Hood River Production Program M&E

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Abstract

This progress report describes the research monitoring and evaluation (RM&E) components of the work performed by the Confederated Tribes of Warm Spring Branch of Natural Resources (CTWSRO-BNR) portion of the Hood River Production Program Monitoring and Evaluation Project (HRPP M&E) during the 2015 fiscal year. Passive Integrated Transponders (PIT) tags were implanted in 9,417 hatchery winter steelhead and 16,424 hatchery spring Chinook salmon in order to compare migratory attributes and survival rates of hatchery fish released into the Hood River through smolt to adult life phases. Water temperatures were recorded at eight locations within the Hood River watershed to monitor the thermal profile in important salmonid rearing streams. Stream flows were monitored in 3 Hood River basin streams. Snorkel surveys were conducted in 200 meters of tributary streams to document fish distribution and species composition. Ground based spawning surveys were conducted on 20.3 kilometers of spring Chinook spawning grounds. Throughout the Hood River Basin a total of 169 spring Chinook redds were observed and 116 carcasses were sampled during spawning ground surveys. A pre-season spring Chinook salmon adult run forecast was generated, which predicted a return adequate to meet escapement goal and broodstock needs with a sufficient surplus to allow tribal and sport fisheries to be opened. A tribal creel survey was conducted from May 5 to July 15 during which Warm Springs tribal members harvested an estimated 240 spring Chinook salmon.

Work Elements: D&E Mark/Tag Animals – PIT tag hatchery spring Chinook salmon, steelhead

Introduction

The HRPP began marking fish with PIT tags in 2005 in response to a review of the program produced by Underwood et al. (2003) and ISRP recommendations that suggested the use of PIT tag technology for monitoring salmonid populations in the Hood River. Currently the CTWS marks a proportion of each hatchery stock released to the Hood River annually. PIT marking and detections are used to address a variety of monitoring objectives listed below.

Objectives:

1. Monitor migration behavior and survival of wild and hatchery salmon and steelhead smolts
2. Provide estimates of escapement of Hood River origin spring Chinook and winter steelhead to Bonneville Dam and the Mouth of the Hood River
3. Compare the survival and migration attributes of spring Chinook smolts produced under different rearing scenarios

A concurrent and complimentary BPA funded M&E project in the Hood River conducted by ODFW (BPA project #1988-053-04) also utilizes PIT tags in cooperation with CTWS in their monitoring program. The ODFW conducted M&E project primarily PIT marks wild fish at the rotary screw trap sites they operate in the Hood Basin. Fish tagged at the screw traps are used for the mark recapture methodology to generate downstream migrant estimates at the traps sites. All adult fish captured in adult traps or through other monitoring activities are scanned for PIT tags. Further detail on ODFW's PIT tag methods and analysis can be found in the Hood River and Pelton Ladder annual report to BPA (Simpson et al. 2014; BPA Project 1988-053-04).

Methods

Our methods for marking fish with PIT tags were based on the protocols outlined in the PIT Tag Marking Procedures Manual provided by the PIT Tag Steering Committee (Columbia Basin Fish and Wildlife Authority 1999). Fish were collected by seining or crowding in rearing ponds or raceways and were unfed for at least 48 hours prior to tagging. Fish were then anesthetized in a tricaine methane sulfonate (MS 222) bath before tag implantation. The fish were not tagged if they exhibited signs of disease, were less than 70 mm in length, or had significant physical deformities. We used TX1400SST full-duplex PIT tags for this project (12.5 mm in length by 2.07 mm in diameter). PIT tags were placed in the abdominal cavity in the pelvic girdle region through the ventral side posterior of the pectoral fin. Tags were injected by hand using Biomark preloaded single use injector needles. After tag implantation the tagged fish were scanned by a PIT tag transceiver to record the unique tag code for each marked fish. Fish were then sent down a watered return pipe to the raceway or recovery tank.

Winter steelhead were PIT tagged by HRPP staff in an ODFW marking trailer at Oak Springs Hatchery. The fish released from the typical acclimation site at the East fork Sandtrap were tagged in January 2015. Another test group of winter steelhead released from a new acclimation site on Neal Creek were tagged in mid-April. Chinook were marked with PIT tags at either the Parkdale Fish Hatchery (PFH) or Moving Falls Fish Facility (MFFF). At the PFH, spring Chinook were PIT tagged in a CTWS tagging trailer in late-January 2015. Hood River stock Chinook reared at Round Butte Hatchery were PIT tagged during mid-March 2015 at the MFFF. After tagging, the marked fish were returned to the raceways to mix with the rest of the untagged population.

Round Butte hatchery reared Chinook were transported to the MFFF in late-February and all of the Parkdale Hatchery produced Chinook were transported to the site in late-February. Hatchery winter steelhead reared at the Oak Springs Hatchery were transported to the Sandtrap and Neal Creek acclimation sites in early-May. A series of three PIT tag antennas were operated at the outflow of each release site, during releases, to account for tag shedding and post tagging mortality. Transceivers at release sites were downloaded to a laptop computer daily during, and for several days following, volitional release periods.

Separate tag files were created for all release groups and the tag files were uploaded to the PTAGIS database. Throughout the year the PTAGIS database was queried to monitor tag detections at the Bonneville Dam and the Columbia River estuary. The latest query used for the information provided in this document took place on December 4, 2015.

Survival estimates were generated from capture histories for each fish based on data downloaded from the PTAGIS database by the Columbia River DART real time data access tool (http://www.cbr.washington.edu/dart). PTAGIS and the Columbia River DART tool also provide detection information on fish ascending the adult passage facilities at Bonneville Dam. This information is used to gauge the incoming run strength; smolt to adult survival rate, and migration timing of PIT marked cohorts. Expanded estimates for total adult returns to Bonneville Dam for a run year are calculated using the equation below.

$$\hat{N} = \left(\frac{1}{M}\right) \times R$$

where,

$\hat{N}$ = Estimated number of fish passing adult ladder
M = Proportion of fish in release group marked with a PIT
R = Number of fish from a release group detected at the adult passage facility

Smolt to adult ratios (SARs) are a common survival metric used for monitoring anadromous salmonid populations (Galbreath et al. 2008). We calculated SARs as the number of PIT tags from a release group that were detected in adult ladders at Bonneville dam at least one year post release, divided by the total number of tags at the time of smolt release for that group. Bonneville was selected as the adult return location for SAR calculations since the adult passage facilities there have reliable and near 100% detection efficiency. No such sites exist in the Hood Basin after the removal of Powerdale dam and trap in 2010.

Results and Conclusions

A total of 5,987 brood year (BY) 2013-14 winter steelhead were PIT tagged at Oak Springs Hatchery and subsequently released into the East Fork of the Hood River at the Sandtrap acclimation site. Another test release of 3,452 hatchery winter steelhead were released from a newly founded temporary acclimation site on Neal Creek. Spring Chinook from both of the hatchery rearing sites used by the HRPP were marked with PIT tags. A total of 16,427 BY 2013 PIT tagged Chinook were released into the West Fork Hood River at the Moving Falls acclimation site. Of the total PIT tagged Chinook released; 5,488 were reared at Parkdale Hatchery; 5,476 were reared at Moving Falls; and 5,460 were reared at Round Butte Hatchery and the Pelton Ladder.

Monitor migration behavior and survival of steelhead and Chinook smolts

In 2015 the estimated out migration survival of hatchery spring Chinook from release sites to Bonneville Dam was 90%. This was tied for the best survival estimated in the eight years monitored thus far. The hatchery winter steelhead had an estimated survival rate of 84%. This was the second highest survival observed to date and well above the average survival of 67% over 10 years of monitoring (Appendix A). The survival rate of wild steelhead smolts tagged at an ODFW screw trap on the mainstem Hood River was estimated at 71%, which was equal to the average of 71%, for that group, over the period of record (Appendix A)[1]. Using a z-test we compared the survival rates between the hatchery steelhead released from acclimation sites and wild steelhead captured as out migrants at the mainstem screw trap. We found there was a significant difference in survival between hatchery fish and wild steelhead marked at the mainstem juvenile trapping site ($P<0.05$). A z-test comparing the survival rates of wild and hatchery spring Chinook also found a significant difference ($p<0.05$)

A common desire in integrated hatchery programs, such as the Hood River steelhead program, is to produce fish with similar traits to the wild population (Galbreath et al. 2008). To determine if the hatchery released fish were manifesting similar outmigration patterns to their wild counterparts, we investigated the detection histories at Columbia mainstem PIT interrogation sites. From these detection histories we calculated and compared migration timing to these locations. The mean migration timing to Bonneville Dam was 1 day later for hatchery winter steelhead compared to the wild steelhead marked at the mainstem Hood River screw trap (Figure 2). The mean migration date to Bonneville for hatchery winter steelhead was May 15, and was May 14 for wild steelhead (Table 1). Using a t-test we compared the mean migration date between PIT tagged wild steelhead at the Mainstem juvenile traps and hatchery winter steelhead released from the Sandtrap acclimation Site. There was a significant difference between the hatchery release group and wild steelhead ($P<0.001$). Mean travel time measured from release site to Bonneville Dam was approximately 6 days longer for hatchery fish compared to wild fish (Table 1). However, these travel times are not directly comparable as most hatchery fish were released 26 km upstream of the Mainstem screw trap where wild smolts are marked and released. These differences in migration date and travel time to Bonneville were slight enough that we feel the acclimation and release strategies in 2015 yielded reasonably similar outmigration patterns between wild and hatchery steelhead.

Table 1. Interrogation rates, survival rates, mean migration date, and travel time to Columbia River detection sites for PIT tagged steelhead and spring Chinook released into the Hood River in 2015.

Release Group	Tag Group	Bonneville Dam				Travel Time Days (SE)
		Bonneville Detected	Capture Probability (SE)	Survival Probability (SE)	Mean Migration Date	
Hatchery STW	9,417	3,122	0.399 (0.031)	0.834 (0.063)	5/15/2015	11.88 (0.14)
Wild Steelhead[1]	3,065	913	0.419 (0.049)	0.714 (0.081)	5/14/2015	4.95 (0.18)

[1] The ODFW Hood River M&E project (BPA project # 1988-053-04), which operated the rotary screw traps in the Hood River basin and mark wild fish with PIT tags, also produces smolt survival estimates using different survival models than described here (Simpson et al 2014). The specific survival rates between our methods and those published by ODFW may differ somewhat, but the survival trends tend to agree between both projects.

Hatchery CHS	16,424	2,902	0.199 (0.020)	0.895 (0.088)	5/2/2015	13.08 (0.08)
Wild CHS	573	95	0.336 (0.137)	0.493 (0.197)	5/16/15	8.49 (0.86)

[1]Includes both winter and summer steelhead.

The mean travel time to Bonneville Dam for hatchery spring Chinook was 13.1 days, with a shortest observed travel time of 2 days and a longest observed travel time of 37.6 days. The mean date of downstream passage of PIT tagged hatchery Chinook at Bonneville Dam was May 2 (Table 1). The mean travel time in 2015 tied with 2014 as the shortest average travel time to Bonneville Dam in 8 years of Chinook PIT monitoring. The mean migration date of wild Chinook was 14 days later than hatchery Chinook. Though the travel time from release site to Bonneville Dam was nearly 5 days shorter for wild Chinook compared to hatchery Chinook (Table 1). We compared the mean date of migration at Bonneville Dam between hatchery Chinook and wild Chinook and found a significant difference ($P>0.001$).

Estimate adult escapement and run timing.

With the removal of Powerdale dam and its associated fish trap in summer 2010, estimating adult escapement to the Hood River has become much more challenging and uncertain. One tool that is being utilized as a way to estimate adult abundance is detection of PIT tagged fish as adults. There is extensive detection infrastructure at Bonneville dam fish ladders, approximately 42 kilometers downstream of the Hood River confluence, which detects nearly all salmonids migrating to upstream tributaries. Based on the PIT tag detections, expanded estimates of total returning adults for each release group were calculated using the PIT tag expansion equation described in the methods section (Table 2). Estimates to Bonneville do not account for any tag loss, harvest, natural mortality, or straying that occurs before fish enter the Hood River. The ODFW Hood River M&E project (BPA project # 1988-053-04) publishes escapement estimates to the mouth of the Hood River using mark recapture models populated by various PIT detection and adult trapping facilities in the Hood River sub basin (Simpson et al 2014). Bonneville estimates remain informative to managers at assessing incoming run strength and relative abundance before final mark recapture estimates are available.

Table 2. Adult detections of PIT tagged hatchery winter steelhead (STW), hatchery summer steelhead (STS), and hatchery spring Chinook salmon (CHS) by years post release at Bonneville adult passage facilities and expanded estimates of total run to Bonneville Dam.

Run Year	Stock	Tag Detections				Expanded Estimates			
		1	2	≥3	Total	1	2	≥3	Total
2005/06	STW	0	-	-	0	0	-	-	0
2006/07		1	10	-	11	2	112	-	114
2007/08		3	51	5	59	15	105	56	176
2008/09		7	128	13	148	50	619	27	696
2009/10		0	365	52	417	0	2,593	252	2,845
2010/11		1	85	93	179	7	550	661	1,217
2011/12		0	189	56	245	0	1,286	363	1,649

2012/13		3	85	36	124	26	787	244	1,058
2013/14		2	110	30	142	19	970	273	1,262
2014/15		1	78	35	114	7	674	309	989
2006	STS	10	-	-	10	281	-	-	281
2007		19	30	-	49	131	843	-	975
2008		-	102	0	102	-	705	0	705
2009		2	-	3	5	17	-	21	37
2010		3	19	-	22	28	159	-	187
2011		-	96	1	97	-	884	8	893
2012		-	-	9	9	-	-	83	83
2008	CHS	45	-	-	45	501	-	-	501
2009		-	66	-	66	-	734	-	734
2010		17	-	2	19	222	-	22	244
2011		50	101	-	151	633	1,316	-	1,950
2012		11	78	5	94	133	988	65	1,186
2013		45	61	1	107	485	738	13	1,235
2014		47	87	4	138	451	937	48	1,436
2015		58	177	2	237	446	1,697	22	2,165

Compare the survival and migration attributes of the spring Chinook smolts reared at three different hatchery facilities and released to the Hood River.

PIT tag information is also used in monitoring to support another program objective: to evaluate and compare spring Chinook rearing at three different hatchery facilities. This evaluation is being accomplished by a physiology investigation conducted by researchers at NOAA Fisheries (BPA Contracts 44907, 58847, 62859 and 46273). In support of the physiology monitoring, PIT tag marking and detections are utilized to monitor survival, and ultimately adult returns, between the rearing groups.

The final adult returns from brood year (BY) 2010 spring Chinook occurred in 2015 completing the returns for the 3-year comparative rearing study. Our comparisons of SAR's thus far imply there is a noticeable difference in survival between each of the three rearing groups. With the Pelton Ladder group displaying the highest SAR, the Carson group the lowest SAR, and the Parkdale group having intermediate survival among the groups; except for BY 2010 where Parkdale had the lowest survival (Figure 1). With the exception of the BY 2010 Parkdale group these SAR results coincide and agree with the rankings of smolt quality produced by the NOAA Fisheries physiology investigation for those brood years, which ranked the Pelton group as highest quality, the Carson group as lowest, and the Parkdale group as intermediate (Larsen et al. 2012).

