



# **Yakima Steelhead Viable Salmonid Population (VSP) Status & Trends Monitoring**

**Yakima Steelhead VSP Project**

**Annual Report 2011**

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This project expands RM & E activities conducted by the co-managers in the Yakima Basin (Yakama Nation and Washington Department of Fish and Wildlife) to better evaluate VSP parameters (abundance, productivity, spatial structure, and diversity) for Yakima steelhead populations. This proposal builds upon the infrastructure and monitoring capacities of the YKFP umbrella M&E project (199506325). Data from this project will be used to evaluate population status and trends (including NOAA status reviews and the AMIP abundance triggers), and address critical uncertainties (e.g., the relationship between resident and anadromous life histories in the Upper Yakima and Naches populations), consistent with the NPCC Fish and Wildlife program, Columbia Basin research plan (uncertainties 3.1, 7.1 & 7.3), NOAA mid-Columbia steelhead recovery plan, and Fish Accords. Better understanding population performance will directly inform efforts to recover steelhead populations in the Yakima Basin.

This report provides status and trend monitoring for the Yakima River Steelhead MPG, Mid Columbia DPS. The VSP project was established through the Northwest Power Planning Council's fast track process (Skamania Workshops) in May 2010. The project (project # 201003000) is funded under two BPA contracts, one for the Yakama Nation and the other for the Washington Department of Fish and Wildlife (WDFW). The WDFW contract work focuses on the Upper Yakima Steelhead population while the YN contract has a much broader scope (e.g., MPG level).

## **Executive Summary**

The National Marine Fisheries Service currently has jurisdiction over steelhead trout *Oncorhynchus mykiss* in the Mid-Columbia (Mid-Columbia Ecologically Significant Unit) due to their depressed abundance and 1996 federal listing as threatened under the Endangered Species Act (ESA). The ESA requires NMFS to develop a recovery plan that identifies actions necessary to restore Mid-Columbia steelhead to a sustainable level such that they no longer require federal protection. In 2009, NMFS completed a recovery plan for Mid-Columbia steelhead. Concurrently, a recovery plan specific to the Yakima Distinct Population Segment (DPS) was developed locally and was adopted by NMFS and included as an appendix in their larger Mid-Columbia plan. The Yakima Basin steelhead recovery plan was developed to provide a roadmap for steelhead recovery in the Yakima. This project strives to conduct research that will support steelhead recovery in the Yakima Basin consistent with the objectives identified in the aforementioned recovery documents.

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## **General Introduction**

This report is intended to satisfy two concurrent needs: 1) to provide a contract deliverable from the Yakama Nation (YN) to the Bonneville Power Administration (BPA) reporting on important steelhead VSP metrics (abundance, productivity, diversity, and spatial structure) for the Yakima steelhead MPG status and trend monitoring, and 2) conduct research that will have broad scientific relevance. This work relies heavily on the infrastructure and staffing associated with the Yakima/Klickitat Fisheries Project (e.g., #199506325; #199506425; #199701325).

This project expands RM & E activities conducted by the co-managers in the Yakima Basin (Yakama Nation and Washington Department of Fish and Wildlife) to better evaluate VSP parameters (abundance, productivity, spatial structure, and diversity) for Yakima steelhead populations. It was developed to fill critical monitoring gaps identified in the 2009 Columbia Basin monitoring strategy review and the FCRPS Biological Opinion RPA review. Data from our research will be used to evaluate population status and trends, inform NOAA status reviews and implementation of the FCRPS Biological Opinion, and address critical uncertainties (e.g., the relationship between resident and anadromous life histories in the Upper Yakima and Naches populations), consistent with the NPCC Fish and Wildlife program, Columbia Basin research plan (uncertainties 3.1, 7.1 & 7.3), NOAA mid-Columbia steelhead recovery plan, and Fish Accords. The improved understanding of steelhead population performance produced by this project will directly inform efforts to recover steelhead populations in the Yakima Basin.

## **Acknowledgments**

We would like to thank Bonneville Power Administration, particularly Sandra Fife, for administering funding for this work. We would also like to thank the staff associated with the Yakima/Klickitat Fisheries Project for providing the foundation for our project.

