Current status and dam operation effects for mainstem spawning fall Chinook salmon in the lower McNary Dam tailwaters, upper John Day reservoir, and John Day Dam tailwaters.

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Joseph J. Skalicky
Donald R. Anglin

U.S. Fish and Wildlife Service
Columbia River Fisheries Program Office
1211 SE Cardinal Court, Suite 100
Vancouver WA, 98683

Prepared for:

The U.S. Army Corps of Engineers
Walla Walla District
201 North 3rd Avenue
Walla Walla, WA 99362

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Summary

The purpose of the study was to assess current levels of fall Chinook salmon (*Oncorhynchus tshawytscha*) spawning below both John Day and McNary dams and to make preliminary assessments of spawning habitat below McNary Dam. The construction of John Day Dam created a reservoir 122 kilometers long and inundated one of the most prolific spawning sites for fall Chinook salmon in the Columbia Basin. However, tailrace habitats in the Columbia and Snake rivers can provide some level of suitable spawning habitat as evidenced by redd surveys. Documented spawning of fall Chinook salmon has occurred below both John Day and McNary dams. From 2002 to 2005, four years of Bonneville Power Administration research funding resulted in an average estimate of 1,133 redds below John Day Dam. In 2004, a reconnaissance survey conducted below McNary Dam identified six redds even though less than three percent of the area was surveyed.

In FY2011, the U.S. Army Corps of Engineers (USACE) funded deep-water fall Chinook redd surveys below John Day and McNary dams resulting in counts of 221 and four redds, respectively. Expanded estimates were only possible for the John Day study site where 1,891 redds were estimated to have been constructed. Redds mapped below John Day Dam were distributed in clusters in locations similar to redds surveyed from 2002 to 2005. The four redds mapped below McNary Dam were located in cobble patches just upstream of the Highway 395 bridge, and no redds were observed downstream from the bridge. The redd count and total redd estimates below John Day Dam are the highest on record while the count below McNary should be considered a minimum given the large survey area. Neither dam's boat restricted zone was accessible during the survey period. Throughout the McNary tailrace study site substrates were assessed, and large patches of bedrock not suitable for spawning were present over approximately 40% of the survey area. With the work competed in fall 2010, future surveys can now focus on areas where there is some potential for spawning to occur based on suitable depth and substrates, and these surveys may result in the first quantitative redd counts and estimates of spawning below McNary Dam.

U.S. v. Oregon (302 F. Supp. 899) legally upheld the Columbia River treaty tribes reserved fishing rights. The parties to the settlement (Parties) have recently proposed a new mitigation level to the USACE relative to the long-term restructured John Day and The Dalles mitigation. The Parties concluded that the appropriate level of mitigation responsibility from both projects is the adult production level equivalent of a minimum of 65,000 natural spawners, whereas the current level of mitigation is only 30,000 adult fall Chinook. The identification and enumeration of existing fall Chinook redds and assessment of current and drawdown spawning habitats below both projects will be integral to future mitigation discussions.

Acknowledgements

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Introduction

This report describes work contracted by the U.S. Army Corps of Engineers (USACE), Walla Walla District as part of a three-year study to assess fall Chinook salmon (*Oncorhynchus tshawytscha*) spawning levels and available habitat below John Day and McNary dams. Project funding was only available for the first year of the study.

The upriver bright stock of fall Chinook salmon in the Columbia Basin predominantly spawns and rears in mainstem corridors and habitats. The majority spawn in the last significant unimpounded section of the Columbia River known as the Hanford Reach which is located immediately upstream of McNary Dam and its reservoir. The construction of the Columbia River hydrosystem unquestionably removed some of the most valuable mainstem spawning grounds for fall Chinook (Fulton 1968). The Columbia River, under what is now John Day Reservoir, was one of these historically used sites. The construction of John Day Dam in 1968 created a reservoir 122 river kilometers (rkm) long and effectively eliminated the vast majority of fall Chinook spawning habitat in this river section. However, spawning habitat is still present for a short distance downstream from most of the mainstem Columbia River dams. Documented fall Chinook spawning in Columbia River tailrace habitats has occurred below Bonneville, John Day, Wanapum, Rock Island and Wells dams (Mueller 2004; Skalicky 2009; Mueller et al. 2008; Horner and Bjornn 1979; Giorgi 1992).

