Elkhorn/Cruiser Effectiveness Monitoring

FINAL REPORT

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Summer 2006 – Winter 2010

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Introduction

An extensive instream restoration project was conducted in the summer of 2006 on Cruiser Cr, a tributary of Elkhorn Cr in the Trask River Basin. This project treated approximately 1.5 miles of the 3 miles of aquatic habitat available in Cruiser Cr to anadromous salmonids. Project activities consisted of a valley floor road decommission, culvert replacements and the placement of approximately 145 logs and 80 boulders in 38 full spanning structure complexes. The upper 3,000 ft of mainstem Cruiser Cr (confluence of Trib B to the falls) was untreated. The narrow transport reach beginning just above the confluence of Trib A and extending 1,000 ft up Trib B was untreated. The headwaters of Trib B above the new culvert crossing were also untreated.

In the summer of 2008, another large wood treatment was conducted in the mainstem of Elkhorn above the confluence of Cruiser Cr. This phase of the project also treated Trib C of Cruiser Cr and the remaining mainstem of Cruiser Cr from the confluence of Trib B to the falls. There were approximately 240 logs placed by helicopter forming 42 full spanning structures in Elkhorn and its tributaries. Approximately 2.4 miles of stream corridor was treated in this 3.3 mile stream section.

A multiple year monitoring effort was conducted on three stream segments to evaluate the effectiveness of this project to increase the overwinter survival of juvenile coho to the smolt stage. The annual monitoring effort consisted of paired snorkel inventories, summer and winter. The first, a summer inventory, establishes a population estimate for the standing crop of summer coho parr rearing in each stream segment (Cruiser, Elkhorn and Trib C of Elkhorn) to the end of their distribution. The second is a post winter survey conducted in late February or early March in these same streams just prior to smolting. The results of both of these surveys are presented in Tables 1 and 2. The key attribute monitored for change is the percent of the summer population that remains in the system over winter. This value is compared to an untreated control reach (lower mainstem Elkhorn, below the confluence of Cruiser Cr) and to the pre-project values collected on each stream reach for two consecutive years prior to treatment (large wood placement). Cruiser Cr did not receive the same pre-project baseline inventory.

Placement of large wood produces many positive changes to channel and floodplain morphologies that can help restore floodplain interaction and improve channel function. Examples of these benefits include the retention of mobile substrates that include nutrient rich fines and spawning gravels; the development of floodplain connectivity that provides low velocity off-channel winter habitats; and the provision of both summer cover from predation and winter cover from high water velocity (in the form of low velocity micro-habitats).

In most coho-bearing streams, it is the lack of large wood complexity during winter flow regimes that appears to limit retention to the smolt stage. Thus, a primary target for this study was to quantify changes in over-winter retention rates for juvenile coho associated with the introduction of large volumes of full spanning trees. The assumption is that there is a benefit to freshwater survival for juvenile coho retained in headwater stream reaches until smoltification.

The goal of the monitoring effort was to quantify the increase in the production of coho smolts as a result of large wood placements in several unique stream reaches. The Cruiser Cr portion of the project did not include a pre-project inventory to establish baseline overwinter retention rates. A more robust pre-treatment evaluation was completed for mainstem Elkhorn Cr and Trib C of Elkhorn. The accompanying tables (Table 1 and 2) indicate pre- and post-treatment retention rates for each stream reach as well as retention rates for a control reach that was maintained as untreated throughout the four year project.

This evaluation does not attempt to quantify or describe the changes in physical habitat conditions as a result of large wood treatment. It does however address the complications associated with this type of assessment in the discussion section of this document and proposes some refinements to the current methodology.

Instream Structure Design

The goal of the structure designs was to place large wood in the active channel to restore normal channel function. However, in the world of channel development, “normal” equates to “dynamic and unpredictable”. It is therefore difficult to anticipate the long term location and function of placed wood. It is reasonable to ask how quickly and in what manner the placed wood is affecting deposition, horizontal scour, and floodplain interaction in the short term at specific sites of placement. In addition, it is reasonable to ask what benefits the reach scale treatments have had on the native salmonid populations. This analysis is not intended to focus on the site specific physical changes in habitat associated with each structure placement. However, obvious radical changes in habitat type, distribution and abundance are highly visible. This effort focuses on quantifying, on a subbasin scale, the response of juvenile salmonids to the radical changes in physical habitat that are clearly observable.

The unique attributes of the design and implementation of this project are important to review because they were instrumental in achieving the rapid success observed. Stream adjacent alder were pre-cut into the active channel as a platform for helicopter placed conifer logs. This approach had a remarkable effect on the performance of the key log structures during their first winter flow cycle. The full spanning key log complexes (tree length, large diameter conifer) placed by helicopter, sealed immediately with transient canopy litter and initiated instantaneous floodplain interaction. It is clear that extensive additional salmonid production capacity resulted from this approach. Considering that each of these structures has a limited life span due to the natural decomposition of the material utilized (Douglas fir logs), the selected approach accelerated and maximized the long term cost/benefit to salmonid production and the restoration of system function.

Most large woody debris projects wait many years for the single storm driven event that recruits enough transient material to the active channel to initiate maximum function. Because all large wood projects are essentially a bandaide until adequate riparian recruitment potential (live conifer) can be developed, it appears much wiser to extend the functional life of that bandaide by getting it to work immediately.

Survey Methodology

The juvenile salmonid survey utilizes the Rapid Bio-Assessment protocol developed by Bio-Surveys, LLC to estimate the rearing population utilizing a 20 percent inventory of pool habitats. A randomly selected pool within a subset of the first five pools begins the survey and every fifth pool after that is snorkeled to the end of coho distribution (two consecutive sample pools with no coho). The snorkel effort has been electrofish calibrated, utilizing calibration ratios developed by ODFW research, and corrections have been made to the published population estimates that incorporate the calculated snorkel bias (see Appendix 1).

Summer inventories are conducted during the day. Winter inventories must be conducted at night because of juvenile salmonid behavior during cold winter flow regimes that cause them to hide and aestivate during daylight hours. The night snorkel inventories utilize an electrofish calibration developed by ODFW research and include correction factors for differential habitat complexities.

Winter night surveys were conducted when flows had dropped sufficiently to provide adequate visibility. A hand-held high intensity halogen lantern illuminated the field of vision. The effective range was approximately 15 feet. All winter night surveys (2007-2010) were successfully completed between the dates of February 23 and March 23 each year. This temporal window was critical to represent maximum winter exposure to critical flows and an accurate estimate of pre-smolts just prior to smoltification. The years with later March inventory dates coincided with deep accumulations of snow and lower than average water temperatures (this suggests that smolt movements would have been delayed).

Appendix 1 describes the development of the Night Snorkel Methodology and the calibration efforts conducted by Bio-Surveys and ODFW.

Survey Conditions

The summer 2006 snorkel inventories were conducted on Sept 11, 2006. Conditions were excellent during low summer flows with perfect visibility. Results from this data are presented with a high level of confidence. The winter 2007 inventories were conducted in Cruiser Cr on Feb 23. Surveys were conducted by both Bio-Surveys staff and BLM district staff (Darin Neff). Conditions were excellent with low clear flows and 4” of snow on the ground. Surveys were completed with a high level of confidence in the data. Surveys on Elkhorn were postponed until March 14 due to a rain on snow event that brought the system out of shape for snorkel inventory from Feb 23 until March 14. The survey was then conducted with excellent visibility and high confidence in the data.

