Snake River Fall Chinook Redd Surveys: A Summary of 22 Years (1991 – 2012)

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Intensive spawning surveys of Snake River fall Chinook salmon were initiated in 1991, and have been continued through 2012. These surveys have been a cooperative effort among several agencies and private interests, and are expected to continue well into the future. The groups most directly involved are the Idaho Power Company, the Nez Perce Tribe, the U.S. fish and Wildlife Service, and the Washington Department of Fisheries. However, several other state and federal agencies assist by providing valuable insight and feedback, as well as variable amounts of funding. The highly cooperative nature of these monitoring efforts has led to the continued success of our program.

Surveys occur each season within the Snake, Clearwater, Grande Ronde, Imnaha, Salmon, and Tucannon Rivers, as well as in several smaller tributaries to the Grande Ronde and Clearwater (Connor et al. 2011; Arnsberg et al. 2012). Surveys along the Tucannon are accomplished by foot, while aerial surveys are conducted along the other rivers and their tributaries (Milks et al. 2005; Connor et al. 2011). Additionally, deep-water video surveys are conducted in areas of the Snake River where habitat occurs at depths too deep to be observed from the air (Connor et al. 2011); it continues to be the consensus among biologists familiar with the region that deep-water habitat is most prevalent within the main Snake River.

In brief, aerial surveys typically take place throughout the spawning season, and deep-water video searches occur from mid-November (just after peak spawning) through early-December. Foot surveys along the Tucannon also occur throughout the spawning season. From 1991 through 2009 aerial surveys typically occurred each week during a seven to eight week period from mid-October through early-December. However, safety concerns, primarily due to a fatal helicopter accident during a similar redd survey being undertaken by Idaho Fish and Game personnel (not associated with our fall Chinook monitoring), prompted us to reduce our aerial surveys to four each season. Presently, aerial surveys are conducted every other week during the spawning season (Connor et al. 2011). This same accident also initiated an interest in testing and developing the use of a small unmanned air system (sUAS) for conducting aerial surveys.

Redd surveys have been useful for several reasons. Primarily the interested parties are most concerned with the potential capacity for spawning, the temporal and spatial distribution of spawning, and the protection of spawning and incubation throughout the basin. In general, our monitoring has shown a clear trend in the increase in the total number of redds counted throughout the basin, which corresponds to the total number of adults estimated to escape past Lower Granite Dam (Figure 1). Within the various contributing river systems, the highest total redd counts have been: Snake River – 2,944; Clearwater River – 1,958; Tucannon River – 541; Grande Ronde River – 303; Imnaha River – 132; and the Salmon River – 60. It has been noted that as the population has increased in recent years, the redd to adult relationship tends to flatten out (Figure 2). This has proven a concern, as it could indicate that habitat capacity is being attained. However, this is not necessarily the case. During recent years, it has become increasingly difficult to obtain accurate counts of redds, especially in the Snake and Clearwater Rivers. The gregarious nature of fall Chinook salmon results in an increasing amount of redd superimposition, as well as redds being constructed in close proximity to each other that blend together and appear as single, large redds (Figure 3). As the spawning season progresses, earlier spawning females perish, or have more difficulty protecting their redd territories. This can result in later spawning females spawning on top of older redds, or very close to older redds. Both superimposition and redds in close proximity (and blending together) makes it difficult for the biologists to keep accurate track of individual redds (Groves et al. 2013).

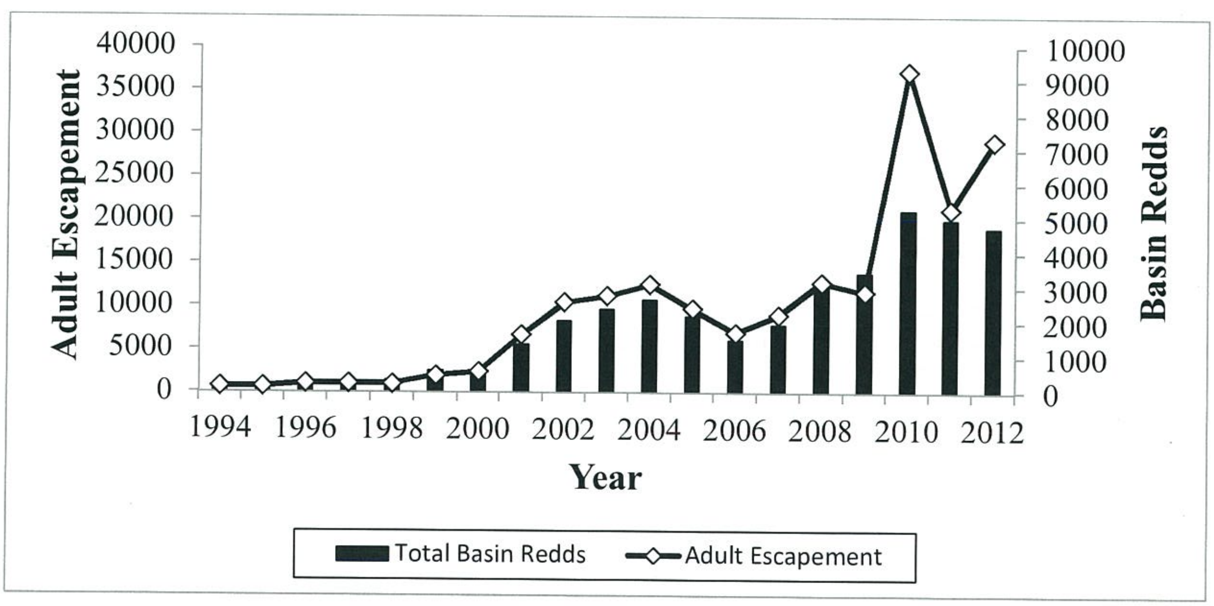


Figure 1. Estimated adult escapement and corresponding total basin redd counts for the Snake River, 1994 – 2012.

