Benefits of Tributary Habitat Improvement in the Columbia River Basin

2014 Update

Habitat restoration in Little Springs Creek a tributary of Idaho's Lemhi River

BONNEVILLE POWER ADMINISTRATION

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Summary

The Biological Opinion (BiOp) for the Federal Columbia River Power System (FCRPS) relies on habitat improvements in tributaries of the Columbia River to offset impacts of federal dams on federally protected salmon and steelhead. The BiOp also requires research, monitoring and evaluation (RM&E) to assess how effectively the habitat improvements improve fish survival and abundance and to inform plans for future habitat improvement efforts.

This report summarizes relevant RM&E findings from 2014, updating a report from 2013 that synthesized results up to that point. Results from RM&E programs involving tributary habitat continue to indicate that well-designed habitat improvement projects that address limiting factors promote significant increases in fish survival and abundance. RM&E results also provide information on key limiting factors and population bottlenecks, which assists in the selection of future habitat actions.

Results from research in 2014 on the Lemhi River, an Intensively Monitored Watershed (IMW) in Idaho, indicate that survival of juvenile Chinook salmon more than doubled over a key stage in the life cycle following intensive habitat improvements in Little Springs Creek, a tributary of the Lemhi. The survival improvements can be tied to the habitat improvements because they were an exception to declines in the population as a whole over the same time period.

Findings from the Lemhi build on earlier RM&E results from other parts of the Columbia Basin. Studies in Bridge Creek, a tributary of the John Day River in Oregon and another IMW, measured a 50 percent increase in seasonal juvenile survival and 160 percent increase in abundance of steelhead following habitat improvements brought about by more stable beaver dams. The increases have persisted over the four years of study to date.

Another IMW in the Entiat River watershed is showing early results, including higher fish densities and survival, as well as larger fish associated with a suite of habitat actions completed about two years ago.

Research in Little Springs Creek, Bridge Creek, and the Entiat is part of the Integrated Status and Effectiveness Monitoring Program (ISEMP), an initiative funded by the Bonneville Power Administration (BPA) and implemented by NOAA Fisheries. ISEMP is designed to better define the relationship between improved habitat quality and increased survival and abundance of salmon and steelhead. Separate studies conducted for the Bureau of Reclamation by the U.S. Geological Survey in the Methow measured as much as 30 percent higher steelhead survival and 26 percent higher Chinook survival in side channels with deeper pools. Together these restoration experiments indicate the potential for significant survival improvements.

The 2014 research results, combined with earlier analyses of the survival benefits associated with habitat improvements, indicate a range of relatively rapid survival increases from 20 percent to more than 60 percent at various scales and over various life stages.

SURVIVAL IMPROVEMENTS FOLLOWING HABITAT IMPROVEMENTS IN THE COLUMBIA RIVER BASIN

Location and improvement	Survival increase (%)	Life stage
Little Springs Creek (Lemhi) habitat restoration	64	Parr-to-smolt
Bridge Creek habitat restoration	50[1]	Parr-to-smolt
Deeper Methow side channels	30 for Steelhead 26 for Chinook	Summer to-fall
Relative habitat improvement[2]	20	Parr-to-smolt

Research results in 2013 and 2014 show salmon and steelhead survival increases from 20 percent to more than 60 percent following tributary habitat improvements at various scales.

This report

A coordinated program of RM&E spanning the Columbia River Basin represents one of the most extensive and sophisticated attempts to relate improvements in the quality of salmon and steelhead habitat to improvements in fish survival and abundance. The RM&E program is a

[1] Average over four years

[2] Paulsen and Fisher (2005) found that habitat improvements accounted for as much as about 20 percent higher survival for fish from areas in the Snake River Basin with the most habitat actions. For more details see preceding report, Benefits of Tributary Habitat Improvement in the Columbia River Basin, 2013.

requirement of the FCRPS BiOp, which relies on habitat improvements to mitigate the impacts of federal hydroelectric dams on salmon and steelhead listed under the Endangered Species Act (ESA). Five years after the BiOp's release in 2008, BPA and the Bureau of Reclamation (Reclamation) recounted the results of initial RM&E efforts in a July 2013 report titled, "Benefits of Tributary Habitat Improvement in the Columbia River Basin: Results of Research, Monitoring and Evaluation, 2007–2012." This update follows up on that 2013 report with a summary of results that have emerged since. This is not a technical report but rather a synthesis of results from recent research.