The summer 2007 snorkel inventories were conducted on September 12, 2007. Conditions were excellent with low, clear flows. Results from this data are presented below with a high level of confidence. The winter 2008 inventories were conducted in Cruiser Cr and Elkhorn between March 20 and March 23. Surveys were conducted by Bio-Surveys staff only. Conditions were excellent with low clear flows and 12” of snow on the ground. Surveys were completed during a concise time frame with a high level of confidence in the data.

The summer 2008 snorkel inventories were conducted on September 8 and 9. These dates were selected to match the survey timing of the previous summer inventories (Sept. 11 and 12). Replicating the survey timing was an attempt to reduce inter-annual variation. Surveys were conducted in low clear flows with excellent visibility just prior to the log placement by helicopter (Oct. 2008).

The winter 2009 inventory was conducted from March 3-7. Surveys were conducted by Bio-Surveys staff only and all surveyors have been present for all pre- and post-inventories to reduce the potential for surveyor variability. Surveys were conducted during low and clear flows with approximately 4” of fresh snow stream side. Conditions during the 2009 winter inventory were however very different than experienced in any previous survey effort. An ice and wind storm had contributed massive quantities of canopy litter and riparian wood resources to the active stream channel. This material had worked in concert with the LWD placement to create highly complex full spanning structures. Many structures matured rapidly to facilitate floodplain interaction and the development of off-channel habitat types. Structure complexes in Trib C of Elkhorn and the helicopter placed structures in Cruiser Cr (above the confluence of Trib B) exhibited less of this functional maturity.

The summer 2009 inventory was conducted from September 23 - 24. The winter of 2010 inventory was conducted from February 24-26. Surveys were conducted by Bio-Surveys staff only, utilizing the same field crew that performed the winter inventories in 2007. Surveys were conducted during low and clear flows with excellent visibility. Conditions were warmer than previous winter inventories and no snow was present. The dominant factor influencing the results of this inventory were the extremely moderate peak flow profiles (see Figure 1) that were maintained throughout the winter.

Influential Flow Dynamics

One of the largest drivers influencing the overwinter retention of juvenile salmonids in headwater habitats is flow (hydraulic potential). The magnitude, duration, timing and frequency of winter flow events are all important flow variables. The dynamic relationship between these variables for each winter flow event is set on top of a stream's morphological profile (gradient, floodplain width, terrace height and channel roughness).

Figure 1 describes the magnitude of these winter flow events as well as the timing relative to the onset of winter. This graphic describes four very different winter flow patterns that occurred during the four year pre- and post-effectiveness monitoring project. These flow patterns were documented by the USGS gauge on Tucca Creek, a tributary of Elk Cr in the Nestucca basin. The gauge is 8.5 air miles from the confluence of Cruiser and Elkhorn Cr. The watershed area of Tucca Cr is 1,978 acres and is very similar to the 2,315 acre Cruiser Cr watershed area. For the purpose of this analysis, the historical flow profiles for Tucca Cr will be utilized as a surrogate for representing the conditions that occurred in Cruiser and Elkhorn during the scope of this project.

1) In the winter of 2006-2007 a radical flow event greater than 300 cfs occurred as the first major freshet of the winter (November) in the Tucca Cr subbasin of the Nestucca. Most mountain subbasins of the Oregon coast range with watershed areas of a similar size would have experienced similar conditions. The impact on summer salmonid parr of this immediate transition from summer low flows to extreme winter runoff was severe, with all four inventoried stream reaches in the project area displaying overwinter retention rates of only 3.5% to 6.7% (treated and untreated combined). Most of the salmonid juveniles were blown completely out of the Elkhorn drainage over the course of this winter. For reference, the maximum historical discharge recorded for the Tucca Cr gauge was the Feb 1996 event that surged to 680 cfs.

2) Similar peak flows were encountered during the winter of 2007-2008 with very similar results for the three stream reaches without a wood treatment (range 5.2% – 5.9% overwinter retention) and very different results for the single treated reach (Cruiser Cr, 16.6% overwinter retention). With peak flows (>300cfs) occurring later into December, juvenile salmonids had the opportunity during multiple pre-peak events of a lesser magnitude to seek and find the low velocity habitats associated with log complexes and interactive floodplains within the project reach.

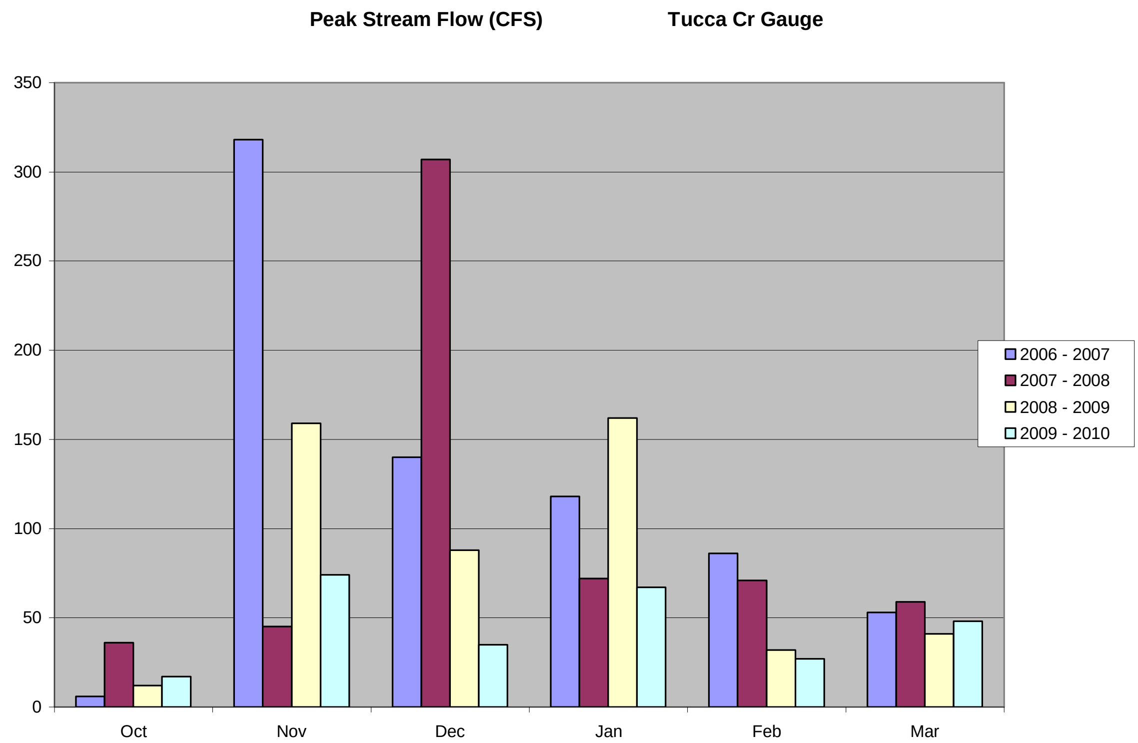
3) During the winter of 2008-2009, there were no events greater than 160 cfs recorded at the Tucca Cr gauge. This condition of a moderate flow profile alone was probably responsible for a portion of the increase in overwinter retention observed for the three treated reaches (Cruiser, Elkhorn above Cruiser and Trib C of Elkhorn). The overwinter retention rates were between 11.2 % and 21.0% with the single untreated control (Elkhorn below the confluence of Cruiser Cr) remaining at 6.7% overwinter retention.

