Yakima Steelhead VSP Project

Resident/Anadromous Interactions Monitoring

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1. Executive Summary

a. Fish Population RM&E

This report provides status and trend monitoring for the Upper Yakima steelhead *Oncorhynchus mykiss* population group. An additional focus of the work relates to resident/anadromous interactions studies associated with the Yakima Steelhead Viable Salmonid Population (VSP) Project. The VSP metrics most desired from a status and trend monitoring standpoint of the upper Yakima steelhead population include abundance, productivity, spatial structure, and diversity. We strategically constructed our monitoring infrastructure to support adult and juvenile abundance and productivity data collection. One confounding factor affecting our abundance and productivity monitoring data is the operation and maintenance of our PIT tag interrogation system. We recommend minor equipment reconfiguration and continual troubleshooting to identify and reduce ambient noise, thereby improving the detection capability of our monitoring infrastructure. This will improve our confidence in our adult and juvenile detections. One additional complication in estimating these metrics is the uncertainty associated with the interactions between anadromous and resident life history forms. The upper Yakima population consists of a large, robust resident *O. mykiss* population, and a severely depressed anadromous population in a highly regulated system; a situation that is fairly unique in the Columbia Basin. The spawning interactions between the life history forms suggests that the resident form of *O. mykiss* may have considerable influence on the abundance, productivity, spatial structure, and diversity metrics of the anadromous form. One of our objectives is to attempt to quantify abundance of each form independent of each other, the productivity, spatial structure, and diversity of the anadromous form considering the influence of the resident life history form. These are no small tasks and have been identified as critical uncertainties that need to be addressed in all the major planning and recovery documents for steelhead in the Yakima population group. We recognize that generating robust VSP estimates takes considerable time. For example, NOAA recommends collecting a minimum of 12 years of spawner abundance data to generate robust productivity estimates. Data collection efforts under this project began in 2011 and we acknowledge that we are early in the data collection activities relative to the desired time series of data to generate these metrics. Our preliminary observations to date suggest that anadromous steelhead run escapement in the upper Yakima has generally been increasing in recent years while other Columbia River regions have generally been experiencing stagnant growth, and in many cases, population declines. Meeting recovery objectives for this population may be achievable, albeit not in the near future given the current observed rate of increase. While compiling VSP data, we are confident that this project will help identify geographic areas of the upper Yakima that support significant anadromous production, so we can make recommendations for future enhancement and protection.

b. Coordination and Data Management for RM&E

We hope the results of our work will have far reaching effects. This includes improving our understanding of how sympatric resident and anadromous O. mykiss interact to influence the status of the depressed and listed anadromous form. The information collected during this contract have been uploaded to Ptagis (PIT tagging data), and have been presented in public and professional forums (e.g., AFS chapter and divisional meetings; annual Yakima Basin Science and Management Conference; other conferences). Our data has also been used to help influence the selection of high priority populations for inclusion in high level reports that are either being drafted (e.g., Steelhead at risk report, WDFW unpublished) or that have been published in technical and non-technical forums.

2. Introduction

This report provides status and trend monitoring for the Upper Yakima steelhead population group. An additional focus of the work relates to resident/anadromous interactions studies associated with the Yakima Steelhead Viable Salmonid Population (VSP) Project. 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). The current report was completed by the Washington Department of Fish and Wildlife in collaboration with the Yakama Nation during the previous contract period. All results should be considered preliminary until they are published in the peer reviewed literature.

a. Fish Population RM&E

F&W Program Strategy: Assess the status and trend of adult natural and hatchery origin abundance of fish populations for various life stages.

F&W Program Management Question: What are the status and trend of adult abundance of natural and hatchery origin fish populations?

Status and Trend Monitoring- Adult Natural and Hatchery Origin Abundance

Hatchery steelhead have not been released in the upper Yakima Basin since 1993 and the releases in the early 1990's were relatively small and experimental in nature. Thus, status and trend monitoring under this contract is directed at the upper Yakima River wild population although we do observe a very small number of hatchery strays annually. A complete census of the adult brood year return is collected at Roza Dam for each return year. The geometric mean adult return for the Upper Yakima population as of the most recent status assessment was 85 adults. However, recently, there appears to be an increasing trend in annual wild adult return numbers (Figure 1).

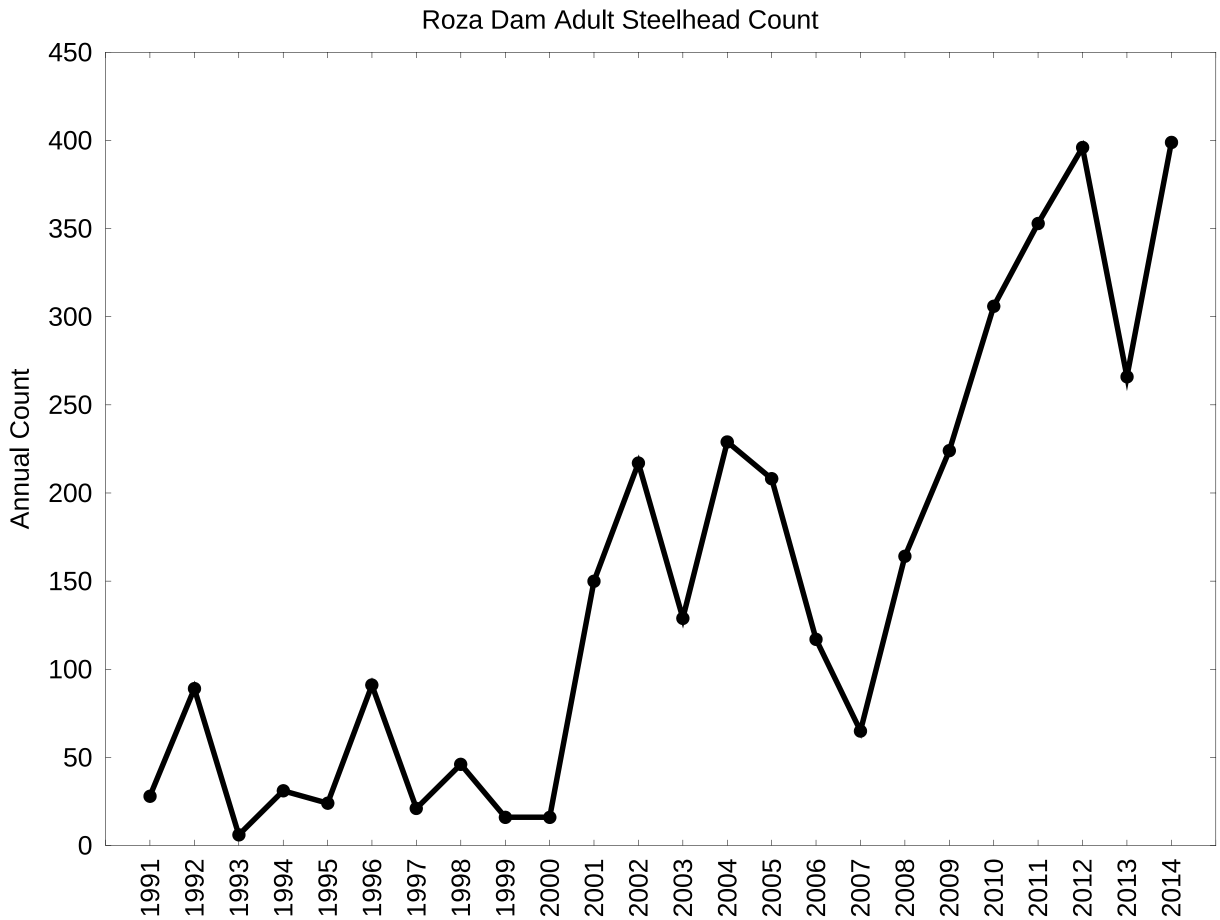


Figure 1. Annual adult summer steelhead return (run escapement) to the Upper Yakima River as enumerated at Roza Dam.

It appears the adult steelhead returns to the Yakima major population group (MPG) are faring well relative to other regions throughout the Columbia Basin (Figure 2). The Prosser Dam count of wild adult steelhead (all 4 Yakima populations combined) presented as a proportion of the wild steelhead count at Bonneville Dam indicates a positive abundance trend since 1995. A similar pattern is observed for the upper Yakima steelhead population passing upstream from Roza Dam. However, the upper Columbia River region (Priest Rapids Dam count: not differentiated by hatchery or wild origin) and lower Columbia between Bonneville and McNary Dams do not appear to be following the same trajectory. The Snake River region (Ice Harbor dam count) does indicate an increasing trend but has remained fairly level for the last several years. While the reason for this increase is unknown, it is a focus of recent discussion. Despite the increasing wild adult trends in the Yakima basin, there is still significant progress to be made to meet the recovery goals that have been established (Figure 3).

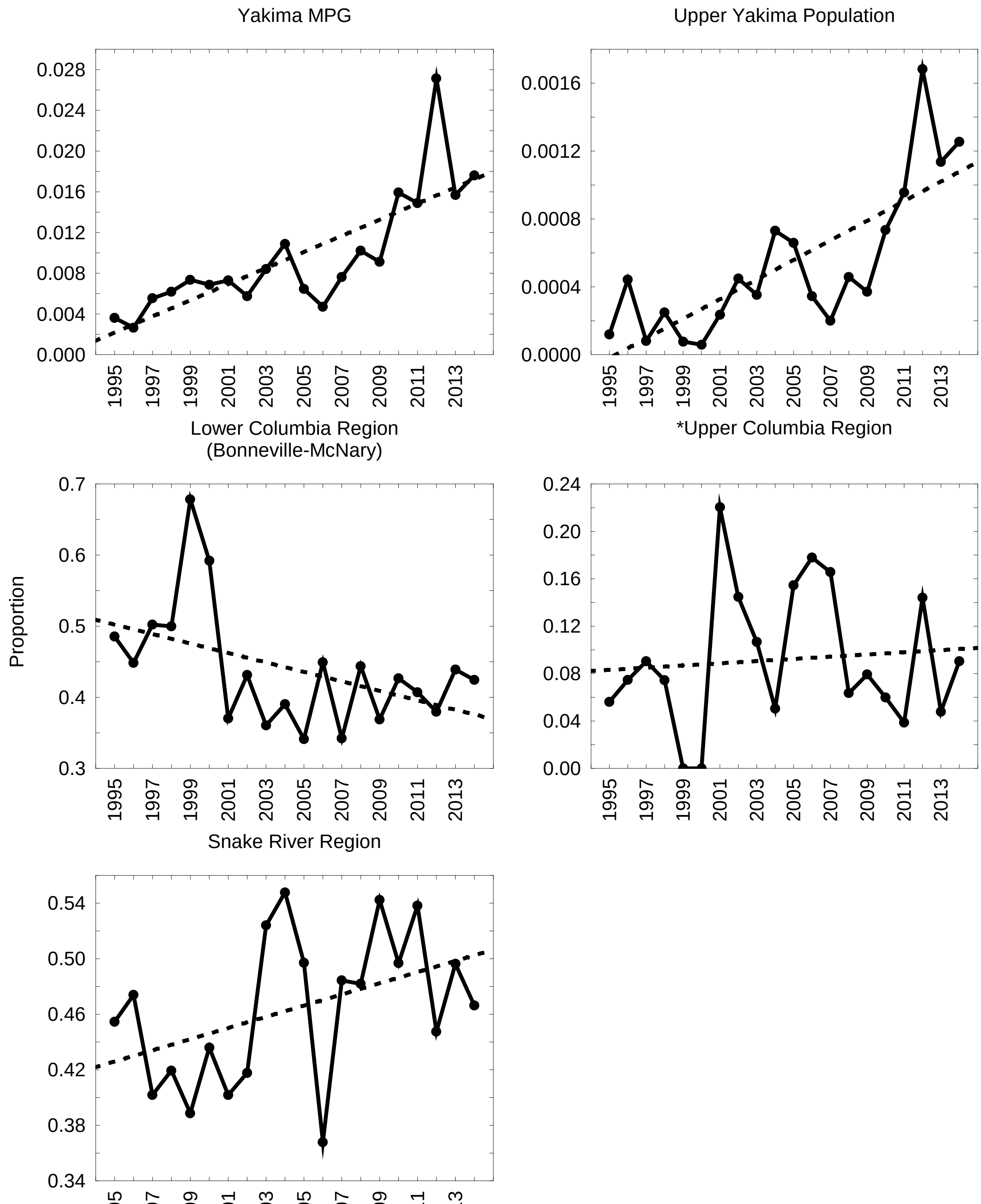


Figure 2. Annual trends in wild steelhead returns in the various Columbia River Regions as a proportion of the Bonneville Dam Count. The Lower Columbia region depicts difference in the Bonneville and McNary dam counts and therefore does not include populations below Bonneville Dam and should be considered incomplete. The asterisk indicates a complete count, not differentiated by hatchery or wild origin. The dashed lines represent the best fit line.

One major objective for the data collected under this work is to provide status and trend monitoring data for the upper Yakima steelhead population that is currently listed as threatened under the ESA. Our data collection activities are documenting progress towards meeting the documented recovery goals. Until recovery targets are met, we contend this project will be necessary to monitor the VSP metrics for the upper Yakima steelhead population until they are delisted and there is no obligation to report their population status or monitor the trends in their VSP metrics. The timeline to completion for these data collection activities is therefore, dependent upon the progress the population makes towards meeting recovery targets and could take a substantial amount of time (Figure 3).

We constructed simple linear models based upon the observed increasing trend in abundance and inherent stochastic variation to estimate the time it would take to reach NOAA's minimum recovery threshold recommendations for the upper Yakima steelhead population (Figure 3). The minimum recovery target established for this population is to achieve 500 adults returning above Roza dam for a period of 10 consecutive years. The long term recovery goal is to maintain a run escapement of 1500 returning adults annually (Conley et al. 2009). Major assumptions that must be noted using this modeling approach include 1) ocean survival remains within the range observed between 1991and 2014, 2) habitat improvement projects of the same magnitude continue to be completed at approximately the same rate as they have over the period of record (and thus the habitat is not be completely restored prior to reaching recovery goal), 3) incidental harvest in commercial or recreational fisheries remain relatively constant and unchanged, and 4) iteroparous spawning rates remain similar through time. Although unrealistic, if these assumptions were reasonably achieved, the short term recovery goal (500 adults) would not be met until approximately the year 2041. This is likely a conservative estimate because the underlying assumptions are unlikely to be achieved over this time series. This relationship illustrates the need to be pro-active with recovery efforts in the Yakima Basin given the current threatened ESA listing status of Mid-Columbia Steelhead under this MPG.

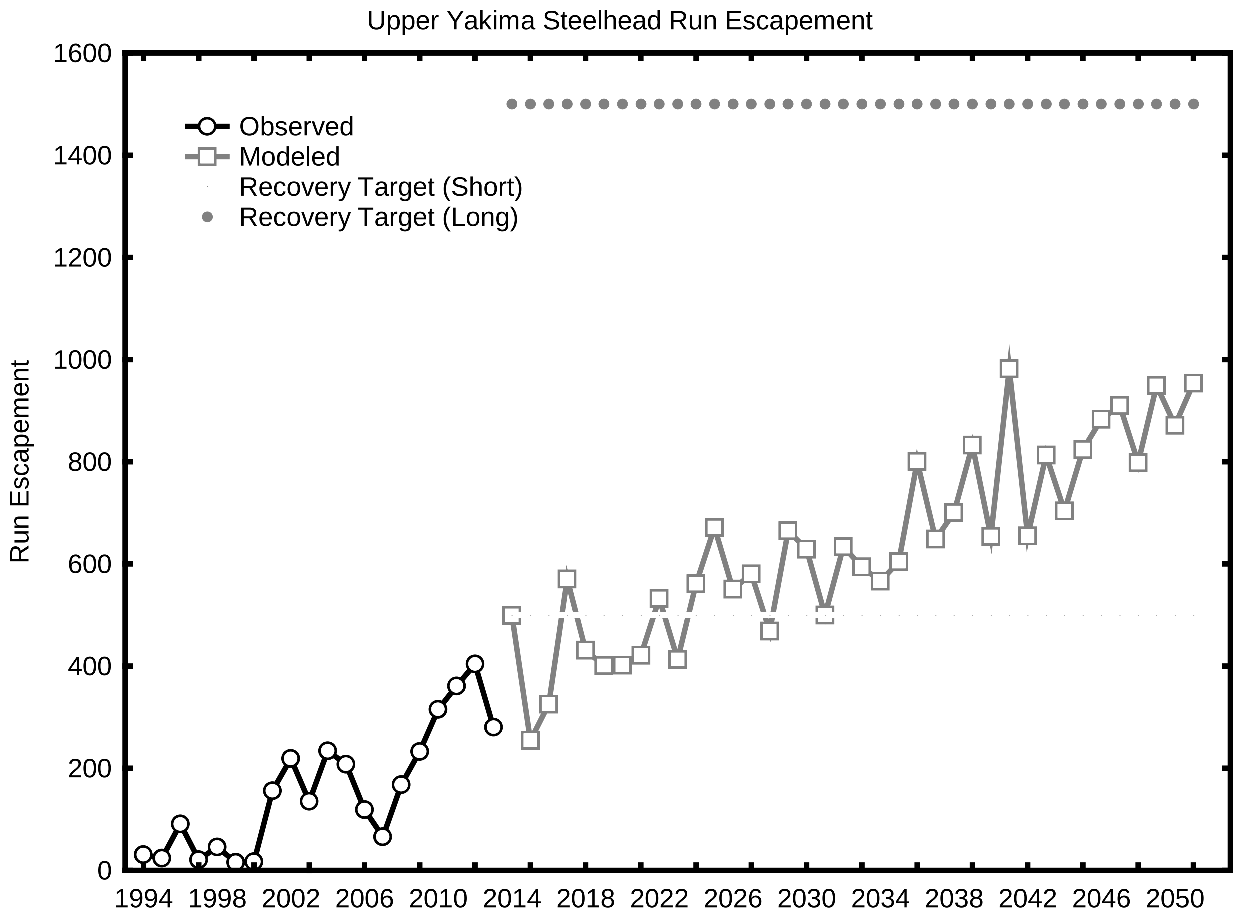


Figure 3. Observed and modeled annual summer steelhead run escapement into the Upper Yakima. The short term and long term recovery targets are presented as dashed lines.

