FISHERY RESEARCH

FIELD PROTOCOLS FOR STREAM SNORKEL SURVEYS AND EFFICIENCY EVALUATIONS FOR ANADROMOUS PARR MONITORING

Photo: Ron Roberts

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TABLE OF CONTENTS

Page

ABBREVIATIONS AND ACRONYMS 1
ABSTRACT 2
INTRODUCTION 3
DEFINITIONS OF SURVEY TYPES 4
ANNUAL PLANNING 6
- Statewide Coordination and Survey Prioritization 6
- Training and Safety 6

BASIC SURVEY PROCEDURES 7
- Fish Surveys in Wadeable Streams 7
- Fish Survey in Large Streams (Corridor Surveys) 11
- Basic Habitat Survey 11

MARK-RESIGHT SURVEYS FOR STEELHEAD TROUT 12
- Introduction 13
- Objectives 13
- Methods 14
  - Site and Transect Selection 14
  - Temperature Monitoring 14
  - Pre-survey Fish Marking 14
  - Snorkel Survey 15
  - Habitat Data 15
    - Cross-section data 15
    - Entire transect data 16

SURVEY WRAP-UP 16
LITERATURE CITED 17
APPENDICES 20

LIST OF TABLES

Page

Table 1. Description of stream habitat classifications. 12

LIST OF FIGURES

Figure 1. A snorkeler surveying fish in a single pass zigzags through the site while moving upstream. The dashed line represents the approximate path of the snorkeler (from Thurow 1994). 9

Figure 2. Two snorkelers counting fish in a transect while moving upstream. Observer 1 counts all fish to the left of center and observer 2 counts to the right (from Thurow 1994). 10

Figure 3. Example of upper caudal fin with square notch removed. 15

LIST OF APPENDICES

Appendix A. Quick reference sheet for conducting mark-resight surveys. 21

Appendix B. Data form for general parr monitoring snorkel surveys. 22

Appendix C. Data forms for mark-resight snorkel and habitat surveys. 23

ABBREVIATIONS AND ACRONYMS

DPS	Distinct Population Segment
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
GPM	General Parr Monitoring
GRTS	Generalized Random-tessellation Stratified
ICBTRT	Interior Columbia Basin Technical Recovery Team
IDFG	Idaho Department of Fish and Game
INPMEP	Idaho Natural Production Monitoring and Evaluation Project
ISEMP	Integrated Status and Effectiveness Monitoring Program
ISMES	Idaho Steelhead Monitoring and Evaluation Studies
MPG	Major Population Group
NOAA	National Oceanic and Atmospheric Administration
VSP	Viable Salmonid Population
XS	Cross Section

ABSTRACT

Snorkel surveys are one of the main techniques used by the Idaho Department of Fish and Game (IDFG) to monitor salmonid populations. This document describes specific protocols currently used by IDFG crews that conduct fish surveys in streams by snorkeling for the purpose of monitoring abundance and distribution of juvenile anadromous salmonids (general parr monitoring, GPM). Beginning in 2007, we made three changes to the GPM program. First, all snorkel crews attend mandatory training to ensure accuracy of surveys and consistency among crews. Second, crews assess snorkeling efficiency (detection probability) of Steelhead Trout parr. Third, we incorporate a probabilistic site selection procedure in order to more objectively assess abundance and distribution. In this report, we detail the procedures used for general parr monitoring surveys, including training and safety, survey planning, delineating and measuring sites, conducting snorkel surveys, and recording habitat data. We also describe procedures for more specialized purposes, i.e., corridor and mark-resight surveys. This document is intended as a training manual as well as a documentation of protocols and methods used to collect and report on a large body of information that is collected annually by IDFG. It will be used to help standardize methods across the state and over time to ensure that data are comparable within a time series.

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INTRODUCTION

Populations of Chinook Salmon *Oncorhynchus tshawytscha* and Steelhead Trout *O. mykiss* in the Snake River basin declined substantially following the construction of hydroelectric dams in the Snake and Columbia rivers. Raymond (1988) documented a decrease in survival of emigrating Steelhead Trout (hereafter Steelhead) and Chinook Salmon (hereafter Chinook) from the Snake River following the construction of dams on the lower Snake River during the late 1960s and early 1970s. Abundance rebounded slightly in the early 1980s, but then escapements over Lower Granite Dam into the Snake River basin declined again (Busby et al. 1996). In recent years, abundances in the Snake River basin have slightly increased. The increase has been dominated by hatchery fish, while the returns of naturally produced Chinook and Steelhead remain critically low. As a result, Snake River spring-summer Chinook were classified as threatened in 1992 under the Endangered Species Act (ESA). Within the Snake River spring-summer Chinook evolutionarily significant unit (ESU), there are seven major population groups (MPGs): Lower Snake River, Grande Ronde/Imnaha rivers, South Fork Salmon River, Middle Fork Salmon River, Upper Salmon River, Dry Clearwater, and the Wet Clearwater. However, the Dry Clearwater and the Wet Clearwater MPGs are considered to be extirpated. A total of 29 extant demographically independent populations have been identified. Snake River Steelhead was classified as threatened under the ESA in 1997. Within the Snake River Steelhead distinct population segment (DPS), there are six MPGs: Lower Snake River, Grande Ronde River, Imnaha River, Clearwater River, Salmon River, and Hells Canyon Tributaries (ICBTRT 2003, 2005; NMFS 2011). However, the Hells Canyon MPG is considered to be extirpated. A total of 24 extant demographically independent populations have been identified.

Anadromous fish management programs in the Snake River basin include large-scale hatchery programs intended to mitigate for the impacts of hydroelectric dam construction and operation in the basin, and recovery planning and implementation efforts aimed at recovering ESA-listed wild salmon and Steelhead stocks. The Idaho Department of Fish and Game (IDFG) anadromous fish program's long-range goal, consistent with basinwide mitigation and recovery programs, is to preserve Idaho's salmon and Steelhead runs and recover them to provide benefit to all users (IDFG 2012). Management to achieve these goals requires an understanding of how salmonid populations function as well as regular status assessments (McElhany et al. 2000). However, specific data on some Snake River Steelhead and Chinook populations are lacking, particularly key parameters such as abundance, age composition, genetic diversity, recruits per spawner, and survival rates (ICBTRT 2003). The key metrics to assessing viability of salmonid populations are abundance, productivity, spatial structure, and diversity (McElhany et al. 2000).