Hydroelectric development of the Snake and Columbia rivers has transformed most of the mainstem riverine habitats into a series of reservoirs with low velocities which has contributed to declines in fall Chinook populations (Dauble et al. 2003). As such, remnant and newly discovered spawning populations could be protected through sound management practices. Documented spawning of an unidentified stock of fall Chinook salmon has occurred below both John Day and McNary dams (Skalicky 2009). Four years of research funded by the Bonneville Power Administration resulted in an average estimate of 1,133 redds below John Day Dam (Skalicky 2009). Elsewhere on the Columbia River, spawning fall Chinook and chum salmon benefit from specific hydrosystem operations (HRFCPPA 2004, Bonneville Power Administration et al. 2010). These operations typically last from three to four weeks during the fall spawning season in November (HRFCPPA 2004). No specific operations exist below John Day Dam where a significant number of redds have been identified. We hypothesize that the net production of fall Chinook salmon below both of these projects may be limited by hydrosystem operations.

Study Area

The Columbia River is the second largest drainage in the United States and supports a wide range of natural and human interests including hydroelectric power production, flood control, irrigation, navigation, native and non-native fish stocks, and sport, commercial and tribal fisheries on those stocks. The former free-flowing Columbia River is now a sequence of slack-water reservoirs with the exception of the Hanford Reach and a tidally influenced section which extends from Bonneville Dam to the Pacific Ocean. The hydrodynamic conditions of the

Columbia River are largely influenced by their respective reservoirs, rather than functioning as a free flowing river. The geographic extent of the work conducted for this report includes the tailraces of both John Day and McNary dams (Figure 1).

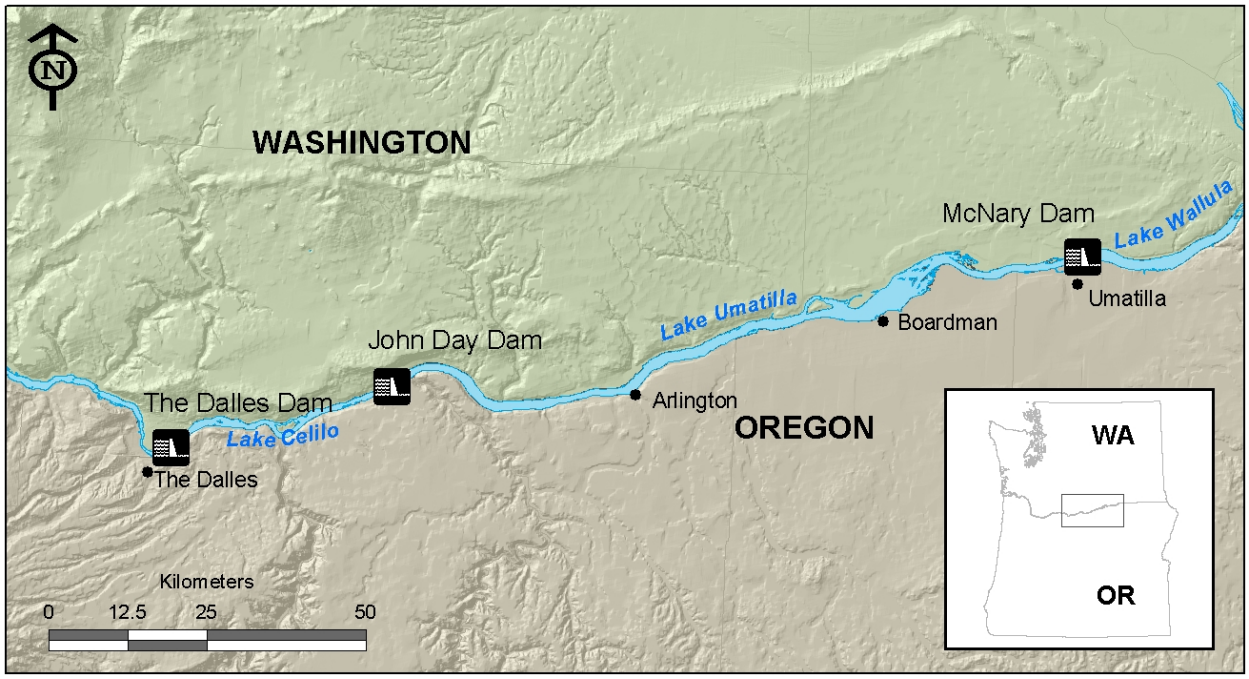

Figure 1. Overview and locations of The Dalles, John Day, and McNary dams and their respective impoundments.