One of our objectives in monitoring steelhead status and trends in population abundance is to use our PIT tag infrastructure to determine the spatial distribution and abundance of adult steelhead spawners in the Upper Yakima population. The radio telemetry study was used to validate the use of our PIT tag infrastructure to estimate the steelhead spawning distribution and abundance by tributary. For adult spawner abundance in the upper Yakima, detections of radio tagged adults (that are also PIT tagged) at our PIT tag arrays are compared to the radio-telemetry mobile tracking detections that have been conducted routinely to determine the detection rate of the PIT tagged individuals at the fixed monitoring sites. Fish that were known to have spawned in multiple streams were used to calculate array detection efficiencies for every interrogation site they were known to have passed. The tributary adult spawner abundance estimate was generated for each tributary by inflating the PIT tag detections upstream from each PIT tag array by the detection efficiency estimated at each array (from detections of radio tagged steelhead; Table 1). The general agreement between the PIT tag array detections and the radio-telemetry verification suggest the fixed site PIT tag arrays can be used to estimate spawner abundance and distribution with reasonable accuracy (Table 1). The annual run of wild adult steelhead migrating upstream from Roza Dam was estimated to be 376 during the 2014 spawning migration (www.YKFP.org). Radio Telemetry monitoring indicated that of the 68 radio-tagged steelhead tracked to their spawning locations, 69% were in tributaries, and 31% were located in the main stem Yakima River upstream from Roza Dam. A large number of main stem river spawners aggregated near the town of Ellensburg indicating this is an important spawning area.

Table 1. Detections of adult steelhead that are double tagged (PIT tagged and Radio Tagged) and the adult detection efficiencies estimated during the spring spawning migration in 2014 in each tributary in the Upper Yakima that has an in stream PIT tag detection array.

Stream	Radio tag detections	Radio and Pit tag detections	Detection efficiency	Pit tag Detections (n)	Expanded Estimate	Percent of total run
Swauk Creek	5	5	1	47	47	12.5
Taneum Creek	6	6	1	62	62	16.5
Main stem Teanaway River	14	8	0.57	15	62	7
North Fork Teanaway	6	4	0.67	34	51	13.6
Upper Main stem Teanaway River (West and Middle Fork)	8	8	1	60	60	16
Manastash Creek	1	13	1	13	13	3.5
Umtanum Creek	1	1	1	1	1	0.3
Wilson Creek	3	NA	NA	NA	NA	NA

We evaluated the tag retention rates for PIT tagged juvenile wild *O. mykiss* in Cowiche, Nile, and Manastash creeks using a dual tagging procedure during several time intervals post tagging. In 2013, we double tagged fish in Manastash Creek in two stream sections. We used coded wire tags (CWT) inserted into the adipose fin tissue or dorsal musculature as the second tag. Unfortunately, we had difficulties distinguishing the presence of a coded wire tag versus a PIT tag on small trout due to the sensitivities of the CWT wand detectors. However, we did conduct recapture sampling in Manastash creek during 2014 regardless of the aforementioned tag differentiation difficulties in order to obtain a 1 year post tagging time interval. The impact of the CWT detection was thought to be minor however, since the effect of poor CWT detections is to reduce the number of confirmed recaptures that have both tags. The effect of concern is the number of CWT fish that do not have a PIT tag which can still be determined from the study. We improved the design in 2014 by incorporating the use of elastomer visual identification (VI) tags as a substitute for the CWT second tag. The VI tags were inserted in the adipose eye tissue and could be fluoresced with UV light in cases where dye was faint or illegible to the naked eye. Recapture sampling was conducted for various time intervals between 1 day and 1 year following tagging in each stream. The number of recaptures missing a PIT tag relative to the number of double tagged recaptures was assumed to reflect the tag loss rate (Figure 4).

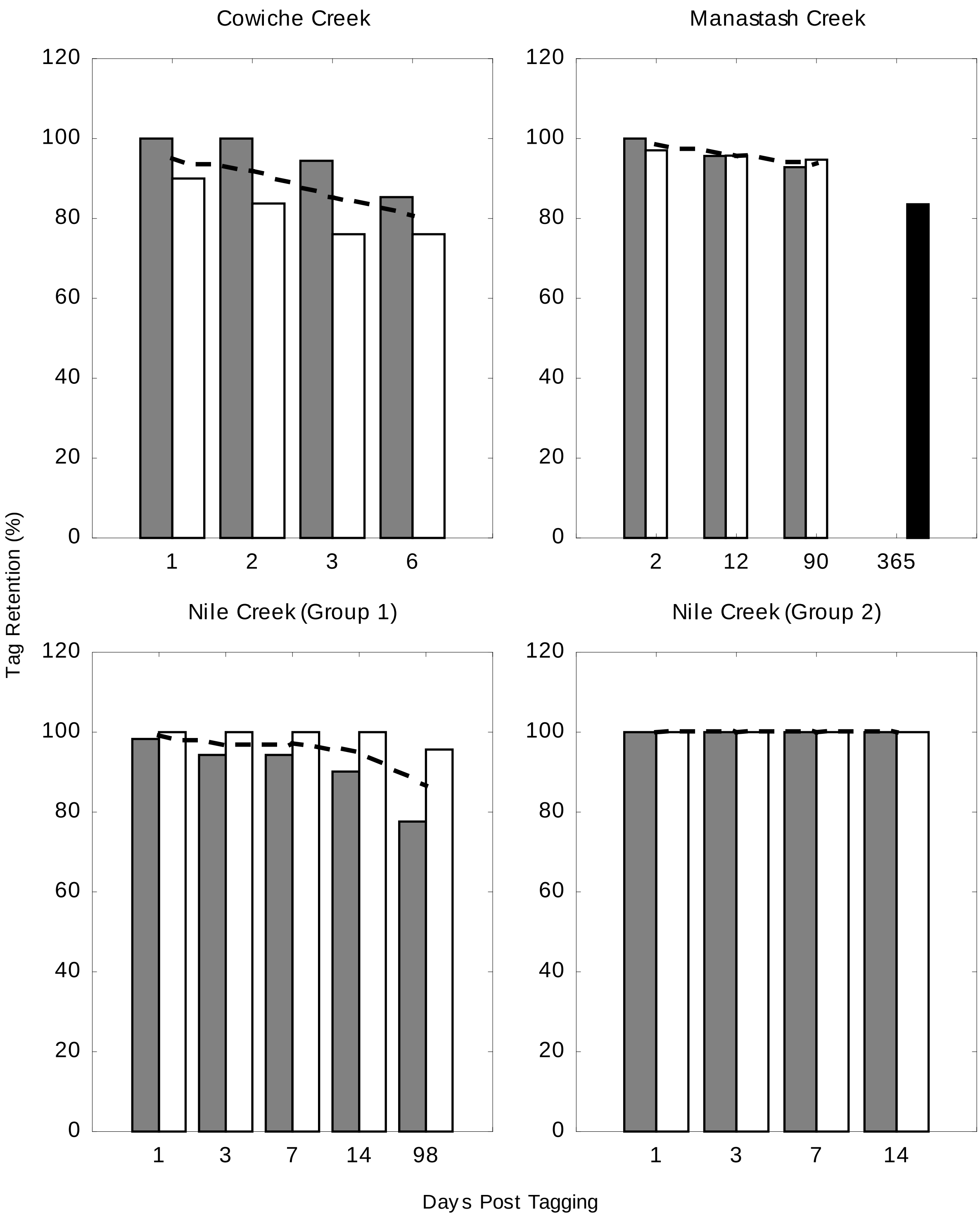


Figure 4. Tag retention rates (%; days post tagging) for PIT tagged wild *O. mykiss* in Cowichee, Manastash, and Nile Creeks in upstream (grey bars) and downstream (white bars) stream reaches. The dashed line represents average tag retention rates from both sections. The black bar depicts tag retention for the combined up- and down- stream reaches in Manastash Creek over a calendar year.

F&W Program Strategy: Assess the status and trend of juvenile abundance and productivity of natural origin fish populations.

F&W Program Management Question: What are the status and trend of juvenile abundance and productivity of fish populations?

Status and Trend Monitoring- Juvenile Abundance and Productivity

Juvenile monitoring of upper Yakima River steelhead is complicated by the large degree of overlap in life history forms during the rearing period. Combined resident and anadromous rearing *O. mykiss* abundance estimates are generated in index monitoring sites annually. One objective of this project is to estimate productivity of each of the life history forms independent from one another. Because there is a high degree of overlap between the life histories during the rearing period, this analysis can only be completed after the spring smolt migration window when known anadromous fish are positively identified as migrants and the population abundance estimates from the year prior can be partitioned by life histories (Figure 5).

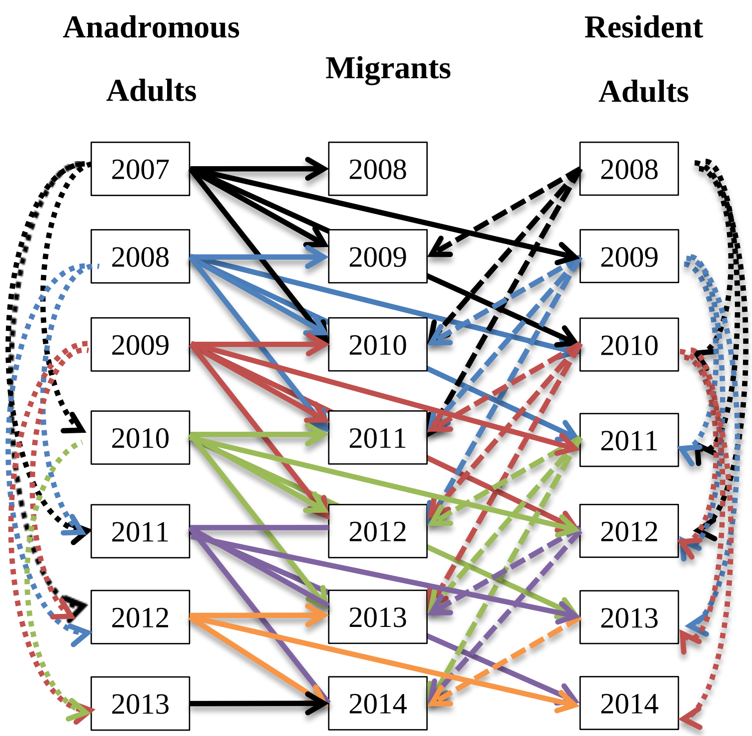


Figure 5. Diagram of potential migrant production from anadromous and resident adult spawners for a sample of brood years. Adult spawners in the spring produce 1 year old migrants the following spring, 2 year old migrants 2 years in the future, and so forth. Four year old migrants are not included although they have been observed, but generally in very small numbers.

This evaluation is further complicated by the fact that there is a high degree of overlap in the length at age of fish in the upper Yakima Basin. Partitioning the abundance estimates into juvenile and resident adult components requires information on the age structure of the population. We use the mixed distribution algorithms proposed by Du (2002) to partition the length frequency distributions of the fish sampled to estimate the age structure of the population in each stream sampled. We included constraints to the model fitting procedure by incorporating the scale/age data acquired from a subsample of fish in each stream. The proportions of fish at age sampled during this contract period are presented in Table 2.

Table 2. Estimated proportions of fish at age for Yakima River Tributaries including Big Creek (BIG), the Cle Elum River (CLE), Little Creek (LITT), Manastash Creek (MAN), Middle Fork Teanaway River (MFT), Main stem Teanaway River (MST), North Fork Teanaway River (NFT), Swauk Creek (SWK), Taneum Creek (TAN), Umtanum reek (UMT), Wenas Creek (WEN), the West Fork Teanaway River, and Main Stem Yakima River sampling sections including the Lower and Upper Canyon sections (LCYN and UCYN respectively), Ellensburg (EBURG), Thorp (THORP) and Cle Elum (CELUM) sections.

Stream	Age0	Age1	Age2	Age3	Age4
			Tributaries		
BIG	0.0	0.75	0.14	0.08	0.02
CLE	0.0	0.76	0.22	0.008	0.002
LITT	0.0	0.66	0.28	0.05	0.01
MAN	0.05	0.65	0.30	0.01	0.0
MFT	0.33	0.43	0.13	0.12	0.0
MST	0.47	0.43	0.08	0.01	0.01
NFT	0.001	0.81	0.19	0.0	0.0
SWK	0.0	0.57	0.34	0.06	0.02
TAN	0.43	0.43	0.14	0.001	0.0
					0.0
UMT	0.0	0.96	0.04	0.0	0.0
WEN	0.73	0.22	0.04	0.0	0.0
WFT	0.0	0.47	0.43	0.09	0.0
			Main stem Yakima River		
LCYN	0.0	0.73	0.22	0.04	0.0
UCYN	0.0	0.85	0.13	0.02	0.0
EBURG	0.0	0.63	0.29	0.08	0.0
THORP	0.0	0.55	0.39	0.37	0.02
CELUM	0.0	0.72	0.19	0.09	0.0

The population abundance of *O. mykiss* is highly variable from year to year in Yakima River tributary streams (Figure 6). However, we still detected significant trends in the population abundance through time. The slope of the best fit trend lines were used to determine if the *O. mykiss* population in each stream is increasing, decreasing, or remaining stable. All 5 of the core long term monitoring tributary streams have abundance trajectories with positive slopes, three of which are significant, and one that is nearly so (Swauk Creek, P = 0.0001; Middle Fork Teanaway River P = 0.01; West Fork Teanaway River P = 0.0005; and North Fork Teanaway River P = 0.06). The Taneum Creek *O. mykiss* population abundance is also highly variable, yet the trend remains fairly consistent across years. The migrant production in 2014 did not appear dependent with the overall O. mykiss abundance in each stream in the same year.