# Chapter 1

## Yakima River Steelhead Radio Telemetry Study

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# Introduction

This is a 3 year study spanning the time frame of September 2011, through the end of June 2014. The study will address the spatial distribution uncertainties for both the Naches and Upper Yakima steelhead populations (Figure 1). In addition, the study will update the radio telemetry study conducted 20 years ago (Hockersmith et al. 1995) that has often been referenced and used for apportioning the Yakima River Major Population Group (MPG) run size enumerated at Prosser Dam to individual population spawner abundances (ICTRT In press, YBFWRB 2009). The study will also test alternative methods for apportioning the total run at Prosser Dam for long term status and trends monitoring needs.

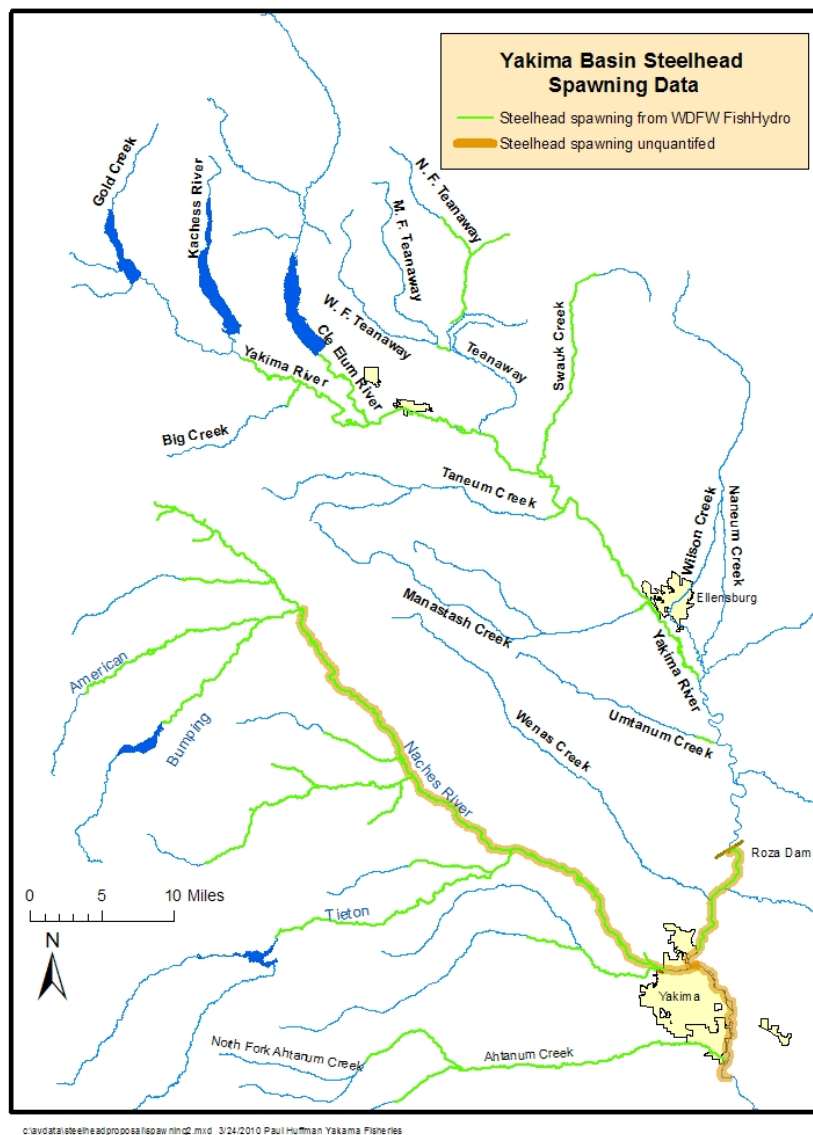


Figure 1. Estimated spawning distributions of Upper Yakima and Naches steelhead populations

Steelhead residing in the Yakima Basin are classified as summer-run. Run timing into the Yakima Basin typically begins in late August or early September, and extends into May of the following year. The large geographic distribution of steelhead in the Yakima Basin results in diverse pre-spawning migration and holding patterns that influence the proportion of fish that survive to spawn. Estimates of run escapement at Prosser Dam (Rkm 75.6) may not accurately reflect spawning escapements due to uncertain pre-spawning mortality rates. Previous abundance estimates have used a generalized rate for the entire MPG. Redd surveys are not reliable for spawner abundance estimates in years and sites when survey efforts are precluded by high flow and low visibility.