The purpose of snorkel surveys is to provide information for monitoring the status of Idaho's wild Chinook and Steelhead populations with respect to the viable salmonid population (VSP) criteria and how abundance and spatial structure are trending over time. In the 1950s, IDFG developed a program to index annual spawning escapement by enumerating Chinook redds in selected areas. The number of redds counted in these areas provides an index of the annual wild adult Chinook spawner abundance at the independent population scale (see ICBTRT 2003 for population delineations). In Idaho, Steelhead redds are not as useful for describing abundance and spatial distribution because turbid, high water associated with snowmelt coincides with Steelhead spawning. Therefore, snorkel survey data describing juvenile abundance and distribution are particularly important.

Snorkel surveys are widely used for monitoring fish populations because they are a versatile, cost-effective technique. Snorkel surveys are feasible where environmental conditions limit the effectiveness of other techniques, such as electrofishing (Schill and Griffith 1984; Bonneau et al. 1995). Gear and personnel requirements are comparatively modest, so logistical demands are reduced and remote locations become feasible to sample (Hankin and Reeves 1988; Thurow 1994). Because snorkel surveys are non-lethal and less intrusive than other field methods, they are an appropriate means to monitor fishes listed under the Endangered Species Act (e.g., Chinook Salmon *Oncorhynchus tshawytscha*, Steelhead Trout *O. mykiss*, Bull Trout *Salvelinus confluentus*). There are four questions that this snorkel program will address relative to population status and the effectiveness of our monitoring techniques:

1) How is abundance of anadromous salmonid parr changing over time?
2) What is the distribution and relative abundance of Steelhead within populations as defined by the Technical Recovery Team?
3) How is Steelhead emigrant production related to parr density?
4) How efficient are snorkel surveys at measuring parr density?

Snorkel surveys are one of the main techniques used by IDFG to monitor juvenile salmonid populations. Methods for conducting fish abundance surveys by snorkeling have been developed and refined by IDFG over the past several decades (e.g., Corley 1972, Lindland 1974, Reingold 1981). Current snorkeling methods for monitoring the parr of Chinook and Steelhead were originally developed by Petrosky and Holubetz (1985) to assess effects of habitat improvement projects. This effort developed into the General Parr Monitoring program (GPM; Scully et al. 1990), and methods were routinely documented with reporting of survey results. Since then, IDFG snorkel survey methods evolved and were especially influenced by Thurow's (1994) review. More recently, O'Neal (2007) summarized current standards for conducting snorkel surveys for salmonids.

This document describes specific protocols currently used by IDFG crews that conduct fish surveys in streams by snorkeling for the purpose of monitoring abundance and distribution of juvenile anadromous salmonids. Beginning in 2007, we made three changes to the GPM program. First, all GPM crews attend mandatory training to ensure accuracy of surveys and consistency among crews. Second, crews assess snorkeling efficiency (detection probability) of Steelhead parr. Third, we incorporate a probabilistic site selection procedure in order to more objectively assess abundance and distribution. This report was motivated by the desire to codify and effectively communicate these changes.

Two IDFG statewide anadromous projects currently rely on snorkeling surveys. Idaho Natural Production Monitoring and Evaluation Project (INPMEP) and Idaho Steelhead Monitoring and Evaluation Studies (ISMES) share objectives for monitoring abundance of summer parr in Idaho's anadromous waters, and crews may contribute to both projects over the course of a season, regardless of their primary funding. Abundance data on resident salmonids that are collected incidentally during surveys are of value to other IDFG research and management programs.

DEFINITIONS OF SURVEY TYPES

The terms "site" and "transect" are often used interchangeably. Within this document we define a "site" as a specific location along a stream. Survey crews are provided coordinates to locate a "site." A "transect" is then established at the site, or as close as possible, within 500 meters upstream or downstream of the site. A transect is an exact area of stream that is surveyed, with upstream and downstream boundaries located at hydraulic controls, defined as any definite change in stream gradient that spans the entire wetted width. Sites with established transects that have been surveyed in prior years should have detailed descriptions of upstream and downstream boundaries, with exact coordinates for the downstream boundary. Occasionally, established transects are changed dramatically by natural events like flooding or fire, requiring the crew to re-establish a transect at the site, describing in detail the transect and new boundaries.

Crews will encounter three basic types of sites during the field season: trend, probabilistic, and mark-resight. Trend sites maintain the connection of the current program to the past and allow assessment of changes in parr abundance over time (Question 1). Probabilistic sites are intended to assess spatial distribution of Steelhead and to relate parr density to emigrant abundance (Questions 2 and 3). Mark-resight sites are meant to assess survey efficiency, or bias, for Steelhead parr (Question 4).

Trend monitoring sites have been previously established with a history of surveys for the past 10 to 30 years, and are further classified as “core” or “non-core” trend sites. Trend sites are surveyed to maintain a long-term juvenile abundance data series for Steelhead and Chinook. These sites were established subjectively to be both representative of habitat and logistically easy to access and survey (Stiefel et al. 2014; see Part 5-wild Chinook and Steelhead juvenile density and spatial structure). Based on logistical difficulty, core transects are surveyed annually or every other year during the months of July and August. Non-core transects are surveyed opportunistically according to IDFG regional management needs. Site names are alpha-numeric and often descriptive. Crews will be provided a prioritized list of trend sites to survey and approximate dates to visit each site.

In 2007 we began establishing sites with a probabilistic approach, specifically employing a generalized random-tessellation stratified (GRTS) design (Stevens et al. 2007) to obtain spatially balanced surveys of Steelhead parr abundance at the population scale. Crews are provided an ordered list of sites “such that each successive site on the list maintains the spatial balance of the full set of sites in the sample” (Stevens et al. 2007). Higher priority sites must be chosen for survey or attempted to be surveyed before lower priority sites can be selected. More than the minimum required number of sites is provided in case some sites must be bypassed. Because GRTS sites are spatially balanced across a given population, visiting sites can be logistically challenging and require careful planning. Surveys of populations that are conducted infrequently are called “extensive.” Some Steelhead parr populations are surveyed annually, or “intensively,” with the GRTS design. These sites are located in target drainages that have juvenile emigrant traps, and snorkeling surveys are used to calibrate parr densities with production of juvenile emigrants estimated from traps (Copeland et al. 2013). A unique “design” number provided for all probabilistic sites serves as the site name, with the lowest design numbers having the highest priority for survey. Rarely, a probabilistic and GPM trend transect may overlap spatially, or either type of transect may be used also for a mark-resight survey. Naming of such overlapping surveys is prioritized in the following order: GPM, probabilistic, then mark-resight; with all survey purposes documented.