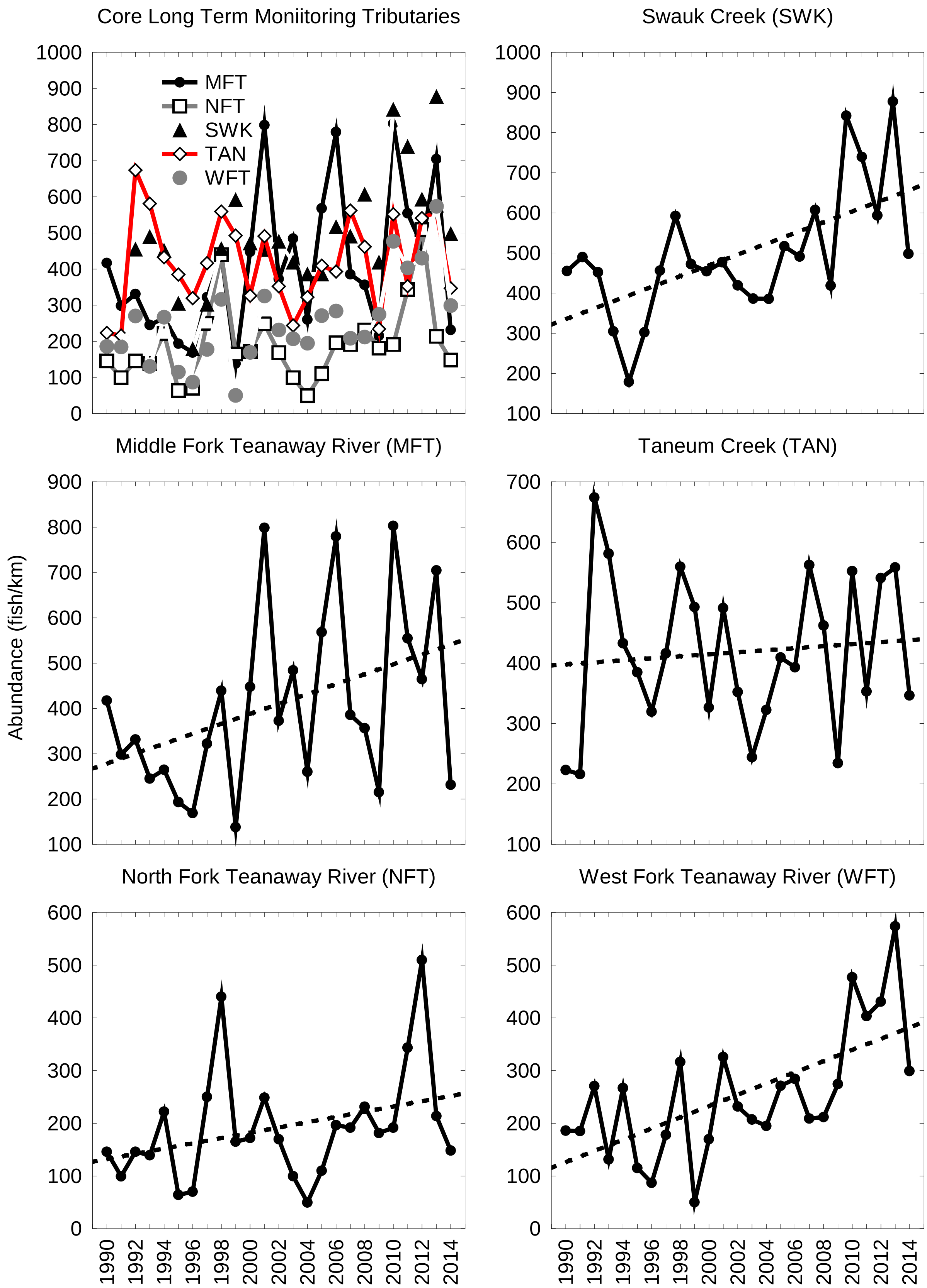


Figure 6. Annual population abundance of *O. mykiss* in core upper Yakima tributary streams. The dashed lines in the individual stream panels represent the best fit trend line.

F&W Program Strategy: Assess the status and trend of spatial distribution of fish populations.

F&W Program Management Question: What are the status and trend of spatial distribution of fish populations?

Status and Trend Monitoring- Spatial Distribution

The spatial distribution of *O. mykiss* in the upper Yakima basin are reported under routine monitoring under the Yakima/Klickitat Fisheries Project (YKFP; 199506325). Utilization (spatial distribution) in tributary streams is monitored via long term 200m long index monitoring sites following electrofishing protocols (Temple and Pearsons 2007). Under the monitoring prescriptions for *O. mykiss* established under the YKFP, tributaries are considered utilized when a minimum of 2 or more individuals occupy the site. When these minimum utilization criteria are met, the spatial distribution is extrapolated to the stream scale based upon the area the site represents. We began baseline data collection activities in 1990 and have a robust dataset for monitoring trends in spatial distribution. Our monitoring to date suggests *O. mykiss* spatial distribution remains stable in the Upper Yakima and substantial change in utilization trends has not been detected.

Spatial distribution in terms of NOAA's recommendations (e.g., spawner distribution; Crawford and Rumsey 2009) is not calculated for the Upper Yakima because we do not collect spawning information for the large resident population or for steelhead adults. This is due to low adult counts and the large geographical area encompassing potential spawning locations (i.e., needle in haystack). The steelhead spawning distribution for the upper Yakima population will be inferred from PIT tag interrogations from our detection arrays at the mouth of each tributary, and in the main stem Yakima River by subtraction.

F&W Program Strategy: Assess the status and trend of diversity of natural and hatchery origin fish populations.

F&W Program Management Question: What are the status and trend of diversity of natural and hatchery origin fish populations?

Status and Trend Monitoring- Diversity

We report only the status and trend in diversity metrics for naturally produced *O. mykiss* because as previously noted, the upper Yakima is composed predominantly of wild fish, and straying of hatchery origin fish into the Upper Yakima is generally very low. Because of the enormous variability of *O. mykiss* diversity metrics, observed change within these variables may reflect natural variation, rather than change in the diversity metrics. For instance, recent work suggests that *O. mykiss* can spawn during any month of the year in different locals, and that appears to be driven in large part by environmental factors (Bill McMillan, Personal

Communication). Thus substantial change in spawn timing may actually reflect the species true plasticity and natural variation for this diversity metric. Detecting small significant changes to highly variable metrics is a difficult task, and generally result in statistical tests with low power (Ham and Pearsons 2000). Other diversity metrics currently monitored include adult spawn timing and distribution of anadromous fish that are radio tagged, age structure of returning anadromous adults, age structure of tributary rearing fish, and sex ratios of adults sampled at Roza Dam (collected via ultrasound). We also address the long term diversity monitoring strategy (Crawford and Rumsey 2009) by collecting genetic tissue samples on adult steelhead returning to Roza dam. In addition, genetic samples have been collected and processed intermittently (e.g., prior to this project) for *O. mykiss* in the upper Yakima Basin providing long term genotypic trend monitoring information for the rearing population (e.g., Campton and Johnston 1985).

PIT tagging a large number of juveniles in their natal streams as juveniles has many advantages. For instance, the diversity indices for several variables for the combined resident and anadromous *O. mykiss* population, as well as each independent life history can be evaluated. Several interesting and important life history characteristics arising from the juvenile tagging studies are described in this report.

b. Coordination and Data Management for RM&E

F&W Program Strategy: Work with regional federal, state and tribal agencies, and non-governmental entities to establish a coordinated, standardized, web-based distributed information network and a regional information management strategy for water, fish, and habitat data. Establish necessary administrative agreements to collaboratively implement and maintain the network and strategy.

F&W Program Management Question:

How has your work supported exchange and dissemination of fish and wildlife data or the development of a database to manage data that may shared regionally, relative to the RM&E data management strategies roadmap?

1. Identification of Management Questions and Strategies
    a. This work is currently being used to inform the Washington Department of Fish and Wildlife draft steelhead at risk report. The information generated under this contract was used to support selection of the Upper Yakima as one of the focal populations for the steelhead at risk report. One of the goals of the report is to identify key threats to the population and key near and long term actions to remedy them. The data has also been made available to NOAA Fisheries in preparation for the 5 year status assessment for the Mid-Columbia Steelhead ESU.
2. Documentation of Protocols
    a. The methods and protocols used in data collection activities have been previously published in the AFS Salmonid Field Protocols Handbook (2007) and also uploaded as “published” methods in MonotoringMethods.org.

3. Data Collection and Generation
    a. Executing the field sampling activities during this contract period has generated a significant amount of data, both in the raw form, as well as digital data (e.g., PIT tag detections of adult and juvenile migrants).
4. Data Entry
    a. Field data collected in the field in raw or hardcopy format has been entered and stored in digital format during this contract period.
5. Agency Data Storage
    a. The digital data saved during this contract has been appended to our databases. The databases are housed on local PC's, as well as backed up on our local server. Our local server is backed up to our secured server housed in Olympia, WA, nightly.
6. Regional Sharing
    a. Much of the data generated under this contract was routinely uploaded to regional databases (e.g. PTAGIS) where it is publicly accessible.
7. Reporting
    a. The data collected under this contract is summarized in annual reports submitted as deliverables under the annual reporting requirements of the contract. The summarized information is also presented to professional audiences at American Fisheries Society's, Chapter, Divisional, and National Levels when appropriate, and to combined professional and non-technical audiences at the Yakima Basin Science and Management Conference held annually (generally at Central Washington University), or at other events as requested.

Location details: For each F&W Program Strategy above, insert maps, aerial photos, or pictures of where your work was conducted. Below are links to existing project or contract map options created in cbfish.org or insert your own.

Project Map:

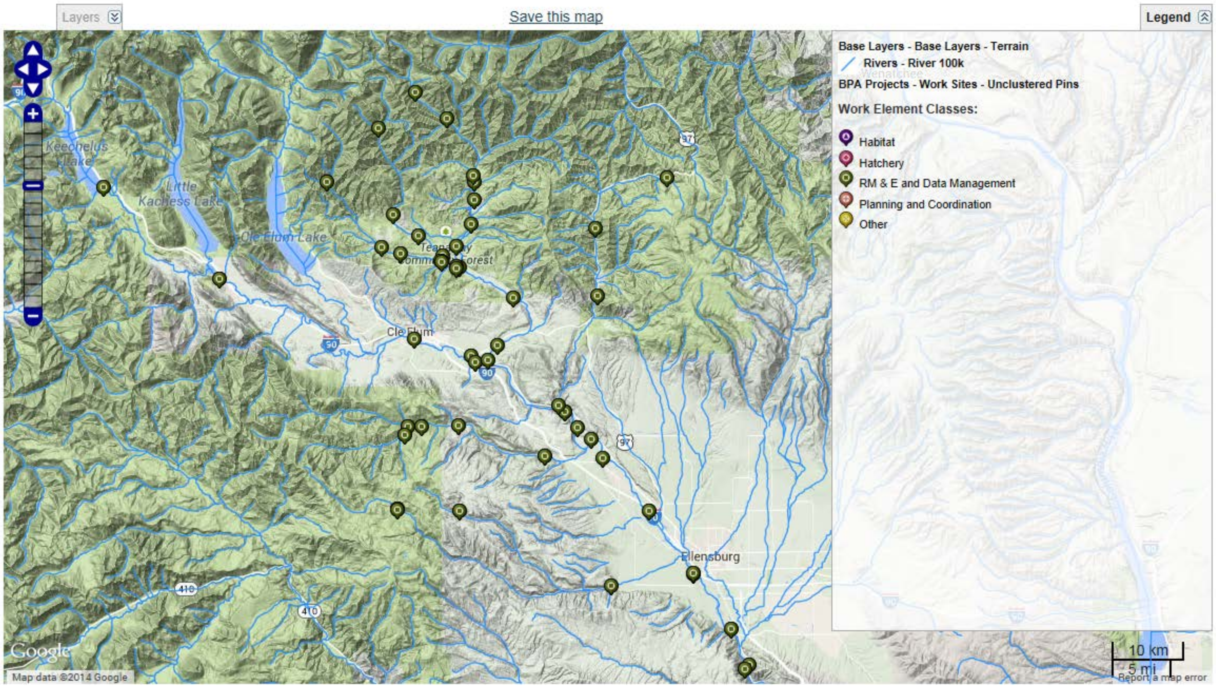
http://www.cbfish.org/Project.mvc/Map/2010-030-00

Contract Map(s):

http://www.cbfish.org/Contract.mvc/Map/64137

Contract Map

Explore the many features (map layers and work site information) of this map.



3. Methods: Protocols, Study Designs, and Study Area

Protocol Title: Resident/Anadromous (2010-030-00) v1.0

Protocol Link: http://www.monitoringmethods.org/Protocol/Details/94

Annual abundance estimates of *O. mykiss* (combined life histories) are generated in tributary streams using mark-recapture methods following Temple and Pearsons (2007; http://www.monitoringmethods.org/Method/Details/118 and http://www.monitoringmethods.org/Method/Details/119). In larger stream reaches, a drift boat mounted electrofisher is used to conduct mark-recapture sampling (http://www.monitoringmethods.org/Method/Details/120 and http://www.monitoringmethods.org/Method/Details/121). The abundance estimates are partitioned into anadromous and resident components by determining the proportion of the population that is detected at downstream locations subsequent to the sampling. Downstream detections of juvenile migrants are obtained from regional PIT tag databases (e.g., Ptagis). Finally, we assign juveniles to their cohort based upon age assignments from reading scales (http://monitoringmethods.org/Method/Details/1120). The cohort tracking will allow us to determine anadromous production from various geographic areas in the upper Yakima after accounting for anadromous spawner input into those areas.

4. Results

a. Fish Population RM&E

F&W Program Strategy: Assess the status and trend of adult natural and hatchery origin abundance of fish populations for various life stages.

F&W Program Management Question: What are the status and trend of adult abundance of natural and hatchery origin fish populations?

A more thorough evaluation and reporting of adult status and trend monitoring and population level tracking of the MPG is presented in Yakama Nation annual technical reports (i.e. Frederiksen et al. 2014). Anadromous wild steelhead adult counts for the upper Yakima population are collected at the Roza adult monitoring facility (Figure 1) and can be viewed via our project website at www.YKFP.org.

Monitoring the adult spawning component of the sympatric resident *O. mykiss* population is much more problematic. We do not have an effective way to distinguish and enumerate resident trout spawners. The Yakima Species Interactions Studies (YSIS) conducted several exploratory spawning surveys for rainbow trout in the early 1990's. A summary of their findings can be found in early YSIS reports (e.g., McMichael et al. 1992; Pearsons et al. 1993; Pearsons et al. 1994). Some general patterns observed include: upper Yakima trout spawn timing in tributary streams appear positively correlated with elevation: there is large spatial and temporal overlap between resident and anadromous spawning: spawning generally occurs February through June: the majority of tributary rainbow trout spawners were age 1+ and 2+ whereas mainstem Yakima River spawners were age 2+ and 3+: rainbow trout often spawn near or in side channel habitat: rainbow trout redds were often associated with organic debris such as instream woody debris.

F&W Program Strategy: Assess the status and trend of juvenile abundance and productivity of natural origin fish populations.

F&W Program Management Question: What are the status and trend of juvenile abundance and productivity of fish populations?

The target number of tags were successfully deployed during this contract period (10,000 in the upper Yakima, 4000 in the Naches sub-basin). Some of the tags allocated to the main stem Yakima River upstream from Easton Dam were re-allocated to other areas due to the low abundance of *O. mykiss* observed in this area (Figure 7).

Scales and length frequency distributions were used to assign the upper Yakima smolts that were detected in 2014 to their respective brood year (Figure 8). The majority of the migrant detections in 2014 were 2 and 3 year olds with a small number age 1 migrants. The 2014 migrants (recruits) were assigned to the appropriate adult spawners (spawners) using the age determinations. We used the average smolt age distribution from 2014 and assigned the annual number of smolts to brood year for the period 2007-2013. Upper Yakima steelhead spawner abundance was positively correlated ($P = 0.005$) with the number of PIT tagged smolt detections in subsequent years (Figure 9).