Little Springs Creek

Background

Little Springs Creek is a spring-fed tributary of the Lemhi River near Leadore, Idaho, that historically provided rearing and spawning habitat for Snake River Chinook salmon and steelhead. Irrigation diversions in past decades largely disconnected the creek from the Lemhi, draining its water in the summer and making it difficult if not impossible for fish to access the stream. In addition, cool water from springs feeding the creek first entered holding ponds where the water was warmed by the sun. These ponds then drained back into the creek at high temperatures that limited its use by salmon and steelhead. Livestock grazing, straightening and channelization also degraded rearing habitat for juvenile salmon and steelhead.

Overall 28 of the Lemhi's 30 major tributaries were disconnected, reducing access to tributary spawning and rearing habitat. Biologists believe the inaccessibility and degraded condition of rearing habitat in the Lemhi depressed survival of juvenile fish. For instance, close to 80 percent of juvenile Chinook salmon emigrate from the emhi and its tributaries in their first year and many die, with few of the early departing fish returning as adults to spawn. The loss of so many young fish is a major limitation on overall productivity. Thus, many of the habitat improvements in the Lemhi system have focused on restoring flows and reconnecting tributaries to improve spawning and rearing habitat. The expectation is that with improved habitat, juvenile fish would stay in the system longer and leave in better condition to survive their seaward migration. Little Springs Creek is entirely on private land, so the cooperation of landowners was essential to advancing restoration.

Habitat improvements

Locally developed restoration plans have led to extensive habitat improvements on Little Springs Creek since approximately 2009. Much of the creek has been restored to a more natural condition and high temperatures and reduced flows that limited the value of the creek for fish have been alleviated. Funding and other assistance for this work was provided by BPA, NOAA Fisheries, the Idaho Department of Fish and Game (IDFG), Idaho Office of Species Conservation (OSC), Pacific Coastal Salmon Recovery Fund, and Trout Unlimited. A habitat improvement agenda of such magnitude takes time to implement, so a phased approached to project implementation followed and involved numerous elements including:

- Creation of a new sinuous channel to carry cool spring water directly into the creek, so it would not warm in the holding pond. This was accompanied by restoration of riparian vegetation along the channel.
- Elimination of irrigation diversions to leave cool water in the stream. Diversions were consolidated and replaced by water pumped from other locations on the Lemhi River, trading cooler spring water previously used for irrigation for warmer main stem water. This included new conservation measures such as sprinklers on adjacent land to reduce the overall need for irrigation water.
- Replacement of two outdated highway culverts that hampered fish access.
- Trout Unlimited led the restoration of upstream portions of the creek's channel in 2009, including fencing to protect the stream and surrounding habitat from livestock grazing.
- Additional habitat improvements in 2012 along a length of the lower creek channel most accessible to fish. The improvements included creation of 20 pools, addition of woody material to enhance complexity and refuge for fish and planting of native willows for shade.

Before and after photos of habitat restoration in Little Springs Creek. Top left and top right show upper Little Springs Creek prior to and after channel restoration and exclusion of cattle. Lower left and lower right show lower Little Springs Creek prior to and after channel reconstruction. Prior to restoration, the lower creek often ran dry during irrigation season. Photographs provided by Jeff Diluccia, Idaho Department of Fish and Game.

Altogether the habitat improvement actions restored the creek's natural contours, improved flows, and dramatically improved temperatures and cover for salmon and steelhead. While Little Springs Creek is one of 17 streams in the Lemhi River Basin prioritized for reconnection to the mainstem river, the intensive improvements based on a 2007 restoration plan have likely made it the most thoroughly restored tributary of the Lemhi. The number and extent of restoration actions, combined with detailed knowledge of the factors known to limit fish numbers, present an important opportunity for research and monitoring to determine the effect of the restoration on fish productivity.