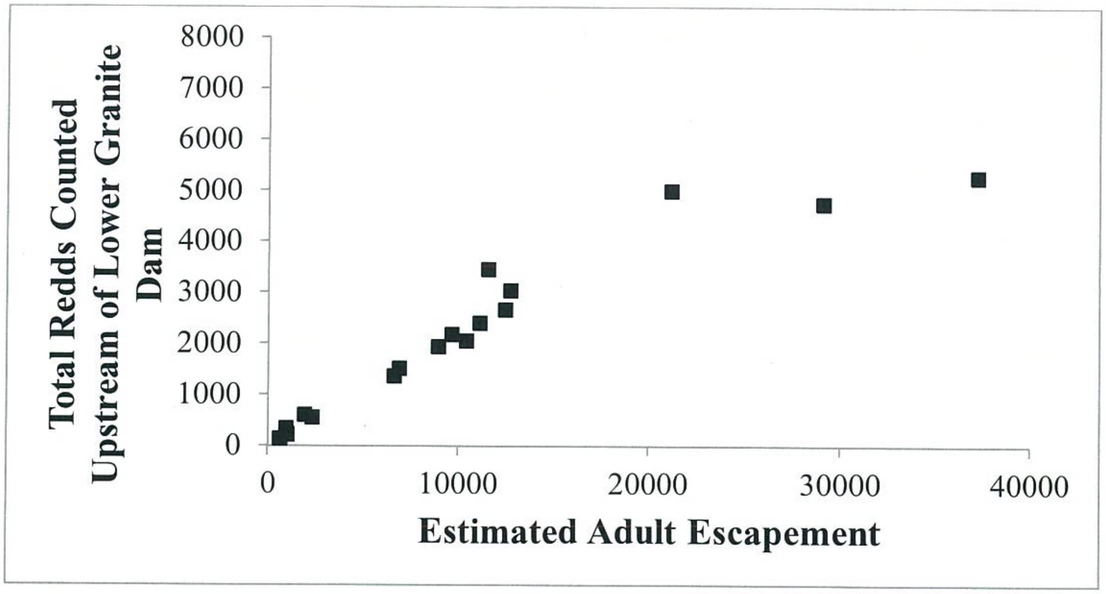


Figure 2. Trend of total basin fall Chinook redds dependant on the estimated adult escapement to the Snake River spawning grounds, 1994 – 2012.

Figure 3. A massive spawning cluster documented on the north shore of the Clearwater River, near the Nez Perce Tribal fish hatchery. Fall Chinook redds span the center of the photograph, from the right (upstream) to the left (downstream) edge of the photograph. Near the center of the spawning cluster a significant amount of superimposition has occurred, making it difficult to obtain an accurate count of the total number of redds present throughout this spawning area. (Photo courtesy of the Nez Perce Tribe)

The intensive aspect of our monitoring program has also resulted in a more detailed understanding of the spatial and temporal distribution of spawning throughout the Snake River Basin (Garcia et al. 2009; Garcia et al. 2010; Connor et al. 2011). Within the Snake, Grande Ronde, Tucannon, and Imnaha Rivers, spawning typically begins during mid-October, peaks during the first week of November, and is completed by the end of the first week of December (Garcia et al. 2009; Garcia et al. 2010). Within the Clearwater River, spawning tends to start earlier (sometimes by late-September), but generally peaks and is complete during a time-frame that is similar to the other river systems within the basin (Garcia et al. 2009; Garcia et al. 2010). Spatially, and at a large scale, the distribution of spawning among the major river systems has remained relatively stable throughout the past 19 years (1994 – 2012), with 54% occurring in the Snake, 27% within the Clearwater, 10% within the Tucannon , 8% within the Grande Ronde, 2% within the Imnaha, and 1% within the Salmon (personal communication, Debbie Milks, Washington Department of Fish and Wildlife; Milks et al. 2005; Garcia et al. 2009; Garcia et al. 2010). Within the Snake River we have documented 231 distinct patches of spawning habitat throughout the entire 100 mile reach between Asotin, WA, and the Hells Canyon Dam (Figure 4).