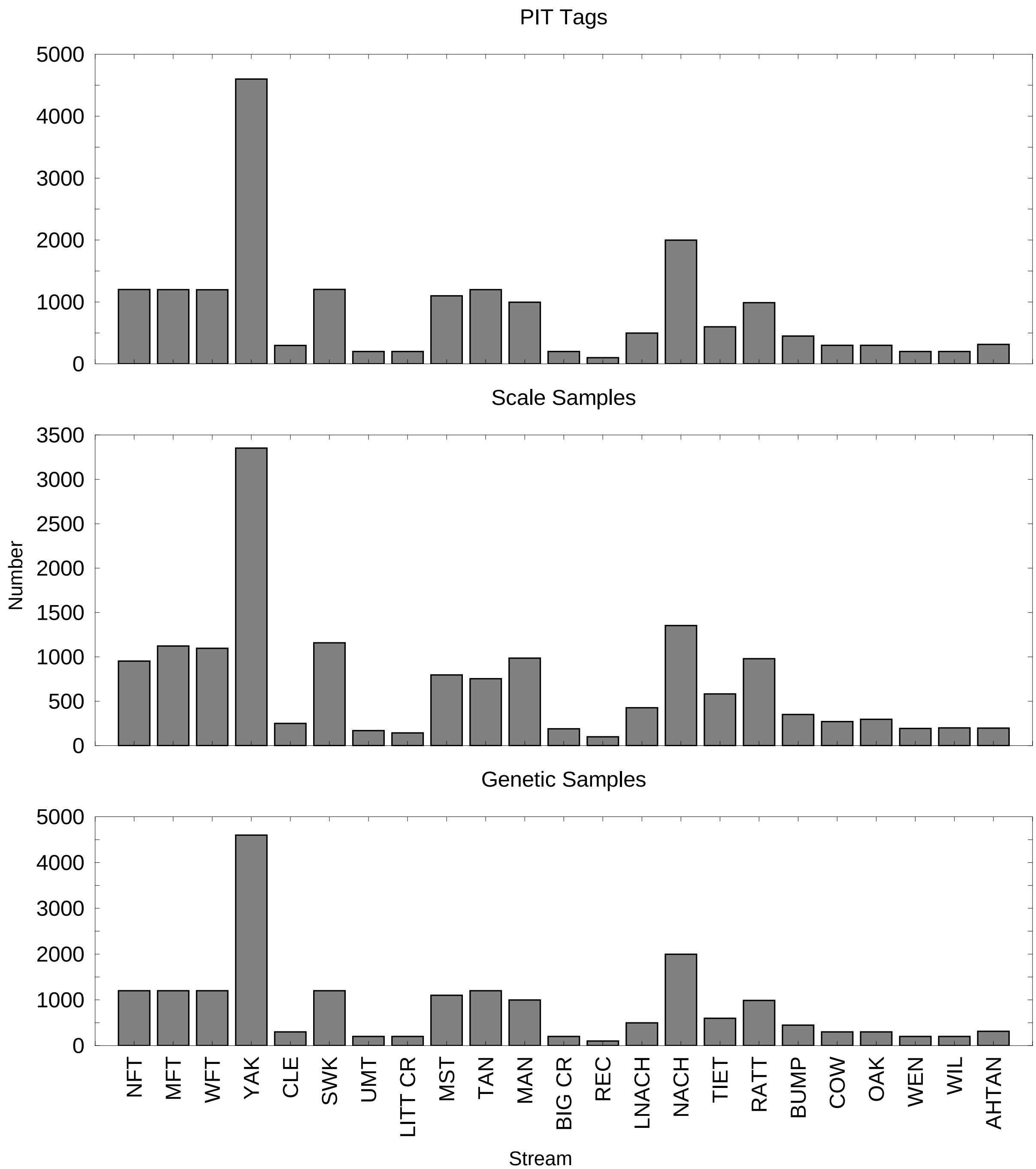


Figure 7. Number of *O. mykiss* PIT tagged, scale sampled, and genetically sampled during this contract period. Stream abbreviations include the North Fork Teanaway River (NFT), Middle Fork Teanaway River (MFT), West Fork Teanaway River (WFT), Yakima River (YAK), Cle Elum River (CLE), Swauk Creek (SWK), Umtanum Creek (UMT), Little Creek (LITT CR), Main stem Teanaway River (MST), Taneum Creek (TAN), Manastash Creek (MAN), Big Creek (BIG CR), Reecer Creek (REC), Little Naches River (LNACH), Naches River (NACH), Tieton River (TIET), Rattlesnake Creek (RATT), Bumping River (BUMP), Cowichee Creek (COW), Oak Creek (OAK), Wenas Creek (WEN), Wilson Creek (WIL), and Ahtanum Creek (AHTAN).

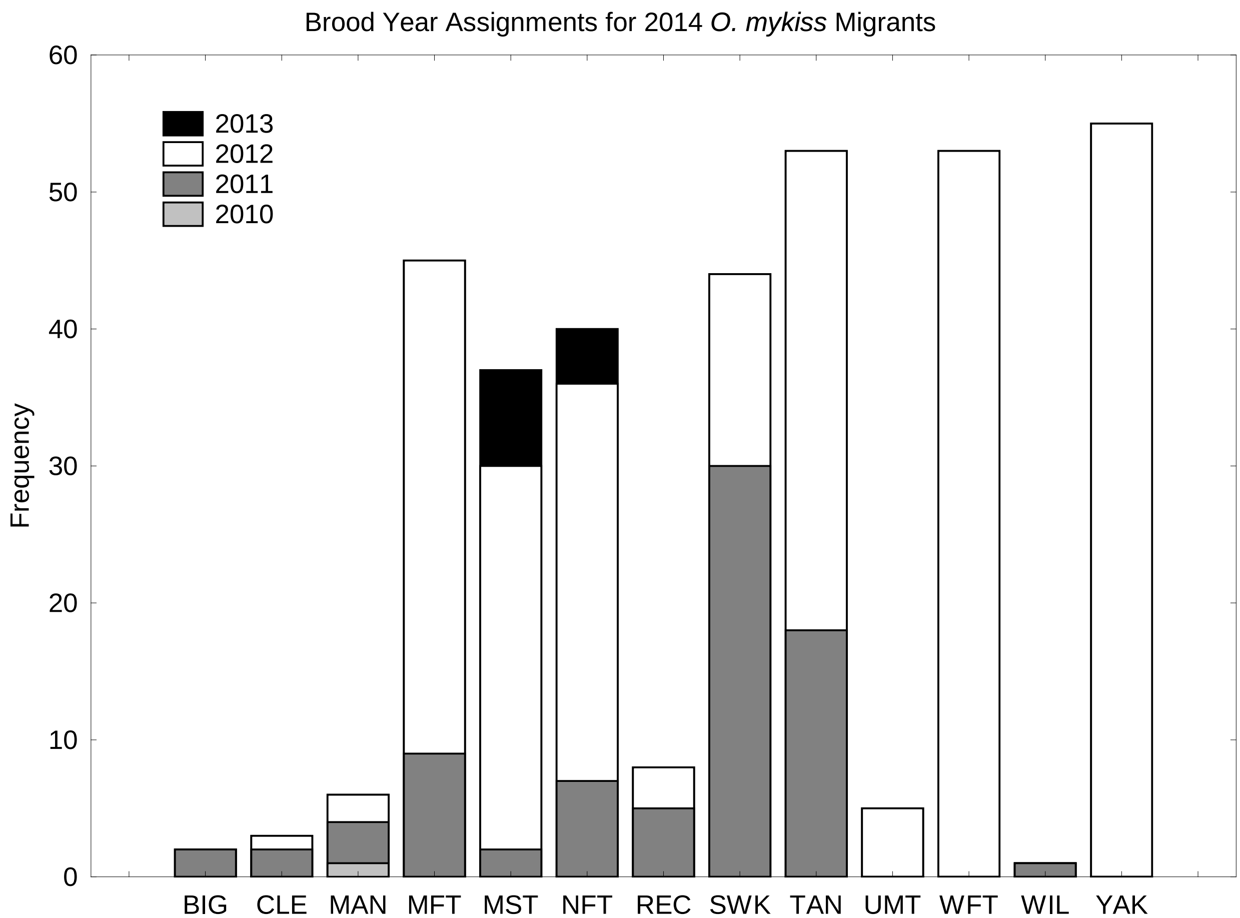


Figure 8. Brood year assignments for upper Yakima steelhead smolts originating from Big Creek (BIG), the Cle Elum River (CLE), Manastash Creek (MAN), the Middle Fork, Main stem, and North Fork Teanaway Rivers (MFT, MST, and NFT respectively), Swauk Creek (SWK), Taneum Creek (TAN), Umtanum Creek (UMT), the West Fork Teanaway River (WFT), Wilson Creek (WIL), and the Yakima River upstream from Roza Dam (YAK) that were detected in 2014.

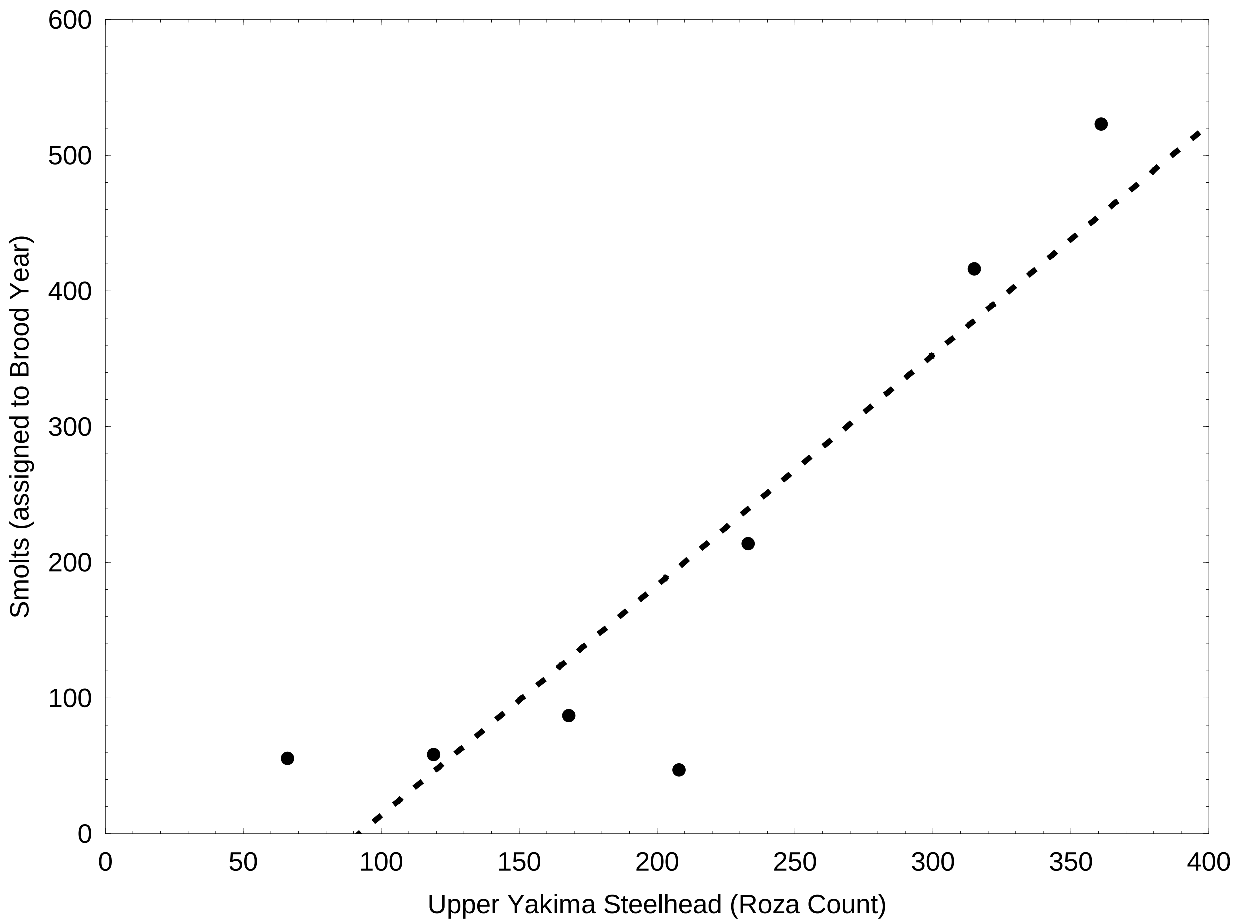


Figure 9. Upper Yakima steelhead spawners (2005-2013) versus smolt migrants detected in subsequent years.

Estimates of rearing abundance of *O. mykiss* (combined resident and anadromous life histories) were generated in tributaries to the upper Yakima as well as in the larger main-stem Yakima. Abundance estimates were generated under a separate project (199506325) and were lagged 1 year. Abundance was expressed as fish/km (Figure 10) and was partitioned into life history components using the proportion of the migrants detected during the spring smolt migration period (e.g., during this contract cycle). Each group of *O. mykiss* tagged in each calendar year that were subsequently detected during the smolt outmigration period 1, 2, and 3 years following the 2012 tagging event are presented in Figure 11. The 2011 tag group was the first group that we can account for the majority of all the potential migrants (migrants in 2011, 2012 and 2013), and we continue this evaluation with the 2012 tag group in this report (Figure 11).

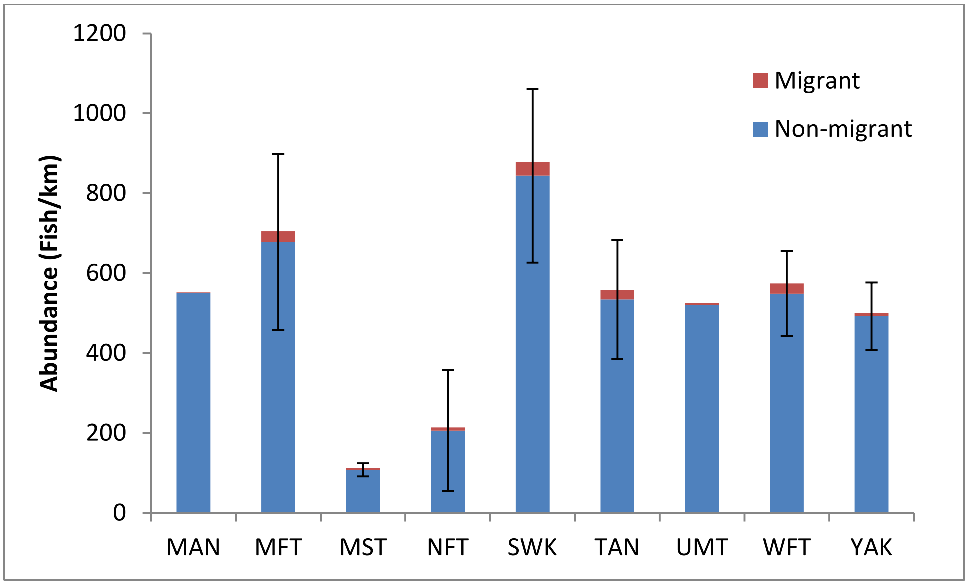


Figure 10. *O. mykiss* abundance estimates for the Yakima river main stem and tributaries generated in 2013partitioned into migrant and non-migrant components using detections in 2014. Error bars represent 1 standard error (SE) of the estimate.

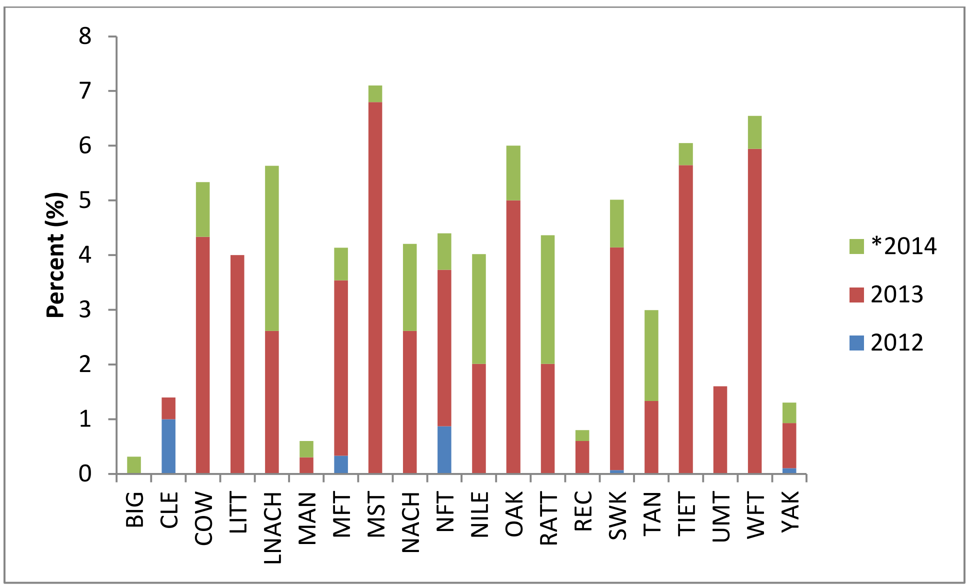


Figure 11. Proportion of the *O. mykiss* tagged in each tributary in 2012 that migrated in 2012, 2013, and 2014. The asterisk indicates incomplete data (predation data from main stem Columbia River bird colonies were not available at the time of this report submission).

F&W Program Strategy: Assess the status and trend of spatial distribution of fish populations.

F&W Program Management Question: What are the status and trend of spatial distribution of fish populations?

In 2014, we standardized our description of steelhead rearing distribution by stratifying each tributary into 200m sampling sections throughout its entire length (Figure 12). The tagging location of each fish tagged is known to the nearest 200m in tributaries, and 300 or 500 in mainstem river sections. We constructed simple frequency plots of steelhead smolt rearing origin from each tributary by river kilometer (Figure 13; Figure 14; Figure 15). In addition, we overlayed the rearing distribution of known resident trout on these frequency plots to see if there were any differences in the stream sections occupied by resident trout and anadromous pre-smolts (Figure 16; Figure 17). It appears that there is a high degree of overlap in the rearing distribution of anadromous and resident *O. mykiss* during the rearing period.