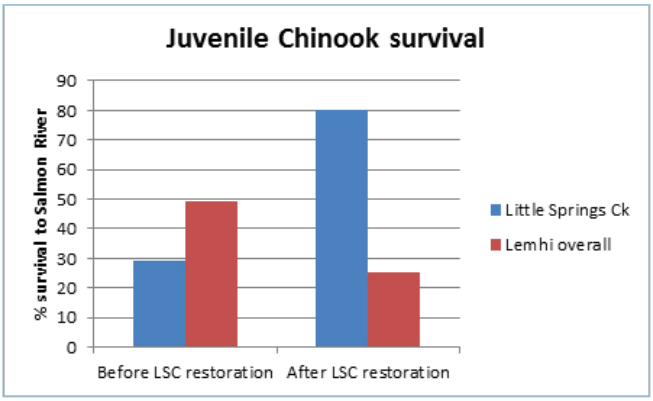
ISEMP and IMWs

The ISEMP project includes IMWs in the John Day, Entiat, and Salmon River sub-basins. Other IMWs are also underway in Washington and Oregon. IMWs were established to detect changes in fish populations resulting from intensive habitat improvements at a watershed scale. For example, crews have installed 14 underwater antenna systems in the Lemhi River and its tributaries to track the movement of fish carrying PIT (passive integrated transponder) tags. Tracking reveals how and when fish use different reaches and tributaries, and how the selection of rearing habitat influences growth and survival. Much of the IMW research in the Lemhi system is related to the benefits of flow improvements and reconnection of streams. The Bridge Creek IMW in the John Day River Basin employs a similar monitoring infrastructure to evaluate the improvement of fish habitat after the stabilization of beaver dams jump-started beneficial ecological processes. Research in Bridge Creek and the Lemhi system demonstrates that increased fish productivity can be clearly linked to habitat improvements.

Survival and abundance increases

Almost immediately after its reconnection to the Lemhi River in fall 2011, Little Springs Creek attracted numerous juvenile Chinook salmon and steelhead that were likely seeking refuge in the creek's cool spring water. In 2012, prior to the large-scale habitat improvement effort in the lower reach of the creek, 29 percent of juvenile Chinook that reared in Little Springs Creek survived to emigrate from the Lemhi into the main stem of the Salmon River. The 2012 emigration rate was slightly lower than the rate for the population at large. The following year the picture changed. In 2013, after completion of the habitat restoration in Little Springs Creek, 80 percent of the juvenile Chinook that reared in Little Springs Creek survived to emigrate from the Lemhi into the mainstem Salmon River. The difference in survival is striking and even more noteworthy given that overall survival of juvenile Chinook in the Lemhi system declined from 2012 to 2013.

A crew installs an underwater antenna in the Lemhi River to track the way fish respond to habitat improvements.

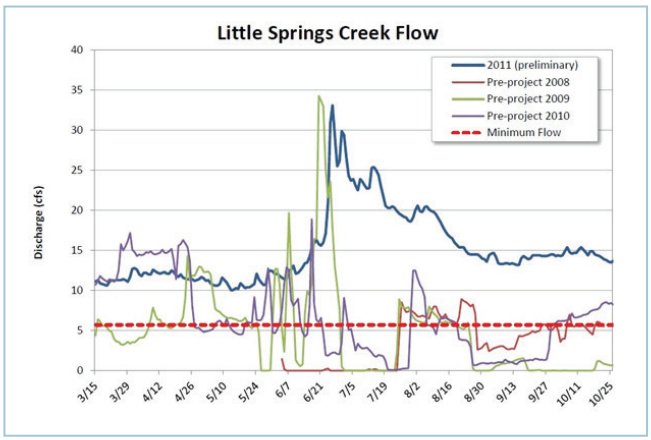


Juvenile Chinook survival in Little Springs Creek increased following restoration of the natural creek channel. The increase ran counter to the trend in comparable unrestored tributaries, indicating a link to the restoration.