The primary objectives of the three year radio telemetry study are to:

1. Better define the Upper Yakima and Naches spawning distributions,
2. Clarify the extent, distribution, and contribution of mainstem spawners,
3. Estimate population specific adult escapement and spawner abundances for each population,
4. Assess, and ground-truth the long-term prospects for using GSI and PIT-tagging techniques for apportioning the total run at Prosser Dam.

The study will also collect other valuable spatial and temporal life history information specific to each population, including:

1. Run timing
2. Pre-spawn migration and holding patterns
3. Pre-spawn survival
4. Spawn timing
5. Number of redds constructed per female
6. Age structures (freshwater, ocean and total) and sex ratios
7. Survival to kelting rates

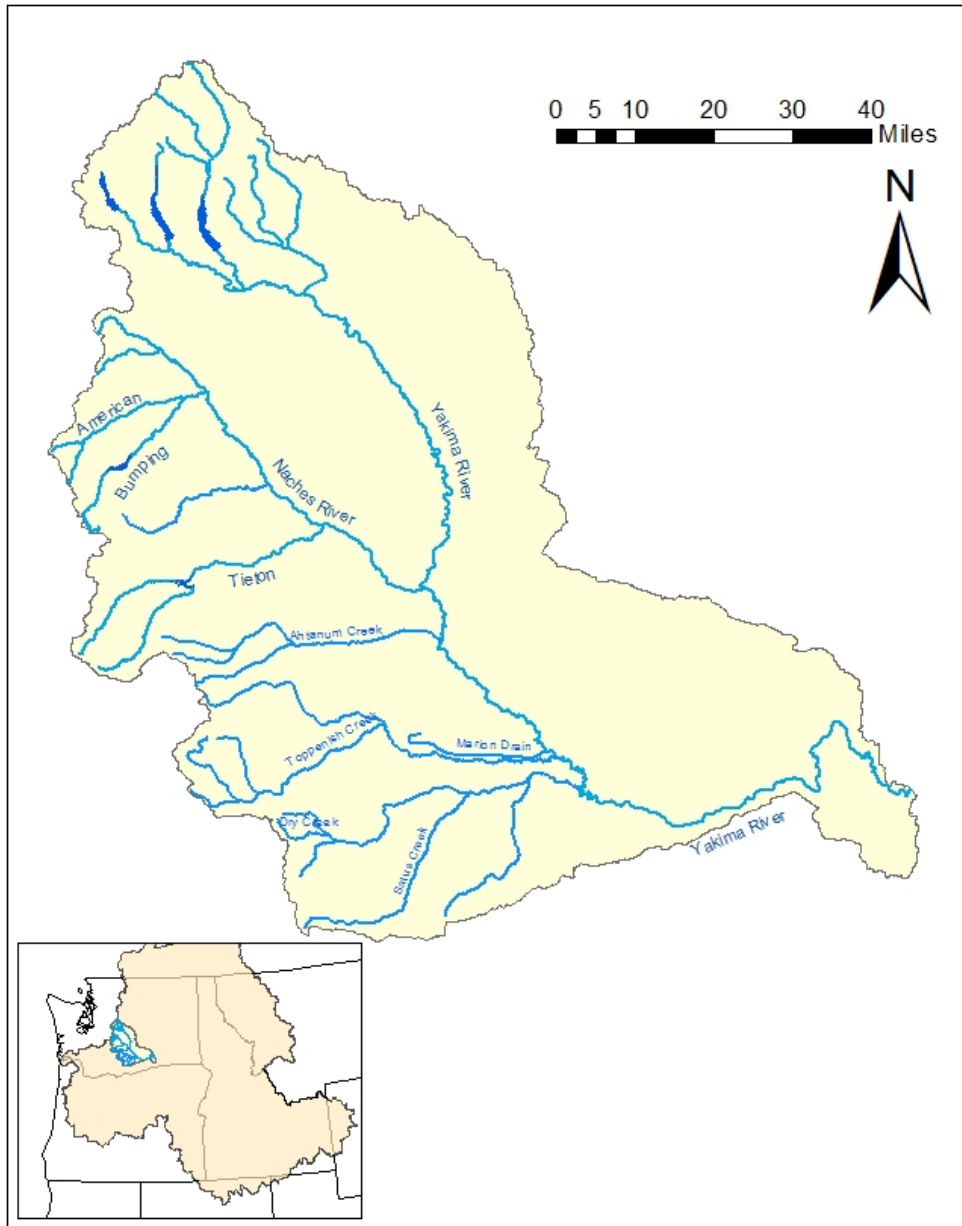
This report chapter is intended to provide annual progress updates for research associated with Biological Objective 1, "Determine spatial distribution and major (MSA) and minor (MiSA) spawning areas of steelhead spawning populations in the Yakima MPG", and for the adult abundance portion of Biological Objective 2 "Estimate juvenile and adult abundance for individual populations" presented in the Yakima Steelhead VSP Project descriptive.