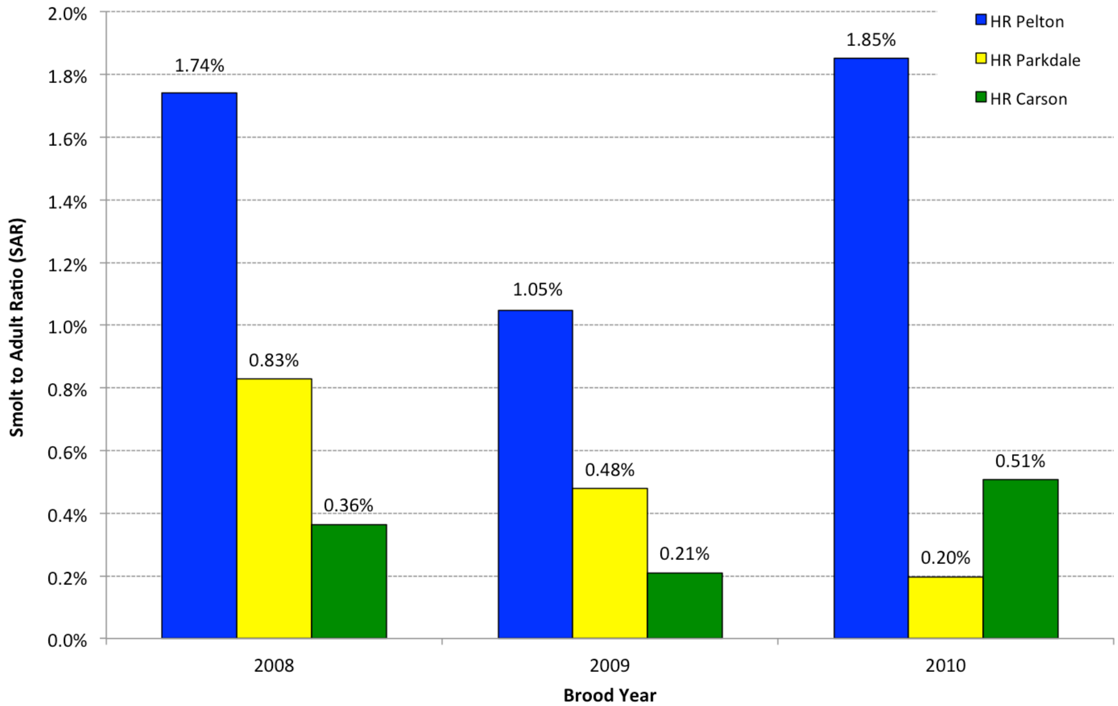

Figure 1. Smolt to adult ratios for three rearing groups of Hood River stock hatchery spring Chinook salmon from brood years 2008 through 2010.

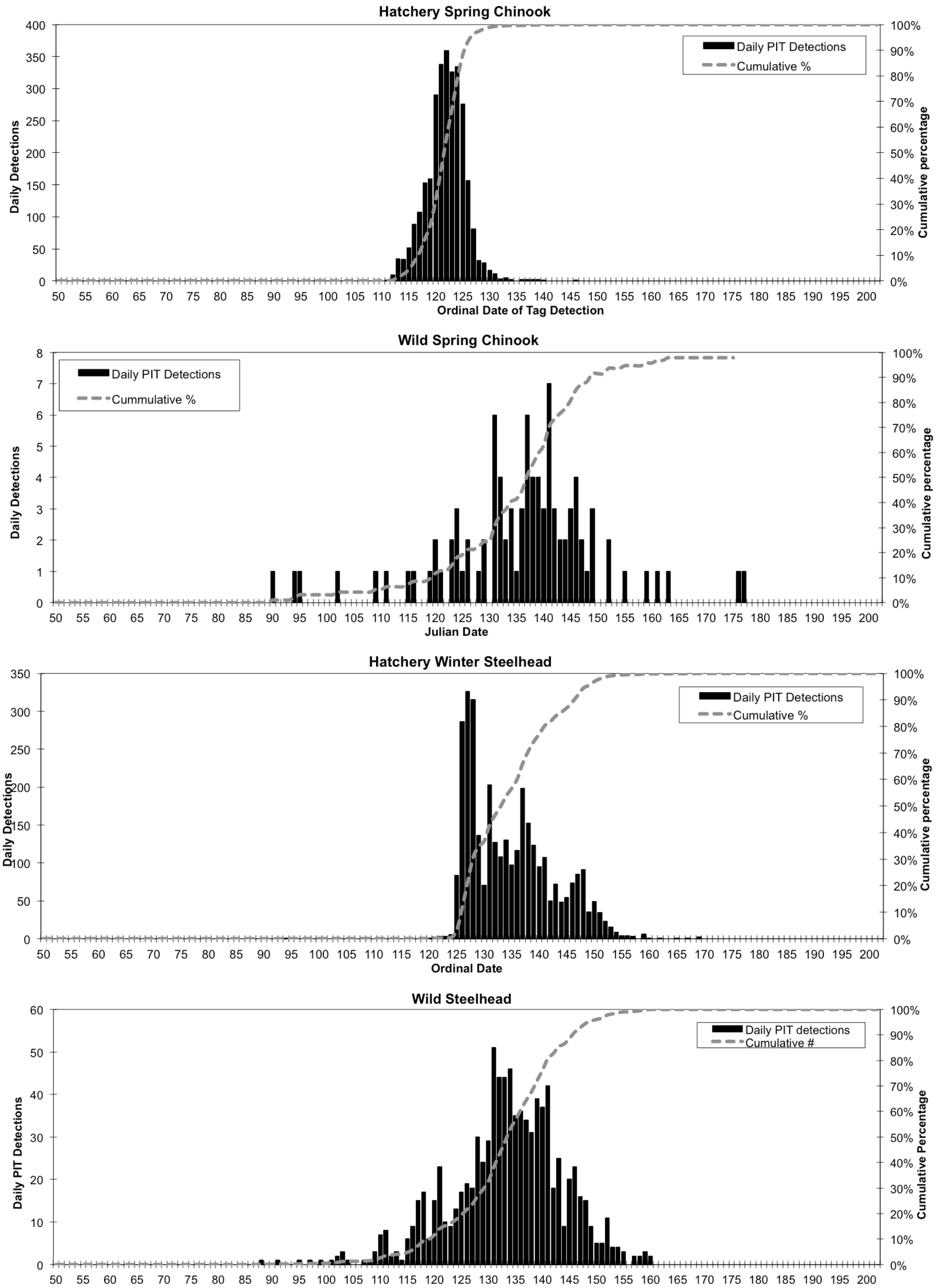

Figure 2. Out migration timing to Bonneville Dam of PIT tagged wild and hatchery steelhead and spring Chinook smolts released in the Hood River during the 2015 migration year.

Adaptive Management & Lessons Learned

Marking fish with PIT tags has been extremely useful in adaptive management. Detection of Hood River fish at Bonneville Dam allows managers to gauge run strength before the fish arrive to the Hood River. This in turn informs managers whether run forecasts are realistic so as to adjust harvest regulations or other management activities accordingly. Survival estimates derived from PIT tags have also allowed us to compare hatchery-rearing groups and make decisions to refine our hatchery production strategies.

Work Element H: Collect/Generate/Validate Field and Lab Data – Collect temperature data in the Hood River subbasin

Introduction

The HRPP began monitoring water temperature at sites throughout the Hood River basin beginning in 1990. Originally, the goal was to ascertain whether the temperature regime in the Hood River basin was suitable to support a spring Chinook population. Results were promising, and the HRPP began reintroducing spring Chinook into the Hood River basin with acclimated smolt releases in 1996. The HRPP continued to monitor water temperature at seven sites in the Hood River watershed to assess temperature trends and gain a better understanding of the thermal regime in the Hood River (Figure 3). This knowledge of the thermal regime gives HRPP managers insight into fish behavior and ecological responses, and allows managers the ability to trend the effectiveness of water quality improvement projects. The HRPP is also interested in whether Oregon Department of Environmental Quality (ODEQ) water quality temperature standards [Total Maximum Daily Load (ORS 340-041-0028)] are being met (Table 3), as well as measuring temperature response to management and/or restoration activities occurring in the basin.

Table 3. Temperature criteria for streams in the Hood River subbasin supporting salmonids (ODEQ, 2003).

Temperature Standard	Area	Time Period
13˚C standard for salmon and steelhead spawning use	West Fork Hood	August 15 – June 15
	Lake Branch	August 15 – June 15
	East Fork Hood	October 15 – May 15
	Neal Creek	October 15 – May 15
	Mainstem Hood River	October 1 – June 15
16˚C standard for core cold water habitat use	West Fork Hood	Year Round
	Lake Branch	Year Round
	Mainstem Hood River	Year Round
18˚C standard for salmon and trout rearing and migration	Neal Creek	Year Round
	East Fork Hood	Year Round
	Roger's Spring	Year Round
12˚C standard for bull trout spawning and juvenile rearing	Middle Fork Hood	Year Round
	West Fork Hood	Year Round

The HRPP's water temperature monitoring effort has evolved over the years in response to new data needs and changes in resource management directives; to this end, several sites have been added, moved, and/or removed. Additionally, temperature data collected by HRPP is frequently shared with other agencies and groups operating in the Hood River watershed; such as the ODEQ, U.S. Forest Service, irrigation districts, and the Hood River Watershed Group. Additional thermographs were deployed at Moving Falls on the West Fork Hood River in late 2008 and in Roger's Spring in 2009. The Moving Falls thermograph was installed to begin monitoring and gathering baseline temperature data at the new location for the smolt rearing and acclimation site constructed in 2011 and the Roger's Spring thermograph was initially installed to monitor the source water for the PFH, and later moved downstream of the PFH to monitor the potential influence of hatchery operations on the thermal regime of Rogers Creek.

Methods

Water temperatures are monitored continuously at one-hour increments using thermographs at sites on the Mainstem Hood River, Middle Fork, East Fork, West Fork, Lake Branch, Neal Creek, and Roger's Spring (Figure 2). We use Onset U22-001 Water Temp Pro v2 thermographs at 6 sites and 2 Onset U20-001 water level data logger that collect both water temperature and barometric pressure data at the other 2 sites. Before deployment to the field a warm bath and cold bath accuracy check is performed for each thermograph. Thermographs are downloaded periodically during the year. At the time of each download, a field audit of thermograph accuracy is performed with a National Institute of Standards and Technology (NIST) certified digital thermometer. Once a year, thermographs are briefly removed from the field for a yearly accuracy check with the warm and cold bath methodology (The Oregon Plan 1999). Thermographs that are not within the acceptable range (±0.5 C° of actual temperature) are replaced. Data is processed through the Eel River Water Temperature Analysis Program version 97.8, to produce summations and to compare data to ODEQ water temperature standards. Charts of average daily water temperature values (˚C) at all sites are included in Appendix B.

On June 15th, all temperature probes were removed for calibration and testing. All probes were found to be within the 0.5ºC range quality standard, and were subsequently reset and redeployed on June 16th. No probe malfunctions occurred during the 2015 monitoring cycle, though the Middle Fork Hood River probe appears to have gone dry from 7-14-15 thru 8-20-15. Data from this time period was excluded from the analysis.

Information on the protocol and methods used for this work element are also published at the following web address,

https://www.monitoringmethods.org/Protocol/Details/761

Results

In 2015, water temperatures throughout the entire Hood River basin were higher than historic averages. Winter, spring, summer, and fall water temperatures were significantly warmer than the 10 year average (Table 4). This was likely due to the higher than average climatic temperatures and below average precipitation throughout 2015 associated with the El Nino / La Nina Southern oscillation and global climate change.

The 2014-2015 winter in the Hood River Basin was warmer and dryer than historic averages (Figure 4 and Table 4). This resulted in less snow pack available on Mt Hood to feed the Hood River watershed throughout the summer and fall. The Natural Resource Conservation Service reported the Hood River Basin SNOTEL monitoring site was 27% of average snow water equivalent on May 1st, 2015 (http://www.wcc.nrcs.usda.gov/nwcc/site. A snow pack approaching such low levels has not been recorded on Mt Hood since the winter of 2004-2005 (29.2% of average snow water equivalent on May 1st); another year with notable drought conditions.

Spring, summer, and fall weather could also be characterized as above average in climatic temperature and below average in precipitation (Figure 4 and Table 4, http://www.accuweather.com/en/us/hood-river-or/97031/.........). All of these factors contributed to the above average stream temperatures recorded in the Hood River basin during the 2014-2015 water year (Table 4).

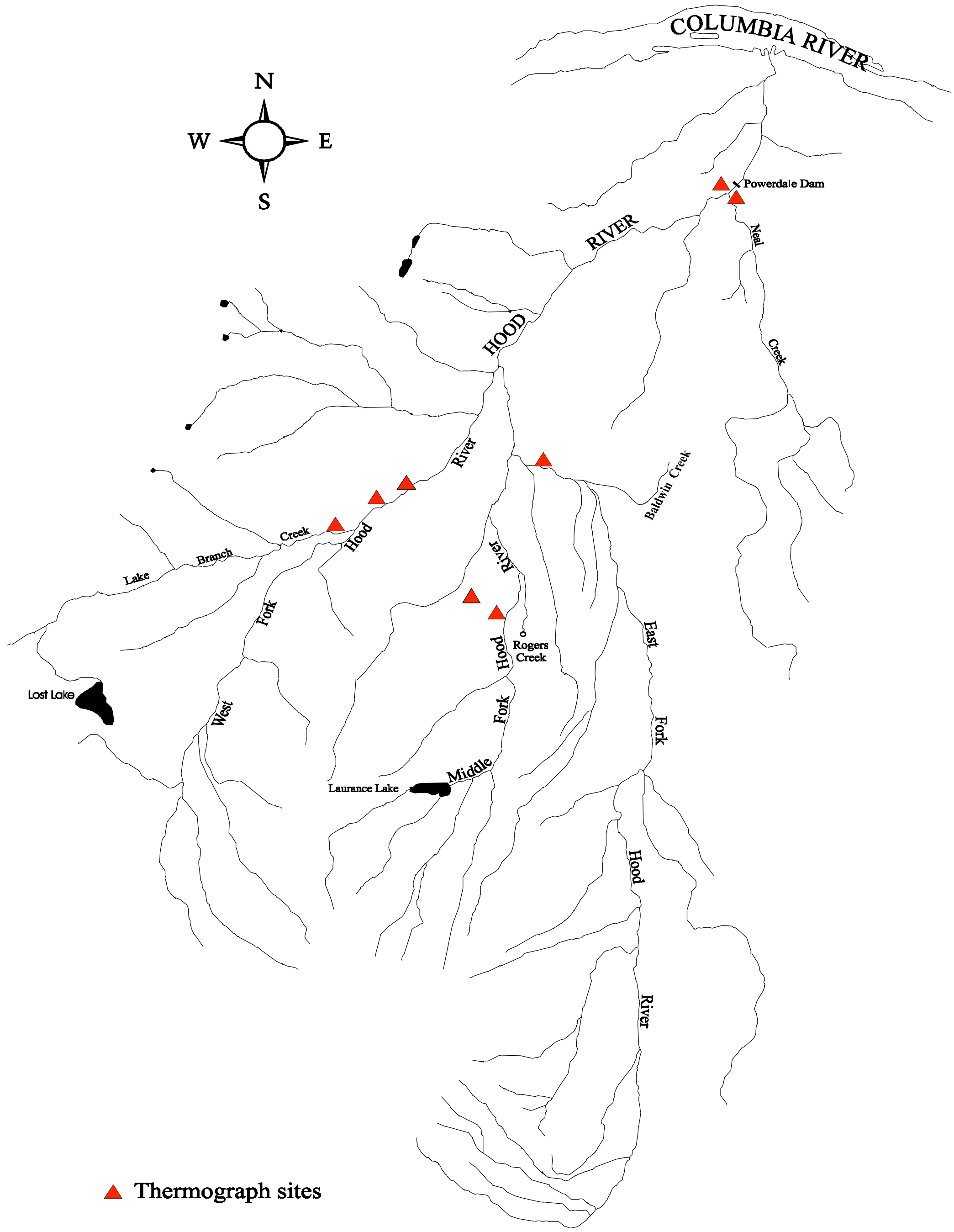

Figure 3. Locations of water temperature sites monitored by CTWS in the Hood River watershed during 2015.

Table 4. Average monthly temperatures (˚C) recorded in 2015, by site and month. Average monthly temperatures for period of record are in parenthesis.