4) During the winter of 2009- 2010, flows were even more moderate with no events greater than 70 cfs recorded at the Tucca Cr gauge. The overwinter retention rates

documented during this winter may represent a short term best case scenario because no major event occurred that overwhelmed the influence of the log complexes. The overwinter retention rates of juvenile coho parr soared to 38.2% in the treated segment of mainstem Elkhorn Cr. This suggests that even higher retention rates could be possible in the future as these young structure complexes continue to mature with the accumulation of additional wood and substrate resources. This maturation process is likely to improve each sites capacity for providing floodplain interaction (greater linkage for longer periods). Even greater overwinter retention rates can be expected with the combination of structure maturation and low winter flow profiles.

Other factors are important to the exceptional success observed for these treated reaches. Of primary significance is the volume of canopy litter that was recruited to the active channel of mainstem Elkhorn during the winter of 2008-2009. A major ice and wind storm struck north coast basins that broke the tops out of riparian alder and toppled many stream adjacent trees into and across the active channel. This material was then transported by peak flows into the key log complexes that were designed to trap and retain migratory canopy litter. Essentially overnight, all of the full spanning structures on the mainstem of Elkhorn Cr and some of the structures on Cruiser Cr were sealing with this transient debris and causing inundation of the available off-channel terraces (floodplain). The resultant channel aggradation created vast areas (unquantified) of low velocity habitat in a stream corridor that had previously been isolated from its floodplain. The historical loss of the riparian conifer required to maintain this link to the floodplain was responsible for this entrenchment, as is commonly observed in most all Oregon coastal basins.

Figure 1



Survey Results

The results in Table 1 summarize the combined summer and winter snorkel survey data with the goal of quantifying overwinter retention rates. The most interesting revelation from the first year of data collection was the similarity in overwinter survival rates between the treated stream (Cruiser) and the untreated stream (Elkhorn). These systems were nearly identical in their ability to retain overwintering coho regardless of the increase in wood density exhibited by the Cruiser Cr wood placement project. This was likely the result of the atypical high flows that occurred during the 2006-2007 comparison of summer / winter retention of salmonids. The dramatic flows experienced by each of these streams as the first significant fall freshet in November occurred just weeks after log structures were placed in Cruiser Cr. This event exposed salmonid juveniles, unconditioned to high flows, to a larger than bankfull flood event. The timing of this event was likely a worst case scenario for summer parr attempting to adjust to available winter habitats.

A similar peak flow event was replicated in 2007-2008 on both Cruiser Cr and Elkhorn. Overwintering populations of juvenile salmonids were again exposed to a major flood event in December of 2007 that was expected to reveal similar overwinter survival results as the previous year. As you will see in the data tables below, there were major differences between the treated Cruiser Cr and the untreated Elkhorn when comparing the first two inventoried years. We would suggest that the primary difference between these two inventories was the differential in the timing of peak flood events between years; the November 2006 peak wreaking havoc on salmonid juveniles unconditioned to increasing flow volumes.

The overwinter retention rates (expressed as a percentage of the summer population) for juvenile coho remained nearly identical for Elkhorn and its untreated tributaries during the second year of pre-project monitoring (5.3 vs 5.6). The overwinter salmonid retention rates however for Cruiser Cr. increased radically in 2008 from the levels observed in 2007 from 5.0 to 16.6 percent of the summer population. This represents a 232% increase in retention rates between the two inventoried years. Note that the total number of smolts produced in Cruiser Cr nearly doubled between the two years. To observe these results from a different angle, the doubling in smolt production resulted from a summer population in Cruiser Cr and its tributaries that was 45% less than the summer population the previous year.

This major increase in production was likely due to the radical increase in habitat complexity in Cruiser Cr that developed on a continuum between the first fall freshet in 2006 and March of 2008. This increase in complexity, although currently unquantified, was noted by the winter inventory crew during the 2008 survey. Substrate deposition, floodplain interaction, channel braiding and other key winter habitat features associated with structure placements were abundant and functional in winter 2008 that were not observed during the winter 2007 inventory. The winter habitat conditions observed in the winter of 2008 suggested that a maturation of channel complexity was in progress.

The paired summer/winter surveys of 2008-2009 also exhibited major improvements in Cruiser Cr from the first sampled year (5% vs. 12.6% overwinter retention). Major storm driven habitat modifications occurred in Cruiser Cr during the winter of 2008-2009 that may initially be responsible for the differential between year 2 and 3 (16.6% vs. 12.6%). Many of the engineered structure placements in the lower transport reach of Cruiser were uprooted and repositioned by powerful winter hydraulics. The original structure logs were still present but played a much more significant role in their new orientations for capturing transient woody debris.

The 2009 inventory was also the first post-treatment year monitored for the mainstem of Elkhorn and Elkhorn Trib C. You will note in Table 1 that radical improvements in overwinter retention were realized during the first post-treatment winter (Pre 5.3% and 5.6% vs. Post 11.8%).

The 2010 winter inventory resulted in little change from the prior year in Cruiser Cr with overwinter retention rates at 16.3%. The effective three year post-project range of overwinter retention for the project reach was 12.6% – 16.6% (first post-project year is not included because of the atypical flow event that occurred immediately after construction). However, the overwinter retention rates for the treated section of Elkhorn (Table 2) exceeded all expectations.

Table 1

Elkhorn and Cruiser Cr juvenile coho contributions by year, season and stream segment

Stream	Summer 2006	Winter 2007	Summer 2007	Winter 2008	Summer 2008	Winter 2009	Summer 2009	Winter 2010
Elkhorn	33,340	1,840	28,104	1,622	18,840	1,952	38,634	9,853
Trib A	310		618		222		342	
Trib B	235		240		1,578		102	
Trib C	9,385	445	4,548	264	3,600	757	5,646	1,231
Total	**43,270**	**2,285**	**33,510**	**1,886**	**24,240**	**2,709**	**44,724**	**11,084**
Over Winter Retention		**Pre 5.28%**		**Pre 5.63%**		**1st Post 11.18%**		**2nd Post 24.78%**
Cruiser	12,790	565	5,370	990	7,152	905	12,462	2,021
Trib A	0		66					
Trib B	4,070	285	3,900	566	1,578	193	1,260	216
Trib A of B	40		0				0	0
Trib B of B	40		54				0	0
Total	**16,940**	**850**	**9,390**	**1,556**	**8,730**	**1,098**	**13,722**	**2,237**
Over Winter Retention		**1st Post 5%**		**2nd Post 16.57%**		**3rd Post 12.58%**		**4th Post 16.3%**

Note: Each of these stream contributions have been corrected for the visual snorkeling bias that was calculated utilizing electrofish calibrations for both daytime summer and night time winter surveys by ODFW in the Alsea basin. These calibration factors are designed to portray a more accurate estimate of true rearing densities throughout a range of variable habitat complexities.
These calibration factors are as follows:
N x 1.20 for summer estimates of all habitat complexities
N x 1.23 for winter nocturnal estimates in low and medium complexity habitats
N x 1.89 for winter nocturnal estimates in high complexity habitats

Note: The over winter retention rates calculated on sheet 1 represent entire sub basin effects and should not be utilized to represent project effectiveness in the case of the Elkhorn mainstem. Refer to sheet 2 in this workbook for a higher resolution analysis of Helicopter project effectiveness (treated verses untreated stream segments).

