Prepared in cooperation with Bureau of Reclamation

Bull Trout (*Salvelinus confluentus*) Movement in Relation to Water Temperature, Season, and Habitat Features in Arrowrock Reservoir, Idaho, 2012

Scientific Investigations Report 2013–5158

U.S. Department of the Interior
U.S. Geological Survey

Cover:
Bull trout collected from Arrowrock Reservoir. Photograph taken by Trevor Watson, Bureau of Reclamation, Boise, Idaho, 2012.

Confluence of Middle Fork and South Fork Boise River arms of Arrowrock Reservoir, Idaho, looking southwest. Photograph taken by Shawna Castle, Bureau of Reclamation, Boise, Idaho, 2011.

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SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

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Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
hectare (ha)	2.471	acre
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
cubic meter (m^3)	264.2	gallon (gal)
cubic meter (m^3)	35.31	cubic foot (ft^3)
	Flow rate	
cubic meter per second (m^3/s)	70.07	acre-foot per day (acre-ft/d)
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
kilometer per hour (km/h)	0.6214	mile per hour (mi/h)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8×°C)+32.$$

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Datums

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Bull Trout (*Salvelinus confluentus*) Movement in Relation to Water Temperature, Season, and Habitat Features in Arrowrock Reservoir, Idaho, 2012

By Terry R. Maret and Justin E. Schultz

Abstract

Acoustic telemetry was used to determine spring to summer (April–August) movement and habitat use of bull trout (*Salvelinus confluentus*) in Arrowrock Reservoir (hereafter “Arrowrock”), a highly regulated reservoir in the Boise River Basin of southwestern Idaho. Water management practices annually use about 86 percent of the reservoir water volume to satisfy downstream water demands. These practices might be limiting bull trout habitat and movement patterns. Bull trout are among the more thermally sensitive coldwater species in North America, and the species is listed as threatened throughout the contiguous United States under the Endangered Species Act. Biweekly water-temperature and dissolved-oxygen profiles were collected by the Bureau of Reclamation at three locations in Arrowrock to characterize habitat conditions for bull trout. Continuous streamflow and water temperature also were measured immediately upstream of the reservoir on the Middle and South Fork Boise Rivers, which influence habitat conditions in the riverine zones of the reservoir. In spring 2012, 18 bull trout ranging in total length from 306 to 630 millimeters were fitted with acoustic transmitters equipped with temperature and depth sensors. Mobile boat tracking and fixed receivers were used to detect released fish. Fish were tagged from March 28 to April 20 and were tracked through most of August. Most bull trout movements were detected in the Middle Fork Boise River arm of the reservoir. Fifteen individual fish were detected at least once after release. Water surface temperature at each fish detection location ranged from 6.0 to 16.2 degrees Celsius (°C) (mean=10.1°C), whereas bull trout body temperatures were colder, ranging from 4.4 to 11.6°C (mean=7.3°C). Bull trout were detected over deep-water habitat, ranging from 8.0 to 42.6 meters (m) (mean=18.1 m). Actual fish depths were shallower than total water depth, ranging from 0.0 to 24.5 m (mean=6.7 m). The last bull trout was detected in early June, suggesting that fish used little, if any, summertime habitat within the reservoir. Water-quality profile measurements indicated that temperature could limit bull trout use of the reservoir during warm, summer months that coincide with decreased water volume. Thermal refuge during this study appeared to be limited based on scarcity of water that was 15°C and cooler. From the first week of August through the latter part of September, little if any suitable habitat remained for bull trout, with most temperatures exceeding 15°C at all locations where water quality profiles were measured.

Introduction

Bull trout (*Salvelinus confluentus*) have been increasingly studied in the Columbia Basin as a result of being listed as a “threatened” species throughout the contiguous United States under the Endangered Species Act (U.S. Fish and Wildlife Service, 1999). Reasons given for the decline of bull trout populations and their resultant “threatened” status include habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, poor watershed management practices, and the introduction of invasive or non-native species. Recent evidence suggests that climate change might exacerbate these conditions with increasing water temperatures and changes in streamflow regimes, conditions that might ultimately lead to a loss of habitat for coldwater-adapted species such as bull trout (Rieman and others, 2007; Wenger and others, 2011; Isaak and others, 2012a). Bull trout are one of the most thermally sensitive coldwater species in North America (Selong and others, 2001), intolerant of water temperatures exceeding 15°C for extended periods of time (Poole and others, 2001; Dunham and others, 2003; Ott and Maret, 2003; Jones and others, 2013). As a result of these and other studies, the U.S. Fish and Wildlife Service formally defined critical bull trout habitat as habitat that has water temperatures ranging from 2 to 15˚C (U.S. Fish and Wildlife Service, 2010). Mesa and others (2013) determined that bull trout food consumption decreased at temperatures greater than 16°C. However, migratory bull trout have recently been tolerating temperatures greater than 16°C in the migratory corridor (Howell and others, 2010). Similar to other coldwater organisms, salmonids such as bull trout require water with oxygen levels of at least 6.5 mg/L (Chambers and others, 2000). The use of habitat by bull trout across the species’ range is strongly linked to watersheds with cold headwaters (Dunham and others, 2003).