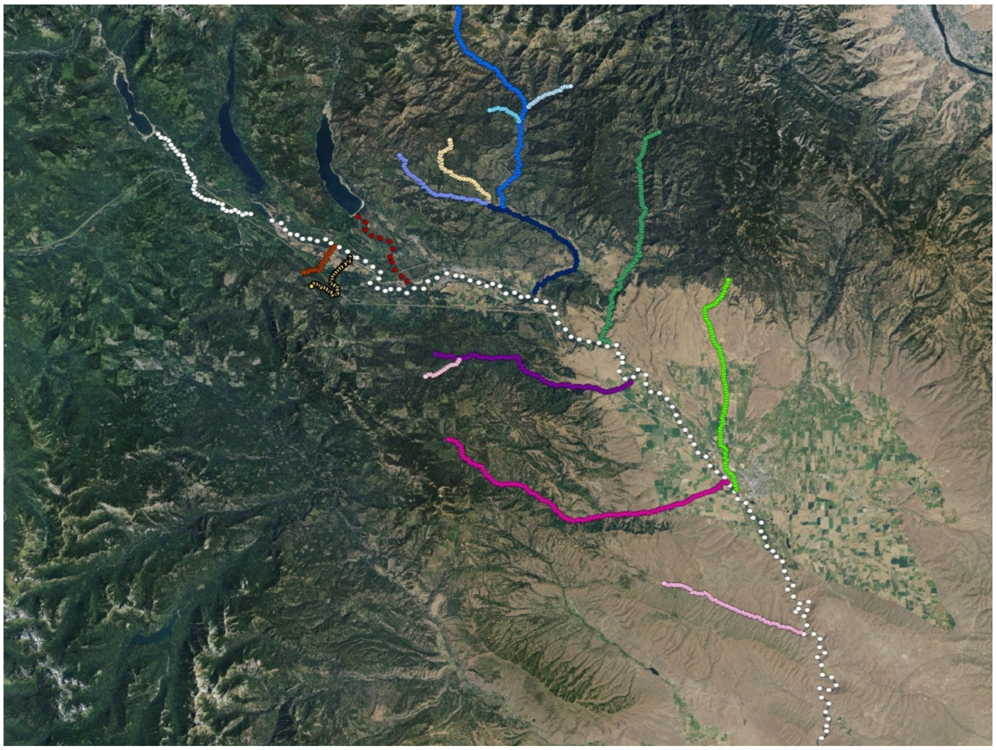


Figure 12. PIT tag collection sites in each tributary stream of the upper Yakima Basin. Collection site names are labeled sequentially moving up the stream channel. Each dot represents 200 m in tributary streams, and 300 m or 500 m in main stem stream sections.

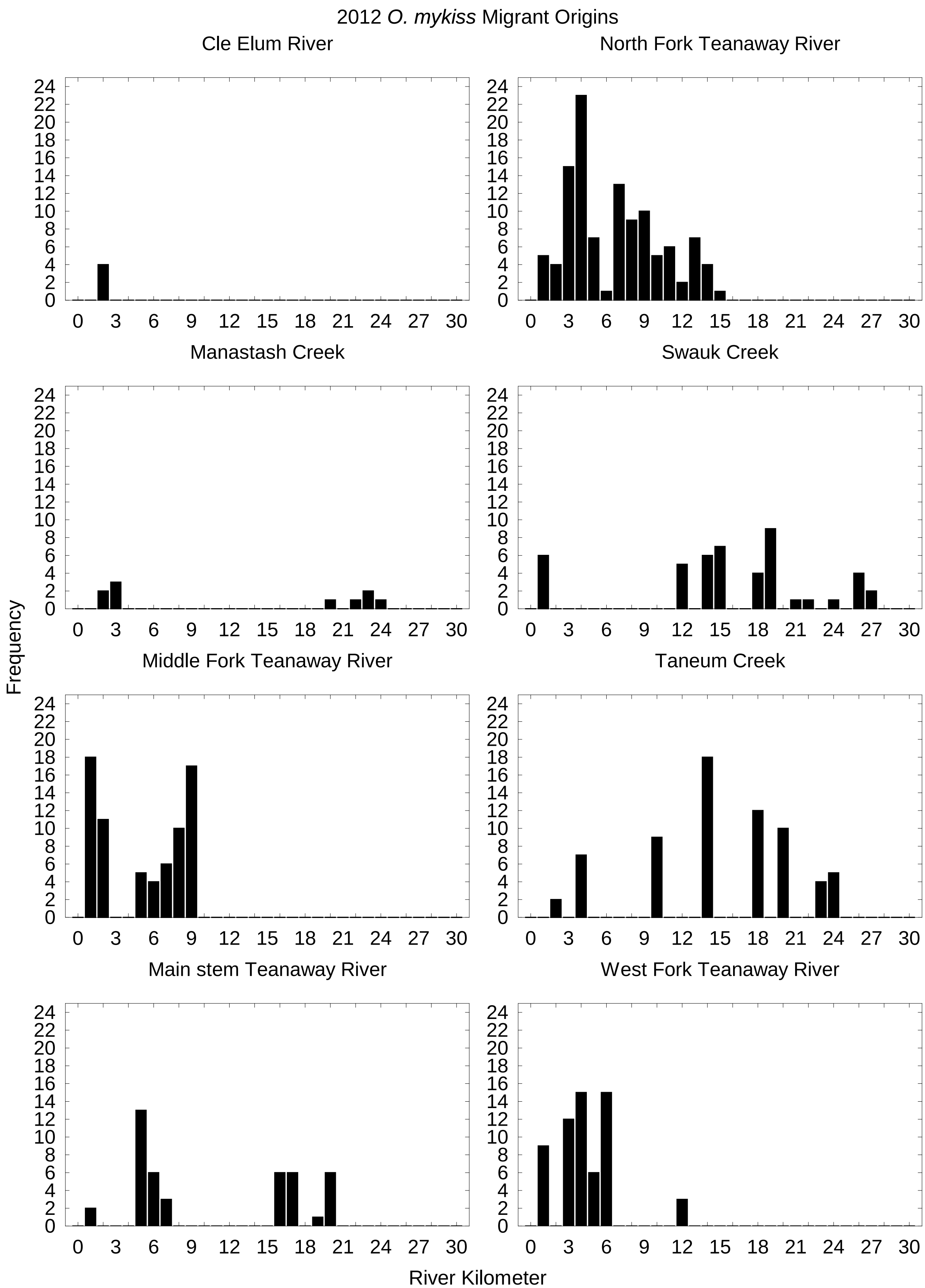


Figure 13. The origin of PIT tagged migrants in 2012.

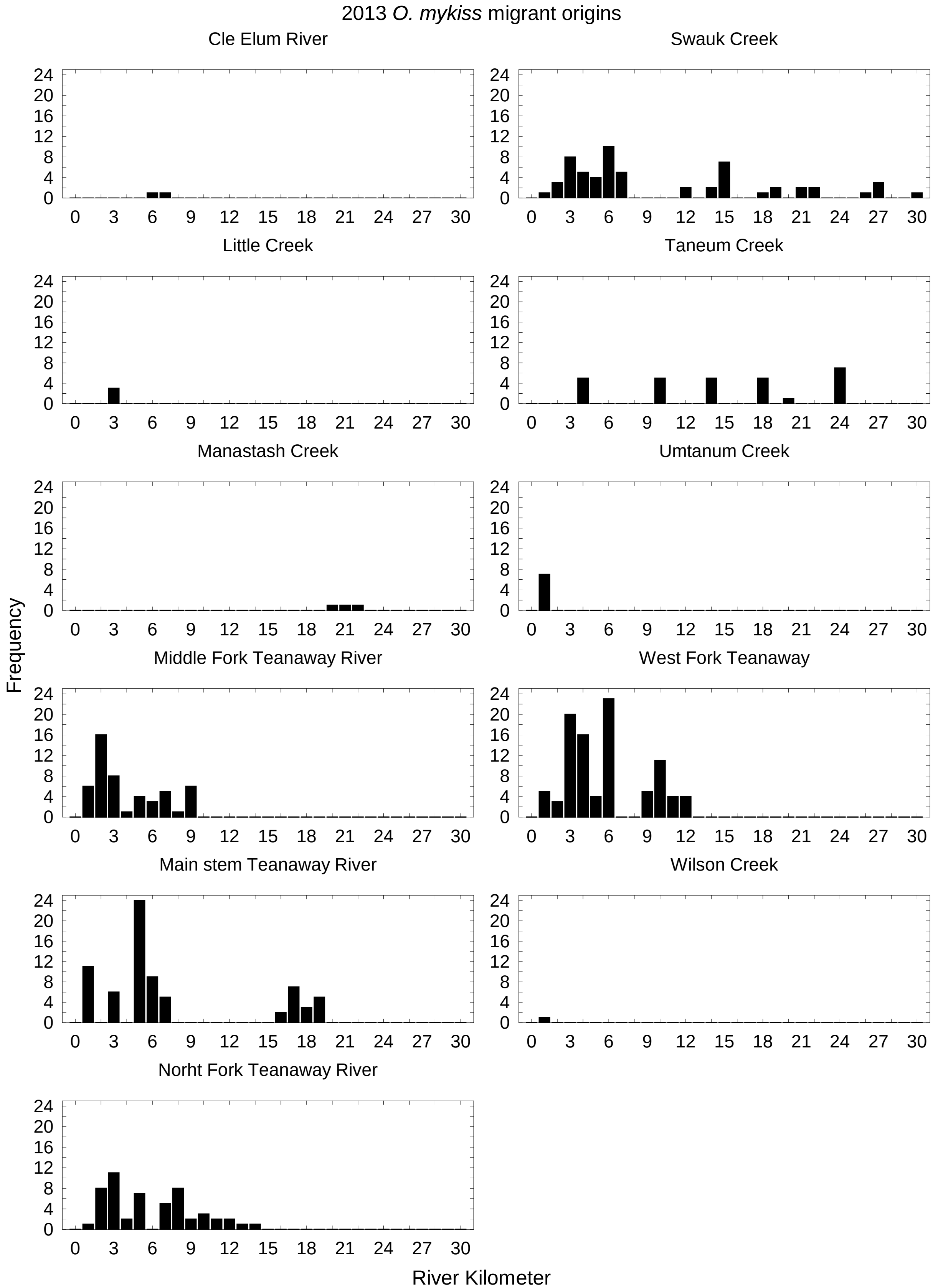


Figure 14. The origin of PIT tagged migrants in 2013.

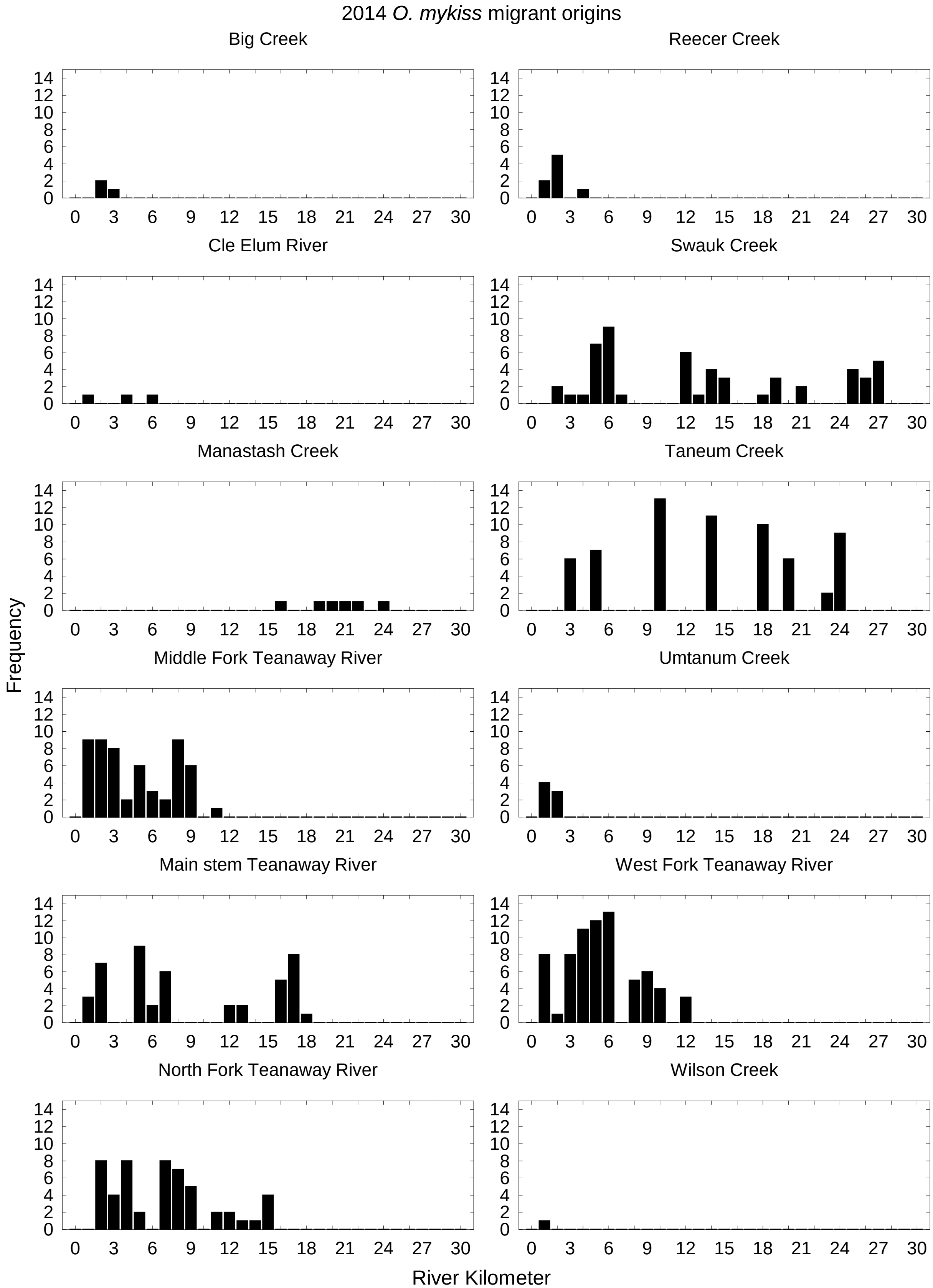


Figure 15. The origin of PIT tagged migrants in 2014.

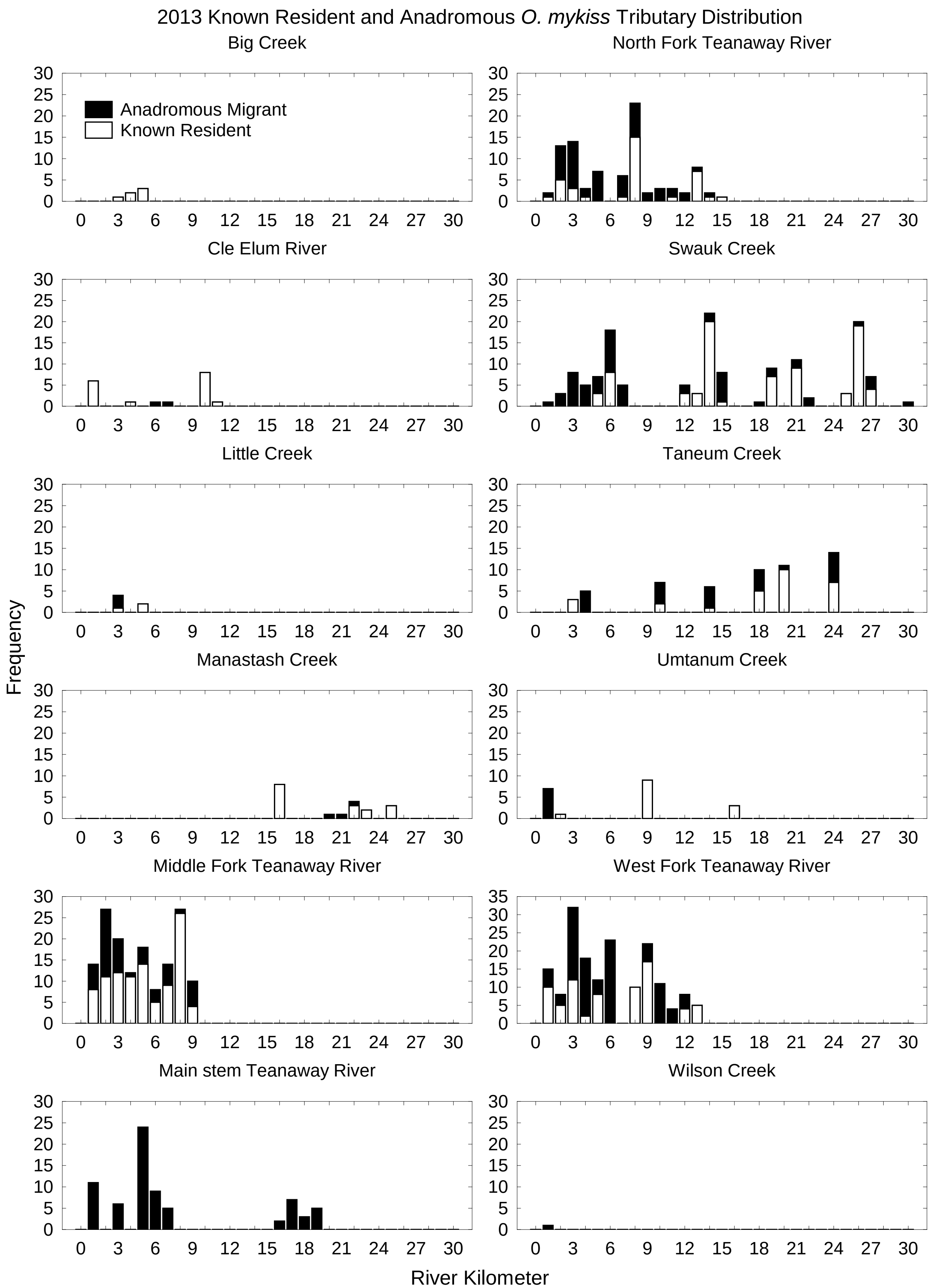


Figure 16. The origin of PIT tagged migrants and known resident rainbow trout in 2013.

