	2/17/2018	broodstock/creel	below blue lake br	1		1		
112	2/17/2018	broodstock/creel	glendale	1		1		
52	2/21/2018	Creel	frisbee golf course	2	1	3	0.625	0.375
53	2/22/2018	Creel	frisbee golf course	2	2	4		
113	2/22/2018	broodstock/creel	above sonar	1		1		
54	2/23/2018	Creel	frisbee golf course	2		2	1	0
114	2/24/2018	broodstock/creel	blue lake br	3		3		
55	2/25/2018	Creel	below sonar	6	3	9	0.666667	0.3333333

Appendix 2. Winter-run Steelhead Trout daily sonar counts per origin type (Natural and Hatchery) in 2017/18, Mad River, Humboldt County, CA.

N=	8224	5270	2954		
	Net Winter SH	NORs	HORs	%NOR	%HOR
12/1/2017	23	20.0	2.9	87.50%	12.50%
12/2/2017	21	10.6	10.6	50.00%	50.00%
12/3/2017	9	4.4	4.4	50.00%	50.00%
12/4/2017	27	13.5	13.5	50.00%	50.00%
12/5/2017	12	5.9	5.9	50.00%	50.00%
12/6/2017	37	18.6	18.6	50.00%	50.00%
12/7/2017	27	20.3	6.8	75.00%	25.00%
12/8/2017	15	11.2	3.7	75.00%	25.00%
12/9/2017	23	17.6	5.9	75.00%	25.00%
12/10/2017	7	5.6	1.9	75.00%	25.00%
12/11/2017	7	5.2	1.7	75.00%	25.00%
12/12/2017	6	4.2	1.4	75.00%	25.00%
12/13/2017	6	4.8	1.6	75.00%	25.00%
12/14/2017	14	12.1	1.5	88.89%	11.11%
12/15/2017	25	22.2	2.8	88.89%	11.11%
12/16/2017	13	11.6	1.4	88.89%	11.11%
12/17/2017	21	18.8	2.4	88.89%	11.11%
12/18/2017	18	16.1	2.0	88.89%	11.11%
12/19/2017	14	11.6	1.9	85.71%	14.29%
12/20/2017	80	68.1	11.4	85.71%	14.29%
12/21/2017	60	51.4	8.6	85.71%	14.29%
12/22/2017	30	25.7	4.3	85.71%	14.29%
12/23/2017	38	32.1	5.4	85.71%	14.29%
12/24/2017	26	13.1	13.1	50.00%	50.00%
12/25/2017	5	2.6	2.6	50.00%	50.00%
12/26/2017	30	15.2	15.2	50.00%	50.00%
12/27/2017	23	9.0	13.5	40.00%	60.00%
12/28/2017	27	10.9	16.4	40.00%	60.00%
12/29/2017	11	4.5	6.8	40.00%	60.00%
12/30/2017	26	10.4	15.6	40.00%	60.00%
12/31/2017	9	6.0	3.0	66.67%	33.33%
1/1/2018	51	34.0	17.0	66.67%	33.33%
1/2/2018	45	12.9	32.1	28.57%	71.43%
1/3/2018	48	25.4	22.6	52.94%	47.06%
1/4/2018	168	88.9	79.1	52.94%	47.06%
1/5/2018	318	168.4	149.6	52.94%	47.06%
1/6/2018	312	187.2	124.8	60.00%	40.00%
1/7/2018	171	99.8	71.3	58.33%	41.67%
1/8/2018	369	276.8	92.3	75.00%	25.00%
1/9/2018	471	261.7	209.3	55.56%	44.44%
1/10/2018	360	200.0	160.0	55.56%	44.44%
1/11/2018	150	83.3	66.7	55.56%	44.44%
1/12/2018	162	90.0	72.0	55.56%	44.44%
1/13/2018	189	105.0	84.0	55.56%	44.44%
1/14/2018	141	78.3	62.7	55.56%	44.44%
1/15/2018	135	75.0	60.0	55.56%	44.44%
1/16/2018	222	123.3	98.7	55.56%	44.44%
1/17/2018	201	111.7	89.3	55.56%	44.44%
1/18/2018	42	23.3	18.7	55.56%	44.44%
1/19/2018	12	6.7	5.3	55.56%	44.44%
1/20/2018	114	63.3	50.7	55.56%	44.44%