The population of bull trout in the upper Boise River Basin, upstream of Arrowrock Dam, is one of the southern-most distributions in the Columbia River Basin, making them particularly susceptible to the effects of climate change (Rieman and others, 1997; Isaak and others, 2012b). Despite the fragmentation of the Boise River Basin by the Lucky Peak, Arrowrock, and Anderson Ranch Dams, the subbasins upstream of Arrowrock and Anderson Ranch Reservoirs support substantial habitat where migratory bull trout are found throughout the upper Boise River Basin (Flatter, 2000; Salow, 2004). Additionally, current water management practices intended to satisfy downstream irrigation demands, flood control, and salmon augmentation flows in these reservoirs might be limiting bull trout habitat and movement patterns. For example, Arrowrock Reservoir (hereafter Arrowrock) summer water-level drawdowns are typically greater than 30 m, or about 86 percent of reservoir water volume, based on mean annual differences in minimum and maximum pool volumes between 1996 and 2012 (Bureau of Reclamation, 2012). Because these large reservoirs are oligotrophic systems, these drawdowns also could limit secondary production that might limit food sources for bull trout (Salow, 2004). However, unregulated river inflows often exceed coldwater water-quality targets; therefore, reducing drawdowns might not improve all conditions.

The primary life-history forms of bull trout are “resident” and “migratory.” Resident populations generally live in tributary streams throughout their life (Rieman and McIntyre, 1993). Migratory populations are categorized as either fluvial or adfluvial. Fluvial populations use headwater streams for spawning, and migrate to main stem rivers. Adfluvial forms use lakes and reservoirs for growth after spending several years in headwater streams. These adfluvial forms can travel great distances, with movements of 16–109 km recorded for bull trout migrating upstream out of Arrowrock in southwestern Idaho (Flatter, 2000). Migratory forms of bull trout reach sexual maturity at 5–7 years of age, live as long as 12 years (Fraley and Shepard, 1989), and are typically 300 mm or more in length (Mogen and Kaeding, 2005). However, not all adfluvial bull trout spawn annually, which might be a life-history strategy in response to energy availability and subsequent body condition (Thorpe, 1994). Previous research has shown that adfluvial bull trout in Arrowrock experience their greatest growth during winter (Salow, 2004), which is contrary to most temperate fishes, which experience their greatest growth during summer.

Despite the numerous studies on bull trout, information on the habits of bull trout in lakes and reservoirs is limited. Bull trout studies on Flathead Lake in Montana (Fraley and Shepard, 1989), Lake Pend Oreille in Idaho (Vidergar, 2000), and Lake Billy Chinook in Oregon (Beauchamp and Tassell, 2001) have provided trophic interactions and life history information. Lentic systems as important rearing and overwintering habitats for migratory bull trout were described by Muhlfeld and Marotz (2005). Assessments on habitat use and movement patterns in lentic systems will provide resource managers with information to manage bull trout reservoir habitat more effectively than in the past. Flatter (2000) and Stiefel and Dare (2006) used acoustic and radio telemetry technology to evaluate bull trout movement patterns and habitat use during autumn, winter, and spring in Arrowrock. Both researchers determined a three-stage pattern of bull trout residence in Arrowrock:

1. Adults arrived in the upper part of Arrowrock (that is, Middle Fork Boise [MFB] River) in autumn.
2. Adults dispersed throughout Arrowrock in winter.
3. Adults returned to the upper part of Arrowrock’s (that is, MFB) arm prior to a spring departure upstream.

Less is known about the bull trout subadult population. For this study, some part of the population was assumed to reside in Arrowrock or the South Fork Boise (SFB) River throughout the year, because subadults would not exhibit spawning behavior. Radio telemetry assessments in Deadwood Reservoir, another highly regulated reservoir in Idaho, determined that bull trout were using tributary confluences in summer (Dmitri Vidergar, Bureau of Reclamation, oral commun., 2012). This pattern suggests there is an affinity for the zone of transition between lentic habitat and large tributaries. However, summertime bull trout movement and habitat use studies are lacking, especially for highly managed reservoir systems such as Arrowrock. Additionally, acoustic telemetry is superior to radio telemetry in detecting fish in deep water. Radio telemetry typically can only detect tags in water less than 9-m deep (Freud and Hartman, 2002). Therefore, conclusions drawn from previous work may be biased due to gear selectivity.

Purpose and Scope

The report presents the results of an acoustic telemetry study to examine movement patterns and habitat use of bull trout from spring to summer (April–August) residency in Arrowrock, a highly regulated reservoir in southwestern Idaho. The primary objectives of the study were to characterize (1) bull trout spring and summer movement patterns and habitat use in Arrowrock and (2) reservoir water-quality conditions with periodic depth-profile measurements throughout the study period. Acoustic telemetry technology, including mobile tracking and stationary receivers, was used to collect spatial data throughout Arrowrock in 2012. Temperature and depth sensors on tagged fish, along with periodic measurements of temperature and dissolved-oxygen profiles, provided information on Arrowrock water-quality conditions during the study period.

