

Chapter 5.—Using Telemetry Techniques to Determine Multiple Redd Formation, Redd Residence Time, and Survey Life of Adult Coho and Chinook Salmon in Spawning Streams

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Abstract

Effective management and conservation of salmon populations rely upon accurate estimates of population size over time (years). Two methods commonly used to estimate salmon escapement into streams are counting redds and counting live fish during spawning ground surveys. Redd counts, when used to index adult populations, or expanded to estimate the total number of adults, rely upon the assumption that a female makes just one redd. Fish counts, using the area-under-the-curve (AUC) escapement model, rely on an accurate estimate of the average time live fish spend in the survey area (known as survey life or SL) or on redds (redd residence time or RRT). Multiple redd formation (MRF), RRT, and SL can be difficult to measure accurately and have received little attention in California streams. This paper will provide telemetry methods to determine MRF, RRT, and SL for adult salmonids in spawning streams based upon 4 years of study. Telemetry can provide additional data as well, such as observer efficiency at seeing redds and live and dead fish, salmonid habitat use and migration patterns, pre-spawn predation, and egg retention. The methods are intensive, yet simple, and have proven to be an efficient, relatively low-cost method to accurately address key assumptions and variables used in fishery models, particularly for long-term population monitoring.

Introduction

Effective management and conservation of salmon populations rely upon accurate estimates of population size over time (years). Two methods commonly used to estimate Pacific salmon (*Oncorhynchus* spp.) escapement into streams are counting redds and counting live fish during spawning ground surveys. Redd counts, when used to index adult populations, or expanded to estimate the total number of adults, rely upon the assumption that a female makes just one redd. Fish counts, using area-under-the-curve (AUC) methodology, rely on an accurate estimate of the average

number of days that a live fish spends in the survey area (survey life or SL) or a female fish spends on redds (redd residence time or RRT).

Multiple redd formation (MRF), defined as constructing and depositing eggs in more than one redd during reproduction, typically is assumed to be negligible or non-existent with respect to population escapement models (e.g., Hill and Irvine, 2001; Greene et al., 2005; Paulsen et al., 2007), and in research studies designed to determine survival from egg deposition to fry emergence in natural redds (Tagart, 1984; Sparkman, 2004). Most models and studies consider single redd formation by Pacific salmon to be the norm. Although there is a large body of literature describing salmonid reproductive behavior (e.g., Briggs, 1953; Groot and Margolis, 1991; Quinn, 2005), relatively little attention has been directed at proving or disproving whether adult female Pacific salmon make multiple redds during reproduction. There are three types of studies that have specifically been used to investigate MRF: (1) genetic analyses, (2) artificial spawning channels, and (3) PIT tagging adult female salmon. Bentzen et al. (2001) used multilocus microsatellite genotypes collected from pre-emergent juveniles to infer that 7% (1 out of 14) of the female Chinook salmon (*O. tshawytscha*) made two redds. Kuligowski et al. (2006) used polymorphic microsatellite loci collected from eyed eggs in redds of steelhead trout (*O. mykiss*) to infer that the eight redds were built by at least five adult females. Schroder et al. (2008) placed adult spring Chinook salmon in an artificial spawning channel and observed that 10% of the females constructed more than one redd. Murdoch et al. (2009) injected PIT tags into adult female spring Chinook salmon prior to their spawning in natural streams and determined that females constructed 1.01 redds/female.

RRT is less difficult to measure than SL because fish are more easily observed on a redd compared to locating and observing fish in various stream locations and habitat types. Three current methods are available for determining RRT: (1) direct observation of spawners with distinct natural markings (e.g., fungus, predator wounds) on redds (Neilson and Banford, 1983), (2) AUC of spawners divided by an independent mark-recapture population estimate of spawners (Parken et al., 2003), and (3) time lapse video recordings of spawners on specific redds (Shardlow, 2004).