ANNUAL PLANNING

Statewide Coordination and Survey Prioritization

Planning begins before the field season. A coordination meeting is attended by all project leaders prior to each survey season to decide on drainages to be surveyed and plan field schedules. General Parr Monitoring sites will be subsampled to maintain the integrity of that trend data set. New sites for intensive and extensive panels are selected. A list of approximately twice the desired number of sites is sent to each snorkel crew for populations of interest. This list must be trimmed to a logistically feasible plan before crews begin field operations. Ideally, each new site will be scouted and photographed before the field crew arrives. Pre-survey reconnaissance aids in the planning process by helping to identify fish passage barriers, accessibility, safety, or other logistical issues.

High priority GRTS sites must be included or rejected before lower-priority sites can be considered in survey plans. Criteria for rejection are: 1) the site cannot be safely surveyed due to either water velocity and depth or pollution, 2) location is above barriers to spring movement of adult Steelhead, 3) insufficient water depth at time of survey, 4) a private owner denies access to the site, or 5) the site is too wide or complex to be surveyed efficiently by the full crew. Detailed reasons for rejection must be recorded, noting whether these reasons are temporary or long-term.

Survey dates do not have to follow the priority order, but can be arranged logistically to optimize efficiency. For example, consider a list of five sites. Sites 1-4 must be included or rejected before site 5 can be considered for survey. If site 3 is upstream from a fish barrier it is removed from the list and other, lower-priority sites can be surveyed. However, site 5 may be surveyed first because it is easier to access and is near other sites.

Training and Safety

Prior to the field season, snorkel crews attend multiday standardized training to ensure all surveys across crews and years are conducted comparably. Training includes important safety training and training on how to use the tools needed to accomplish surveys. Training also includes fish identification and practice estimating fish length underwater, wilderness first aid, and swift water awareness and rescue techniques. Crews also receive field experience with survey equipment (Appendix A), its use and maintenance, including personal snorkeling and wading gear, satellite phones, GPS units, cameras, habitat measuring tools, and proper data recording.

Seasonal personnel are presented with a background on the projects that rely on snorkel surveys. All crew members must understand the purpose of the research, the approaches and methods, and the underlying logic. All are encouraged to ask questions until every member has a clear understanding of the goals, objectives, and tasks required. Literature referred to in this document is made available (i.e. O'Neal [2007] and Thurow [1994]). Crew members are encouraged to spend time thinking about the project and provide constructive criticism; all ideas and input are critical.

Travelling in remote areas and working in and around streams and rivers is inherently dangerous. We approach safety training and practice very seriously. Transects must be delineated to be safely and efficiently surveyed by snorkelers. Crews are made aware that assessment of sites is often not possible until the summer field visit, when they must decide if a survey is possible and safe. If large wood, overhanging vegetation, or turbulence is excessive, a survey by snorkeling is not appropriate from both safety and efficiency perspectives. Other reasons for not conducting a survey include excessive turbidity, light conditions or storm clouds, heavy rain, or nearby lightning. Sometimes surveys can be rescheduled if conditions preventing snorkeling are transient in nature.

Crews are trained and encouraged to work safely as a team. Proper protective footwear is required at all times, and good wading boots must be worn in and around water. Wading boots with felt, sticky rubber, and/or cleated bottoms work well on wet substrates; however, cleats are very slippery on dry granite boulders. Crews must be particularly cautious about getting feet entrapped between rocks or debris; and when snorkeling downstream to avoid getting caught on debris. Individuals should monitor each other's progress as snorkelers move up or down the stream, including before, during, and after actual snorkeling. The data recorder's duties include awareness of the location and condition of each snorkeler at all times.

BASIC SURVEY PROCEDURES

Fish Surveys in Wadeable Streams

To be surveyed for fish abundance by underwater observation (snorkeling), a stream must be of adequate width to accommodate at least one snorkeler and of adequate depth to allow observation of fish. Safety hazards, as discussed previously, must be considered. Crews must thoroughly document, with photos and written description, any site that is not appropriate for a snorkel survey.

When arriving at a snorkel site, it is important to not disturb the stream within the transect area before conducting the survey. Any disturbance may "spook" fish and cause them to move into and/or out of the site, introducing a source of bias. All preparation for a snorkel survey should be done on the stream bank away from the shoreline or at least 10 meters downstream of the transect. Both downstream and upstream transect boundaries should be located before starting the survey.

Specific transect locations and lengths will be adjusted by the crew leaders based on actual stream conditions. Transects retained from the past will already be defined, and subsequent surveys should use those transect boundaries. When the crew arrives at the site, conditions might be such that it is not desirable to survey at the designated location (e.g., it is in a braided reach). Desired transect length is 100 m. with boundaries adjusted to fit within hydraulic controls. If necessary, a site can be moved up to 500 m from the designated point, but this adjustment should be kept as short as possible. It is important to document all boundary adjustments made in the field. Record coordinates of the downstream boundary of the surveyed site on a GPS unit, in decimal degrees, using datum WGS84. When not possible to record coordinates, the location can be marked on a topographic map of 1:24,000 scale or smaller or on an aerial photo.

Snorkelers enter the stream downstream from the downstream hydraulic control boundary to minimize fish disturbance within the transect. The hydraulic control at the upstream boundary will minimize fish being pushed upstream beyond the transect without being observed (herding).