Bull trout locations in Arrowrock will provide information about the potential for entrainment through Arrowrock Dam. Results from this work are being used to address Terms and Conditions in the U.S. Fish and Wildlife Service (2005) Biological Opinion for Bureau of Reclamation (hereafter Reclamation) Operations and Maintenance projects in the Snake River Basin above Brownlee Reservoir. This Biological Opinion contains a 30-year incidental take statement and corresponding reasonable and prudent measures that outline nondiscretionary actions to minimize take for bull trout in Arrowrock. Reclamation is required to maintain bull trout habitat conditions when possible within the operational range of Arrowrock.

Description of Study Area

The upper Boise River Basin (upstream of Arrowrock Dam) is in southwestern Idaho (fig. 1). The basin is about 5,700 km^2, with altitude ranging from 930 to 3,230 m. The U.S. Forest Service manages most land in the upper Boise River Basin, with land uses consisting primarily of grazing, timber harvest, mining, and recreation. Climate in the basin is characterized by cold wet winters and hot and dry summers with maximum air temperatures commonly exceeding 30°C. Precipitation commonly ranges between 60 and 100 cm/yr. High streamflows generally are snowmelt-driven during spring, with low flows occurring during the rest of the year (McGrath and others, 2001).

Three dams have been constructed on the upper Boise River to form Arrowrock, Anderson Ranch, and Lucky Peak Reservoirs. These reservoirs operate collectively as one system for irrigation, flood control, and recreation. Arrowrock Dam, the oldest of these structures, was constructed in 1915 and is managed by Reclamation. The full pool altitude of Arrowrock is 980 m, covering 1,275 ha, with a pool volume of about 3.36×10^8 m^3 and maximum depth of about 60 m. Arrowrock, a narrow canyon reservoir, is highly regulated, with about 86 percent of its volume typically released annually, which equates to a lower water-level altitude of about 945 m (Bureau of Reclamation, 2012). Two major tributaries, the MFB and SFB Rivers form the two major arms of Arrowrock. The MFB is an unregulated river, whereas the SFB River is regulated downstream of Anderson Ranch Dam, and is free-flowing for about 43.5 km before it enters Arrowrock. Streamflow during the 2012 water year was greater than normal for the MFB and SFB Rivers. For the 2012 water year, the annual mean discharge at the MFB River at Twin Springs (U.S. Geological Survey [USGS] streamgage 13185000) was 41.74 m^3/s and at the SFB River immediately downstream of Anderson Ranch Dam (USGS streamgage 13190500) was 34.86 m^3/s, which were greater than the longer term (20 year) mean annual discharge by 23 and 28 percent, respectively. These two large tributaries create areas in the upper sections of Arrowrock where the rivers transition into lentic waters where bull trout are commonly found (Stiefel and Dare, 2006). Based on studies by Flatter (2000) and Salow (2004), streamflows and water temperatures in these major tributaries are important factors contributing to the migration behavior of bull trout in this system.

Arrowrock supports a sport-fishery consisting of rainbow trout (*Oncorhynchus mykiss*), kokanee (*O. nerka*), mountain whitefish (*Prosopium williamsoni*), yellow perch (*Perca flavescens*), and smallmouth bass (*Micropterus dolomieui*). Other nongame fish in the reservoir include largescale sucker (*Catostomus macrocheilus*), bridgelip sucker (*C. columbianus*), northern pikeminnow (*Ptychocheilus oregonesis*), and chiselmouth (*Arocheilus alutaceus*). Idaho Department of Fish and Game regularly stocks Arrowrock with kokanee and rainbow trout fingerlings (Idaho Department of Fish and Game, 2012).

