Geography and Timing of Salmonid Spawning in Idaho

April 25, 2014

Prepared by:

Mark Miller
BioAnalysts, Inc.
4725 North Cloverdale Rd. Ste 102
Boise, ID 83713

Erin Iverson
AnchorQEA
720 Olive Way, Suite 1900
Seattle, WA 98101

Don Essig
Idaho Department of Environmental Quality
1410 N. Hilton
Boise, ID 83706-1255

This report was commissioned by the Department of Environmental Quality (DEQ) to gather together information on the presence, likely presence, and areas suitable for salmonid spawning in waters of the state of Idaho. It provides a base of information useful to the potential development of rule and guidance on the occurrence and timing of use of waters in the state by salmonid fishes for spawning. It is not itself guidance or rule and does not create any rights or benefits enforceable at law by any person.

Table of Contents

List of Figures

List of Tables

INTRODUCTION

The Idaho Department of Environmental Quality (DEQ) identified a need to establish when and where spawning occurs for salmonid fishes throughout Idaho. This document provides background information on the development of the geography and timing of salmonids in Idaho. This document expands on the efforts of prior work assembled in Appendix F of the Second Edition of Watershed Body Assessment Guidance (WBAGII) (Grafe et. al. 2002). The previous literature review produced a series of tables that described general spawning locations along with incubation and emergence periods. In this effort, new information sources were compiled to augment that information and produce a series of Geographic Information System (GIS) maps to describe the location of potential spawning areas in Idaho. A statewide map including associated data tables compatible with ESRI ArcGIS were developed to display the information and facilitate application of water quality standards for salmonid spawning.

The reason for developing information on salmonid spawning and incubation/emergence periods is associated with the federal Clean Water Act (CWA), which requires states and tribes to restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA, are to adopt water quality standards necessary to protect fish among other beneficial uses. Idaho's water quality standards (WQS) say that waters that provide or could provide a habitat for self-propagating populations of salmonid species are to be protected for salmonid spawning (see IAC 58.01.02 at § 100.01b, available online at http://adminrules.idaho.gov/rules/current/58/0102.pdf). Specifically, DEQ has set temperature criteria for these waters where salmonid spawning has been designated as a beneficial use. Idaho's current temperature criteria for salmonid spawning are water temperatures of 13°C or less with a maximum daily average no greater than 9°C, while Region 10 of the Environmental Protection Agency (EPA 2003) recommends a single criterion of 13°C as a seven day average of daily maximum temperatures (7DADM, aka MWMT).

The following sections describe the methods used to create the geography and timing of salmonid spawning in Idaho. Also, included is information developed by species on spawning and incubation/emergence periods that should help assessors of beneficial use support in their decision making process. Providing maps for the entire state of Idaho and each species covered would be much too large for this report. However, examples of selected species have been provided for the Big Creek drainage in the Middle Fork Salmon River. Complete information will be available on the DEQ website when it becomes available.

METHODS

Several information sources including regional and statewide data sets were used to describe the geography and timing of salmonids in Idaho. These data sets include information on salmonid

life history, periodicity, and fish distributions to help describe the spawning and incubation/emergence periods. Statewide information sources that describe fish distributions and life history were secured from fish distribution layers created and updated by StreamNet and Idaho Department of Fish and Game. Intrinsic habitat potential developed by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA Fisheries) for Endangered Species Act (ESA) listed salmon and steelhead was also used to describe potential spawning location (Cooney and McClure 2007). Information was reviewed from many sources including published status reviews and updates provided by the US Fish and Wildlife Service (USFWS) and NOAA Fisheries, subbasin summaries/assessments/plans from the Northwest Power Planning Council, subbasin assessment and total maximum daily load (TMDL) documents developed by DEQ, management plans developed by the Idaho Department of Fish and game (IDFG) and Upper Salmon Basin Watershed Project (USBWP) Technical Team. Other sources of information that were integrated into this process-included peer reviewed literature from regional libraries (Universities, IDFG, BPA, and StreamNet).

Resource databases were also integrated into the process that may not necessarily be covered in the available literature. Databases such as the Idaho Fish and Wildlife Information System (IFWIS) maintained by the IDFG is a repository of data on spawning ground surveys, stream surveys, and juvenile smolt traps located throughout Idaho. This data is available through the IFWIS web portal https://fishandgame.idaho.gov/ifwis/portal/. Spawning ground survey information and juvenile trap data were used to describe spawning and incubation/emergence periods. Spawning ground data were useful in documenting general periods of spawning within a subbasin while information that is more specific was obtained from individual reports when they were available. Juvenile trap data (fish collected in rotary screw traps) was reviewed against fork length (FL) for steelhead (≤30mm FL) and Chinook salmon (≤42mm FL) that would indicate recently emerged fry. In addition, the Beneficial Use Reconnaissance Program (BURP) from DEQ and their fish sampling in different parts of Idaho was also reviewed for locations of fish species and size ranges that would be indicative of newly emerged salmonids.

Potential spawning distribution and periodicity information was compiled into ArcGIS and was associated geographically at the HUC 12 subwatershed level and the DEQ water body identification (WBID) system. Once the data were developed, it was sent out for review to different agencies, tribes, and entities in Idaho in a web based review process to allow biologists the chance to edit as needed spawning and incubation/emergence time periods based on their professional knowledge, literature and observations in particular subwatersheds. Some follow up calls were made to key people if there was no response or if the review process conflicted with their schedules. Edits from biologists throughout Idaho were incorporated into the GIS database information.

Identification of Spawning Areas

Idaho Department of Fish and Game and National Marine Fisheries Service were contacted to acquire information on potential spawning distributions of resident and anadromous salmonids in Idaho. These agencies provided source information and contacts to describe stream use and spawning habitat for most salmonids. The University of Wyoming was also contacted to obtain distribution information for redband trout in Southeast and Northern Idaho. The redband trout distribution layer is part of a range-wide assessment to describe their current and historical distributions (May et al. 2012). Salmonid spawning distribution layers are not portrayed in this document but can be viewed on the DEQ website when they become available. There are other native species in Idaho where no GIS information could be obtained. Many of these fish without GIS coverage have a limited range in Idaho and tend to be obligate lakeshore spawners with the exception of mountain whitefish. These fish include:

- Pygmy whitefish (Pend Oreille and Priest Lakes; Lakeshore and stream spawner)
- Mountain whitefish (Statewide except Palouse River drainage; Stream spawner)
- Bear Lake whitefish (Bear Lake; Lakeshore spawner)
- Bonneville cisco (Bear Lake; Lakeshore spawner)
- Bonneville whitefish (Bear Lake; Lakeshore spawner)

Introduced and Non-native Species

Several introduced and non-native salmonid species have become important recreational fisheries in Idaho. Many recreational opportunities occur throughout the state for kokanee, lake trout, brook trout, brown trout and rainbow trout. These salmonids occupy many of the streams, rivers, lakes, and reservoirs in Idaho inhabited by native species. There are no statewide GIS distribution layers available for these species that could be incorporated. Moreover, some areas are regularly planted to maintain population levels and recreational opportunities. Idaho Fish and Game has developed a fisheries management plan that outlines major drainages where native and introduced salmonid species occur (IDFG 2012, see Table 1). For these species, spawning and incubation/emergence periods were developed although much of the information relies on literature outside of the state of Idaho. The information presented in this document for these species is for general guidance and does not appear in the GIS layers or associated tables developed for native species because regional detail on timing are lacking.

Table 1. Native, introduced, and non-native salmonids in major drainage systems in Idaho (from IDFG 2012).

	Major Drainage Systems							
					Snake River			
Common Name	Kootenai	Pend Oreille	Spokane	Palouse	below Shoshone Falls	above Shoshone Falls	Bear River	In-dependent

Common Name	Major Drainage Systems							
					Snake River			
	Kootenai	Pend Oreille	Spokane	Palouse	below Shoshone Falls	above Shoshone Falls	Bear River	In-dependent
Native Salmonids								
Bear Lake whitefish							X	
Pygmy whitefish		X						
Bonneville cisco							X	
Bonneville whitefish							X	
Mountain whitefish	X	X	X		X	X	X	X
Sockeye Salmon					X			
Bull trout	X	X	X		X			X
Kokanee	X	X[1]	X[1]		X	X[1]		X[1]
Chinook			X[1]		X			
Golden trout	X		X		X	X		X
Westslope Cutthroat trout	X	X	X		X			
Yellowstone Cutthroat trout						X		X
Bonneville Cutthroat trout							X	
Rainbow trout	X	X[1]	X	X	X	X[1]	X[1]	X[1]
Redband trout	X				X			
Steelhead					X			
Introduced or Non-native Salmonids								
Coho Salmon[2]					X	X		
Lake whitefish		X						
Brown trout		X	X	X	X	X	X	
Atlantic salmon					X			
Blueback trout					X			
Brook trout	X	X	X	X	X	X	X	X
Lake trout		X			X	X	X	
Splake[3]		X	X		X	X		
Arctic grayling	X		X		X	X		X
Lahontan cutthroat trout					X	X		X

1. Native in part of the state, but introduced into this drainage.

2. Natural population of Coho extirpated; new population of hatchery origin.

3. A splake is a cross between a male brook trout (*Salvelinus fontinalis*) and a female lake trout (*Salvelinus namaycush*). Splake do not typically reproduce.

Native Species

StreamNet and IDFG provided species distribution (in GIS format) information for westslope cutthroat trout (WCT), Yellowstone cutthroat trout (YCT), Bonneville cutthroat trout (BCT), steelhead/rainbow trout, and spring/summer and fall Chinook. For the GIS distribution layers, IDFG identified use types for Chinook and steelhead/rainbow trout (Table 2). When available, the spawning and rearing use type was used to describe the locations of where fish spawn. The spawning and rearing use type may be overly inclusive for potential spawning habitat because it also includes rearing areas. DEQ acknowledges this limitation but also recognizes that spawning and rearing habitat overlap throughout the stream network. Users of the spawning maps should

be cognizant that small juvenile anadromous salmonids often use small tributary streams for rearing or refuge that *would not be used* for spawning.

Table 2. Fish distribution layers available native salmonids of Idaho (Cooney and Holzer 2006; StreamNet 2012; May et al. 2012).

Species	Identified Use Types					
	Intrinsic Habitat Potential	Spawning and Rearing	Rearing and Migration	Migration only	Year-round use	Current and Historic Distribution
Fall Chinook		X	X	X		
Spring/summer Chinook	X	X	X	X		
Steelhead/Rainbow Trout	X	X	X	X	X	
Westslope Cutthroat Trout					X	
Yellowstone Cutthroat Trout					X	
Bonneville Cutthroat Trout					X	
Redband Trout						X

The Interior Columbia Basin Technical Recovery Team (ICTRT) is one of a series of Technical Recovery Teams established by NOAA Fisheries to provide scientific input into regional recovery planning efforts for listed salmon and steelhead (Cooney and McClure 2007). As part of those efforts, the ICTRT assembled information into GIS layers for both stream type Chinook and steelhead spawning reaches to assess habitat quality within currently and historically occupied portions of the Interior Columbia Basin (ICB)(Cooney and Holzer 2006; Appendix C). The analysis they used was intended to provide a simple and objective overview of the distribution of historical production potential across tributary habitats for Chinook and steelhead populations. Using information on biological-habitat based relationships and channel characteristics (i.e., gradient, valley confinement, stream width) they developed areas within the ICB that displayed areas of negligible to high intrinsic spawning potential for Chinook and steelhead. Detailed information on their methodology (Appendix C) can be viewed online at http://www.nwfsc.noaa.gov/trt/col/trt_viability.cfm. We used this information in conjunction with the IDFG spawning and rearing use layers to define spawning areas for Chinook and steelhead within Idaho.

For native resident salmonids, there is little information statewide that can be used to depict their spawning locations. For cutthroat trout (WCT, YCT, BCT) and redband trout, the only available spatial information was based on year-round use or current distribution (Table 2). Part of the difficulty in providing comprehensive coverage for cutthroat and redband trout is that they are spring spawners. These native resident salmonids spawn from March into July often in locations that can be difficult to access (i.e., snow covered, roadless, etc.) where monitoring during the spawning period can be further complicated by high flows and turbidity. Hence, there has not

been a systematic documentation of native trout spawning locations throughout the state of Idaho. The available cutthroat and redband GIS layers were refined based on channel gradient and stream order to portray potential spawning locations.

For redband trout, there has been an ongoing range wide assessment as part of the Western Trout Native Trout Initiative. The assessment included a series of workshops to compile information on the distribution of redband throughout their native range outside the current range of anadromous steelhead (May et al. 2012). For the purposes of this document, the redband trout distribution covered northern and southwestern Idaho excluding the Salmon and Clearwater River basins. The GIS layers provided were considered to represent the current and historic distribution (circa 1800) of redband trout in Idaho. The distribution layers also contained a points database for temporary (i.e., culverts) and permanent (i.e., dams) barriers that may have eliminated redband trout from their historic distribution. For our purpose, temporary barriers were judged as transitional with a high likelihood that they would be repaired to reconnect the current distribution to the next most upstream permanent barrier or to a natural barrier. Reconnected stream segments were included in the depiction of potential spawning areas.

For Bonneville cutthroat trout, GIS distribution information obtained for this analysis was documented in the status review for Bonneville cutthroat trout, where fish were considered present (63%), unknown (30%), extirpated (6%) and non-fish bearing (1%) from the historically available habitat (Teuscher and Capurso 2007). Bonneville cutthroat trout were considered present if they had been observed within the past five years (Teuscher and Capurso 2007). Streams identified as unknown have not been sampled in the past five years or more. Extirpated was defined by systems with previous observation (pre-1999), but no collections within the past five years. Non-fish bearing was given to streams that were sampled, but no fish of any species were found and the lack of fish was not linked to human disturbance. Streams that were identified as extirpated and non-fish bearing were not considered potential spawning areas.

For Yellowstone cutthroat trout, potential spawning areas were generated from the present GIS distribution information (IDFG 2007a).