## Methods

### *Study Area*

The Yakima Subbasin is located in south-central Washington. It drains an area of 6,155 square miles and contains about 1,900 river miles of perennial streams (Figure 2). The Yakama Indian Reservation is located in the southwest corner of the subbasin just south of the city of Yakima. Major Yakima River tributaries contained within the Reservation include Satus and Toppenish watersheds. The Yakima River originates near the crest of the Cascade Range above Keechelus Lake at an elevation of 6,900 feet and flows 214 miles southeastward to its confluence with the Columbia (RM 335.2). Major tributaries outside the Yakama Indian Reservation include the Kachess, Cle Elum and Teanaway rivers in the northern part of the subbasin, and the Naches River in the west. Six major reservoirs are located in the subbasin. The Yakima River flows out of Keechelus Lake (157,800 acre feet), the Kachess River from Kachess Lake (239,000 acre feet), the Cle Elum River from Cle Elum Lake (436,900 acre feet), the Tieton from Rimrock Lake (198,000 acre feet), and the Bumping from Bumping Lake (33,700 acre feet). Topography in the subbasin is characterized by a series of thrust fault ridges extending eastward from the Cascades. These Ridges divide the Yakima River into several macro floodplain reaches, each unique to its own physical characteristics. Elevations in the subbasin range from about 7,000 feet in the Cascades to about 350 feet at the confluence of the Yakima and Columbia rivers.



Paul Huffman, Yakama Nation Fisheries, 12/13/2011 C:\av\data\subbasin\yak\yakbasin.mxd

**Figure 2. Map of the Yakima River Basin and proximity in the Interior Columbia Basin.**

### **Radio tag description**

We will be using digitally encoded Lotek MCFT2-3A-M gastric implanted radio tags for the duration of the study. The radio tags are 16x46mm in size, and have an air weight of 16 grams. The tags are outfitted with motion sensors capable of emitting both active and inactive codes. A

radio tag implanted in a live swimming fish will continually transmit an active code. In the event the tag has been regurgitated or the fish has been depredated, the tag will emit an inactive code after laying motionless for 24 delay period. The motion sensor feature will greatly assist in determining tag regurgitation rates and depredation events of individual fish.