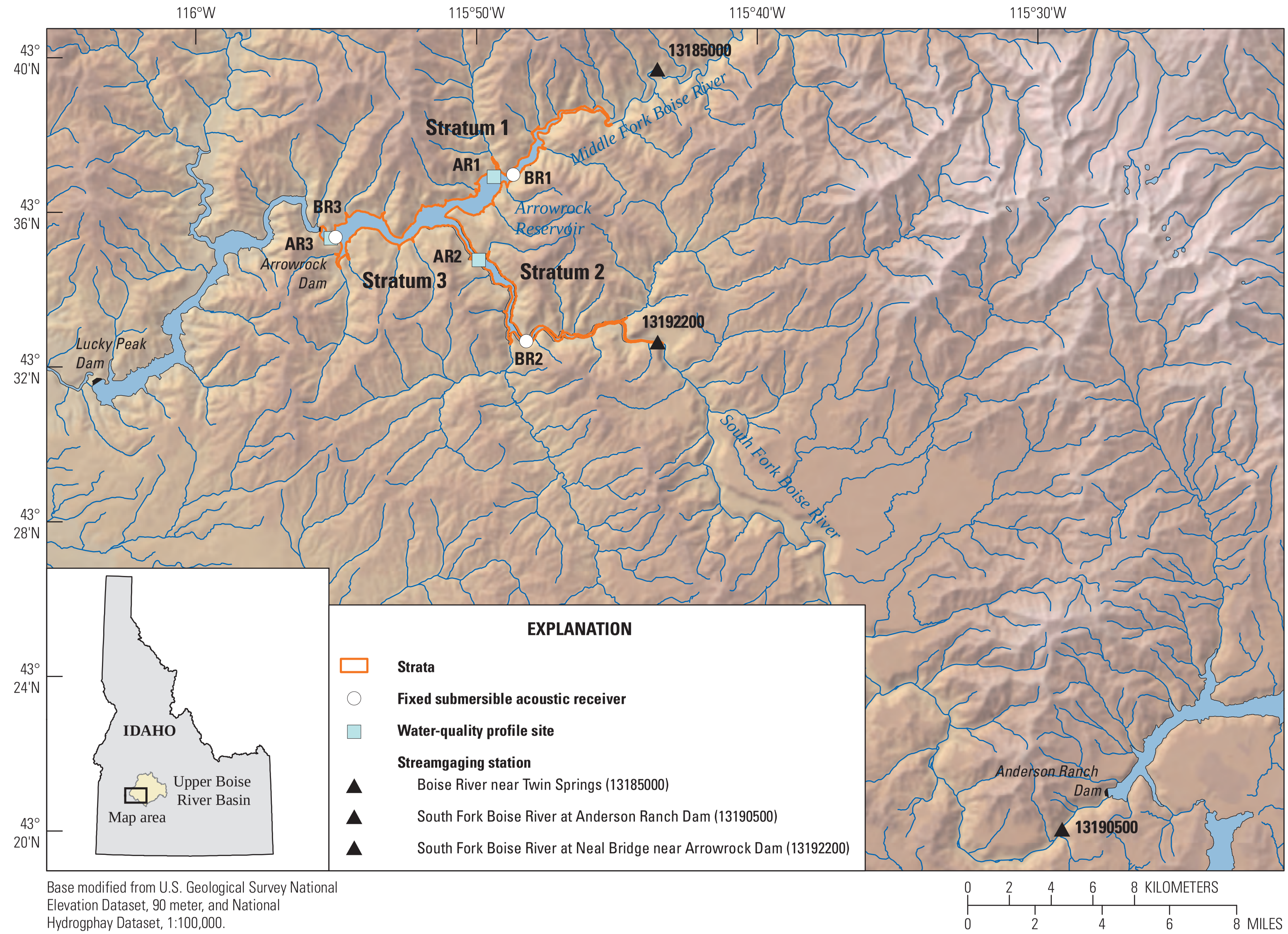

Figure 1. Study area and locations of acoustic receivers, water-quality profile sampling sites, and major sampling strata, Arrowrock Reservoir, Idaho.

Methods

This acoustic study was part of a larger assessment by Reclamation on Arrowrock, consisting of a bull trout population estimate, age and growth study, radio telemetry to assess movement, and food-habits characterization. Because of the large size, limited access, and major tributary influences of the MFB and SFB Rivers, Arrowrock was partitioned into three strata: stratum 1, MFB arm; stratum 2, SFB arm; and stratum 3, main body for capturing fish and recording relative bull trout locations and movements within the reservoir (fig. 1). Total surface area of Arrowrock at full pool for stratums 1, 2, and 3 were 36, 26, and 38 percent, respectively.

To characterize habitat conditions for bull trout in Arrowrock, Reclamation measured biweekly reservoir water-quality profiles within each of these strata from May to October 2012 (fig. 1). Seasonal reservoir distribution and movement patterns of adult salmonids have been associated with changing temperature and dissolved-oxygen concentrations measured at various depth profiles (Baldwin and others, 2002). USGS streamgages that monitor continuous water temperature and streamflow are located on the SFB (USGS streamgage 13190500) about 2.5 km downstream of Anderson Ranch Dam, SFB at Neal Bridge (USGS streamgage 13192200) about 1.3 km upstream of Arrowrock, and on the MFB River at Twin Springs (USGS streamgage 13185000) about 5.2 km upstream of Arrowrock. Continuous streamflow and temperature data were summarized from the USGS National Water Information System (U.S. Geological Survey, 2012). Reservoir surface altitude data for Arrowrock were obtained through the Reclamation Hydromet database (Bureau of Reclamation, 2012).

