Title:	Evaluation of factors required for estimating post-release survival of adult Chinook salmon and coho salmon following collection in a beach seine or purse seine in the lower Columbia River.

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Introduction

The ideal commercial fishing gear for lower Columbia River fisheries would allow fishermen to effectively collect and harvest adult hatchery salmon but also provide the ability to safely release wild salmon that are encountered. Gill nets have traditionally been used by commercial fishermen in the Columbia River but fishery managers are considering alternative fishing gears, such as beach seines and purse seines, which are believed to have higher post-release survival rates. The Washington Department of Fish and Wildlife (WDFW) is seeking an accurate assessment of post-release survival of adult fall Chinook salmon and coho salmon that are captured by commercial fishermen during August–October in the lower Columbia River. A field evaluation that accurately assesses post-release survival will require significant effort and expense because survival rates are desired for three fish species (tule Chinook salmon, bright Chinook salmon, coho salmon) and two commercial fishing gear types (beach seines and purse seines). A radiotelemetry study that was funded by WDFW and conducted by the U.S. Geological Survey (USGS) during 2013 provided information about movement patterns and general fates of Chinook salmon and coho salmon that were collected with beach seines and purse seines (Liedtke et al. 2014). This study provided information that is useful for developing a study to estimate unbiased post-release survival of alternative commercial fishing techniques but also identified several critical uncertainties that need to be addressed.

To accurately estimate post-release survival rates researchers must be able to determine the status (alive or dead) of tagged fish during the days and weeks following capture and release. Results from the 2013 evaluation showed that this wasn't possible during that study for several reasons:

(1) A substantial percent (26 percent of tule Chinook salmon, 21 percent of bright Chinook salmon, and 14 percent of coho salmon; Liedtke et al., 2014) of tagged fish moved downstream and out of the study area following release. Downstream movement patterns could be observed for live fish that were seeking their natal stream or for dead fish that were being moved by river currents, so the status of tagged fish that were last detected moving downstream was uncertain.

(2) The transmitters that were used during the study contained an activity sensor that, if working properly, should provide information about the status of tagged fish (i.e., the fish is alive and moving, or the fish has died or regurgitated the transmitter). However, we observed that 240 radio transmitters emitted an "inactive" signal while present inside fish that were actively moving upstream and passing Bonneville Dam (USGS, unpublished data).

(3) Detection records indicated that species-specific differences were observed in detection patterns. Chinook salmon were tagged with a transmitter that was larger and emitted a stronger signal than transmitters that were used for tagging coho salmon. This appeared to result in substantial differences in detection probabilities. For example, 98% of the tagged Chinook salmon were detected during the study period whereas 92% of the coho salmon were detected (Liedtke et al. 2014). Furthermore, detection probabilities of Chinook salmon on individual fixed sites were relatively high (70% or higher) while detection probabilities on the same sites were relatively low for coho salmon ($<50\%$; USGS, unpublished data).

Based on these observations, WDFW and USGS determined that additional information should be collected during 2014 to assist with the development of a study plan that would have a high probability for successfully determining unbiased post-release survival rates of adult Chinook salmon and coho salmon following capture in a beach seine or purse seine. The 2014 work plan addresses the needs to collect additional information and includes the following objectives:

Objective 1: Determine movement patterns of dead or dying adult salmon following release from alternative commercial fishing gear.

Objective 2: Determine maximum detection probabilities of live tagged fish for boat mobile tracking and fixed telemetry detection gates.

Objective 3: Evaluate the factors affecting the performance of activity-sensing radio transmitters.

Objectives and Tasks

Objective 1: Determine movement patterns of dead and dying adult salmon following release from alternative commercial fishing gear.