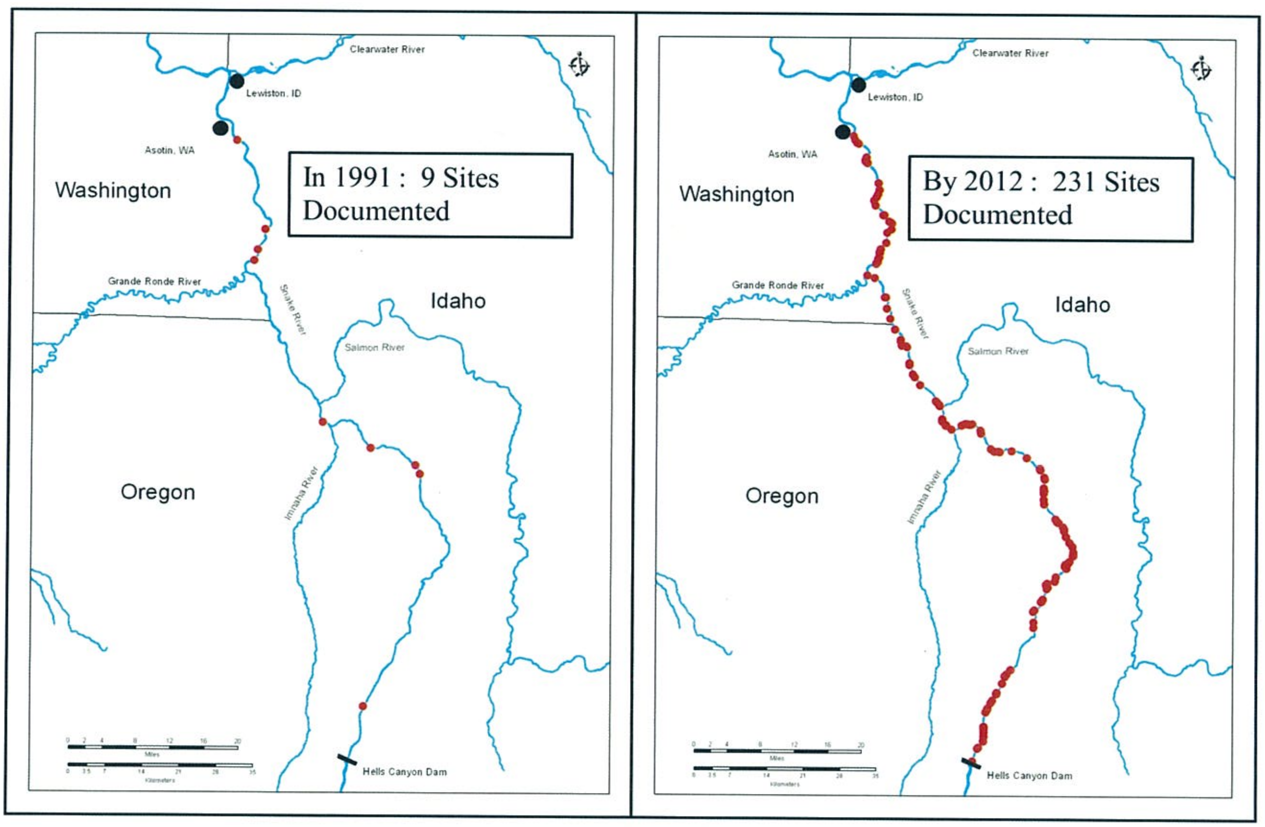


Figure 4. Comparison of the number of distinct spawning sites documented in 1991, compared to the total number of distinct spawning sites documented by 2012, within the Snake River between Asotin, WA and the Hells Canyon Dam.

One initial aspect of our spawning monitoring program was the need to locate redds and collect data describing specific habitat use parameters (e.g. depth, velocity, substrate), and to create habitat use curves useful for modeling habitat capacity in a large river system. Our efforts corroborated past observations of fall Chinook salmon spawning in a large river system, validating that these fish tend to use habitats as deep as 10.0 m, and areas where water velocities tend to be as high as 2.1 m/s (Chapman et al. 1986; Swan 1989; Groves and Chandler 1999). These were important parameters to understand when modeling and estimating habitat capacity, especially for the Snake River.

The subsequent development of models of spawning habitat capacity has been a valuable product resulting from our redd survey program (Connor et al. 2001; Groves et al. 2013). An early physical habitat simulation model indicated that the capacity of the main Snake River is roughly 2,500 redds (Connor et al. 2001). This early model did not distinguish between shallow and deep-water habitats. A more recent estimate, based on our long-term redd count data, and a stock-recruit model (using adults as stock, and redds as recruits) estimated that the redd capacity of the Snake River is 2,976 (±1,077) for shallow-water habitat, and 1,466 (±976) for deep-water habitat (Groves et al. 2013).

For a single year total, the highest empirical count of redds within the Snake River has been 2,944, observed during 2010. This observation (as well as our models) indicates that the Snake River can support one recovery criterion designated for these fish – that is, enough spawning habitat is present to allow for a population of no fewer than 2,500 natural-origin adults to spawn within the Snake River (ICTRT 2007). Given a gender ratio of 1 female per 1.5 males (Milks et al. 2005), a population of 2,500 adults should produce 1,000 redds. Our empirical data exceeds the 1,000 redd criterion by almost 2,000 redds, and our modeled estimates (for shallow and deep water habitat combined) exceed the criterion by about 3,400 redds (Figure 5).