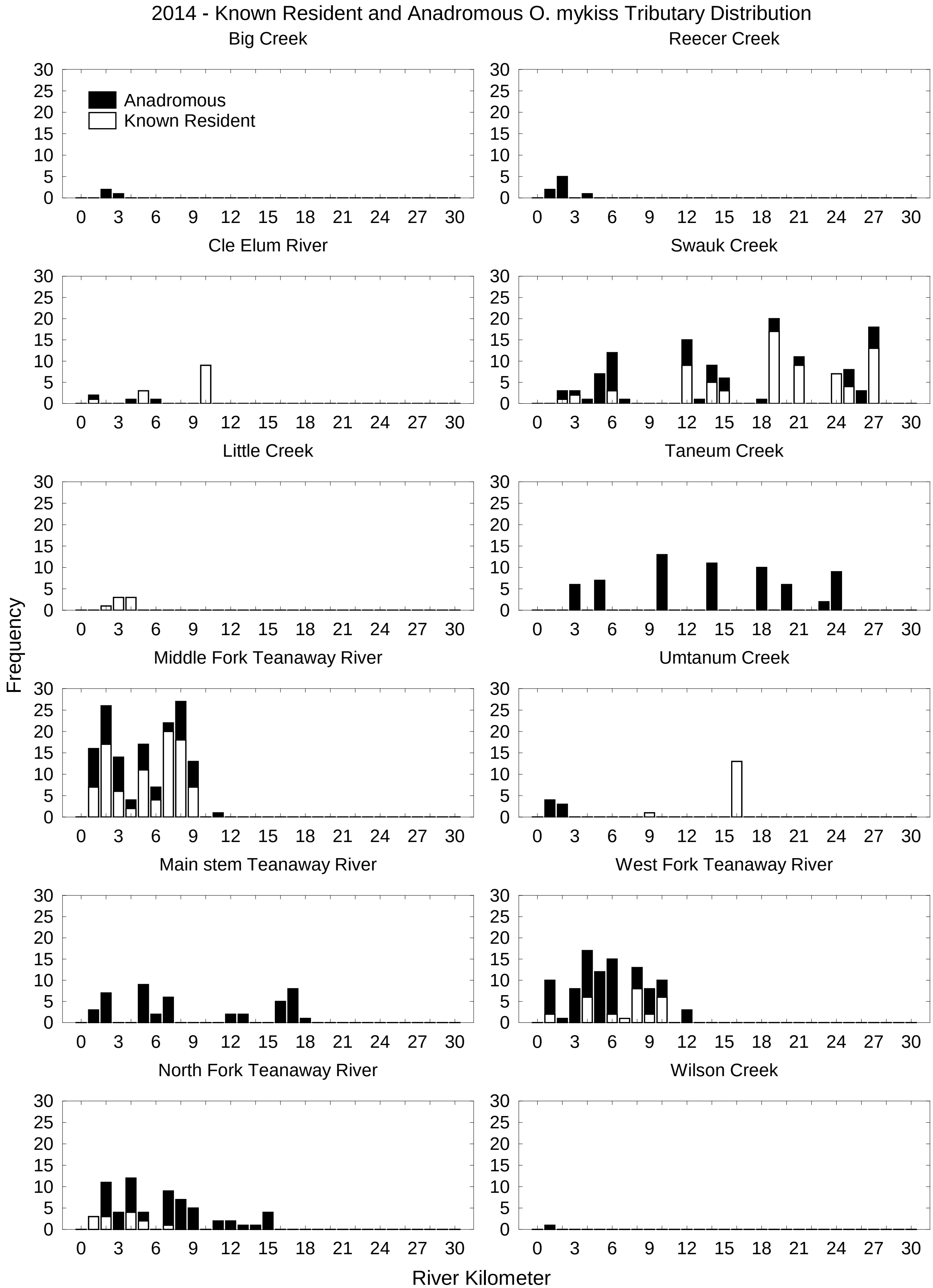


Figure 17. The origin of PIT tagged migrants and known resident rainbow trout in 2014.

F&W Program Strategy: Assess the status and trend of diversity of natural and hatchery origin fish populations.

F&W Program Management Question: What are the status and trend of diversity of natural and hatchery origin fish populations?

Juveniles

Pit tagging a large number of juvenile *O. mykiss* in their natal streams provide several interesting and important results related to life history diversity. First, it appears the bulk of the migration for juvenile steelhead smolts, and perhaps pre-smolts, emigrate from their natal streams during the spring (Figure 18). We also observed a large fall migration of tagged juvenile *O. mykiss* out of the upper Yakima tributary streams (Figure 18). We speculated that the fall migration may be driven by dropping stream temperatures and increased fall discharge. While there was no clear relationship between these variables, there may be an inverse relationship between average monthly stream temperature and monthly emigration from the Teanaway basin (Figure 19). While the juvenile emigration from the tributary streams did occur primarily in the spring and fall period, fish did move past our interrogation site during all months of the calendar year.

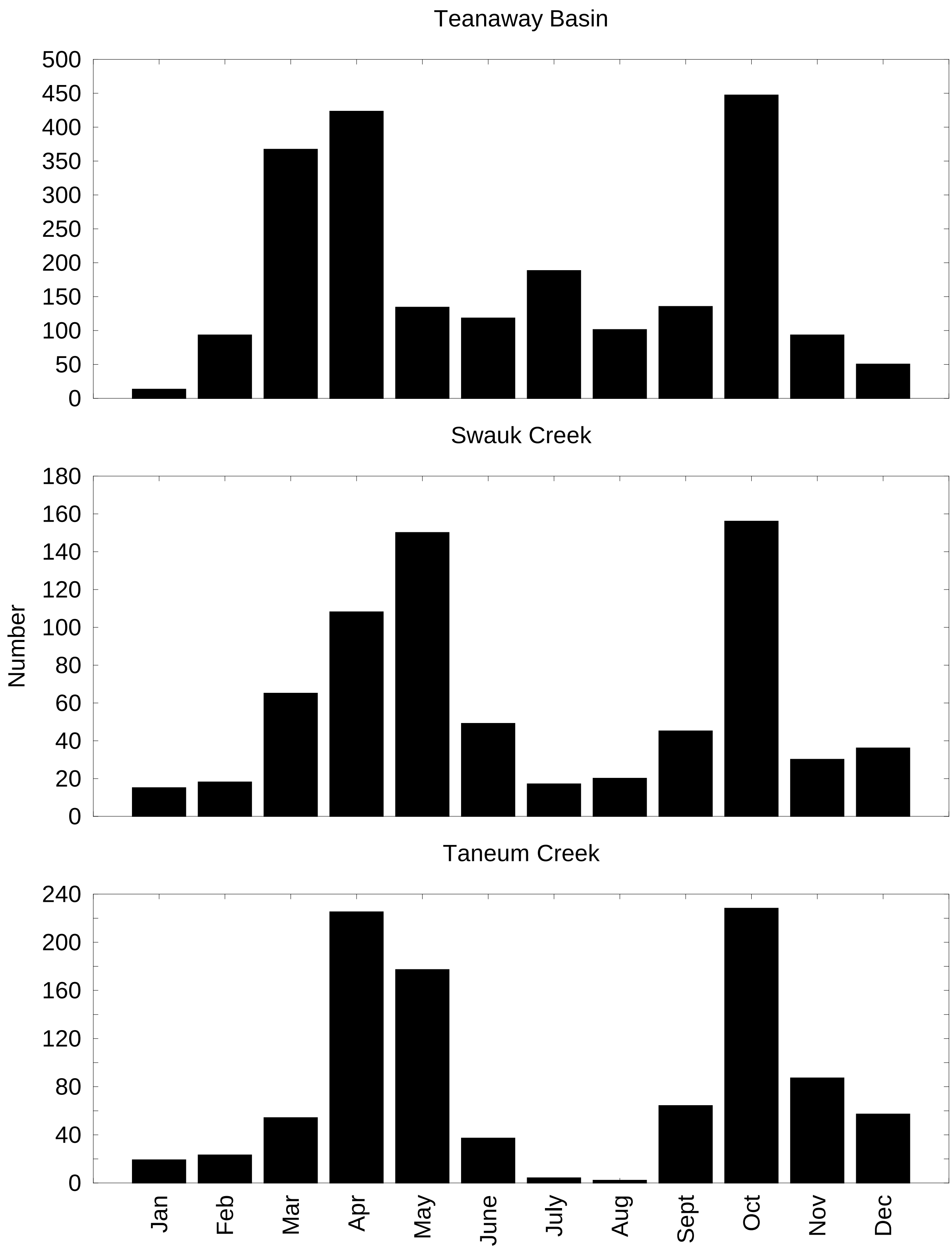


Figure 18. Number of fish migrating from select upper Yakima tributaries by month for the years 2009-2104 combined.

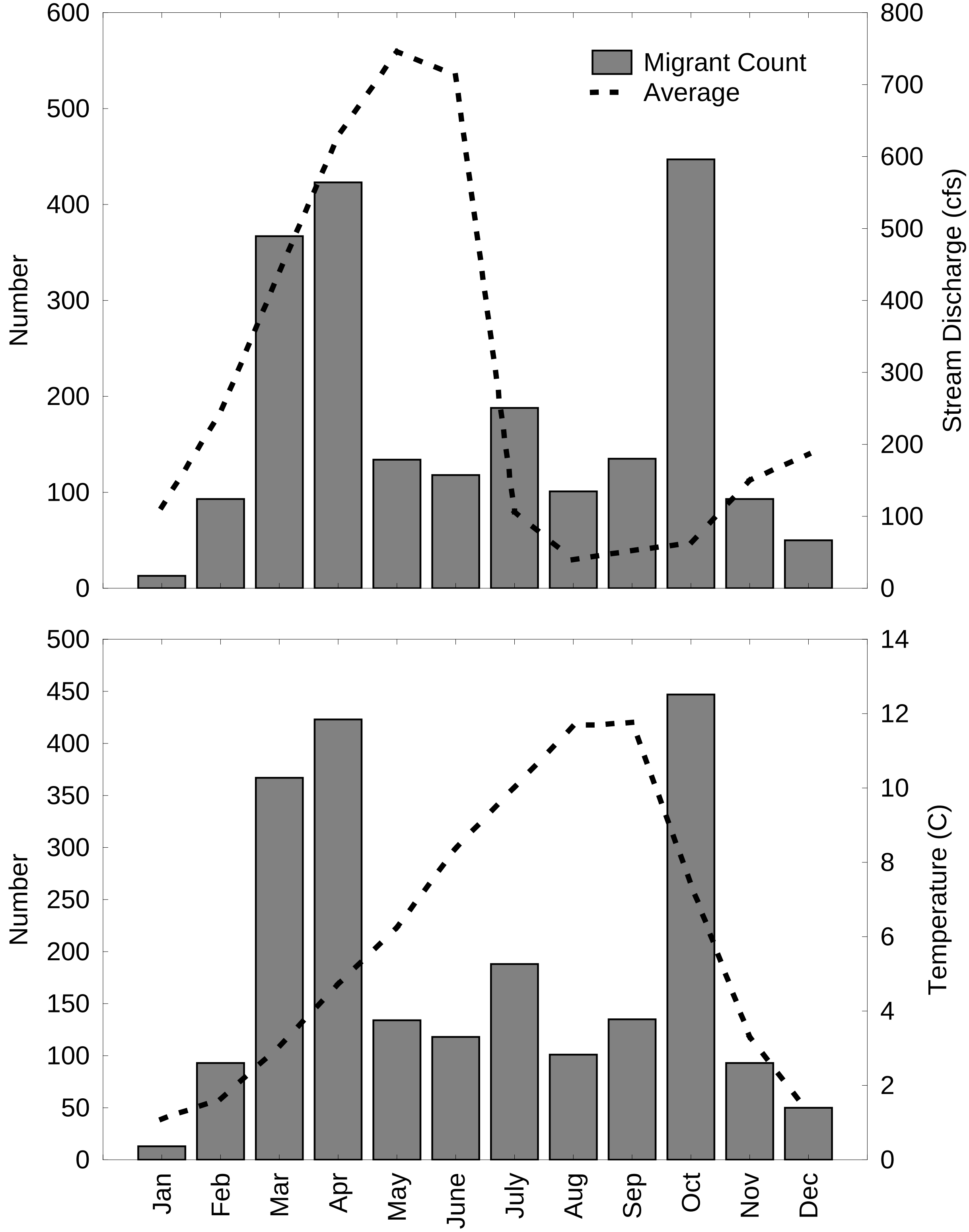


Figure 19. Number of juvenile emigrants detected each month at the mouth of the Teanaway River relative to average monthly stream discharge (cfs) and stream temperature (C).

We were interested to know if the length vs. weight relationship of anadromous juveniles at the time of tagging were any different than that of the resident or rearing *O. mykiss* population.

An analysis of co-variance (ANCOVA) of the $\log_{10}$ transformed length vs. weight relationship indicates that there is a slight, but significant, difference in the length/weight relationship between life history forms ($P < 0.001$). Anadromous juveniles generally weigh less at a given length than their resident counterparts (Figure 20) although the variation around these average relationships would make it difficult to distinguish between life histories for individual fish.