The two pre-project inventories on Elkhorn, conducted prior to the summer 2008 large wood placement, resulted in overwinter retention rates of 6.7% and 5.9%. To be clear, the overwinter retention rates posted above in Table 1 are presented as basin-scale views. There are higher resolution views of survival rates available for the Elkhorn inventories because there are essentially three independent reaches contained within Elkhorn Cr. These are as follows:

1) The untreated Elkhorn mainstem below the confluence of Cruiser Cr.
2) The treated Elkhorn mainstem above the confluence of Cruiser Cr.
3) The treated Trib C of Elkhorn, which exhibits channel morphology very different from mainstem Elkhorn (lower gradient, broader parent floodplain).

Table 2 below takes a more critical look at how these independent reaches performed to provide overwintering habitat during their first post-treatment winter (2009). You will note that a significantly higher overwinter retention rate exists for Trib C when parsed out of the basin scale review (Pre- 4.7% and 5.8% vs. Post- 21%). In addition, if the treated section only of mainstem Elkhorn is parsed out of the basin scale view presented in Table 1, the true overwinter retention rate increases to 14.1%.

During the second post-treatment winter (2010), overwinter retention rates in Trib C remained identical to the previous year at 22%. The replicability of these overwinter retention rates encourages high confidence that the sampling methodology is succeeding at representing actual real world values. The 2010 results from the treated mainstem segment of Elkhorn were phenomenal with overwinter retention rates soaring to 38% of the summer population of coho still rearing in headwater habitats just prior to their migration to the ocean. This represents a 378% increase when compared to the untreated control reach. Prior to treatment, the untreated Elkhorn control reach exhibited very similar overwinter retention rates to the treated Elkhorn reach. Therefore, the best comparison is to the control and not to the pre-treatment values on Elkhorn (the control incorporates the powerful variable of winter flow profile).

Table 2

Elkhorn Cr Pre - Post Project Monitoring

This analysis takes a higher resolution look at Elkhorn Cr by breaking the basin into unique treatment segments.
Compares over winter retention of coho in the project reach (Elkhorn from Cruiser Cr. to falls, including Trib C) for 2 years prior to helicopter log placen
(Pre) and 2 years after log placement (Post)
The following 3 reaches are reviewed seperately because they either differ in morphology or treatment.
These estimates of over winter retention of juvenile coho should be utilized to specifically evaluate project effectiveness and quantify the increase in sr
production associated with LWD placement from pre-project estimates of over winter retention.

Year	Elkhorn below Cruiser (Untreated Control)	Over Winter Retention	Elkhorn Above Cruiser (Treatment Reach)	Over Winter Retention	Trib C Elkhorn (Treatment Reach)	Over Winter Retention
	Pop.estimate		*Pop.estimate*		*Pop.estimate*	
2006 (S)	13,260		20,627*		9,385	
2007 (W)	467	3.52%	1,374	Pre 6.66%	445	Pre 4.74%
2007 (S)	12,234		16,728*		4548	
2008 (W)	631	5.16%	991	Pre 5.92%	264	Pre 5.8%
2008 (S)	9,426		11,214*		3600	
2009 (W)	628	6.66%	1,324	**Post 11.81%**	757	**Post 21.03%**
2009 (S)	16,776		22,300*		5,646	
2010 (W)	1,341	7.99%	8,512	**Post 38.17%**	1,231	**Post 21.8%**

The highlighted over winter retention rates identify the only two segments treated during the summer 2008 helicopter project
Note the substantial difference between the untreated lower mainstem and the treated section of Elkhorn above the Cruiser Cr confluence
* These values include the minor contributions of Tribs A and B on the assumption that summer juveniles drop out of these steep tributaries
during winter flow regimes and attempt to winter rear in mainstem Elkhorn. This assumption has been verified by sampling the first few pools
during winter nocturnal surveys in both Tributaries.

Discussion

Differences in morphology and hydraulic potential are the primary drivers in determining the efficacy of any instream restoration project. It is important to dissect the issues of morphology that are in play at the reach level in the context of discussing the effectiveness of the restoration work conducted in Elkhorn and Cruiser Cr. An assessment of risk level, structure longevity and functionality were conducted by the BLM staff to initially evaluate the levels of success that could be achieved from each stream segment.

In their preliminary design phase, obvious transport reaches with essentially vertical canyon wall confinement were not included in the proposed wood treatment. The risk of structure failure or the development of an impassable adult barrier was significant enough to eliminate these reaches. A large segment of Cruiser Cr (3,500 ft) extends from the mouth at its confluence with Elkhorn Cr to the bridge below the confluence of Trib A. This stream reach is paralleled by a valley bottom road that encompasses at least 50% of the available floodplain in most locations. During the design phase it was determined that specific structure design criteria would be utilized that would assist the stream in recapturing its historical floodplain. The road was fluffed with an excavator to relieve compaction, the entire road fill was removed at each first order stream crossing and deflection structures were placed to initiate roadbed scour. It is important to note that the underlying morphological metrics of steep gradient and hillslope confinement have been key components of achieving success in recovering floodplain function without the expense of road removal.

The full spanning log structures placed in this confined stream reach have gone through a chaotic series of events in the four years of monitoring reviewed in this report. These events can be summarized as follows:

Winter 1 - Settlement, initial sealing and seating.
Winter 2 - Accumulation of average levels of canopy litter.
Winter 3 - Accumulation of massive levels of storm driven canopy litter, initiating rapid bedload accumulation resulting in aggradation. Partial adult barrier developed.
Winter 4 - Radical hillslope and road bed failure as aggraded active channel relieves hydraulic pressure horizontally. Partial adult barrier completely removed by horizontal channel migration.

Cruiser Cr stream gradients average approximately 4%. The watershed area is approximately 2,315 acres (3.6 sq miles). There are two short reaches (850 ft and 1,000 ft) within the 3 mile stream corridor that exhibit the morphological potential for developing an interactive floodplain with the use of large wood structure placements. The remaining 2.6 miles of Cruiser Cr and its primary tributary (Trib B) are hillslope confined and exhibit only limited potential for developing complex channel characteristics. It is significant to note that the progression of events documented above were required for the successful recovery of sinuosity in the stream segment confined by historical valley floor road construction. The roadbed erosion and toe slope failure were the positive result of appropriate design. A process has been initiated that may very cost effectively result in the recovery of the historical meander belt. The continued monitoring of the increasing sinuosity observed in this segment of Cruiser Cr is going to be a valuable and unique opportunity for learning how to cost effectively recover floodplain function.