John Day Dam Study Area

The John Day Dam study site is located just downstream of the dam from rkm 346 to 349 (Figure 2). The study site is bisected by a small gravel island 1.8 rkm below the dam, and by the large eddy (Preachers Eddy) located immediately downstream of the island. The north half of the tailrace study site lies adjacent to the Washington shoreline, contains the navigation locks and shipping channel, and is immediately downstream of the spill gates. The southern half of the tailrace study site is bounded by the Oregon shoreline and is immediately downstream of the powerhouse (Figure 2). Fish ladders are located along both shorelines at either end of the dam.

Figure 2. Aerial view of John Day Dam and the downstream study site.

McNary Dam Study Area

The McNary Dam study site is located at the next dam upstream from John Day Dam, and is the larger of the two sites. McNary Dam is located at approximately rkm 470. Prior to dam construction, fall Chinook salmon were historically documented spawning in what is now John Day Pool (Fulton 1968). The study site extends from the dam, downstream four rkm past the mouth of the Umatilla River and Plymouth Island (Figure 3). The Umatilla River enters the Columbia River from the south near the downstream end of the study site and is adjacent to the city of Umatilla, Oregon.

Figure 3. Aerial view of McNary Dam and the downstream study site.

Methods

Redd Surveys

To identify, map, and count redds, a 6.5 m survey vessel was used with a bow-mounted davit and 24-volt electric hoist. The hoist and davit were used to deploy underwater video equipment and maintain a constant depth over the river bottom. The video equipment was deployed on an underwater sled adopted from Groves (1998) and weighted with two 22.7 kg lead fish. The sled was mounted with a low-light, high sensitivity underwater camera with two lasers mounted in parallel for scale reference when focused on the river bottom. In the vessel, two monitors, one for each of the survey crew, were used to identify fall Chinook redds and assess the associated habitat conditions. GPS receivers, accurate to approximately one meter were used for recording the geographic locations of all data.

To conduct and guide the underwater videography surveys below John Day Dam, a series of transects was plotted parallel to the river flow using our GIS. A transect spacing of 15 m was used to preclude surveying a single redd more than once from adjacent transects. The 15 m spacing also accounts for the accuracy of our GPS equipment, fall Chinook redd size, and the ability of our survey vessel to maintain an accurate position over each transect to within +/- 3 m. Below McNary Dam, a transect spacing of 45 m was used due the large size of the study area. In subsequent years and after accounting for unsuitable spawning substrates and depths, transect spacing will be decreased to 15 m over potential spawning locations.

To identify individual fall Chinook redds, several discriminating criteria that have successfully been utilized in the past were used in this study. Sharp, localized changes in bed topography, substrate sorting, variations in background contrast, and relative abundance of both periphyton and invertebrates were used in descending order of significance as the criteria to identify fall Chinook redds. These criteria have successfully been used in other fall Chinook redd surveys in the Columbia and Snake rivers (Mueller 2004; Visser et al. 2002; Groves 1998; Skalicky 2009). Substrate sorting occurs as similar sized substrate particles settle out of temporary suspension just downstream of salmon redds in distinct clusters or patches. The largest of these patches is known as the tailspill and can be very pronounced. However, the identification of tailspills or even entire redds can become somewhat difficult as the amount of time passes between the completion of a redd and the actual survey date. Additionally, if salmon redds are superimposed, identification of individual redds can become difficult.

Surveys were initiated by navigating to the downstream end of the first transect using GPS receivers with chart (transect) plotting capabilities. As the vessel operator held position on the downstream end of the transect, the hoist operator lowered the sled to a location just above the substrate with the lasers and river bottom in view. The vessel was then powered forward along the transect at an approximate rate of 0.7 m/s. As the vessel was powered forward along the transect into the current, the hoist operator adjusted the sled height over the bottom maintaining a relatively constant distance of about a meter over the substrate. When a redd was encountered, the vessel operator held a fixed position over the redd while it was assessed in real-time and its geographic position and habitat attributes were recorded on a GPS. Depth, dominant substrate,

subdominant substrate, and percent fines were recorded. Dominant and subdominant substrates were classified using a modified Brusven Index coding system (Delong and Brusven 1991). Substrate descriptions and class values are documented in Table 1 and percent fines in Table 2. Each transect was surveyed a single time and point measurements were made every 50 m along the transect to describe habitat conditions even if no redds were present.

