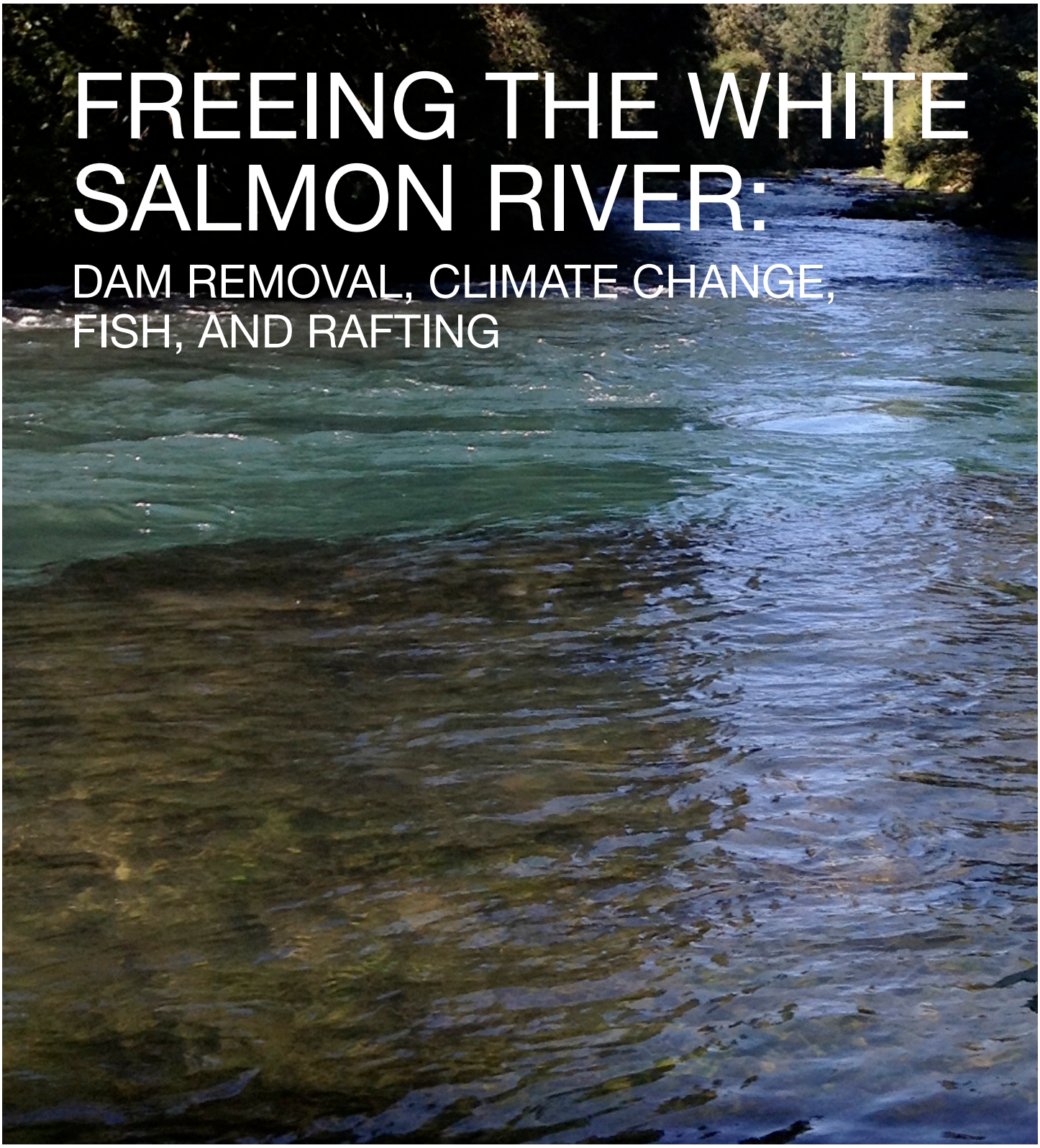

FREEING THE WHITE SALMON RIVER:

DAM REMOVAL, CLIMATE CHANGE, FISH, AND RAFTING

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FIGURE 1 - Dam Site before removal

INTRODUCTION

Dam removal is emerging as an increasingly utilized method of river management (Doyle, Harbor, & Stanley, 2003). However, the job does not end with the termination of the physical removal; dam removal may change ecological conditions, types and conditions of river use, and extended management plans are needed to address these changes and ensure a positive transition. The Condit Dam at river mile 3.3 on the White Salmon River in Washington state was removed in 2011, largely for the purpose of reintroducing anadromous fish species back to the river (Washington State Department of Ecology 2007). The process involved collaboration among a diverse group of stakeholders, from the PacifiCorps (the owner of the dam), the Yakama Nation, NOAA fisheries, federal and state agencies including the Forest Service (USFS), various environmental groups, and river raft/running companies (PacifiCorp 2011). However, in the wake of this collaborative effort a potential conflict of use has recently arisen on the newly freed White Salmon River.

With the recent removal of Condit Dam on the White Salmon River (See Figure 2), native fish species, including Chinook salmon *Oncorhynchus tshawytscha*, have a rare opportunity to return to a river that they have not visited for nearly a century. Chinook salmon will have access to an additional 12 miles of habitat upstream of the dam site and steelhead *Oncorhynchus mykiss* will have access to an additional 33 miles of habitat (NPCC 2004). This has provided an increased opportunity to fish for anadromous fish in the river upstream of the old dam site to BZ falls. In addition to the newly accessible habitat for fish, dam removal has opened five more miles of recreational whitewater boating in the former reservoir and bypass reach downstream of the former dam. The opportunity for the boating community to float past the dam site and continue down to the Columbia River has prompted much interest. It is estimated that approximately 25,000 boaters, mostly in paddle rafts and kayaks, use the river each year. There is concern among the federal land management agencies regarding effects of boating-related activities on recolonization and proliferation of endangered Chinook salmon. Although white-water rafting is economically important to many rural communities, it may have adverse effects during pre-spawn holding and spawning periods (SNF 1995; NOAA Fisheries 2003). Rafts and kayaks floating down the river while salmon are staging, selecting redd locations, and/or spawning, have been anecdotally recognized to cause displacement of fish from redds (SNF 1995). The extent to which displacement reduces reproductive success has not been empirically determined. In addition, other assumptions suggest rafts and kayaks (float boats) may impact spawning salmon by either delaying onset of spawning or eliciting more rapid spawning than would occur under natural conditions (Fornander 2008). Because fall Chinook salmon leave the White Salmon River shortly after they emerge, spawning and incubation are thought to be among the most critical stages for their lifecycle in freshwater (Quinn 2005). Reduced habitat quantity, reduced channel stability, and increased peak flow may also limit productivity of fall Chinook salmon in the White Salmon River (Allen and Connolly 2005).

While effects of wading anglers (associated with recreational fishing) on salmonid redds has been determined to significantly reduce survival of eggs and pre-emergent fry (Robert & White 1992), float boating has not been researched extensively and no studies address its effect on the reproductive success of spawning salmon. Anecdotally, researchers with the USFS on the Salmon River in Idaho, have witnessed interactions between float boats and spawning salmon, indicating that the action of floating at close proximity to spawning salmon may have increased the frequency that Chinook salmon were displaced from redds, leading to increased mortality (SNF 1995). Human-induced disturbances of pre-spawning or spawning fish could result in reduced reproductive success and/or premature death. Damage to embryos in the gravel may occur if boats come

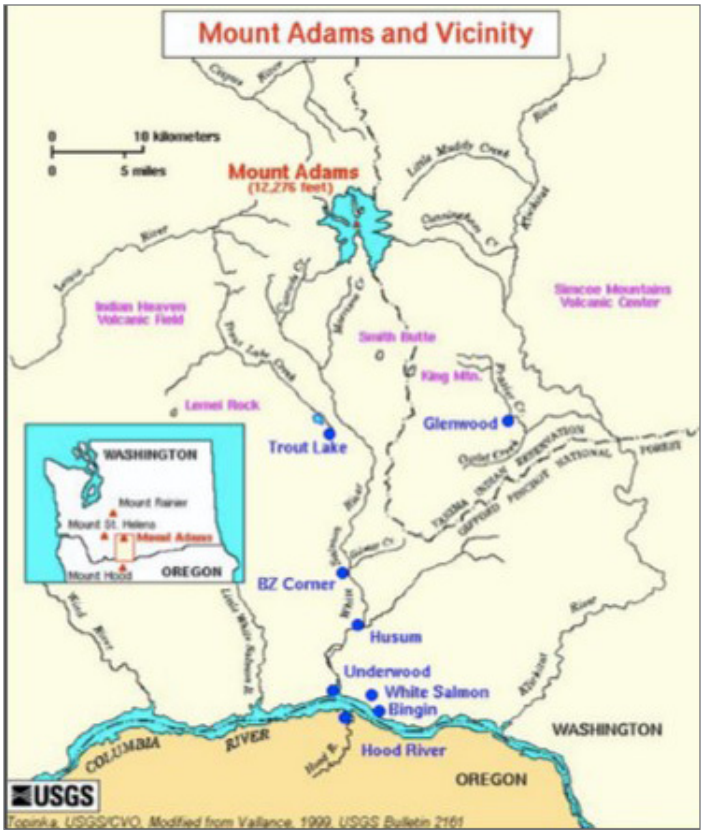

FIGURE 2 - Map of the White Salmon Watershed

FIGURE 3 - Condit Dam pre-removal
(Conduit Dam (c)spokesman, CC BY-NC-SA 2.0)

in contact with gravel or boaters wade on salmon redds. Salmon may repeatedly be displaced from their spawning areas by boaters, thereby reducing energy reserves, which could also adversely affect survival and/or reproductive success. Anecdotal information exists of repeated incidences of recreational fishermen wading directly on top of newly established salmonid redds, and to a lesser extent, intentionally catching or snagging spawning salmon while on redds (Robert & White 1992).