Before surveying, underwater visibility and water temperature are measured downstream of the transect. Visibility is measured as the distance a snorkeler can see underwater under relatively calm water conditions with no obstructions. Measurements should be made in an area of average or representative visibility conditions for the entire transect. Measure the underwater visibility using a Secchi disk-like approach as follows: One crew member suspends the sighting object that is comparable in color and contrast to fish species expected in the water column. A crew member's wading boot is often ideal. A snorkeler drifts downstream away from the object until the sighting object becomes unidentifiable, then moves upstream until the object reappears clearly. Measure and record the distance between the object and the observer's facemask. Avoid using brightly colored objects to measure visibility, as that will result in measurements biased high. Calibration of this measurement among all crew members should be practiced as part of training. A minimum visibility measurement for continuing the survey is somewhat subjective, though surveys in water with visibility less than one meter are generally discouraged. A minimum temperature of 10°C is a standard guideline for snorkel surveys targeting salmonids. If possible, wait for the stream to warm to 10°C or revisit the site at a later time or date. Record stream temperature and underwater visibility at the time of the survey.

Enough snorkelers should be used to survey the entire stream width in one pass. The number of snorkelers used during a survey is dependent upon three factors: 1) the width of the stream channel, 2) the underwater visibility, and 3) the amount of physical obstructions (e.g., large boulders, turbulence, log jams, split channels, overhanging vegetation). Ideally, adjacent snorkelers are visible to each other during the survey. Snorkelers coordinate lane widths prior to starting (i.e., a bank snorkeler may look just to the bank, or also to the adjacent snorkeler's shoulder). Coordination is ongoing between adjacent snorkelers as site width changes, fish move across lanes, or large schools of fish span multiple lanes. If too few snorkelers are used, the entire site may not be adequately surveyed, though too many snorkelers used may result in herding fish, also biasing the survey.

Snorkelers proceed slowly upstream, avoiding sudden movements. The data recorder should follow the snorkelers from a central position such that the data from the snorkelers can easily be heard. Because most salmonids are oriented with their head upstream in the current, a snorkeler moving upstream is less likely to startle fish. As Heggenes et al. (1990) reported, a snorkeler who moves slowly can nearly touch a fish before they are frightened. Fish are counted as the line of snorkelers (not individual snorkelers) passes, so duplicate counts are avoided. Extreme care is taken to search for fish throughout the entire site including the stream margins and all cover components (i.e. undercut banks, substrate, and organic debris). The data recorder coordinates snorkelers to ensure that all areas are covered, especially shallow areas along the shoreline that are obstructed from the observer's view. Typically, salmonid fry and parr utilize shoreline habitats and are difficult to see from a distance. If at any time snorkelers need to remain stationary to wait for a crew member to catch up in order to stay in formation, he/she must keep their head in the water and continue to look for fish. The data recorder is responsible for keeping snorkelers in a consistent line across the stream.

In small streams with good visibility, one snorkeler may be able to see from shore to shore. In the scenario below (Figure 1), only one snorkeler is required and counts all fish in the entire site. Depending on the characteristics of the site, the snorkeler may survey up the center of the site and count fish by zigzagging outward to both banks. Although water clarity may allow one observer to see across the width of the stream, another snorkeler may be required to count fish concealed by visual obstructions (e.g., boulders, turbulent water). Sites with predominately shallow habitats (pocket water, riffles) typically require more observers than deep-water habitats (Thurow 1994).

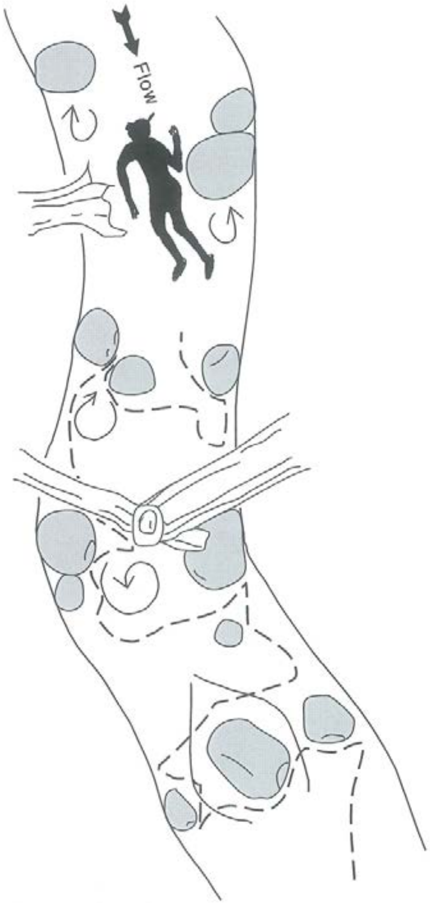

Figure 1. A snorkeler surveying fish in a single pass zigzags through the site while moving upstream. The dashed line represents the approximate path of the snorkeler (from Thurow 1994).

If two snorkelers are used during a survey, the site is divided into two lanes (Figure 2). Snorkelers begin in the center of the channel, move upstream at the same pace, and count all fish between themselves and the bank (Thurow 1994). If three or more snorkelers are used during a survey, the unit is divided into relatively equal lanes. Snorkelers nearest to the shore should concentrate on fish between themselves and the shore because fry and parr salmonids are often found near shore. The snorkelers away from the shores divide the remaining portion of the channel into equal lanes. Middle snorkelers can count fish on both sides of themselves, while maintaining communication with adjacent snorkelers to avoid missing fish or double counting. The distance between snorkelers in the middle of the channel should always be less than the maximum underwater visibility (Thurow 1994). Sometimes a slight "V" shape in the snorkeler lineup is advantageous to observe fish without herding, with mid-channel snorkelers slightly downstream from shoreline snorkelers. In transects with complex habitat and/or varying channel widths, the data recorder must manage snorkeler distribution and consistent upstream movement of the crew by directing individual observers into specific areas or adding and removing observers to balance adequate observation across the channel while avoiding herding of fish.