There were distinct differences in juvenile salmonid retention between the two treated reaches of Elkhorn (the mainstem of Elkhorn from Cruiser Cr to the confluence of Trib C and Trib C itself). Radical increases in overwinter retention were observed in both, but mainstem Elkhorn substantially out performed Trib C during the low flow winter of 2010. The following observations may be related to the quantifiable differences. Surveyors noted well-seated structure complexes in the mainstem Elkhorn section with significant bedload accumulation. The structures in this reach had received the supplemental benefits of massive quantities of canopy litter not observed in Trib C. One explanation for this difference is that mainstem Elkhorn has three times the hydraulic potential of Trib C to transport this migratory material and deliver it to the structure complexes. Trib C clearly did not have the transient wood load accumulation observed in Elkhorn. In addition, Trib C has a much narrower active channel resulting in a higher frequency of structure wood sitting up on the first terrace and not as integrally associated with the wetted channel as observed in Elkhorn.

Table 3 displays an increasing annual trend in pre-project overwinter retention rates in the untreated control section of Elkhorn Cr. This reach is the 2.8 mile section of the mainstem from its confluence with the MF-NF Trask to the confluence of Cruiser Cr. This zone was untreated during the Elkhorn large wood placement project and was monitored as an untreated control for all four years of the pre- and post-monitoring. When this trend is reviewed in relation to the different peak flow regimes between years, there is a distinct correlation between peak flow and the systems capacity to retain juvenile salmonids. The worst case scenario is represented by the conditions in 2006 / 2007 when a large peak flow event occurred in November. The best case scenario was the low peak flow event of 2010. This presentation of the data merely indicates the obvious, that streams present a highly variable series of regulatory events that influence juvenile salmonid success and that the magnitude of peak flows is one of those powerful variables.

Table 3

Year	Pre project over winter retention	Peak flow (Tucca gauge)	Peak flow timing
2006 / 2007	3.52%	>300 cfs	November
2007 / 2008	5.16%	>300 cfs	December
2008 / 2009	6.66%	160 cfs	January
2009 / 2010	7.99%	70 cfs	November

Assessing physical changes in aquatic habitats (Can it be done?)

We have reviewed the changes observed in seasonal coho abundance as a result of instream structure development. What about the physical habitat changes that drive the observed increase in fish abundance? The following text attempts to identify the issues at play in the hopes of preparing resource managers for the inevitable discussion of why and how.

If winter habitat is limiting for juvenile salmonids, as is suggested by many research documents, then a clear definition of winter habitat would be a prerequisite for providing more of it and measuring changes in its abundance. Winter habitat is low velocity habitat with cover, typically associated with off-channel habitats on floodplains including low gradient tributaries, secondary channels, ponds, alcoves and tidal marshes. Locations that provide interaction with the floodplain guarantee that, as flows fluctuate, a shift to adjacent low velocity habitats will require limited use of a fish's caloric resources. In addition, winter habitats also exist within the active channel prism in the form of micro habitats created by wood complexity and pool type (dam pools and lateral scours). Preferred habitats for juvenile salmonids (primarily coho and cutthroat) that function throughout the winter, display a combination of complex cover, no velocity, and immediate linkage to adjacent low velocity habitats on the floodplain during increasing flow regimes. Winter maintenance of the body condition attained during the summer is critical for juvenile salmonids during winter flow regimes. Juveniles in poor condition and those of smaller than average length are the first to depart from 3rd and 4th order stream corridors with the approach of winter flows.

Therefore, an evaluation of winter habitat would have to involve an assessment of potential interactive floodplain surface area. At what flow should this surface area be quantified? There is a definitive need to establish a replicable metric for evaluation. Therefore it makes some sense to suggest that the mean bankfull indicator be utilized as a metric of potential floodplain interaction. Mean bankfull may not be the critical flow stage but it is at least a visible indicator that can be identified and replicated by introductory level technicians. As the bankfull indicator makes excursions onto the adjacent floodplain, surface areas of off-channel habitat could be estimated. These evaluations could also be conducted during summer flow regimes when streams are stable and wadeable. This data is currently not available from standard Aquatic Habitat Inventories.

The second level of evaluation involves the low velocity micro habitats that exist within the channel prism. These are areas associated with cover or inside meander bends that are habitats within a normal habitat unit (pool). They do not exhibit the firm borders and hydraulic controls typically associated with a habitat unit but definitely function differently from the remainder of the habitat unit surface area because of the low or absent velocity. Both of these fundamental types of winter habitat exist within a range of variable qualities and therefore can be ranked for several other important attributes--cover, complexity, and linkage (active channel / floodplain)

There is a significant data gap in our understanding of the dynamic function of complex woody structure and its benefits, especially for the provision of winter refugia for juvenile salmonids. Part of this lack of institutional knowledge is our continuous insistence on counting sticks and stones (the only way to gather data with introductory level biological technicians). If we could alter the current paradigm to view the functionality of wood and resist the desire to count, we could begin to understand what makes a certain wood configuration productive for salmonid juveniles and begin to replicate it. For this approach to function, we need to interface the variable functionalities of woody structure (habitat) and its winter rearing potential by collecting and comparing the associated fish abundances. This approach trusts the fish to guide us in identifying functional winter habitat.

The actual quantification of winter habitat is clearly problematic. Attempt to describe a set of metrics that can be utilized in the winter, in a replicable fashion, from year to year by different surveyors with varying degrees of experience and you begin to realize that valid comparisons between years may be a fool’s errand. The very nature of winter habitats is dynamic because of almost daily alterations in flow and the subsequent changes in active channel elevation. Each of these shifts results in comparable shifts in off-channel surface area, floodplain interaction and micro-habitat surface area. The whole drama of complex change goes far beyond existing concepts and measurement tools.

Assuming that we are not likely to acquire a replicable methodology for the direct measure of winter habitat we should set our sights on improving summer methodologies. This would require the development of supplemental indexes that profile channel complexity, floodplain interaction and site specific evaluations of winter habitat continuity through a range of flow regimes.

Appendix 1.

An evaluation and calibration of winter juvenile Coho snorkel counts

Introduction

Rapid Bio-Assessment (“RBA”) is a method for quantifying stream fish populations that has been successfully used by Oregon coastal Watershed Councils for twelve years to evaluate the summer distribution and abundance of juvenile salmonids on the 6^{th} field scale. In this method, snorkeling is utilized to visually identify and count juvenile salmonids without removing them from the stream. The standard protocol samples every 5th pool utilizing a random start.

Considerable effort has been expended during these inventories to evaluate the accuracy of the method. The gist of these findings is that summer snorkel inventories for Coho during the summer are replicable, with visual estimates typically underestimating the actual number by less than 20 percent. The “calibration coefficient” for summer snorkel surveys is thus generally set at 1.20. The actual rate for any given pool can vary under several influences, principally diver experience, pool cover complexity, stream width, water clarity, and species specific behavior.

The RBA method was also utilized during this effort for winter night inventories of juvenile salmonids. Winter population data provides a basis for detecting seasonal shifts in population size and distribution, and for evaluating the success of in-stream structure projects intended to improve winter habitat. There is precedence for this approach. Roni and Fayram (2002) found that nocturnal snorkel counts do not significantly differ from estimates produced by daytime multi-pass reduction electrofishing.

This encouraged us to conduct winter nocturnal snorkel inventories and to compare estimates produced by this method with those produced by daytime electrofishing. Ratios of estimates produced by the two methods can then be used to calibrate future diver counts.