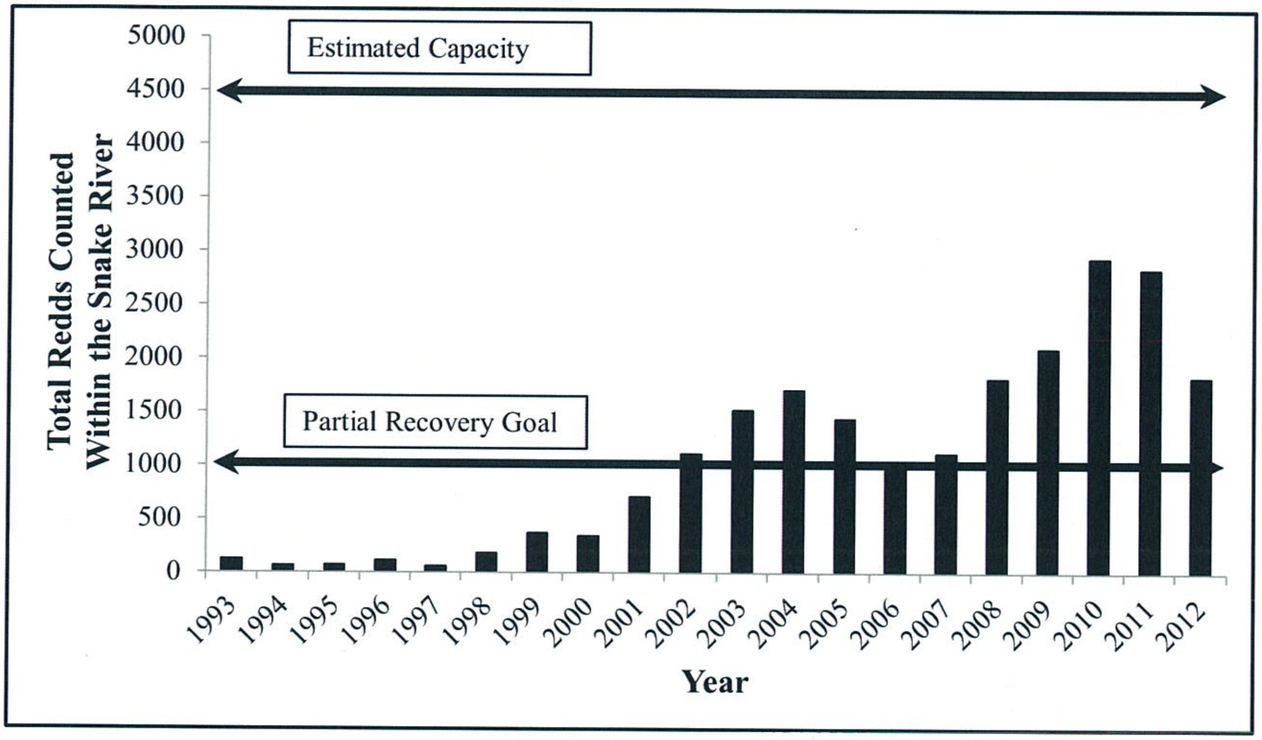


Figure 5. The total number of redds (solid bars; shallow and deep combined) that have been observed in the main stem Snake River (1993 – 2012), and the estimated capacity of the main stem Snake River, in relation to the partial recovery goal of 1,000 redds produced by a natural population of 2,500 spawning adults.

During our 22 years of intensive redd counts, the highest observed number of redds within the Snake River has been 1,972 in the shallow-water habitat (2011), and 994 in the deep-water habitat (2010). It has also been noted that the percent of spawning within shallow and deep habitat has remained rather static at 70% and 30%, respectively (Figure 6).

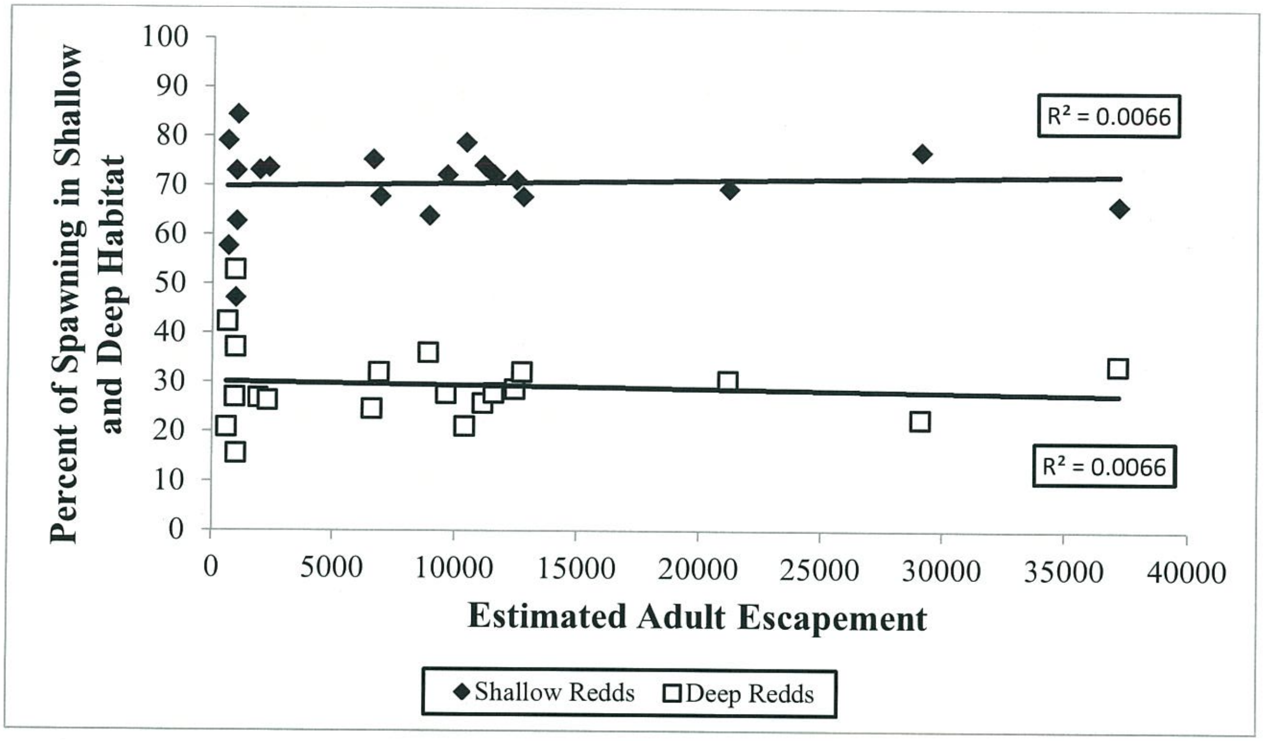


Figure 6. Relative percent of spawning within the main stem Snake River that occurs in shallow and deep water habitat, 1994 – 2012.