	Hood River 2000-2015	West Fork 1990-2015	W.F. Moving Falls 2009-2015	Neal Creek 2001-2015	Lake Branch 1999-2015	Middle Fork 1994-2015	East Fork 1990-2015	Roger's Spring 2009-2015
Jan	4.8 (3.8)	4.4 (3.3)	4.5 (3.7)	5.5 (4.6)	4.5 (3.5)	3.5 (3.2)	4.1 (3.3)	3.7 (3.2)
Feb	6.1 (4.5)	5.4 (3.7)	5.6 (4.1)	7.1 (5.1)	5.5 (3.7)	5.1 (3.4)	5.3 (3.8)	4.4 (3.7)
Mar	7.3 (5.8)	6.2 (4.5)	6.4 (4.8)	8.3 (6.7)	6.1 (4.4)	6.5 (4.6)	6.7 (5.2)	5.4 (4.4)
Apr	8.2 (7.2)	6.7 (5.5)	6.9 (5.9)	9.3 (8.4)	6.6 (5.3)	7.6 (6.2)	7.7 (6.8)	6.1 (5.5)
May	11.9 (9.6)	9.4 (7.3)	9.9 (8.0)	12.2 (11.0)	8.9 (7.1)	10.6 (8.6)	11.5 (8.7)	8.2 (6.9)
Jun	15.8 (12.2)	12.0 (9.2)	12.8 (10.2)	15.3 (13.1)	11.0 (9.0)	12.3 (9.8)	15.7 (10.9)	8.8 (8.1)
Jul	17.2 (14.8)	13.2 (11.0)	14.1 (12.3)	16.3 (15.2)	11.7 (10.8)	- (10.7)	17.5 (14.1)	9.7 (9.3)
Aug	15.8 (15.0)	12.4 (11.3)	13.2 (12.5)	15.3 (14.9)	10.9 (10.6)	- (10.7)	15.9 (14.7)	10.2 (10.4)
Sep	12.4 (12.5)	9.9 (9.7)	10.5 (10.6)	12.3 (12.6)	9.0 (9.0)	10.4 (10.1)	11.6 (11.9)	10.0 (10.4)
Oct	10.3(9.0)	8.9 (7.6)	9.2 (8.9)	11.1 (9.7)	8.4 (7.4)	9.1 (7.8)	9.6 (8.0)	9.3 (8.1)
Nov	6.1 (5.5)	6.3 (5.3)	6.1 (5.6)	6.6 (6.4)	6.4 (5.5)	5.1 (5.0)	4.7 (4.9)	5.5 (5.1)
Dec	4.6 (3.6)	4.4 (3.6)	4.5 (3.6)	5.6 (4.5)	4.4 (3.8)	3.3 (3.1)	3.4 (2.8)	3.7 (3.5)

Table 5. Number of days that the seven-day average maximum temperature exceeded ODEQ temperature standards at each thermograph site in 2015.

	Hood River	West Fork	W.F. M. Falls	Neal Creek	Lake Branch	Middle Fork	East Fork	Roger's Spring
18° C Salmonid Rearing	n/a	n/a	n/a	14	n/a	n/a	79	0
16° C Cold Water Habitat	91	7	18	n/a	0	n/a	n/a	n/a
13° C Salmonid Spawning	0	0	0	0	0	n/a	0	n/a
12° C Bull Trout	n/a	98	113	n/a	n/a	121*	n/a	n/a

*Incomplete data set, would likely be higher.

Conclusions

Analysis of the temperature data indicates that six streams exceeded temperature standards set by ODEQ during 2015; two more than in 2014 (Table 5). Not only did more streams exceed the temperature standards in 2015, but also the periods of exceeded were substantially longer than in previous years.

The mainstem Hood River site recorded 91 days that exceeded the seven-day average temperature for the 16ºC cold-water habitat; 42 more days than 2014. The Middle Fork exceeded the seven-day average 12ºC Bull trout temperature criteria for 121 days; substantially more days than in past years. The days of exceedance for the Middle Fork were likely even more than the 121 days recorded, as the temperature probe at this monitoring site appears to have gone dry during the peak of the drought period. Data from this time period (36 days) was, therefore, not included in the data analysis. The days of exceedance for the Middle Fork would have likely been greater than 140 days.

The West Fork, (recently designated as critical Bull trout habitat) exceeded the 12ºC seven day average temperature for 98 days at the West Fork Bridge site and for 113 days at the West Fork Moving Falls site; 40 days and 28 days more, respectively, than in 2014. In addition, the West Fork exceeded the 16 ºC seven day average temperature for 7 days at the West Fork Bridge site and 18 days at the West Fork Moving Falls site. No exceedance of the 16 ºC seven day average temperature was recorded in 2014, or in recent history, at these sites.

The East Fork Hood River exceeded the seven-day average 18ºC salmonid rearing temperature criteria for 79 days; 53 days more than in 2014. In general, the number of streams and the number of days in which these streams exceeded the ODEQ temperature standards were significantly higher than historically for the Hood River basin.

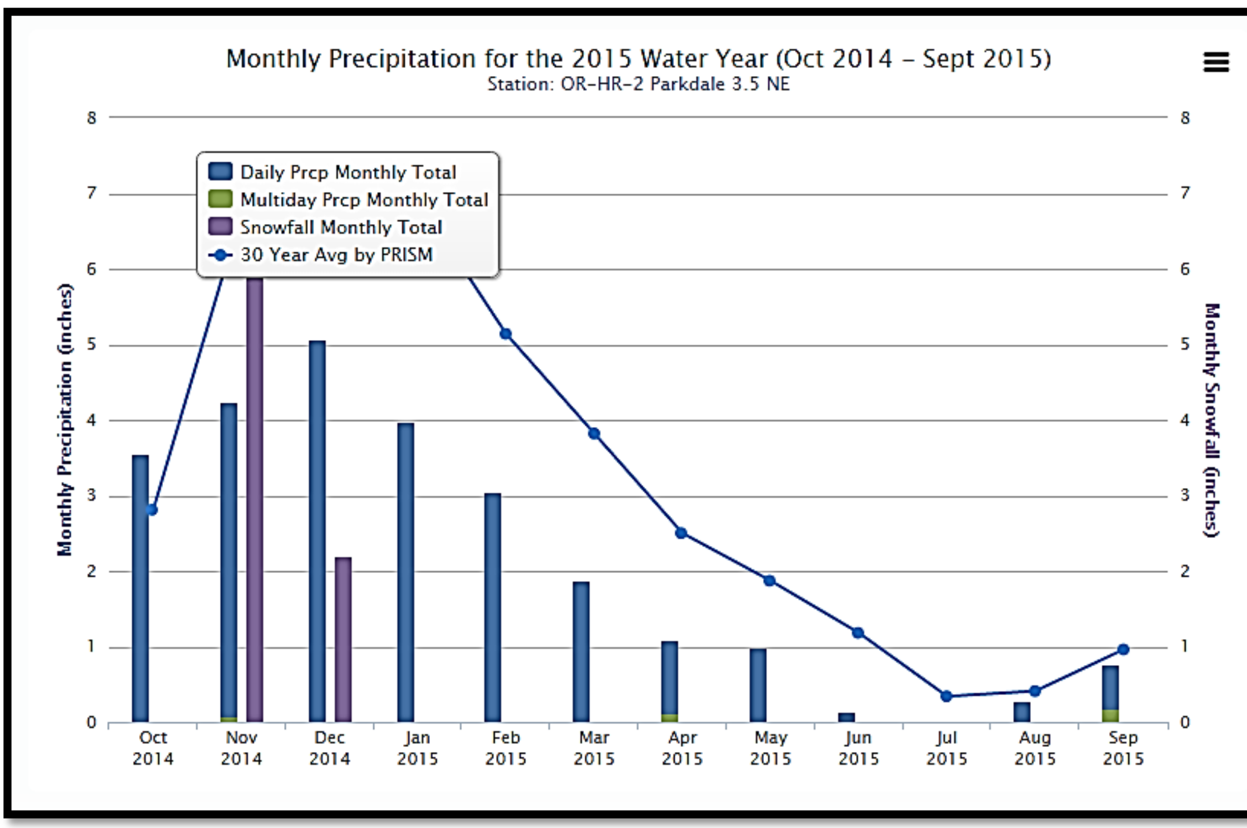

Figure 4. 2015 Water Year data for the Parkdale, OR region from the website:
http://cloud.cocorahs.org/wys/StationWysCharts.html?station=OR-HR-2&wateryear=2015

Adaptive Management & Lessons Learned

Maintaining a long-term data set of stream temperatures gives managers a tool for tracking trends over time. Additionally temperature data my provide information used to explain phenomenon observed. For instance fish mortality events, shift in migration or spawn timing, etc. This is especially relevant given global climate change and more locally specific shifts in the hydrograph resulting from receding glaciers on Mt. Hood. In some cases the temperature data collected by this project may be able to measure changes effected by habitat restoration or water management activities.

Work Element I: Collect/Generate/Validate Field and Lab Data – Record stream flows in the Hood River basin.

Introduction

Hood River fisheries managers are interested in stream flows in Neal Creek and Odell Creek as they pertain to various issues such as water rights, water allocation, and habitat restoration activities. Additionally, Neal Creek and Odell Creek enter the Hood River downstream of the USGS stream flow-monitoring site at Tucker Bridge. These are two of the largest tributaries downstream of the Hood River Mainstem stream gauge; therefore knowing the discharge rates of these streams facilitates more accurate estimates of total stream flow at the mouth of the Hood River. Furthermore, Neal Creek has been proposed as a future steelhead smolt acclimation site. Monitoring of annual flow conditions provides useful information if managers do in fact decide to operate an acclimation site on that stream. For Odell Creek, a small hydropower facility located on the stream has been projected for removal in the near future and flows monitored before and after will be useful to track changes, and potentially aid in assessing future restoration projects. Stream flow monitoring at Rogers Creek is in support of the Parkdale Fish Hatchery, and is located in Rogers Creek approximately 0.1 river miles downstream of the hatchery weir (Figure 5). In addition, all flows are monitored to observe long-term trends, flow patterns, and to track stream condition changes.

Methods

Field methods used for measuring discharge in cubic feet per second (cfs) have been adapted from the USFS stream inventory handbook (2012) and discharge is computed by using the mid-section method recommended by USGS (Young 1950). Monitoring sites were selected in areas with minimal turbulence and laminar flow. At the selected cross-section, a tape measure is positioned across the stream at the sample site perpendicular to the thalwag. Depth and velocity measurements were taken at consistent increments along the cross section tape so that 25-30 total measurements were taken. The depth of each subsection was measured in tenths of feet with a top-setting wading rod. Velocity was measured with a Marsh-McBirney model 2000 portable flow meter attached to the wading rod.

In the streams we monitored, flows can vary widely and change rapidly depending on weather and water management. To capture the variability in stream flow, Onset HOBO U20 water level data loggers, set to record on 1-hour increments, were deployed at all monitoring sites. Barometric pressure measurements, recorded by the loggers, were correlated to discharge by creating a ratings curve between flow measurements, staff gauge readings, and pressure readings. In order to effectively calculate a ratings curve that reflects the full range of flows at the site, we attempt to take discharge measurements at approximately 0.1' intervals on the staff gauge. A minimum of 10 discharge measurements was sought to create a sufficiently strong ratings curve. Particular attention was paid to low flow and high flow periods (fall and spring) in order to capture the entire range of flows. To calibrate the pressure readings recorded by the water level loggers, an additional barometric pressure logger was deployed near the discharge sites to measure atmospheric pressure. This sensor is located so that it is within +/- 1000ft elevation difference and less than 20 miles from all water depth sensors at the stream flow sites. Total barometric pressure is calculated by subtracting the air pressure from water pressure. The unit of measure for pressure used in our analysis was inches of mercury (in HG). To ensure accuracy, water level loggers were downloaded periodically throughout the year and accuracy tested annually to assess any drift in instrument readings.

Barometric loggers were downloaded on a quarterly schedule, and data was imported and analyzed with Hoboware and Excel software. Ratings curves were developed for each water year from October 1 – September 30. New ratings curves are established for each subsequent water year, since stream channel morphology at monitoring sites can change over time.

Information on the protocol and methods used for this work element are also published at the following web address,

https://www.monitoringmethods.org/Protocol/Details/760

Results and Discussion

Neal Creek and Rogers Creek both had nine flow measurements taken, and Odell Creek had seven measurements. The failure to meet our desired minimum of ten discharge measurements was due in part to drought-influenced stream flow patterns. As a result of the drought the drop from higher winter flows to very low summer flows was rapid. This coupled with an unusual lack of spring freshets provided few opportunities to take measurements during the full range of intermediate flows. Despite lacking the desired 10 measurements, we feel that we were still able to produce satisfactory rating curves with high R^2-values.

Typical hydrograph patterns in Hood River tributaries we monitor is for low flows in early fall, abrupt peaks in flows will usually occur throughout the winter and early spring (corresponding to rain events), followed by flows gradually declining during the entire spring until base low flows are reached during the summer. Flows, in all creeks monitored, appeared to display these same generalized as previous years; however these stream flow patterns were shifted approximately one month earlier than is normal. Additionally, the decline of flows during the spring was more abrupt than typical, likely a result of severely low snowpack during the winter. As a result the summer flows were lower than average and the base flow period was longer than normal. This phenomenon was observed region wide as drought conditions were declared in most watersheds in Oregon and Washington during the summer of 2015 (http://www.ecy.wa.gov/drought/; http://apps.wrd.state.or.us/apps/wr/wr_drought/current_updates.aspx; and http://www.drought.gov/drought/content/resources/reports).

Neal Creek

A total of nine discharge readings were completed for the 2014 – 2015 water year, to develop a ratings curve. Average monthly estimates of discharge for Neal Creek ranged from 15.5 to 48.4 cfs for this water year (Table 6). The overall pattern of flows in Neal Creek followed a similar trend to all other sites monitored. This year's flows appeared to be shifted one month earlier than usual (Figure 6). For example, peak flow events typically occur sometime in late February to mid-March; however this year's high flow events were in late-January and mid-February. Also keeping with this pattern, flows typically recede in late-April/ early-May and summer flows begin in June and continue throughout the summer until fall freshets began in mid-October. This year however, summer flows began in May and continued throughout the end of the water year.

Flows measured at the Neal Creek site were influenced by a temporary water diversion for a steelhead acclimation site from April 15 – May 8, 2015. During this time period an estimated average of 0.36 cfs was diverted a short distance upstream of the stream flow site and returned to Neal Creek downstream of the site.

Table 6. Average, maximum, and minimum discharge values in Neal Creek for each month for the 2015 water year (October 2014 – September 2015) and monthly averages over the previous water years monitored (2010-2014).