Tags will use Lotek's 2000 code set, and spread out over 5 different narrowband radio frequencies consisting of 150.680, 150.720, 151.520, 151.720, and 151.800. The motion sensor feature of the radio tags limits the number of tags to 100 per frequency. With an anticipated number of tags ranging from 400-500 per year (see sampling design below), it was necessary to use 5 different frequencies. The use of 5 frequencies will also reduce the incident of emitted signal collisions that compromise the ability of receivers to detect and record individual tag codes. To further alleviate tag collisions within individual frequencies, 4 different burst rates will be used consisting of 3.5, 4.0, 4.5, and 5.0 seconds. The operational life of tags will range from 330 days to 185 days. With tagging efforts spread over an 8 month period, it was necessary to vary the tag life to ensure tags from one year are not emitting signals into the next years study period. As an example, steelhead tagged in September and October will receive a tag with a life expectancy of 330 days, expected to last through August or September of the following year. A steelhead tagged in April will receive a tag with a life expectancy of 185 days, also expected to last through September before termination.

### **Sample size and distribution of radio tags**

A large enough sample size of radio tagged adults will be needed for the following:

- 1) Population specific adult & spawner escapement- Multiplying the proportion of tagged fish migrating into each of the four independent sub-populations by the total steelhead run size counted at Prosser Dam will generate steelhead abundance levels for each Yakima Basin steelhead sub-population.
- 2) Population specific life history analysis- Run-timing, adult holding, spawn timing, age structure, sex ratios and kelting rates will be estimated from biological sampling of adults that are radio tagged and partitioned into populations based on spawn location and GSI assignment.

Other important considerations for estimating and selecting an appropriate number of adults to be tagged for the study include: 1) the proportion of run that utilizes the right bank ladder where the denil trap is located, and 2) the strength of annual run size the sample is to be drawn from. Additionally, we used 90% confidence limits ( $z = 1.645$ ) for our estimates in order to keep sample sizes reasonable. Our approach to sampling a finite population is summarized by the following equations:

Equation 1.  $p \pm d$

to

Equation 2  $p \pm z * \sqrt{\frac{p * (1 - p)}{n} * [1 - \frac{n}{N}]}$

wherein:

z is from a standardized normal-distribution table (z table1)  
p is the estimated proportion of a given population in the Prosser adult run size  
N is the adult passage at Prosser  
n is the sample size at Prosser

In Equation 2,  $\frac{p^*(1-p)}{n}$  is the usual variance of the sample proportion and  $[1 - \frac{n}{N}]$  is the adjustment in that variance due to sampling from a finite population.

The sample size is thus estimated by equating from Equations 1 and 2

$$d = z * \sqrt{\frac{p^*(1-p)}{n} * [1 - \frac{n}{N}]}$$

and then solving for n and using  $Q = n/N$  as the proportion sampled,

$$\text{Equation 4.a } Q = n/N = \frac{1}{1 + \frac{N * d^2}{z^2 p^*(1-p)}}$$

and **Equation 4.b.  $n = Q * N$**

Three total run sizes were used in the analysis consisting of the recent 5 year mean (3156), min (1523) and max (5793 and still counting) run sizes enumerated at Prosser dam from 2005/06 to 2009/10. The variability across the 5 year period emphasizes the need for evaluating sampling sizes across a fairly broad range of run sizes potentially occurring within the three year study period.

Estimated proportions of individual populations within the run at large were needed for the sample size analysis. We used the 10 year geometric mean abundances estimated by the ICTRT that were derived for stock status assessments for the Yakima River MPG (YSFWRB 2009). We computed population proportions by dividing their respective geometric means by the total sum of 10 year geo-means (Table 1). The largest and smallest populations were both used in the analysis which consisted of the Naches (37.7%) and the Upper Yakima (6.5%). For simplicity, the Naches proportion was rounded to 40% and the Upper Yakima was rounded to 10%. The 6.5% is based on the abundance of adults enumerated at Roza dam and does not include any mainstem spawning activity below the dam. Therefore, we felt the use of 10% was adequate for this analysis.

**Table 1. 1995-2004 Geometric means of spawner abundance for Yakima MPG populations (ICTRT 2007).**

Yakima River Steelhead Population				
	Satus	Toppenish	Naches	Upper Yakima
1995-2004 Geomean	405	344	505	87
Proportion of total spawners	30.2%	25.6%	37.7%	6.5%

For column E in tables x and x we set up the confidence limits as:

$$d = r \cdot p$$

where r is the desired +/- value as a proportion of p

A range of r values were initially considered (Table 2) for p = 0.1 (Upper Yakima population receiving 10% of Prosser's passage) and p = 0.4 (Naches population receiving 40% of Prosser's passage).