A winter-time study of this type was cooperatively conducted by Bio-Surveys and ODFW research staff during 2002. The study included day and night snorkel surveys as well as electroshock mark and recapture estimates. This approach provides comparisons among three types of survey techniques, the principle interest being how well winter night snorkel counts compare with estimates produced by electrofishing, a sampling method of known reliability.

The study site was a short 300 meter segment of the mainstem of Lobster Creek, a tributary of Five Rivers in the Alsea basin. Lobster Creek is a 4th order subbasin with an average winter active channel width of 13.2 meters. This stream was selected for the study because high summer rearing densities of Coho have been observed in it and because it offers good visibility during storm events that otherwise shorten the sampling window. In addition, this segment of Lobster Cr is representative of high quality Coho habitat for the mid coast of the Oregon coast range.

The following data were collected for each of the six Lobster Creek sample pools:

1) Replicate day snorkel counts by two experienced snorkelers. Diver expertise strongly affects both identification and count accuracy.
2) Night snorkel diver counts by the same two snorkelers.
3) Electroshock mark and recapture estimates of pool population size. Although electrofishing does not provide a true census of a pool population, it is generally reliable and is commonly used to evaluate snorkel count effectiveness.
4) Night-time water temperature. Fish activity level, feeding, detachment from cover and other behaviors are influenced by temperature, and these behaviors affect snorkel count efficiency. Note that day temperature varied little from night temperature in this study.
5) Pool complexity (rated 1-5 on an ascending scale based on the amount of cover provided by wood, large substrate, overhanging vegetation, and undercut banks). The more complex the cover, the more difficult fish observation.
6) Pool dimensions. The wider the stream, the greater the chance that a fish can swim by the snorkeler unnoticed.

Methodology

Lobster Creek

Six pools of different levels of cover complexity in Lobster Creek were snorkeled twice during the day by different divers and then twice again at night. On the following day, these same pools were blocked with fine mesh nets at pool head and tail and electrofished to produce mark-and-recapture estimates of number of fish in each pool. Each pool was rested at least 30 minutes between snorkel events to allow fish to return to pre-disturbance behavior.

Electrofishing used three 1,000 volt Smith Root backpack shockers, which were operated simultaneously to broaden the field of effective galvanotaxis. Captured fish were measured and caudal fin clipped without anesthetization, allowed to recover at least two hours, and then released back into the blocked pool. Recapture was initiated after an additional two hours to allow the fish to re-orient to pool structure. The same capture method described above was used in the recapture process.

All of the work occurred February 10 to 26, 2002 during receding flow conditions, with night stream temperatures between 3 and 6 deg C. Water clarity was excellent throughout the study.

Complexity ratings were re-classified from the original scale of 1-5 to “High” (4 and 5) or “Medium” (2 and 3) to group data for analysis. Note that Low complexity pools were not included in the sampling program because such pools typically have too few fish to justify inclusion in this limited study.

Water temperature at the time of sampling varied between 2.50 and 5.56 degrees C. As a matter of preliminary investigation, we divided the pools into the four pools having temperatures greater than 5 degrees C, and the 2 pools less than 5 degrees C. With two snorkeler counts per pool, this provided 10 counts for the higher temperature pools and 4 counts for the lower temperature pools.

Data analysis

The primary goal of the study was to create expansion factors that can be used to elevate snorkel count data to estimates of pool population size. This is accomplished by calculating the average ratio of electrofishing estimate to snorkel count. It was also helpful to view the relationship as “what fraction is the snorkel count of the electrofish estimate”, which is the average ratio of snorkel count to electrofish estimate.

The two ratios are related, but each must be calculated independently: Mathematically, the reciprocal of one average is not the other average.

The ratio can be seen graphically as the slope of the line when snorkel count is charted against electrofish estimate. Log and square root transforms did not improve linearity of this relationship for the Lobster Creek data, which is limited to six pools having moderate to large Coho populations. However, the Green River/EF Green River displays better with a sqrt+0.5 transformation, and is presented in this mode.

Zero counts created problems of division when calculating ratios that were not satisfactorily resolved by adding constants to the counts. For this analysis, data pairs involving zeros were omitted.

Results

Lobster Creek

Diver expertise and count replication
Replicate night counts of the same pool are extremely close, and replicate day counts are also very close (Figures 1 and 2). Our assessment is that differences between divers had little influence on the relation between snorkel counts and electrofish estimates in this study. This may be explained by the fact that the two divers have considerable experience and have worked together for many years.

Pool width effects
Pool size varied insufficiently in the six sample pools to warrant analysis.

Water temperature effects

We found that the average daytime snorkel to electrofish estimate ratio was distinctly lower for the lower temperature group than for the higher temperature group (Table 5). This distinction did not hold true for night snorkel observations.

Pool complexity effects
The average ratio of snorkel count to electrofish estimate was lower for high complexity pools than for low complexity pools (Table 4). This difference is substantial for both day surveys (0.46 vs. 0.25) and night surveys (0.84 vs. 0.54). The 0.84 night ratio for medium complexity pools is similar to that found in previous studies aimed at calibrating daytime summer snorkel surveys.

Night snorkel counts vs. electrofish estimates
The relationship between night snorkel count and electrofish estimate appears to be clearly defined with little scatter (Figure 1). It is probable that the relationship is curvilinear with a decreasing slope. That is, proportionally fewer fish are probably seen by the snorkeler as the pool population increases. However, we lack sufficient data in the 0 to 100 fish range to properly define the curve.

Day snorkel counts vs. electrofish estimates
In contrast to the night count vs. electrofish relationship, the day count vs. electrofish relationship exhibits no pattern at all (Figure 1). Replicate snorkeler counts agree well, as in the night vs. electrofish presentation.

Day vs. night snorkel counts
Figure 4 charts night vs. day snorkel counts. Note that the counts have been transformed by adding a constant 0.5 and then by the square root function. Despite considerable scatter, a positive slope is suggested.

It is apparent in Figure 4 that day counts produce more zero counts than night counts. The general superiority of night counts over day counts is seen in the following summary:

- Total fish observed in the 77 pools: Day = 765, Night = 1330.
- Average of Night Count minus Day Count: 9.3 fish.
- Number of pools where the day count was zero, and the night count exceeded zero: 11
- Reverse of above: 1.
- Number of pools where the day count exceeded the night count: 16.
- Reverse of above: 45.

Discussion

Day vs. night surveys

The Lobster Creek data, although quite limited, show a very strong relationship between night snorkel counts and electrofishing estimates. On the other hand, the day snorkel counts are highly variable and exhibit no definable relationship to either electrofish estimates or night counts.

The more extensive Green/EF Green data suggest that a reliable relationship may exist between day and night snorkel counts, and by extension perhaps between day counts and electrofish estimates. However, the day vs. night relationship becomes highly tenuous at low counts. Specifically, there appears to be a much greater likelihood that a zero day count will occur when the night survey finds fish than the other way around. That is, night surveys are more likely than day surveys to find fish in sparsely populated pools.

It would be desirable to identify what factors contribute to zero or greatly reduced day counts in pools where night surveys or electrofish capture finds several to many fish. Based on very limited data, we speculate that changes in fish behavior relating to temperature change may be one of these factors, acting in the following manner: After a freshet, clearing weather and receding stream levels commonly produce a drop in stream temperature. Under these conditions, Coho tend to be less active and more cover oriented during the day. Under the same conditions, Coho appear to be less cover-oriented at night. This behavioral pattern may produce much of the variability and reduced observation rates found in daytime snorkel counts when compared to nighttime counts.