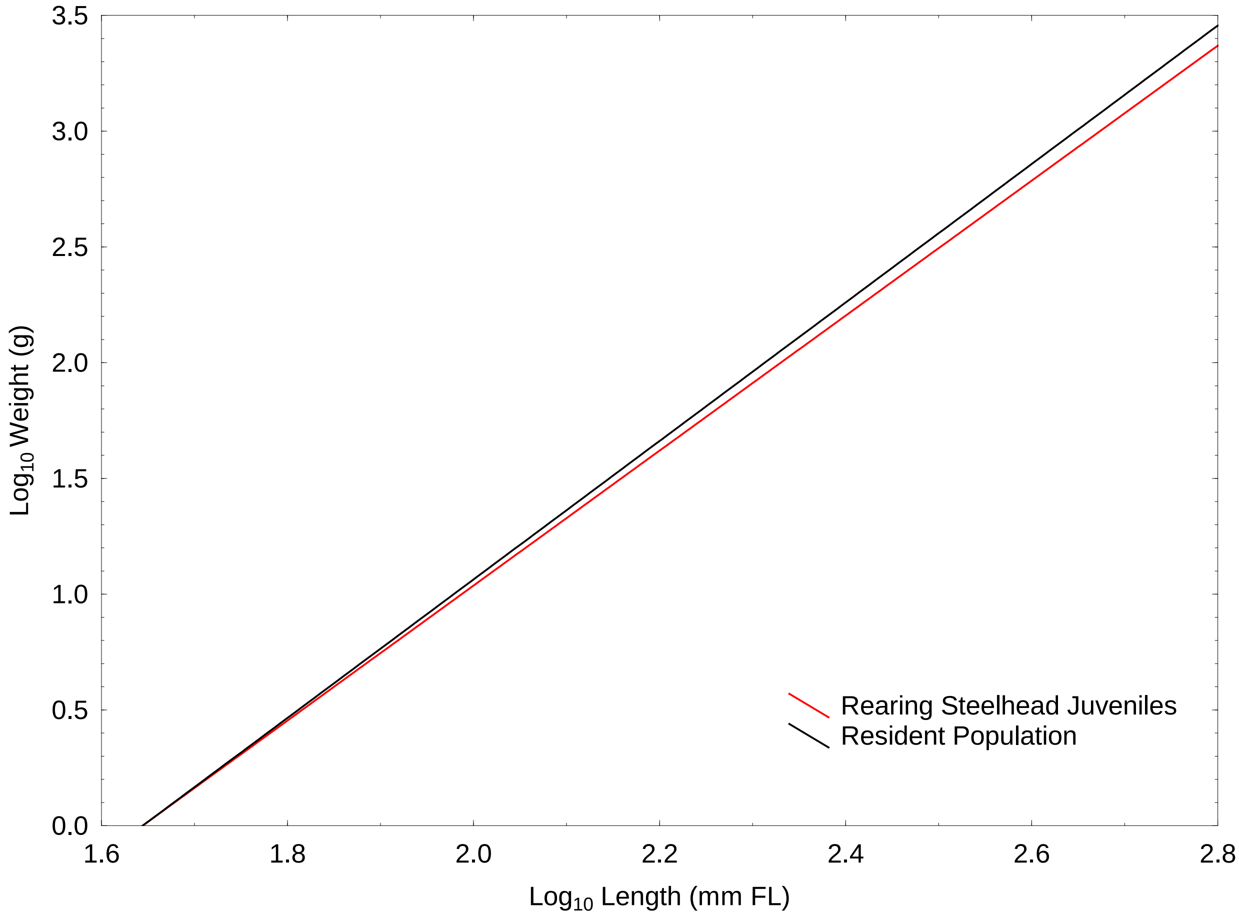


Figure 20. Log_{10} transformed length weight relationship for resident *O. mykiss* and rearing steelhead juveniles. The steelhead were tagged as juveniles and detected as returning adults in subsequent years. The resident population was defined as tagged individuals that were not detected as migrants in subsequent years.

Adults

As our project progresses, we are beginning to observe increased number of steelhead adults returning to the Yakima Basin that were tagged as juveniles in their natal streams several years prior. This information provides an opportunity to describe diversity metrics from the population perspective comparing the Naches population to the Upper Yakima population, as well as resident and anadromous life histories. The information for the Naches is somewhat limited given that we initiated our juvenile tagging studies last year. However, we expect that we will see increased information in the coming years as additional adult fish from the Naches population begin returning. Until that time, the comparisons of adult diversity metrics of fish tagged as juveniles are based upon small numbers of fish.

It has been thought that the Upper Yakima Steelhead population returns slightly earlier than the Naches population. The evidence suggests this is the case, although the average day (Julian Date) that PIT tagged adults are detected at Bonneville Dam (average for return year 2008-present; years were combined due to lack of year effect between 2008 and present) was not significantly different for Naches basin tributaries, this trend is still apparent (Figure 21). However, the small number of returning Naches Fish contributed to large variance which likely obscured the effect.

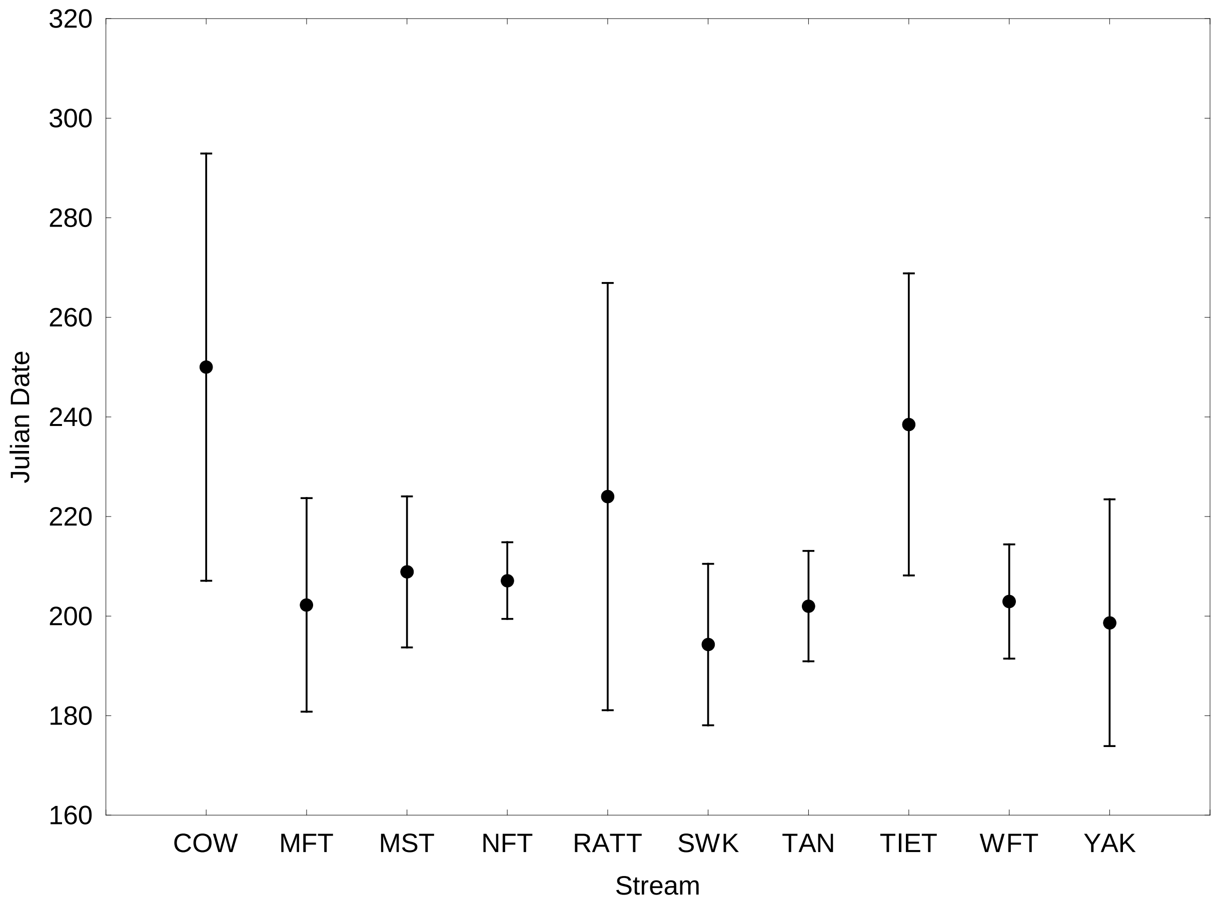


Figure 21. Julian date of the first detection of returning steelhead adults at Bonneville Dam for fish PIT tagged in their natal streams as juveniles (an ANOVA supported combining all years). Stream abbreviations include Cowiche Creek (COW), Middle Fork Teanaway River (MFT), Mainstem Teanaway River (MST), North Fork Teanaway River (NFT), Rattlesnake Creek (RATT), Swauk Creek (SWK), Taneum Creek (TAN), Tieton River (TIET), West Fork Teanaway River (WFT), and the main stem Yakima River (YAK).

The wide spread detections of PIT tagged Yakima Steelhead throughout the Columbia Basin suggests that it is not uncommon for these fish to wander during their adult migration. Several adults have been detected on the PIT tag array at the mouth of the Deschutes River in Oregon. Some have been detected in the Snake River while several have been detected at upper

Columbia River main stem dams. The tag history of one of our adult steelhead revealed that it was tagged as a juvenile in the West Fork Teanaway River in July of 2011 (124mm fork length), was detected migrating upstream in the Columbia River in July of 2013 at Bonneville, the Dalles, and McNary dams. This individual bypassed the mouth of the Yakima River, and continued upstream and was detected at every main stem Columbia River Dam, finally passing Wells Dam in September of 2013. It was then detected in the Methow River in October 2013. In March 2014 it was detected at McNary dam, then at Roza dam, and finally it was last detected on the Taneum Creek instream PIT tag array in April 2014. This fish appears to have overwintered in the upper Columbia River, upstream from Wells Dam. Of the adult returns that originated from the upper Yakima that were tagged as juveniles, few were detected returning to their natal streams (Figure 22). Lack of detections could be due to poor detection efficiency at Yakima interrogation sites, straying, or mortality prior to spawning. The pre-spawning movements and holding are interesting because these fish represent the behaviors of natural origin *O. mykiss* in the current hydrosystem.

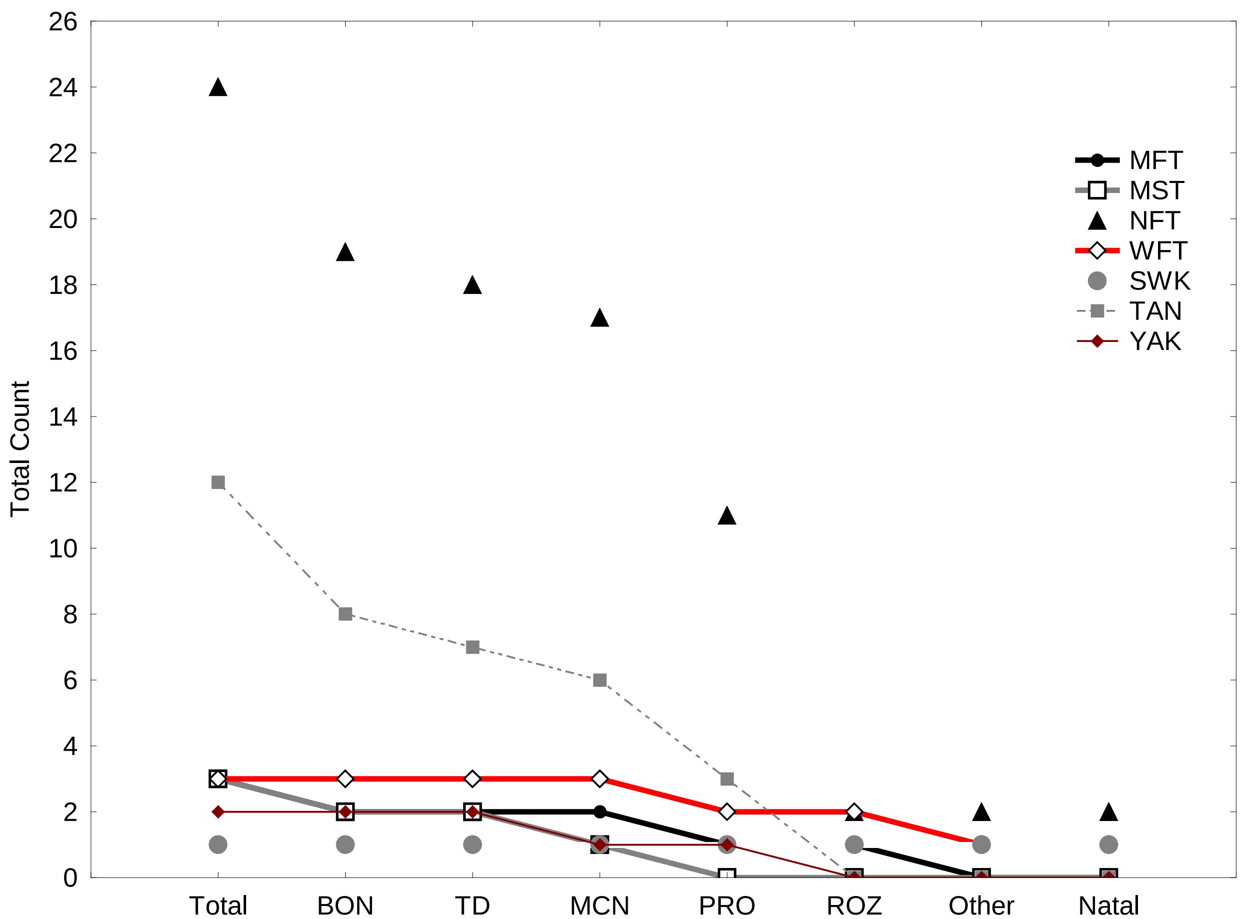


Figure 22. Total number steelhead adults that were PIT tagged as juveniles in the Middle Fork (MFT), Mainstem (MST), North Fork (NFT), and West Fork (WFT) Teanaway Rivers, Swauk Creek (SWK), Taneum Creek (TAN), and the main stem Yakima River (YAK) that migrated

upstream in the Columbia River (2008-2013). The total number of number of adults and the number moving upstream beyond Bonneville (BON), the Dalles (TD), McNary (MCN), Prosser (PRO), Roza dam (ROZ), some other upper Yakima interrogation site (Other), or their presumed natal stream are presented. Spawning migration 2014/2015 is not presented as they should be overwintering at this point in time.

Adult steelhead migrated into the Teanaway basin from mid-March through mid-May in 2014. The lower Main-stem Teanaway instream PIT tag array located near the mouth of the Teanaway River operated continuously during this period. Detections from the upstream North Fork, and upper Mainstem arrays were used to back calculate the passage timing of adults that were not detected on the lower array by using the average migration speed of fish that were detected at both an upstream and downstream interrogation site. The date that adults that were detected or estimated to have passed the Lower Teanaway array in 2014 were overlayed on a line plot of average daily discharge measured at the USBOR Teanaway Forks gauging station (Figure 23). Adults entered the Teanaway during the months of March, April, and May when they were presumed to have spawned. This evaluation indicates the importance of having upstream detections to facilitate back calculations of adult detection efficiency.

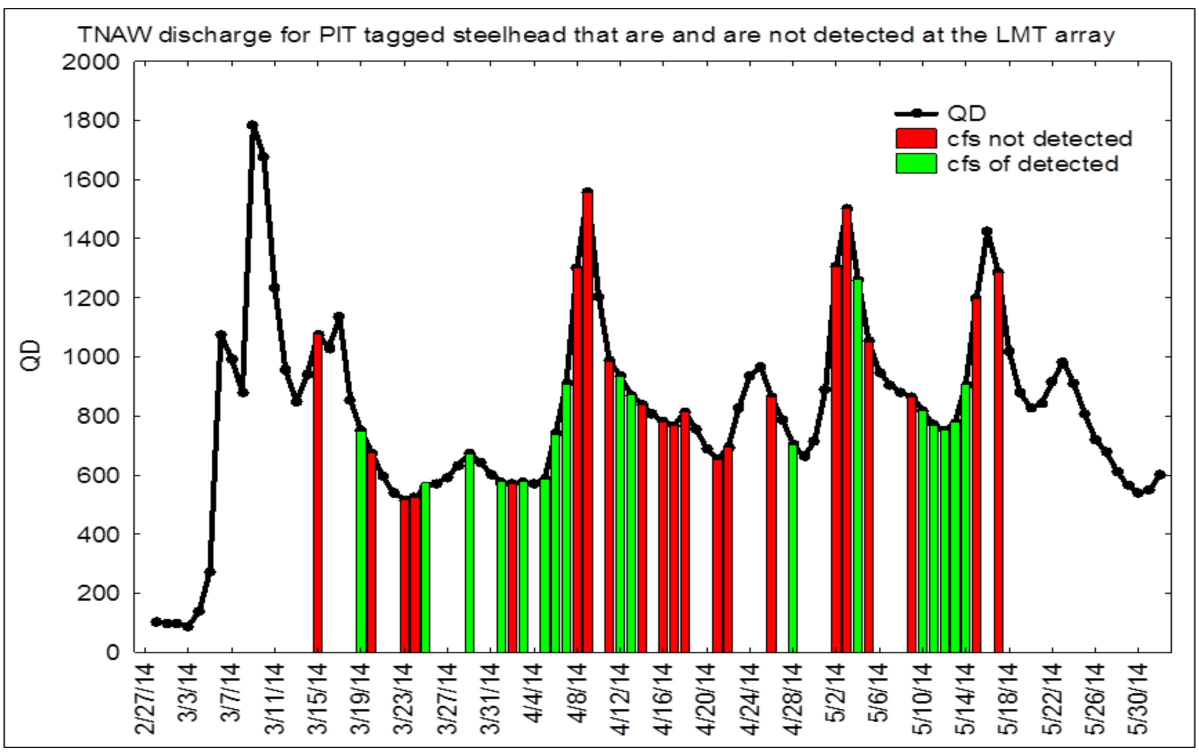


Figure 23. Mean daily stream discharge (QD) in the Teanaway River and the discharge (cfs) during periods of adult detections and periods when adults were not detected at the Lower Mainstem Teanaway (LMT) instream PIT tag array.

b. Coordination and Data Management for RM&E

We hope the results of this work will provide useful information supportive of the Columbia River BiOp, uncertainty resolution, NOAA's upcoming status assessments, as well as all those interested in the status and trends for the *O. mykiss* populations in the Yakima Basin. We are particularly interested in improving our understanding of how sympatric resident and anadromous O. mykiss interact to influence the status of the depressed and listed anadromous form. The information collected during this contract have been uploaded to Ptagis (PIT tagging data), and have been presented in public and professional forums (e.g., AFS chapter and divisional meetings; annual Yakima Basin Science and Management Conference). Our data has also been used to help influence the selection of high priority populations for inclusion in high level reports that are being drafted (e.g., Steelhead at risk report, WDFW unpublished).