Month	Average	Maximum	Minimum	2010-2014 Average
October	17.8	25.7	14.5	23.5
November	16.9	34.2	13.1	13.8
December	24.7	97.4	15.6	25.5
January	45.5	263.0	19.5	31.6
February	48.4	105.5	29.2	44.2
March	34.4	48.3	25.0	62.3
April	22.2	41.0	13.9	51.0
May	20.0	27.9	13.2	38.6
June	16.5	21.4	12.4	30.5
July	15.5	28.8	11.3	22.5

August	16.2	21.6	11.6	22.1
September	17.6	21.3	12.5	23.0

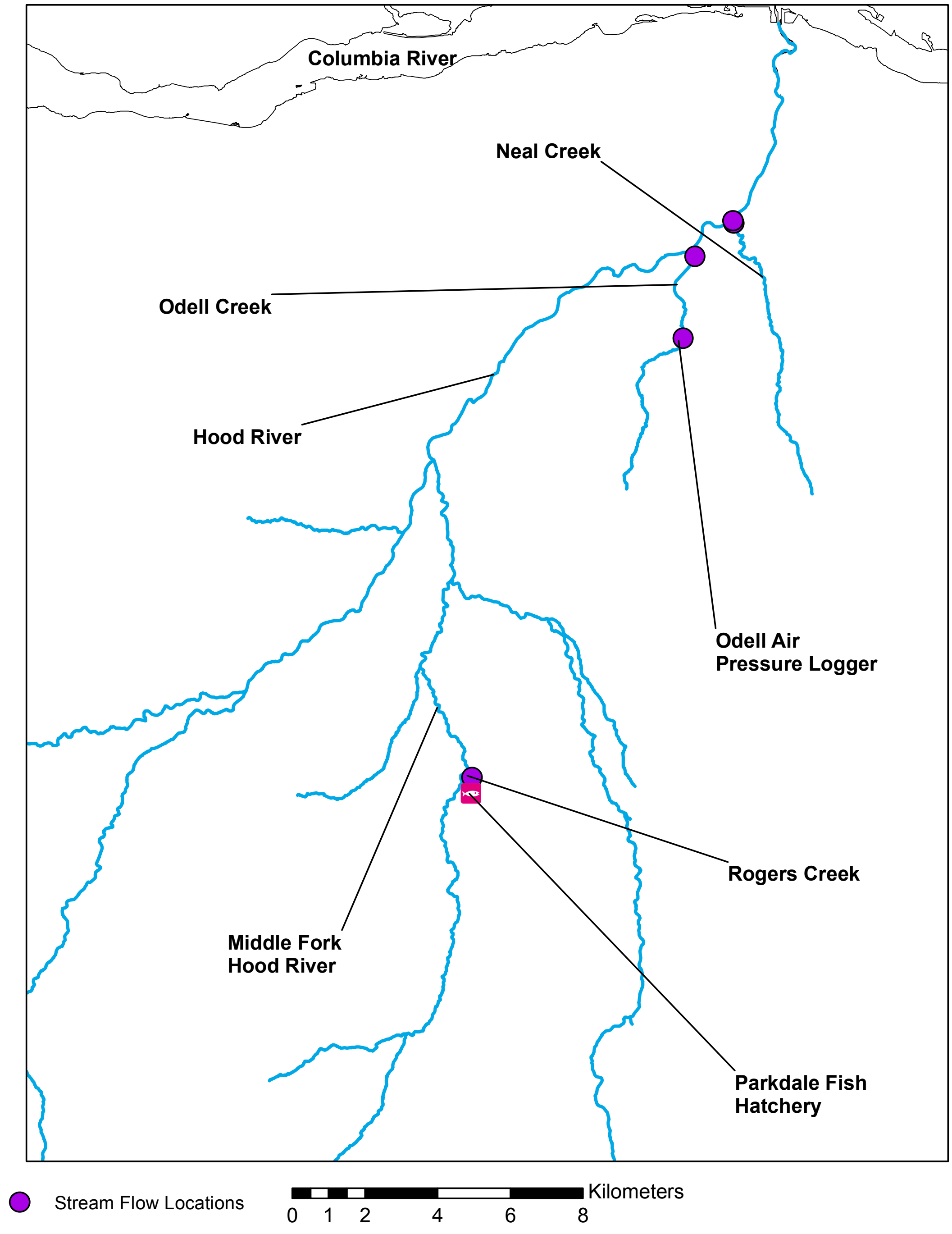

Figure 5. Stream flow monitoring sites in the Hood River Basin operated during the 2015 water year (October 1, 2014 to September 30, 2015).

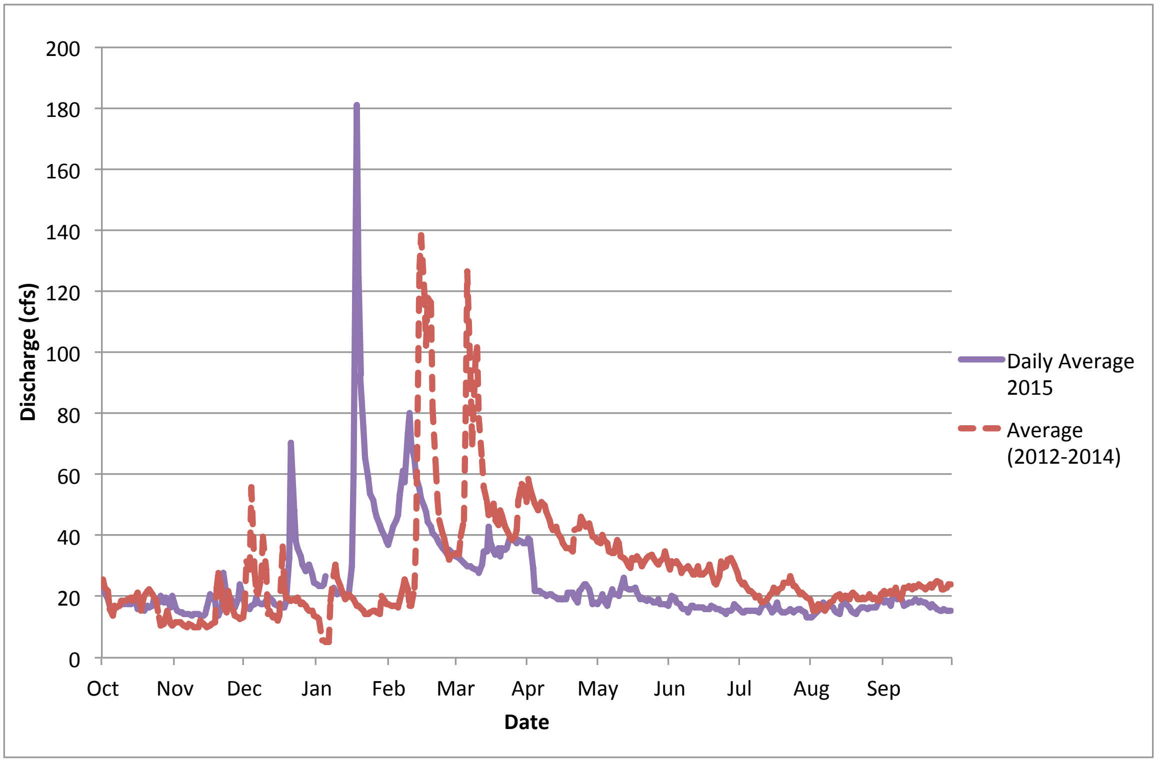

Figure 6. Neal Creek daily average flows for 2015 water year and collective daily average flows from 2012-2014.

Odell Creek

The Odell Creek stream flow monitoring site has been operated since July 2011 and is located downstream of a small hydropower facility (RM 0.2). A total of seven flow measurements were conducted during the 2015 water year. Average monthly estimates of discharge ranged from 7.1 to 22.8 cfs for the 2015 water year (Table 7). Similar to the other streams we monitored, Odell Creek flows in 2015 tended to be lower than the average from previous years (Figure 7).

Table 7. Average, maximum, and minimum discharge values in Odell Creek for each month for the 2015 water year (October 2014 – September 2015) and monthly averages over the previous water years monitored (2011-2014).

Month	Average	Maximum	Minimum	2011-2014 Average
October	7.2	10.8	5.6	6.9
November	7.1	27.2	4.6	8.3
December	13.7	99.5	6.7	11.9
January	22.8	234.4	8.5	15.9
February	19.7	82.3	8.0	35.7
March	10.4	15.6	6.3	32.5
April	12.5	16.9	7.7	22.1
May	12.4	16.9	7.1	14.0
June	10.2	14.0	6.2	12.3
July	10.0	12.3	6.3	11.4
August	9.9	12.9	7.1	11.5
September	9.8	13.6	6.5	11.2

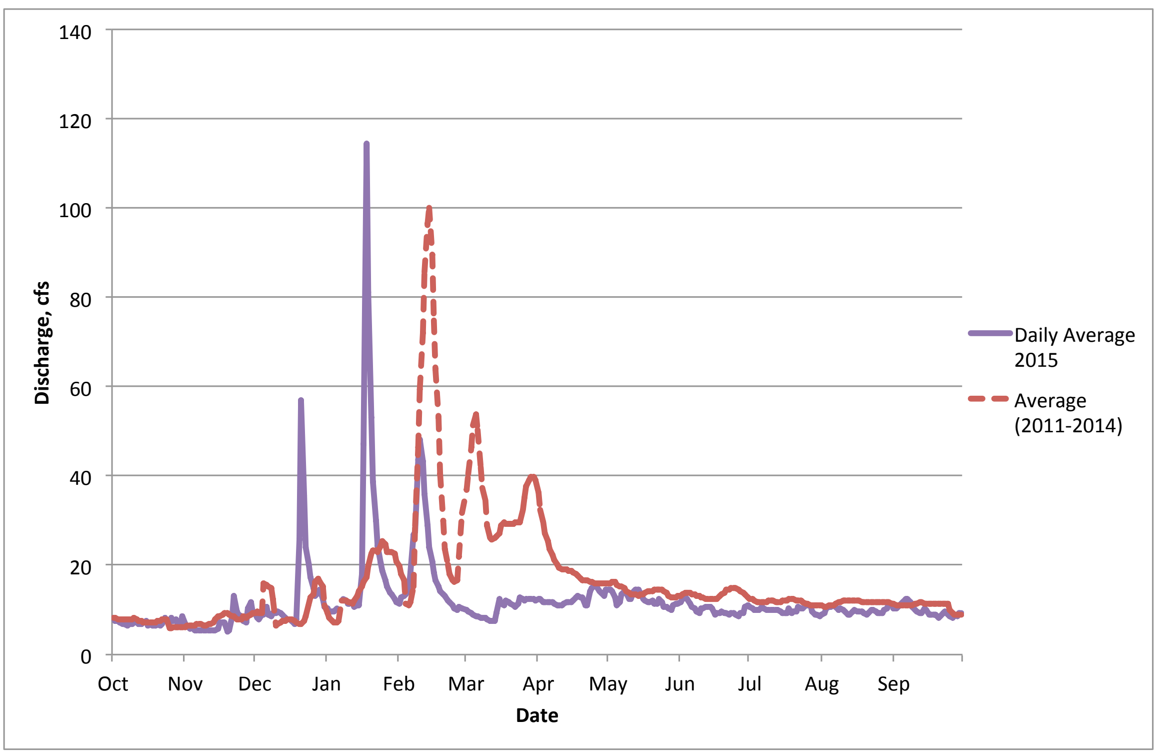

Figure 7. Daily average flows in Odell Creek during the 2015 water year and collective daily average flows from 2012-2014.

Rogers Creek

Average monthly discharge estimates in Rogers Creek ranged from 7.7 – 66.7cfs (Table 8). Similar to both Neal and Odell Creeks, this year's flow pattern in Roger's Creek was shifted ahead approximately one month as compared with previous years' flow data. Additionally the summer low flows appeared lower than past years and lasted longer than is usual (Figure 8).

Table 8. Average, maximum, and minimum discharge values in Rogers Creek for each month for the 2015 water year (October 2014 – September 2015) and monthly averages over the previous water years monitored (2009-2014).

Month	Average	Maximum	Minimum	2009-2014 Average
October	42.4	67.0	9.4	38.4
November	60.0	77.7	10.8	48.3
December	66.7	91.8	55.4	50.0
January	61.1	71.7	52.3	44.9
February	52.7	64.8	38.9	51.2
March	46.6	54.8	39.1	55.5
April	46.6	57.1	34.5	53.5
May	30.3	52.5	9.4	44.1
June	8.2	14.0	5.9	29.8
July	7.7	10.0	5.8	20.2
August	9.0	17.0	5.7	18.6
September	25.2	34.7	13.0	28.2

Figure 8. Daily average flows in Rogers Creek during the 2015 water year and collective daily average flows from 2012-2014.

Adaptive Management & Lessons Learned

Stream flow monitoring in these tributaries has been utilized for various management purposes. Since Neal Creek and Odell Creek enter the Hood River below the USGS gauge, operated on the Mainstem Hood River at Tucker Bridge, stream flow monitoring at these tributaries aids in more accurate total water flow estimates to the mouth of the Hood River. Additionally irrigation water transfers influence Neal Creek and Odell Creek and so maintaining a data set on flows for these streams allows the opportunity to assess any effects of changes in water management. The Parkdale Fish Hatchery is located on Rogers Creek, which connects the Hatchery to the Middle Fork Hood River. Stream flow monitoring is useful to hatchery operations and managers assessing access of migrating fish to and from the Hatchery. As we realize the effects of climate change, which is projected to have a significant impact on stream flow patterns in the Pacific Northwest region, maintaining a long term stream flow data set in these tributaries will allow us to track shifting trends over time.

Work Element J: Collect/Generate/Validate Field and Lab Data –Spring Chinook salmon preseason adult run size forecast.

Introduction

The Hood River Production Program has generated run forecasts for adult spring Chinook salmon returning to the Hood River mouth annually since 2001. Run forecasts are used to guide various management decisions such as: sport and tribal fishery regulations and broodstock collection.

Several different models have been utilized to generate spring Chinook run predictions in the Hood River. Initially, the HRPP used cohort models that required age data from the previous run to predict the incoming run; based on the age structure of the population. For these models, the number of jacks (3-year-olds) was used as an indicator for the following year's return of 4-year-old adults. Similarly, the run of 5-year-old adults was estimated based on the previous year's run of 4-year-olds. These cohort-based models were accurate at times, but were vulnerable to inexplicable shifts in age structure; for instance, an unusually high rate of jacks. Also, the models relied on data collected at Powerdale Dam, which was removed in the summer of 2010. In order to mitigate for the loss of data collection at the Powerdale dam trap and to attempt to reconcile inaccuracies with the cohort models, the HRPP contracted Western EcoSystems Technology (WEST, Inc.); to develop multiple regression forecast models for Hood River anadromous fish populations. During 2008, WEST, Inc. produced a suite of run predictors, including forecast models for: adult wild summer steelhead, adult wild winter steelhead, adult hatchery winter steelhead, and wild steelhead smolt production. The final version of the run forecast models produced, and the accompanying report "Forecast Models for Hood River spring Chinook and Steelhead" (Griswold et al. 2009), was submitted to the CTWS in May 2009. Since then, the HRPP has been using these multiple regression models to forecast runs and continue to further refine prediction models with alternative predictor variables using the template produced by WEST, Inc.

Methods

The statistical forecast models produced by West, Inc. are one season ahead multiple regression models. Four parameters were selected as predictor variables for each multiple regression model using a stepwise regression method (Neter, et al. 1996). A model based bootstrap procedure was used to provide 90% prediction intervals for the forecasts (Davison and Hinkley 1996). These models use biological and environmental variables as predictors that influence or cause a response in the target population. For instance, snow water equivalent values measured on Mt. Hood can be indicators for stream flow and temperature conditions that influence juvenile salmonid production and survival in the Hood River. When selecting the predictor variables, the objective was to utilize the fewest number of variables to keep the models as simple as possible, yet still provide fairly high accuracy and precision in making estimates. Additionally, the predictor variables had to be from sources that are collected and published consistently and are readily available to biologists utilizing the forecast models.

The suite of predictor variables selected by WEST, Inc. for the natural Chinook prediction model were: Bonneville Dam Chinook counts five years prior, the square of Bonneville Dam spring Chinook counts five years prior, annual October Mt. Hood mean snow depth six years prior, and November Mt. Hood Mean snow depth six years prior to the return year being predicted. The Bonneville Dam spring Chinook counts are an indicator for the parent stock producing the predicted cohort. The Mt. Hood snow depth variables are thought to influence rearing conditions for juvenile Chinook produced in the Hood River. The fit of the model for the natural adult Chinook multiple regression model produced by WEST, Inc. was relatively high with a R^2 value of 0.70. By comparison, the previously used single regression model using jack counts had a relatively low R^2 value of 0.15. Since the development of the original models by WEST, Inc., we had noticed a decline in model fit in subsequent years. For the wild Chinook model the R^2 had declined from 0.70 in 2008 to 0.15 in 2014. In response we have experimented with alternative predictor variables to substitute into the models in an attempt to improve the statistical fit. The predictor variables used for the 2015 forecast were: estimated spring Chinook spawners in the Hood River 4 years prior, the square of Hood River spawners 5 years prior, a base flow index measure for the Hood River at the Tucker Bridge stream gauge 2 years prior, and the Pacific Decadal Occelation value (PDO) two years prior to the return year being predicted (Appendix C). The fit of the model was greatly improved by substituting predictor variables and the R^2 value increased from 0.16 to 0.76.