1/21/2018	129	71.7	57.3	55.56%	44.44%
1/22/2018	11	6.1	4.9	55.56%	44.44%
1/23/2018	102	56.7	45.3	55.56%	44.44%
1/24/2018	42	23.3	18.7	55.56%	44.44%
1/25/2018	0	0.0	0.0	55.56%	44.44%
1/26/2018	22	12.2	9.8	55.56%	44.44%
1/27/2018	68	37.8	30.2	55.56%	44.44%
1/28/2018	78	43.3	34.7	55.56%	44.44%
1/29/2018	90	50.0	40.0	55.56%	44.44%
1/30/2018	42	23.3	18.7	55.56%	44.44%
1/31/2018	141	94.0	47.0	66.67%	33.33%
2/1/2018	165	110.0	55.0	66.67%	33.33%
2/2/2018	78	52.0	26.0	66.67%	33.33%
2/3/2018	213	142.0	71.0	66.67%	33.33%
2/4/2018	135	90.0	45.0	66.67%	33.33%
2/5/2018	129	86.0	43.0	66.67%	33.33%
2/6/2018	102	68.0	34.0	66.67%	33.33%
2/7/2018	120	80.0	40.0	66.67%	33.33%
2/8/2018	114	79.8	34.2	70.00%	30.00%
2/9/2018	93	65.1	27.9	70.00%	30.00%
2/10/2018	65	45.5	19.5	70.00%	30.00%
2/11/2018	65	45.5	19.5	70.00%	30.00%
2/12/2018	105	91.9	13.1	87.50%	12.50%
2/13/2018	105	91.9	13.1	87.50%	12.50%
2/14/2018	96	84.0	12.0	87.50%	12.50%
2/15/2018	83	72.6	10.4	87.50%	12.50%
2/16/2018	56	44.8	11.2	80.00%	20.00%
2/17/2018	106	106.0	0.0	100.00%	0.00%
2/18/2018	45	28.1	16.9	62.50%	37.50%
2/19/2018	71	44.4	26.6	62.50%	37.50%
2/20/2018	56	35.0	21.0	62.50%	37.50%
2/21/2018	40	25.0	15.0	62.50%	37.50%
2/22/2018	61	38.1	22.9	62.50%	37.50%
2/23/2018	40	40.0	0.0	100.00%	0.00%
2/24/2018	26	26.0	0.0	100.00%	0.00%
2/25/2018	63	42.0	21.0	66.67%	33.33%
2/26/2018	48	32.0	16.0	66.67%	33.33%
2/27/2018	84	56.0	28.0	66.67%	33.33%
2/28/2018	67	44.7	22.3	66.67%	33.33%
3/1/2018	3	2.1	0.9	69.81%	30.19%
3/2/2018	47	32.8	14.2	69.81%	30.19%
3/3/2018	72	50.3	21.7	69.81%	30.19%
3/4/2018	60	41.9	18.1	69.81%	30.19%
3/5/2018	84	58.6	25.4	69.81%	30.19%
3/6/2018	49	34.2	14.8	69.81%	30.19%
3/7/2018	87	60.7	26.3	69.81%	30.19%
3/8/2018	36	25.1	10.9	69.81%	30.19%
3/9/2018	13	9.1	3.9	69.81%	30.19%
3/10/2018	13	9.1	3.9	69.81%	30.19%
3/11/2018	51	35.6	15.4	69.81%	30.19%
3/12/2018	21	14.7	6.3	69.81%	30.19%
3/13/2018	23	16.1	6.9	69.81%	30.19%
3/14/2018	2	1.4	0.6	69.81%	30.19%
3/15/2018	2	1.4	0.6	69.81%	30.19%
3/16/2018	3	2.1	0.9	69.81%	30.19%
3/17/2018	3	2.1	0.9	69.81%	30.19%
3/18/2018	15	10.5	4.5	69.81%	30.19%
3/19/2018	7	4.9	2.1	69.81%	30.19%
3/20/2018	23	16.1	6.9	69.81%	30.19%
3/21/2018	15	10.5	4.5	69.81%	30.19%
3/22/2018	0	0.0	0.0	69.81%	30.19%
3/23/2018	0	0.0	0.0	69.81%	30.19%
3/24/2018	0	0.0	0.0	69.81%	30.19%
3/25/2018	0	0.0	0.0	69.81%	30.19%
3/26/2018	6	4.2	1.8	69.81%	30.19%
3/27/2018	11	7.7	3.3	69.81%	30.19%
3/28/2018	15	10.5	4.5	69.81%	30.19%
3/29/2018	4	2.8	1.2	69.81%	30.19%
3/30/2018	22	15.4	6.6	69.81%	30.19%
3/31/2018	11	7.7	3.3	69.81%	30.19%