Table 1. Substrate classes and size ranges used for classification during spawning surveys.

Code	Particle size (mm)	Particle size (inch)	Description
1	<6.3	<.25	Fines
2	6.30 - 25.4	0.25 - 1.0	Pebble
3	25.4 - 50.8	1.0 - 2.0	Gravel
4	50.9 - 76.2	2.0 - 3.0	Large Gravel
5	76.3 - 152.0	3.0 - 6.0	Cobble
6	150 - 300	6.0-12.0	Large Cobble
7	>300	>12.0	Boulder
8	NA	NA	Bedrock

Table 2. Percent fine codes and descriptions.

Code	Description
1	0 and 25 percent of substrate belongs to Substrate code 1
2	25 and 50 percent of substrate belongs to Substrate code 1
3	50 and 75 percent of substrate belongs to Substrate code 1
4	75 and 100 percent of substrate belongs to Substrate code 1

In addition to the underwater video camera, a side-scan sonar unit was used to assess large patches of bedrock in the study site. This assessment was not initially planned but became necessary to limit the amount of time the camera was deployed over the very hazardous bedrock areas while conducting redd surveys. Bedrock is highly irregular and the camera can easily become snagged along with the boat, which is dangerous in a moving water environment. The side-scan sonar unit cannot discriminate between smaller classes of substrate but works well for plotting large patches of bedrock at a scale appropriate for the Columbia River.

Redd Population Estimates

The analytical methodology conducted in our GIS analysis consists of tasks related to enumeration of redds surveyed in each redd cluster, delineating the spatial extent and total area of each redd cluster, and determining the actual proportion and percent of the whole cluster surveyed with transects. Once the ratio of the total area surveyed to the number of redds is calculated, that ratio is applied to the entire cluster area to estimate the total number of redds the cluster likely contains.

Data collected in the field for point locations of redds were first differentially corrected to an accuracy approaching +/- 1.0 m and then imported into the GIS. In the GIS, we plotted the locations of all observed redds for each survey along with the locations of the survey transects

and the actual path surveyed. These positions vary slightly, and it is also possible to drift laterally from one transect to an adjacent transect during a survey. This can potentially result in mapping a single redd twice. Within the GIS we reviewed these data, and redds that were recorded twice were corrected to a single observation.

Mainstem Columbia River spawning fall Chinook spawn in aggregations or groups resulting in "clusters" of redds. Redds within 15 m of one another and numbering more than 10 are usually considered a "cluster" (Anglin et al. 2006; Geist et al. 2000; Visser et al. 2002). We used these criteria to identify clusters and calculate a maximum convex polygon around the perimeter of each cluster using a GIS algorithm. With this information, the GIS was then used to determine the total area of the redd cluster which we defined as the total area used. A three meter buffer was added to this polygon since the center of each redd was mapped, rather than the distal edge.

The next analytical component required for the redd assessment was to determine the actual area surveyed within each redd cluster. In the GIS, we determined the length of each transect within each redd cluster and multiplied it by the camera's field of view or width. To determine the field of view width, we randomly assessed images and calculated the average field of view width. The lengths of survey lines falling within each cluster along with the widths were multiplied, then summed to determine the amount of riverbed surveyed within the cluster.

To complete the analysis, we calculated the ratio of area searched to redds observed. This produced an area/redd estimate which was then extrapolated to the entire area represented by the convex redd polygon (redd cluster). This analysis was conducted individually for each of the redd clusters. With this technique, we quantified the total area of each redd cluster, the amount or percent of each cluster that we surveyed with video, the area/redd estimate for the area searched, and the estimate of the number of redds in the entire cluster.

Results

Redd Surveys

Fall Chinook redds were successfully identified and mapped below both John Day and McNary dams in the fall of 2010. Redd mapping below John Day Dam occurred the week of 29 November 2010 and mapping below McNary Dam occurred during the week of 7 Dec 2010. A total of 221 and four redds were mapped below John Day and McNary dams, respectively (Figure 4 and Figure 5). All redds in the John Day site were located over cobble and gravel substrates with depths ranging from 2–8 m. Redds mapped below McNary Dam were located in depths ranging from 7–9 m, and cobble and gravel were the dominant substrates. Water velocities were not measured at either study site. Due to the presence of the avian deterrent lines

over the boat restriction zone (BRZ) at John Day Dam, the BRZ area could not be accessed and surveyed. BRZ surveys planned for the McNary study site were cancelled due to adverse weather.

