Foot-based Visual Surveys for Spawning Salmon

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(Note to readers: this supplemental protocol complements two full protocols—Carcass Counts, page 59, and Redd Counts, page 197.)

Background and Objectives

Background

Adult salmonids return from the sea to spawn in their natal streams. Since adult spawner abundance is, for many populations, the principle measure of abundance and enables estimation of potential egg deposition, it is crucial to be able to obtain accurate estimates of the number of spawners to monitor abundance, relative to escapement goals or other management objectives. As salmon and steelhead *Oncorhynchus mykiss* enter rivers or streams over an extended period of time, and since there is continuous mortality (for salmon) and/or emigration (for steelhead), it is very difficult to obtain an estimate of the total number of spawners. Spawner counts, therefore, ideally should be replicated weekly throughout the spawning period to estimate total escapement. More frequent surveys will provide a more accurate estimate of spawner abundance.

Streamflow and turbidity, among other factors, influence the accuracy of spawner counts. Given the spawn timing of salmon and steelhead, counts must often be conducted under suboptimal conditions; however, streams in many regions are relatively clear, and thus, it is possible to count spawning salmon directly as they dig their egg nests (redds) and actively mate. Counts of spawning fish are usually done on foot or from a boat (although boat-based surveys are not discussed in this chapter). Spawning counts are often done on steelhead and chinook salmon *O. tshawytscha*, chum salmon *O. keta*, and coho salmon *O. kisutch*.

In addition to supporting spawning escapement estimates, live fish counts describe spawning timing, particularly when redd and carcass counts are also available. Comparatively high live fish and low redd and carcass numbers may indicate that spawning is just beginning. The opposite (low live fish and high redd and carcass numbers) can indicate that spawning in that stream is nearly complete. Material in this protocol has been extensively drawn from Heindl (1989). This method is mainly used where road networks are highly developed (for access) in southern British Columbia and Japan.

Rationale

Counting live salmon while walking along a stream is one of the oldest and simplest methods of estimating spawner abundance. Foot surveys are an effective method of counting spawning salmon because the fish are large enough to observe directly, and when done correctly, surveyors can achieve measurable accuracy for certain species of salmon and for steelhead (Waldichuk 1984; Irvine et al. 1992; Nickelson 1998). Furthermore, by combining the estimated number of spawning fish and total redd counts, one can determine the number of carcasses needing to be recovered (sampled) to evaluate key demographic aspects of hatchery and supplementation programs. Labor costs associated with visual spawner index counts have been found to be less than those associated with mark–recapture or fish counting weir techniques (Irvine et al. 1992); however, live fish are wary, mobile, and easily camouflaged and, in some situations relatively nocturnal in their spawning habits, thus reducing the accuracy of visual direct counting methods.

Visual spawner surveys may be the basis for estimating total escapement in an entire basin or for simply monitoring spawner abundance in one or more index reaches. Surveys may seek only to estimate peak spawner abundance or to describe total spawning timing. Reaches for survey and survey frequency must, therefore, be selected carefully to achieve the desired objective.

Objective

The objective of visual spawner surveys is to determine total or relative abundance of river or stream populations by directly counting the numbers of spawning fish on their redds.

Sampling Design

Site selection

Site selection for foot surveys of spawners is based on timing of returning fish, water clarity, and access to banks with a view of the stream. Foot surveys need to be conducted where the clarity of water is high enough to distinguish spawning fish from the substrate. Timing of spawning can affect potential for high water clarity. For example, spring spawners such as steelhead may be spawning at higher water levels when water is more turbulent and has higher turbidity. Foot surveys conducted for steelhead should be timed for when water clarity is expected to be the greatest. Salmon that return to spawn in the fall are generally spawning when water clarity is higher than that for steelhead. Surveys are frequently conducted under suboptimal visibility, so a visibility factor must be subjectively estimated by the surveyor and applied to counts. This can create a source of bias in visual counts. Additional insights into behavioral aspects of salmon spawning activity can be found in Perrin and Irvine (1990), Barlaup et al. (1994), Fleming (1996), Webb and Hawkins (1989), and Webb et al. (1990).

Access to banks with a clear view of the stream is critical for effective implementation of the foot survey protocol. If the stream is in a steep V-notch and surveyors cannot safely get close to the stream to view spawning activity, then a foot survey is not an effective method. Similarly, if the survey is to be conducted over a considerable length of stream, thick vegetation may impede surveyors' progress and reduce the efficiency of the survey. Surveyors should not need to walk in the stream to conduct the survey as this action would disturb the spawning fish.