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SL is an important variable used in the AUC escapement model (Perrin and Irvine, 1990; Korman et al., 2002; Parken et al., 2003). SL is a difficult variable to determine accurately, and several authors have indicated SL to be specific to species, stock, sex, stream, time of adult entry, and year (Perrin and Irvine, 1990; English et al., 1992; Lady and Skalski, 1998; Korman et al., 2002). In order to reduce systematic biases in estimated escapement over years, Perrin and Irvine (1990) and Hilborn et al. (1999) recommended determining SL on an annual basis. Perrin and Irvine (1990) reported eight independent methods to determine SL, with most methods consisting of variations in: (1) extensive mark-recapture and foot surveys, (2) repetitive counts of live and dead fish, and (3) AUC of counts of live fish divided by an independent mark-recapture population estimate. Korman et al. (2002) used radio telemetry to determine SL for adult steelhead trout.

This paper will provide telemetry techniques to determine MRF, RRT, and SL for adult salmonids in spawning streams based upon 4 years of study; results from the third year (YR 2007–08) are presented for illustration. Telemetry may be used to gather additional data as well: (1) observer efficiency at seeing redds, (2) observer efficiency at seeing live and dead fish, (3) salmonid habitat use and migration patterns, (4) pre-spawn predation, and (5) egg retention.

Site Description

The study was conducted in Prairie Creek, a tributary of Redwood Creek in Humboldt County, California (fig. 1). The Prairie Creek watershed lies within the Northern California coastal zone in Redwood National and State Parks, and is forested with old growth redwood (*Sequoia sempervirens*) and Sitka spruce (*Picea sitchensis*). Prairie Creek is a relatively pristine, fourth order, low-gradient stream (0.0032 m/m) that drains a 34.4 km² watershed. Mean annual discharge is 1.49 m³/s and bank full discharge is 5.6 m³/s. Prairie Creek supports annual runs of adult Chinook salmon, coho salmon, and steelhead trout that are listed as threatened under the U.S. Endangered Species Act (Federal Register, 1997, 1999, and 2000).

Adult salmon populations in Prairie Creek were surveyed annually by foot within pre-designated, stream-index reaches, which encompassed a total of 15 km of stream habitat. The 15 km was divided into five reaches, and within each reach, meter markers were placed every 50 m on nearby trees for associating distances to locations of redds, live fish, and carcasses. An adult counting and marking weir is located at Rkm 8.4, just downstream of major spawning areas and survey index reaches (fig. 1). Annual adult escapement over the past 9 years ranged from 70 to 660 for coho salmon, and 30 to 531 for Chinook salmon (W. Duffy, U.S. Geological Survey, California Cooperative Fish and Wildlife Research Unit,

personal commun., 2009). Prairie Creek was ideal for this type of research because there is a large network of trails along the mainstem and tributaries, and a road parallels most of Prairie Creek. Additionally, Prairie Creek clears rapidly after storm events, thus increasing the probability of visual observations. In streams with poorer access, telemetry techniques may prove to be even more effective than other techniques (e.g., mark-recapture and foot surveys) because less time is spent trying to locate tagged fish.

Methods

Telemetry Equipment

Advances in telemetry technology have greatly increased the ability to quickly detect individual fish. An important aspect in choosing equipment for a study like this one is the ability to use radio transmitters (tags) that have a unique code assigned to a common frequency; depending on the company, there can be up to 521 codes per frequency.

LOTEK Wireless, INC (New Market, Ontario, Canada) digitally encoded radio telemetry equipment was used in this study, and therefore the method of fine tuning the receiver applies specifically to LOTEK equipment. In this study, I used a SRX_400 W5 scanning telemetry receiver, digitally encoded radio transmitters (Model MCFT-3A; Frequency 159.660 and 159.680 MHz), and two antennas (H; Yagi 4 element) that were tuned to the transmitter's frequency. Fixed stationary receivers were not used in this study because road and trail access in Prairie Creek were adequate to detect tagged fish nearly anywhere within the basin. In larger systems, stationary receivers are useful in recording the movements of tagged fish entering and leaving the system.

The receiver for mobile tracking was programmed and adjusted for the telemetry equipment used in this study. Each receiver was programmed with two different frequencies (e.g., 159.660 and 159.680 MHz) to match the radio transmitter tags used in this study. The scan time, which is the amount of time the receiver scans (listens) for radio transmitters on a given frequency, was set to equal 1.5 times the burst rate of the transmitter. That is, for a transmitter set with a 3 s burst rate, the scan time would be set at 4.5 s. The receiver would scan for the first frequency for 4.5 s and then scan for the second frequency for 4.5 s. Scan times were set beyond the burst rate in order to account for drift and timing of the transmitter's signal. The receiver also can be set to simply detect a single frequency when needed. Whether scanning for two frequencies or detecting a single frequency, multiple codes for a given frequency will be detected and displayed if multiple tagged fish are within detection range.