In this context, we believe that daytime winter counts at specific sites such as a particular pool or structure may provide reliable data when winter stream temperatures are elevated (>6 deg C) sufficiently to stimulate fish movement. This approach could then be useful when assessing conditions at or near restoration sites. However, the best method for assessing reach-level population changes appears to be night snorkeling.

Overall, we conclude that night counts are more reliable than day counts, especially in low count pools. This was the expected result, as well as a primary impetus for the Lobster Creek study.

Defining the snorkel:electrofish relationship

We need to better define the snorkel count vs. electrofish estimate relationship for sparsely populated pools (which typically are low complexity pools). Does the ratio found at higher counts hold true? Or, is the relationship curvilinear? If the latter, what transformation best represents the pattern (linearizes the relationship and randomizes the residuals)? How are the various influences (pool complexity and width, temperature, etc) factored in?

Sufficient low count data needed to define this part of the relationship are difficult to obtain. In a pool with one to a few fish, missing a single fish by either sampling method can have a large effect on the ratio estimator. In addition, data points that involve one or two fish often generate extremely large or small ratios and thus excessive scatter. A few such points can distort an otherwise much more consistent relationship found for higher count pools.

The Lobster Creek sampling approach was to avoid these problems by focusing on medium and high complexity pools known to support a substantial Coho population. We therefore currently lack winter snorkel vs. electrofish data that define the relationship in the low count range.

Calibration

Conversion of snorkel counts to electrofish estimates could use two basic approaches: The equation of a fitted curve, or a table of conversion ratios (expansion factors). Current data are insufficient to support development of an equation. Thus, we default to a tabular approach. As described, day counts proved to be too variable to generate reliable conversion ratios.

The table of conversion ratios to calculate probable electrofish estimates from night snorkel counts might be based on one to several predictor variables, including diver expertise, pool complexity, pool dimension (principally width), water temperature, and as yet undefined stream-specific conditions. At this point, we really only have useful data concerning pool diver expertise and complexity, with diver expertise a minor effect in the current data. This leaves us with pool complexity, which we believe is a highly important influence on both Coho selection of pools and on snorkel count effectiveness.

Current data are limited to pools of medium and high complexity, and because Coho favor pools of higher complexity, sample pool populations were also generally high. Lacking data for low complexity pools with few to no fish, we assigned the medium complexity ratio to low complexity pools, to produce the following working calibration table:

	Pool Complexity		
	Low	Medium	High
Day snorkel count	Not defined	Not defined	Not defined
Night snorkel count	1.23	1.23	1.89

These expansion factors represent average ratios of electrofish estimate to snorkel count data from the Lobster Creek study. The values are likely to change as more information becomes available.

Figures

Figure 1. Relation between night snorkeler counts and electrofish mark and capture estimates of juvenile Coho in Lobster Creek sample pools.

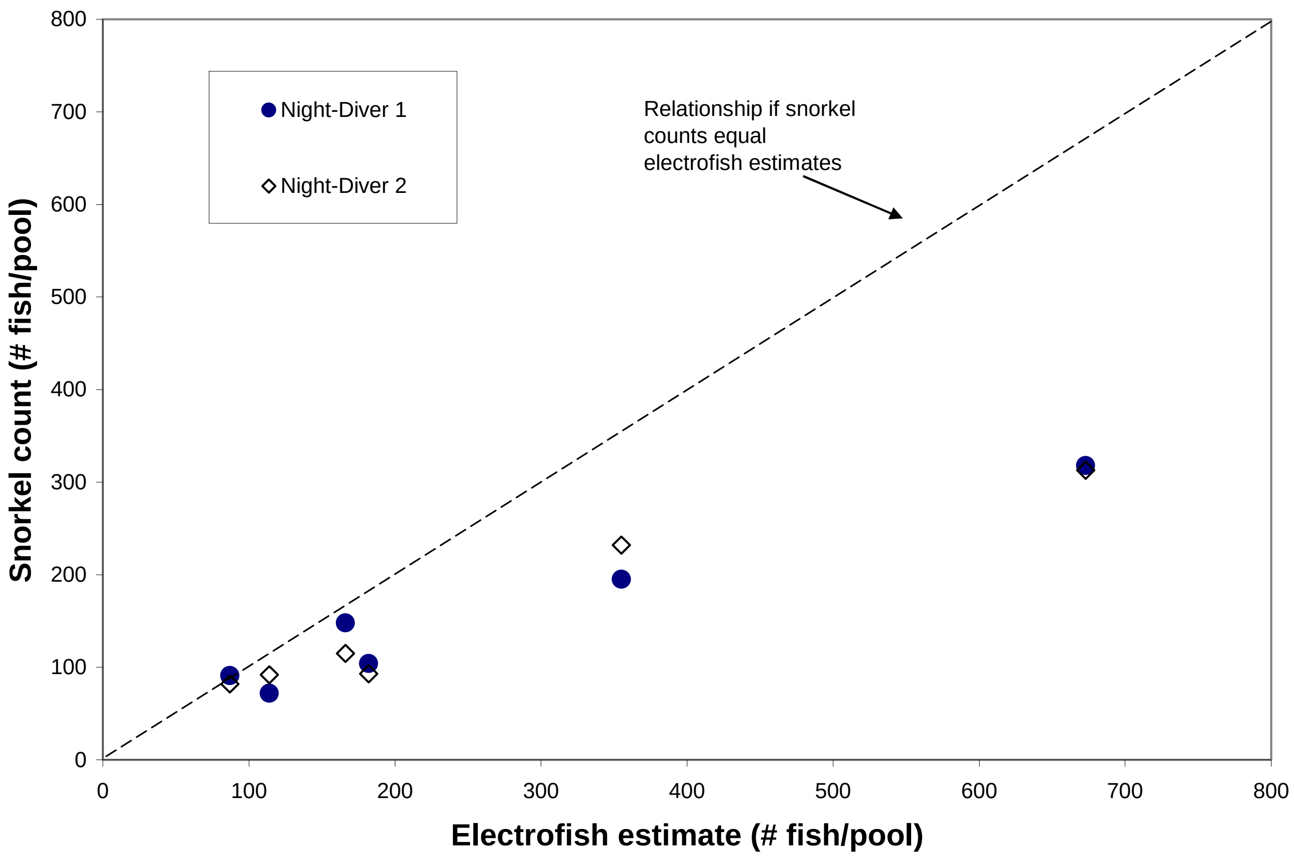


Figure 2. Relation between day snorkeler counts and electrofish mark and capture estimates of juvenile Coho in Lobster Creek sample pools.