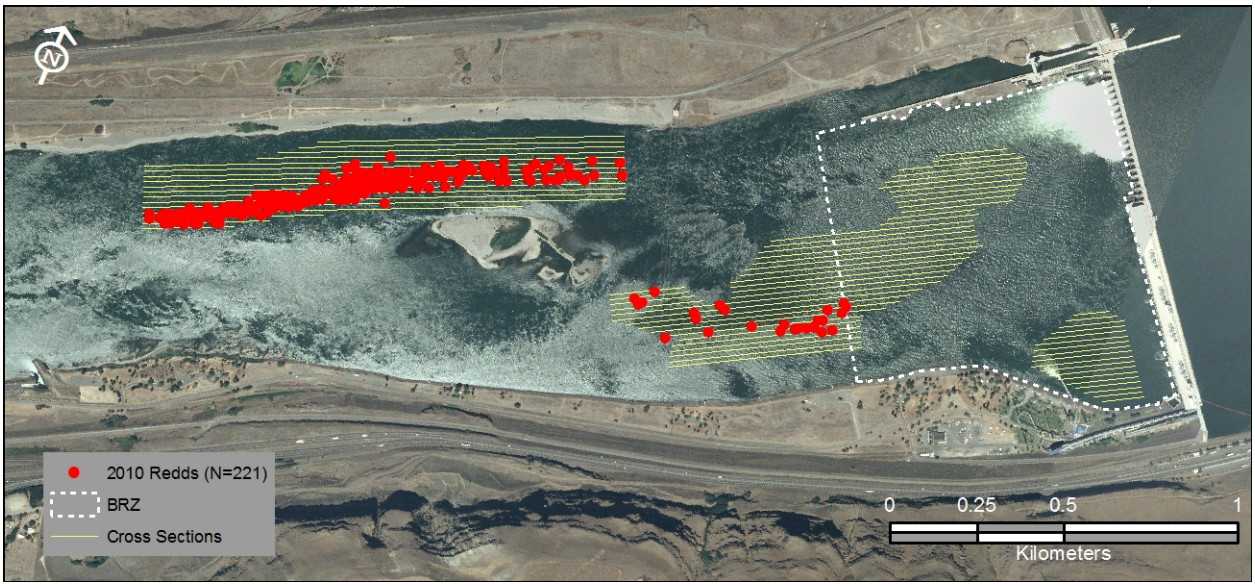

Figure 4. **Map depicting 221 fall Chinook salmon redds identified in the Columbia River below John Day Dam during fall 2010. Note that the transects extending into the BRZ could not be searched in 2010 due to the presence of avian deterrent lines. Transect spacing is 15 m.**