Bull Trout Capture and Tagging

Bull trout were captured for this study from March 28 to April 20, 2012 (table 1). Contract anglers (that is, Hickey Brothers Research, Bailey's Harbor, Wisconsin) hired by Reclamation, with assistance from multiple government agencies, used a random grid sampling design throughout Arrowrock to estimate the population by mark and recapture methods. A total of 107 grids were sampled, each with a surface area of about 14 ha. Gill nets used were 366-m long with 0.04–0.1 m mesh, and were set for 30-minute intervals. A total of 67 bull trout were captured during the spring gill netting effort, which took about 110 hours throughout Arrowrock. Of the total bull trout captured, 84 percent were from stratum 1, 3 percent were from stratum 2, and 13 percent were from stratum 3. All bull trout were visually assessed after handling to ensure they were in good condition before being released. From the spring sampling effort, 6 bull trout mortalities out of 67 fish captured (9 percent) resulted from the initial netting, handling, and surgeries. Most mortalities resulted from entanglement in the gill nets prior to handling. Bull trout fitted with acoustic tags ranged from a length of 306 to 630 mm and a weight of 251 to 2,450 g (table 1). Release sites after tagging were predominantly in stratum 1, where 14 of the bull trout were netted in the spring sampling period. Four other fish were released in strata 2 and 3.

Live captured bull trout were anesthetized using a portable electronarcosis system similar to that used by Hudson and others (2011). After fish were immobilized and could not maintain equilibrium, they were measured for fork length and total length in millimeters, and weighed in grams. Scale and fin samples were taken for aging and genetic analysis. Passive integrated transponder (PIT) tags, each uniquely coded, were injected with a hypodermic needle into muscle below and just behind the dorsal fin of each bull trout. Only a core group of biologists trained in fish surgical procedures performed the field surgeries explained below.

Surgical equipment and acoustic transmitters (tags) with temperature and pressure sensors that weighed 10 g in air (model MM-MS-11-28, 12 × 60 mm, LOTEK Wireless Inc., Newmarket, Ontario) were disinfected with a 10 percent iodine solution and implanted in fish using a technique similar to Ross and Kleiner (1982). The incision was closed with stainless steel staples rather than sutures to reduce handling time and infection (Swanberg and others, 1999).

Because temperature and depth are important habitat parameters for bull trout, tags with the capability to record these parameters were placed in bull trout selected for tracking. Prior to deployment, the accuracy of tag temperature, with a range of -6.0 to 34.0°C, was compared with a National Institute of Standards and Technology thermometer in an ice bath and at room temperature to ensure they were functioning and accurate to manufacture specifications of +0.8°C. Tags transmitted at 76 kHz, with a burst rate of one every 10 seconds, and battery life of 165 days. A total of 18 bull trout were fitted with these tags (table 1). The locations of the release sites in Arrowrock are shown in figures 2 and 3.

A few of the sampled bull trout potentially could have been subadults (300–350 mm, total length) and were included in this study to test the possibility of tracking subadults, which were considered less likely to migrate out of Arrowrock to spawn in upstream tributaries. However, the acoustic tag weight precluded the tagging of fish that were less than 250 g in weight and less than 300 mm in total length, because the tag weight would have exceeded 4 percent of the fish's body weight, a weight ratio that exceeds the ratio prescribed by Zale and others (2005).

Table 1. Summary of bull trout sizes, tag numbers, and release site locations in Arrowrock Reservoir, Idaho, 2012.

[**Stratum captured:** Sratum 1, Middle Fork Arm (BR1); Stratum 2, South Fork Arm (BR2); Stratum 3, Dam Site (BR3). **Abbreviations:** PIT, passive integrated transponder; mm, millimeter; g, gram; –, no tag number]

Tag No.	Date	Stratum captured	Total length (mm)	Fork length (mm)	Weight (g)	Archival tag No.	PIT tag No.	Latitude	Longitude
61000	03-28-12	3	582	561	1,835	110A-0988	4722374D7C	43.595	-115.869
61600	04-02-12	1	342	327	349	–	47233E7026	43.613	-115.829
60600	04-02-12	1	442	422	825	110A-0983	472E540E41	43.610	-115.836
60500	04-03-12	2	370	355	378	–	472A7B673D	43.592	-115.834
60900	04-04-12	2	566	546	1,905	–	472C241503	43.578	-115.820
60100	04-06-12	1	345	332	358	110A-1003	472E480224	43.619	-115.825
59700	04-06-12	1	313	305	285	–	472E1A4A7F	43.640	-115.797
60000	04-06-12	1	360	352	345	110A-1002	472A24606A	43.635	-115.795
59900	04-06-12	1	342	330	317	–	472C267058	43.640	-115.794
59800	04-06-12	1	306	293	251	–	472E53410C	43.637	-115.798
60200	04-06-12	1	326	316	280	–	4723536630	43.633	-115.798
60400	04-06-12	1	315	304	265	–	4723477234	43.633	-115.799
60800	04-12-12	1	381	365	304	–	47241A3128	43.617	-115.817
60300	04-12-12	1	376	361	270	–	471A42326E	43.617	-115.816
61100	04-12-12	1	446	430	471	L110A-0987	472E28290E	43.618	-115.816
[1]61300	04-18-12	1	630	610	2,450	L110A-0795	472212123F	43.630	-115.796
60700	04-20-12	1	580	561	2,150	L110A-0989	472C483014	43.619	-115.817
61500	04-20-12	3	452	435	865	L110A-1005	472E53044C	43.602	-115.895

[1]Recaptured in stratum 1, 10-04-12, total length 640 mm, weight 2,200 g; archival tag missing.