For the Snake River, a point of interest among our management agencies has continued to be the relative amount of spawning that occurs downstream and upstream of the Salmon River confluence. This is due in part because the general gradient and overall morphology of the Snake River tends to change radically at a point near the confluence of those two rivers. Upstream of the Salmon River, the Snake has a relatively higher gradient, has a more confined channel, and has considerably more areas of rapids (Groves and Chandler 1999). This concern is also predicated by the use of acclimation facilities and release points for juvenile hatchery fish that occur at points within the Snake River both downstream and upstream of the Salmon River confluence. Our annual redd count data for the Snake River indicate that the overall trend may be toward a slight increase in the percent of spawning upstream of the Salmon River confluence (Figure 7); however, the trend-line is driven by a single low point observed during 1993. Even with the 1993 data point, the mean percent spawning upstream of the Salmon River confluence has actually remained rather stable at 57% (+/- 6%).

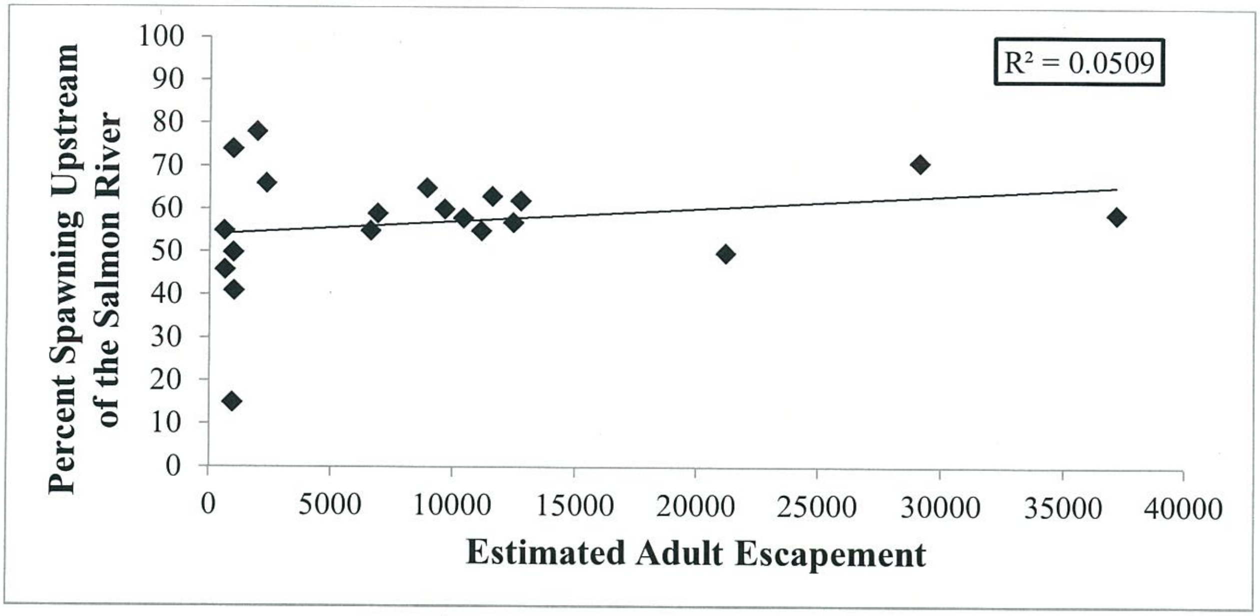


Figure 7. The relative percent of spawning within the main stem Snake River that occurs upstream of the Salmon River confluence, 1993 – 2012.

With respect to water management, during and post-spawning, redd surveys along the main Snake River have allowed us to identify what we term "critical" redds. These redds are in very shallow water, and would be at the greatest risk of dewatering if flows were to be reduced (Figure 8). Knowing where those redds are located, and understanding where they might be located, allows water managers to protect actual and potential critical redds.