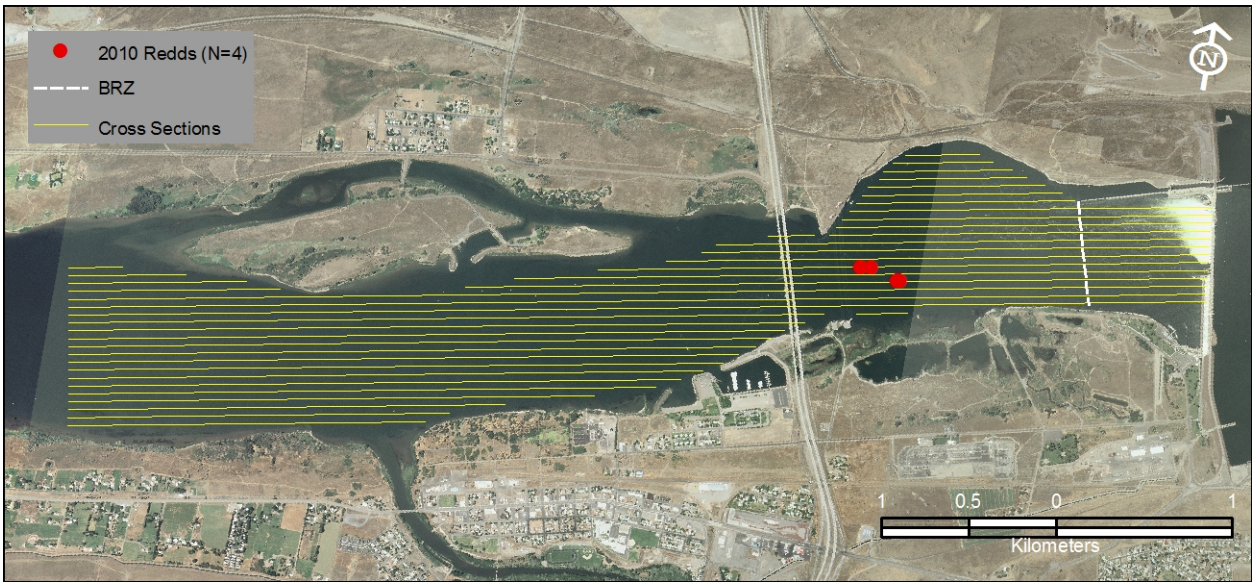

Figure 5. **Map depicting four fall Chinook salmon redds identified below McNary Dam in fall 2010. Transect spacing is 45 m.**

An assessment of substrate characteristics in the John Day study area was previously conducted by Skalicky (2009) and was not reassessed for this evaluation. In the McNary study area,

however, comprehensive substrate data had not been collected. Substrates were mapped while conducting the redd surveys throughout the entire study site except for the BRZ. Figure 6 depicts the distribution of suitable substrates throughout the study site for fall Chinook as well as the distribution of the large unsuitable bedrock patch mapped with side-scan sonar. The large bedrock patch accounted for approximately 40% of the study area. Figure 7 depicts the locations of each of the 614 substrate measurement points located along the transects.

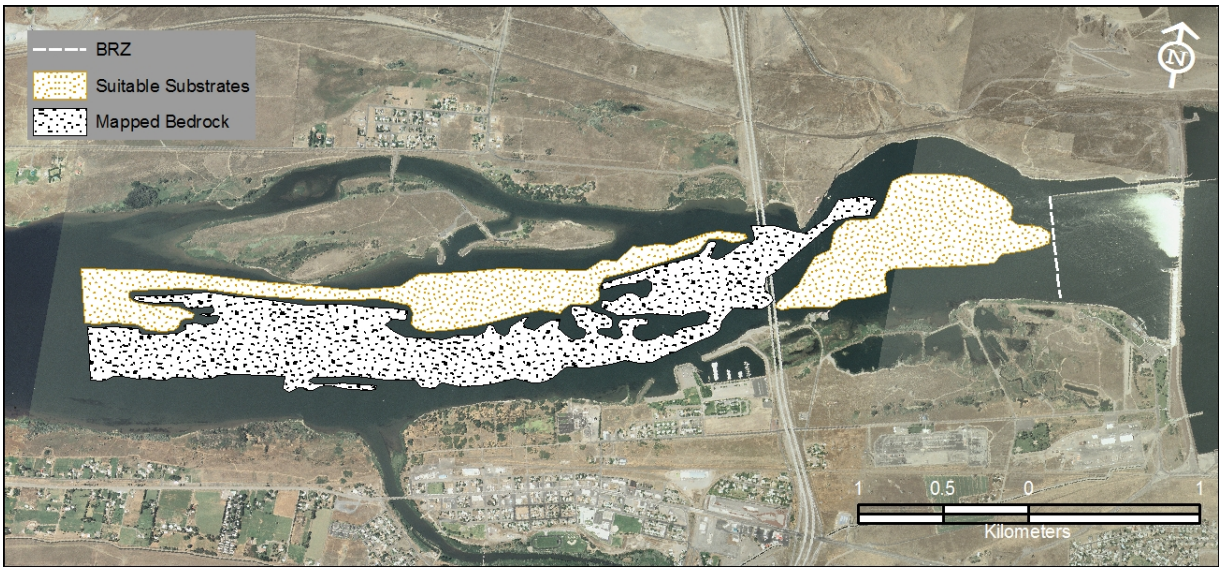

Figure 6. Distribution of suitable fall Chinook spawning substrates (cobbles and gravels) and unsuitable bedrock substrate mapped with side-scan sonar below McNary Dam.