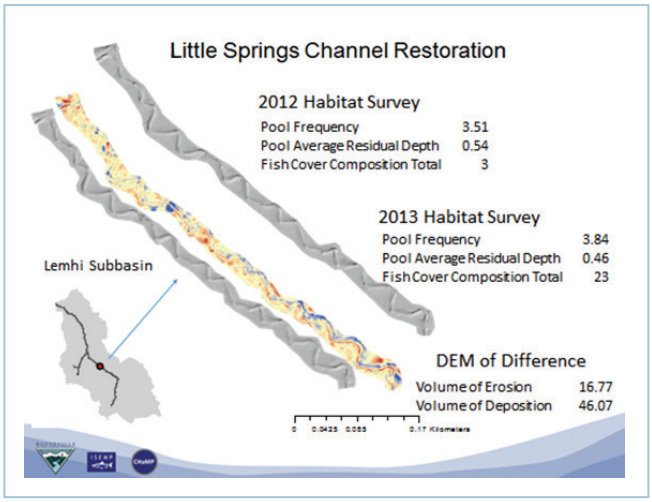
Similarly, the abundance of juvenile Chinook salmon in Little Springs Creek increased about five-fold from 2012 to 2013 even as the overall abundance of juvenile Chinook in the Lemhi declined by 62 percent. More juvenile Chinook per square meter reared in Little Springs Creek in 2013 than any other comparable stream in the Lemhi system. The abundance of juvenile steelhead in Little Springs Creek also increased from 436 juveniles in 2012 to 1,297 in 2013. It is important to note that the findings represent only one year following restoration, and the benefits of habitat improvements are expected to accrue over multiple years. Assuming the trends hold, the improvement in survival would represent one of the most significant examples of the benefits of habitat restoration that has been documented so far in the Columbia River Basin[3].

The IMW approach provides such detailed data from before and after restoration that scientists are confident that the increases in juvenile survival and abundance are not only statistically significant but also differ from larger trends in survival and abundance in the Lemhi overall. In other words, the changes documented in Little Springs Creek are not the result of background shifts in number or distribution of fish, given that those were trending in the opposite direction. The results demonstrate with certainty that the habitat restoration actions in Little Springs Creek resulted in increases in abundance and survival that stand out against trends in the population at large.

Biologists believe that the restored habitat improved conditions for fish, likely providing a more reliable source of cooler water and improved refuge from predators. The improved conditions, in turn, translated into higher survival for fish that reared in Little Springs Creek as they emigrated from the Lemhi. Access to improved rearing habitat such as the restored reaches of Little Springs Creek is likely to be



Heavy blue line indicates improved flows in Little Springs Creek following the relocation of a diversion so natural flows remained in the creek. In some prior years flows dropped to zero, indicating the creek ran dry. From Idaho Water Transactions Program Final Report, October 2009 to September 2011.



A Digital Elevation Model (DEM) of a portion of Little Springs Creek shows that the creek evolved after the habitat improvements. The frequency of pools and the amount of fish cover increased between 2012 and 2013.

[3] Beasley, C., 2014. Lemhi River Little Springs Creek Reconnection. Unpublished report. Results were reported at the 2014 meeting of the Western Division, American Fisheries Society.

especially important in more extreme environmental conditions including warm years with low water, such as 2013. Climate change analyses indicate that such conditions may become more frequent in the Northwest.

CHaMP and the habitat connection

Continuing work in Little Springs Creek and the Lemhi system is seeking to answer questions such as whether specific habitat changes or features correspond to observed changes in fish abundance and survival. The Columbia Habitat Monitoring Program (CHaMP), a project to measure and track habitat quality and trends across the Columbia Basin, is one tool being used to answer these questions. Researchers can assess changes in habitat against detailed fish data provided by ISEMP and the IMWs. Together these projects are helping to describe and measure the relationships between habitat improvements and improvements in fish abundance and productivity.

One example of habitat monitoring supported by CHaMP is provided by digital elevation models (DEMs). DEMs provide a three-dimensional map of the stream channel down to the centimeter. Comparing DEMs over time reveals even slight changes in the depth and contour of the channel. DEMs also provide data that can be used to evaluate the effect of habitat improvement actions in stream systems. For example, a comparison of DEMs for Little Springs Creek from 2012 and 2013 reveal that the creek evolved after the habitat improvements in ways that are likely to further benefit fish. The frequency of pools and the amount of fish cover, which typically affect flow and provide refuge for fish, increased between 2012 and 2013. This indicates that in addition to the implemented habitat improvements, natural processes have further improved the habitat function and value in the reconstructed reach.