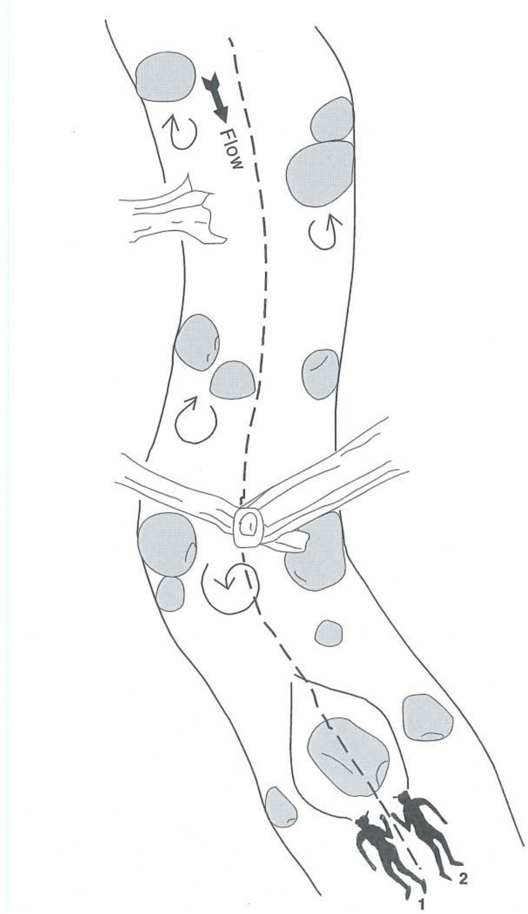

Figure 2. Two snorkelers counting fish in a transect while moving upstream. Observer 1 counts all fish to the left of center and observer 2 counts to the right (from Thurow 1994).

All salmonids are counted by species. Trout and char are reported by 1-inch size classes. Steelhead and Westslope Cutthroat Trout *O. clarkii lewisi* smaller than 2 inches in length are difficult to differentiate during underwater observation and therefore are grouped into a category of "trout fry." Snorkelers should use caution when differentiating 2" to 4" Steelhead parr from Cutthroat Trout since they appear very similar. Salmon species are reported by age, either as young-of-the-year ("zeros") or yearlings. The two age groups are usually quite distinct in relative length, with young-of-year <4" in most streams (Scully et al. 1990); however, overlap in lengths of the two ages can occur across time and space (i.e., zeros in a low elevation stream late in the summer will often be of similar length as yearlings observed at higher elevations early in the summer). Any non-salmonid fishes, amphibians, and bivalve invertebrates are recorded if present and identified to the lowest taxon possible without compromising the survey of salmonid abundance. Time can be spent following the abundance survey to further identify these animals.

During the survey, fish counts are relayed to a data recorder. Snorkelers will opportunistically relay counted fish to the recorder as determined by 1) snorkeler memory, 2) “pauses” in fish observations, and 3) avoiding talking over other snorkelers. The data recorder should stay in position to hear and direct all snorkelers. The snorkeler briefly pulls his/her head out of the water and clearly relays counted fish to the data recorder. Eye contact between the recorder and snorkeler should be established before information is relayed. Data relays should follow a standard protocol decided by the crew. A suggested relay system is to report Steelhead before resident fishes, small size to large size, trout fry, and then Chinook yearlings and zero’s. For example, “Steelhead 4, 4, 7, 8…Bull Trout 9…yearling 1…zeros 55,” which translates to two Steelhead at 4”, one Steelhead at 7”, one Steelhead at 8”, one Bull Trout at 9”, one yearling Chinook, and 55 young-of-year Chinook. Some crews develop hand signals to report species and size of fish observed. This method works well in wide or high noise sites, and should be part of training if a crew chooses to use it. Snorkelers may alternatively wear a plastic arm cuff with attached pencil to record fish data in wide or high noise sites; or if the stream width requires observations by the entire snorkel crew.

Regardless of the method used above, the designated data recorder directs the survey by making sure all areas of the site are surveyed, keeps snorkelers in formation, and adjusts the number of snorkelers in the site as the width changes. The data recorder is responsible for all data management, and either collects or coordinates the collection of physical data (refer to Habitat Survey section below). See Appendix B for sample data sheets used for trend surveys.

A crew size of six individuals has proven to be optimal for surveying a variety of stream widths. It is rare to encounter wadeable streams that require more than five or six snorkelers. Additionally, the crew can be divided in half or thirds to simultaneously survey multiple sites in smaller streams.

Fish Survey in Large Streams (Corridor Surveys)

Some sites are located in stream reaches that are not conducive to snorkeling in an upstream direction, due to excessive depth and/or velocity. At such sites the transect is surveyed by floating from the upstream boundary to the downstream boundary. The entire stream width may or may not be surveyed. Typically, a corridor along the bank is surveyed. Transect area is based on the surface area of the corridor visible to the observer (Scully et al. 1990). This method assumes that most fish orient to the banks, which may be true for juveniles (Korman et al. 2010). Adjustments to assigned lanes during the survey can be difficult in larger streams; therefore, each observer must understand how the entire survey is to be conducted and what areas are to be surveyed before starting. Detailed methods specific to the transect must be recorded to allow repetition of the survey in subsequent years.

Basic Habitat Survey

This section describes the minimum physical information required to complete a survey of fish abundance at a specific location. As with the fish survey, a designated data recorder coordinates all data collection. After completing a snorkel survey of fish, crew members collect measurements to calculate the surface area of the transect. All measurements are recorded in tenths of meters. Total length is measured following the thalweg. The thalweg is the course that the main current of the stream follows. Crew members can assist with length measurements by holding the tape in the thalweg at stream bends. Sometimes the tape can be thread through vegetation to approximate the thalweg. The reel end of the tape is kept upstream and tag end downstream during length measurements for ease of managing the tape. A minimum of three stream widths are measured at each site, at locations that are representative of the site. Stream width is measured perpendicular to the thalweg of the stream. Widths should be taken at least 10 m apart, but no further than 50 m apart. Include a width measurement at both upstream and downstream transect boundaries. Six width measurements are typical for a 100 m site. Width measurements include the wetted width that was surveyed (i.e., wetted areas that were too shallow to snorkel are excluded from measurement, as are islands).

In 1984 IDFG adapted Platts et al. (1983) habitat methodology into a short list of habitat types that can be easily distinguished to maintain consistency among crews and across years and streams, in order to monitor changes in habitat across time (Petrosky and Holubetz 1985). We maintain the original four habitat types to distinguish as pool, riffle, run, and pocket water. These classifications are described in Table 1. An estimated percentage of the predominant habitat types over the entire transect should be recorded.