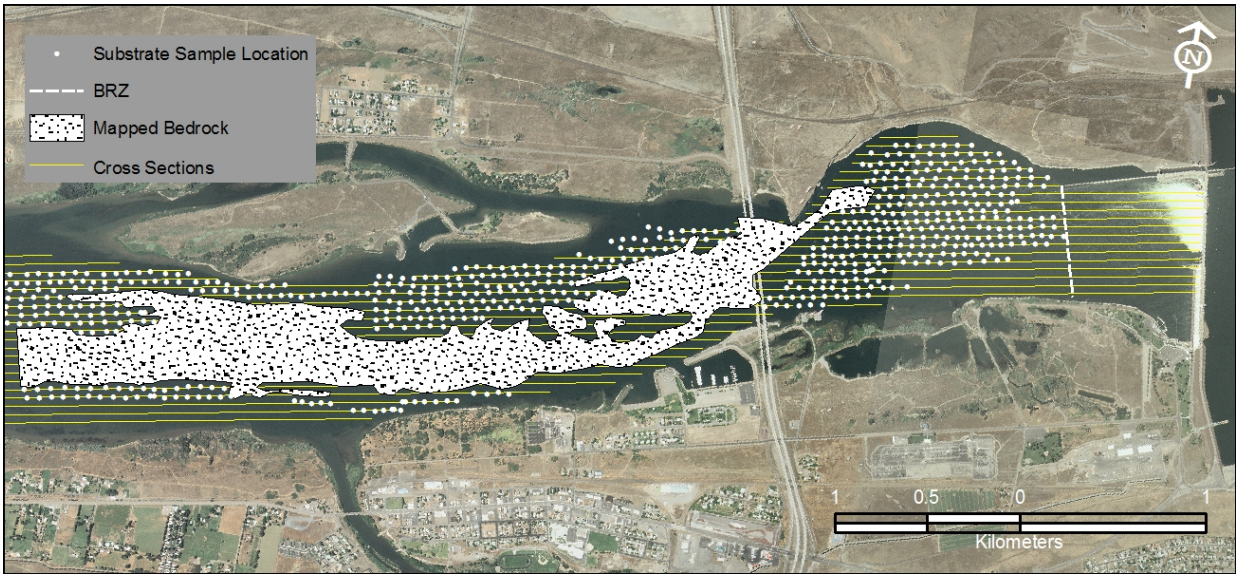

Figure 7. Survey locations of 614 substrate point measurement sites assessed with underwater videography below McNary Dam. The distance between each point is approximately 50 m.

Fines where mapped at each of the 614 measurement points, and 98% of the measurements fell within the 0-25% category, which equates to higher quality spawning habitat with less embedded substrates. Percent fines and substrates in areas less than approximately 1 m in depth were not surveyed. Outside of the large bedrock patch mapped in the center portion of the river channel, substrates were variable but were primarily composed of cobble and gravel (Figure 8).

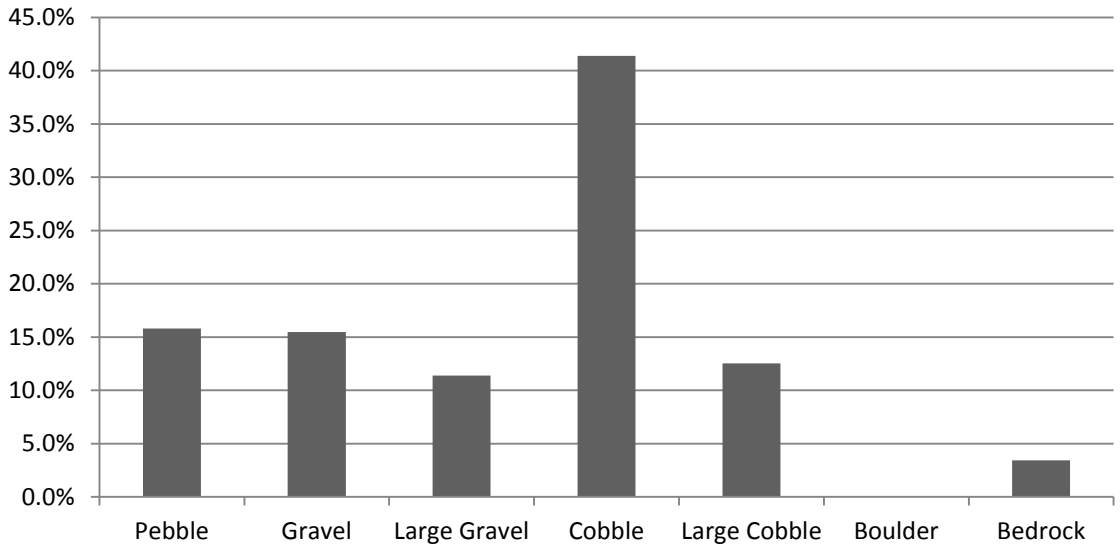

Figure 8. Proportions of dominant substrate types mapped in the McNary Dam tailrace study site for 614 point measurements. These measurements are outside of the large bedrock patches depicted in Figure 7 and do not include areas less than 1 m in depth.