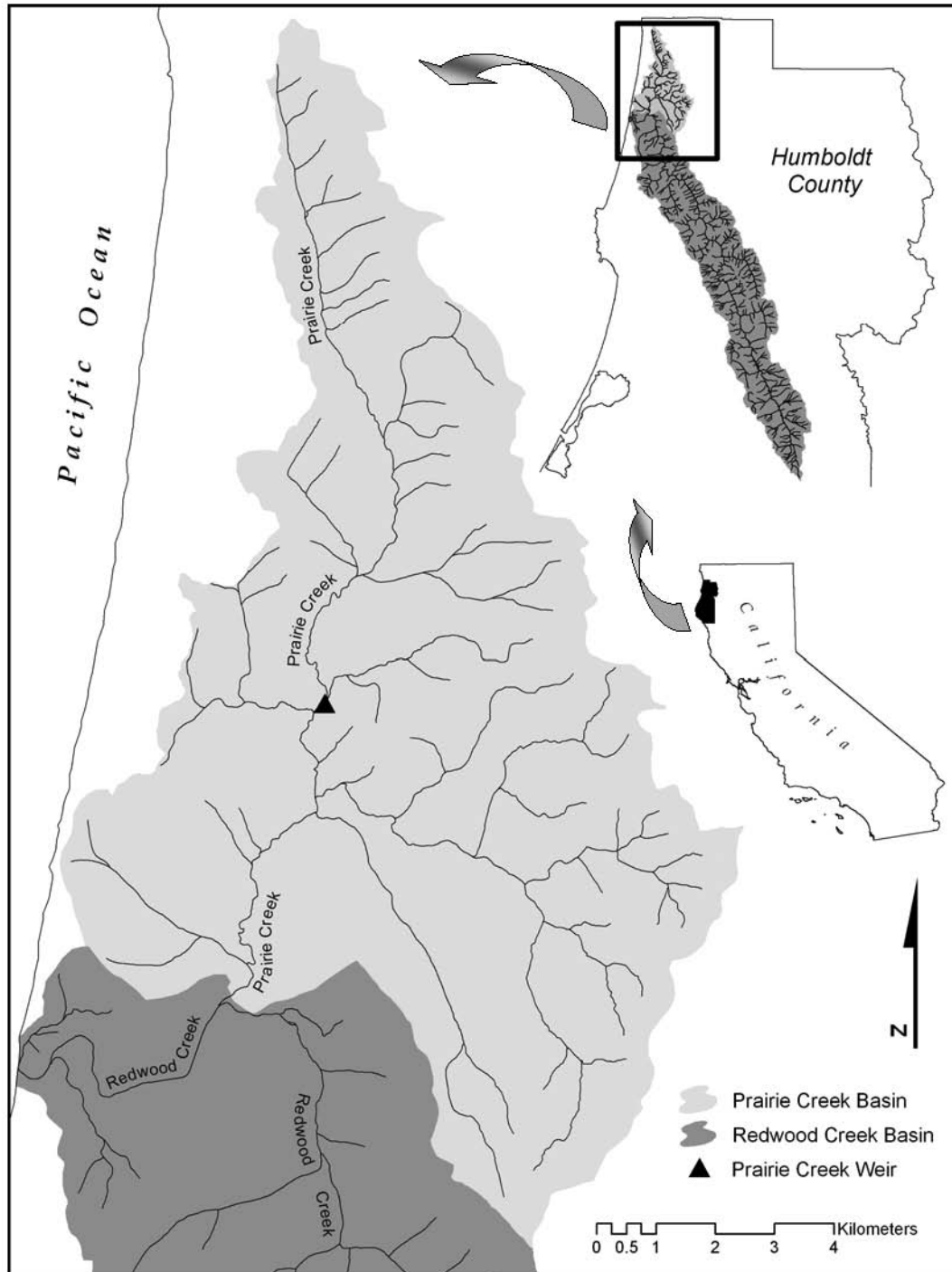


Figure 1. Map of Prairie Creek watershed with adult salmon weir (J. Garwood, California Department of Fish and Game, personal commun., 2009).