**Table 2. Values of d (for +/-d) across a range of r values for Naches and Upper Yakima populations.**

Computed values of d for +/-d		
r values	Upper Yakima (p = 0.1)	Naches (p = 0.4)
r = 0.1	0.01	0.04
r = 0.2	0.02	0.08
r = 0.4	0.04	0.16

Using the largest and smallest proportionate populations in the analysis created a lower and upper bound for the +/- d values so it was not necessary to analyze the other two populations based on the assumption that proportions of these populations fall within the range of 10-40%.

Initial estimates of sample sizes using r values ranging from 0.1 – 0.4 for the 5 year min, max and mean run sizes indicated that larger sample sizes were needed for smaller p values (0.1) in order to achieve similar +/- d values to those estimated for larger p values (0.4). This suggests the sample size needed for the radio telemetry study should be based on the acceptable confidence limits computed for the smallest p value of 0.1 (i.e. upper Yakima population at 10% of the total run). The specified confidence limits for a p value of 0.1 using the upper and lower r values (0.1 and 0.4) are summarized in column J. (Table 3). Results for an r value of 0.1 provide a confidence interval of 9.0-11.0% but the sample sizes ranging from 937 to 1714 are not reasonable, cost effective, and require an un-achievable sampling rate that may also have undesired impacts to a listed species. In contrast, results for an r value of 0.4 demonstrate a cost effective sample size ranging from 138 to 148 that requires a small proportion of the run to be

tagged. However, there are several concerns and deficiencies with this sample size. A confidence interval of 6.0-14.0% may not provide an accurate estimate for comparison to stock proportion estimates from GSI techniques. Without an accurate estimate for comparison, our ability to assess and validate the long term usage of GSI for disaggregating the run at large will likely be compromised. In addition, it is doubtful a sample size ranging from 138 to 148 will be of sufficient size for conducting life history analysis when apportioned to each of the four individual steelhead populations.

**Table 3. Summary of sample size analysis across an expected range of Yakima River steelhead run sizes for p=0.1 (upper Yakima), and r values of 0.1 and 0.4.**

A.	B.	C.	D.	E.	F.	G.	H.	I.	J.				
Population	Prosser adult passage (N)	Proportion of Run in Subbasin (P)	Desired +/- Value as a proportion (r) of p	actual +/- value +/-d = +/-r*p	Desired Confidence Interval Percentage	Table Z value	Proportion of Prosser passage tagged (Q)	Number (n) Sampled at Prosser	Specified Confidence Limits Summary				
Upper Yakima	1,523.00	0.1	0.1	0.01	90%	1.645	0.62	937	90%	CI=	9.0%	to	11.0%
	3,156.00	0.1	0.1	0.01	90%	1.645	0.44	1,375	90%	CI=	9.0%	to	11.0%
	5,793.00	0.1	0.1	0.01	90%	1.645	0.30	1,714	90%	CI=	9.0%	to	11.0%
Upper Yakima	1,523.00	0.1	0.4	0.04	90%	1.645	0.09	138	90%	CI=	6.0%	to	14.0%
	3,156.00	0.1	0.4	0.04	90%	1.645	0.05	145	90%	CI=	6.0%	to	14.0%
	5,793.00	0.1	0.4	0.04	90%	1.645	0.03	148	90%	CI=	6.0%	to	14.0%

**Table 4. Summary of sample size analysis across an expected range of Yakima River steelhead run sizes for p=0.1 (upper Yakima) and p=0.4 (Naches), and respective r values of 0.2 and 0.08.**