Photos of the transect boundaries and any unique landmarks at the site or within the transect are recorded to aid future crews in locating the site, and to document the general habitat. A minimum of two photos should be recorded: one from downstream of the downstream boundary looking upstream into the transect and including the downstream boundary, and a second from upstream of the upstream boundary looking downstream into the transect and including the upstream boundary. Additional photos may be taken if necessary to document the entire site. One method to track photos taken with a digital camera is to record on the data sheet a description of each photo and the time it was taken, which will be recorded with the photo. Another method is to write the stream and site name and date on a white board, and have a crew member display it in all site photos.

Table 1. Description of stream habitat classifications.

Relative Velocity	Description	Habitat type
Slow water	With hydraulic control at downstream transition	Pool
Mixed	Numerous boulders or other obstructions that create small pools in an otherwise fast water reach	Pocket water
Fast water	Little surface turbulence	Run
	Abundant surface turbulence	Riffle

MARK-RESIGHT SURVEYS FOR STEELHEAD TROUT

The previous section describes methods that form the foundation of completing fish abundance surveys for salmonid fishes conducted in streams by snorkeling. In 2007 we implemented a program designed to measure observational bias inherent in underwater surveys of fish abundance, specifically of juvenile Steelhead. This section provides background information, objectives, and describes fish and habitat data collection methods used for mark-resight surveys.

Introduction

The quantitative use of underwater observations made by snorkel surveys depends on assumptions that should be rigorously assessed. Raw counts are neither censuses nor density estimates (Link and Sauer 1998). Use of uncorrected counts may lead to biased conclusions regarding fish occurrence and abundance (Bayley and Peterson 2001; Thurow et al. 2006). For example, the Idaho Supplementation Studies (ISS; project 1989-098-00) ceased snorkel surveys because population estimates for Chinook parr generated from snorkeling were imprecise and inaccurate, and often less than the number of juvenile emigrants actually counted at screw traps (Walters et al. 1999). For rigorous use of snorkel data, researchers and managers need to assess the precision and accuracy of the observations (Dolloff et al. 1996). In the ISS example, accuracy was not assessed; consequently, data collected were not useable for generating population estimates with precision adequate for that project.

One method used to address bias in estimates of fish occurrence and abundance is to correct the estimates through the use of a statistical model using ancillary data to model and predict bias (e.g., Peterson et al. 2004; Thurow et al. 2006). Bias estimation facilitates tracking of abundance because probability of detection must be estimated for valid population estimation (Pollock et al. 2002). Occurrence and distribution data may be similarly corrected (e.g., Bayley and Peterson 2001). This approach to snorkel data was demonstrated for Bull Trout by Thurow et al. (2006). In that study, Thurow et al. compared snorkel counts to multipass population estimates of Bull Trout, calibrated for electrofishing efficiency, to estimate snorkeling efficiency at over 200 sites in 1st-3rd order streams. They used these data to build models predicting the effect of stream habitat features and fish size on snorkeling efficiency, thus producing a statistically valid method to correct raw snorkel count data for sampling bias.

The protocols described below are designed to enable crews to estimate population abundance and size structure through observation of marked individuals. This information will enable biologists to predict probabilities of detection under different conditions. The ultimate goal of this research is to develop protocols for estimating the sampling effort and techniques required to achieve a desired level of accuracy in detecting the presence/absence and abundance of native salmonids within different habitat types. Our central hypothesis is that probabilities of detecting fish are influenced by the sampling method, sampling effort, physical features of the sampling unit, fish density, and fish size. Our focus for this “observability” work is on Steelhead parr because of their large size range and wide range of microhabitat preferences. To evaluate this, a diversity of sites should be selected each year for efficiency evaluations.

Objectives

1. Estimate the probability of detecting Steelhead parr using snorkeling.

2. Compare probabilities of detection for different size classes of Steelhead parr.

3. Describe the influence of physical channel features including stream size, visibility, water temperature, channel complexity, and abundance of cover on probabilities of detection.

Methods

Site and Transect Selection

Select sampling sites in areas that have known Steelhead presence and can accommodate an approximate 100 m transect with hydraulic controls at both upstream and downstream boundaries. The site must also have reaches of approximately 50 m both upstream and downstream of transect boundaries bounded by hydraulic controls that can be snorkeled (termed "oversample reach"). Transects may be complimentary to other work, such as trend or probabilistic transects. Only wadeable sites, where the entire width and length of a stream reach can be surveyed, are appropriate for mark-resight surveys. Avoid stream reaches that have side channels or braided channels, because the habitat will be too complex to complete an efficient survey. Our intent is to capture relatively gross differences in conditions (e.g. high, medium, low habitat, and hydraulic complexity) rather than attempting to precisely measure all habitat conditions. Attempt to select areas that are readily accessible to maximize time spent sampling.

Temperature Monitoring

Install a thermograph and record temperatures at 15 minute intervals during the entire sampling period. Record the date and time the thermograph is submerged and the date and time it is removed. The thermographs will already be programmed and calibrated, and may or may not be waterproof. Regardless, they must be placed in waterproof protective PVC casings before submersion to protect them from potential damage (e.g. impact from hooves, or scour). Each unit has a unique serial number that must be recorded on the data sheet. Select a location where the water column is well mixed, the water is deep enough to submerge the data logger, and take care to ensure data loggers are not directly exposed to the sun. Fully submerge the unit in the water and hold it in place with rocks or a rope tied to something unmovable.

Pre-survey Fish Marking

Use only angling gear to capture and mark all age 1+ Steelhead parr (>3 inches) throughout the main transect. Record the starting and ending times and water temperatures. The desired minimum number of marked fish is 30. However, fewer than 30 may be marked if fish densities are low. Westslope Cutthroat Trout *O. clarkii lewisi* may serve as surrogates if few Steelhead parr are available. Site length can be expanded if necessary to meet the minimum number marked. Mark and release fish immediately and as close as possible to the same area caught. Do <u>not</u> anesthetize fish. Make a square notch in the upper caudal fin with a pair of scissors (Figure 3). Make sure excess fin tissue is pulled away and that the mark is sharp, angular, and obvious to snorkelers. The amount of fin tissue removed should be ≤10% of the caudal fin. If a fish is hooked deeply, or otherwise injured during capture, release it without a mark. The number of fish marked by length group to the nearest inch is recorded on the mark-resight data sheet (Appendix C). Do not fish in the oversample reach or import fish into the transect. Only use barbless hooks. Wait 12 to 24 hours before initiating the snorkel survey.