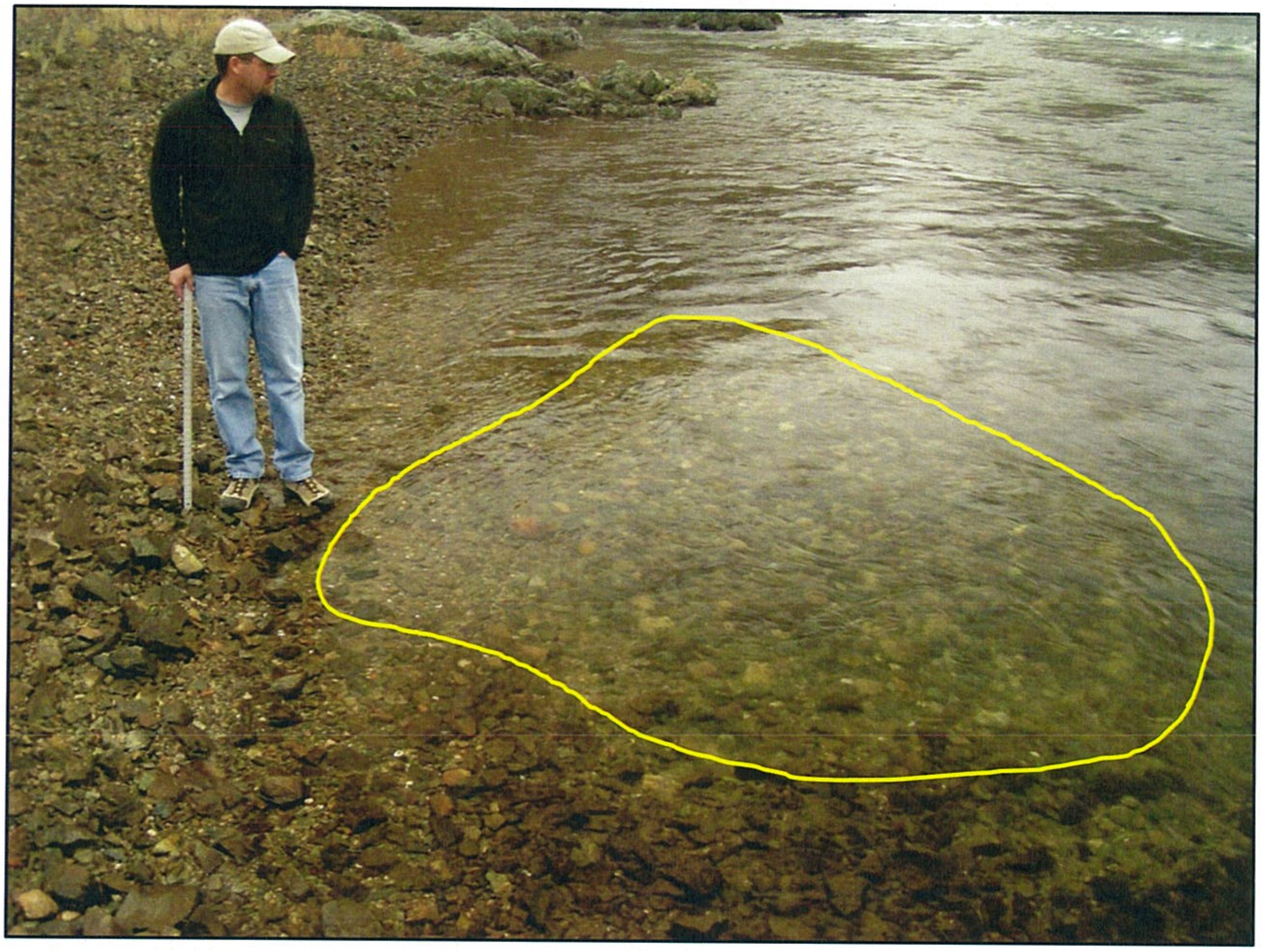

Figure 8. Biologist standing on the shoreline of the main stem Snake River, next to a critically shallow redd (outlined in yellow). Flow of water is from the bottom, toward the top of the photograph. Stable flows during the spawning period, followed by maintenance of a minimum flow throughout the incubation period (provided by the Idaho Power Company), reduces the risk of dewatering critically shallow redds. (Photo courtesy of Idaho Power Company)

Safety concerns in recent years have provided us with the opportunity to test the efficacy of a small unmanned air system (sUAS) for conducting our aerial spawning surveys. Our choice of sUAS has been a small multi-rotor platform. These craft are small, weighing less than 2.5 kg with a camera payload, and have the capabilities for autonomous waypoint flight, for hovering over designated positions, and for collecting either still photos or high definition video. During the fall of 2011 the Idaho Power Company tested a hexa-rotor platform (Figure 9a), and during the fall of 2012 a crew from the University of Alaska was contracted to test a similar quad-rotor platform (Aeryon Scout, Figure 9b). Both of these craft are small (diameters of about 1 m, height of about 0.3 m), and weigh less than 2.5 kg. Waypoints can be uploaded into the sUAS navigation chip and saved for future flights, and still photographs taken from these craft can be geo-tagged (Figure 10), and can be used for comparing redd development from week to week (Figure 11). As the Snake River fall Chinook population continues to increase, this type of data should prove useful in the future for describing and estimating redd superimposition, and for understanding the effect of this phenomenon. Total flight time of these rotor-craft sUAS is limited to 10 – 15 minutes; however, we have found this to be adequate for our needs. Because neither of these craft is useful for collecting full census information, a sampling protocol has been developed in conjunction with the University of Idaho, Department of Statistics, which allows us to calculate an estimate of total redds based on data collected at a select number of spawning locations. For example, within the Snake River, tests conducted in 2011 resulted in an unbounded estimate of 1,922 redds (compared to 1,949 reported by biologists flying the entire river by helicopter); and tests conducted in 2012 resulted in an estimate of 1,581 redds (+/- 674), compared to 1,375 reported by biologists surveying from a helicopter. Tests will continue to be conducted during the fall of 2013, and will be expanded to include a fixed-wing sUAS with the capability of flying for longer periods of time.