The best predictor variables West, Inc. identified for the hatchery Chinook prediction model were: Bonneville Dam annual spring Chinook jacks two years prior to the Hood River adult hatchery spring Chinook return, average of spring transition dates three and four years prior to the hatchery spring Chinook return, annual median Bonneville Dam turbidity over the period 4/15-6/30 (three years prior to return), and median annual Bonneville Dam screen water temperature over the period 4/15-6/30 (three years prior to return). The Bonneville jack count is a surrogate cohort strength indicator. Spring transition dates are indicators for ocean conditions and productivity. Temperature and Turbidity values at Bonneville Dam are indicators for smolt outmigration conditions and survival in the Columbia River. The fit of the model for the hatchery adult Chinook multiple regression model for the 2014 run had an R^2 value of 0.52, which was decreased from an R^2 value of 0.88 when the models were first developed in 2008, and continued a trend of declining fit over the years. By comparison, the previously used single regression model using jack counts had a R^2 value of 0.73. To attempt to resolve this loss of fit we substituted some of the predictor variables to attempt to improve the accuracy of the regression model. The predictor variables we utilized for the 2015 return were: an estimate of Hood River spring Chinook jacks the previous year, the average of spring (April-June) Pacific Decadal Oscillation (PDO) values 2 and 3 years prior, the Pacific Northwest Index (PNI) value 3 years prior, and Multivariate ENSO index (MEI) values 2 years prior (Appendix C). Hood River jack returns should more accurately reflect population trends for the Hood stock specifically as opposed to the Bonneville counts and the PDO, MEI and PNI measures are alternate climate and ocean productivity indexes to the spring transition date value. Substituting these predictor variables improved the R^2 value of the model from 0.52 to 0.80.

Information on the protocol and methods used for this work element are also published at the following web address,

https://www.monitoringmethods.org/Protocol/Details/768

Results

The Multiple Regression Model forecasted 323 wild adult Chinook, with a 90% prediction interval of 254-398 (Table 9). This run size would be well above the recent available 10-year average of 124 wild adults during run years 2001-2010.

The adult hatchery Chinook forecast produced by the multiple regression model was 1,100, with a 90% prediction interval of 972-1,305 (Table 9). A run of this size would be well above the recent 10-year average hatchery run size of 737 during run years 2003-2014 (Table 10).

Table 9. Hood River spring Chinook run forecasts with upper and lower bootstrap 90% prediction intervals for 2015.

	Forecast	Lower 90%	Upper 90%
Natural	149	111	189
Hatchery	1,100	972	1,305
Total	1,423	1,226	1,703

Table 10. Run estimates generated for adult hatchery produced spring Chinook and actual returns to the Hood River mouth from 1997 to 2015. Run estimates from 2010 and previous based on counts at Powerdale Dam, after Powerdale dam was removed in 2010 estimates are based on mark recapture models.

Run Year	Age Ratio	Linear Regression	Multiple Regression	Published Forecast	Actual Run
1997	162	213	-	-	279
1998	26	216	-	-	20
1999	22	186	-	-	89
2000	58	201	-	-	21
2001	1,372	425	-	1,388	597
2002	5,343	1,183	-	1,006	1,304
2003	313	343	-	346	344
2004	172	233	-	168	148
2005	1,957	541	-	600	633
2006	846	392	-	280	920
2007	422	346	-	431	402
2008	3,783	872	-	872	974
2009	4,291	1,023	1,231	1,231	998
2010	2,811	838	1,086	637	653
2011	-	-	695	695	1,377
2012	-	-	645	645	690
2013	-	-	949	949	820
2014	-	-	1,335	1,335	1,086
2015	-	-	1,100	1,100	2,223

*Escapement estimates not published for 2011

Conclusions

Run forecasting is extremely challenging due to the myriad factors in both freshwater and marine environments that influence salmonid survival rates, many of which are still poorly understood by fisheries science. Since we began using the multiple regression run forecast models in 2008 we have been reasonably successful at predicting whether runs would be above, below, or near average. Which is in contrast to the previous models based on jack returns which occasionally produced vastly inaccurate predictions that had major fisheries management consequences. The hatchery Chinook run forecast for 2015 indicated an above average run. Escapement estimates for 2015 suggest that the run was in fact much larger than average run of hatchery spring Chinook. Though we did fail to predict just how large it would be.

Adaptive Management & Lessons Learned

Run forecasts are an important asset to fisheries managers for a variety of purposes including; setting harvest regulations and planning for broodstock collection and adult monitoring activities. Developing run forecast models have also been informative in determining the processes that influence Hood River adult salmonid abundance, both in the marine and freshwater environment. A lesson we have learned is that prediction models are not static. To maintain a good statistical fit and effective predictive value we must continue to assess model performance and explore alternative predictor variables.

Work Element K: Collect/Generate/Validate Field and Lab Data –Spring Chinook salmon tribal harvest monitoring.

Introduction

Pre-season run forecasts generated by HRPP staff predicted a run of spring Chinook salmon adults that would be in excess of broodstock and escapement needs. Thus the Confederated Tribes of Warm Springs Tribal Council authorized a spring Chinook fishery for enrolled Warm Springs tribal members on the Hood River from April 1 to July 15, 2015. The entire Hood River watershed was opened to harvest of adipose-marked hatchery Chinook except: those areas of the West Fork upstream of the Green Point Creek confluence, Rogers Creek, and within 100 feet of a fish weir located on the mainstem Hood River near the former Dee Mill site. To monitor harvest of the 2015 spring Chinook run, HRPP conducted creel surveys of tribal fishers at the Punchbowl Falls area of the lower West Fork Hood River (RK 0.5). Some tribal fishing may have occurred below the West Fork; however, all fishing within the sport fishing boundaries is monitored by ODFW, which conducts creel surveys in this area from November – June.

Methods

Essentially all tribal fishing efforts occur in the vicinity of Punchbowl Falls, near the mouth of the West Fork Hood River. Punchbowl Falls is a natural concentration point for holding Chinook salmon, and is well suited to both hook and line angling and dip net fishing methods. As with past years, neither CTWS nor ODFW creel surveyors interviewed any tribal fishers that used access sites other than Punchbowl Falls during 2015.

The Chinook season officially opened April 1, 2015. Based on previous run timing and PIT tag detections at Bonneville Dam, we did not believe significant numbers of Chinook to be present in the Punchbowl area until May. Creel surveys started on May 5, a date determined based on previous observations of run timing and fishing effort. The first tribal fishers and Chinook harvests were observed at Punchbowl Falls on Saturday May 7. Creel surveys continued until the close of the season on July 15.

Since tribal members seldom fish at locations other than Punchbowl Falls, we utilized a single access point creel design as described by Pollock et al. (1994). We scheduled creel shifts into two stratums: weekdays (Monday-Friday) and Weekend/Holiday. Each weekday had two potential shifts, a morning shift from 8:00 AM to 4:00 PM, and an evening shift from 1:30 PM to 9:30 PM. On weekend days, creel surveyors worked a 12-hour shift. Night fishing is not prohibited by tribal fishing regulations, however no night fishing has yet been reported in the Hood River tribal fishery in any of the previous 8 seasons the Chinook fishery has been opened; therefore, we did not sample any periods from dusk to dawn. Weekday creel shifts to be sampled were selected using a random number generator. Creel surveyors were present at the access point and recorded when fishers entered and exited the fishing area as well as what type of fishing gear they were using (i.e. hook and line, dip net, etc). When fishers left the fishing area, creel surveyors would interview them as well as inspect any fish they had caught. Fishers were asked to fill out a questionnaire form, which asked some demographic questions and gave fishers the opportunity to make comments and suggestions. Creel surveyors identified catch by species, life history form (jack or adult), and measured the fork length of fish harvested. Creel surveyors inspected the fish for marks, scanned for CWT and PIT tags, and recorded all marks and codes for any floy or PIT tags the fish possessed. If a CWT was detected, the creel surveyors were instructed to ask the fisher if they could remove the snout so that CTWS biologists could recover the CWT.

Mean daily fish effort and catch were calculated by dividing the sample value by selection probability. Effort and catch totals for each stratum were estimated by multiplying the means by the number of days in each stratum, as shown in the equation below (reproduced from Pollock et al. 1994). Only the equations for estimating effort are shown, but the same statistical methods are utilized for generating harvest estimates.

$$N_1 e_1 = N_1 \times e_1$$

Where:

$N_1 e_1$ = total effort for the stratum
N_1 = total days within the stratum
e_1 = sample mean for effort recorded for the stratum

Population variance of stratum (effort) calculated by

$$s_1^2 = \frac{1}{n_1 - 1} \sum_{i=1}^{n_1} (e_{1_i} - \bar{e}_1)^2$$

Where:

n = number of sample days
e = sample mean of effort

And therefore estimated variance for each stratum was calculated by the equation

$$V\hat{a}r(\bar{\bar{y}}) \approx \frac{s_1^2}{n}$$

And standard error is calculated by

$$S\hat{E} = \sqrt{V\hat{a}r}$$

The overall effort estimate, variance and standard error for effort across both stratum are

$$\hat{E} = \hat{E}_1 + \hat{E}_2$$

and

$$V\hat{a}r(\hat{E}) = V\hat{a}r(\hat{E}_1) + V\hat{a}r(\hat{E}_2)$$

and

$$S\hat{E} \approx \sqrt{V\hat{a}r(\hat{E})}$$

Where:

$\hat{E}$ =total fishing effort
$\hat{E}_1$ =fishing effort for stratum 1 (weekday)
$\hat{E}_2$ =fishing effort for stratum 2 (weekend/holiday)

Results and Discussion

Tribal fishing effort (fisher hours) was ranked second and harvest (Chinook retained) was ranked third in the 12 seasons a tribal Chinook fishery has occurred in the Hood River. Creel surveyors observed 57 fishing groups and 118 individual trips; totaling 478 hours of effort. Creel surveyors observed 167 spring Chinook salmon harvested in the Punchbowl Falls fishery. Expansion calculations of the creel observations estimate 770 hours of effort and 240 Chinook harvested. The standard error of the estimates was 145 hours for effort and 72 fish for harvest (Table 11). The tribal fishery peaked the second week of May and remained robust throughout the end of May. The fishery declined abruptly in the beginning of June and harvest remained relatively low through the end of the season (Figure 9).

Nearly all fishing efforts and harvests were with hook and line angling methods, although dip nets and jump nets were occasionally used. Creel surveyors were instructed to record other species besides spring Chinook that were caught or taken by fishers. No steelhead or other fish were reported in the harvest this year. Five Chinook were reported as caught and released by tribal fishers.

The Hood River Chinook run has become a reliable opportunity for tribal fishers with a season opened 12 of the past 15 years and consecutively for the last 9 years. Both the estimated fishing effort and harvest were ranked in the top 3 out of 12 fishing seasons in the history of the HRPP (Figure 10). We suspect that the recent high levels of both effort and harvest in the Hood River may have partially been the result of poor returns to the Deschutes River system; prompting tribal members to fish the Hood at a higher rate than normal.

The timing of the fishery at Punchbowl Falls appears to be shifting earlier than in the past. Before Powerdale dam was removed in 2010, it was uncommon to observe tribal fishers earlier than Memorial Day weekend in late-May. Peak fishing effort and harvest did not occur until sometime in June, or even early July, in some years. Whereas in 2013-2015, we have observed the highest weekly totals for harvest and fishing effort to occur in May. We hypothesize that Powerdale Dam caused a delay in migration through the mainstem Hood River. Chinook now arrive to the Punchbowl area, on the West Fork, earlier than when the dam was in place. Fishers have begun to realize this and are now making fishing trips earlier in the run. To accommodate this apparent shift, we now begin creel surveys in early-May so we are less likely to miss early season fishing.

Table 11. Expanded estimates of tribal effort, harvest, and catch per unit effort (CPUE) by sample stratum at Punchbowl Falls in 2015.

Stratum	Sample Days	Sample Mean	Total Days	Stratum Total	SE
Weekday					
Effort	49	8.97	53	475.2	115.6
Harvest	49	2.52	53	133.5	57.8
Weekend					
Effort	18	14.05	21	295.1	145.4
Harvest	18	5.07	21	106.4	42.2
Total Effort (hrs)				770	145.4
Total Harvest				240	71.6
CPUE (Hrs/Fish)				3.21	

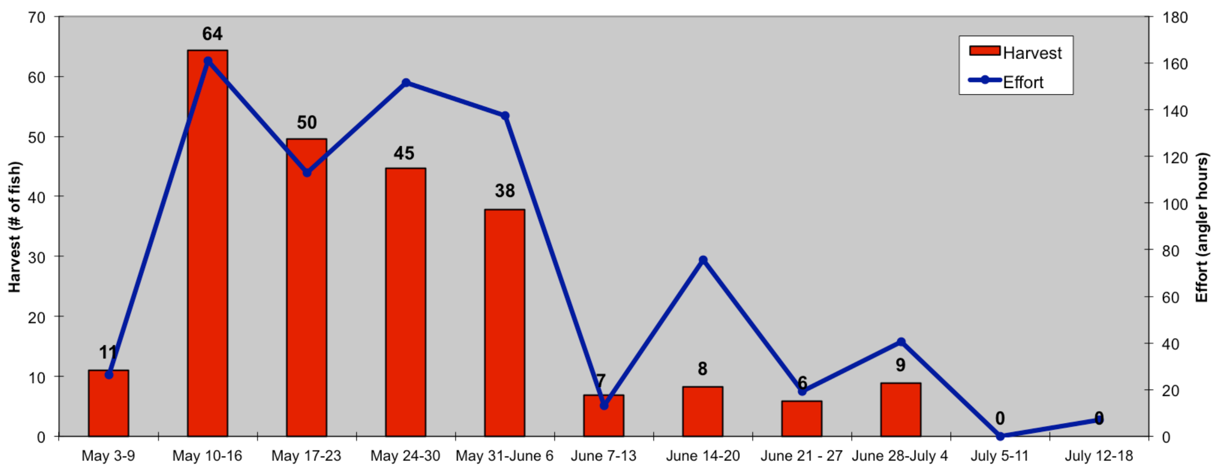

Figure 9. Expanded estimates of fishing effort and Chinook harvest during the tribal subsistence spring Chinook fishery at Punchbowl Falls during the 2015 run year by weekly period.

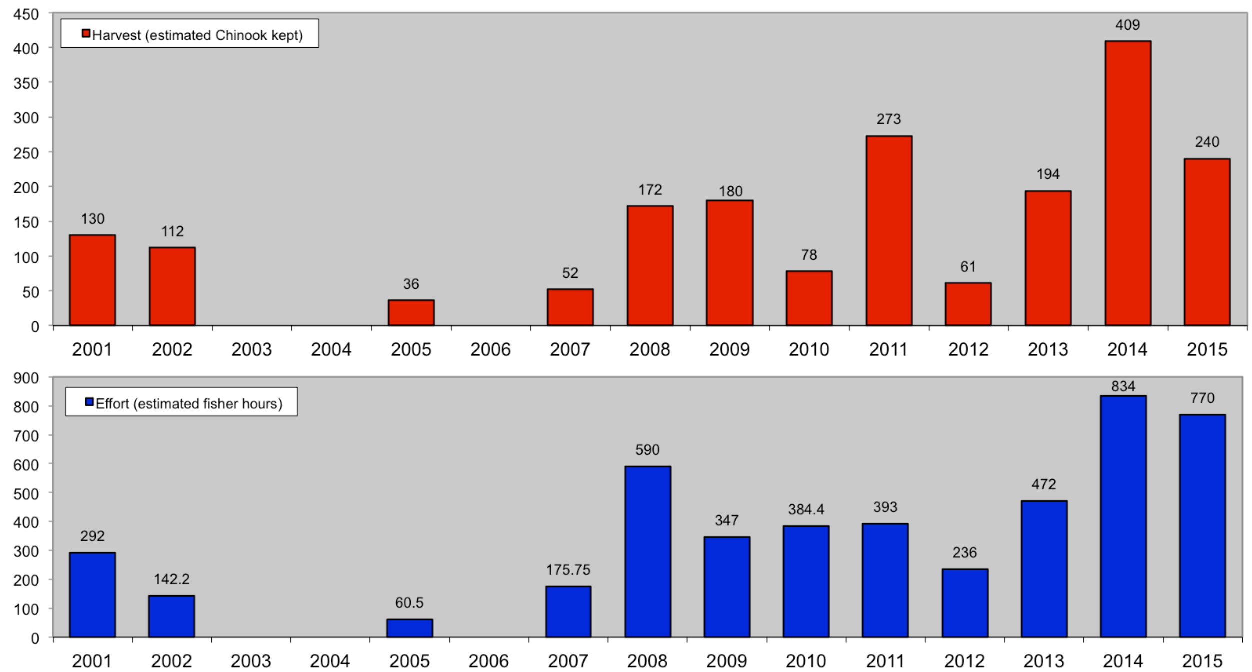

Figure 10. Estimated annual spring Chinook harvest and effort in the tribal subsistence fishery at Punchbowl falls from 2001-2015 (no tribal fishing seasons during 2003, 2004, 2006).