To improve the accuracy and precision of escapement estimates obtained using visual surveys, a variety of sampling approaches can be used to identify portions of a stream to survey for fish. The easiest approach may be to use a simple random sampling design. With this design, each section of a stream has the equal probability of being selected; however, if sampling units can be divided into homogeneous groups, then stratified random sampling is generally preferable to simple random sampling, since stratification usually results in a smaller variance than that given by comparable simple random sampling (Cochran

1977). A stratified random sampling design to estimate escapement is achieved by stratifying the watershed and then randomly selecting sample sites within each stratum. Alternatively, sample units within each stratum can be selected on the basis of easy access by surveyors and/or on the basis of expected or actual locations of fish. This latter type of sampling has been termed stratified index sampling (Johnston et al. 1987; Bocking et al. 1988). As visual surveys are typically conducted on foot, surveyors should evaluate a few representative stream reaches (e.g., 250 m long each) prior to the start of spawning surveys to determine suitability for surveys based on water depth and flows.

In their 3-year project with coho salmon in British Columbia, Irvine et al. (1992) examined stratified random and stratified index sampling designs for estimating the numbers of spawning fish. The approach was evaluated in two streams with widely varying escapements; estimates of adult fish using the stratified index design were always similar to estimates obtained through an independent mark–recapture program. The stratified random design underestimated fish numbers in every case but one. Because the distribution of fish was aggregated, with random sampling there was a higher probability of sampling low fish abundance areas than high-abundance areas. Numbers of jack coho were underestimated with each sampling design, probably because the surveyors overestimated the efficiency of seeing these fish.

Sampling frequency and replication

Surveys are typically conducted on 6 (Irvine et al. 1992) to 10 (T. Mosey, Chelan County Public Utilities District, personal observation) stream reaches per crew per day. Foot counts are generally conducted every 7–10 d throughout the spawning season to observe fish on their redds. Replication of foot surveys is necessary to count the total or relative number of spawners over the spawning season. For each target species, the expected spawning season should be identified, and surveys should ideally be scheduled to start before the first spawner enters the stream and continue until after the last spawner completes the spawning process. Counts that are conducted more frequently will have a higher accuracy than those that are conducted less frequently. Estimates of residence time, as determined from redd life, vary from several days to 21 d. Irvine et al. (1992) found that the residence time of coho in their British Columbia study area was between 13 and 17 d (with one exception of 8 d). It is important to note that residence timing varies among different reaches, annually for a given population, and between rivers. A general recommendation is to conduct spawner surveys weekly.

Field/Office Methods

Setup

Prior to arrival

Streams should be divided into survey reaches prior to sampling. This can be done either through a randomized sampling design or through previous surveys that identify where the target salmonid is known to spawn. Before a survey is undertaken, the surveyors must be well aware of what reaches they are to survey, the target species, when the spawning season begins and ends, what the time interval for the survey is, what data are needed, and what equipment is required. The project leader must ensure that each surveyor or team carries all necessary equipment.

Events Sequence

Survey Description

Surveys should begin at the earliest anticipated beginning of spawning in order to reflect the overall spawning interval. Live fish may be encountered practically anywhere in the stream. Prior to spawning, fish may concentrate in deep pools (e.g., chinook) or hide in the foam and boil of the riffles (e.g., steelhead). They also may hide under cut banks and in logjams. As spawning progresses fish are more often observed on or near the spawning riffles.

Live fish survey

The following are tasks to perform upon arrival at the survey reach

(1) Turn on the global positioning system (GPS) device and after gaining satellite contact, record the coordinates (latitude–longitude or universal transverse mercators [utm]) of the beginning of the survey reach.

(2) Begin at the downstream terminus of the spawning reach and proceed slowly upstream. Fish are less likely to observe you approaching from downstream and, therefore, are less likely to swim to cover before they can be counted.

(3) Wearing polarized glasses will help reduce surface glare and allow the fish to be more easily observed; wearing dark clothing/rain gear will help the sampler blend into the streamside forest vegetation.

(4) Fish that detect your movement will usually dart downstream but may dart upstream into a nearby pool; the sampler should wait a few seconds to determine if the fish will return to the redd to avoid double counting farther upstream.

(5) Record the live fish observed as you move upstream; look carefully for auxiliary males, especially jacks that may be positioned near the actively spawning pair or the redd.

(6) It is not unusual to find live spawned-out fish in slack water below spawning riffles. These live "carcasses" should not be included in the live fish count.

(7) Walk all stream channels (side channels and backwater pools).

(8) At the end of the reach, verify your position with the GPS device and record the coordinates.

(9) Record survey data in the survey field book or on appropriate forms and transfer to a database for data management.

(10) Repeat steps 1–9 for each reach sampled and for each day sampled.

(11) Survey visits should be conducted every 7–10 d; wait until the end or termination of each survey visit to record weather, flow, and visibility for each reach surveyed.