To help address information gaps for the year around or current distribution of native salmonids, two basic mapping rules were applied to those distributions to describe potential spawning areas. These mapping rules were narrowed down the broader distribution information to potential spawning areas based on stream size and gradient. In effect, the mapping rules eliminated large rivers used as adult rearing and migration and tributary stream reaches that had sustained gradients greater than five percent as potential spawning habitat. This is not to say these less suitable areas could not see pockets of spawning use on occasion, but we do not expect them to support significant spawning as a primary use.

As a surrogate for stream size, Strahler's (1957) stream order was used to exclude large streams within a drainage network that are unlikely to contain spawning habitat for native trout. Researchers have noted that cutthroat trout tend to occupy high elevations and low stream orders (Platts 1974, 1979; Fraley and Graham 1981; Rieman and Apperson 1989; Zurstadt and Stephan 2004). McIntyre and Rieman (1995) compiled life history information on westslope cutthroat trout from a variety of sources within their geographic distribution. They found that spawning occurs in stream orders 1-4 for adfluvial and fluvial life history forms and in stream orders 1-3 for resident forms (McIntyre and Rieman 1995). The information suggests that potential spawning areas occur in first-order to larger fourth order streams and is probably applicable to other cutthroat (Bonneville and Yellowstone) and redband trout. We applied a mapping rule to the distributions of cutthroat and redband trout that limited potential spawning to stream orders from first-order to fourth order streams.

Like other salmonids, trout spawn in low-to-moderate gradient stream reaches. Indeed, most large anadromous salmonids do not spawn in stream reaches greater than 4% slope because of the reaches' high bed-load transport rate, deep scour, and coarse substrate (Roni et al. 1999). Most high gradient stream reaches transport smaller suitable gravels and cobbles, which leaves exposed bedrock or large substrate. For cutthroat and redband trout, researchers have noted that most spawning occurs in lower stream gradients (Greswell 2011; Holocek and Walters 2007; Magee et al. 1996; Marotz and Fraley 1986; Mulfeld 2002; Schmetterling 2000; USFWS 1999; Zurstadt and Stephan 2004). The status review for westslope cutthroat trout characterized spawning habitat as low-gradient stream reaches that have gravel substrate ranging from 2 mm to 75 mm (0.8 to 3 inches) in diameter (USFWS 1999). Several researchers confirm that westslope cutthroat trout spawn in low gradient stream reaches (Magee et al. 1996; Zurstadt and Stephan 2004; Schmetterling 2000; Marotz and Fraley 1986). In the Taylor Fork, Magee et al. (1996) found that mean stream gradients where westslope cutthroat spawning occurred ranged from 0.5% to 4.0%. In the Bear Valley watershed of the Middle Fork Salmon River, stream gradients where cutthroat spawned ranged from 1% to 2% (Zurstadt and Stephan 2004). Schmetterling (2000) reported that cutthroat trout spawned in stream reaches with gradients up to 3% in tributaries of the Blackfoot River, Montana. In Bristow Creek, a tributary to Lake Koocanusa, cutthroat spawned in a reach with a 4.4% gradient (Marotz and Fraley 1986). For Yellowstone cutthroat trout, Greswell (2011) depicted spawning streams as most perennial streams with groundwater and snow-fed water sources with stream gradients in spawning areas usually less than 3%. For redband rainbow trout, researchers have noted that spawning occurs in similar low gradient stream reaches (Mulfeld 2002; Holocek and Walters 2007). The occurrence of redband trout in southwest Idaho streams occurred in gradients from 0.2% to 8.4% (Zoellick et al. 2005). Information on spawning of Bonneville cutthroat trout is scarce although the expectation is that their spawning habitat selection is similar. The information suggests that these native salmonids do not select stream gradients greater than 5% for spawning habitat. We applied a mapping rule

to the distributions of cutthroat and redband trout that limited potential spawning to stream gradients <5%.

For GIS modeling of stream gradients each stream reach from INSIDE Idaho was divided into segments 200 meters in length, starting at the most downstream portion of the reach and moving upstream. For each of these reach segments, a minimum (downstream-most point) and maximum (upstream-most point) elevation was calculated using the USGS 10-meter NED. Because spatial agreement between the streams data and the NED is not perfect, a procedure using Euclidean geometry had to be used to determine the minimum and maximum channel elevations for each 200-meter segment. The methodology used follows methods laid out in the GIS Data Acquisition and Modeling section of Viability Criteria for Application to Interior Columbia Basin Salmonid ESUs (Cooney and Holzer 2007; Appendix C).

Initially, potential spawning areas were mapped in segments having less than a 5% average gradient and a Strahler stream order less than or equal to 4. Areas with higher gradients or higher stream orders were not considered potential spawning habitat. Additionally, potential spawning areas were limited only to those streams with suitable physical characteristics within the distribution of cutthroat and redband trout. Because the stream gradients were calculated in 200-meter segments, rather than along an entire reach, all areas downstream of potential spawning segments were included if they fit both the stream order criteria and were within the distribution. That is, streams may have reaches (segments) of low gradient interspersed with higher gradient segments. When this occurred, we reconnected the most upstream and downstream segments of stream gradients at 5% or less to show a continuous stream line segment. If a stream maintained a gradient above 5% these areas were not included in potential spawning areas. The potential spawning areas do not separate the different life-history forms, but instead identify the combined or "lumped" potential spawning areas of resident, fluvial and adfluvial forms.

We compiled the potential spawning areas for Chinook, steelhead, westslope cutthroat trout, Yellowstone cutthroat trout, Bonneville cutthroat trout, and redband trout into GIS format with associated data tables describing the spawning and incubation/emergence periods. As an example, the distribution information for spring/summer Chinook, steelhead, and westslope cutthroat trout are provided for the Big Creek watershed of the Middle Fork Salmon River (Figures 1-3). Mapping rules were applied to the westslope cutthroat trout distribution to display the spawning distribution (Figure 3). The combined range of native salmonids across the state likely overlaps many regionally important recreational fisheries on non-native/introduced salmonids that do not have comprehensive distribution information. The distribution of these important fish was identified as a data gap. However, non-native and introduced salmonids such as rainbow trout, kokanee, brook trout, lake trout, and brown trout would be afforded the protection provided to native salmonids by application of spawning temperature criteria where there distributions overlap.

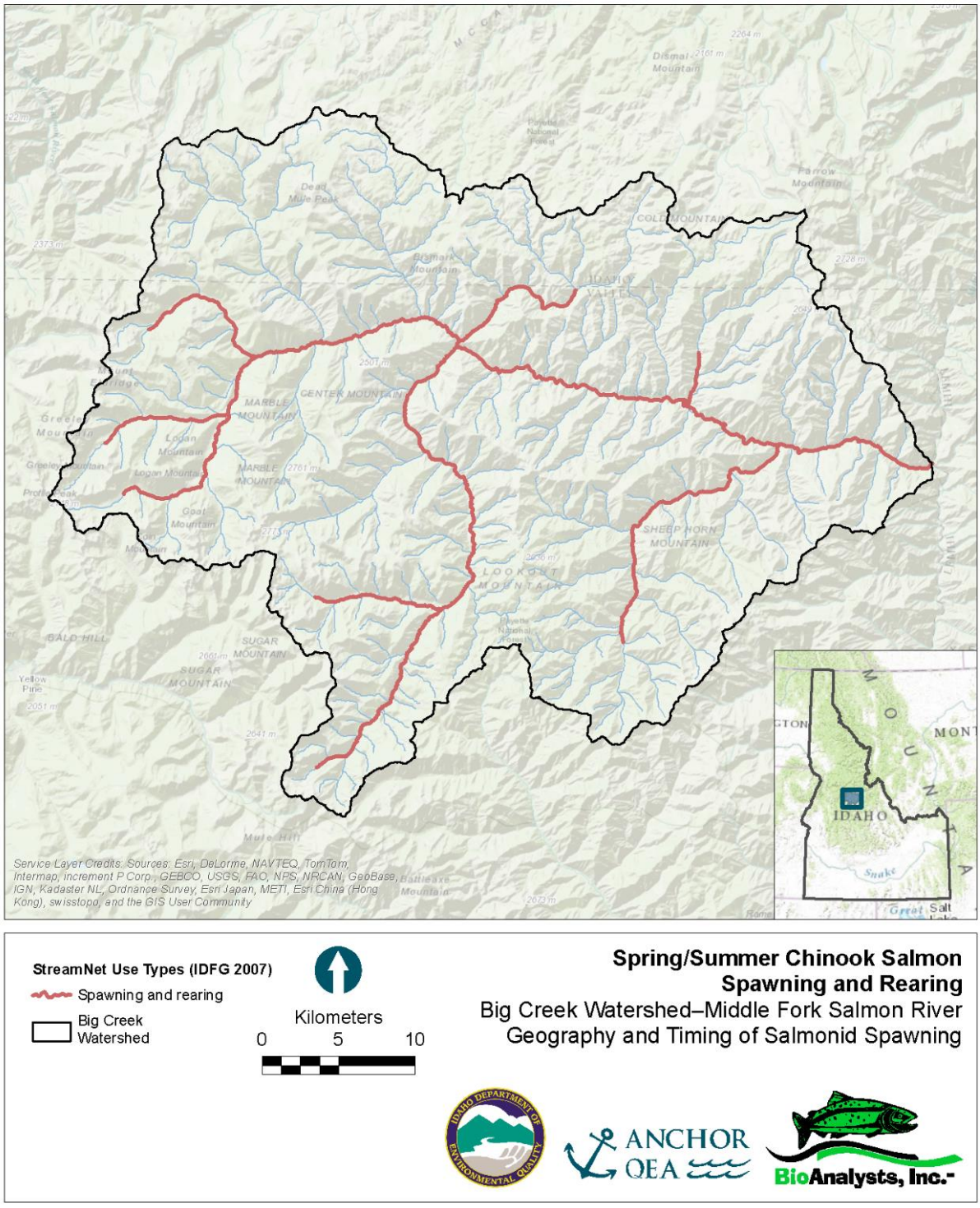

Figure 1. Potential spawning distribution of spring/summer Chinook in the Big Creek watershed of the Middle Fork Salmon River basin.

Figure 2. Potential spawning distribution of steelhead in the Big Creek watershed of the Middle Fork Salmon River basin.

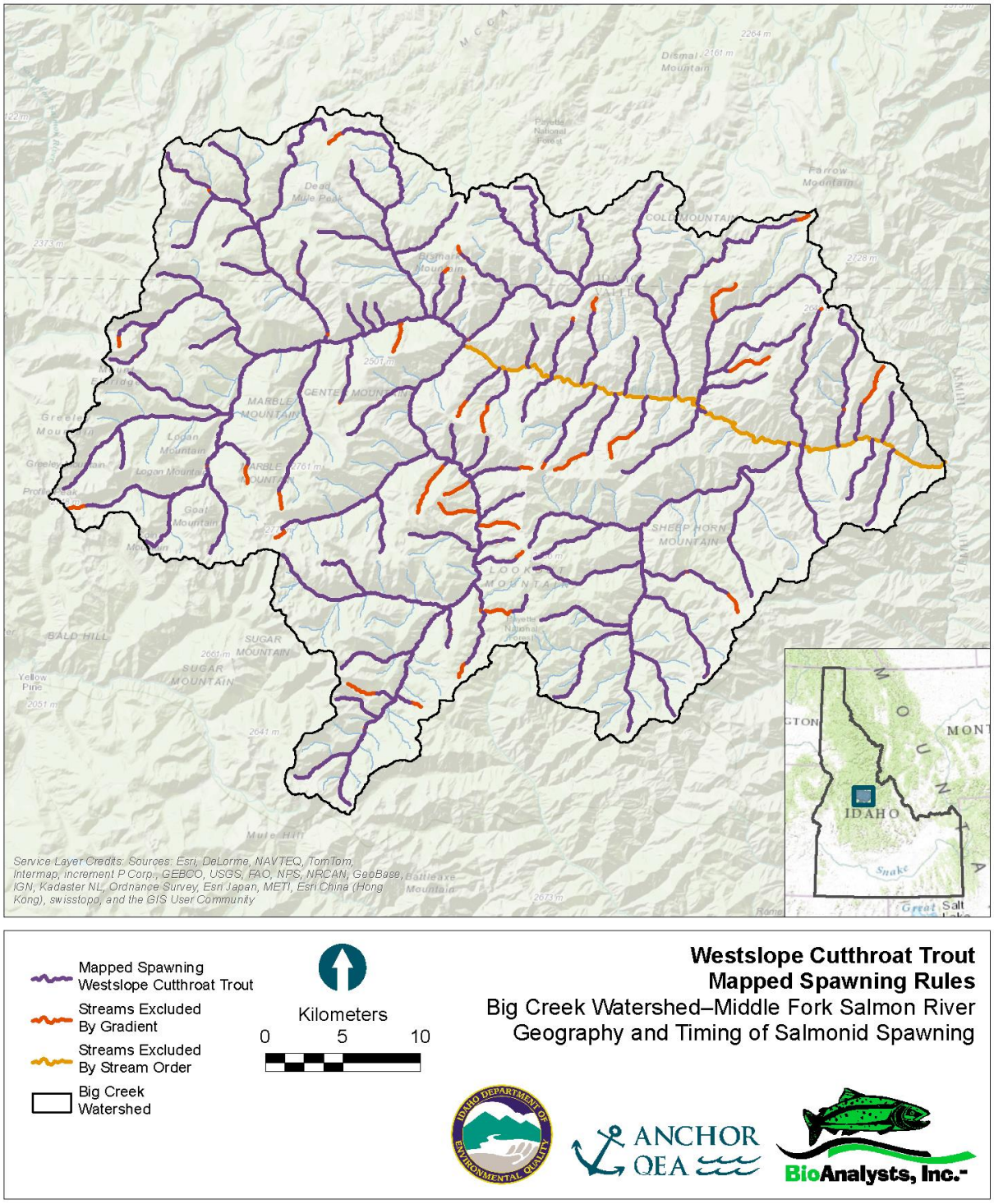

Figure 3. Potential spawning areas of westslope cutthroat trout in the Big Creek watershed of the Middle Fork Salmon River basin.