With increased pressure from water-based recreation on the White Salmon River and increased interest from commercial rafting companies about floating the new section of river, many questions arise regarding the effect of float boats on the spatial and temporal establishment of redds within the corridor. Fornander (2008) demonstrated that commercial float boating at current levels on the Salmon River in Idaho did not alter the time of redd establishment. However, reproductive success could potentially be influenced in other ways, such as altered spawning locations, displacement of females protecting established redds, and/or the displacement of males prior to fertilization. Without research, possible negative effects of float boating on salmon populations will not be identified in time to mitigate long-range impacts to re-establishing salmon populations. Alternatively, regulations prohibiting commercial rafting may be imposed that compromise portions of the local economy, even though the activity had little negative impact on the fish population. As salmon recolonize and proliferate in the White Salmon River following the removal of Condit Dam, research needs to be undertaken to examine the effect of float boaters on salmon populations.

FIGURE 4 - Rafting Over Husum Falls

MOTIVATION FOR STUDY

The ecosystem currently undergoing restoration following the dam removal is in a state of recovery; therefore, it may be more vulnerable to anthropogenic stressors, such as over-use, than another healthy riparian ecosystem. Climate change is, perhaps, the largest anthropogenic threat faced by ecosystems today. The effects of climate change on riverine systems include changes in magnitude and seasonality of flow due to faster rates of snowmelt, changes in temperature, increasing rates of erosion and levels of sediment. Salmon are keystone species with narrow ranges of temperature and sediment tolerance (Brenkman et al. 2012). To prepare this recovering ecosystem for potential future degradation caused by climatic changes, it is crucial to reduce non-climatic stressors, such as over-use, as much as possible to maximize the overall adaptive capacity of the ecosystem (Liverman & Moser 2013) and, consequently, promote the successful reintroduction of salmon populations into the White Salmon River. If recreational boating does in fact cause disturbance to salmon spawning behavior, taking action to reduce this stressor could increase the resilience of salmon populations in the future when climatic changes may further threaten their re-colonization into the watershed. The interests of other stakeholders, such as the fish managers and the recreational boating community, are also tied to the impacts of climatic changes to the area (Montag, Swan, Jenni, & Nieman 2014).

Although it is known that river running is popular on the White Salmon and many other rivers for both commercial and personal users, there are only a few recreational-use studies previously conducted, that address use levels on the river. There is no knowledge about whether or not the current amount of use on the river is sustainable, or if it is having negative impacts on the river ecosystem and specifically, the salmon species that the dam removal was to benefit. The Chinook salmon in this region are listed as an endangered species and are under federal protection. Until there is more information about recreational use and how it affects the salmon lifecycle, it is impossible to develop a management plan for the area that addresses the needs of all users, from the endangered Chinook salmon, to the recreational boating community.

The ultimate question of the current phase of research is: does water-based recreation alter Chinook salmon spawning behavior in the White Salmon River, Washington? However, this report only addresses the recreational use aspect of the study, as the ultimate research question cannot be answered until more data is collecting regarding the behavior of salmon in conjunction with river use on the White Salmon River. Chinook, Coho, steelhead, chum and bull trout are all in the watershed and are listed as endangered species. Chinook Salmon are the main concern because of the time and location of spawning on the main stem of the White Salmon river during late summer and fall when water is low and boating still occurs. The goal of this study was to collect baseline data to determine if the spatial and temporal patterns of water-based recreation overlapped with Chinook salmon spawning behavior. How these processes spatially overlap fluctuating hydrological conditions on the White Salmon River and what the management options could be for the future were additional goals. Based on the answer to this question, it is possible to develop a hypothesis regarding how the level of river use may be impacting Chinook salmon spawning behavior for a future more detailed study.

FIGURE 5 - Post-dam removal flow through Northwestern Lake (White Salmon River (c)www.columbian.com, CC BY-NC-SA 2.0)

FIGURE 6 - Rafters navigating the final drop down Stealhead Falls (Stealhead Falls(c) www.columbian.com, CC BY-NC-SA 2.0)

FIGURE 7 - Salmon on spawning run up the White Salmon River (Whitewater(c)wet planet, CC BY-NC-SA 2.0)

ECOSYSTEM PROCESSES

THE SALMON

Salmon spawn in freshwater environments before returning to the ocean to grow in a more nutrient-rich environment (Crozier et al. 2007). Typically, juvenile Chinook salmon spend two to three months in a freshwater environment before migrating to the sea, where they may spend two to four years before returning to spawn. Spawning occurs during varying seasonal runs depending on local factors such as river temperature and flow rate. Suitable spawning conditions depend on gravel type and composition, water depth and water velocity. Chinook salmon are the largest of the Pacific Salmon species (NOAA Fisheries 2014). The Upper Columbia River Spring Run Chinook were listed as an endangered species in 1999 (Salmon Species Listed Under the Federal Endangered Species Act 2010).

FIGURE 8 - Fall Chinook Salmon run
(Fall Chinook (c)Washington FWS, CC BY-NC-SA 2.0)

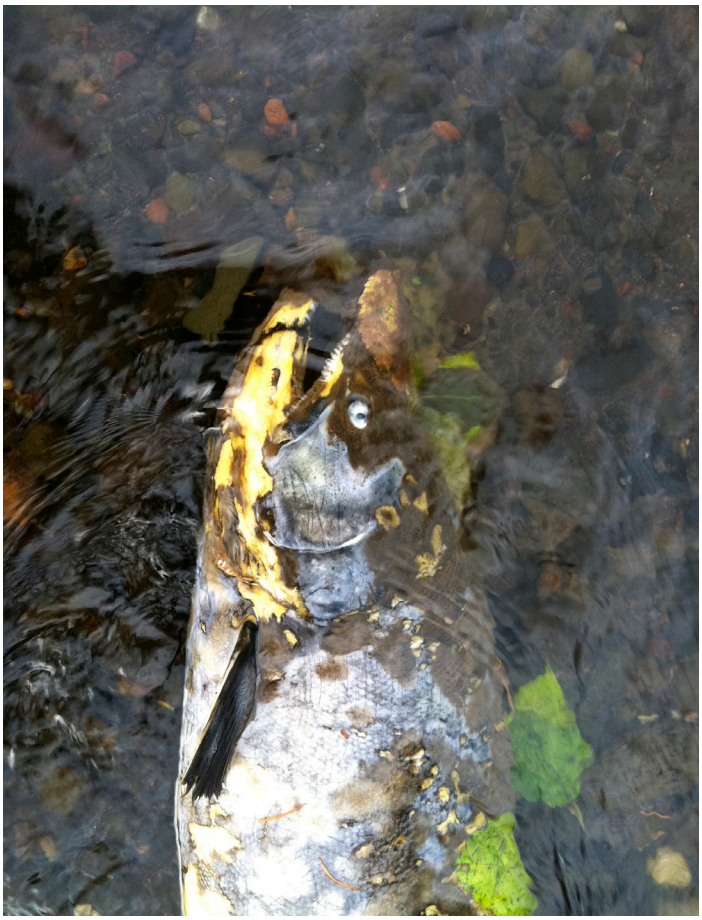

FIGURE 9 - Fall Chinook Salmon carcus
(Salmon With Eye (c)seattletimes.com, CC BY-NC-SA 2.0)

Marine conditions are a large factor in salmon survival; however, freshwater conditions also have a large impact on the survival of juvenile salmon. Dams can also pose a threat to salmon survival throughout their lifecycle, from water releases disrupting eggs embedded in gravel bars to entrapment of fry traveling downstream and the obstruction of the migratory paths of adults returning to spawn (Harnish, Sharma, Mcmichael, Langshaw, & Pearsons 2014) Although Pacific Salmon species are very adept at localized adaptation that comes with their migratory lifecycle, a study conducted on the Snake River indicated that the survival of juvenile Chinook salmon is strongly correlated with summer temperature and fall streamflow, making them vulnerable to climate-change induced changes (Crozier et al. 2007).

On the White Salmon River, NOAA Fisheries are responsible for upholding the protection of endangered species such as Chinook salmon. However, their protection involves potential conflict with other river uses, such as hydropower, irrigation, and recreation (Poff et al. 2003). Collaboration between scientists and managers is necessary to guide sustainable river management that can balance the needs of these differing uses.

FIGURE 10 - Challenging the River in a Raft

WHO ARE THE STAKEHOLDERS?