Emerging results in the Entiat River

IMWs are not only scientific undertakings, but also social undertakings. The Entiat IMW in north-central Washington is examining the benefits of habitat improvements for ESA-listed salmon and steelhead in a “real-world” setting involving numerous private landowners and other diverse interests. ISEMP works closely with the community to discuss planned habitat actions and obtain access to the river for monitoring. However, developing an effective IMW in the Entiat required changing the way the community approached habitat restoration, organizing habitat actions into more intensive “bursts” or pulses of multiple projects to better support the research.

A feasibility study examined concerns and drew heavily on input from local residents and stakeholders, funding agencies and project sponsors. The feasibility study in turn led to wider discussions with project sponsors, the Regional Technical Team and Upper Columbia Salmon Recovery Board (UCSRB), all of which agreed on a habitat improvement program on the Entiat through 2020. The design focuses habitat funding on specific watersheds such as the Entiat on a rotating basis, allowing for more intensive habitat actions in those areas in those years.

Early results from the Entiat are positive. Some of the first projects and monitoring results derive from off-channel habitat, such as side channels. The lack of accessible side channels is considered a limiting factor for fish in the Entiat. Initial monitoring shows that Chinook and steelhead densities are noticeably higher in off-channel habitat, including newly restored off-channel habitat[4].

Emerging results also reveal improved survival of juvenile spring Chinook in upper sections of the Entiat, where habitat improvement actions began about two years ago, compared to lower sections of the river where habitat improvements came later. Fish from upper reaches of the Entiat are also slightly larger in size upon leaving the watershed, which likely reflects the benefit of improved habitat.

Juvenile Chinook densities are higher in lower reaches of the river, where lower survival may be a function of more fish competing for limited resources. Habitat actions that began in the Entiat this year will help test whether improvements in habitat increase the carrying capacity to the point that survival in the lower river also increases. Biologists are tagging fish in the Entiat twice each year to track their movement and survival, which will provide additional data in coming years.

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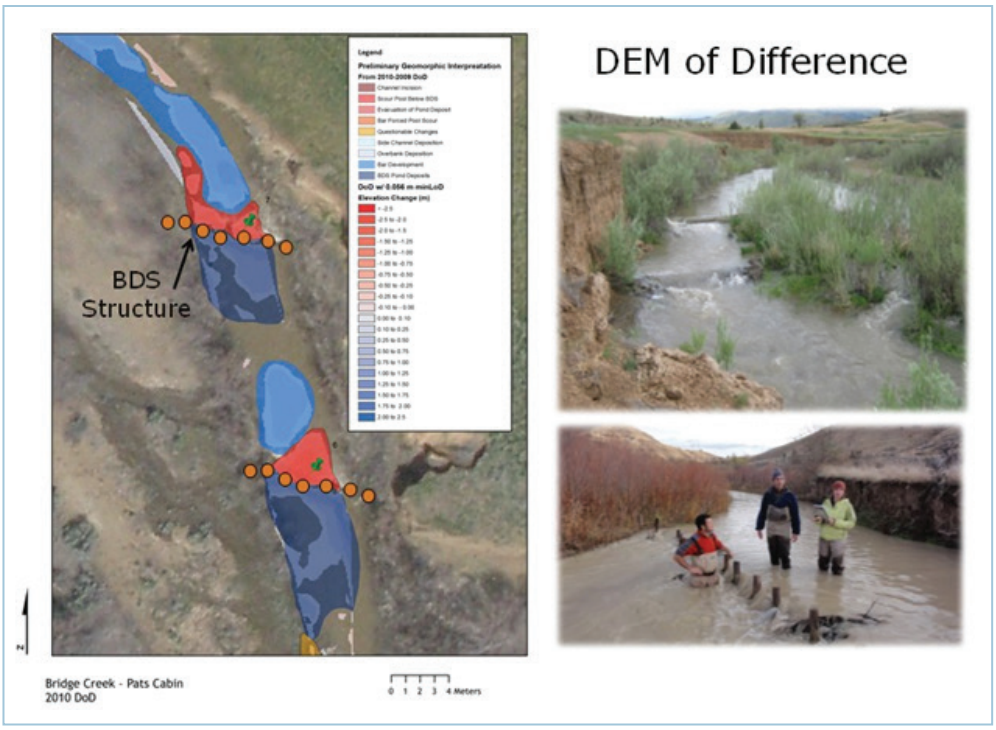
[4] ISEMP Lessons Learned Synthesis Report Update, 2012

Revisiting Bridge Creek

Bridge Creek, an IMW in Oregon's John Day River, was among the first research experiments under the FCRPS BiOp to demonstrate benefits of habitat improvements in the form of increased fish survival and abundance. Experimental restoration in Bridge Creek involved providing secure anchors for beaver dams that had previously washed out during high flows. Dramatic changes in habitat became apparent less than six months after the anchors were installed. By 2012 fish survival and abundance had increased. Additional monitoring since then has shown that the benefits are not fleeting but rather are continuing to accrue over succeeding years.