Development of Spawning and Incubation/Emergence Periods

We gathered information on life-history periodicity for salmonids that is more recent to augment the previous information developed in Append F of the Water Body Assessment Guidance, Second Edition (Grafe et al. 2002). Core periods identified in that document are still applicable, except where updated (Table 2). In our effort to update the prior information, it became apparent that year-to-year variability in time of spawning and emergence was evident. That variability is probably common throughout western states and is likely the result of stream discharge and temperatures that may vary annually with the prevailing weather conditions. Researchers also mentioned elevation as an important consideration (Budy et al. 2012; Gresswell 2009; Holubetz Petrosky 1995; USFWS 1995). Although it is well know that weather and climate changes with elevation, it is hard to define a single elevation that can be applied because climate is also confounded by other prevailing environmental conditions such as aspect. To reflect some of the variability in the spawning and incubation/emergence periods observed, a range of dates have been applied (Table 3).

Spawning and incubation/emergence time periods were broken down into one of four weeks per month. In part, this accommodated the detail of periods reported in some literature sources while some literature provided only generic "start" or "end" or "mid" month descriptive information for periods of spawning or incubation/emergence. Generic terms were used as a break point to portray that level of detail. The weeks of the month were broken down by dates. Here is an example for April:

- Apr 01-07 (Week 1)
- Apr 08-14 (Week 2)
- Apr 15-21 (Week 3)
- Apr 22-30 (Week 4)

For clarity, spawning is the act of constructing a redd followed by depositing and fertilization of eggs. For some lakeshore spawners, and mountain whitefish in streams, there is often no redd construction only the deposition of eggs and fertilization. Some of these spawners have negatively buoyant eggs that sink and adhere to the substrate. Incubation is the period from fertilization to hatching; the term alevin describes yolk sac fry after hatching. Emergence is the time at which the alevin has absorbed the yolk sac and emerges from the substrate, and is termed a fry. In this document, the end of the incubation/emergence period is considered emergence from the gravel unless otherwise noted.

During the period from spawning to emergence, the assessor should be aware that the critical time for exceedance of temperature criteria will differ based on salmonid reproductive behavior. For late summer and fall spawners the critical period is most likely during spawning and early

stages of incubation when stream temperatures are beginning to cool from their summer maximums. The opposite is true for spring spawners, where the later stages of incubation through emergence is likely the more critical period. In general, spring spawners initiate reproduction as stream temperatures begin to warm from the winter minimums. In addition, some native and introduced salmonids have spawning behaviors where eggs are deposited in streams or lakes, or both. We have tabulated these general patterns (Table 3).

Table 3. Spawning and incubation/emergence periods for native and introduced salmonids in Idaho.

Fish Species	Initiation of Spawning Period	End of Incubation/Emergence	Spawning Location(s)
Late Summer, Fall and Winter Spawners			
Spring/Summer Chinook	July 22-August 15	June 1-June 30	Stream
Fall Chinook	October 15	May 7-June 30	Stream
Coho Salmon	October 15	April 30	Stream
Sockeye Salmon	September 15	May 31	Streams and Lakes
Bull Trout	September 1	May 31	Stream
Mountain Whitefish	October 1	April 30	Stream
Kokanee Salmon	August 1-mid November	June 30	Streams and Lakes
Brown Trout	October 1	June 30	Streams
Brook Trout	September 1	May 31	Streams
Lake Whitefish	November 1	May 31	Lake
Blueback Trout	October 15	April 15	Lake
Mountain Whitefish	October 1	April 30	Streams
Atlantic Salmon	October 15	May 31	Streams
Lake Trout	September 7	May 31	Lake
Pygmy Whitefish	October 1	May 31	Streams and Lakes
Bonneville Cisco	January	May 7	Lake
Bonneville Whitefish	December	--	Lake
Bear Lake Whitefish	February	--	Lake
Spring Spawners			
Summer Steelhead	February 1	July 15 to August 15	Streams
Redband/rainbow trout	March 15	July 15	Streams
Cutthroat Trout	March 15	July 1-Oct 31	Streams
Arctic Grayling	April 1	June 30	Streams
Golden Trout	May 22	August 31	Streams

For most of the Salmon River Basin, the Upper Salmon Basin Watershed Project (USBWP) technical team developed work windows for general guidance to State, Federal, and Tribal entities. The work windows provide guidance for timing of instream projects involving the use of machinery with the primary purpose of protecting incubating eggs, fry in the gravels (prior to emergence), and spawning adults (USBWP 2005). Professional biologists familiar with fish distribution and life cycles in the Upper Salmon River Subbasin tabulated these work windows. They reflect the general timing of spawning, incubation, and emergence. The technical team

developed life history information for westslope cutthroat trout, bull trout, spring Chinook salmon, and steelhead/redband rainbows/rainbow trout. The USBWP technical team developed spawning and incubation time-periods into four quarters per month. We used their information to help develop our spawning and incubation periods.

In the following section, we discuss by species the distribution and spawning and incubation/emergence periods we have developed. This section provides assessors a working background of some of the key source information for defining spawning and incubation/emergence periods. The list of salmonids species included follows the list presented in the 2013-2018 IDFG Fisheries Management Plan (IDFG 2012). The tables include a spawning period and an incubation/emergence period associated with each species.

Spring/Summer/Fall Chinook (*Oncorhynchus tshawytscha)*

Collectively, the distribution of spring/summer and fall Chinook in Idaho includes the Snake River below Hells Canyon Dam and parts of the Salmon and Clearwater River basins. The distribution of spring/summer Chinook is predominantly in the tributaries of the Salmon and Clearwater River basins. In both river systems, spring Chinook salmon tend to use smaller, higher elevation streams while summer Chinook are more variable and overlap with areas of spring Chinook. Fall Chinook salmon tend to use large, lower elevation streams or main-stem areas in the Snake, lower Salmon and Clearwater rivers (Mathews and Waples 1991).

Adult Chinook salmon that migrate upstream past Bonneville Dam from March through May, June through July, and August through October are categorized as spring-, summer-, and fall-run fish, respectively (Mathews and Waples 1991). In general, there is a five-month spawning period for Chinook salmon (all races) in Idaho, which extends from late July into December progressing from upstream higher elevation tributaries downstream to the lower elevation larger mainstem rivers where fall Chinook spawn. The spring/summer Chinook spawning period can extend from late July to about mid-October (Keifer et al. 1992; Venditti et al. 2007; USBWP 2005; Young and Blenden 2011) (Table 4). Fall Chinook typically spawn from about mid-October to mid-December (Arnsberg 1992; Arnsberg et al. 1992; Groves and Chandler 1999) (Table 4).

The incubation period for Chinook salmon is variable and highly dependent on stream temperatures that determine the rate of development (Alderdice and Velsen 1978; Velsen 1987). Velsen (1987) reported that at ambient temperatures (average daily) from 2.3 °C to 16.8 °C incubation ranged from 172 to 16 days to 50% hatch, respectively. Emergence may occur several days to weeks after hatching. For Chinook, the incubation/emergence period can extend into June and sometimes July (USBWP 2005; Rondorf and Tiffan 1997; Connor et al. 2002). Connor et al. (2002) report a broad range in emergence timing in their work; the median range in emergence timing for fall Chinook from year to year for the upper and lower reaches of the Snake River and Lower Clearwater River varied by up to two to four weeks (see their table 2). The researchers suggested that fry generally emerged earlier when mean winter-spring water temperature was warmer than when it was cooler (Connor et al. 2002). The latest emergence

dates occurred in the lower mainstem Clearwater River and are likely influenced by cold-water releases from Dworshak Dam. Majority of the information on emergence for fall Chinook indicates emergence around mid-May to end of June (Arnsberg et al. 1992; Connor et al. 2002; Herger et al. 2002) (Table 4).

For spring/summer Chinook, the USBWP (2005) technical team indicated end of incubation by late April with a period of fry presence extending through May and into June. The rather long period of fry presence reported for many areas in the Salmon River Basin likely reflects a window or period of fry emergence that covers different spawning areas (elevation) and environmental conditions. The presence of recently emerged small Chinook salmon fry (≤42mm FL) in smolt traps (IFWIS 2012, unpublished juvenile trap data) of the Salmon, Pahsimeroi, and Middle Fork Salmon rivers in March through May certainly comports well with incubation and emergence periods indicated by the USBWP (2005). Cannamela (1992) reported that for the Upper Salmon River the emergence period was from late March to early June. In the Secesh River in the South Fork Salmon River drainage, presence of fry was most apparent in May and June (IFWIS 2012, unpublished juvenile trap data). In the South Fork Clearwater River drainage, researchers have classified early to late April as the emergence period (Keifer et al. 1992; Herger et al. 2002). The presence of recently emerged small Chinook in the South Fork Clearwater and Lochsa River drainages also appears to indicate April and May as the end of incubation/emergence (IFWIS 2012, unpublished juvenile trap data). Information on emergence for spring/summer Chinook indicates emergence in March, April and May in most areas of Idaho (Cannamela 1992; Kiefer et al. 1992; Herger et al. 2002; USBWP 2005) (Table 4). Presence of small fry later in the year (June) may also occur at some locations. The spawning and incubation/emergence period (July 22-April 20) for spring/summer Chinook in the Big Creek watershed in the Middle Fork Salmon River basin is provided as an example (Figure 4).

Table 4. General spawning and incubation/emergence periods for spring/summer and fall Chinook.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spring/Summer Chinook												
Spawning												
Incubation/ Emergence												
Fall Chinook												
Spawning												
Incubation/ Emergence												

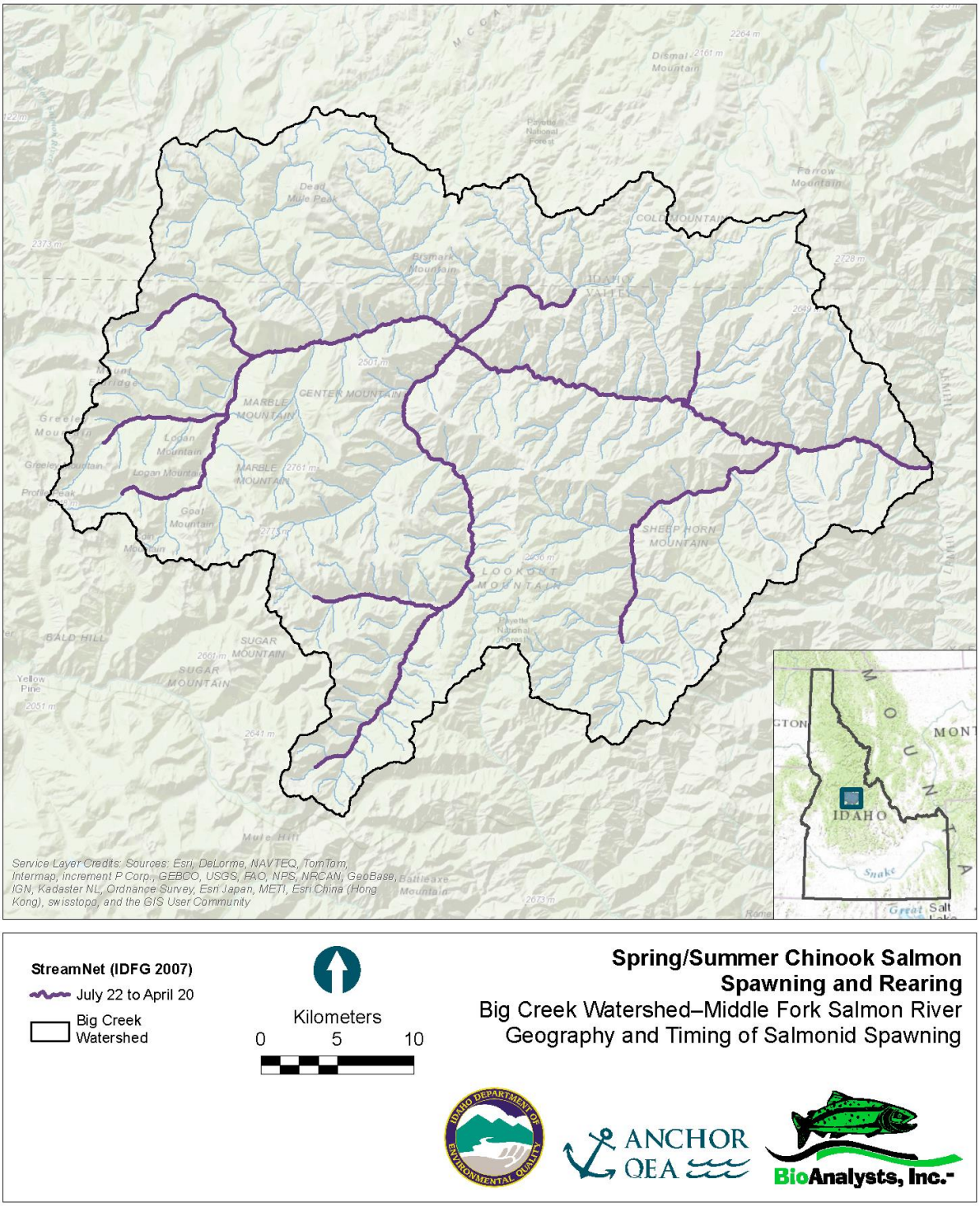

Figure 4. Spawning/emergence period (July 22-April 20) designated for the Big Creek watershed of the Middle Fork Salmon River basin.

Summer Steelhead (*Oncorhynchus mykiss*)

The distribution of steelhead in Idaho includes the Snake River below Hells Canyon Dam and parts of the Salmon and Clearwater River basins. The distribution of steelhead is predominantly in the tributaries of the Salmon and Clearwater River basins. In both river basins, steelhead spawn in tributaries although spawning is known to occur in the larger tributary mainstem rivers (Thurow 1987; Leth et al. 2000). The construction of Dworshak Dam eliminated the North Fork Clearwater as accessible anadromous fish habitat after 1971.