Adaptive Management & Lessons Learned

Harvest monitoring is of critical importance for fisheries managers. The results from this monitoring are used for determining seasons and regulations annually. In some cases this data may even be used to make fishery changes mid-season. Conducting this monitoring over many years has permitted us to observe some shifting trends. For instance, in years since Powerdale Dam was removed (after 2010) we have noticed that fish appear to arrive to the West Fork Hood River earlier, and as a result we now see fishing effort occurring earlier than when the dam was in place.

Work Element L: Collect/Generate/Validate Field and Lab Data –Spring Chinook spawning surveys.

Introduction

Spawning surveys have been conducted during the spring Chinook spawning period since 1997 to assess the recolonization of habitat in the Hood River basin, following reintroduction. The West Fork was the original, and remains the primary, stream receiving hatchery Chinook smolts. In addition, the West Fork was considered to have more suitable Chinook spawning and rearing habitat than the other streams in the Hood River Basin when reintroduction began (O'Toole 1991). Based on these assumptions, spawning surveys were initially focused only in the West Fork subbasin. As the reintroduction program has progressed through time, Chinook have been released from the Parkdale Fish Hatchery into the Middle Fork Hood River and Chinook have naturally dispersed throughout the Hood River basin. As a result, the HRPP began to add surveys in additional streams to document the dispersion of spawning in the Hood River Basin. Rogers Creek (Middle Fork tributary) was surveyed beginning in 2000, and reaches in Green Point Creek (West Fork), Dog River (East Fork) and Tony Creek (Middle Fork) were added in 2008. Spawning surveys in Bear Creek and Clear Branch (Middle Fork) were added in 2010.

To account for spawning in the East Fork, Middle Fork, and the Mainstem Hood River, we attempt a helicopter survey flight to observe redds and spawning fish, if weather and water visibility conditions permit. We were able to conduct two spawning survey flights during 2015 spawning season.

Methods

Salmonid redds were observed during multiple-pass foot or "ground" surveys conducted throughout the spring Chinook spawning period. Two persons were present on survey passes, and at least one person in the survey crew had a minimum of one previous year's experience at conducting spawning ground surveys in the Hood River basin. In most cases surveyors had several years of such experience. In small easily wadable streams, surveys were conducted in an upstream direction to mitigate turbidity caused by surveyors wading in the stream and to avoid spooking fish; thus enabling easier observation of spawners constructing or guarding redds. Due to the steep gradient and constrained morphology of the Hood River watershed, larger streams were usually infeasible to survey in an upstream direction and were alternatively surveyed in a downstream direction.

Recommendations for spawning survey frequency given in Gallagher et al. (2007) suggest that spawning survey passes should be conducted before any fish are spawning and that they occur at 7-14 days intervals until spawning activity has completely ceased. The spawning period for spring Chinook salmon in the Hood River occurs during an approximately 8 week period from mid-August to early-October. Three survey passes were conducted in each segment starting at the beginning of the spawning period. On this schedule, reaches were visited approximately every two weeks. We no longer conduct a pre-spawning survey pass for spring Chinook spawning surveys, as is recommended by Gallagher et al. (2007). The rational given for a pre-survey pass is to identify old redds and redd-like features to prevent over counting redds during the spawning period. In our experience with enumerating spring Chinook salmon redds in the Hood River basin, we do not think this is necessary. Spring Chinook are the first fall spawning salmonid in the Hood River and excavate redds during the low flow period in late summer and fall. Old Chinook redds from the previous year, or steelhead redds from the spring, are virtually undetectable by this time due to scour from spring high flows, sediment deposition, and algal growth coloring the substrate. There has been very little spatial or temporal overlap observed between spring Chinook and either fall Chinook or coho salmon spawning in the Hood River.

For each survey the date, survey crew, start/end time of survey, start/end water temperature (ºC), water visibility, and start/end GPS coordinates were recorded on the header of a standardized data sheet. When redds were encountered, they were marked with a labeled flag placed on the adjacent stream bank and a painted rock in the substrate depression. The color of flagging and rocks used to mark redds were unique for each survey pass, in order to prevent double counting on subsequent surveys and to compensate for potential redd superimposition. A GPS location was logged for each redd on the GPS unit and recorded onto the data sheet. Also, the apparent species creating the redd was noted, as well as the number of adult fish present in the immediate vicinity of the redd. Redds were labeled on the data sheet and on the flagging using a consistent 4 digit alphanumeric code. The date, redd ID, and survey crew were marked on the flagging to provide relevant information for crews encountering redds on subsequent surveys.

Simple necropsies were performed on carcasses encountered to determine sex, spawning success, and check for obvious signs of infection by bacterial kidney disease (BKD) or other diseases. All carcasses encountered were scanned with a Northwest Marine Technology wand detector to determine the presence or absence of a CWT. If a CWT was detected, the entire upper snout of the fish from the eye forward was removed and bagged with a coded card in order to recover the tag later. All fish were scanned for PIT tags with a portable PIT tag reader, and a MEPS (middle eye to posterior scale) length was measured in centimeters. After a carcass was processed, the caudal peduncle was severed to prevent double counting on subsequent surveys, and the carcass was returned to the stream.

Information on the protocol and methods used for this work element are also published at the following web address,

https://www.monitoringmethods.org/Protocol/Details/758

Results and Discussion

Chinook spawning surveys were conducted from August 21 to October 6, 2015. The first completed redds were observed above Ladd Creek in the West Fork on August 21. A total of 169 spring Chinook redds were documented during ground surveys (Table 12). This year's Chinook redd count was the highest in the history of the program (since 1997). In addition to a high abundance of redds, this year also had the highest number of carcasses sampled and live fish observed. The second highest number of redds documented was 122 redds in 2011.

The greatest density of redds was observed in Dog River (a tributary to the East Fork), with 17 redds in just a 0.14 mile reach (Table 12). Most of these Chinook in Dog River were natural origin, and the spawning was all observed downstream of the large beaver dam on the west side of Highway 35. Lake Branch also had an unusually high redd density with 33.3 redds/mile in the reach downstream of the falls. On the final pass conducted in Lake Branch, we surveyed a one-mile section upstream of the falls (the normal end point of the survey) to observe if any Chinook passed the above the falls to spawn. We did not observe any redds nor Chinook above the falls, despite the high density of fish and redds below the falls, lending evidence that the falls on Lake Branch may in fact be a barrier to adult spring Chinook.

Table 12. Summary of Chinook redds, carcasses, and live fish observed during spring Chinook spawning ground surveys in the Hood River basin in 2015.

Stream	Redds	Carcasses	Live Fish	Miles Surveyed	Redd Density (redds/mile)
West Fork Hood River	118	79	165	14.7	8.0
McGee Creek	2	0	0	1.1	1.8
Green point Creek	0	0	0	1.2	0.0
Lake Branch	30	13	37	0.8	33.3
Tony Creek	2	0	1	0.7	2.9
Dog River	17	24	16	0.14	121.4
Bear Creek	0	0	0	0.9	0.0
Rogers Creek	0	0	0	0.15	0.0
Clear Branch	0	0	0	0.6	0.0
Basin Total	169	116	222	20.3	8.3

A total of 116 carcasses were inspected during spawning surveys, 65 of which were female and 44 were male (two of these males were mini jacks). Necropsies performed on the fish showed no obvious signs of BKD or other diseases. Eighty-seven fish (62 females and 25 males) appeared to have spawned completely. Twelve fish (1 female and 11 males) were considered to have partially spawned. Six fish (1 female and 5 males) were considered pre-spawn moralities. For 11 of the carcasses we were unable to determine spawning success due to severe decomposition and/or predator scavenging of the carcass. Seventy-four of the carcasses scanned positive for the presence of a CWT, and snouts were collected from those carcasses. The information from CWT recoveries will be submitted to the ODFW coded wire tag coordinator for inclusion into the RMPC database. In addition, 64 carcasses scanned positive for the presence of a PIT tag and those tag codes were submitted to the PTAGIS database.

There were two helicopter-based surveys conducted during fall of 2015. The first aerial survey was conducted on September 24, 2015 during which we identified two spring Chinook redds and three live fish. Nine other redds during that survey were identified as fall Chinook redds. The second aerial survey was conducted on October 23, 2015 during which we identified 39 fall Chinook redds. The vast majority of those redds (36) where located in the Mainstem Hood River, 2 were observed in the East Fork, and 1 in the Middle Fork.

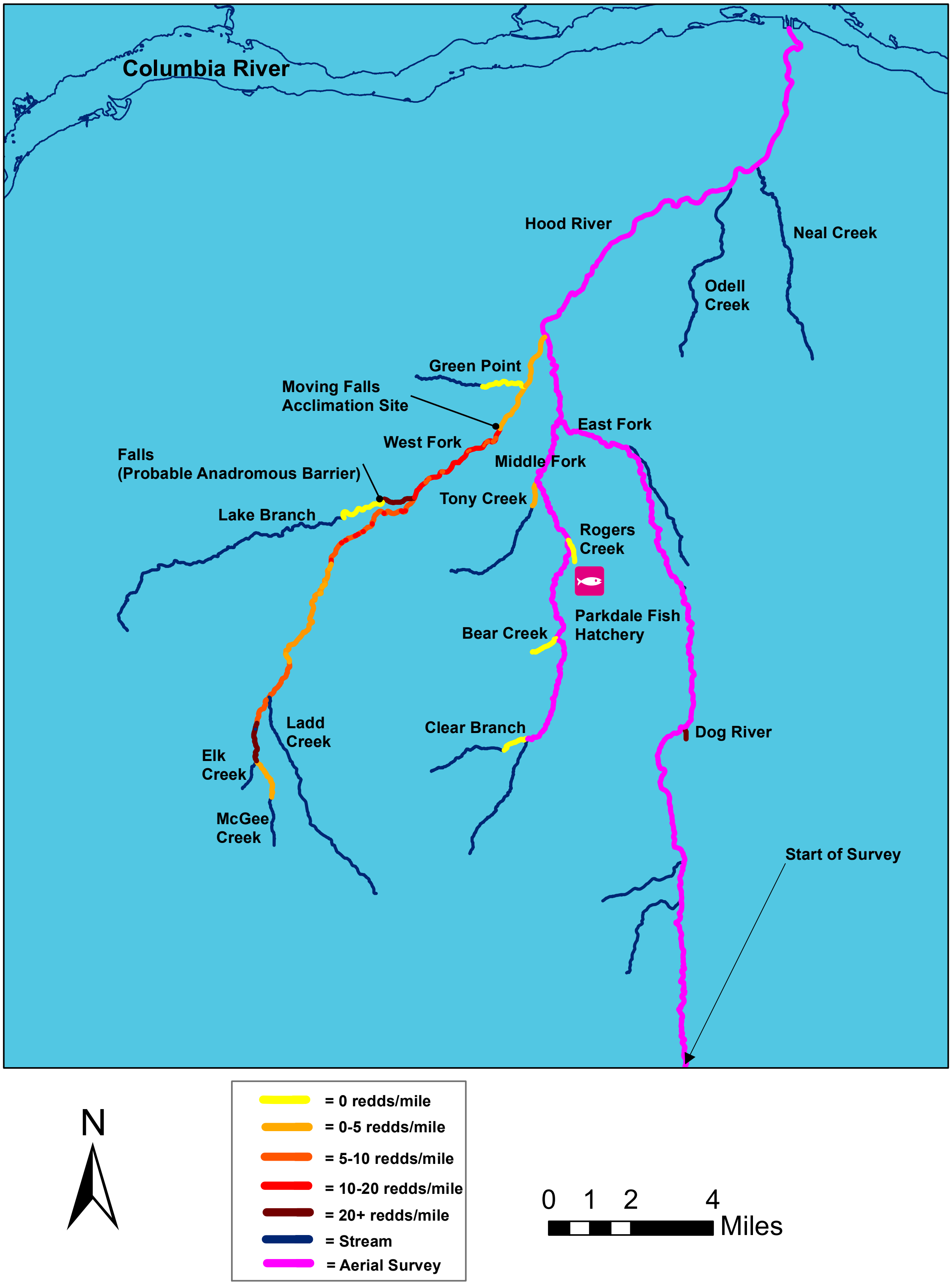

Figure 11. Distribution and density of redds/mile of spring Chinook redds observed in the Hood River Basin during ground surveys in 2015.

Adaptive Management & Lessons Learned

Conducting spawning surveys for many years has allowed managers to gauge trends in spawning activity over a wide range of adult returns and fisheries management strategies. Most notably in recent years we have observed a reduced number of redds relative to apparently abundant adult returns. This shift appears to coincide with changes in fisheries exploitation and adult trapping that occurred following the removal of Powerdale Dam. Understanding how these changes have affected the spawning abundance can inform managers as they make decisions for such things as fishing regulations, trapping operations, and broodstock collection. Additionally spawning surveys have been one of the tools used to document expanding distribution of spring Chinook throughout the course of reintroduction.

Element M: Collect/Generate/Validate Field and Lab Data – Conduct basin-wide juvenile spring Chinook distribution surveys.

Introduction

The Hood River Production Program was founded in 1991 to reintroduce spring Chinook and supplement winter and summer steelhead stocks. One of the first projects the HRPP embarked upon was fish surveys of the Hood River and its major tributaries to determine species composition, community assemblage, distribution, and rearing densities (Olsen et al. 1997). Methods employed were generally electrofishing depletion techniques. Since these initial surveys, the HRPP has been supplementing populations of winter steelhead, summer steelhead, and spring Chinook for over 20 years and over several complete generations of adult returns. Various monitoring efforts have observed salmon and steelhead presence in many areas considered unoccupied prior to the inception of the HRPP. However, no deliberate and systematic effort has been made to map the distribution of these reintroduced, supplemented, and hopefully expanding populations since the initial surveys at the beginning of the Hood River M&E program. To address this uncertainty, the HRPP began annual surveys in 2011 to reassess juvenile salmon and steelhead distribution in the Hood River basin and to document the extent of recolonization after a period of hatchery supplementation. The observations from these surveys have been submitted to the appropriate parties to update fish distribution designations in the ODFW and StreamNet (www.streamnet.org) databases.

Methods

To select streams to survey, we compiled a list of streams that HRPP and other local biologists deemed suitable habitat and accessible to anadromous fish. Our goal is to visit as many streams as we can during the summer field season each year until all streams on the list have been surveyed. At that time we will begin revisiting the previously surveyed streams in the original order, thus employing a de facto rotating panel design for sampling streams (Table 13). However, due to allocating much of the field crew time to snorkeling for a parr abundance project, only one stream was surveyed in 2015.