Gain can be thought of as the window of detection, or more accurately as an internal attenuation setting that can act as a filter by reducing the strength of the transmitter signal as well as ambient noise. Gain can have values ranging from 1 to 99; the larger the value, the greater the detection window. For example, a gain set at 90 will allow the receiver to detect transmitters at a greater distance from the antenna and receiver than a gain of 10. The main drawback with a high gain setting is background noise (static) increases; however, the chirp of the transmitter emanating from the receiver can still be heard and if the power is great enough, frequency and code will be displayed.

Power refers to signal strength, and can range from values < 10 to the maximum value of 235. The closer the antenna is to a tagged fish at a given gain setting, the stronger the signal strength and the greater the power reading. Gain settings and resultant power readings can be used to locate tagged fish. By decreasing gain and keeping power readings high (> 180) while approaching tagged fish, the location of the tagged fish can be pinpointed. The power of the signal strength also is influenced by: (1) antenna type, (2) antenna orientation and direction relative to the tagged fish, (3) condition of coaxial cable used to connect antenna to receiver, (4) signal interference from trees, undercut banks, water depth, and other physical obstructions, (5) water conductivity, and (6) sinuosity of the stream. When power readings become too low, the receiver will still transmit the chirp of the radio transmitter; however, frequency and code will not be displayed until power readings increase.

A variety of radio transmitter sizes are available, depending on the size of fish to be tagged. The general rule of thumb is to have the transmitter weight $\leq 2\%$ of the fish's weight (Winter, 1983). The frequency of the transmitter in the U.S. is often dictated by Federal Communications Commission standards, and the exact frequency to be used depends on the State in which the study is conducted. Radio transmitters suitable for adult coho and Chinook salmon in this study were 46 mm long, 16 mm in diameter, weighed 6.7 g in water, and set at the factory to emit a signal every 3 s. The operational life of the radio transmitter is dependent on how often the transmitter sends a signal, and at 3 s, transmitter life is expected to be 572 days of continual use (H. Tam, LOTEK Wireless, personal commun., 2009). Several intermittent signal options also are possible with most transmitters; however, the transmitters I used were perfectly suited for this study. Each transmitter broadcasts the radio signal via a flexible, whip antenna ($L = 460$ mm). Three rubber rings (4 mm wide) cut from latex surgical tubing (2 mm thick; 6 mm inside diameter) were attached to each radio transmitter prior to insertion to decrease the probability of fish regurgitating the transmitter once inserted (Keefer et al., 2004).

Adult Capture and Tagging

Adult salmon were intercepted and captured at an adult counting weir, located just downstream of spawning grounds (fig. 1). Zimmerman and Zabcar (2007) describe the general procedure for operating adult salmon weirs. Salmon were captured for tagging throughout the spawning run in order to collect and compare data from early, mid, and late-returning fish, and to provide an average value for RRT and SL that represented the population at large. Several studies have documented that RRT or SL can vary depending on when the adult migrated upstream. In general, earlier returning adults spend more time in the stream or on the redd than later arrivals (Neilson and Banford, 1983; Perrin and Irvine, 1990; McPhee and Quinn, 1998). Once captured, candidate female salmon were placed into a typical holding cradle for measurement (Fork Length (FL); cm), and inspection and tagging. Females used in the study (for investigating MRF) did not show any signs of previous reproduction (e.g., expelling single eggs, caudal fin wear from digging in the substrate, and deflated belly).

Transmitter insertion methods generally followed the protocols for esophageal implants provided by Eiler (1990) and English et al. (2005). Esophageal implants are preferable to surgical methods because the process: (1) takes less than 2 minutes, (2) does not require anesthetizing fish, and (3) reduces the amount of stress associated with tagging. Before tagging, radio transmitters were sterilized in a 10:1 solution of water and iodine disinfectant for 10 minutes. Adult fish were then placed upside down in the cradle before tagging so that reproductive organs would not interfere with transmitter placement (Ward and Miller, 1988). Radio transmitters were inserted through the esophagus into the stomach cavity using a semi-flexible tube (Inner Diameter 5.9 mm, Length 360 mm) until the transmitter stopped at the posterior portion of the stomach. The insertion tube was then removed, leaving the transmitter in the stomach and the antenna protruding from the fish's mouth. Care was taken to avoid pushing the transmitter through the stomach wall. Over a 4-year period, a total of 36 female coho salmon and 6 female Chinook salmon were tagged with radio-transmitters. Several male salmon also were tagged.