Data Handling, Analysis, and Reporting

Data from spawner surveys should be entered into a database for data management. A combined data set for redd counts and/or carcass counts is often used; however, separate counts for live spawners should be maintained in the database. Table 1 provides metadata for variables that should be collected during the spawner surveys.

TABLE 1. — Database parameters for spawner count data.

Description	Metric	Format	Comments
Species	Text	Text	Note the species sampled.
Live	#	XXXX.	Number of live fish observed.
River	Text	Text	Record the stream name and section being surveyed.
Reach length	Meters	XXXX.X	Record the total distance of the survey reach.
Days sampled	#	XXXX.	Record the total number of days sampled.
Reach	Text	Text	Record the reach description and reach code.
Date	Date		Record the date of the survey.
Samplers	Text		Record the last name of the samplers.
Start latitude	D, M, S	XX,XX,XX	Record the latitude of the beginning survey point.
Start longitude	D, M, S	XX,XX,XX	Record the longitude of the beginning survey point.
End latitude	D, M, S	XX,XX,XX	Record the latitude of the end survey point.
End longitude	D, M, S	XX,XX,XX	Record the longitude of the end survey point.
Temp	°C	XX.X	Record the stream temperature at the time of the survey.
Time	Time	Time	Record the time the survey began.
Conditions	Text	Text	Record the water conditions and weather at the time of the survey.
Other	Text	Text	Describe other samples taken and remarks.

Data analysis procedures will vary with the objectives of the survey. Generally, however, data are evaluated with respect to the abundance or relative abundance of spawners throughout the spawning season. Relative abundance could be as simple as replicated spawner counts at the same site over several spawning seasons to compare the size of the counts across years. Using these data to estimate population abundance can only be done if sample sites are representative of that population both spatially and temporally. Other methods, such as area-under-the-curve (AUC) (English et al. 1992), may be used to extrapolate the total number of spawners from the survey data.

Personnel Requirements and Training

Responsibilities

A crew of two surveyors should be used. They can split up part of the survey area if needed, but two persons should be employed for safety reasons.

Qualifications

The person conducting a spawning survey should have been properly trained by an experienced field biologist and should have a degree in biology or 1 year of experience in sampling fish in the geographic area where sampling is to occur. Volunteers can be used when carefully trained and evaluated.

Training

Crews should be trained in the classroom first with illustrations of counting techniques, equipment needed, process for location of survey reaches, and so forth. Training should include at least one survey (a paired count), with individual crew members matched up with an experienced instructor who can assist the student in locating redds and in detecting and identifying spawners as they hold in the stream.

Where spawner stream reaches have been randomly selected, a pilot survey should be conducted during the summer to verify accessibility of survey segments and collect other physical information.

Operational Requirements

Field schedule

The field schedule for spawner surveys is generally in the fall or winter for salmon species and in the spring for steelhead. The schedule is determined by the spawning season for the target species of the survey.

Equipment list

Equipment

The foot surveyor should be equipped with hip boots or waders and dark clothing or rain gear to minimize disturbance to spawners, polarized sunglasses, appropriate survey forms, and a handheld GPS device. Additional equipment for boat/canoe surveys (as needed for access to some stream/river sections) are life vests, dry bags, a survival kit (containing matches, food, whistle, emergency blanket, etc.), helmets, and a throw line. (See equipment list below.)

Item	Comments
Data forms and backing	E.g., clipboard or digital data device
Pencils	
GPS handheld device	Used to record survey latitude and longitude or UTMs
Cell phone and/or two-way radios	Useful for emergencies and for maintaining contact with other crews
Satellite phone and personal locator beacon	For emergency situations; carried by crew members in areas where cell phone or two-way radio communication is restricted due to topography or limited coverage network
Polarized glasses	
Wading gear (hip boots/chest waders)	Not recommended if rafting
Metric measuring tape	
Water thermometer	
First-aid kit	
Colored flagging or biodegradable spray paint	For marking multiple survey reaches
Indelible markers	For marking flagging

Item	Comments
Day pack	For carrying supplies, lunch, etc.
Extra clothing	Jacket, rain gear, hat
Rubber raft	If floating a river
Air pump	If floating a river
Spare oar or paddle	If floating a river
Spare oarlock	If floating a river
Tool kit	Pliers, crescent wrench, wire, heavy tape, bolts, nuts, washers, etc.
Rope	If floating a river
Waterproof bag	If floating a river
Flotation vest	If floating a river

Budget

The following guidelines can be used to calculate the budget:

Activity/Item	Cost
Equipment	
Staff time*	3 h
Travel time	(dependent on survey site)
Preparation time	1 h
Training	1 h
Lab workup	2 h
Data analysis	8 h

* for two biologists to walk the stream reach

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