THE BOATING COMMUNITY

There are eight main river outfitting companies operating on the White Salmon River, in addition to private rafting and kayaking use. River running is an economic staple of the White Salmon community and draws tourists from cities in the surrounding region such as Portland as well as national and international visitors. After agriculture, it is the largest industry in the local economy (Friends of the White Salmon River 2012). River outfitting companies employ both seasonal workers and White Salmon residents. In addition to being a principal economic activity, it is also very socially and culturally significant for the White Salmon community. Some of the river outfitters, such as Zoller's Outdoor Odyssey, have been operating in the area for generations. Many river guides, when they have finished their commercial trips for the day, will run the river again in kayaks with friends. Community members enjoy gathering at Husum Falls during the day to witness the kayakers and rafts' descents (See Figure 4). For many community members, river running is not only a financial practice, but also a very personal and ingrained way of life.

THE YAKAMA NATION

A treaty signed with the government in 1855 granted the Yakama tribe 1,130,000 acres for their reservation out of the original 12 million acres of land that the tribe used to occupy (See figure 11). The treaty was not ratified by the United States government until 1859, and although the treaty was supposed to include time for the Yakama people to migrate to and establish the area, the governor of Washington declared that the area was open for white settlement only 12 days after the treaty was signed (The Yakama Nation Main Agency Offices 2014). In order to reclaim the area, the Yakama banded together with other tribes in the region that had been similarly deceived in a series of skirmishes known as the Yakama War. The war ended later in 1859 and the Yakama people moved onto their designated reservation on the banks of the Yakima River.

The Yakama culture and livelihood is very closely tied to the salmon runs that have historically occurred throughout the Columbia River Basin (The Columbia River Inter-Tribal Fish Commission 2014). However, the construction of the system of dams throughout the basin has radically altered the salmon lifecycle and consequently, the lifestyle of the native people who rely up them (Harnish et al. 2014). Celilo Falls, located on the Columbia River East of The Dalles, Oregon, was an important trading area and sacred fishing grounds for several tribes in the region before it was completely flooded by the construction of the Dalles Dam in 1957 (The Yakama Nation Main Agency Offices, 2014). Before the Condit Dam was constructed, the Yakima used to

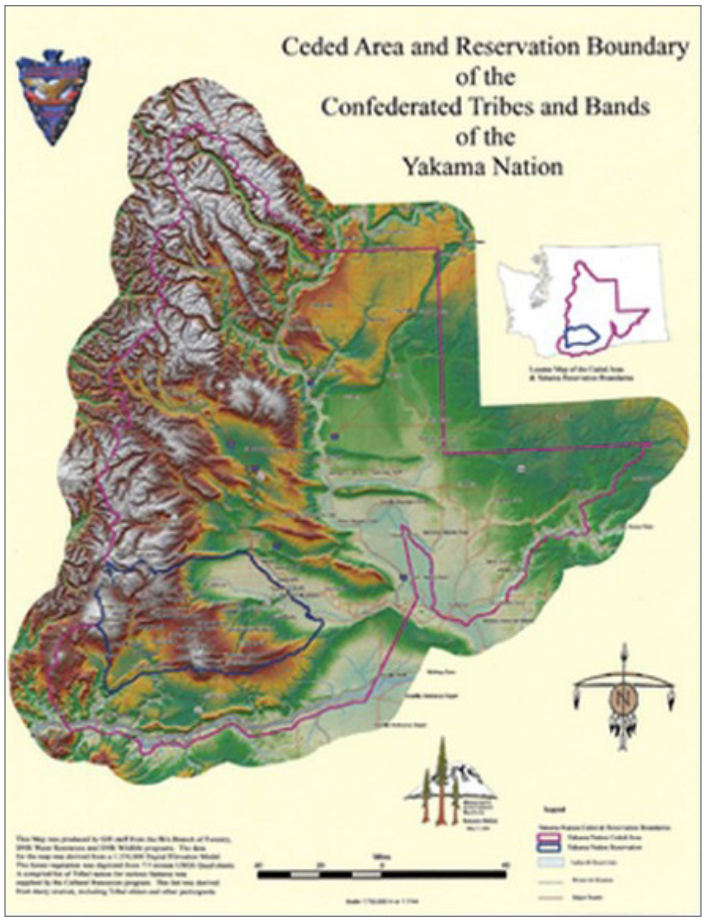

FIGURE 11 - The Yakama Nation Territory
(The Yakama Nation Main Agency Offices, 2014)

fish for salmon and steelhead on the White Salmon River and its confluence with the Columbia is a traditional trading area (Washines 2011). The Yakama Nation was a key player in the removal of the Condit Dam in 2011; along with the Columbia River Inter-Tribal Fish Commission, they co-sponsored the first engineering study with PacifiCorp that demonstrated that dam removal was an economically feasible option and were involved in negotiations throughout the entire process.

The removal of the dam is regarded as a huge success, particularly among the tribal community who have fought to restore the salmon's cycle of life that they have historically relied upon. As a community, the Yakama Nation is also vulnerable to the potential effects of climate change on the watershed, as their existence is so closely tied to the state of the salmon populations (Montag et al. 2014).

FIGURE 12 - Northwestern Lake boat ramp, after dam removal

METHODS

To capture boating activities on the river we used Photowatcher time-lapse cameras. Plotwatcher cameras were used to capture continuous photography of boating use for 100 days from June 27th through October 4th 2014 using five cameras on three different sections of the river. Cameras were placed and data analyzed based on the following three river sections:

- Upper Section – BZ corners to Husum Falls (2 cameras).
- Middle Section – Below Husum Falls to the Take out at Northwestern Lake (1 camera).
- Lower Section – Northwestern Lake take out to the confluence with the Columbia River (2 cameras)

All Plotwatcher cameras were checked once a week, batteries were changed, and data was downloaded, stored, and cleared from the 32GB memory cards. Cameras were set at 1 second intervals to ensure fast moving boats would be captured in simultaneous frames. Cameras were pretested and calibrated and adjusted in late June into early July. Cameras automatically turned on at 9:00am and turned off at 10:00pm. The cameras sampled continuously, collecting data from July 8th through October 4th. The intent of running the cameras for 100 days was to capture the early, peak, and shoulder seasons of commercial and private boating use on the river.

The data logging protocol consisted of running the Plotwatcher software time-lapsed photography and stopping the photography anytime a party was observed on the river. Each party was documented by camera location, capturing the date, time, and whether occupants were from commercial outfitters, private rafter, or kayakers. We also counted the number of visitors in each boat. River guides were counted in our overall counts but subtracted from the analysis of total number of visitors. In some cases, there were commercial rafts that had kayaker parties alongside so they were included in the assessment of total party size, but counted as kayaks. In this study, we were more interested in number of boats passing by the monitoring locations as a way to capture daily patterns of river use. Also, for purposes of this study, we logged all kayakers as private, knowing that some companies do have kayaking lessons, with unusually large kayaking parties traveling on the river, but differences in private kayaks versus those taking lessons was far too difficult to discern from the photography.

FIGURE 13 - Plotwatcher camera

FIGURE 14 - A winter view of the White Salmon River

RESULTS

The results include the boat counts that were collected with the Plotwatcher cameras from June 30, 2014 to October 4, 2014, as well as stream gauge data from the USGS and 2014 spawning surveys of Spring and Fall Chinook salmon conducted by the Washington Department of Fish and Wildlife and the U. S. Fish and Wildlife Service. For purposes of this study, we were most interested in deriving the seasonal patterns of use of boating on the river during the 100-day sampling period. The camera data of river use was summarized to capture the date and time the boats passed each of the cameras and to count the total number of boats passing the camera each day. In addition an analysis was conducted to discriminate between commercial rafts, private rafts, and private kayaks. Commercial outfitters were identified in the analysis to determine which sections of the river were most commonly used. Finally, we estimated the total number of visitors in each boat and the total number of boats per party. When determining the party size from the camera data, it was either obvious as the boats were all from the same commercial company, and were in close proximity of each other, or in some cases we waited five minutes to ensure a lagging boat with was counted as part of the larger party. Further for purposes of this study we included river guides as part of the overall visitor counts for each boat.

HOW MUCH BOATING USE IS OCCURRING ON THE WHITE SALMON RIVER?

The total number of visitors counted in the boats on the river was n=34,095, minus rafting guides n=29,085. Of the n=9,327 boats counted on the river over the 100-day sample period, there were n=5,010 rafts and n=4,317 kayaks. Of the n=5,010 rafts, there were only n=242 non-commercial or private rafts identified, thus providing a total commercial count of n=4,770. Commercial outfitter rafting use on the Upper Section n=2,459 of the river was slightly higher than the middle Section n=2,004 and much higher than the Lower section n=307. Figure 15 shows rafting and kayaking use by river Section.