Bridge Creek had the potential to provide important habitat for steelhead but had endured erosion and channel incision, a degraded condition that is common in many Columbia Basin streams and exacerbated by intensive grazing, development and other factors. Incised streams cut deeply into the ground and become faster, straighter and disconnected from the floodplain. In addition, the water table drops with the channel bottom to the point where the roots of streamside vegetation can no longer access water and the plants die. When healthy, the vegetation provides a host of benefits such as shade and shelter for fish. The consequences of losing such riparian vegetation include higher water temperatures and loss of spawning and rearing habitat. Studies have linked channel incision to degraded water quality, limited habitat capacity and reduced fish populations.

The experimental restoration involved installing posts in stretches of Bridge Creek to provide better anchors for dam construction. The dams slowed water flow, creating deeper pools, reducing water temperatures and improving groundwater exchange. The slower water flow also facilitated deposition of sediments, which gradually rebuilt the incised streambed to the point where it could again access the historic floodplain. The deeper water and rising streambed allow water to flow out onto the floodplain more often. This creates a more dynamic and complex system, such as a more sinuous multi-channel stream with healthy riparian vegetation. That provides more opportunities for fish to forage and avoid predation and fast water. Such changes were expected to remedy habitat factors that limit fish populations in Bridge Creek.



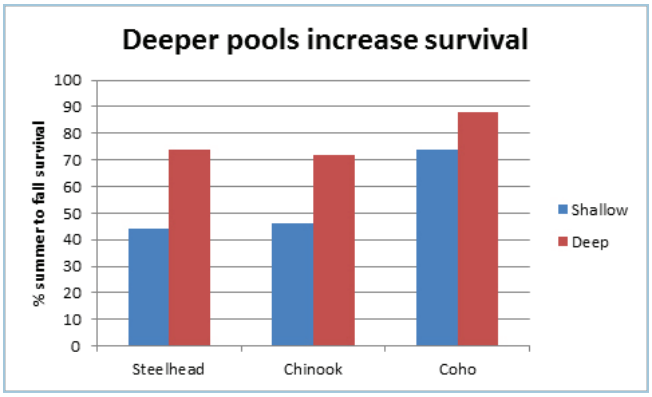
Clockwise, from left: A Digital Elevation Model (DEM) shows the elevation of the water surface on a segment of Bridge Creek after installation of Beaver Dam Stabilization (BDS) structures. Darker blue shows areas (mostly upstream of the dams) that have gotten deeper (and likely cooler) and red (right below the dams) has gotten shallower. Top right: Bridge Creek before the BDS structures were installed. Lower right: installing the BDS structures in Bridge Creek.

Fish populations responded, with steelhead abundance in the experimental watershed rising beyond that of the control watershed following the installation of the stabilizing posts. Survival also improved: while steelhead survival had been higher in the control (unrestored) area preceding the experimental restoration the picture reversed afterwards, with the survival in the restored area rising to or exceeding that of the control area. In the four years since the restoration juvenile steelhead survival increased an average of 50 percent, with a 160 percent increase in juvenile abundance compared to a control watershed without restoration. The habitat restoration that led to the improvements came at a minimal cost compared to other restoration practices because it involved little more than installing the stabilizing posts and then letting beavers take over and bring about more distinct changes.

Researchers described the restoration approach used in Bridge Creek in the journal BioScience[5].