Eight of the bull trout that were large enough to handle the additional weight were also fitted with archival tags that had temperature and depth sensors weighing 3 g in air (model LAT1100-A, 8 × 16 × 27 mm, LOTEK Wireless Inc., Newmarket, Ontario). Archival tags were attached externally, just below the dorsal fin, and followed procedures outlined in Howell and others (2010). Accuracy of temperature for each archival tag with a range of -5.0 to 35.0˚C were compared with a thermometer in an ice bath and at room temperature to insure that they were within the manufacturer's specifications of ±0.2ºC. Archival tags were programmed to take water temperature readings every 20 seconds, and had a battery life of 570 days. Acoustic transmitter tags (depth range of 0–105 m, ±2.1 m) and archival tags (depth range of 0–50 m, ±0.5 m) depth readings were checked prior to deployment to ensure they were functioning properly. Weight of a single tag or in combination was limited to no more than 4 percent of the fish's body weight (Zale and others, 2005).

A follow up recapture effort by Reclamation using 15-minute gill-net sets was completed in the autumn (September 24–November 2, 2012), targeting the upper Middle Fork arm of Arrowrock, where bull trout would be returning to the reservoir to overwinter. This recapture effort was necessary to complete the bull trout population estimate and to recapture tagged fish. Due to road closures in the upper basin, fish weirs on the South Fork and Middle Fork Boise River could not be operated, which meant that bull trout migrating back to Arrowrock could not be captured and tagged. A total of 114 bull trout was captured during the autumn gill netting effort of about 135 hours using 183 m long gill nets with 0.04–0.1 m mesh. Fourteen bull trout previously captured during the tagging events in the spring were recaptured. The autumn recapture effort failed to recover any of the archival tags placed on fish with acoustic tags. Bull trout mortalities for the autumn recapture effort were 4 percent from initial netting, handling, and surgeries. One fish was recaptured in autumn from stratum 1 that was previously fitted with acoustic and archival tags (tag number 61300, table 1). However, the archival tag was missing at the time of recapture. This large fish had lost about 10 percent of its weight (2,450–2,200 g) from the previous spring, suggesting it had likely returned from spawning upriver.