Adult steelhead migrating upstream that are destined for Idaho streams are called summer steelhead and are classified as either A-run or B-run steelhead. The time of adult migration and ocean life history, distinguish the two runs. A-run steelhead migrate upstream earlier from June through August and tend to spend one year in the ocean. B-run fish migrate later in summer and fall, spend two years in the ocean and tend to be larger.

The spawning period for steelhead in Idaho covers a period of four and a half months (Table 5). Holubetz (1995) speculated that spawn time may be related to elevation. In high elevation tributaries, steelhead typically spawned in a narrow time frame between April 15 to May 15 (Thurow 1983; Orcutt et al. 1968). In lower elevation and intermediate elevation, streams spawning occurred over a longer time period including March, April, May, and June (Holubetz 1995).The Upper Salmon Basin Watershed Project Technical Team set spawning periods for different areas of the Salmon River Basin (USBWP 2005). The spawning period across the entire basin extends from mid-March to mid-June. Steelhead may begin spawning in mainstem areas first progressing upstream to tributaries. In the South Fork Salmon River, Thurow (1987) observed that tributary spawning began one to two weeks later than it did in the mainstem and speculated that this might be in response to colder water in tributary spawning areas. This progression of steelhead spawning might also hold true in other large tributaries of the Clearwater and Salmon River basins such as the Middle Fork Salmon, Lochsa, Selway, and South Fork Clearwater rivers. In the Clearwater subbasin, B-run steelhead spawning occurs from mid-March through early June, while A-run steelhead spawn from February through early May (NPT and IDFG 1990, as cited in Ecovista 2003). Life history information developed in the South Fork Clearwater Basin TMDL expressed a steelhead spawning period for the mainstem and other tributaries of the basin extending from the start of February to mid-May (Herger et al. 2002).

The steelhead incubation period is variable and highly dependent on stream temperatures that determine the rate of development (Velsen 1987). Velsen (1987) reported that at ambient temperatures (average daily) from 2.0 °C to 15.5 °C, 50% hatch took about 124 to 19 days, respectively. Similar to Chinook, steelhead emergence may occur several days to weeks after hatching. In the Clearwater subbasin, B-run steelhead emergence occurs in June and July while A-run steelhead emergence occurs mid-April through May (NPT and IDFG 1990, as cited in

Ecovista 2003). For steelhead the incubation and emergence period can extend from February to mid-July or even mid-August depending on location and environmental conditions (Thurow 1987; Ecovista 2003; Herger et al. 2002; USBWP 2005)(Table 5). Variability reflecting environmental conditions can be seen in steelhead emergence in the South Fork Salmon River (Thurow 1987). In 1984, 98% of the steelhead fry emerged by August 10 and in 1985, 98% emergence occurred by July 17. Thurow (1987) pointed out that lower stream discharge and warmer water temperatures accelerated emergence in 1985 as compared to 1984. In the Salmon River basin, the USBWP technical team consistently showed fry presence sometimes extending through October 3 to 3.5 months after the end of incubation. This seems rather late considering the periods of emergence reported by others. Field observations noted by R. Thurow, fisheries biologist for USDA Forest Service, confirm that in the Salmon River March into August is an appropriate spawning and incubation/emergence period (Thurow 1987). The majority of information on spawning and incubation/emergence indicates a period from February to mid-July or mid-August depending on environmental conditions (Table 5). The spawning/emergence period for steelhead in the Big Creek watershed of the Middle Fork Salmon River basin is provided as an example (Figure 5).

Table 5. General spawning and incubation/emergence period for steelhead.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning												
Incubation/ Emergence												

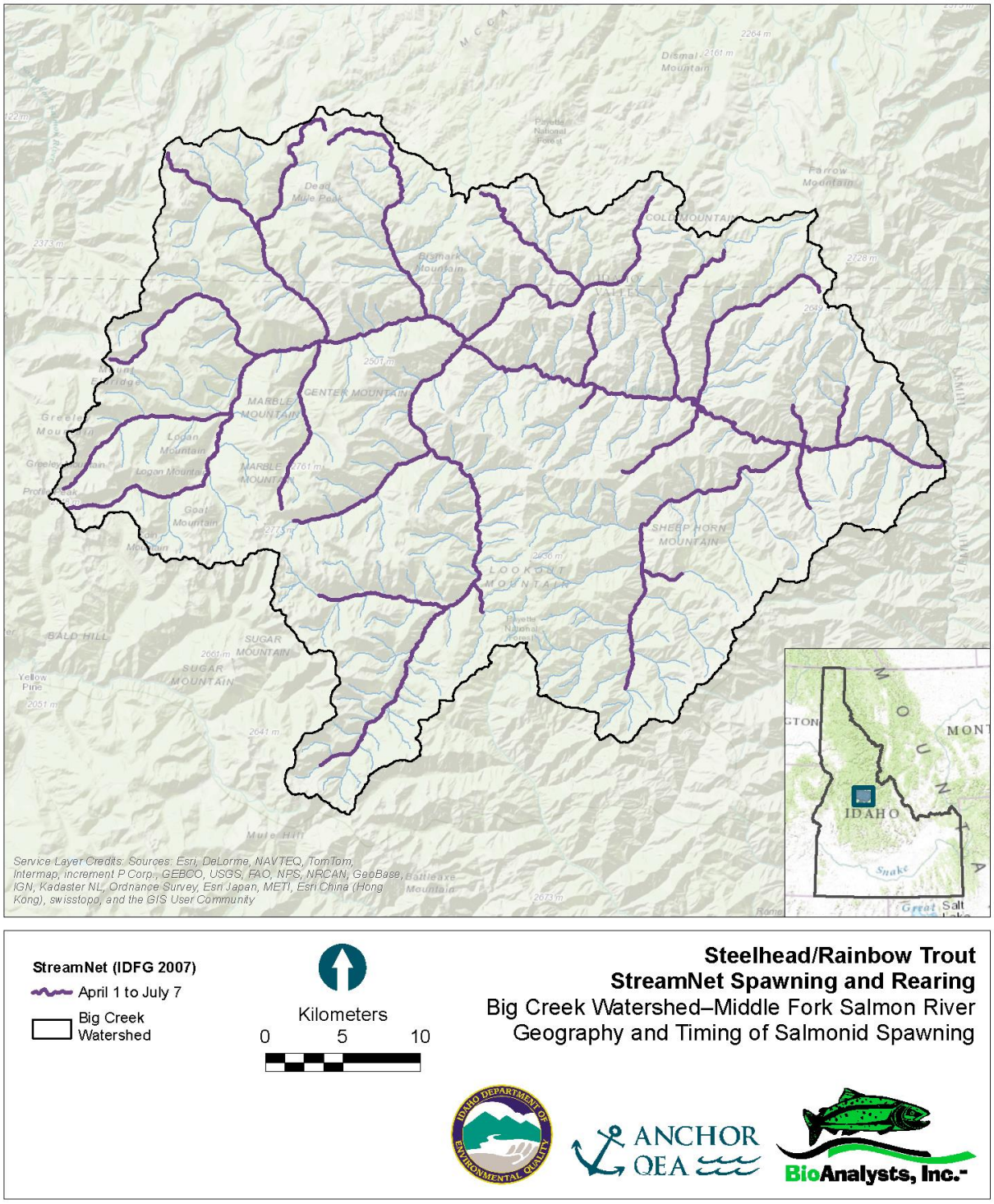

Figure 5. Spawning/emergence period (April 1-July 7) for steelhead in the Big Creek watershed of the Middle Fork Salmon River basin.

Redband/Rainbow Trout (*O. mykiss gairdneri*)

In Idaho, the distribution of redband trout includes areas of the Columbia River basin east of the Cascades to barrier falls on the Kootenay, Pend Oreille, Spokane, and Snake rivers (Behnke 1992, Wallace and Zaroban 2013). That distribution includes tributaries downstream from Shoshone Falls on the Snake River, Salmon River basin, Clearwater River basin, and Kootenai River and Hangman Creek in Northern Idaho (Table 1). Rainbow trout (not redband) occur in every drainage in Idaho, having been introduced into the Palouse, Snake River above Shoshone Falls, Bear River, and independent river drainages (Table 1).

Information on spawning and incubation/emergence periods for native redband trout is scarce particularly in the Southwest Idaho (Schill et al. 2004). In Northern Idaho the spawning period is about one and a half months from mid-April to end of the first week of June (Downs 2000; Holecek and Walters 2007; Paragamian et al. 2008). In Southwestern Idaho, the spawning and incubation/emergence period is an identified data gap. In conversations with Dan Schill, a fish biologist with the IDFG, he recounted only a single occasion where active redband trout spawning had been observed. In late May, Schill et al. (2004) observed several redband trout spawning in Duncan Creek a tributary stream in the Bruneau River system. The predominant movement of redband trout observed in April and May was upstream and suspected to be associated with spawning (Schill et al. 2004). Fry were observed on Little Jacks Creek and Jump Creek on June 12 (D. Schill, personal communication).

Spawning and emergence periods for redband trout and rainbow trout are often reported along with steelhead (Herger et al. 2002; USBWP 2005). The time-periods reported there are appropriate for the Clearwater and Salmon River basins. In Northern, Southwestern and Eastern Idaho streams the default period of mid-March to mid-July should be used outside the geographic range of steelhead (Grafe et al. 2002) (Table 6).

Table 6. General spawning and incubation/period for redband and rainbow trout outside the geographic range of steelhead.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning			■	■	■	■						
Incubation/ Emergence			■	■	■	■	■					

Coho Salmon (Oncorhynchus kisutch)

Coho were native to portions of Idaho in the Clearwater River basin but in 1927 with the construction of Washington Water Power Diversion Dam, passage was blocked (NPT and FishPro 2004). Coho salmon were officially recognized as extirpated from Idaho in 1986. In the Clearwater River drainage, the Nez Perce Tribe began a Coho salmon reintroduction program in

1994 with an escapement goal of 14,000 Coho salmon past Lower Granite Dam. By 1999, the first redds were observed in the Potlatch River (NPT and FishPro 2004, see their Table 6-3). Counts of adult Coho at Lower Granite Dam over several years (2003-2007) have averaged over 2,100 fish (HSRG 2009). In 2005, spawning was observed in the Potlatch River, Lapwai Creek, Lolo Creek, Clear Creek, and the South Fork Clearwater River (NPT 2005 as cited in HSRG 2009). We expect the abundance and distribution of Coho salmon in the Clearwater River drainage to change over time with increases in returning fish and as natural production increases.

Coho salmon have also been planted in Cascade (Payette drainage) and Island Park (Henrys Fork) reservoirs but it is unknown whether natural reproduction occurs. Coho in the Payette and Henrys Fork drainages are outside their native range.

The spawning period of Coho salmon in the Clearwater extends from mid-October to end of the first week of December (J. Hesse, personal communication). Historical information on the Coho salmon in the Grande Ronde River showed that fish enter the river in mid-September and that spawn time was bimodal with peaks about November 1 and December 1 (Cramer and Witty 1998). Cramer and Witty (1998) noted that fry likely emerged from the gravel in mid-March through April. Simpson and Wallace (1982) reported spawning in October with fry hatch out in March or early April. End of April was considered an appropriate period for emergence (J. Hesse, personal communication). Spawning and incubation/emergence periods reported here for Coho salmon should be viewed with the knowledge that only recently has natural reproduction reoccurred in the Clearwater River drainage (Table 7).

Table 7. General spawning and incubation/emergence periods for Coho salmon.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning												
Incubation/ Emergence												

Cutthroat Trout (*Oncorhynchus clarkii*)

There are three subspecies of native cutthroat that are recognized in Idaho (Behnke 1992, Wallace and Zaroban 2013) and are geographically isolated from one another (IDFG 2007a) (Table 1). Westslope cutthroat trout (WCT) (*O. c. lewisi)* occur in central Idaho in the Salmon and Clearwater river drainages and in northern Idaho in the Kootenai, Pend Oreille, Priest, and Coeur d' Alene drainages (Behnke 1992, Wallace and Zaroban 2013). Bonneville cutthroat (BCT) (*O. c. utah)* are native to the Bear River system in southeastern Idaho (Teuscher and Capurso 2007). Yellowstone cutthroat trout (YCT) (*O. c. bouvieri)* are found in Eastern Idaho in the Snake River system upstream from Shoshone Falls (IDFG 2007a). The finespotted Snake

River cutthroat trout (*O. clarkii behnkei*), occurs only within the native range of the Yellowstone cutthroat trout (Gresswell 2009). This subspecies cannot currently be distinguished genetically from the Yellowstone subspecies (Greswell 2009). Within their range, cutthroat trout exhibit a variety of life history strategies inhabiting lakes, rivers and small tributary streams (Behnke 1992; Gresswell 2009; May 2009; McIntyre and Rieman 1995; IDFG 2007a; Teuscher and Capurso 2007, Wallace and Zaroban 2013).

The spawning period for cutthroat trout is variable occurring over a nearly four-month period extending from March through early July (Gresswell 2009; Herger et al. 2002; IDFG 2007a; Nielson and Lentsch 1988; Thurow et al. 1988; Teuscher and Capurso 2007; USBWP 2005; IDFG 2013). For westslope cutthroat trout in the Salmon River basin, the spawning period typically starts in April or May (sometimes March) and is complete by last week of June or first week of July (USBWP 2005). Movement of westslope cutthroat trout into tributaries in the spring during migration studies in the Upper Salmon River and Upper Middle Fork Salmon River comport with the spawning periods reported (Schoby and Curet 2007; Zurstadt and Stephan 2004). Similar spring movements in April, May and June associated with spawning have been found in the Coeur d'Alene (WCT) and Bear (BCT) river watersheds (Dupont 2008; Colyer et al. 2005). In the South Fork Clearwater, the spawning period is reported to extend from mid-March to end of June (Herger et al. 2002). IDFG (2013) reported that spawning in the Lochsa River drainage occurs in April and May when waters are around 6-9°C. The spawning period reported by Herger et al. (2002) and IDFG (2013) is similar to that reported by the USWBP (2005) for nearly the entire Salmon River basin and thus is probably comprehensive enough to apply to Clearwater River Basin. Field observations by Thurow and Bjornn (1978) and other researchers (Averett 1962; Rankel 1971) in the St. Joe River drainage indicate a spawning period from early April to mid-June. Bonneville cutthroat trout in Bear Lake began spawning in late April and spawning was complete by late June (Nielson and Lentsch 1988). Throughout their geographic range, Gresswell (2009) reported that Yellowstone cutthroat might spawn between March and August. However, for Yellowstone cutthroat trout populations in Idaho streams, spawning typically occurred between early May and early July (Thurow et al. 1988).