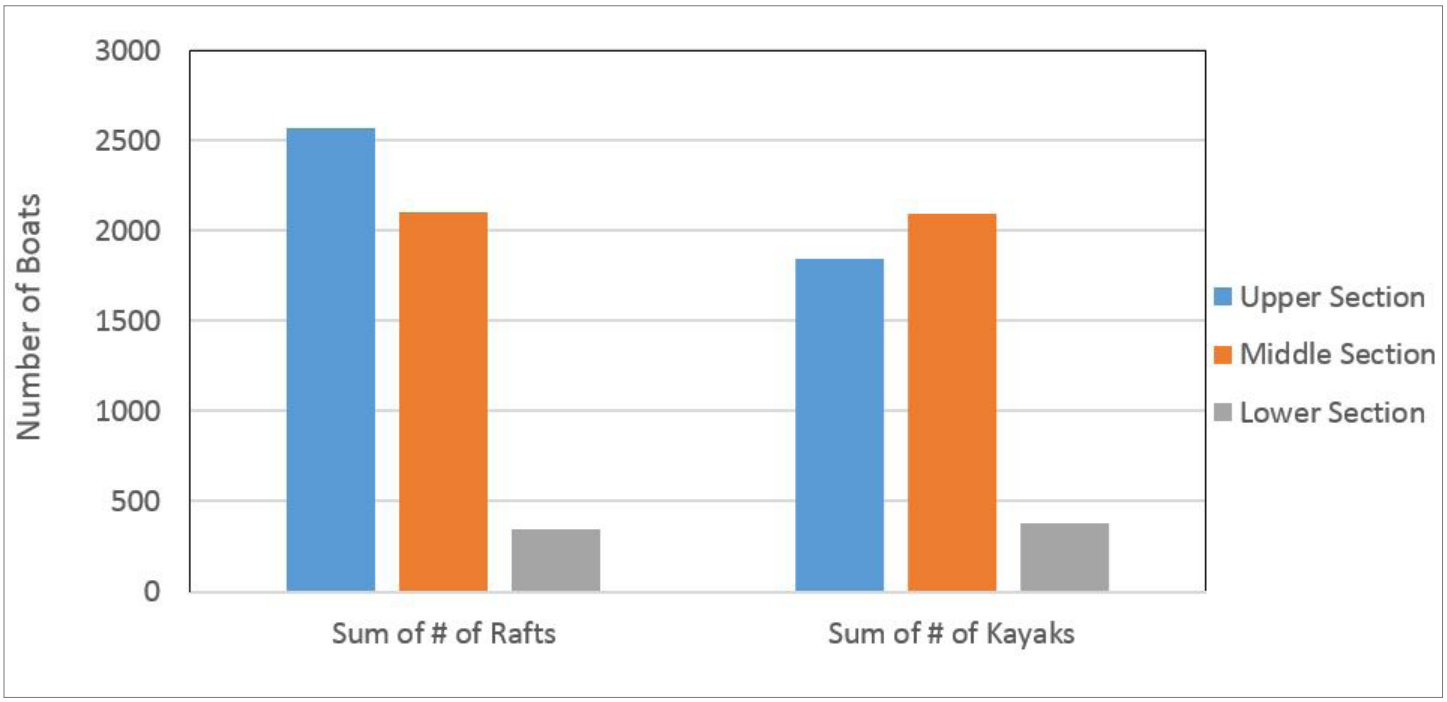

FIGURE 15 - Total Number of Boats on the White Salmon River

HOW MUCH RAFTING USE OCCURS ON THE WHITE SALMON RIVER THROUGHOUT THE SEASON?

The Upper Section of the White Salmon is consistently seeing more rafts than the other two sections of the river (See Figure 16). Weekends are definitely the most used times on the river. During July and August upwards of 100 to 150 rafts can be seen on a single day. For example, on August 30th there were 108 rafts on the Upper Section of the river. The middle Section of the river is busiest during the July –August and even into early September with 40 to 70 rafts on the river per day. Again, on August 30th over 50 rafts were observed on that day. The lower Section of the river was receiving very little daily use (8-10 rafts) and declined to very few in September and October 2014.

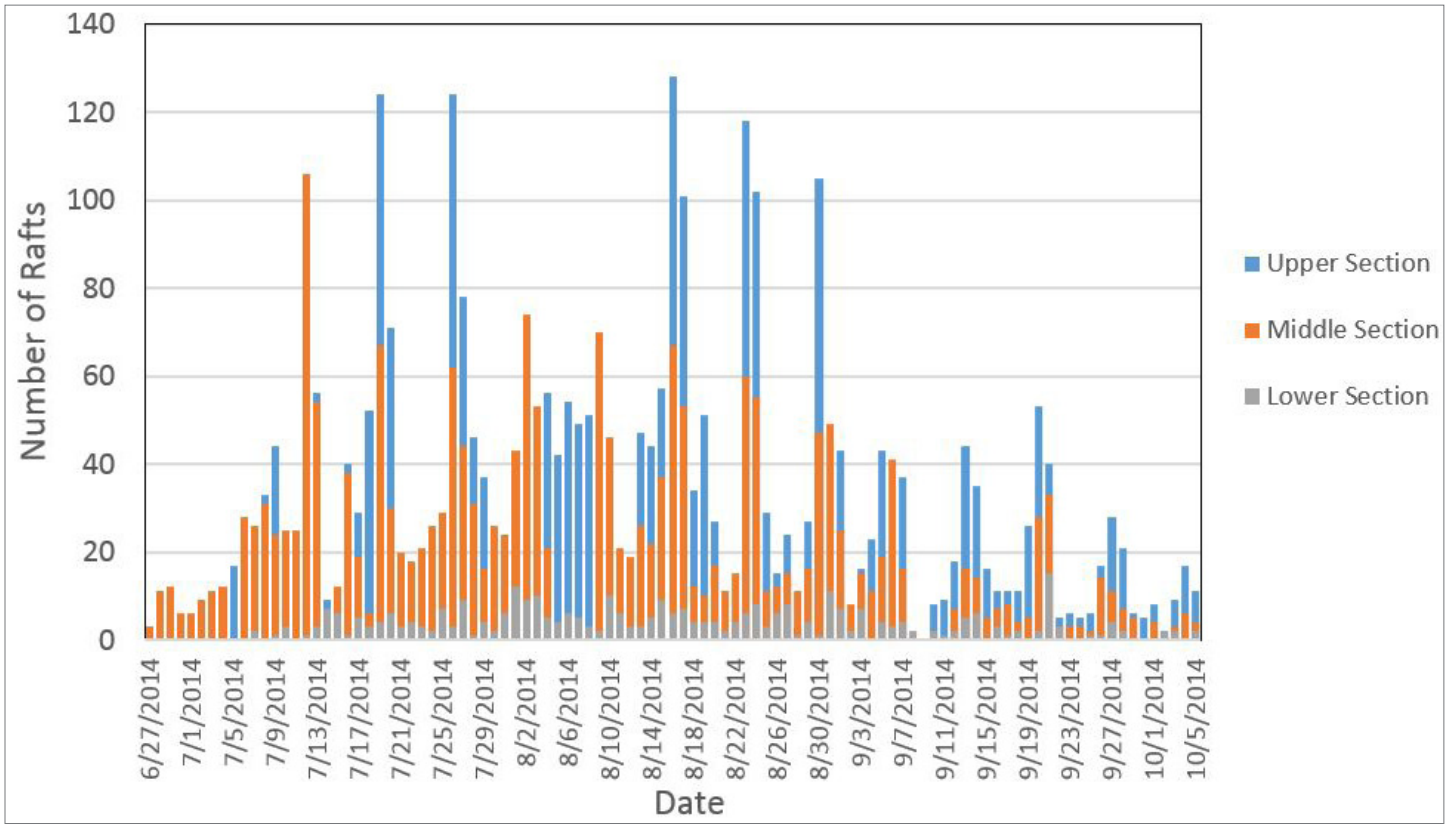

FIGURE 16 - Total Number of Rafts on the White Salmon River

HOW MUCH KAYACK USE OCCURS ON THE WHITE SALMON RIVER THROUGHOUT THE SEASON?

As reported earlier, there were n=4,317 kayaks observed on the river during the 100-day sample period. Kayaking is greatest on the middle Section of the river with spikes of n=78 kayaks observed on August 2nd and consistently on average between 30-40 kayaks per day. Kayaking use is most prominent during the late afternoon into early evening, after which commercial use subsides for the day. The Upper Section has similar patterns of kayaking use with some spikes in use of between 50-60 kayaks in September into October (See Figure 17).