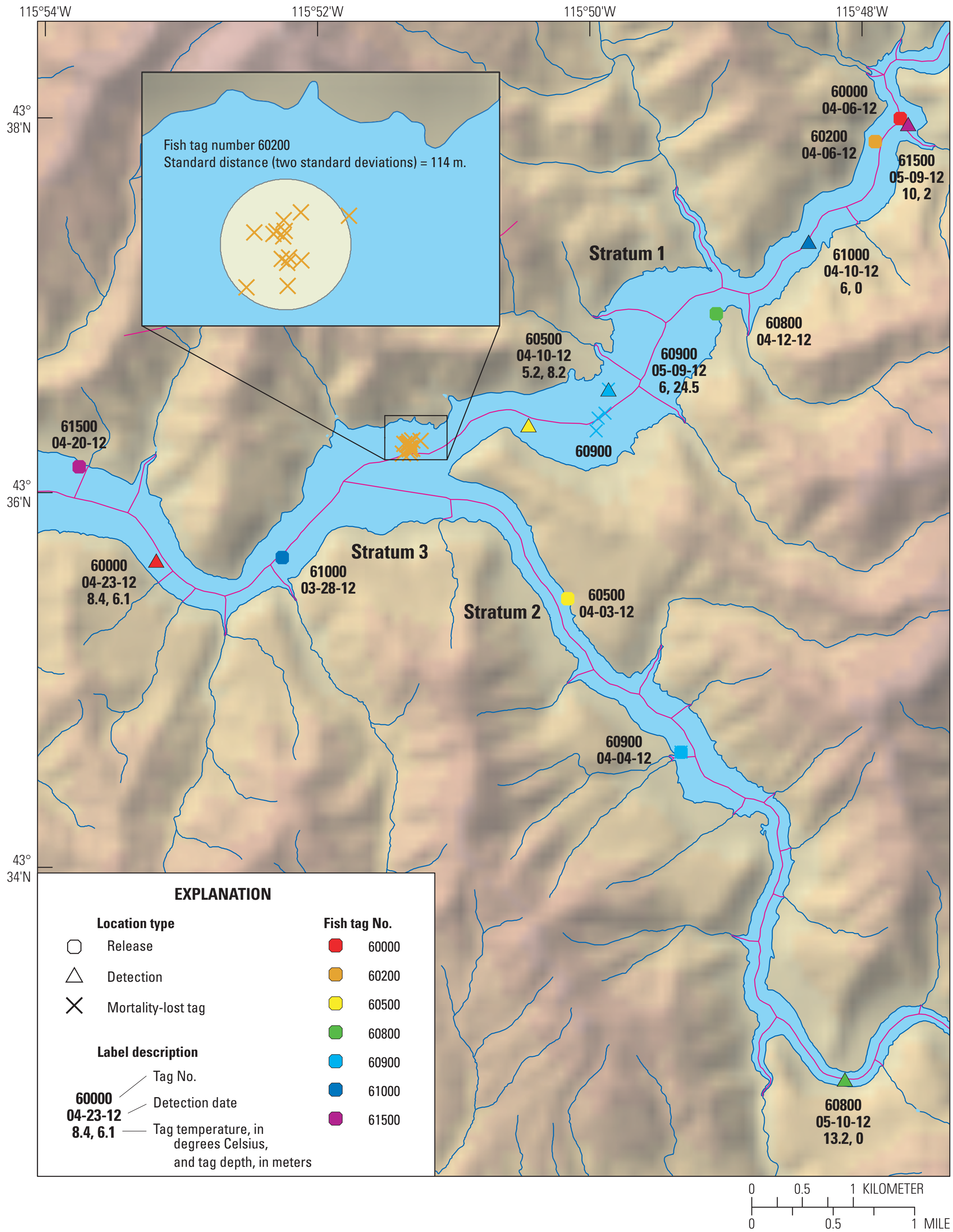

Figure 2. Bull trout release sites, detections, and tagged-fish mortalities or lost tags with date of detection, tag temperature, and tag depths for three strata, Arrowrock Reservoir, Idaho, March 28–May 10, 2012. Mobile tracking error associated with tag 60200 also is shown. The error occurred from April 23 to August 21, 2012.

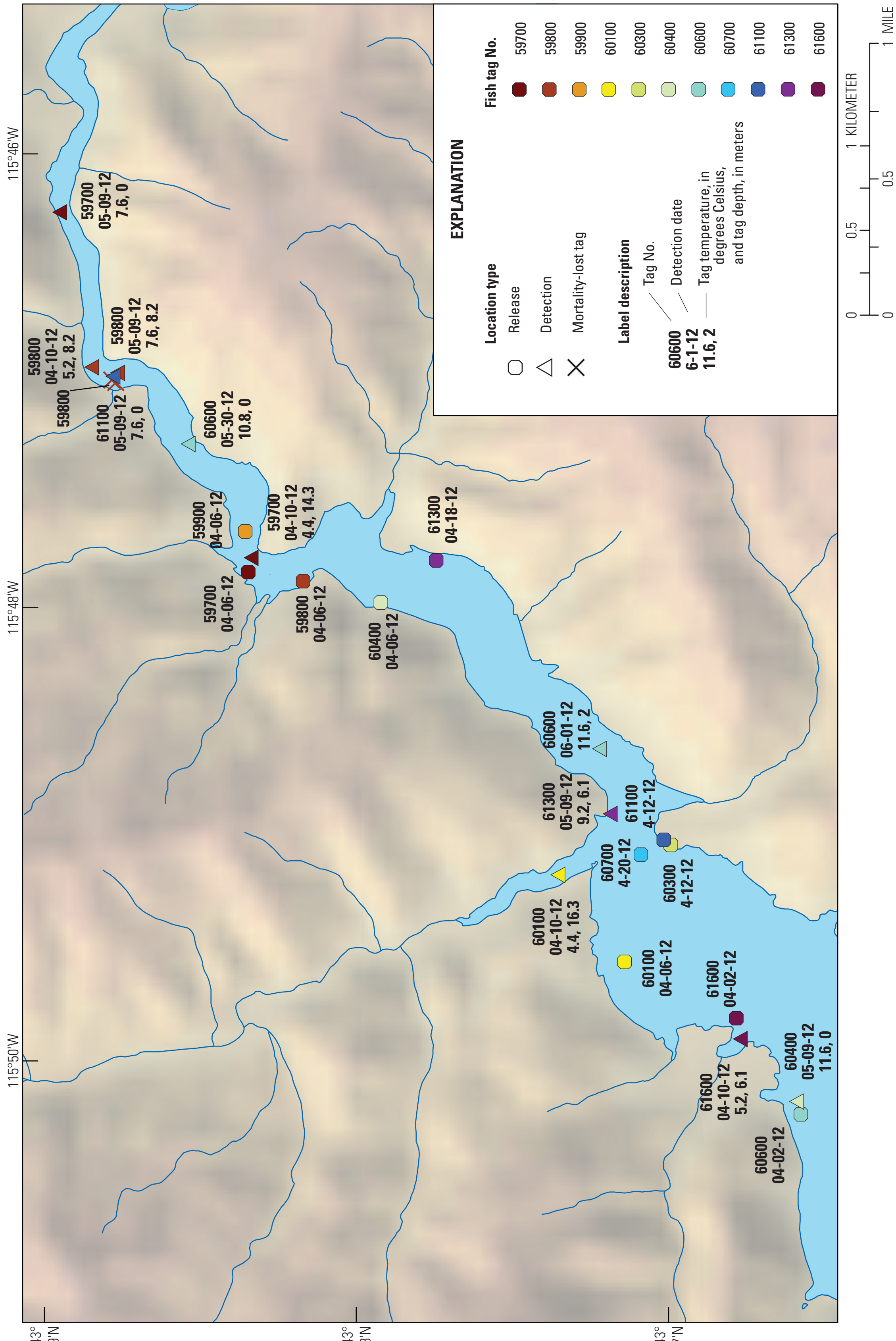

Figure 3. Bull trout release sites, detections, and tagged-fish mortalities or lost tags with date of detection, tag temperature, and tag depths for stratum 1, Arrowrock Reservoir, Idaho, April 2–June 1, 2012.