The incubation period for cutthroat trout is variable and like other salmonids is dependent on stream temperatures that determine rate of development (Budy et al. 2012; Drinan et al. 2012; Hickman and Raleigh 1982). Depending on temperature, eggs hatch within 4 to 6 weeks after egg fertilization but may take as long as 7 weeks (Hickman and Raleigh 1982). As cited in Hickman and Raleigh (1982), cutthroat trout remain in the gravel for about two weeks after hatching and emerge 45 to 75 days after egg fertilization depending on water temperature (Calhoun 1944; Lea 1968; Scott and Crossman 1973). The end of the incubation period reported in the Salmon River basin (WCT) was usually between the third week of July to end of the first week of August (USBWP 2005). Presence of cutthroat fry reported in most areas extended through October in the Salmon River basin. Fry emergence in the St. Joe River system was reported as June and July with some possibly in August (Averett 1962; Averett and MacPhee

1971; Thurow and Bjornn 1978). In the South Fork Clearwater, the incubation/emergence period was reported to extend from mid-March to mid-August (Herger et al. 2002). In the Lochsa River drainage, emergence occurs in June and July (IDFG 2013). Thurow et al. (1988) reported for Yellowstone cutthroat trout that fry emergence normally begins in mid-July with the peak in August tapering off but extending into fall. The USFWS reported that emergence of Bonneville cutthroat trout typically occurs in mid-to-late summer (USFWS 2001). Although the description provided by USFWS (2001) is rather unclear, the assumption here is that emergence may occur as late as end of July possibly into August.

The extended period of fry presence (emergence) reported for many areas is likely explained by location (elevation) or possibly prevailing environmental conditions (stream discharge and temperature). For example, in the Logan River drainage in Utah, Budy et al. (2012) found that eggs of Bonneville cutthroat trout in a high elevation tributary required nearly 50% longer to develop. As noted in both the Chinook and steelhead sections, variability in emergence (2-4 weeks) can also occur inter-annually depending on environmental conditions. The majority of information on spawning and incubation/emergence periods in Idaho indicate a period from mid-March to July and August. Emergence may extend into late October depending on location and environmental conditions (Table 8). The spawning/emergence period for westslope cutthroat trout in the Big Creek watershed of the Middle Fork Salmon River basin is provided as an example (Figure 6)

Table 8. General combined spawning and incubation/emergence periods for all three subspecies of cutthroat trout (westslope, Yellowstone, and Bonneville).

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning												
Incubation/ Emergence												

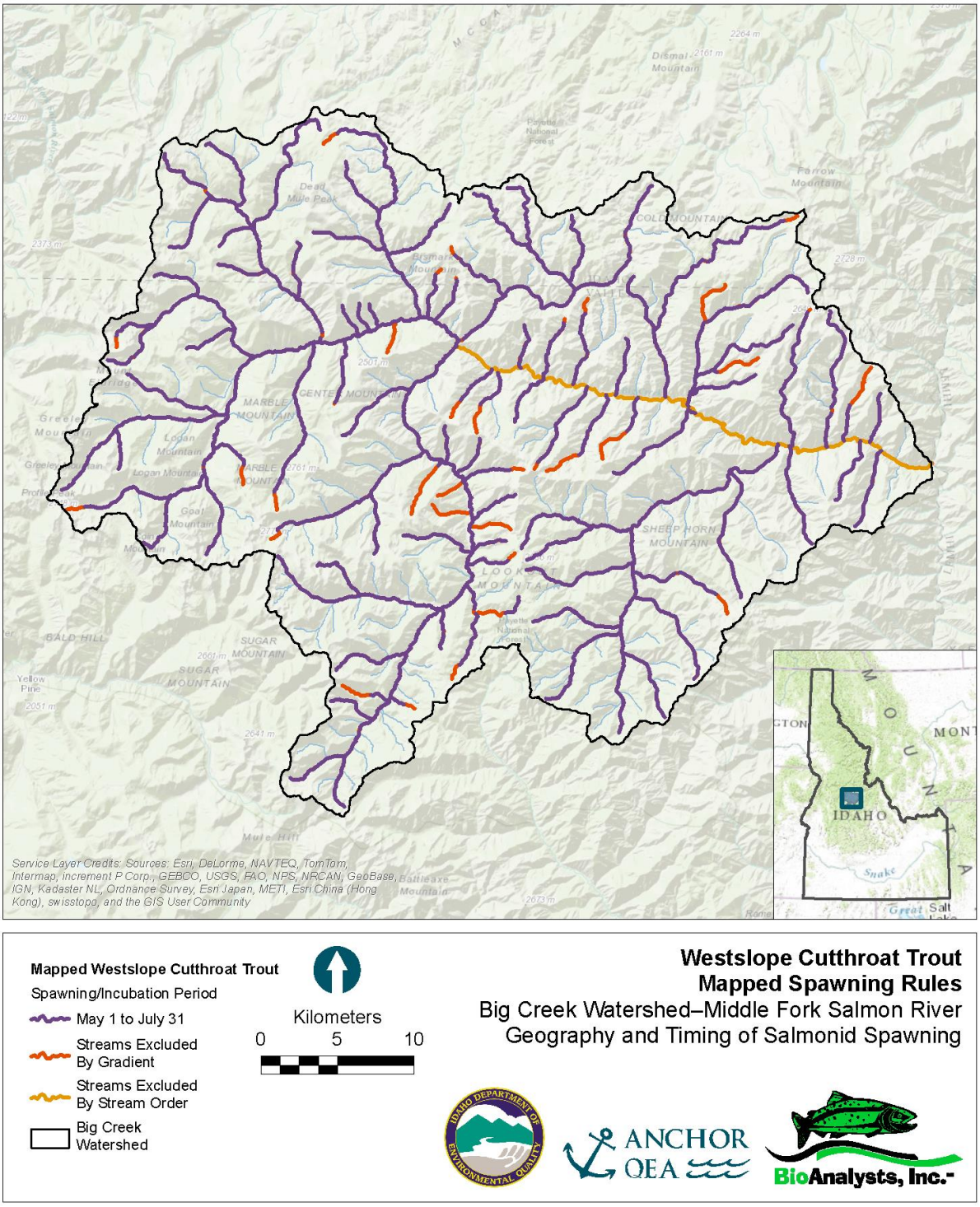

Figure 6. Spawning/emergence period (May 1-July 31) for westslope cutthroat trout in the Big Creek watershed of the Middle Fork Salmon River basin.

Sockeye Salmon (*Oncorhynchus nerka*)

In Idaho, sockeye are restricted to the upper Salmon River basin in Red Fish Lake and formally occurred in Alturas Lake, Yellowbelly, Pettit Lake, and Stanley Lake (NOAA Fisheries 2011). At the time of listing in 1991, the only confirmed population that belonged to this ESU was the beach-spawning population of sockeye from Redfish Lake. In recent years, the return of sockeye has exceeded the needs of the broodstock program and alternative supplementation strategies have been used to help re-establish natural production. The strategies include releasing adults to spawn naturally, planting boxes with eyed-eggs for incubation and early rearing, and releasing hatchery-reared smolts to Sawtooth Valley lakes (NOAA Fisheries 2011).

Snake River sockeye spawn over about a two-month period (Table 9). Snake River sockeye salmon adults enter the Columbia River from June through July with a peak arrival to Redfish Lake in August with spawning primarily in October (Bjornn et al. 1968; as cited in NMFS 1995). Recent spawning surveys in Redfish Lake have documented spawning in beach areas from about mid-September to end of the first week of November (Petersen et al. 2007; Petersen et al. 2012). Eggs hatch in the spring between 80 and 140 days after spawning. Fry remain in the gravel for three to five weeks and emerge in April through May (NMFS 1995). The spawning and incubation/emergence period is from mid-September to end of May (Table 9).

Table 9. General spawning and incubation/emergence periods for Sockeye salmon in the Upper Salmon River basin.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning									■	■	■	
Incubation/ Emergence	■	■	■	■	■				■	■	■	■

Kokanee (*Oncorhynchus nerka kennerlyi*)

Kokanee are a non-anadromous (resident) form of sockeye salmon that are native to Idaho that have also been planted outside their native range. Kokanee are reported to be in every major drainage except the Bear and Palouse River drainages occupying many natural lake systems and reservoirs (IDFG 2012). Kokanee native to Idaho are currently found in lakes accessible to sockeye salmon in the Stanley Basin in the upper Salmon River drainage (Redfish, Alturas, Pettit, Stanley) and Warm Lake in the South Fork Salmon River (IFWIS 2005). There is also a geologically isolated stock in the Kootenai River drainage. IFWIS (2005) did not report native kokanee in the Payette River drainage but sockeye were once native to that system as well.

The spawning period for kokanee can occur from August to January with researchers noting both early and late spawning behavior with spawning occurring along beaches of lakes and reservoirs and in tributaries streams (Hassemer 1984; Maiolie et al. 1998; Wahl et al. 2010; Waples et al. 2011). Waples et al. (2011) stated that two major stock groups of kokanee occur in Idaho. There

is late-spawning group from northern Idaho (including Lake Pend Oreille and Coeur d'Alene Lake) and an early, stream-spawning group from central Idaho (including populations from Deadwood, Dworshak, and Anderson Ranch Reservoirs and Payette Lake). Kokanee from Lake Whatcom (near Bellingham, Washington) may be the original source of the northern Idaho kokanee populations (Waples et al. 2011). All native kokanee are classified as early spawners (August and September) with most spawning occurring in streams (IFWIS 2005).

In Northern Idaho, Hassemer (1984) studied the spawning ecology of kokanee in Coeur d' Alene Lake and Pend Oreille Lake. In Coeur d' Alene Lake the first signs of beach spawning occurred the last week of November and continued into mid-December. In Pend Oreille Lake, beach spawning was first noted in mid-November and continued to the end of the first week of December (Hassemer 1984; Maiolie et al. 1998; Wahl et al. 2010).

Kokanee spawning in tributary streams have been observed spawning from August through mid-November depending on location. Spawning in tributary streams of Pend Oreille Lake occur from the first week of November to the end of first week in December while early run kokanee areas are surveyed in late September (Maiolie et al. 1998; Wahl et al. 2010). In Dworshak Reservoir, on the North Fork Clearwater River system, tributary spawning occurs from second week of September through mid-November (Horton 1980). In southern Idaho, tributary spawners from Anderson Ranch Reservoir spawned in the South Fork Boise River drainage in August and September (Pollard 1970). Time of spawning for kokanee may be influence by two factors; the origin of the stock and spawning location (stream or lake).

There is very little information on the emergence timing of kokanee in Idaho. Emergence in Lake Pend Oreille occurs in May and peaks in June (Clark and Bennett 2002). Maiolie and Elam (1997) noted an increase in the number of fry in Dworshak Reservoir in June. This recruitment of fry to the reservoir suggest emergence in May and June (possibly April) similar to Lake Pend Oreille. The assumption is that most of the fry observed in Dworshak Reservoir were from tributary streams. The spawning and incubation/emergence period from August through June should be viewed as a range encompassing much variability in spawn time but limited on known emergence periods (Table 10).

Table 10. General spawning period for stream and lake/reservoir spawning kokanee in Idaho.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning								■	■	■	■	■
Incubation/ Emergence	■	■	■	■	■	■		■	■	■	■	■

Lake Whitefish (*Coregonus clupeaformis*)

Lake whitefish are native to parts of North America but are not native to Idaho. In Idaho, lake whitefish are currently found in Pend Oreille Lake and were introduced into the lake in the 1890s (IDFG 2012) (Table 1). Lake Whitefish were also introduced into Coeur d'Alene Lake, Hayden Lake, and Bear Lake where they do not appear to have become established (College of Idaho 2013).

The lake whitefish is a cool-water species that moves from shallow to deep water as warming occurs and back to shallow water in the cooler months. Lake whitefish spawn in the fall, usually November and December in the Great Lakes area where it is native. Lake Whitefish spawn in shallow water at depths of less than 7.6 m over a hard or rocky bottoms and sometimes over sand (Scott and Crossman 1973). The eggs are deposited at random over the spawning grounds and remain there until they hatch in April or May the following year. The spawning and incubation period in Idaho is unknown but is similar to other native whitefish (see below). The spawning and incubation/emergence period of November to end of May should only be used as a general guide (Table 11).

Table 11. General spawning and incubation/emergence period for lake whitefish.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning											■	■
Incubation/ Emergence	■	■	■	■	■							

Pygmy Whitefish (*Prosopium coulteri*)

In Idaho, Pygmy whitefish are native to the Pend Oreille drainage and occur in Lake Pend Oreille and Priest Lake (Simpson and Wallace 1982; IDFG 2012). Spawning is reported to take place in October, November, or December depending on the region (Simpson and Wallace 1982; Scott and Crossman 1973). Spawning fish move into streams or may spawn in shallow, gravel

areas along lakeshores. Pygmy whitefish have been observed spawning in Priest Lake during the last week of October (Simpson and Wallace 1982). Information on the emergence period of pygmy whitefish is scarce other than emergence occurs in early spring. Emergence of pygmy whitefish is probably similar to other fish of the genus so the month of May is suspected. Information on pygmy whitefish is scarce so the reported spawning and incubation/emergence period is for general guidance only (Table 12).