Timeline: September—October 2014

The status of many fish that moved downstream following capture, tagging, and release during 2013 could not be determined because this movement pattern could be observed for live fish that were seeking a natal stream located downstream of the release site as well as for dead fish that were being moved downstream in the river currents. The 2013 study had three fixed sites located downstream of the collection area (Figure 1; zone G) and a substantial number of tagged fish were last detected at these sites as they moved downstream after tagging (Liedtke et al. 2014).

Little is known about the behavior and movement patterns of dead or dying adult salmon in the Columbia River and this information is important for understanding these movement patterns if they appear in telemetry datasets. For example, dead or dying fish may not be detected during the study period if they sink to the bottom of the river and remain at that location while their transmitters are active. However, if decomposition processes eventually cause the carcass to rise to the surface, or if the carcass is mobilized and moved downstream by the river currents it is possible that these fish would be detected as they pass fixed sites, and therefore generate a detection history that would be difficult to discern from live fish that are actively moving downstream.

The tasks for Objective 1 are:

(1) Determine the movements of dead, marked hatchery salmon, specifically whether they are moved downstream where they can be detected by fixed sites.

(2) Determine the movements of mortally injured marked hatchery salmon and whether they sink and remain in one location or are moved downstream where they can be detected by fixed sites.
(3) If dead/dying salmon are moved downstream, determine movement rates that can be compared to movement rates of live fish.