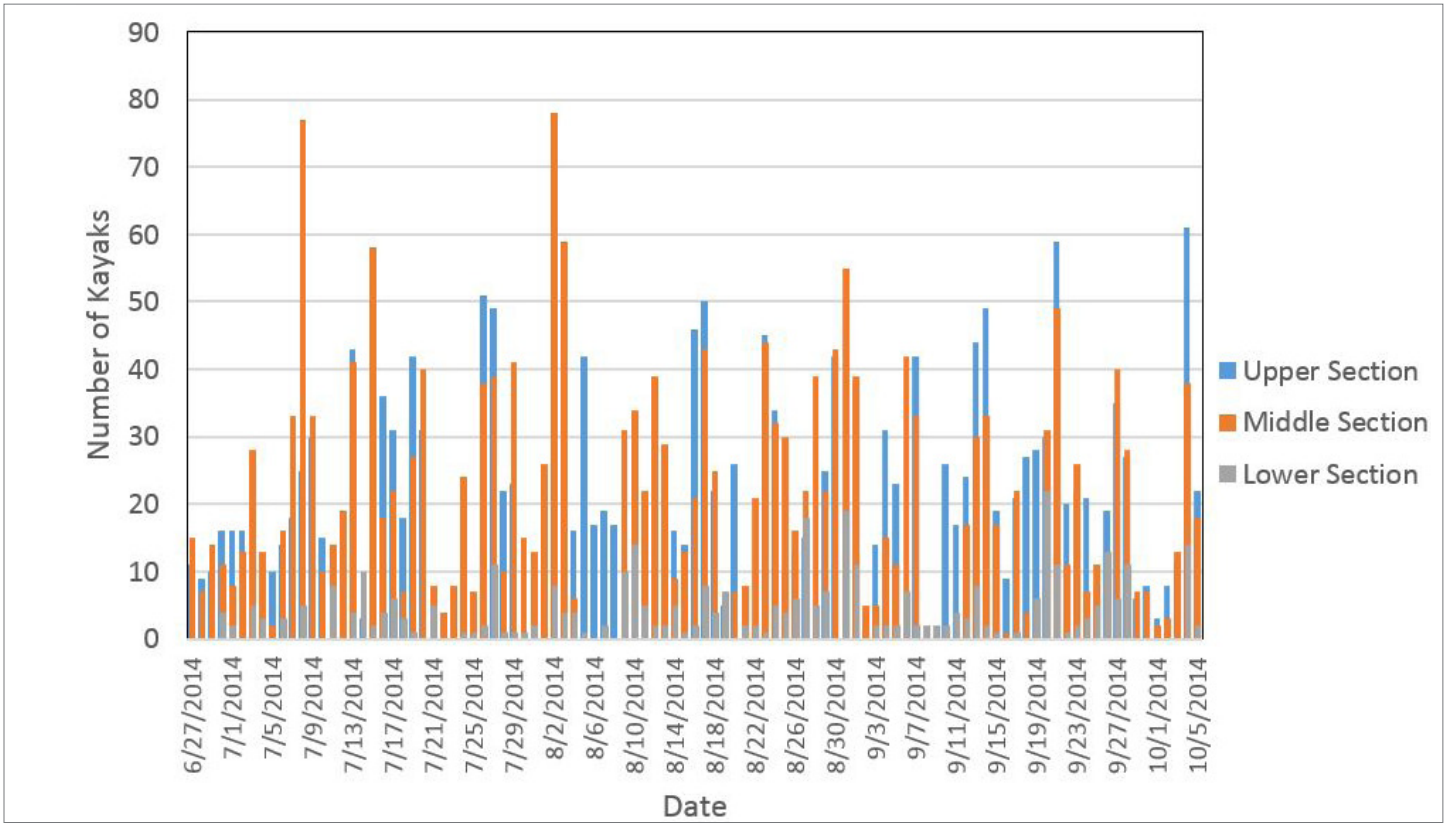

FIGURE 17 - Total Number of Kayaks on the White Salmon River

HOW MUCH VISITOR USE OCCURS ON THE WHITE SALMON RIVER THROUGHOUT THE SEASON?

While the seasonal pattern of use of boating on the river was the intent of this study, it was interesting to acquire information on the number of visitors the river received during the 100-day sample. Figure 18 provides a glimpse of those statistics. As stated above, nearly 30,000 visitors float the White Salmon River in either rafts or kayaks from June through early October. The Upper Section of the river receives more visitors in boats than the middle and Lower Sections. On July 26 we observed n=1,281 visitors, with use levels of n=1,019 on August 21st on the Upper Section During those dates it can be seen that there were between n=800 to n=900 and n=700 visitors on the Upper Section of the river. The Middle Section on July 26 received over n=400 visitors, while on August 30th nearly n=300 visitors floated the Middle Section.

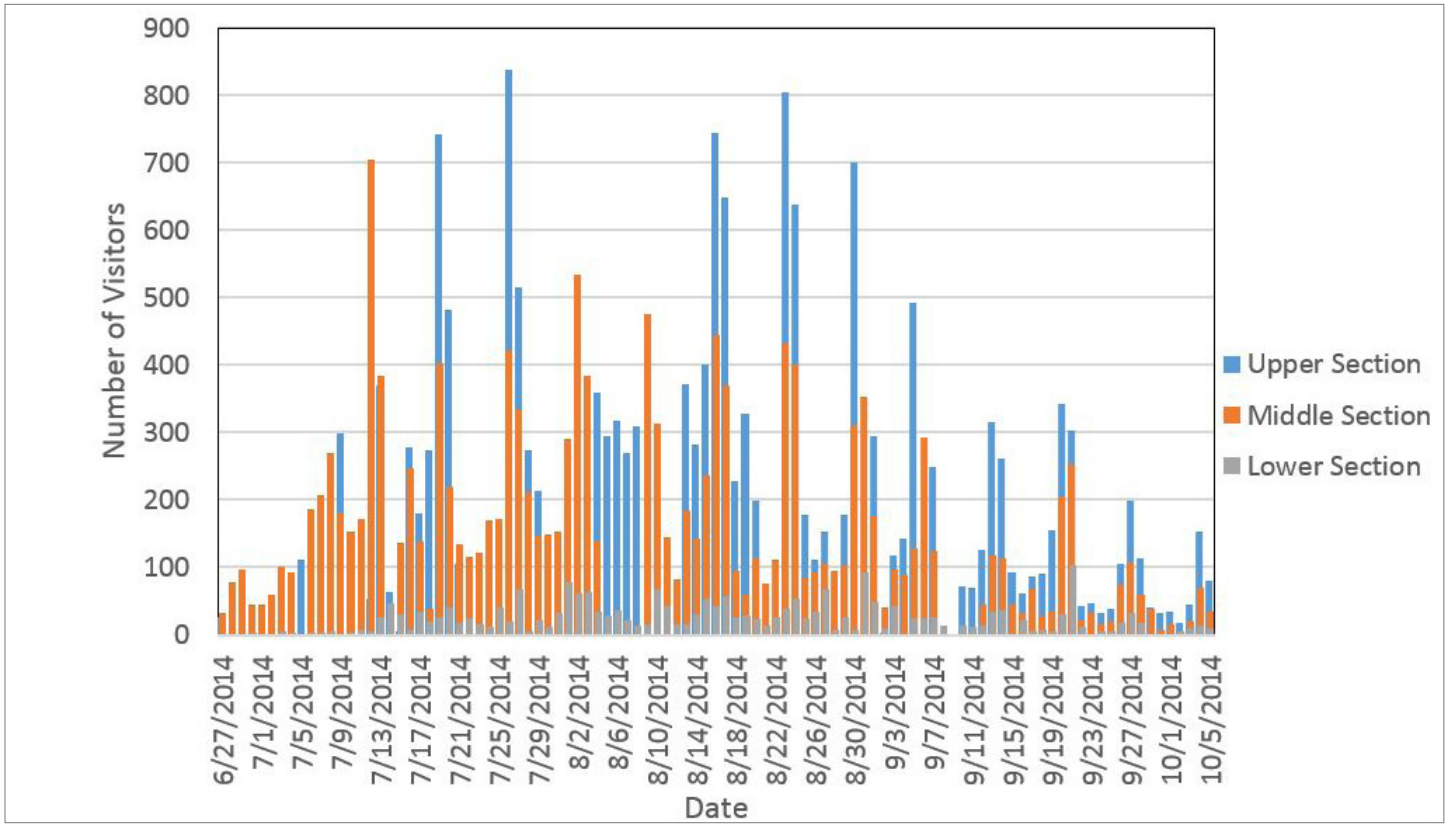

FIGURE 18 - Total Number of Visitors on Boats on the White Salmon River

WHAT IS THE DAILY PATTERN OF RAFTING USE ON THE WHITE SALMON RIVER?

The daily pattern of use was very predictable. On the Upper Section of the river, rafts generally arrive 10:00am thru noon and peak again 3:00pm thru 5:00pm. The Middle Section of the river sees very similar patterns while the patterns of use in the Lower Section generally occur early to mid-afternoon averaged over the 100-day sampling period (See Figure 19).