Table 12. Suspected spawning and incubation/emergence period for pygmy whitefish.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning										■	■	■
Incubation/ Emergence	■	■	■	■	■							

Bear Lake (*Prosopium sp.*)

There are three fish species of the genus *Prosopium* that are only found in Bear Lake of Idaho and Utah (IDFG 2012; Palacios et al. 2007; Simpson and Wallace 1982). The Bear Lake whitefish (*P. abyssicola)*, Bonneville cisco (*P. gemmiferum)*, and Bonneville whitefish (*P. spilonotus*) spawn during the winter. Spawning is usually associated with rocky bottoms of the lake from December through February (Palacios et al. 2007). Spawning of Bonneville whitefish occurs in December while Bonneville cisco and Bear Lake whitefish spawn in January and February, respectively (Palacios et al. 2007). Emergence of age-0 fish in early May was only reported for Bonneville cisco that spawn in January so the window of emergence might likely extend after early May.

For Bear Lake, the reported spawning and incubation/emergence period occurs from December through early May (Table 13). Information on the emergence period of Bear Lake fish is limited and the period should be viewed as such.

Table 13. General spawning and partial incubation/emergence period reported for Bear Lake Whitefish, Bonneville cisco, and Bonneville whitefish.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning	■	■										■
Incubation/ Emergence	■	■	■	■	■							■

Mountain Whitefish (*Prosopium williamsoni*)

Mountain whitefish are distributed throughout Idaho inhabiting both streams and lakes with the exception of the Palouse River drainage (Table 1). Mountain whitefish are late fall or early

winter spawners depositing their eggs over gravel or gravel and rubble (Scott and Crossman 1973; Simpson and Wallace 1982; IDFG 2007b). Field observation in the Salmon and Boise river basins suggest a spawning period of October and November with emergence from March through April (R. Thurow, personal communications). In the Logan River, Utah, spawning occurred from late October to mid-December at night over rocky areas in the river in pools or deep riffles (Stalnaker et al. 1974).

In their literature review, Northcote and Ennis (1994) reported that eggs hatch in early spring, which in southern populations may be in early March and into early April in more northern populations. Time of emergence information is scarce with one observation beginning in April and continuing into May (Sheep Creek, Alberta). Another observation of emergent fry occurred in June (Williston Reservoir tributaries, BC) (Northcote and Ennis 1994). In Idaho, the reported spawning and incubation/emergence period extends from October through at least April (Table 14).

Table 14. General spawning and incubation/emergence period for mountain whitefish.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning										■	■	■
Incubation/ Emergence	■	■	■	■						■	■	■

Lahotan Cutthroat (*Oncorhynchus Clarkii henshawi*)

Lahotan cutthroat are not native to Idaho but are known to occur in the Snake River basin above and below Shoshone Falls and in some independent basins (Table 1). Most Lahontan cutthroat were planted in reservoirs in southern and eastern Idaho (IDFG 2012). Lahontan cutthroat trout are planted in several reservoirs of the Owyhee River drainage (Little Blue Creek, Bybee, Payne Creek, Grasmere, and Shoofly)(IDFG 2012). Lahontan cutthroat have also been planted in Mud Lake and Island Park Reservoir. It is unclear whether natural production occurs in these waters. If natural production does occur salmonid spawning criteria may be applicable.

Lahontan cutthroat trout spawn from April through July depending on streamflow, elevation, and water temperature (USFWS 1995). As cited in the recovery plan (USFWS 1995), Lahontan cutthroat trout eggs hatch in 4 to 6 weeks, depending on water temperature, and fry emerge 13 to 23 days later (Calhoun 1942; Lea 1968; Rankel 1976). Spawning and incubation/emergence periods reported here are for Lahontan cutthroat trout within their native range. Given the information provided, the spawning and incubation/emergence period could extend from April through mid-October depending on local conditions (Table 15).

Table 15. General spawning and incubation/emergence period reported for Lahontan cutthroat trout.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning				■	■	■	■					
Incubation/ Emergence				■	■	■	■	■	■	■		

Brown Trout (*Salmo trutta*)

Brown trout were first introduced into Idaho in 1892, but it was not until 1948 that introductions became successful (Simpson and Wallace 1982). Brown trout can be found in all drainages of Idaho except the Kootenai and independent drainages (Table 13). Brown trout typically spawn from October to December with some spawning noted in January (Scott and Crossman 1973; Simpson and Wallace 1982). In Warm River and Robinson Creek (Henrys Fork), spawning was reported to occur in October and November (Brostrom 1987; Brostrom and Spateholts 1985). In the South Fork Snake River, brown trout redds were observed as late as mid-December (Corsi and Elle 1989).

Like other salmonids, the incubation period is dependent on temperature. The incubation period for brown trout was 148 days from fertilization to hatching at 1.9° C and 34 days at 11.2 °C (Embody 1934; as cited in Raleigh et al. (1986). In Idaho, eggs hatch in 2 to 4 months after fertilization (Simpson and Wallace 1982). Emergence of brown trout fry in Idaho is not well documented. The emergence period reported for brown trout varies from late February through June (Belica (2007). Emergence in late February was noted as one the earliest reported and occurred in tailwaters of the White River in Arkansas. Emergence reported in Montana (Clark Fork tribs) and California (mountain stream) are probably a better comparison for Idaho. In those streams emergence occurred from late April through June (Belica 2007). The spawning and incubation/emergence period for brown trout should be viewed with the knowledge that the emergence period for brown trout in Idaho is not well documented (Table 16).

Table 16. General spawning and incubation/emergence periods for brown trout.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning										■	■	■
Incubation/ Emergence	■	■	■	■	■	■				■	■	■

Atlantic Salmon (*Salmo salar*)

Atlantic salmon are not native to Idaho but were planted in Payette Lake, Deadwood Reservoir and several lakes in the Sawtooth Mountains (Simpson and Wallace 1982). Atlantic salmon are native to northeastern U.S. and Canada, Iceland, Northwestern Russia and parts of Europe. Quigley and Arbelbide (1997) reported that Atlantic Salmon maintain a self-sustaining population in the Interior Columbia Basin but it was not clear if that included those introduced in Idaho. There is no information that could be found on the spawning and incubation/emergence periods for landlocked Atlantic Salmon in Idaho.

Atlantic Salmon spawn in the fall typically mid-October to mid-November (Danie et al. 1984). In Maine, landlocked Atlantic salmon are reported to spawn from mid-October to late November (Boucher 2004). In a Maine stream, fry emergence occurred between second and last week of May. Further north in New Brunswick emergence in streams extended from mid-June to the end of June (Danie et al. 1984). The spawning and incubation/emergence reported here should only be used as a guide until more information becomes available and spawning has been confirmed (Table 17).

Table 17. General spawning and incubation/emergence periods for Atlantic salmon.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning										■	■	
Incubation/ Emergence	■	■	■	■	■					■	■	■

Blueback Trout (*Salvelinus alpinus oquassa*)

Blueback trout or Sunapee trout are not native to Idaho but have been introduced into several lakes at the headwaters of the Salmon River in Idaho including Alice Lake, Alpine Lake, and Sawtooth lakes (Reingold and Davis 1987; Davis and Reingold 1988). Sunapee trout were introduced in 1925 and were forgotten until the late 1970s when Idaho Department of Fish and Game recognized this species in Sawtooth Lake (Reingold and Davis 1987). Reingold and Davis (1987) reported that IDFG examined old stocking records and found Sawtooth Lake, Alice Lake and five (unknown) other lakes in the Redfish Lake Creek drainage as recipients of Sunapee trout fry.

Natural reproduction must have maintained the fish in those lakes for all those years. As cited in Reingold and Davis (1987), Sunapee trout spawn from mid-October to mid-November when surface water temperatures drop below 15 °C. Spawning habitat consist of offshore reefs with rubble, boulder, and gravel substrates. Depths of spawning sites ranged from a few inches to 20 feet with little or no site preparation and eggs hatch in 79 to 122 days in water of 3.0 to 11.0 C (Reingold and Davis 1987; NHFG 2005). The New Hampshire Fish and Game (NHFG 2005)

reported that eggs hatch in the late winter and upon egg yolk sac absorption fry move to deeper water. For arctic char (*Salvelinus alpinus*), hatching is believed to occur at the start of April with emergence from the gravel after ice break up (Scott and Crossman 1982). There are no observations that document the spawning behavior or incubation/emergence timing of Sunapee trout in Idaho. The spawning and incubation (not emergence) period reported here should only be used as a guide until more information becomes available (Table 18).

Table 18. General spawning and incubation (not emergence) period reported for Sunapee and Arctic char.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning										■	■	
Incubation/ Emergence	■	■	■	■	■					■	■	■

Brook Trout (*Salvelinus fontinalis*)

Brook trout are not native to Idaho but are found in all major drainages of the state (Table 2). In Idaho, brook trout occur in many of the drainages where native resident salmonids exist particularly cutthroat (IDFG 2012; Teuscher and Capurso 2007; IDFG 2007a; IDFG 2013). In his review, Dunham et al. (2002) expressed that some of the invasion success of brook trout is associated with environmental factors, including temperature, landscape structure, habitat size, stream flow, and human influences.

Brook trout are fall spawners typically spawning in late September, October and November (Neve and Moore 1983; Simpson and Wallace 1982; Scott and Crossman 1973). Like other salmonids, stream temperature determines the length of time required for egg development (incubation period). As cited in Raleigh (1982), the incubation period (to hatching) for brook trout eggs requires about 28 days at 14.8° C, 45 days at 10° C, and 165 days at 2.8° C, (Brasch et al. 1958; Embody 1934). Fry emergence occurs in April and May (Simpson and Wallace 1982; Raleigh 1982) (Table 19). This information comports well with field observations in the St. Joe, Salmon River, Blackfoot River and Big Wood River basins where spawning generally occurs from August to December with emergence in April and May (R. Thurow, personal communication) (Table 19).

Table 19. Spawning and incubation/emergence period for brook trout.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning									■	■	■	
Incubation/ Emergence	■	■	■	■	■					■	■	■

Bull Trout (*Salvelinus confluentus*)

Bull Trout are native to Idaho and occur in every drainage except the Bear, Palouse and Snake River above Shoshone Falls (IDFG 2012; Table 1). The bull trout spawning period for salmonid spawning temperature has been set by federal rule for Idaho, so unlike other species, spawning criteria for bull trout waters need to be applied in September and October regardless of local information (WQS § 250.02.f; 40 CFR 131.33; Grafe et al. 2002).

As cited by Batt (1996), the incubation period for bull trout is about 100 to 145 with hatching occurring in late January requiring an additional 65 to 90 days for yolk sac absorption (Heimer 1965, McPhail and Murray 1979, Allan 1980, Weaver and White 1984; Shepard et al. 1984). Fry normally emerge from early April through May depending upon water temperatures and increasing stream flows (Pratt 1992; Ratliff and Howell 1992). The spawning and incubation/emergence period for bull trout extends from September through end of May (Table 20).

Table 20. General spawning and incubation/emergence periods for bull trout.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning									■	■		
Incubation/ Emergence	■	■	■	■	■				■	■	■	■

Lake Trout (*Salvelinus namaycush*)

Lake trout (Mackinaw) are not native to Idaho but can be found in the Pend Oreille, Snake River, and Bear lake drainages (Table 1). Lake trout are known to occur in Priest Lake, Upper Priest Lake, Pend Oreille Lake, Warm Lake (SF Salmon),Stanley Lake, Payette Lake, Palisades Reservoir, and Bear Lake (IDFG 2012). Lake trout spawn in lakes during October and November depositing eggs over rubble bottoms at varying depths (Scott and Crossman 1973; Simpson and Wallace 1982). Spawning of lake trout in Lake Pend Oreille occurred from the second week of September to the third week of October (Schoby et al. 2007; Wahl and Dux 2010). This research appears to be the only documentation of the spawning period in Idaho. These observations extend the potential spawning period from about mid-September to end of November (Table 20). The incubation period for lake trout has been reported as ending in March or April (Simpson and Wallace 1982) with some delayed incubation noted until June (Scott and Crossman 1973). One month after hatching the young lake trout seek out deeper waters (Scott and Crossman 1973). Outside the former studies noted, the spawning and incubation/emergence period for lake trout in Idaho is not well documented. The spawning and incubation/emergence period reported here should be used only as a guide as more information on lake trout is documented (Table 21).

Table 21. General spawning and incubation/emergence periods for lake trout.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning									■	■	■	
Incubation/ Emergence	■	■	■	■	■				■	■	■	■

Arctic Grayling (*Thymallus arcticus*)

Arctic Grayling are not native to Idaho but have been introduced to alpine lakes in the Kootenai, Spokane, and Snake River drainages (IDFG 2012; Simpson and Wallace 1982). At the time that it was written, Simpson and Wallace (1982) indicated that about 35 mountain lakes were stocked with arctic grayling and at least 5 or 6 were mentioned (not by name) to have substantial reproducing populations. Arctic grayling spawn from April to early June with hatching occurring rather quickly in 11 to 18 days later depending on water temperatures (Simpson and Wallace 1982). Scott and Crossman (1973) reported that hatching took place 13 to 18 days later at 7°C-11°C and alevins spend about another 8 days absorbing their yolk. In Idaho, arctic grayling spawn in streams of alpine lakes soon after ice break up and unlike other trout do not build redds preferring to deposit their eggs directly over sand to rubble sized substrates with gravel the preferred substrate. Given the information provided, the spawning and incubation/emergence period is expected to occur from April through June depending on location (Table 22).

Table 22. General spawning and incubation period for arctic grayling.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning				■	■	■						
Incubation/ Emergence				■	■	■						

Golden Trout (*Oncorhynchus aquabonita*)

Golden trout are not native to Idaho but have been introduced into the Kootenai, Spokane, Snake, and some independent drainages (IDFG 2012; Table 1). Golden trout have been planted in alpine lakes of the Kootenai, Priest, Pend Oreille, Little North Fork Clearwater, Salmon, Payette, Boise, and sinks drainages. The sinks drainages include the Big and Little Lost Rivers, Birch, Medicine Lodge and Camas Creeks. In their native range (Kern Plateau, CA), golden trout spawn in streams when water temperatures reach 7-10° C, usually in late May or June (Pister 1991; as cited in Stephens et al. 2004). Eggs hatch in about 20 days at 14°C. The fry remain in the substrate until the yolk is used up. Two to three weeks after hatching, they emerge from the substrate (Curtis 1934; as cited in Stephens et al. 2004).