A.	B.	C.	D.	E.	F.	G.	H.	I.	J.				
Population	Prosser adult passage (N)	Proportion of Run in Subbasin (P)	Desired +/- Value as a proportion (r) of p	actual +/- value +/-d = +/-r*p	Desired Confidence Interval Percentage	Table Z value	Proportion of Prosser passage tagged (Q)	Number (n) Sampled at Prosser	Specified Confidence Limits Summary				
Upper Yakima	1,523.00	0.1	0.2	0.02	90%	1.645	0.29	435	90%	CI=	8.0%	to	12.0%
	3,156.00	0.1	0.2	0.02	90%	1.645	0.16	510	90%	CI=	8.0%	to	12.0%
	5,793.00	0.1	0.2	0.02	90%	1.645	0.10	551	90%	CI=	8.0%	to	12.0%
Naches	1,523.00	0.4	0.08	0.03	90%	1.645	0.29	435	90%	CI=	36.7%	to	43.3%
	3,156.00	0.4	0.08	0.03	90%	1.645	0.16	510	90%	CI=	36.7%	to	43.3%
	5,793.00	0.4	0.08	0.03	90%	1.645	0.10	551	90%	CI=	36.7%	to	43.3%

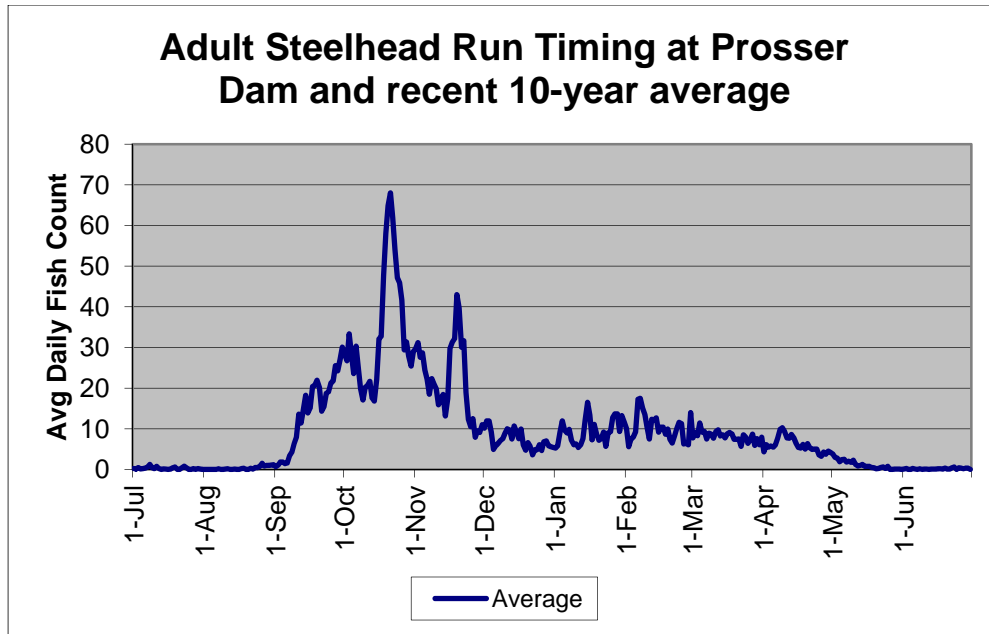
Of the  $r$  values considered in the sample size analysis, 0.2 provides a reasonable confidence interval of 8.0-12.0% (upper Yakima population) while keeping the sample size within a cost effective range, and achievable sample rate. The specified confidence limits are summarized in Column J. of Table 4. For run sizes ranging from 1523 to 5793, sample sizes of 435- 551 require approximately 10-29% of the run to be tagged (Table 4, columns I and H). A tagging rate of 10-16% is attainable for mid to larger run sizes but at smaller run sizes, the required tagging rate increases to about 29%. If this circumstance arises, the number of fish tagged will likely range from ~300 to 350 fish at a sample rate of about 19-22%. Run sizes are often difficult to predict, but we anticipate a range from about 2500-5500 adults over the 3 year duration of the study.

Confidence intervals and  $r$  values for the Naches population ( $p=0.4$ ) were calculated using the estimated sample sizes for  $p=0.1$  and  $r=0.2$  over the range of run sizes (Table 4). This was done by inputting the sample size estimates into excel's solver and solving for  $r$  (column D). The  $\pm r$  values were estimated at 0.08 with a confidence interval of 36.7-43.3%.