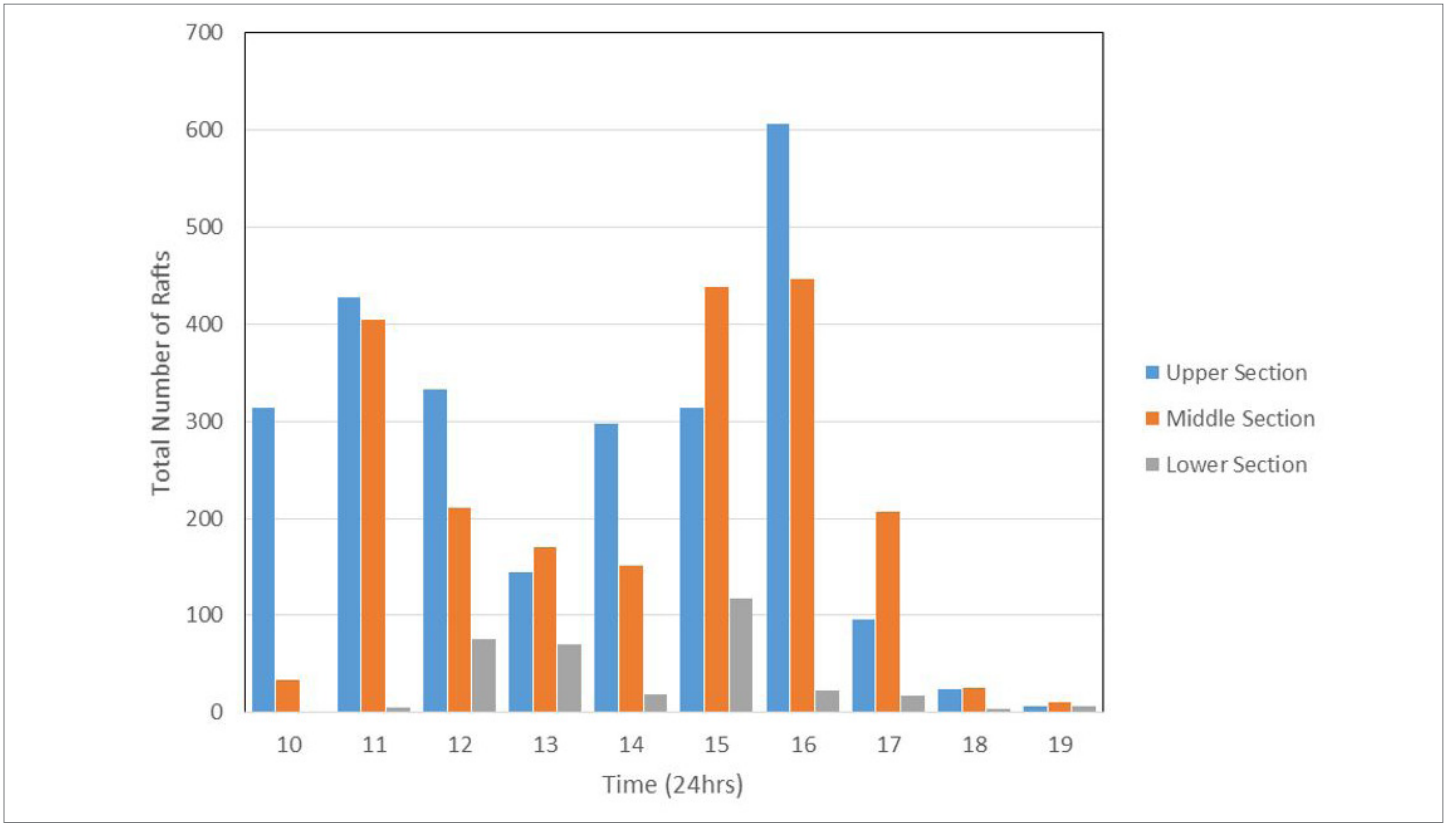

FIGURE 19 - Daily pattern of Rafting use on the White Salmon River

WHAT IS THE AVERAGE PARTY SIZE OF RAFTS ON THE WHITE SALMON RIVER?

The average party size for commercial rafts on the river varied by river =section and throughout the season. On the upper and Middle Sections of the river the average party size was between 5 to 6 boats beginning to drop off in mid-August down to 3 to 4 boats. However there were still spikes in use throughout September where we could still see up to 4 to 5 boats. The average party size dropped down near the end of September into October to a party size of two boats. The Lower Section of the river was not receiving very much total use and the average party size was 1 to 2 boats with the odd spike of 3 to 4 boats (See Figure 20).

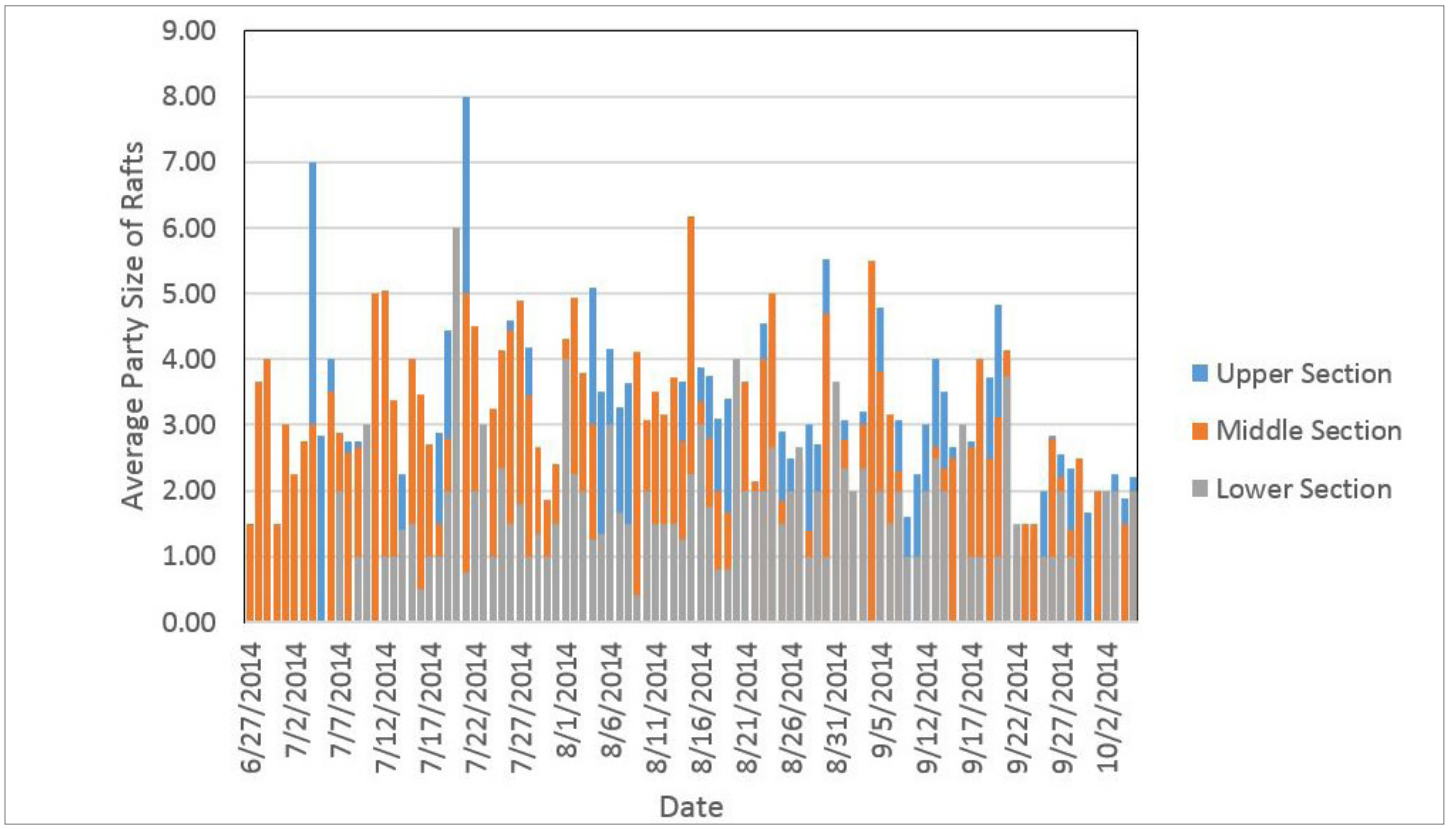

FIGURE 20 - Average Party Size of Rafts

WHAT IS THE AVERAGE TIME DIFFERENCES BETWEEN RAFTS ON THE WHITE SALMON RIVER?

To obtain a better understanding of how frequently rafts traveled down river, we calculated the average time difference between aggregated raft parties by river section, expressed in minutes. Figure 21 shows the results of this analysis. Again, the lower Section of the river with the least amount of rafting received the greatest average time difference between boats of 100–150 minutes reflecting a less dense pattern of boating use. The upper Section of the river that received high amount of use also had the least average time difference between boats ranging from 30-50 minutes and expands into more infrequent trips towards the end of the season as you would expect. The Middle Section of the river average time difference between boats was small at the beginning of the season ranging from 40-60 minutes to between 80-150 minutes towards the end of the season (See Figure 21). As the season progressed, there was a similar pattern in greater distance between boats or less frequently seen on the river. It is interesting to note however that there is still fairly high frequency of rafts on the river the end of August through September. This is important to consider given the overlap with increased salmon spawning activities during those times.