In Idaho, spawning normally occurs in July in inlet or outlet streams of lakes (Simpson and Wallace 1982). Simpson and Wallace (1982) reported that golden trout might even spawn on gravel shorelines of lakes although the success of such spawning is unknown. Emergence time for golden trout in Idaho is unknown and for alpine lakes emergence is likely to vary by location. As a general guide, based on the reported information, the spawning and incubation/emergence time period is from late May to end of August (Table 23).

Table 23. General spawning and incubation/emergence time period for golden trout.

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning												
Incubation/ Emergence												

REFERENCES

Alderdice, D.F. and F.P.J. Velsen. 1978. Relation between temperature and incubation time for eggs of Chinook salmon (*Oncorhynchus tshawytscha*) J. Fish. Res. Brd. Can. 35:69-75.

Allan, J. H. 1980. Life history notes on the Dolly Varden charr (Salvelinus malma) in the upper Clearwater River, Alberta. Alberta Energy and Natural Resources, Fish and Wildlife Division, Red Deer Alberta, Canada.

Arnsberg, B. D. 1992. 1992 Fall Chinook salmon aerial redd surveys on the Clearwater, S.F. Clearwater, and lower Salmon Rivers. Lapwai, ID. Nez Perce Tribe Department of Fisheries Management.

Arnsberg, B. D., W. P. Connor, E. Connor, M. J. Pishl and M. A. Whitman 1992. Mainstem Clearwater River study: assessment for salmonid spawning, incubating, and rearing. Final report. Portland, OR. Prepared for Bonneville Power Administration. Project no. 88-15, Contract no. DE-BI79-87BP37474.

Averett, R. C. 1962. Studies of two races of cutthroat trout in north Idaho. Boise, ID, Idaho Department of Fish and Game, F-47-R-1.

Averett, R. C. and C. MacPhee 1971. Distribution and growth of indigenous fluvial and adfluvial cutthroat trout (Salmo clarki), St. Joe River, Idaho. Northwest Science 45(1): 38-47. 1398.

Batt, P. E. 1996. Governor Philip E. Batt's State of Idaho Bull Trout Conservation Plan. Boise, ID, Office of the Governor.

Behnke, R. J. 1992. Native trout of Western North America. American Fisheries Society, Monograph 6, Bethesda, Maryland.

Behnke, R. J. 2002. Trout and salmon of North America. The Free Press. 359 pp.

Belica, L. 2007. Brown Trout (*Salmo trutta*): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region.

Bjornn, T.C., D.R. Craddock and D.R. Corley. 1968. Migration and survival of Redfish Lake, Idaho, sockeye salmon, Oncorhynchus nerka. Transactions of the American Fisheries Society. 97:360-373.

Boucher, D. 2004. Landlocked Salmon Management Plan. Department of Inland Fisheries and Wildlife, Division of Fisheries and Hatcheries.

Brasch, J., J. McFadden, and S. Kmiotek. 1958. Brook trout. ecology, and management. Wisconsin. Department of Natural Resources. Publ. 226. Life history,15 pp.

Brostrom, J. K. 1987. River and stream Investigations. Job 1: Henrys Fork fisheries investigation. Boise, ID, Idaho Fish and Game, F-73-R-8.

Brostrom, J. K. and R. L. Spateholts 1985. River and stream investigations. Job 1: Henrys Fork fisheries investigation. Boise, ID, Idaho Fish and Game, F-73-R-7.

Budy, P., S. Wood and B. Roper 2012. A study of the spawning ecology and early life history survival of Bonneville cutthroat trout. North American Journal of Fisheries Management 32: 436-449.

Burner, C. J. 1951. Characteristics of spawning nests of Columbia River Salmon. Fish. Bull. 61:1-50.

Calhoun, A.J. 1942. The biology of the black-spotted trout *(Salmo clarki henshawi)* (Gill and Jordan) in two Sierra Nevada lakes. Ph.D. dissertation. Stanford University, Palo Alto, California. 218 pp.

Cannamela, D. A. 1992. Potential impacts of release of hatchery steelhead smolts on wild and natural juvenile Chinook and sockeye salmon. White paper prepared by the Idaho Department of Fish and Game.

Clarke, L. R. and D. H. Bennett 2002. Newly emerged kokanee growth and survival in an oligotrophic lake with *Mysis relicta*. Transactions of the American Fisheries Society **131**(1): 176-186. TAFS 131:176

College of Idaho. 2013. Species description of Coregonus clupeaformis (Mitchill, 1818): lake whitefish. https://www.collegeofidaho.edu/coregonus-clupeaformis-mitchill-1818-lake-whitefish. College of Idaho, Nampa, Idaho.

Connor, W. P., H. L. Burge and R. Waitt. 2002. Juvenile life history of wild fall Chinook salmon in the Snake and Clearwater Rivers. North American Journal of Fisheries Management 22: 703-712

Cooney, T., and D., Holzer 2006. Appendix C: Interior Columbia Basin Stream Type Chinook Salmon and Steelhead Populations: Habitat Intrinsic Potential Analysis. Interior Columbia Basin Technical Recovery Team.

Cooney, T., and M., McClure 2007. Viability Criteria for Application to Interior Columbia Basin Salmonid ESUs Review Draft March 2007. Interior Columbia Basin Technical Recovery Team.

Colyer, W., J. Kershner, and R. Hilderbrand. 2005. Movements of Fluvial Bonneville Cutthroat Trout in the Thomas Fork of the Bear River, Idaho–Wyoming. North American Journal of Fisheries Management. 25: 954–963.

Corsi, C. and S. Elle. 1989. Region 6 (Idaho Falls) Rivers and Streams Investigations. Job No. 6 (IF)-c. Project F-71-R-12. Idaho Department of Fish and Game.

Cramer, S. P. and K. L. Witty 1998. The feasibility for reintroducing sockeye and coho salmon in the Grande Ronde Basin, Under Contract to Nez Perce Tribal Executive Committee and Nez Perce Fisheries Resource Management.

Curtis, B. 1934. The golden trout of the Cottonwood Lakes (*Salmo agua-bonita* Jordon). Transactions of the American Fisheries Society 64:259-265.

Danie, D., J. Trial and J Stanley. 1984. Species Profiles: Life Histories and Environmental Requirements of Coastal Fish and Invertebrates (North Atlantic) Atlantic Salmon. United States Fish Wildlife Service and United States Army Corps of Engineers, FWSlOBS-82111.22.

Davis, J. A. and M. Reingold 1988. Regional fisheries management investigations. Job 6: salmon subregion mountain lakes, lake and reservoir, river and streams, Williams Lake and Stanley subasin lakes investigations; technical guidance, salmon and steelhead investigations, and Salmon and Middle Fork Salmon Rivers snorkeling transects. Boise, ID, Idaho Fish and Game, F-71-R-12.

Drinan, D. P., A. V. Zale, M. A. H. Webb, M. L. Taper, B. B. Shepard and S. T. Kalinowski 2012. Evidence of local adaptation in westslope cutthroat trout. Transactions of the American Fisheries Society 141(4): 872-880.

Downs 2000. Kootenai River Fisheries Investigations: Rainbow trout recruitment. Idaho Department of Fish and Game. IDFG 99-20.

Dunham, J., S. Adams, R. Schroeter and D. Novinger. 2002. Alien invasions in aquatic ecosystems: Toward an understanding of brook trout invasions and potential impacts on inland cutthroat trout in western North America. Reviews in Fish Biology and Gisheries 12: 373-391.

Dupont, J., E. Lider, M. Davis and N. Horner 2008. Movement, mortality, and habitat use of Coeur D'Alene River cutthroat trout panhandle region 2004. Idaho Department of Fish and Game Fishery Management Annual Report.

Ecovista, 2003. Clearwater subbasin management plan. Northwest Power and Conservation Council. Portland, OR.

Embody, G.C. 1934. Relation of temperature to the incubation periods of eggs of four species of trout. Trans. Am. Fish. Soc. 64: 281–292.

Fraley, J. and P. Graham 1981. Physical habitat, geologic bedrock types and trout densities in tributaries of the Flathead River drainage, Montana. Pages 178-186 *In* N.B. Armantrout,

editor. Acquisition and utilization of aquatic habitat inventory information. Proceeding of a symposium held 28-30 October, 1981 American Fisheries Society, Western Division, Portland, OR.

Grafe, C.S., C.A. Mebane, M.J. McIntyre, D.A. Essig, D.H. Brandt, and D.T. Mosier. 2002. The Idaho Department of Environmental Quality Water Body Assessment Guidance, Second Edition-Final. Idaho Department of Environmental Quality, Boise, ID.

Gresswell, R. E. 2009. Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvier*): a technical conservation assessment. Bozeman, MT. Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project**:** EC-9250.

Greswell, R. E. 2011. Biology, status and management of Yellowstone cutthroat trout. North American Journal of Fisheries Management. 31:782–812, 2011

Groves, P. A. and J. A. Chandler. 1999. Spawning habitat used by fall Chinook salmon in the Snake River. North American Journal of Fisheries Management 19(4): 912-923.

Hassemer, P. F. 1984. Spawning ecology and early life history of kokanee (Oncorhynchus nerka) in Coeur d'Alene and Pend Oreille lakes, Idaho. Moscow, ID, University of Idaho.

Hesse, J. 2013. Personal communication on the spawning and incubation/emergence period of Coho salmon in the Clearwater River drainage. Director of Biological Services, Nez Perce Tribe.

Hickman, T., and R. Raleigh. 1982. Habitat suitability models: cutthroat trout. FWS/OBS·82/10.5. Western Energy and Land Use Team Office of Biological Services, Fish and Wildlife Service, U.S. Department of the Interior.

Hatchery Science Review Group (HSRG). 2009. Clearwater River Coho population and related hatchery programs. Columbia River hatchery reform project.

Herger, L., A. Storrar and T. Dechert 2002. Appendix D. Fisheries Resources In: South Fork Clearwater River subbasin assessment and TMDLs, 2003.

Heimer, J. T. 1965. A supplemental Dolly Varden spawning area. University of Idaho, Moscow, Idaho, MS Thesis.

Holecek, D. E. and J. P. Walters. 2007. "Spawning characteristics of adfluvial rainbow trout in a north Idaho stream: implications for error in redd counts." North American Journal of Fisheries Management 27(3): 1010-1017.

Holubetz, T. 1995. Wild steelhead studies 1993 annual report. Idaho Department of Fish and Game, Boise, ID. U. S. Department of Energy, Bonneville Power Administration, Portland, OR. IDFG 95-44, Project No. 91-073, Contract No. DE-B179-91BP21182.

Horton, W. D. 1980. Dworshak Reservoir Fisheries Investigations. Boise, ID, Idaho Fish and Game, U. S. Army Corps of Engineers contract #DACW68-79-C-0034. 9523

Idaho Department of Fish and Game (IDFG). 2007a. Management plan for conservation of Yellowstone cutthroat trout in Idaho. Idaho Department of Fish and Game, Boise, ID.

Idaho Department of Fish and Game (IDFG). 2007b. Mountain Whitefish Conservation and Management Plan for the Big Lost River Drainage, Idaho.

Idaho Department of Fish and Game (IDFG). 2012. Fisheries Management Plan 2013-2018. Idaho Department of Fish and Game, Boise, ID.

Idaho Department of Fish and Game (IDFG). 2013. Draft Management plan for conservation of westslope cutthroat trout in Idaho. Idaho Department of Fish and Game, Boise, ID.

Idaho Fish and Wildlife Information System (IFWIS). 2012. Database of unpublished juvenile trap information. Idaho Department of Fish and Game, Boise, ID.

Idaho Fish and Wildlife Information System (IFWIS). 2005. Kokanee conservation status and classification information. Idaho Department of Fish and Game, Boise, ID.

Keifer, S., Rowe, M., and Hatch, K. 1992. Stock summary reports for Columbia River anadromous salmonids, Vol. 5: Idaho, for coordinated information system. Bonneville Power Administration, DOE/BP-94402-5, Portland, OR.

Lea, R. N. 1968. Ecology of the Lahontan cutthroat trout, Salmo clarki henshawi, in Independence Lake, California. M.A. Thesis, Univ. Calif., Berkeley, Calif. 95 pp.

Leth, B. D., T. B. Holubetz and D. Nemeth. 2000. Evaluation and monitoring of wild/natural steelhead trout production. Annual progress report January 1, 1996 - December 31, 1996. Portland, OR. Bonneville Power Administration, DE-B179-91BP21182. IDFG Report Number 00-08.

May, B. E. 2009. Westslope cutthroat trout status update summary 2009. Bozeman, MT, Wild Trout Enterprises, LLC.

May, B. E., B. J. Writer and S. Albeke. 2012. Redband trout status update summary 2012. Bozeman, MT. Wild Trout Enterprises, LLC.

Magee, J. P., T. E. McMahon, and R. F. Thurow. 1996. Spatial variation in spawning habitat of cutthroat trout in a sediment-rich stream basin. Transactions of the American Fisheries Society 125:768–779.

Maiolie, M. A. and S. C. Elam 1997. Dworshak Dam impacts assessment and fisheries investigation: Kokanee depth distribution in Dworshak Reservoir and implications toward minimizing entrainment, annual report 1994. Portland, OR, Bonneville Power Administration, DOE/BP35167-7.

Maiolie, M. A., W. J. Ament, S. Elam and B. Harryman 1998. Kokanee impacts assessment and monitoring on lake Pend Oreille, Idaho. Annual progress report for October 95 - September 96. Portland, OR, Bonneville Power Administration.

Marotz B., and J. Fraley. 1986. Instream flows needed for successful migration spawning and rearing of rainbow and westslope cutthroat trout in selected tributaries of the Kootenai River.

Matthews, G., and R. Waples. 1991. Status Review for Snake River Spring and Summer Chinook Salmon. NOAA Technical Memorandums F/NWC-200. National Marine Fisheries Service, Northwest Science Center, Coastal Zone and Estuary Studies Division, Seattle, WA.