Table 13. Streams surveyed for juvenile distribution 2011-2015

	2011	2012	2013	2014	2015
Elk Creek	X				
Dog River	X				
Jones Creek	X				
Tony Creek	X				
McGee Creek		X			
Red Hill Creek		X			
Bear Creek			X		
EF Neal Creek				X	
Clear Branch					X

We used daytime snorkeling methods based on those described by Thurow (1994) to observe and identify rearing salmon parr and other fish in the sample streams. The snorkel survey period occurred from late-July until spring Chinook spawning surveys began in mid-August. During this time period, streams are typically low and water temperatures are peaking, which is when juvenile salmonids should be most active and easiest to observe. We conducted snorkel surveys mid-day when light and visibility were greatest. Each stream was surveyed according to a stratified design. Beginning at the mouth of the stream we would measure 100m sections with a tape measure stretched along the stream bank. After the initial 100m of stream was surveyed, the crew measured out 200m, which was not surveyed, and then measured out another 100m section to snorkel. As long as obligate anadromous species (i.e. Chinook or other salmon) were observed, we kept surveying upstream, surveying every third 100m section until two consecutive surveys resulted in no salmon observed.

Depending on the wetted width of the stream surveyed, either one or two snorkelers proceeded in an upstream direction identifying species and visually estimating size class of fish observed in pool and riffle habitat units. The three size categories used were <100mm, 100-200mm, and >200mm total length. An additional crew member followed along on the bank to record observations on a datasheet. Water temperature during a survey was measured with a thermometer and recorded on the data sheet. GPS coordinates were logged at the upstream and downstream ends of the surveyed reaches. Each habitat unit (pool or riffle) was measured for dimensions. Length was measured by the tape measure stretched along the stream section, 3-5 measurements of the wetted width taken with another tape measure, and a maximum depth of the unit measured with a wading staff marked at 0.1 foot increments. Water visibility was determined by measuring the distance from one of the surveyor's snorkel mask, in the water, to the point at which the features of laminated cutouts of 200mm salmonids could no longer be distinguished.

Information on the protocol and methods used for this work element are also published at the following web address, https://www.monitoringmethods.org/Protocol/Details/766

Results and Discussion

Rainbow trout/steelhead (O. mykiss) were the only fish species positively identified in Clear Branch during snorkel surveys. Surveyors also reported numerous trout fry that were too small to positively identify. Bull trout and cutthroat trout have been documented in this section of Clear Branch in the past, though none were identified during these surveys (Table 14). Since no obligate anadromous species were observed only two 100-meter stream segments were snorkeled.

Table 14. Densities (fish/100m^2) observed by species during snorkel surveys in 2015

	O. mykiss	Unknown Fry	Bull Trout	Chinook	Coho
Clear Branch	4.78	8.51	NA	NA	NA

Adaptive Management & Lessons Learned

Snorkel surveys have been a useful tool for documenting fish distribution in the Hood River basin. This is especially germane for the spring Chinook population that was reintroduced, and we expect to increase in distribution, if the reintroduction is progressing successfully. Fish observations made via this work element have been used to update fish distribution maps in StreamNet.org and other agency records.

Work Element P: Collect/Generate/Validate Field and Lab Data – Estimate capture efficiency of Moving Falls Fish Facility adult fish trap

The trap efficiency evaluation was postponed due to construction at the Moving Falls site during summer of 2015. This project will resume during 2016.

Work Element R: Collect/Generate/Validate Field and Lab Data – Hood River wild steelhead smolt run type classification

The Hood River is one of a relatively few river systems in the Columbia River Basin which has both summer and winter race steelhead occurring naturally. These populations are considered to be unique and are thus managed separately. Correctly identifying the race of individuals during monitoring activities via physical characteristics, especially during juvenile life phases, can be difficult and uncertain. In an attempt to develop a tool that may help us properly identify winter and summer steelhead juveniles and calibrate results from juvenile monitoring, in cooperation with the ODFW Hood River M&E project we contracted CRITFC geneticists at the Hagerman Genetics Laboratory to genotype individuals from a mixed population of O. mykiss collected in the Hood River. The genetic samples were collected from downstream migrating fish at screw traps and adult traps in Hood River subbasin operated by ODFW. The results are to be presented in the ODFW Hood River M&E program 2015 annual report (BPA project # 1988-053-04)

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Appendices

Appendix A. Survival rate, standard error and travel time to Bonneville Dam and the Columbia River Estuary for PIT tagged groups of hatchery spring Chinook, summer steelhead, winter steelhead, and wild steelhead smolts emigrating from the Hood River.

	Smolt Migration Year	Survival	SE	Mean Travel Time (days)	
				Bonneville Dam	Estuary Trawl
Spring Chinook (Hatchery)	2007	0.42	0.07	27.3	30.3
	2009	0.81	0.20	16.2	26.1
	2010	0.68	0.07	14.6	19.3
	2011	0.90	0.38	16.0	24.3
	2012	0.57	0.19	19.2	22.0
	2013	0.75	0.10	14.3	18.2
	2014	0.68	0.12	13.1	21.3
Summer Steelhead (Hatchery)	2005	0.33	0.22	48.3	54
	2006	0.62	0.22	36.9	42.9
	2008	0.24	0.11	41.0	46.0
	2009	0.57	0.08	16.7	19.3
Winter Steelhead (Hatchery)	2006	0.29	0.6	88.8	83.8
	2007	0.53	0.13	41.2	42.9
	2008	0.70	0.08	13.7	16.7
	2009	0.70	0.14	14.2	16.1
	2010	0.59	0.07	12.1	14.8
	2011	0.67	0.24	10.8	14.1
	2012	0.68	0.13	12.1	17.3
	2013	0.98	0.16	12.1	14.6
	2014	0.74	0.14	14.2	16.1
Wild Steelhead[1] (undetermined run)	2005	0.38	0.25	8.2	11.4
	2006	0.77	0.68	16.8	47.5
	2007	-	-	37.6	38.7
	2008	-	-	27.5	42.6
	2009	-	-	12.6	14.3
	2010	0.99	0.23	9.2	10.0
	2011	0.42	0.22	5.2	7.2
	2012	0.76	0.29	4.5	6.0
	2013	0.92	0.24	5.0	9.2
	2014	0.73	0.27	7.6	10.8

[1]Includes both winter and summer steelhead.

Appendix B. Stream Temperature.

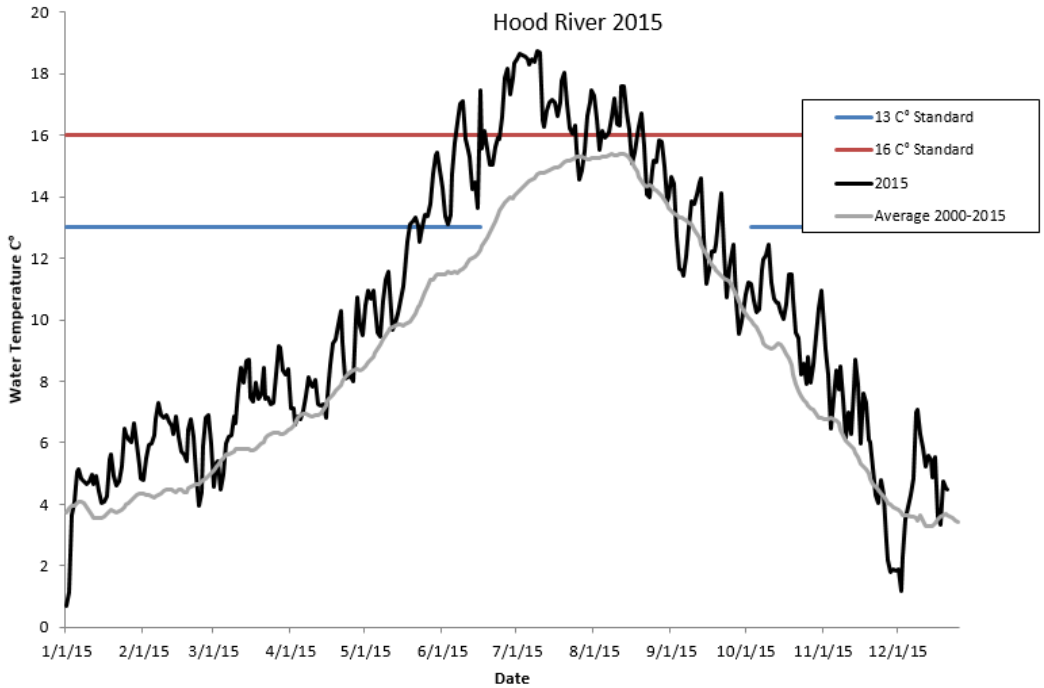

Figure A1. Average daily water temperature (˚C) recorded for the mainstem Hood River near the former Powerdale Dam (dam was removed in 2010) monitoring site, RKM 6.76, UTM 10T; 0615117E; 5057678N

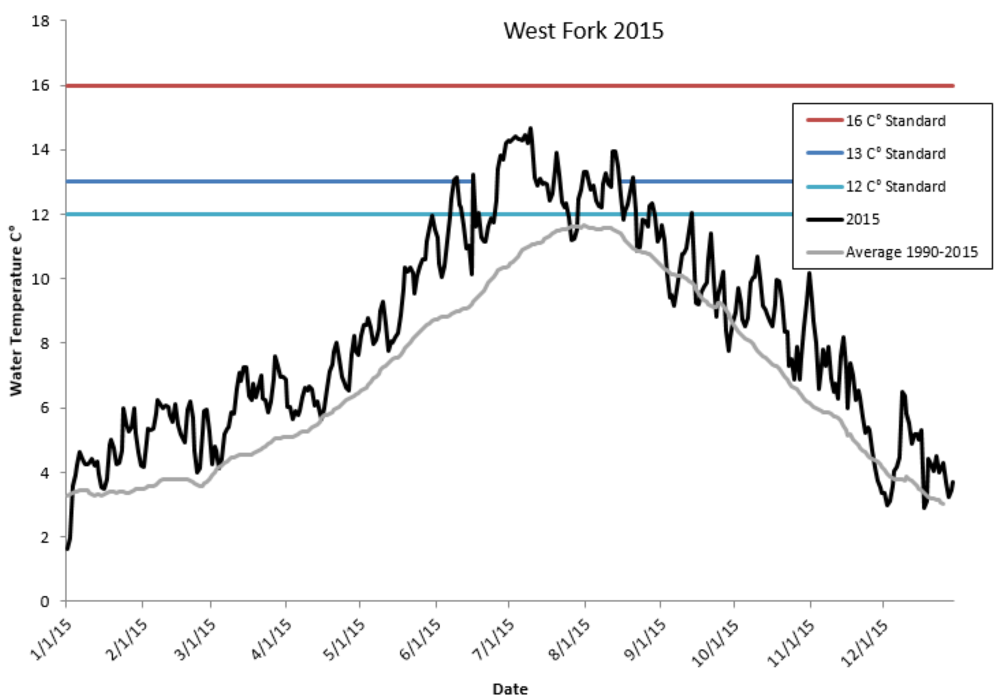

Figure A2. Average daily water temperature (˚C) recorded in the West Fork Hood River at the Lost Lake Road bridge, RKM 7.56, UTM 10T; 0602443 E; 5045709 N

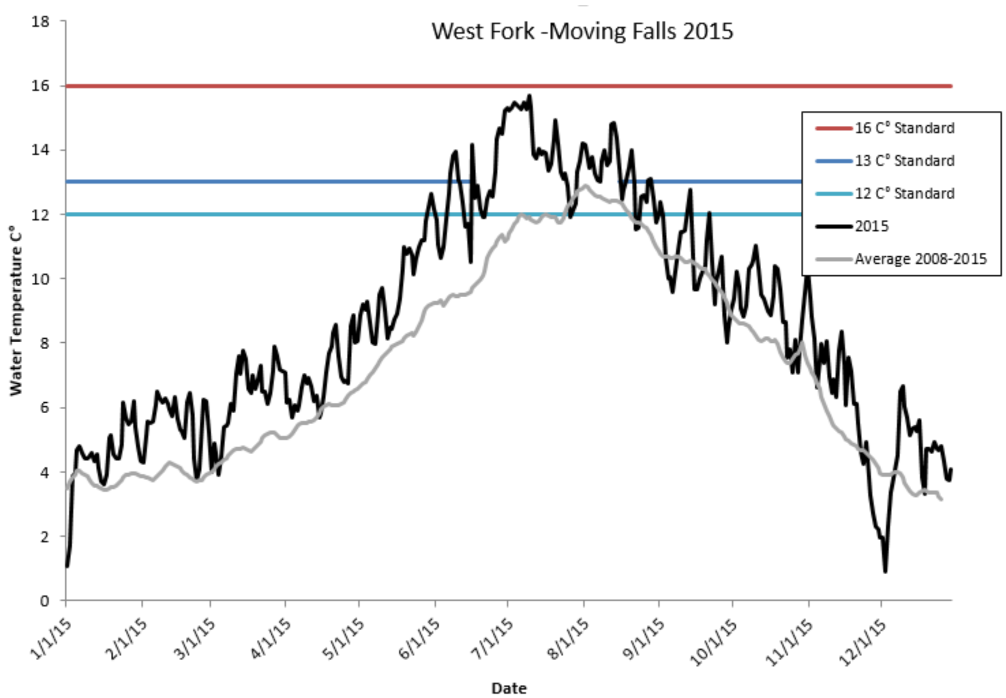

Figure A3. Average daily water temperature (˚C) recorded in the West Fork Hood River at Moving Falls, RKM 4.18, UTM 10T; 0604844 E; 5047580 N

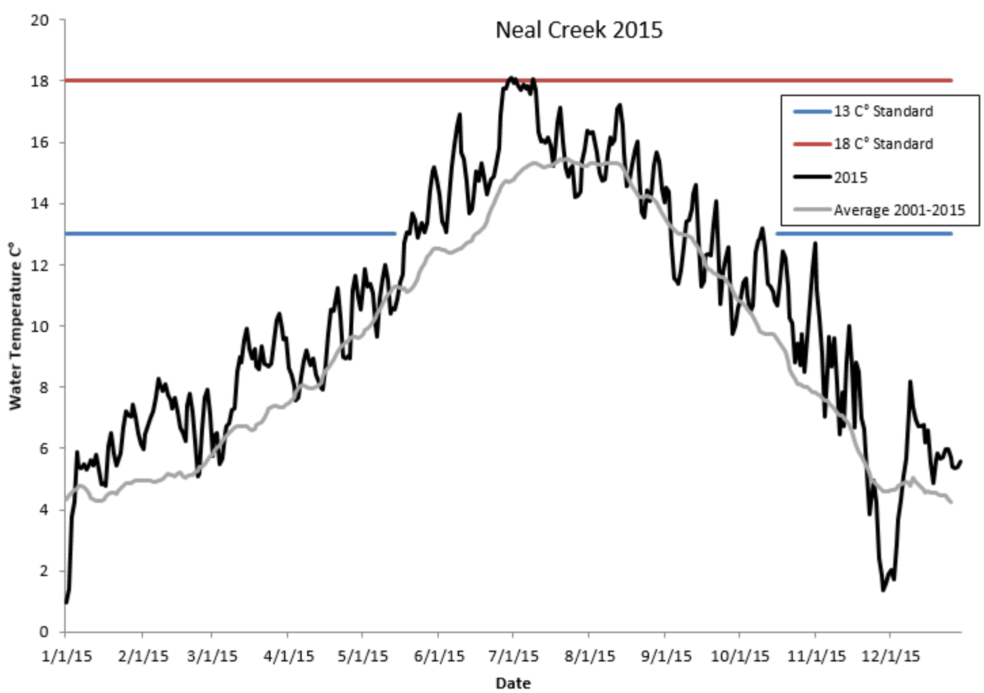

Figure A4. Average daily water temperature (ºC) recorded in Neal Creek near its mouth, RKM 0.16, UTM 10T; 0614858 E; 5057667 N