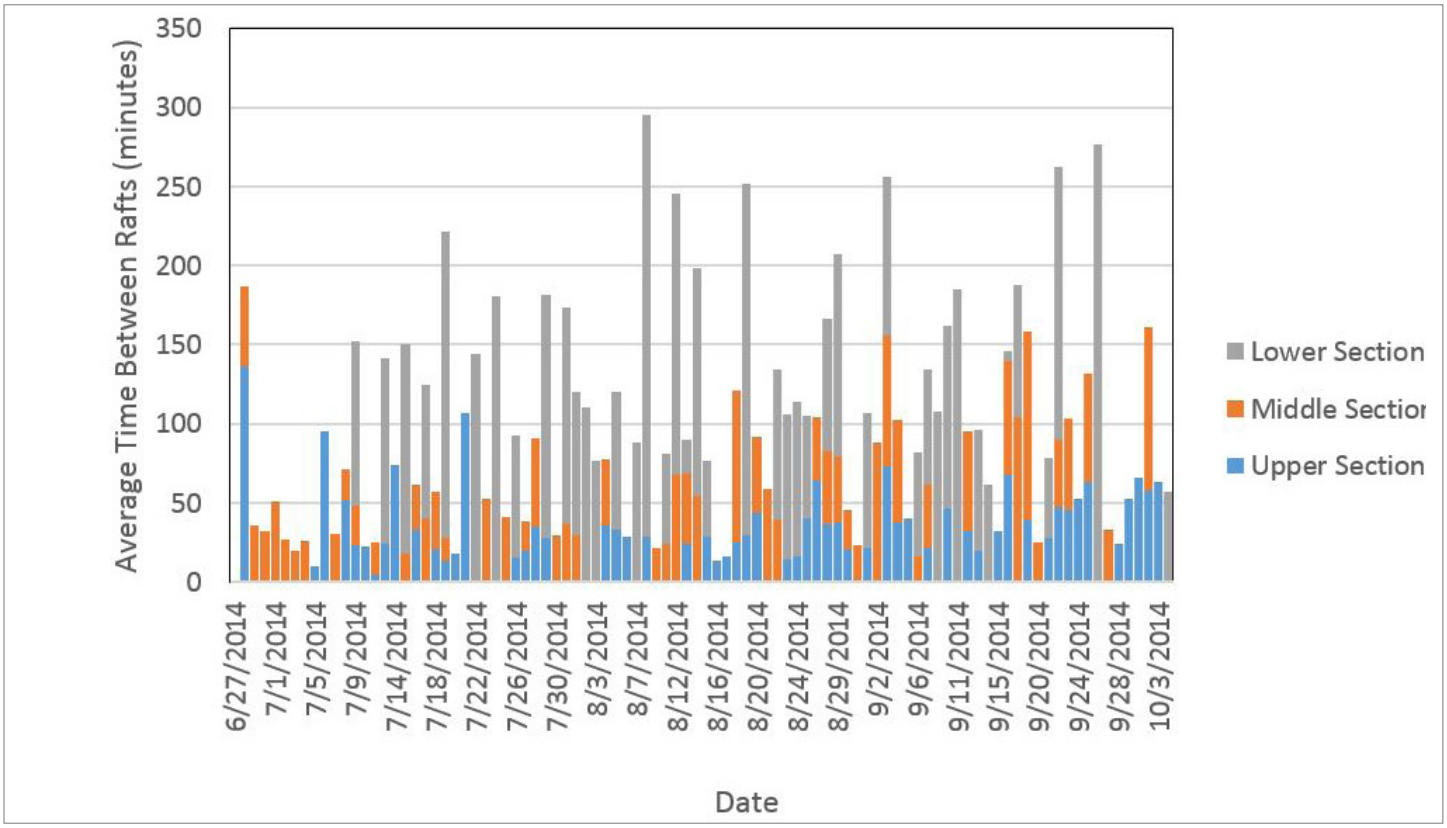

FIGURE 21 - Average time between aggregated raft parties (minutes) (colors switched around for river sections)

WHEN DO RAFTING ACTIVITIES COINCIDE WITH LOW STREAM FLOWS?

Figure 22 illustrates the relationship between the stream stage height obtained from the USGS 14123500 stream gage on the Lower Section of the White Salmon River near Underwood Washington during summer of 2014 and rafting activity for the 100-day sample. This graph depicts the higher flows from the springtime run-off gradually decreasing throughout the summer and into the fall. While the high season for the rafting community is commonly during the months of July and mid-August, this figure shows that the end of August through October, when stream flows are at the annual lowest level, there was still relatively active rafting use occurring on the Upper and Middle Sections of the White Salmon River. This represents a management challenge. The figure does, however, reveal that during the sample period there was very little rafting use occurring on the lower Section of the river during these same periods.

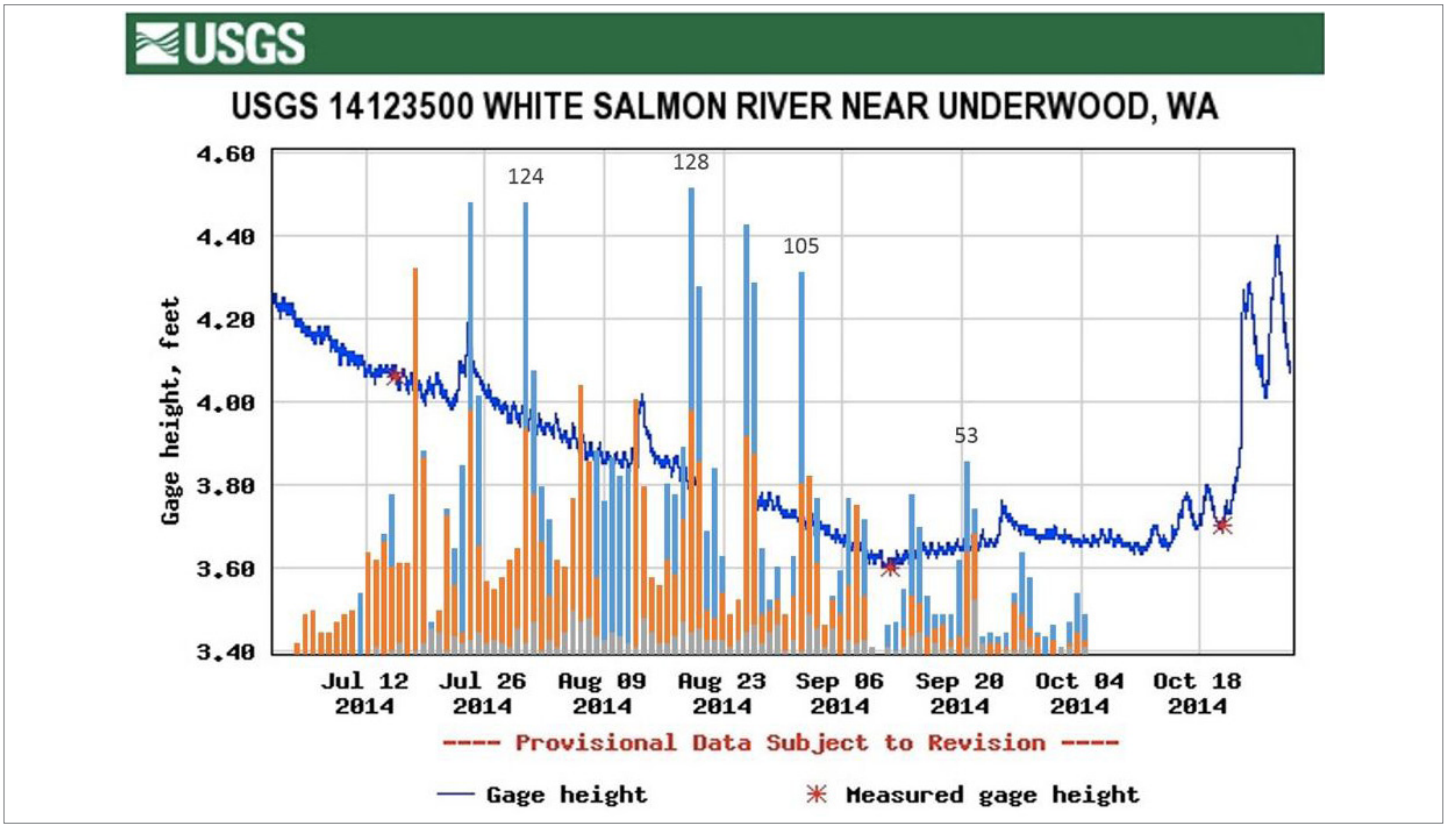

FIGURE 22 - Stream stage height (y-axis) and rafts by River Section
(Blue Upper Section, Orange Middle Section, Grey Lower Section – not to scale – x-axis)

WHEN DO BOATING ACTIVITIES COINCIDE WITH SALMON SPAWNING ACTIVITIES?

In order to compare the Fall Chinook run survey data of redd construction, to rafting use the river, we used the spawning survey data collected on 9/18/2014 & 10/2/2014, as those dates fell within the boating sampling period ending October 5th (WDFW 2014). An evaluation of Figure 24 indicates that no Fall Chinook salmon were identified in survey sections 1, 2, 3, 4-1 or 4-2 (except for a single fish in section 1 during the first survey which was likely a spring Chinook salmon), and coincided with the Upper and Middle Sections of the river. The vast majority of salmon, as high as n=202 redds, were found along the lower Section (survey sections A,B,C,D) of the river below or just above the old dam site, which is the section of river receiving the least rafting use (See Figure 23).