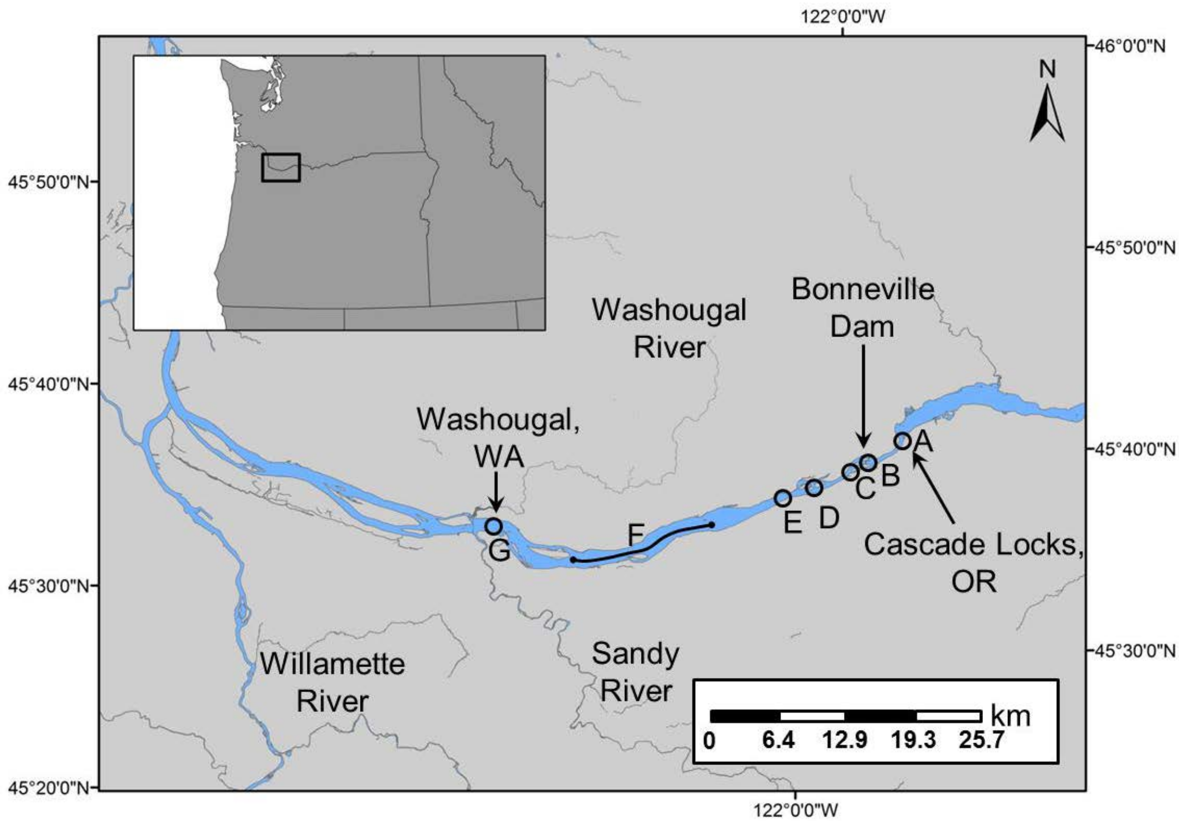

Figure 1.—Map of the study area during 2013. Specific detections were comprised of multiple fixed sites and included the Bridge of the Gods (zone A), Bonneville Dam (zone B), Bonneville Dam tailrace (zone C), Hamilton Island complex (zone D), Skamania Landing (zone E), and Washougal, Washington (zone G).

To evaluate these factors we will tag and release dead and dying adult salmon and monitor their movements using a combination of fixed sites and boat mobile tracking. An array of fixed sites will be deployed at Washougal, Washington and at a secondary location downstream of Washougal, Washington. These sites may supplement mobile tracking detections if the dead fish are moved downstream in the river currents. An additional task in this objective will be the deployment of a GPS drifter (drogue) unit that is released with the tagged fish and drifts downstream with river currents to provide data on water velocity and water travel time. These data may be useful for determining expected travel rates for dead fish that float downstream in the river.

For the first task (dead fish), we will work with WDFW to obtain dead hatchery marked fish, tag them, release them, and track them intensively by boat for up to 12 hours. We propose to tag and monitor 3-5 dead fish, using a combination of coho salmon and Chinook salmon of a variety of sizes. The physical attributes of the release location may be significant drivers in whether or not the dead fish are moved downstream. For example, a release site for a beach seine captured fish would likely be in relatively shallow water, where the fish may drop to the bottom and be able to be tracked without interruption. Alternately, a fish captured by a purse seine would be released into deeper water and could sink to the bottom out of range of detection, and would therefore not be effectively tracked. We plan to release some dead fish from each type of release location to assess their movement patterns. A drogue will be deployed with releases of tagged fish to document the water movement patterns and velocities.

For the second task (killed fish), we will tag and release 15 dying fish (marked hatchery fish) during three sessions for the study. For each session, five mortally injured fish will be tagged and released simultaneously (near the point of capture) and each fish will be tracked by a mobile tracking boat for 24 h post-release to determine the short-term movements of the tagged fish (Table 1). Data collected by each of the mobile tracking boats during the initial 24 h period should be useful for understanding the movement patterns of the dead fish and each fish probably won’t need to be intensively monitored beyond that window. Following the 24 h post-release period, a single mobile tracking boat will collect daily positions of each dead fish during an abbreviated (approx. 8 h) tracking shift (Table 1). We propose to complete all three sessions within a week so that mobile tracking crews will have the greatest chance to collect additional information on fish locations and movements. The tracking period may be shortened based on early findings and more killed fish may be released an monitored if we determine that it is feasible for each boat to effectively track more than one killed fish at the same time.

Table 1.—Proposed tagging and release (R) and mobile tracking (T8 = 8 h shift, T24 = 24 h tracking to be completed by 2 crews each working a 12 h shift) schedules for three sessions where dying adult salmon movements are evaluated.

Boat number	Day of the week						
	Sun	Mon	Tues	Wed	Thurs	Fri	Sat
1		R, T24	T8	R, T24	T8	R, T24	T8
2		R, T24		R, T24		R, T24	
3		R, T24		R, T24		R, T24	
4		R, T24		R, T24		R, T24	
5		R, T24		R, T24		R, T24	

For the third task we will calculate the time intervals and distances traveled between successive detections with individual tagged fish and summarize movement direction and rates. Fish movement direction and rates will be compared to drogue movement rates to determine whether fish were moving similarly to a passive particle and whether drogues can be used to predict fish movements in the future.