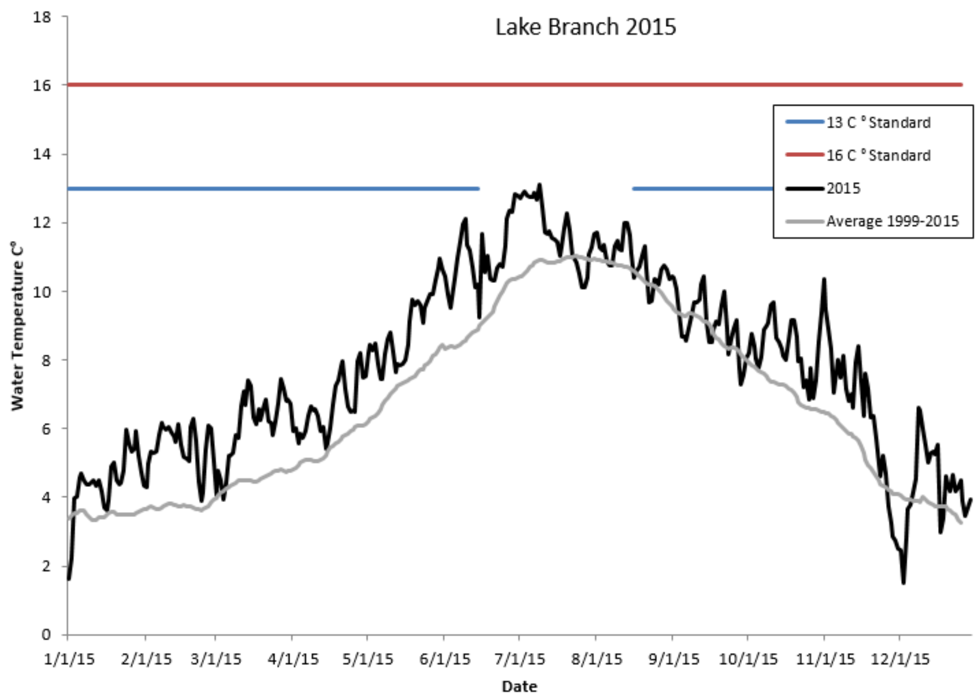

Figure A5. Average daily water temperature (ºC) recorded in Lake Branch near its mouth, RKM 0.16, UTM, 10T; 0601338 E; 5044637 N

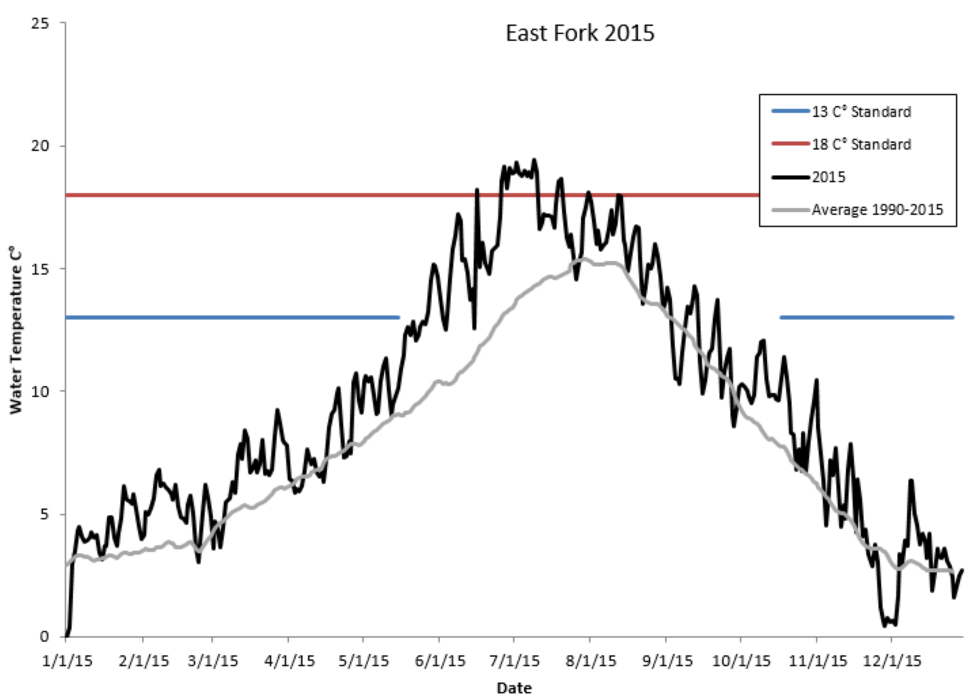

Figure A6. Average daily water temperature (ºC) recorded in the East Fork Hood River at the County Gravel Pit off Dee Hwy, RKM 1.45, UTM 10T; 0608100 E; 5047236 N

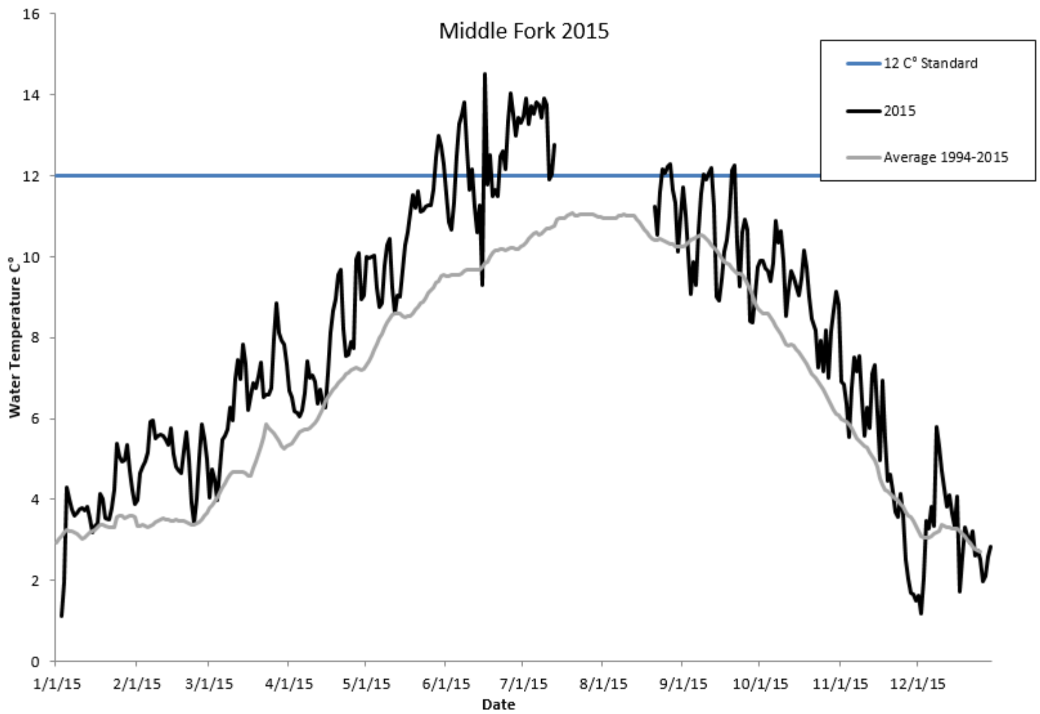

Figure A7. Average daily water temperature (ºC) recorded in the Middle Fork Hood River at Red Hill Drive, RKM 7.56, UTM 10T; 0607335 E; 5042130 N

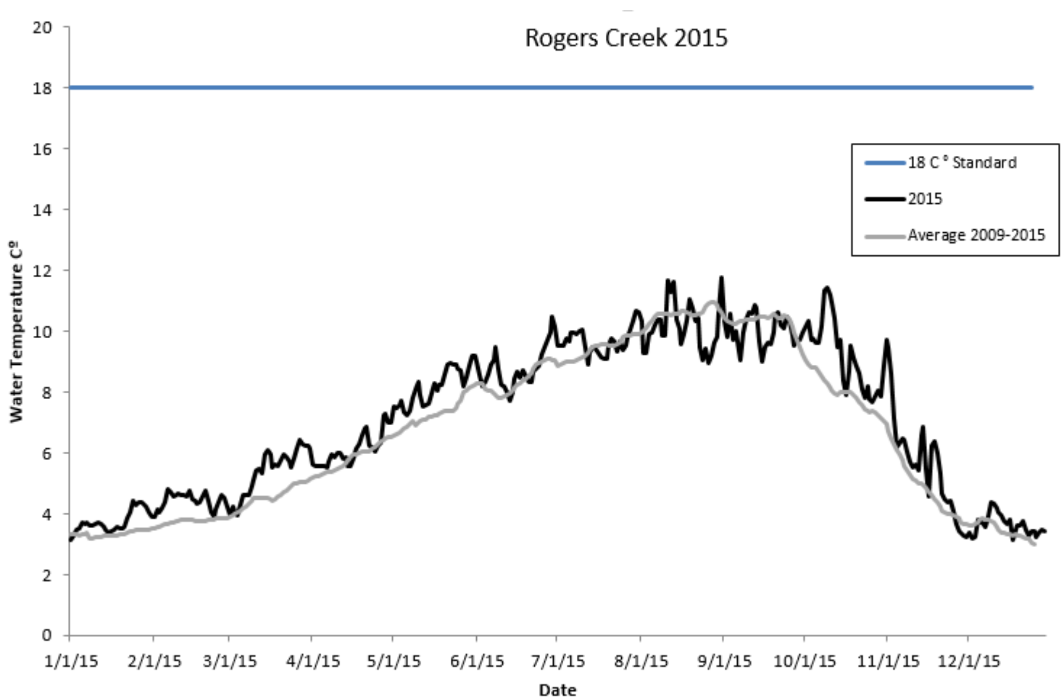

Figure A8. Average daily water temperature (ºC) recorded in the Roger's Spring near Red Hill Drive, RKM 0.64, UTM 10T; 0607670 E; 5042233 N

Appendix C. Predictor variables used for Hood River adult hatchery and natural origin spring Chinook run forecast models

Hatchery Origin Chinook forecast model variables

Year	HR Jacks t-1	Spring PDO t-2,3	PNI t-3	MEI t-2
1995	5	1.4033	1.28	1.992
1997	15	1.0500	1.086	0.508
1998	1	1.3833	0.636	-0.14
1999	2	1.7300	0.004	1.121
2000	5	1.3350	-0.483	2.178
2001	149	-0.0033	0.33	-0.664
2002	530	-0.4217	-0.538	0.188
2003	36	-0.2033	0.449	0.22
2004	15	-0.3967	0.88	0.801
2005	183	0.2417	0.097	0.07
2006	85	0.7067	0.771	0.495
2007	36	0.9250	0.959	0.782
2008	436	0.9967	0.921	-0.018
2009	492	0.3450	-0.698	0.213
2010	555	-0.6800	0.096	-0.348
2011	276	-1.1783	-0.976	0.375
2012	550	-0.2767	-0.077	0.609
2013	177	-0.0500	0.598	-0.281
2014	518	-0.4933	0.053	0.73
2015	482	-0.5433	0.181	0.108

HR Jacks t-1 = estimate of ocean age 1 Chinook returning to the Hood River.
Spring PDO t-2, 3 = Average of PDO value for April-June for 2 and 3 years prior to forecast year.
PNI t-3 = Pacific Northwest Index value 3 years prior to forecast year.
MEI t-2 = Multivariate ENSO Index values 2 years prior to forecast year.

Natural Origin Chinook forecast model variables

Year	HR spawners t-4	HR spawners t-5^2	Base Flow Index t-2	July PDO t-2
1996	452	3.27E+09	0.2611	0.06
1997	503	7.82E+09	0.2229	1.71
1998	300	1.23E+10	0.1851	0.77
1999	83	4.07E+08	0.2349	2.35
2000	111	1.04E+08	0.2862	-0.04
2001	354	2.65E+09	0.2883	-0.66
2002	99	1.30E+10	0.2712	-0.66
2003	117	1.47E+09	0.35	-1.31
2004	216	1.49E+09	0.2652	-0.31
2005	887	3.18E+10	0.2962	0.96
2006	867	1.54E+11	0.3934	0.44
2007	457	7.26E+10	0.3154	0.66
2008	369	1.36E+05	0.257	0.35
2009	581	3.38E+05	0.2055	0.78
2010	1,023	1.05E+06	0.2846	-1.67
2011	609	3.71E+05	0.2942	-0.53
2012	933	8.70E+05	0.3324	-1.05
2013	1,074	1.15E+06	0.267	-1.86
2014	836	6.99E+05	0.28	-1.52
2015	1,459	2.13E+06	0.3369	-1.25

HR spawners t-4 = estimate of spring Chinook present on spawning grounds 4 years prior to forecast year.
HR spawners t-5^2= estimate of spring Chinook present on spawning grounds 5 years prior to forecast year, squared.
Base Flow Index t-2 = Base Flow index generated by the (IHA) program for Hood River at the Tucker stream flow gauge 2 years prior to forecast year.
July PDO t-2 = Average of PDO value during July 2 years prior to forecast year.

Appendix D. Releases of PIT tagged winter steelhead (STW), spring Chinook (CHS), and summer steelhead (STS) by CTWS in the Hood River uploaded to the PTAGIS database and detections by PIT arrays in the Columbia River Basin as of December 15, 2015.

Release Year	Species /Stock	Location Code[a]	Tag Codes Uploaded	Juvenile Detections		Adult Detections	
				Bonneville	TWX	Bonneville	Hood River
2015	STW	SNDTRP	5,985	2,055	166		
2015	STW	NEALC	3,432	1,067	87		
2015	CHS	MVFLAP	16,424	2,902	399		
2014	STW	SNDTRP	6,440	895	114	19	5
2014	CHS	MVFLAP	14,950	1,682	128	58	26
2014	CHS	PARK	4,482	447	40	0	0
2013	STW	SNDTRP	4,138	594	114	72	17
2013	STW	PARK	1,655	275	74	24	7
2013	CHS	MVFLAP	12,321	1429	256	182	34
2013	CHS	PARK	6,084	401	68	43	3
2012	STW	SNDTRP	3,305	374	73	103	16
2012	STW	PARK	1,689	158	30	26	3
2012	CHS	MVFLAP	10,276	659	69	124	29
2012	CHS	PARK	5,084	140	15	10	1
2011	STW	SNDTRP	3,485	257	56	101	30
2011	STW	PARK	1,253	67	13	27	5
2011	CHS	BLKBAS	7,290	573	45	45	23
2011	CHS	PARK	5,091	289	20	37	11
2010	STW	SNDTRP	2,048	570	54	126	22
2010	STW	PARK	2,095	427	38	96	20
2010	STW	COL4	30	0	0	0	0
2010	CHS	BLKBAS	7,467	1,325	170	82	20
2010	CHS	PARK	5,068	938	108	57	12
2009	STW	SNDTRP	2,504	403	62	81	8
2009	STW	PARK	2,212	294	46	73	5
2009	STW	HOODR	1,179	63	7	15	0
2009	STW	COL4	459	33	3	1	0
2009	STS	BLKBAS	4,382	720	117	140	3
2009	STS	COL4	234	20	4	4	0
2009	CHS	BLKBAS	5,682	593	81	89	1
2009	CHS	PARK	3,944	333	34	58	2
2008	STW	SNDTRP	57	6	0	2	0
2008	STW	PARK	2,159	425	47	125	51
2008	STW	HOODR	4,416	1070	104	267	98
2008	STW	COL4	16	1	0	0	0
2008	STS	BLKBAS	1,139	86	7	18	2
2008	STS	COL4	57	3	1	4	0
2007	STW	HOODEF	2,413	278	29	90	68
2007	STW	HOODMF	1,555	204	17	47	41
2007	STW	HOODR	1,010	79	11	35	20
2007	STW	COL4	14	0	0	0	0
2007	CHS	HOODWF	7,515	575	93	93	51
2007	CHS	HOODMF	3,970	222	40	28	13
2006	STW	HOODEF	546	27	4	1	0
2006	STW	HOODMF	212	10	0	1	0
2006	STW	HOODR	12,187	694	76	52	14
2006	STW	COL4	379	19	7	1	1

2005	STW	HOODR	4,943	110	47	9	2

[a] Location codes can be referenced at the PTAGIS website at http://www.ptagis.org/sites/map-of-mrr-sites