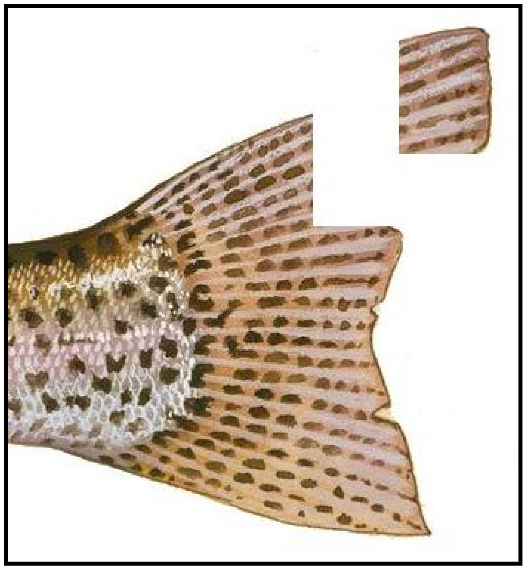

Figure 3. Example of upper caudal fin with square notch removed.

Snorkel Survey

In lieu of installing block nets to prevent fish migration between the time fish are marked and observed by snorkeling, we snorkel beyond the site boundaries both upstream and downstream to detect any marked fish that have moved out of the transect, thus the establishment of lower and upper “oversample reaches” discussed above.

Follow standard snorkel survey procedures as previously described. Record data on standardized mark-resight data sheets (Appendix C) to ensure that data are collected uniformly and accurately across the regions. Begin the survey at the downstream boundary of the lower oversample reach. Within both upper and lower oversample reaches, only number of marked Steelhead observed need to be recorded, by inch group. In the main transect follow standard snorkel survey procedures for recording fish counts, with the added recording of marked vs. unmarked Steelhead.

Habitat Data

A habitat data form specific to mark-resight surveys will be used (Appendix C). Habitat measurements are taken at two scales: at systematically placed cross sections that span the wetted width of the stream perpendicular to the thalweg and for the entire site. Start at the downstream boundary of the transect and make measurements as the crew moves upstream. The data recorder directs the crew and should call for measurements as they are needed.

Cross-section data—Establish cross sections (XS) perpendicular to the flow at 10-m intervals throughout the transect, as measured in the stream thalweg, with the first XS at the downstream boundary. Habitat measurements are recorded in an upstream direction, starting on the right bank looking upstream (snorkeler’s right), and proceeding to the left stream bank. This provides a consistent frame of reference. At each XS record the dominant type of habitat type (riffle, run, pool, or pocket water), measure wetted channel width, measure depth with a stadia rod marked in tenths of meters at ¼, ½, and ¾ intervals along the cross section, and record the maximum depth along the entire XS. Stand downstream from the stadia rod to avoid influencing water surface level. Visually classify the substrate into size classes along the entire XS. Substrate composition is recorded for a one meter band (1/2 m each side of tape) parallel to the XS. Estimate the percent of the substrate in six size classes: fines (<6 mm), gravel (6-75 mm), cobble (75-150 mm), rubble (150-300 mm), boulder (>300 mm), and bedrock. Make sure percentages total 100%. Mean depth of each XS is the average of depths at 1/4, 1/2, and 3/4 the channel width and dividing the sum by four to account for zero depth at each bank (Platts et al. 1983).

Entire transect data—Measurements made on pools, woody debris, and bank cover components will be summed through the entire surveyed transect. Pools are an important factor influencing snorkeling efficiency. Count the number of pools and measure the length of each pool. Pools are defined as either having a length greater than or equal to the wetted channel width, or occupying the entire wetted width. Record the dominant pool forming feature within the entire transect: boulder, large woody debris (LWD), meander, bedrock, beaver dam, artificial, or other (describe). For ease of survey, the data sheet has the pool count and measurement at each XS. If a pool spans more than one XS, only count it at the first XS. Multiply the number of XS the pool spans by the spacing between XS and add the length below and above the first and last XS that the pool extends to get total pool length. Also measure the maximum depth of the deepest habitat in the entire surveyed transect, not restricted to XS locations.

Count the number of pieces of LWD, defined as a piece of wood, lying above or within the active channel, at least 3 m long by 10 cm in diameter. Live pieces of wood (e.g. live trees) count as LWD if they are within the active channel. Live wood must also be leaning at an angle of 45 degrees or less over or in the channel to be included in either measure. Do not count trees that are standing straight up; they should not be within the bankfull (or active) channel anyway, unless there has been a major recent disturbance. Also record the number of LWD aggregates (more than four single pieces acting as a single component) and root wads.

Measure the total length of the transect by summing the number of XS and adding the length of the final segment. For the entire transect, measure cover for each of two cover types: overhanging vegetation and undercut banks. Undercuts are defined as areas beneath stream banks, boulders, bedrock, or wood that are solid portions of the stream bank. Overhanging vegetation is defined as live vegetation and may include grasses, sedges, shrubs, and trees that extend beyond the bank and provide shading over the active channel. Record the length and average width of individual areas of undercut banks and overhanging vegetation along each bank to the nearest 0.1 m with a 1 to 2 m long stadia rod. Overhanging vegetation and undercut banks must be within 0.5 m of the water surface to be included. Our intent is to include overhanging vegetation and undercuts that provide cover and shading that fish will occupy.

SURVEY WRAP-UP

Retrieve all flagging, etc., from the site and recover the thermograph. Check the data sheets to be certain all pertinent information has been recorded and any missing information is explained in comments. Crew leaders are responsible for the quality of the data their crew collects.

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APPENDICES

Appendix A. Quick reference sheet for conducting mark-resight surveys.