I varied the frequency of the transmitter for every other fish when tagging multiple fish on the same day to minimize the probability of signal collision (error code on the receiver) when two or more tagged fish were within close proximity to each other in the stream. Fish tagged on the same day would occasionally be detected the following day in the same location, and if the frequency and timing of the signal pulse of the transmitters were identical, signal collision would occur.

Radio tagged salmon were then placed upright in the cradle and a second tag was applied to the leading edge of the dorsal fin. The secondary tags, similar to Peterson Discs, were small in size (length = 35 mm, width = 0.5 mm, height = 13 mm) and allowed for visual identification of a radio-tagged fish. The secondary tag was small enough to not bias live fish observation probabilities because the observer would see the fish first and then the tag. I used yellow tags because many spawning salmon will have yellow coloration on their back and fins from normal skin and tissue degeneration. After applying both tags, fish were occasionally held in a large tub for up to 10 minutes to assess immediate transmitter regurgitation, and then released upstream of the adult weir. However, most fish were simply released into the stream immediately after tagging because short-term transmitter regurgitation was not observed.

Mobile Tracking

Radio tagged fish were tracked and located nearly every day by one or two technicians. Depending upon the skill of the tracker, stream access points, and location of tagged salmon, one person was able to collect data on up to 15 fish in an 8-hour period. However, fewer fish were usually tracked each day due to natural mortality of spawning adults. To save time finding tagged salmon, two mobile tracking strategies were used: vehicle and foot. The Yagi 4 element antenna, attached to a pickup truck, was first used to get rough locations of each fish because the range in detection is about two times greater than for the H antenna at a given gain setting. The Yagi antenna was often aimed at the river to increase signal strength and probability at detecting transmitters; however, most of the time the antenna worked just as well pointing posterior to the truck. Gain was set anywhere from 60 to 90 and allowed for detecting transmitters up to 1.2 km away in the thickly forested streams of the basin. When a fish was detected, fish location was referenced to survey index reach number, tributary confluence, or mile marker on road signs. If a given fish was not located by truck, I assumed that the salmon: (1) had migrated out of range, (2) had left the study section, or (3) was close to another tagged salmon with the same transmitter frequency and timing of the signal pulse. Other possibilities included transmitter failure, or removal by a predator or poacher. The receiver will display an error code when two tagged fish with the same transmitter frequency are very close to one-another and the transmitters emit a signal within 100 ms of each other (J. Stevenson, BioAnalysts, Inc., personal commun., 2009). However, the error code also could be due to signal interference by trees and landforms. In those

cases, I frequently obtained the correct code by waiting a few minutes for an uninterrupted signal to reach the receiver or by slightly changing the angle and direction of the antenna to increase reception.

Once all fish were generally located, I programmed the receiver out of scan mode and singled in on the nearest frequency (and code). Mobile tracking on foot included wearing waders and using the H antenna with the receiver. Polarized glasses also were worn to increase the ability to see tagged fish. Walking upstream decreased the probability of fleeing behavior. The gain of the receiver was reset to 60 and by angling the H antenna upstream, downstream, or directly towards the river, a given power reading would display when the receiver picked up the transmitter's signal, along with transmitter frequency and code. The direction of travel to track the salmon was determined by the highest power reading and antenna direction. I then followed the signal by observing signal strength and antenna direction at various distances from the tagged salmon. When power readings approached 200–230, I reduced the gain to 40, observed the immediate power reading decrease to a lower value, and continued to follow the signal. As the distance between the tagged fish and antenna decreased, the power readings increased and the sound of the transmitter's chirp also became louder. When power readings once again reached values near 200, the gain was lowered to 20 or 30 and tracking continued. When power readings were near 170 and gain was set at 20–30, I was usually able to observe the fish in a given habitat type (pool, run, etc.), or on a redd.