Redd Population Estimates.

For the two redd clusters mapped below John Day Dam in 2010, we calculated the total area (m^2) of each cluster. The redd clusters represented the total area used by spawning fall Chinook at this study site, and serve as the basis for our spatial extrapolation and calculation of a total redd estimate. The redd cluster along the Washington shoreline was larger than the Oregon shore cluster. Within each redd cluster, the actual area of the bottom imaged by the camera ranged from 11.6–11.7 % of the total cluster area. This percentage, along with the number of redds observed resulted in a total redd population estimate of 1,891 redds (Table 3). Since only four redds were mapped below McNary Dam and 45 m transect spacing was used, a total redd population estimate was not possible at this study site.

Table 3. Data used to calculate total redd estimates for the 2010 fall Chinook redd surveys in two distinct redd clusters mapped below John Day Dam.

Variable	Washington Channel Redd Cluster	Oregon Channel Redd Cluster
Transect Length Sum (m)	8,671	4,063
Transect Area Surveyed (m^2)	15,174	7,110
Redd Cluster Area (m^2)	129,757	61,264
% Area Searched	11.7%	11.6%
Redds Observed	196	25
Ratio - Area Surveyed/Redds Observed	77.4	284.4
Redd Cluster Population Estimate	1,676	215
Total John Day Tailrace Redd Estimate	**1,891**	

Discussion

Both the direct fall Chinook redd counts and the expanded redd estimates for the John Day Dam tailrace study area are the highest on record and correspond to high fish ladder window counts at the mainstem dams during fall 2010. Counts of adult fall Chinook passing John Day and McNary dams in 2010 were the second highest and highest counts respectively, since 1990. Below John Day Dam, the survey data suggest that additional redds are likely present and continue into the BRZ along the Oregon shore. In the McNary BRZ however, data collected by Mueller et al. (2010) indicated that the substrate sizes are too large and outside the suitable range for fall Chinook use. Even though only four redds were counted below McNary Dam, additional redds were likely present and possible missed due to the relatively coarse 45 m transect spacing. However, it is not likely that a very large number of redds were present in the fall of 2010 considering the total amount of area assessed with only four redds observed. Further, the large patches of bedrock pose a significant limitation with respect to the amount of available spawning habitat. It is likely, but unknown, that a significant amount of suitable habitat could exist further downstream into the reservoir near the former island complexes. Additional assessments and modeling of fall Chinook spawning habitat would be required to determine both the amount and the quality of habitats available for a range of alternative hydrosystem operations. Currently, the resources are not available to conduct the required spawning habitat assessments.

The large patches of bedrock mapped below McNary Dam were recorded with a side-scan sonar unit. The side-scan sonar work was not included in the original study plan, but having the equipment installed and available on the survey vessel worked to the project's advantage for efficient, large scale mapping of this unsuitable substrate type. Conducting redd surveys and/or substrate surveys with an underwater video camera over irregular bedrock is dangerous to both the video equipment and the survey vessel because of the potential to snag the equipment on the irregular river bottom. While not conducive to discriminating between cobble and gravel substrate classes, the side-scan sonar unit works well for mapping large patches of bedrock.

The origin of the fall Chinook that are spawning below John Day and McNary dams is unknown, but several possibilities exist. These Chinook could be stray fish originating from a naturally

spawning upriver bright stock such as the Hanford Reach stock, or they could actually be vestiges of the fall Chinook population that historically spawned in the 160 km section below the Snake River confluence with the Columbia as cited by Fulton (1968). A third possibility is that these Chinook could be hatchery strays from upriver facilities. And finally, these fall Chinook could be a combination of stocks from each of these sources.

To date, no specific hydrosystem operations have been developed or implemented to enhance existing spawning habitat, or provide new, or more stable spawning habitat for the fall Chinook spawning below John Day or McNary dams. There may be several options for increasing the amount of spawning habitat below these two projects. These options include restoring the upstream portion of the reservoirs to a more normative riverine condition through a temporary (2-3 weeks) drawdown of each of the pools. This could result in a substantial increase in both the amount and quality of fall Chinook spawning habitat in these two river sections by returning conditions to those of a free flowing river.

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