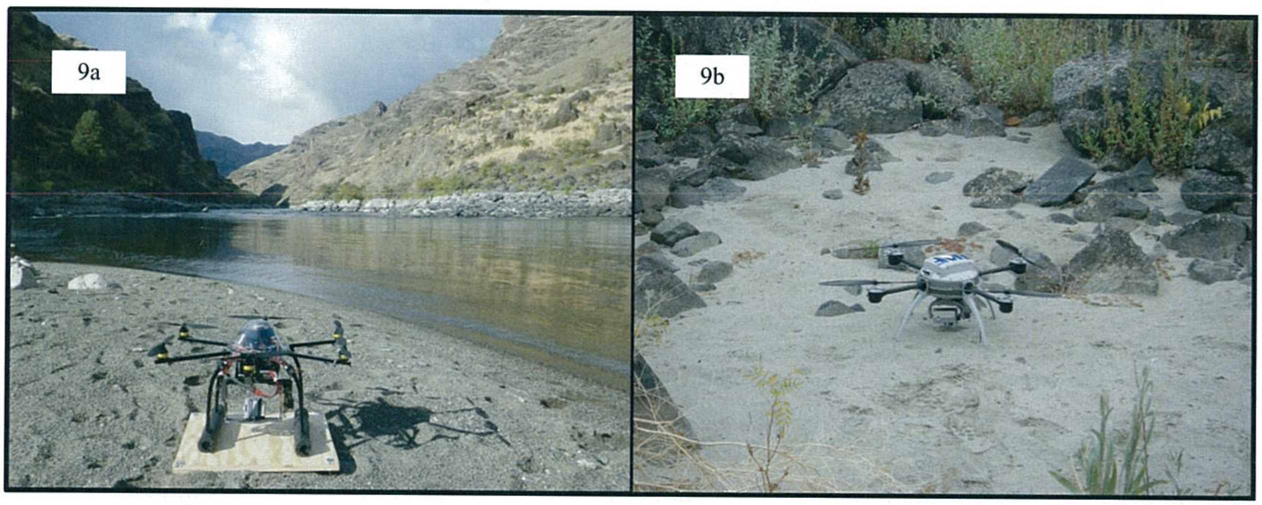


Figure 9. Two small unmanned air craft being tested for conducting redd surveys on the Snake and Clearwater rivers. Panel 9a shows an off-the-shelf hexacopter that was tested during the fall of 2011. Panel 9b shows the Aeryon Scout (quadrocopter) that was tested during the fall of 2012, in conjunction with the University of Alaska, Fairbanks. (Photos courtesy of Idaho Power Company)