In streams that are very clear like Prairie Creek, salmon tended to be wary and frequently fled to nearby cover if disturbed. Thus, the ability to visually locate salmon and observe behavior was increased by standing alongside a tree or crouching within riparian vegetation. If the salmon was not visible, then chances are the fish was hiding in an undercut bank, log jam, or deep pool. I found that it was very common for adult salmon to hide in undercut banks and log jams in Prairie Creek. Naturally, the probability of seeing tagged fish was enhanced with increasing stream clarity; however, if stream discharge was very low, salmon tended to increase hiding behavior. If the fish was still not visible, I reduced the gain to 10–20, observed the power reading decrease, angled the antenna to get maximum power, and then waded in the direction to where power readings increased. Under normal circumstances with a gain of 10–20 and power near 150, the tagged salmon will be hiding within a few meters of the receiver and antenna. Once the salmon was located either visually or by relying upon power, gain, and antenna direction, pertinent data were recorded in a field notebook (appendix 1, sample data sheet).

Data Collection

Radio tagged salmon were tracked and located nearly every day 7 days a week, and detailed notes pertinent to study objectives were recorded for each fish (appendix 1). Each fish was assigned a specific data sheet, which greatly simplified data recording and data analysis. The amount of time spent observing a given female depended on how long it took to collect necessary data. Data collected on MRF, RRT, and SL data can be stratified into three categories: (1) survey index reach, (2) tributaries, and (3) watershed. The stratification allowed for discerning any differences in variables relative to surveyed mainstem index reaches, and non-surveyed areas in mainstem and tributaries. Data for watershed included survey index reach areas, and non-surveyed areas.

Multiple Redd Formation.—Adult female salmon may build test redds or digs (no eggs present) before building a “true” redd (Briggs, 1953; Sparkman, 2004) and therefore I had to observe actual spawning by female and male salmon before I considered a redd to be a “true” redd. I found that the effort spent residing on and building a test redd was less than 1 day and for true redds was many days. Test redds for coho salmon also were less than 1.5 m long (including upstream pot or depression) and much smaller than true redds. Typical signs of actual spawning included: (1) female in upright position with mouth open as eggs are expelled, (2) presence of male alongside female when she expels the eggs, (3) male quivering as he releases milt to fertilize eggs, and (4) digging action of female to cover the fertilized eggs. The process was repeated many times over multiple days until spawning was completed. Solitary females exhibiting digging behavior were not considered to be spawning, and on several occasions, I examined the digs and found no eggs present. When a female and male were found on a fresh redd, ribbon tape with detailed information (e.g., date, frequency/code of female, redd in progress, reference location in stream using meters) was hung on nearby riparian vegetation directly perpendicular to the upstream pot (future egg pocket for true redds). Test redds also were flagged with ribbon tape because I would not necessarily know if the test redd would become a true redd until the next day, or if spawning was observed. The flagging also helped to detect any increase in the size of the redd over time, which in turn helped validate additional spawning activity. I also flagged each new pot in subsequent days to further document additional spawning had occurred when not directly observing spawning activity.

Female salmon were tracked and located each day, including the day they died. Once dead, I removed the radio transmitter from the stomach and noted the location of the transmitter and recorded egg retention. The transmitter was then rinsed in stream water and de-activated by attaching a magnet on the transmitter near the reed switch. All radio transmitters were recovered from tagged fish each year.

Redd Residence Time.—The amount of time (d) that a female spends on the redd included: (1) initial redd construction, (2) spawning, and (3) guarding the redd. If any of these behaviors were observed, then that day would count towards RRT. Female salmon did not always reside on the redd throughout the spawning period. Sometimes they would be hiding nearby in undercut banks, log jams, or under overhanging branches, or simply residing in clear view within 1–10 m of the redd. This behavior tended to increase during low-flow conditions. In those cases when a female was not observed on the redd, I would either stay at the site until she appeared on the redd (usually within 15 minutes), or return at a later time during the same day. If the female salmon was within 5 m of the redd, I considered her to be next to the redd, which would then count as part of her RRT. I made the assumption that she would occupy the redd sometime during that day, which was supported by observing her on the redd later that same day, or on following day(s). RRT for each fish is determined by summing the number of days each female salmon was observed on a redd and RRT for AUC is simply the average of these values.