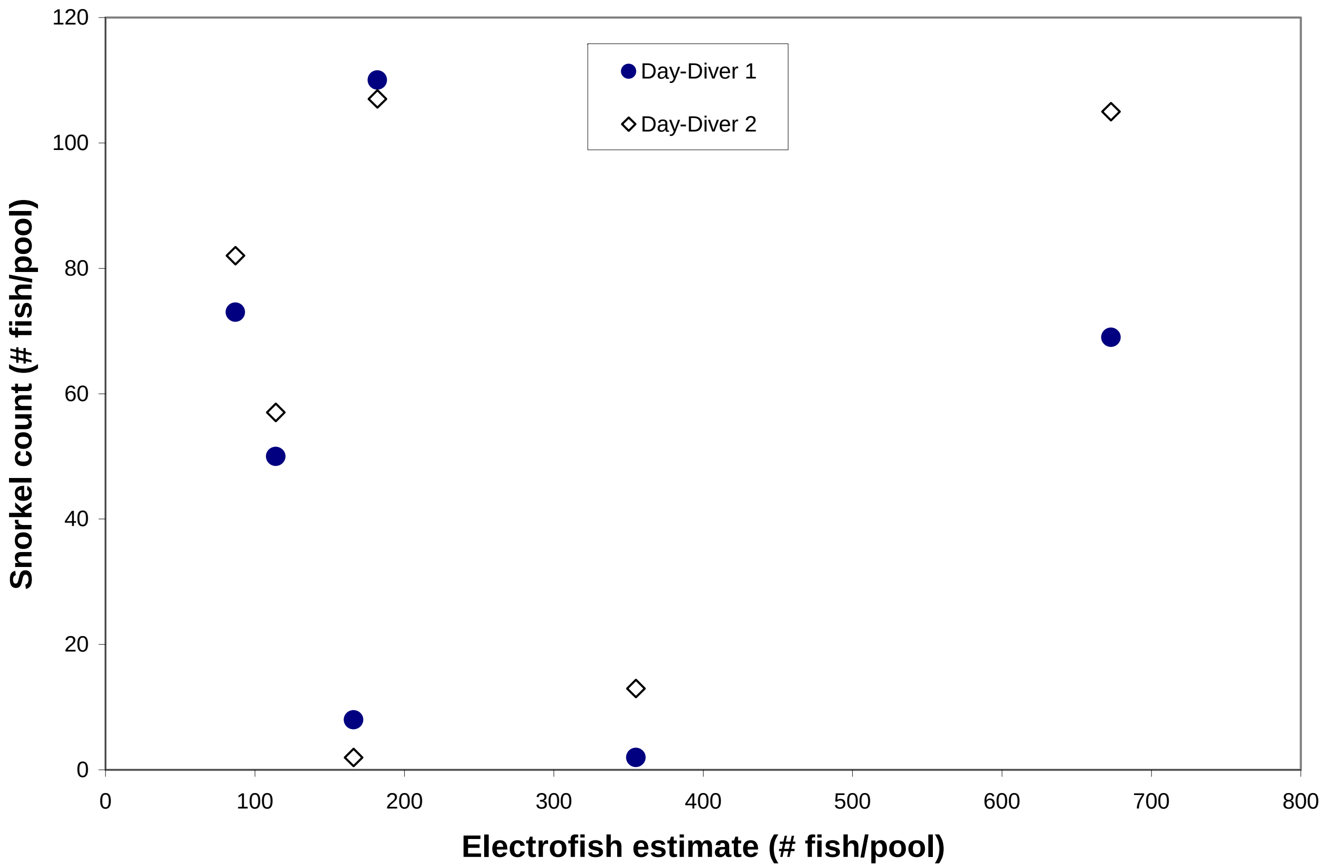


Figure 3. Relation between day and night snorkeler counts of juvenile Coho in Lobster Creek sample pools.

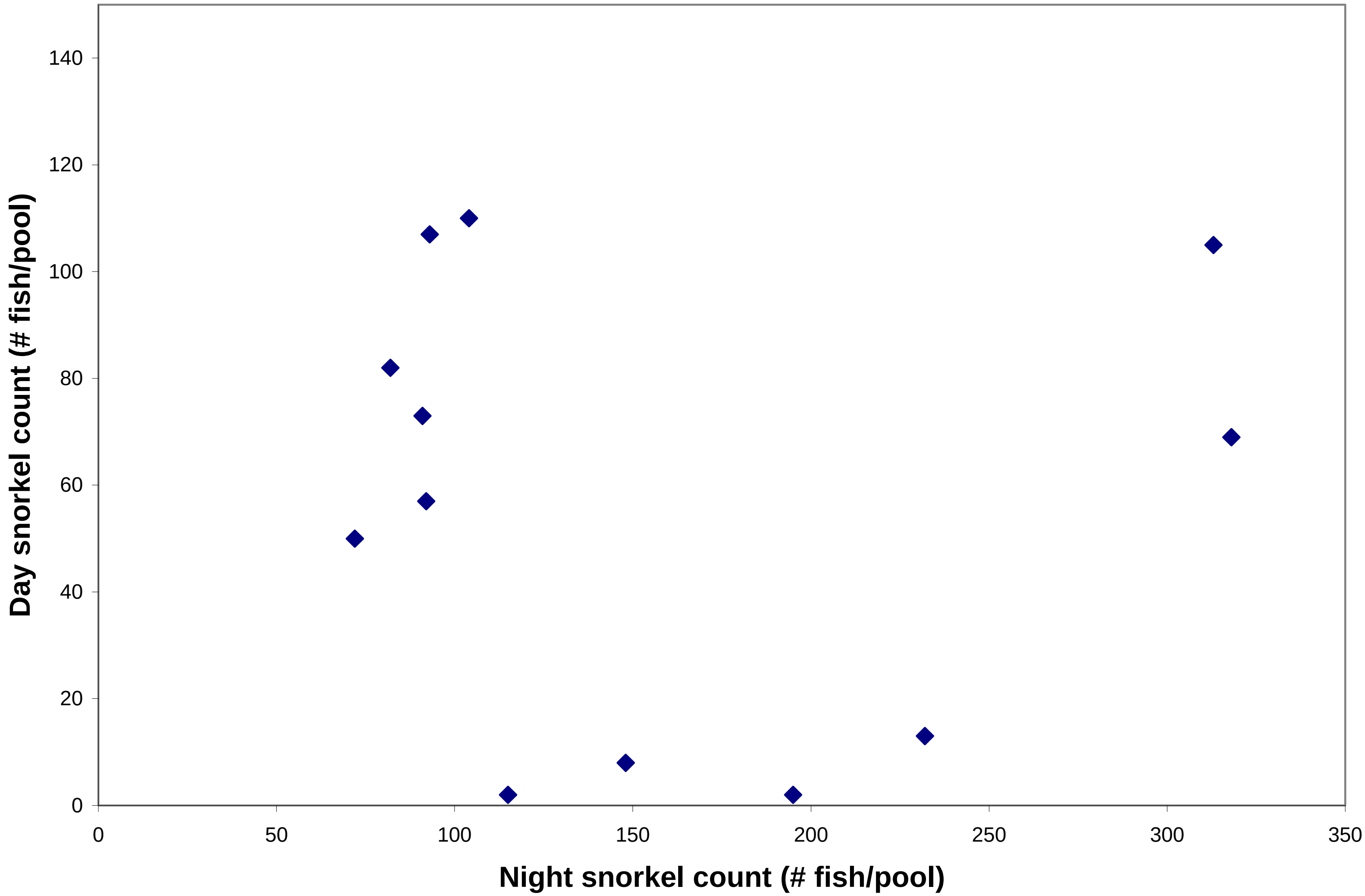


Figure 4. Relationship between night and day snorkel count, Green River and EF Green River, 2002