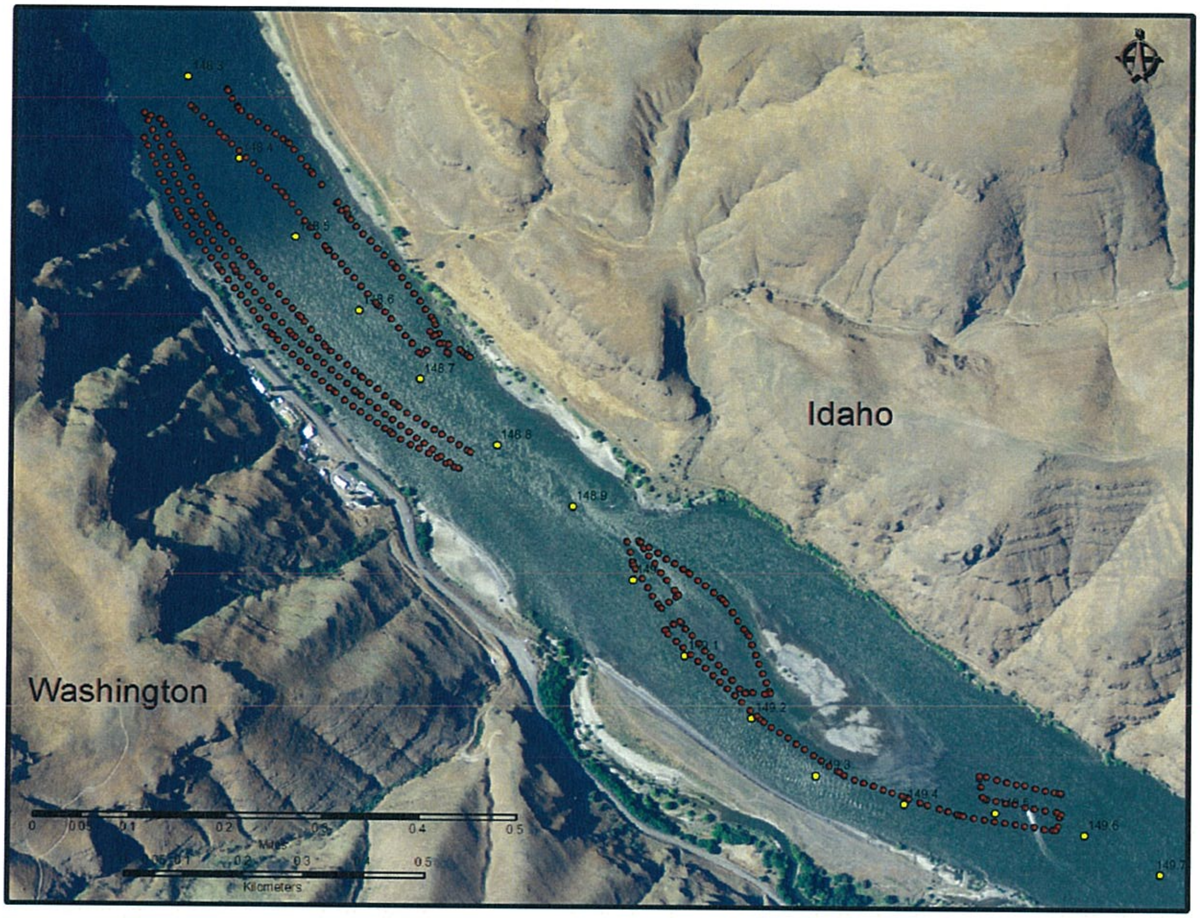


Figure 10. General site map on the lower Snake River, showing waypoints used for flying unmanned air craft at low elevation (approximately 30 m above ground level) over potential fall Chinook spawning areas. Photographs are taken and are geo-tagged at each waypoint.

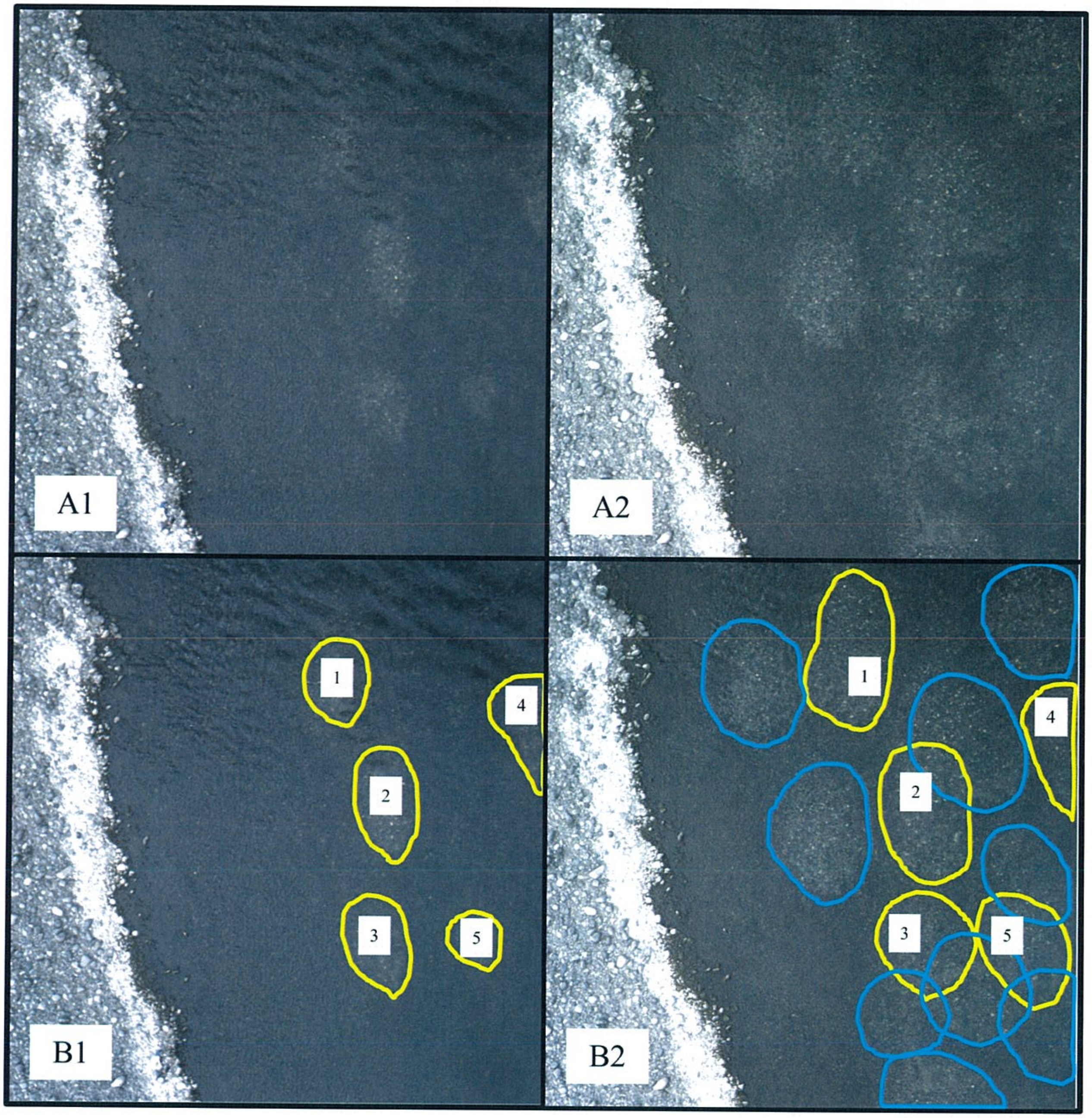


Figure 11. Example photographs taken from a sUAS. The upper panels show the raw photographs obtained by the unmanned air craft at one of the Snake River spawning areas, one week apart. Panel A1 was obtained on 29 Oct 2012 and panel A2 was obtained on 05 Nov 2012. The lower panels highlight the redds present each week, illustrating both the change in size of the original five redds (B1, outlined in yellow and numbered 1 - 5), the construction of eight additional redds (B2, outlined in light blue), as well as the superimposition of several of the new redds on and around the original redds.

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