McIntyre, J. D., and B. E. Rieman. 1995. Westslope cutthroat trout *in* Young, M. K., ed. Conservation Assessment for Inland Cutthroat Trout. Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-GTR-256.

McPhail, J. D. and C. B. Murray. 1979. The early life history and ecology of Dolly Varden (Salvelinus malma) in the upper Arrow Lake. Department of Zoology and Institute of Animal Resources, University of British Columbia, Vancouver, British Columbia.

Muhlfeld, C. C. 2002. Spawning characteristics of redband trout in a headwater stream in Montana. North American Journal of Fisheries Management 22(4): 1314-1320.

National Marine Fisheries Service (NMFS). 1995. Attachment 1: Listed species, critical habitat, biological requirement, and status under environmental baseline in 1995. http://swr.nmfs.noaa.gov/attach1.htm#1. Snake River Sockeye Salmon(1).

Nielson, B.R. and L. Lentsch. 1988. Bonneville cutthroat trout in Bear Lake: Status and management. American Fisheries Society Symposium 4:128-133.

Neve, L. c. and V. Moore 1983. Population estimates and size regimes of cutthroat and brook trout in Diamond, Kendall and Spring Creeks, Idaho. Northwest Science **57**(2): 85-90. EC-7118

NOAA Fisheries. 2011. 5-Year Review: Summary & Evaluation of Snake River Sockeye, Snake River Spring-Summer Chinook, Snake River Fall-Run Chinook, Snake River Basin Steelhead, National Marine Fisheries Service, Northwest Region Portland, OR.

Northcote, T. G. and G. L. Ennis 1994. Mountain whitefish biology and habitat use in relation to compensation and improvement possibilities. Reviews in Fisheries Science **2**(4): 347-371.

Nez Perce Tribe (NPT) and Fish Pro. 2004. Coho salmon master plan Clearwater River basin.

Nez Perce Tribe (NPT) and Idaho Department of Fish and Game (IDFG). 1990. Clearwater River Subbasin Salmon and Steelhead Production Plan. Funded by the Northwest Power Planning Council;Columbia Basin Fish and Wildlife Authority.

New Hampshire Fish and Game Department (NHFG). 2005. Appendix A Fish Species Profiles In: New Hampshire Wildlife Action Plan. Concord NH.

Northcote, T.G., and G.L. Ennis. 1994. Mountain whitefish biology and habitat use in relation to compensation and improvement possibilities. Reviews in Fisheries Science 2:347-371.

Palacios, P., C. Luecke, and J. Robinson, Justin. 2007. Fish of Bear Lake, Utah, Natural Resources and Environmental Issues: Vol. 14, Article 15.

Paragamian, V. L., J. Walters, M. Maiolie, K. Handley, M. Campbell, C. Kozfkay, and E. Tretter. 2008. Kootenai River fisheries investigations: salmonid studies. Annual progress report May 1, 2007 -- April 30, 2008. Portland, OR. Bonneville Power Administration, Project Number 1988-06500, Contract Number 00004691.

Peterson, M. B. Moore, K. Plaster, and P. Kline. 2007. Snake River Sockeye Salmon captive broodstock program research element annual progress report. January 1, 2006—December 31, 2006, IDFG Report Number 07-28.

Peterson, M., K. Plaster, K. Kruse, K. McBaine, and C. Kozfkay. 2012, Snake River sockeye salmon captive broodstock program research element annual progress report January 1, 2011—December 31, 2011. IDFG Report Number 12-06.

Pister, E. P. 1991. Golden trout (*Oncorhynchus aguabonita*). Pages 280-285 in J. Stol and J. Schnell, editors. Trout. Stackpole, Harrisburg, Pennsylvania.

Platts, W. S. 1974. Geomorphic and aquatic conditions influencing salmonids and stream classification. U.S. Forest Service.

Platts, W. S. 1979. Relationships among stream order, fish populations, and aquatic geomorphology.

Pollard, H. 1970. Job No. 4. Survival and Growth of Kokanee and Coho Salmon in Anderson Ranch Reservoir. Lakes and reservoir investigations, Project F-53-R-5. Idaho Department of Fish and Game.

Pratt, K. L. 1992. A review of bull trout life history. In Howell, P.J., and D.V. Buchanan, eds. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter, American Fisheries Society, Corvallis, OR.

Quigley, T. M. and S. J. Arbelbide 1997. Assessment of ecosystem components in the interior Columbia Basin and portions of the Klamath and Great Basins: Volume 3 (chapter 4-5). Portland, OR, U. S. Forest Service, PNW-GTR-405.

Raleigh, R. F. 1982. Habitat suitability index models: brook trout. Fort Collins, CO, U. S. Fish and Wildlife Service, FWS/OBS-82/10.24. EC-9199

Rankel, G. 1971. St. Joe River cutthroat trout and northern squawfish studies. Job 1: Life history of St. Joe River cutthroat trout (Research) March 1, 1970 to February 28, 1971. F-60-R-2. Boise, ID. Idaho Fish and Game.

Rankel, G.L. 1976. Fishery management program, Summit Lake Indian reservation, Humboldt County, Nevada. Special Report of the U.S. Fish and Wildlife Service, Division of Fishery Services, Reno, Nevada. 35 pp.

Ratliff, D.E. 1992. Bull trout investigations in the Metolius River-Lake Billy Chinook System. Pages 37-44 in Howell, P.J. and D. V. Buchanan eds. Proceedings of the Gearhart

Mountain bull trout workshop. Oregon Chapter, American Fisheries Society, Corvallis, OR.

Reingold, M. and J. A. Davis 1987. Regional fisheries management investigations. Job 6: salmon subregion mountain lakes, lowland lakes, river and streams, investigations; technical guidance, salmon and steelhead investigations. Boise, ID, Idaho Fish and Game, F-71-R-11.

Rieman, B. E., and K. A. Apperson. 1989. Status and analysis of salmonid fisheries: westslope cutthroat trout synopsis and analysis of fishery information. Idaho Department of Fish and Game, Boise. Job Performance Report, Project F-73-R-11, Subproject II, Job 1.

Rondorf, D. W. and K. F. Tiffan. 1997. Identification of the spawning, rearing and migratory requirements of fall Chinook salmon in the Columbia River Basin. DOE/BP-21708-5. Portland, OR. Bonneville Power Administration.

Roni, P., Weitkamp, L.A., Scordino, J., 1999. Identification of Essential Fish Habitat for Salmon in the Pacific Northwest: Initial Efforts, Information Needs, and Future Direction. In: Benaka, L. (Ed.), Fish habitat: Essential fish habitat and rehabilitation. American Fisheries Society, Symposium 22, Bethesda, MD, pp. 93-108.

Schill, D., E. Mamer, S. Elle. 2004. Population studies of desert redband trout. Idaho Department of Fish and Game. IDFG Report Number 04-03.

Schmetterling, D.A., 2000. Redd characteristics of fluvial westslope cutthroat trout in four tributaries to the Blackfoot River, Montana. North American Journal of Fisheries Management 20, 776-783.

Schmetterling, D.A., 2001. Seasonal movements of fluvial westslope cutthroat trout in the Blackfoot drainage, Montana. North American Journal of Fisheries Management. 21:507–520.

Schoby, G. P. and T. Curet 2007. Seasonal migrations of bull trout, westslope cutthroat trout, and rainbow trout in the Upper Salmon River Basin, Idaho. Report 2003, 2004, 2005. Boise, ID. Bureau of Land Management Idaho Department of Fish and Game. IDFG 07-12.

Scott, W. B. and E. J. Crossman. 1973. Freshwater fishes of Canada. Ottawa, ON, Canada. Fisheries Research Board of Canada, Bulletin #184.

Shepard, B., K. Pratt, and P. Graham. 1984. Life histories of westslope cutthroat and bull trout in the upper Flathead River basin, Montana, Kalispell, MT. Montana Department of Fish, Wildlife and Parks.

Simpson, J. and R. Wallace. 1982. Fishes of Idaho. University Press of Idaho, a division of the Idaho Research Foundation, Inc. Moscow, ID.

Stalnaker, C.B., and R.E. Gresswell. 1974. Early life history and feeding of young mountain whitefish. Utah State University, Logan Utah. Report prepared for U.S. Environmental Protection Agency, Ecological Research Series. Project 18050 DPL. EPA-660/3-73-019.

Stephens, S., C. McQuire, L. Sims, P. Strand, L. McDougal, A. Zerrenner and P. Epanchin. 2004. Conservation Assessment and Strategy for the California Golden Trout (*Oncorhynchus mykiss aguabonita)* Tulare County, California. California Department of Fish and Game, San Joaquin Valley and South Sierra Region, CA.

Strahler, A N. 1957. Quantative analysis of watershed geomorphology. Trans. Am. Geophys. Union 38(6): 913-920.

StreamNet GIS Data. 2012. Metadata for westslope cutthroat trout, summer steelhead, fall Chinook, Coho, Yellowstone cutthroat trout, Bonneville cutthroat trout, and spring/summer Chinook salmon fish distribution spatial data sets. Portland (OR): StreamNet, 2012. http://www.streamnet.org/mapping_apps.cfm

Teuscher, D. and J. Capurso. 2007. Management plan for conservation of Bonneville Cutthroat Trout in Idaho.

Thurow, R.F. and T.C. Bjornn. 1978. Response of cutthroat trout populations to the cessation of fishing in St. Joe River tributaries. Forest, Wildlife and Range Experiment Station Bulletin No. 25. University of Idaho, Moscow. 35 pp.

Thurow Russ. 1983. Middle Fork Salmon River Fisheries Investigations. Federal Aid in Fish Restoration. Project F-73-R-5. Job Performance Report. November 1983. IdahoDepartment of Fish and Game. Boise.

Thurow, R. 1987. Evaluation of the South Fork Salmon River steelhead trout fishery restoration program. Period covered: March 1, 1984 to February 28, 1986. Contract no.14-16-0001-86505. Boise, ID. Idaho Fish and Game.

Thurow, R. F., C. E. Corsi and V. K. Moore. 1988. Status, ecology, and management of Yellowstone cutthroat trout in the upper Snake River drainage, Idaho. American Fisheries Society symposium 4: 25-36.

Thurow, R. F. 2000. Spatial Dynamics of Chinook Salmon Populations Within Idaho's Frank Church Wilderness: Implications for Persistence. USDA Forest Service Proceedings RMRS-P-15-VOL-3.

Trotter, P.C. 1987. Cutthroat: Native trout of the west. Colorado Associated University Press, Boulder, CO.

Upper Salmon Basin Watershed Project Technical Team, (USBWP). 2005. Upper Salmon River recommended instream work window and fish periodicity for river reaches and tributaries

above the Middle Fork Salmon River including the Middle Fork Salmon River Drainage. Revised Nov. 30, 2005. Salmon, Idaho.

United States Fish and Wildlife Service (USFWS). 1995. Recovery plan for the Lahontan cutthroat trout. USDOI, U.S. Fish and Wildlife Service, Portland, OR.

United States Fish and Wildlife Service (USFWS). 1999. Status Review for Westslope Cutthroat Trout in the United States. USDOI, U.S. Fish and Wildlife Service, Portland, OR and Denver, CO.

United States Fish and Wildlife Service (USFWS). 2001. Status Review for Bonneville cutthroat trout (*Oncorhynchus clarki utah*). USDOI, U.S. Fish and Wildlife Service, Portland, OR and Denver, CO.

Velsen, F. J. 1987. Temperature and incubation in Pacific salmon and rainbow trout: compilation of data on median hatching time, mortality, and embryonic staging. Can Data Rep Fish Aquat Sci 626: 1–58.

Venditti, D. A., A. Kohler, K. A. Apperson, A. Brimmer, B. Bowersox, C. Bretz and J. Lockhart (2008). Idaho supplementation studies. Brood year 2005 cooperative report August 1, 2005 - July 31, 2007. Portland, OR. Prepared for U. S. Department of Energy Bonneville Power Administration. IDFG Report Number 08-07.

Wahl, N., A. Dux, W. Ament, and W. Harryman, 2010. Kokanee and rainbow trout research, Lake Pend Oreille, 2008. Lake Pend Oreille Fishery Recovery Project Annual Progress Report. March 1, 2008—February 28, 2009. IDFG Report Number 10-02.

Wallace, R. L. and D. W. Zaroban. 2013. Native Fishes of Idaho. American Fisheries Society, Bethesda, Maryland. 216p.

Weaver, T. M. and R. G. White. 1984. Coal Creek fisheries monitoring study No. III. Quartley progress report. Bozeman, MT. USDA Forest Service, Montana State Cooperative Fisheries Research Unit. 94p.

Waples, R., P. Aebersold, and G. Winans. 2011. Population genetic structure and life history variability in *Oncorhynchus nerka* from the Snake River Basin. Transactions of the American Fisheries Society 140:716-733.

White, R.G., and Cochnauer, T.G. 1975. Stream resource maintenance flow studies, Part 1: Proposed methodology for recommending stream resource maintenance flows for large rivers, Part 2: Interim stream resources maintenance flows, Priority listing for future stream resource maintenance flow studies in Idaho Streams, Stream type and applicable methodology for determining stream resource maintenance flows for key stream sections of Idaho streams. Idaho Fish and Game, Boise, ID.

Young, W., and Belden, M. 2011. Chinook Salmon (*Oncorhynchus tshawytscha*) Spawning ground surveys in the South Fork Salmon River and Big Creek, 1996-2008. Report prepared for U.S. Fish and Wildlife Service Lower Snake River Compensation Plan,

Cooperative Agreement No. 141101J005. Report prepared by Nez Perce Tribe Department of Fisheries Resources Management Lapwai, ID.

Zoellick, B. W., D. B. Allen and B. J. Flatter 2005. A long-term comparison of redband trout distribution, density, and size structure in southwestern Idaho. North American Journal of Fisheries Management 25(3): 1179-1190.

Zurstadt, C. F. and K. Stephan (2004). Seasonal migration of westslope cutthroat trout in the middle fork Salmon River drainage, Idaho. Northwest Science 78(4): 278-285.