5. Synthesis of Findings: Discussion/Conclusions

Lessons Learned: Explain how the results of this project benefit fish and wildlife. Address each applicable sub-strategy and management question(s), provided in the Introduction for higher-level or project/program level adaptive management. If studies are incomplete, discuss preliminary findings. (Refer to the RM&E Annual Technical Reporting guidance document for more information on content to include).

a. Fish Population RM&E

One of the primary objectives of this work is to collect population level status and trend data for the upper Yakima O. mykiss population (both life histories). These data collection efforts are ongoing. One of the secondary benefits is that the data are collected in a manner to answer critical uncertainties associated with the interactions of life history types in this sympatric population. Little is known about how the interactions between resident an anadromous forms of *O. mykiss* affects the recovery objectives mandated for the anadromous form. Bettering our understanding of these interactions will fill these data gaps, and help facilitate our recovery efforts.

Our monitoring yielded several new and exciting results this contract period, particularly with respect to diversity and spatial structure metrics. This information will be useful for monitoring trends in the diversity and spatial structure metrics in future years that will support NOAA fisheries and the Columbia River BiOp, and uncertainties research. Many of the variables monitored will also be used to inform life cycle modeling efforts, and high level documents for the populations in the MPG (e.g., steelhead at risk report). Steelhead are notably the most complex species in the Pacific Salmonid group and recent research conducted under this project, (and elsewhere), are beginning to improve our understanding of the complexities of this species which will in turn, inform best management of the species.

This is the second year that our in stream PIT tag interrogation sites at all of our major tributaries were operating during the entire adult spawning migration period such that we could estimate adult detection efficiencies for our monitoring sites in the upper Yakima. The detection efficiencies were used to estimate spawner abundance in each major upper Yakima Tributary, and main-stem spawners were to be assigned by default. While the adult detection efficiencies were generally high, we have detected noise and interference issues at several of our PIT tag arrays that reduce our detection capabilities from what their potential is. We recommend minor equipment reconfiguration and continual troubleshooting to identify and reduce these sources of noise, thereby improving the detection capability of our monitoring infrastructure. We also recommend evaluating detection efficiencies by using upstream temporary interrogation sites to to back-calculate the efficiencies at the permanent interrogation sites. This will be particularly important with the end of the radio telemetry project. These minor improvements will improve our confidence in our adult and juvenile abundance and productivity monitoring metrics in the coming years.

The proportion of the O. mykiss tagged in upper Yakima tributary streams that were detected as migrants period at Main stem Columbia River Dams (including detections as PIT tag mortalities on the Bird Colonies), during this contract period were consistent with our observations in previous years. On average, 3% of population PIT tagged in the upper Yakima were detected as migrants. However, this was the first year that we could assign the entire migration to their respective brood year. This is important because we can now present the proportion of the population that are migrants, grouped by brood year: not just the number of tags observed migrating in a given year. This improves the accuracy of our estimates and facilitates spatial and temporal comparison of trends.

Accounting for tag retention rates in tagging studies is critical when making comparative estimates of population parameters based upon tagged fish. In general, high PIT tag retention rates for migrating anadromous juveniles have been reported in the literature. Our tag retention study based upon dual tagging procedures indicated that tag retention rates of tagged O. mykiss were generally high in our tributaries. However, there is some indication that long term tag retention (e.g., greater than a Calendar Year) may be impacted by resident fish spawning act in females. Tags injected in the peritoneal cavity of pre-spawning females may be shed during spawning. This phenomenon has been observed for rainbow trout (Meyer et al. 2011). The information generated from our tag retention study will be necessary to incorporate in comparisons of resident and anadromous abundance, survival, and productivity estimates. We will also need to account for tag induced mortality rates in our tagging studies. However, long term tag induced mortality is very difficult to measure in the stream setting. We have the opportunity to pursue a long term tag mortality study in conjunction with a re-conditioned Kelt breeding study that is being initiated in the semi-natural spawning channel at the Cle Elum Supplementation and Research Facility in the spring of 2015. We will consider this option in 2015.

One potentially useful product generated during this contract period includes the geo-referenced plots of smolt production from each tributary stream. One strategy for recovering anadromous fish resources in the Yakima Basin is to repair fish habitat. Plots of *O. mykiss* smolt production per river kilometer in each tributary display stream reaches that are important for the natural production of anadromous steelhead juveniles. While we have identified the stream reaches that are producing steelhead smolts in the upper Yakima, we will work to improve the evaluation by attempting to identify causative factors. If we are successful, we will be able to provide recommendations for habitat protection or specific habitat improvement actions that will benefit anadromous steelhead rearing so habitat managers can prioritize actions aimed to benefit steelhead rearing.

b. Coordination and Data Management for RM&E

The data collection activities associated with this work is ongoing. The data that is being collected is uploaded to regional databases where appropriate (e.g. PTagis), and has been made available and presented locally to help local recovery planning, as well as recovery planning efforts at the statewide level (e.g., WDFW).

6. References

Campton, D. E., and J. M. Johnston. 1985. Electrophoretic evidence for a genetic admixture of native and nonnative rainbow trout in the Yakima River, Washington. Transactions of the American Fisheries Society 114:782-793.

Conley, A, J. Freudenthal, D. Lind, P. Mees, and R. Visser. 2009. Yakima Steelhead Recovery Plan. Yakima Basin Fish and Wildlife Recovery Board. Available: http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/middle_columbia/mid-c-yakima.pdf January 2015.

Crawford, B. A., and S. Rumsey. 2009. Draft guidance for monitoring recovery of Pacific Northwest salmon and steelhead. National Marine Fisheries Service Northwest Region.

Du, J. 2002. Combined algorithms for constrained estimation of finite mixture distributions with grouped data and conditional data. Masters Thesis. McMaster University, Hamilton, Ontario.

Frederiksen, C., D. E. Fast, W. J. Bosch, and G. M. Temple. 2014. Yakima steelhead VSP project: Yakima River steelhead population status and trends monitoring. Annual Report for the period 10/15/2011-10/14/2012, submitted to the Bonneville Power Administration, Portland, Oregon.

Ham, K. D., and T. N. Pearsons. 2000. Can reduced salmonid population abundance be detected in time to limit management impacts? Canadian Journal of Fisheries and Aquatic Sciences 57:17-24.

McMichael, G. A., J. P. Olson, E. L. Bartrand, N. Fischer, J. N. Hindman, and S. A. Leider. 1992. Yakima River Species Interactions Studies, Annual Report FY1991, submitted to the Bonneville Power Administration, Portland, Oregon.

Meyer, K. A., B. High, N. Gastelecutto, E.R. J. Mamer, and F. S. Elle. 2011. Retention of passive integrated transponder tags in stream-dwelling rainbow trout. North American Journal of Fisheries Management 31:236-239.

Pearsons, T. N., G. A. McMichael, E. L. Bartrand, M. Fisher, J. T. Monahan, and S. A. Leider, with contributions from G. R. Strom, and A. R. Murdoch. 1993. Yakima Species Interactions Study, Annual Report 1992, submitted to Bonnevill Power Administration, Portlans Oregon.

Pearsons, T. N., G. A. McMichael, S. W. Martin, M. Fisher, and S. A. Leider, with contributions from G. R. Strom, A. R. Murdoch, K. Wieland, and J. A. Long. 1994. Yakima River Species Interactions Studies, Annual Report 1993, submitted to Bonneville Power Administration, Portland, Oregon.

Temple, G. M., and T. N. Pearsons. 2007. Electrofishing: backpack and driftboat. Pages 95-132 in D. H. Johnson, B. M. Schrier, J. S. O'Neal, J. A. Knutzen, X. Augerot, T. A. O'Neil, *and T. N. Pearsons. Salmonid Field Protocols Handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland.*

Appendix A: Use of Data & Products

Pit tag data files are contained at the regional PTagis Database: http://www.ptagis.org/

Raw electronic data files (Database) are secured on the WDFW Corporate server in Olympia, WA, as well as on WDFW district 8 field office personal computers. Data housed on personal computers are duplicated on the local office server which is in turn backed up on the WDFW corporate server in Olympia, WA nightly.

Published sampling protocols identified in this contract are accessible via the Monitoring Methods.org website: https://www.monitoringmethods.org/

Appendix B: List of Metrics and Indicators

Category	Subcategory	Subcategory Focus 1	Subcategory Focus 2	Specific Metric Title
Fish	Abundance of Fish	Fish Life Stage: Adult - Pre-Spawner	Fish Origin: Natural	
Fish	Abundance of Fish	Fish Life Stage: Adult - Spawner	Fish Origin: Natural	
Fish	Abundance of Fish	Fish Life Stage: Adult Fish	Fish Origin: Natural	
Fish	Abundance of Fish	Fish Life Stage: Juvenile - Migrant	Fish Origin: Natural	
Fish	Abundance of Fish	Fish Life Stage: Juvenile Fish	Fish Origin: Natural	
Fish	Age Structure: Fish	Fish Life Stage: Adult - Pre-Spawner		
Fish	Age Structure: Fish	Fish Life Stage: Adult - Spawner		
Fish	Age Structure: Fish	Fish Life Stage: Adult Fish		
Fish	Age Structure: Fish	Fish Life Stage: Juvenile - Migrant		
Fish	Age Structure: Fish	Fish Life Stage: Juvenile Fish		
Fish	Distribution of Fish Species	Fish Life Stage: Adult - Spawner		
Fish	Distribution of Fish Species	Fish Life Stage: Adult Fish		
Fish	Distribution of Fish Species	Fish Life Stage: Juvenile Fish		
Fish	Entrainment	Fish Life Stage: Juvenile - Migrant		
Fish	Genetics: Fish Diversity, Fitness or Variation	Fish Origin: Natural		
Fish	Length: Fish Species	Fish Life Stage: Adult Fish		
Fish	Length: Fish Species	Fish Life Stage: Juvenile Fish		
Fish	Mortality: Fish	Fish Life Stage: Adult - Pre-Spawner		
Fish	Productivity: Fish	Fish Life Stage: RANGE: Adult to Adult	Fish Origin: Natural	
Fish	Productivity: Fish	Fish Life Stage: RANGE: Adult to Juvenile	Fish Origin: Natural	
Fish	Sex Ratio: Fish	Fish Life Stage: RANGE: Adult to Adult	Fish Origin: Natural	
Fish	Stock Identity	Fish Life Stage: RANGE: Adult to Adult		
Fish	Survival Rate: Fish	Fish Life Stage: Juvenile	Fish Origin: Natural	

		Fish		
Fish	Survival: Fish	Fish Life Stage: Juvenile - Migrant	Fish Origin: Natural	
Fish	Survival: Fish	Fish Life Stage: RANGE: Juvenile to Adult	Fish Origin: Natural	
Fish	Timing of Life Stage: Fish	Fish Life Stage: Adult - Pre-Spawner		
Fish	Abundance of Fish	Fish Life Stage: Adult - Pre-Spawner	Fish Origin: Natural	
Fish	Abundance of Fish	Fish Life Stage: Adult - Spawner	Fish Origin: Natural	
Fish	Abundance of Fish	Fish Life Stage: Adult Fish	Fish Origin: Natural	
Fish	Abundance of Fish	Fish Life Stage: Juvenile - Migrant	Fish Origin: Natural	
Fish	Abundance of Fish	Fish Life Stage: Juvenile Fish	Fish Origin: Natural	
Fish	Age Structure: Fish	Fish Life Stage: Adult - Pre-Spawner		
Fish	Age Structure: Fish	Fish Life Stage: Adult - Spawner		
Fish	Age Structure: Fish	Fish Life Stage: Adult Fish		
Fish	Age Structure: Fish	Fish Life Stage: Juvenile - Migrant		
Fish	Age Structure: Fish	Fish Life Stage: Juvenile Fish		
Fish	Distribution of Fish Species	Fish Life Stage: Adult - Spawner		
Fish	Distribution of Fish Species	Fish Life Stage: Adult Fish		
Fish	Distribution of Fish Species	Fish Life Stage: Juvenile Fish		
Fish	Entrainment	Fish Life Stage: Juvenile - Migrant		
Fish	Genetics: Fish Diversity, Fitness or Variation	Fish Origin: Natural		
Fish	Length: Fish Species	Fish Life Stage: Adult Fish		
Fish	Length: Fish Species	Fish Life Stage: Juvenile Fish		
Fish	Mortality: Fish	Fish Life Stage: Adult - Pre-Spawner		
Fish	Productivity: Fish	Fish Life Stage: RANGE: Adult to Adult	Fish Origin: Natural	
Fish	Productivity: Fish	Fish Life Stage: RANGE: Adult to Juvenile	Fish Origin: Natural	
Fish	Sex Ratio: Fish	Fish Life Stage: RANGE:	Fish Origin: Natural	

		Adult to Adult		
Fish	Stock Identity	Fish Life Stage: RANGE: Adult to Adult		
Fish	Survival Rate: Fish	Fish Life Stage: Juvenile Fish	Fish Origin: Natural	
Fish	Survival: Fish	Fish Life Stage: Juvenile - Migrant	Fish Origin: Natural	
Fish	Survival: Fish	Fish Life Stage: RANGE: Juvenile to Adult	Fish Origin: Natural	
Fish	Timing of Life Stage: Fish	Fish Life Stage: Adult - Pre-Spawner		
Fish	Abundance of Fish	Fish Life Stage: Adult - Pre-Spawner	Fish Origin: Natural	
Fish	Abundance of Fish	Fish Life Stage: Adult - Spawner	Fish Origin: Natural	
Fish	Abundance of Fish	Fish Life Stage: Adult Fish	Fish Origin: Natural	
Fish	Abundance of Fish	Fish Life Stage: Juvenile - Migrant	Fish Origin: Natural	
Fish	Abundance of Fish	Fish Life Stage: Juvenile Fish	Fish Origin: Natural	
Fish	Age Structure: Fish	Fish Life Stage: Adult - Pre-Spawner		
Fish	Age Structure: Fish	Fish Life Stage: Adult - Spawner		
Fish	Age Structure: Fish	Fish Life Stage: Adult Fish		
Fish	Age Structure: Fish	Fish Life Stage: Juvenile - Migrant		
Fish	Age Structure: Fish	Fish Life Stage: Juvenile Fish		
Fish	Distribution of Fish Species	Fish Life Stage: Adult - Spawner		
Fish	Distribution of Fish Species	Fish Life Stage: Adult Fish		
Fish	Distribution of Fish Species	Fish Life Stage: Juvenile Fish		
Fish	Entrainment	Fish Life Stage: Juvenile - Migrant		
Fish	Genetics: Fish Diversity, Fitness or Variation	Fish Origin: Natural		
Fish	Length: Fish Species	Fish Life Stage: Adult Fish		
Fish	Length: Fish Species	Fish Life Stage: Juvenile Fish		
Fish	Mortality: Fish	Fish Life Stage: Adult - Pre-Spawner		
Fish	Productivity: Fish	Fish Life Stage: RANGE:	Fish Origin: Natural	

		Adult to Adult		
Fish	Productivity: Fish	Fish Life Stage: RANGE: Adult to Juvenile	Fish Origin: Natural	
Fish	Sex Ratio: Fish	Fish Life Stage: RANGE: Adult to Adult	Fish Origin: Natural	
Fish	Stock Identity	Fish Life Stage: RANGE: Adult to Adult		
Fish	Survival Rate: Fish	Fish Life Stage: Juvenile Fish	Fish Origin: Natural	
Fish	Survival: Fish	Fish Life Stage: Juvenile - Migrant	Fish Origin: Natural	
Fish	Survival: Fish	Fish Life Stage: RANGE: Juvenile to Adult	Fish Origin: Natural	
Fish	Timing of Life Stage: Fish	Fish Life Stage: Adult - Pre-Spawner		