Survey Life.—The amount of time a live fish spends in survey reaches, tributaries, or within the watershed is easily determined using telemetry techniques. Similar to determining MRF and RRT, each fish is tracked daily and detailed notes on location are recorded. Notes on location for each fish included: (1) stream or tributary in which the fish was detected, (2) distance in stream referenced to meter markers, and (3) habitat type. SL for each fish is simply determined by summing the number of days each salmon was alive and SL for AUC is simply the average of these values.

Miscellaneous Information.—Depending on time constraints and budget for research, various additional yet important information can be collected, such as: (1) observer efficiency at seeing redds (Muhlfeld et al., 2006), (2) observer efficiency at seeing live (Korman et al., 2002) and dead fish, (3) habitat use and migration patterns, (4) percent use of specific areas (e.g., survey reaches) within the watershed (Korman et al., 2002), (5) pre-spawn mortality, and (6) egg retention. Observer efficiency, defined as the probability of visual observation or as the number of observation days divided by the total number of possible observation days is easily determined for redds and live and dead fish. Observer efficiencies can be determined by the tracker (e.g., deciding whether I could have seen the redd, live or dead fish while surveying the stream), or by documenting whether an independent survey crew made specific observations (Muhlfeld et al., 2006). Habitat use and migration patterns are determined by documenting the location and habitat type of tagged fish each day, and percent use of a specific area is determined by summing the number of days a tagged fish was found in specific areas (e.g., survey reach or non-survey reach), divided by the total number of days a tagged fish was

located in all areas combined. Pre-spawn mortality can be determined by noting whether the fish survived to spawn, and egg retention can be determined by counting the number of eggs present in the tagged female carcass.

Results

We tagged 14 female coho salmon and one female Chinook salmon in study year 2007–08. Detection probabilities per tagged fish ranged from 93 to 100% and averaged 99.5% for all fish. One female coho salmon was preyed upon before spawning; the remaining female coho and Chinook salmon successfully spawned. None of the 15 females built multiple redds; however, 27% constructed small test redds before building a true redd. Of the four females that built test redds, only one built her true redd within 40 m of the test redd.

RRT for the female Chinook salmon equaled 4 d, and SL equaled 27 d. The female Chinook salmon was preyed upon while on the redd sometime after I observed her on day 4 and before my observation on day 5. RRT for female coho salmon in index reaches averaged 11 d and in tributaries averaged 10 d. SL in index reaches averaged 24 d and in tributaries averaged 10 d (table 1). Egg retention for 13 females ranged from 0 to 20 eggs and averaged 3 eggs per female.

Discussion

The use of telemetry techniques to determine MRF, RRT, and SL overcame many of the shortcomings associated with previous methods reported in the literature. The high probability of detection (99%) of radio tagged fish eliminated biases in RRT or SL that are often associated with mark-recapture and intensive surveys because tagged fish could be located quickly every day. This in turn allowed for determining exact values of RRT and SL. Given that RRT and SL may need to be determined annually (Perrin and Irvine, 1990), telemetry techniques may prove to be the best technique for obtaining accurate and precise estimates of RRT and SL. The success of this research project ultimately depends upon locating each fish nearly every day, which in turn depends upon equipment reliability and skill with

Table 1. Redd residence time (d) and survey life (d) of adult female coho salmon in the Prairie Creek Watershed, 2007–08.

[SEM, standard error of mean]

Code	Redd Residence Time (d)		Survey Life (d)	
	PC Index	Tributaries	PC Index	Tributaries
11	8		35	4
12	9		44	
13		11	28	13
14	9		18	
16	15		21	
17	9		22	5
18	12		16	
22			18	
23		10		12
24	17		49	
25		11		13
29		5		14
31	8		11	5
32		13	6	17
Average	10.9	10.0	24.4	10.4
SEM	1.2	1.3	4.0	1.8

operating the telemetry receiver and antenna. The methods are intensive, yet simple, and have proven to be an efficient, relatively low-cost method to accurately address key assumptions and variables used in fishery models, particularly for long term population monitoring.

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Appendix 1. Sample data sheet.

Agency/Entity Name: _____ Study Name and Year _____ Page of _____

Date Tagged: _____
Tagger: _____

Species: _____ FL (cm) _____ Sex _____

Frequency: _____ Code: _____

[illegible]