Angling:

Items needed:

HOBO (thermograph)	Net
Fly rod	Hemostats
Reel	Scissors
Line	Pencil
Tippet	Write in the Rain paper
Flies	

Things to remember:
Pick a site (100m) without a braided channel
Release all bleeding or injured fish unmarked
Fish must be >3'' total length
Cut a square notch in top lobe of caudal fin (proportionally large enough to re-sight but not harm fish)
Try to mark at least 30 fish
Only mark Steelhead or Cutthroat Trout
Record lengths and species of all fish marked

Snorkeling:

Items needed:
Mark-resight data sheets

Things to remember:
Wait 12-24 hours before snorkeling
50m oversample reaches downstream and upstream from the transect
Only record number and size of marked fish in oversample reaches
Collect all other information as for regular snorkel surveys

Habitat:

Items needed:
Stadia rods (2)
Mark-resight habitat data sheets
Measuring tapes (2)
Range finder for sites greater than 15m wide
Conductivity meter

Things to remember:
Start at bottom of transect
Establish at least 8 cross sections
Set cross sections at 10m intervals
Measure from river left bank to river right bank
Aggregates are 4 pieces of wood or more
Live wood with an angle >45 degrees counts as LWD
Substrate composition is measured 0.5m upstream and downstream from tape
Pools must have a length ≥ wetted width or occupy the entire wetted width
Only count pools in the first cross section if it spans more than one but record the total pool length
Overhanging vegetation and undercut banks must be within 0.5m above the water surface
Remove thermograph (HOBO) when finished with survey

Appendix B. Data form for general parr monitoring snorkel surveys.

IDFG NATURAL PRODUCTION SNORKELING -- 2014

Stream_________________________________Site_________________________________H_2O Temp____°C
Date_________________ Time______________ Recorder/Crew___________________ Channel Type: B / C
Pics: Bottom_________________ Top____________________ Weather______________ # Snorkelers_____
WGS84 Latitude__________________________________Longitude_________________________________
Program: GPM / other reason____ Visibility__________m
Lengths (m)____,____,____,____,____Total Length_____ Widths (m) ____,____,____,____,____,_____
Estimate Percent Habitat Types: Pool__________; Riffle__________; Run__________; Pocket_________
Amphibians (spp, life stage, number) ____
Non-Salmonid Fish____
Live Mussels Pres: Y / N Empty Mussel Shells Pres: Y / N Specie(s) ________________
Live Mussel Sizes: <2" Y/ N 2-5" Y / N >5" Y / NLive Mussel Abundance: Low/Med/High

INCH	**STHD**	**CUTT**	**BROOK**	**BULL**	**MWF**
<2					
2		2		2	
3		3		3	
4		4		4	
5		5		5	
6		6		6	
7		7		7	
8		8		8	
9		9		9	
10		10		10	
11		11		11	
12		12		12	
13		13		13	
14		14		14	
15		15		15	
16		16		16	
>16 specify					
CHN 0				**Trout Fry**	
CHN 1				**Adults CHN**	

Comments____

____

Appendix C. Data forms for mark-resight snorkel and habitat surveys.

IDFG NATURAL PRODUCTION SNORKELING RESIGHT-- 2014

Stream________________________________Stratum_____________________Site____________________
Date_________________ Time________________ Recorder/Crew________________ Channel Type: B / C
Pics___________________________ Weather____________________________# Snorkelers______________
Visibility__________m H_2O Temp__________°C
WGS84 Latitude________________________________Longitude_______________________________________
Lengths (m)_____,____,____,____,____ Total Length______ Widths (m)_____,_____,_____,______,_____,____
Estimate Percent Habitat Types: Pool________; Riffle________; Run________; Pocket________
Amphibians (spp, life stage, number)____
Non-Salmonid Fish____
TroutFry (<2" sthd, cutt)
____

	Marked Fish ONLY										
	50 M Below		50 M Above								
INCH	STH	CUT	STH	CUT	NO Mark STH	Mark STH	NO Mark CUT	Mark CUT	BRK	BLT	MWF
<2											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
>16 Specify size											
TOTAL											
CHN0											
CHN 1										Adult CHN	

Appendix C. Continued.

Stream____________________________ Stratum______________________Site_______________________

Date_________________ Start Time________________ Start H_2O Temp__________°C

End Time________________ End H_2O Temp__________°C

Weather__________________________________ # Anglers______________

FISH MARKED FOR RESIGHT SURVEY

INCHES	STHD	CUTT
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
>16 Specify		
TOTAL MARKED		

Comments____

____

____

____

Appendix C. Continued.

PHYSICAL DATA FORM FOR MARK-RESIGHT SNORKEL SURVEYS

STREAM: STRATUM: SITE:

DATE: RECORDER/CREW: WGS84 LAT: LONG:

HABITAT TYPES: P=POOL, RF=RIFFLE, RUN=RUN, G=GLIDE, PW=POCKETWATER | TOTAL UNIT LENGTH:

TRANSECT NO.		10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
HABITAT TYPE																
WETTED WIDTH																
DEPTH (m)	1/4															
	1/2															
	3/4															
	MAX															
POOL	COUNT															
	LENGTH (m)															
WOOD	LWD COUNT															
	(>3.0 X 0.1 m)															
NO. AGGREGATES																
NO. ROOTWADS																
PERCENT SUBSTRATE	FINES (<6mm)															
	GRAVEL (6-75 mm)															
	COBBLE (76-150 mm)															
	RUBBLE (150-300 mm)															
	BOULDER (>300 mm)															
	BEDROCK															

DOMINATE POOL FORMING FEATURE: BOULDER / BEDROCK; MEANDER / BEAVER; LWD / ARTIFICIAL; OTHER:_______________

TRANSECT MAX DEPTH:______(m)

Appendix C. Continued.

STREAM:			STRATUM:		SITE:		
DATE:		RECORDER/CREW:		WGS84 LAT:		LONG:	
OVERHANGING VEGETATION (LENGTH X WIDTH)				UNDERCUT BANKS (LENGTH X WIDTH)			
LEFT BANK		RIGHT BANK		LEFT BANK		RIGHT BANK	
LENGTH	WIDTH	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH	WIDTH

Comments:

DICHOTOMOUS KEY TO FAST WATER HABITAT TYPES

1a) Little or no surface turbulence (2)
1b) Abundant surface turbulence (3)

2a) No surface turbulence with uniform channel bottom (GLIDE)
2b) Little surface turbulence and no major flow obstructions (RUN)

3a) Shallow, swiftly flowing, turbulent water with partially exposed substrate (RIFFLE)
3b) Deep, swiftly flowing, turbulent water with partially exposed large obstructions and numerous eddies and scour pockets (POCKET WATER)

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