Objective 2: Determine maximum detection probabilities of live tagged fish for boat mobile tracking and fixed telemetry detection gates.

Timeline: September—October 2014

High detection probabilities of tagged fish will be necessary to monitor the status of all tagged fish (alive or dead) and to determine the time of death for fish that die after being captured in a beach seine or purse seine. Mobile tracking efforts and fixed telemetry sites used during the 2013 study were primarily focused on determining movement patterns and dam passage rates for radio-tagged fish (Liedtke et al. 2013). In many cases, the detection probabilities of the mobile tracking efforts and individual fixed sites during that study would not be sufficient for a future survival evaluation aimed at accurately estimating mortality from beach seining and purse seining. Thus, it will be important to determine the maximum possible detection probabilities for live fish using boat mobile tracking and fixed telemetry detection gates.

The tasks for Objective 2 are:

(1) Determine if boat mobile tracking can be used to continuously monitor tagged fish following release from a beach seine or purse seine.
(2) Determine the maximum detection probability for fixed telemetry detection gates
(3) Determine the relationship between detection rates of each species (coho and Chinook salmon) and the depth of the river bottom where fish are located.[msz1]
(4) Determine the relationship between detection probability and water depth for Lotek 3-V and 7-V tags.[msz2]

To evaluate these factors we will tag and release a total of 10 adult Chinook salmon and 10 adult coho salmon during four sessions. For each session five tagged fish will be released simultaneously and continuously tracked for 24 h by an individual mobile tracking boat (Table 2). Each mobile tracking boat will be staffed by two crews that work 12 h shifts apiece. Releases will occur two times per week during successive weeks. The post-release behavior of tagged fish is unlikely to change significantly beyond the 24 h post-release period so results from the 24 h shift should represent the expected results that could be obtained during a more rigorous study in which multiple fish could be encountered from different release groups by mobile tracking crews. Additional tagged fish may be monitored, and will be added to the study effort adaptively. For example we hope to release 3-5 extra tagged fish for each tracking session and have each tracking boat monitor the movements of multiple fish. Even with limited mobile tracking effort these extra fish will aid future study planning through detections on fixed stations.

Table 2.—Proposed tagging and release (R) and mobile tracking (T24 = 2 teams working12 h shift) schedules for weekly releases of live fish.

Boat number	Day of the week						
	Sun	Mon	Tues	Wed	Thurs	Fri	Sat
1		R, T24			R, T24		
2		R, T24			R, T24		
3		R, T24			R, T24		
4		R, T24			R, T24		
5		R, T24			R, T24		

A series of fixed telemetry detection gates will be established and maintained to monitor fish movements and determine the maximum detection probabilities that could be achieved during a future study. Detection gates typically consist of multiple fixed sites that are located within a specific river reach. These sites are generally established such that the collective coverage of the individual sites provides full coverage of the area where tagged fish must pass. Radio telemetry transmitters are not typically detectable by aerial antennas when the transmitter is located more than 30 ft below the water surface. Thus, locating riverine reaches where depths are primarily less than 30 ft increases the probability of detecting fish that pass through that reach. We plan to establish three detection gates, one located upstream of the release site, one located near Washougal, Washington, and the final site located downstream of Washougal, Washington. The first and third detection gates will likely consist of at least three individual fixed stations (e.g., one located on either shore and the third located on some form of structure in the near the middle of the channel). The identification and deployment of fixed sites depends on many variables. Fixed sites must be located in areas where vandalism or theft is unlikely and these areas (private land sites, navigation markers, islands, etc.) often require permission to deploy equipment. For that reason, we do not present specific locations in this document because much of the work that is required to identify and secure these locations is forthcoming. However, we are confident that the Washougal, Washington sites which were used during 2013 could be used again during 2014. We plan to deploy sites in identical locations during 2014 and data collected at the Washougal sites can be compared to data collected at the new sites in 2014 along with data collected during 2013 to determine the relative performance of various sites during the study. The fixed sites will be operated for about one month following the last released fish and will monitored for the presence of dead and live tagged fish.