Improving habitat value in the Methow

Fish habitat beyond the main river channels is known as off-channel habitat. Off-channel habitat is valued for the potential to improve production and survival of salmon and steelhead by providing refuge and access to food resources. Off-channel habitat includes side channels, wetlands and beaver ponds. Significant off-channel habitat has been lost to diking, diversions, road construction and other development. The BiOp's tributary habitat program includes the improvement and restoration of off-channel habitat. Research in the Methow River in Washington by the U.S. Geological Survey, funded by Reclamation, documented the importance of side channels in salmon and steelhead production and also provided insight into side channel restoration likely to produce the greatest benefits for fish[6].



The depth of seasonally disconnected side channels in the Methow River affected summer-to-fall survival of fish in the side channels, with survival of all species higher in deeper pools.

The research found little difference in fish densities or smolt production between side channels with different degrees of connection to the main channel of the Methow, but did find differences in fish survival between side channels shallower than one meter and those with pools one meter or deeper. Side channels generally included high densities of juvenile salmon and steelhead and low numbers of large predatory fish such as bull trout, brook trout and rainbow trout known to be present in the mainstem Methow River. This indicates that the side channels may provide important refuge from predators. Shallow pools on the other hand are characterized by low dissolved oxygen, high water temperatures, lack of water and other factors that may depress survival. The conclusions together indicate that side channels are important habitat for salmon and steelhead smolts in the Methow and that their restoration has "great potential" to improve Methow salmon and steelhead populations.

The authors concluded that habitat restoration should aim to restore ecological processes rather than merely engineer new streams. Restoring the processes that naturally create deeper pools in side channels will help maintain deeper pools over time so they do not fill in later. Research showed that the presence of large wood and total cover is important to salmon and steelhead densities. For example, appropriate wood placement promotes deeper pools, encourages scour, adds fish cover, and increases food availability. Based on these results the authors concluded that where restoration actions cannot fully connect side channels, they should improve habitat in partially connected and seasonally disconnected side channels.

[5] Pollock et al., 2014. Using Beaver Dams to Restore Incised Stream Ecosystems. BioScience 64: 274-290.

[6] Martens, K.D., and Connolly, P.J., 2014. Juvenile Anadromous Salmonid Production in Upper Columbia River Side Channels with Different Levels of Hydrological Connection. Transactions of the American Fisheries Society. 143: 757-767.

Density dependence and habitat improvement

While steelhead abundance and survival increased following habitat improvements in the Bridge Creek IMW, steelhead growth simultaneously slowed. Biologists concluded that the slowing growth resulted from density dependence, which refers to the effects of increased competition for limited resources that can take place as a population expands and approaches the carrying capacity of the habitat.

Density dependence is widely recognized in population ecology as a potential consequence of population increases amid habitat with limited carrying capacity. As the population approaches that carrying capacity, competition increases and growth slows in the absence of additional resources. Carrying capacity can be limited by numerous factors, from food resources to sufficient cover from predators. The FCRPS BiOp accounts for the effect of density dependence as populations grow.

Evidence of density dependence "provides support for the need to increase capacity and productivity of tributary habitats as a means to enhance salmon survival and abundance," noted the Northwest Power and Conservation Council's (NPCC) Independent Scientific Advisory Board (ISAB). Populations with steep density-dependent effects could be targeted for restoration (ISAB 2013)[7].

[7] Independent Scientific Advisory Board, 2013. Review of NOAA Fisheries' Life-Cycle Models of Salmonid Populations in the Interior Columbia River Basin. ISAB 2013-5.

Conclusion

Research findings summarized in the mid-2013 report, "Benefits of Tributary Habitat Improvement in the Columbia River Basin: Results of Research, Monitoring and Evaluation, 2007–2012," provided early evidence of the relationship between habitat improvements and increases in fish survival and abundance. Additional results reported since then further define the relationship. Although the magnitude varies, habitat improvements have been shown to produce from 20 percent increases in survival among fish from areas with many habitat actions to a survival increase of 50 percent or more following intensive, concentrated habitat actions.

The examples of habitat improvements described above are representative of the hundreds of improvements completed or underway, under the FCRPS BiOp. The results of individual projects can provide information to help project the benefits that can be expected from other, similar improvements. The findings taken together indicate that the survival increases anticipated by the BiOp from habitat improvements are achievable through the targeted restoration, informed by science, that the Action Agencies are implementing. Continued RM&E under the BiOp will provide additional information over time, which will be included in future BiOp progress reporting.

BONNEVILLE POWER ADMINISTRATION

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