FIGURE 23 - Map of Fall Chinook Salmon redd surveys (WDFW 2014)

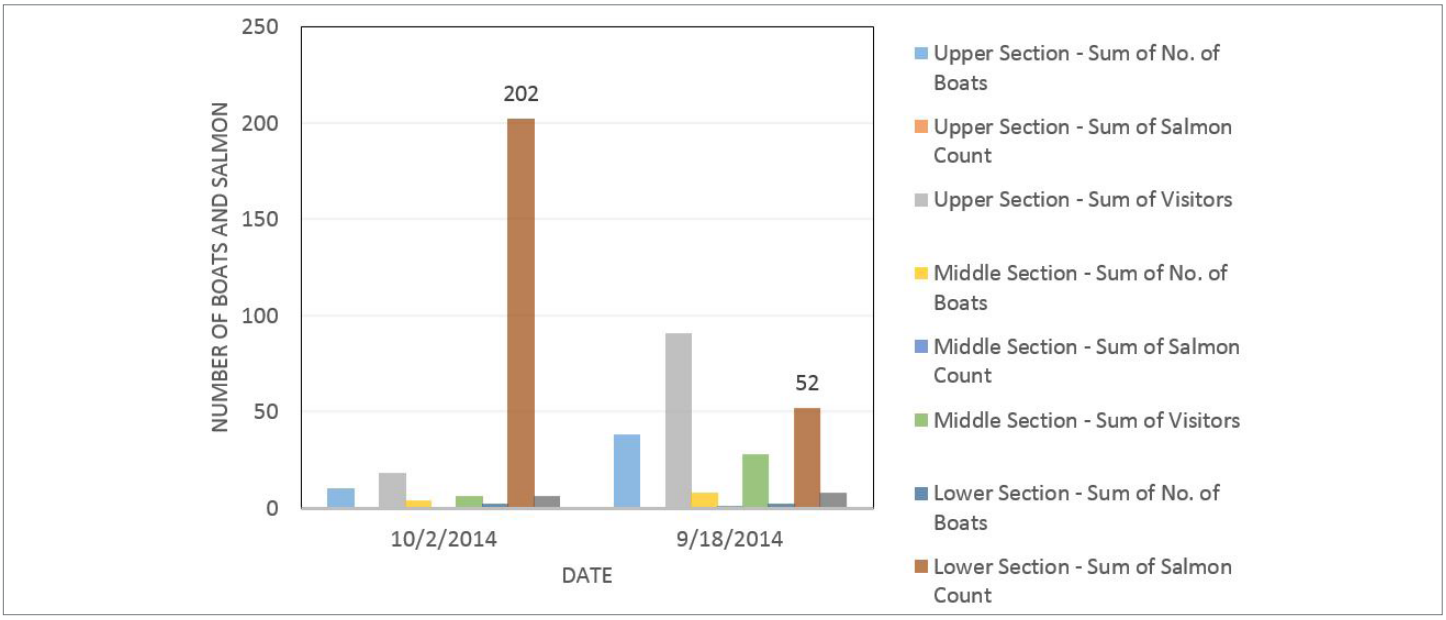

FIGURE 24- Relationship of Boats to Salmon for Chinook Sampling Period

FIGURE 25 - Spirit Falls on the White Salmon River (Spirit Falls (c)Jeff Hollett, CC BY-NC-SA 2.0)

DISCUSSION AND CONCLUSIONS

The purpose of this study was to collect baseline data to determine if the spatial and temporal patterns of water-based recreation overlap with Chinook salmon spawning behavior, and how these processes spatially and temporally overlap with fluctuating hydrological conditions on the White Salmon River. We found that the White Salmon River received nearly 30,000 visitors from June 30, 2014 to October 4, 2014. There were over 5,010 rafts and 4,317 kayaks observed during this time period. This number is likely slightly larger, as there was a gap in the data for several days during the sampling due to technical difficulties. It is safe to say that the White Salmon River was receiving high levels of use during the summer season of 2014. With this information, keeping in mind how use was distributed between users and different sections of the river, this begs a discussion about addressing the difficult question of, how much use, is too much use? Is this amount of use sustainable, or will it have harmful effects on the river ecosystem and ultimately, the Chinook salmon? Could this level of use create conflicts between recreational and commercial users derived from competition for a shared resource?

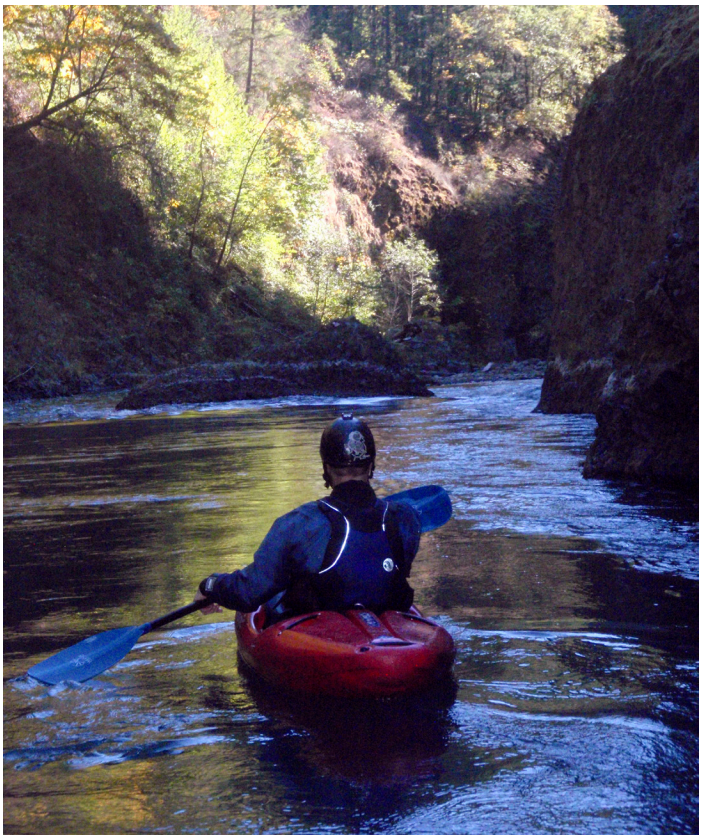

FIGURE 26 - A solitude kayaker on the lower section of the river

FIGURE 27 - Bottom of Big Borther Falls White Salmon River
(Bottom of Falls (c) Andrew Morrissey, CC BY-NC-SA 2.0)

To put the boating use levels on the White Salmon River in perspective, about 26,000 people raft the Colorado River from Lee's Ferry to Diamond Creek each year on permitted trips (Jackson 2012). This includes both private and commercial users. Additionally, approximately 10,000 people float the popular Middle Fork of the Salmon River as it flows through the Frank Church River of No Return on Wilderness, in Idaho on permitted trips as well (Middle Fork 2015). The Hells Canyon National Recreation area on the Snake River is a permitted river with a 112-day primary boating season. Permitted use allows 224 commercial launches from eight outfitter guide companies from the Hell's Canyon Creek. The maximum allowable is 8 floatcraft/party with a maximum of 24 persons (including river guides) (U.S.D.A 1999). The Lower Deschutes River has daily and seasonal targets for boaters established by river segment. Those management targets range from as low as n=325 and n=19,600 on river section 4 to the highest range on river section 2 of n=1,700 and 74,100 (U.S.D.I 1993).

The White Salmon River is a heavily used rafting and kayaking river with the Forest Service being the permitting agency for the commercial rafting companies. The river management strategy is to allow every person desiring to float the river, whether commercial guide or private boater, would have equal opportunity to do so. Boaters do not have to compete for a river permit to run the river (U.S.D.A 1991). Although the visitors on the White Salmon River are only on the river for a few hours during the day, users on the Colorado River are staying for two or more weeks. The White Salmon is also a much shorter river in length and width than the Colorado and as a result use is more concentrated, with greater intensity for a short period of time. Although this amount of use is not sustained for the whole year and begins to decline at the end of August, early September, the peak river running season coincides with spring and fall salmon runs.

The ultimate question we aim to pursue is, does water-based recreation alter Chinook salmon spawning behavior in the White Salmon River? This study was not set up to answer this question, so at this point in time we cannot say one way or the other. However, based primarily on the Fall Chinook Salmon spawning survey of 2014, the majority of documented redds were located on the lower Section of the river, or the Section with the least amount of rafting use. So, at this point there is little to no overlap between rafts and salmon. The Salmon are still in the process of returning to the habitat above the dam site that was inaccessible to them for almost a century. Spring Chinook spawn earlier than fall chinook, but so far in very low numbers. This is the population with the greatest potential overlap with recreational use, since they tend to spawn higher up in drainages (putting them in the Upper and Middle Sections) and they start in August. Surveys have revealed that each year their numbers have been increasing. Until further research is conducted that specifically looks at the spawning of the Chinook salmon in the White Salmon River, little if any conclusions can be drawn about the potential impacts that recreational boating is having on their behavior. As the river bed continues to change and reveals more preferred gravel beds for reproduction, the Middle Section of the river could provide more attractive spawning grounds for salmon. There may be critical periods of time and spatially explicit locations, when stream flows are low, salmon reproductive times are high, and when the rafting use is still at relatively sufficient levels. More discussions need to focus on these interactions as it pertains to the long term viability of the salmon population.

This study has provided a spatial-temporal view of boating use on the White Salmon River. River use patterns on the White Salmon are spatially and temporally diverse. These patterns change over the boating season in response to stream flow conditions. Understanding these patterns in relationship to the changing patterns of the river and understanding more about how the salmon are adapting to these conditions is critical to a sustainable future for those that live, play and depend on the river. The greatest challenge in the near future will be to engage the White Salmon River community and the fishery managers in an open, meaningful collaborative process to develop alternative management solutions that incorporate the needs of all stakeholders. The future collaboration among stakeholders is necessary to ensure the protection and successful reintroduction of salmon species into the White Salmon River and to foster a community and ecosystem that is resilient to the impacts of future change.

FIGURE 28 - Down the Narrows on the White Salmon River (Down the Narrow (c)pixgood.com, CC BY-NC-SA 2.0)

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