During the 2013 study some fixed sites had very low detection probabilities for tagged coho salmon. Although this could have resulted from a variety of causes, one hypothesis is that the tagged coho were traveling in deep water, limiting the ability of the fixed sites to detect the tags. In order to learn more about this potential challenge for future proposed work in 2015, we will conduct tasks 3 and 4. Task 3 will evaluate the ability of fixed gear and mobile tracking efforts to detect tagged fish over a variety of water depths. This task will involve recording water depth for each mobile detection and the general water depths within range of each fixed site and then reviewing the detection history for each tagged fish to look for correlations between water depth and detection probability. Task 4 will be a series of tests to determine the maximum depth and distance at which both 3 v and 7 v transmitters can be detected by fixed sites and mobile tracking. These maximum detection ranges will be helpful in interpreting the detection probabilities evaluated in task 3. Task 4 will be completed early during the field effort to help inform mobile crews of fish depth and guide efforts to locate tagged fish.

Objective 3: Evaluate the factors affecting the performance of activity-sensing radio transmitters.

Timeline: October 2014—February 2015

The performance of the activity-sensing radio transmitters during 2013 did not allow us to determine the status (alive, dead, spit tag) of tagged Chinook salmon and coho salmon so laboratory evaluations are planned to better understand factors affecting their performance. The activity-sensing transmitters can be programmed to different sensitivity levels and factors such as fish movement, the orientation of the tag inside the fish, and signal output power may affect how well these tags perform and are detected during a given study.

The tasks for Objective 3 are:

(1) Determine minimal movement rates by adult salmon that are required to maintain emission of an active signal code.
(2) Determine if tag orientation affects the emission of active/inactive signal codes.
(3) Collaborate with tag manufacturers to determine if transmitter developments such as increased signal output and increased sensitivity are possible for a 2015 study.

A series of laboratory-based trials are proposed to evaluate how factors such as movement rates by adult salmon and tag orientation affect the performance of activity-sensing radio transmitters. These trials will be adaptive because new information will likely arise as results from successive trials are obtained. For that reason we do not include extensive plans for these trials in this document. However, the basic premise will be to tag and monitor fish in a hatchery raceway and swimming flumes at the Columbia River Research Laboratory to better understand the sensitivity of these motion sensors. The target species for this objective are Chinook salmon and coho salmon as they are the target species for the field-based activities. We have initiated correspondence with local hatcheries and are hopeful that we will be able to use the target species for this objective. However, the availability of Chinook salmon and coho salmon in hatcheries will likely decline during November 2014 when spawning occurs, and we may be compelled to use surrogate fish (i.e., rainbow trout, winter steelhead) to complete the tasks for this objective as we envision that these trials could be conducted through February 2015, depending on the availability of fish and the results obtained.[msz3]

Summary

The study plan outlined above is designed to supplement data collected during 2013 to provide a comprehensive dataset that could be used to plan a future study, and to develop and populate parameters in a model that would simulate scenarios of tagged fish survival following release from beach seines or purse seines. The study plan includes field and laboratory activities that would be conducted during September 2014–February 2015. A preliminary summary of results will be available in the form of a PowerPoint presentation by January 31, 2015. The final product for these efforts would be a detailed PowerPoint presentation that would be available by March 1, 2015.

References

Liedtke, T.L., Kock, T.J., Evans, S.D., Hansen, G.S., and Rondorf, D.W., 2014, Post-release behavior and movement patterns of Chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*Oncorhynchus kisutch*) after capture using alternative commercial fishing gear, lower Columbia River, Washington and Oregon: U.S. Geological Survey Open-File Report 2014–1069, 36 p. http://dx.doi.org/10.3133/ofr20141069.