The sample rate analysis indicates that reasonable statistics can be achieved with sample sizes ranging from approximately 430-550 and that  $r$  values will range from 0.2-0.08, depending on the actual proportions of each individual population. Actual tagging numbers will likely range from 350-500 and will be dependent on the actual run size, and right bank ladder usage where the trap is located.

### **Distribution of tagging effort**

Run timing of steelhead over Prosser Dam (Rkm 75.6) typically begins in late August/ early September, and extends into the latter part of May (Figure 3). Although not apparent from the 10 year mean, the run is characterized by a bi-modal peak with the first occurring in the late October/early November period, and the second generally occurring in the January or February the following year. The Sample efforts will be stratified across the entire run beginning in September and potentially extending into the first part of May. Specifically, historical estimates of the proportion of run passing Prosser dam on a monthly basis will be used to guide the stratified tagging effort based on the 10 year mean.



**Figure 3. Yakima River summer steelhead run timing at Prosser Dam (RKM 75.6).**

### **Tag application and bio-sampling procedures**

Radio tagging operations will be conducted at a denil fish trap located adjacent to the right ladder on the Prosser Dam (Rkm 75.6). During trapping operations, the main ladder is blocked, leading fish up a steep pass before entering one of two chutes. One chute leads to a large holding tank where fish are collected when personnel are not actively working on fish. Fish are then re-directed into a staging tank via a second chute where personnel collect fish using a dip net. Fish identified for sampling and tagging are then transferred into a tank where they are anaesthetized with clove oil prior to sampling and tagging. Recognizing that tricain methanesulphonate (MS-222) is the most commonly used and accepted chemical fish anaesthesia, it has a 21 day withdrawal period and should not be used on fish potentially caught and consumed by human anglers within the 21 day withdrawal period. In the case of the Yakima and this particular study, tribal subsistence fisheries do occur above the Prosser denil trap, and a handful of steelhead are caught for ceremonial and subsistence. Unlike MS-222, clove oil is rapidly excreted or metabolized, leaving no residues and requiring no withdrawal time (Keene et al. 1998). Other studies have shown that few differences exist between the anaesthetic effects of clove oil and MS-222 on the physiological response of this to stress (Wagner et al. 2003), and that clove oil is more effective at reducing the short-term stress response induced by handling and blood sampling (Wagner et al. 2003). Upon sedation, scale and DNA (tail fin clips) samples will be collected first while keeping the fish partially submerged. Lengths, weight, and sex information will then be collected prior to scanning the fish for external marks, CWTs, and PIT tags. If an existing PIT-tag is not detected upon interrogation, one will be placed in the dorsal sinus cavity located adjacent to the dorsal fin. Lotek MCFT2-3A-M (16x46mm in size, 16 grams air weight) radio tags will be placed through the mouth, and into the stomach using a PVC esophageal implant tube. Fish will be placed in an adjacent recover tank and held for approximately 20 minutes or until total equilibrium is regained, and reappearance of avoidance swimming is evident. Upon recovery, fish will be immediately released upstream of Prosser Dam and the



denil trap. Radio tags will be spread across the 150-152 Mhz frequency range using 5 different channels. Twelve to 14 month duration radio transmitters will be used for tracking pre-spawn migration and holding patterns prior to, and through the spawning period, and during their subsequent outmigration to the Pacific Ocean. We are anticipating a small proportion of these tags will be recovered from out migrating kelts captured at the Prosser hatchery facility. These recovered tags can be used for tagging additional steelhead at Roza Dam. Additional radio tagged adults in the Upper Yakima will contribute to several project objectives and work Tasks (e.g., 5B).

## **Acknowledgements**

We are thankful for the staff dedicated to the Yakima steelhead VSP monitoring project and we are grateful for the guidance, expertise, and resources provided by the Yakima/Klickitat Fisheries Project. Finally, we would like to thank Sandra Fife, Bonneville Power Administration, who was helpful in securing and administering funding for this work. This work was funded through contracts from Bonneville Power Administration to the Yakama Nation for the Yakima Steelhead VSP Monitoring Project.

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