Tracking Tagged Bull Trout

All mobile tracking was done using a 2.4 × 6.9 m aluminum jet boat with custom welded 5 cm tubular aluminum poles supporting hydrophones at the port and starboard bow locations. Cavitation of the hydrophone poles was greatly reduced by securing gunny-sacks around the submerged parts of the poles, which allowed for increased tracking speeds. The boat was also outfitted with an Eagle Optima depth finder and transducer that constantly monitored bottom depth to the nearest 0.1 m. A Garmin model 60 CSx Global Positioning System (GPS) unit set to record in NAD83 datum was used to record a track path for each tracking event and record fish locations. Accuracy for locations on the water for this unit ranged from ±3 to 4 m.

Mobile tracking of acoustic-tagged fish by individual strata occurred from April 10 to August 21, 2012. Tracking of bull trout was performed weekly on separate strata, with an attempt to sequentially rotate tracking events among the three strata. Five tracking events were completed in each of the three strata. Mobile tracking was performed on days that were not windy to maximize performance of the acoustic hydrophones. On a few occasions, strata that had low winds were selected out of the tracking sequence in order to reduce interference. Tracking generally started or ended at the location where tag number 60200 had become stationary at the bottom of the reservoir, because the bull trout shed the tag, or the bull trout died. This centrally located tag was convenient for testing equipment functionality and for quantifying the horizontal accuracy of tracking over the study period. At the start of each mobile tracking event, and periodically during the day, an acoustic tag was lowered into the water to ensure that equipment was functioning properly. Initial range tests were performed by suspending acoustic tags from a buoy on a calm day at the surface and at a depth of 10 m. Based on these tests, it was determined that a maximum range of about 400 m was possible with the acoustic tracking equipment. Plate and Bocking (2010) determined comparable ranges using similar acoustic telemetry equipment. Boat speeds influenced tracking efficiency because of increased vibration on the hydrophones and stress on the structural integrity of the hydrophone mounts. Acoustic signals were readily detected at speeds of 3.2–4.8 km/h. When weak signals were detected, the boat speed was lowered to 1.6 km/h to listen for the signal and determine direction. A distance of at least 300–400 m from shore was maintained while tracking wide sections to maximize reservoir coverage. This procedure usually involved tracking parallel to the shoreline, especially in the wider stretches of stratum 3, the main reservoir. Any bull trout that remained in the same location since the last detection and on the bottom based on depth sensor readings either were assumed to be dead or had expelled the acoustic tag.

A LOTEK MAP 600 RT receiver with two hydrophones mounted at 0.5 m below the water surface on the port and starboard bow of the jet boat were used to detect and record acoustic signals during mobile tracking events. A computer with an external power-harness connection and LOTEK MAP Host software recorded tag detections. The software provided a visual display showing power and directionality from each hydrophone to aid in locating tagged fish, and recorded the date, time, tag number, temperature, and depth readings from the tag sensor. Field testing on known tag locations determined that a relative signal power of 80 or more from the hydrophones was adequate to describe the approximate location of a tagged fish. A waypoint was created for each fish location using the Garmin GPS unit. Total water depth and surface water temperature also were recorded at each of these fish detections.

One fixed-site LOTEK submersible acoustic receiver (model WHS3250) was placed in each of the three strata (fig. 1) from May 7 to September 5, 2012 to record fish movements between Arrowrock and the two major tributaries, MFB and SFB Rivers. The battery life of 84 days for these units required at least one change of batteries to cover the entire summer period. After being placed in the strata, a range test was completed to ensure that fish passing through the area could be detected from bank to bank. Generally, these units were able to detect fish at least 400 m from the stationary receiver. During mobile tracking, these fixed site receivers were checked to ensure they were functioning. This was done by detecting an acoustic signal that was broadcast out of the receiver every minute that it functioned properly.

Each unit was suspended from a large cone buoy at a depth of 10 m and anchored to the bottom near the middle of Arrowrock to maximize detection of tagged bull trout. A small weight was placed on the rope just below the unit so that a depth of 10 m was maintained from the surface during reservoir drawdown. This 10 m was judged to be the approximate depth of the thermocline during the summer stratification period. These units recorded the unique acoustic tag number, date, time, temperature and depth of each detected fish. Upon retrieval, the units were taken back to the office where the data were downloaded. The stationary receiver for the Middle Fork Arm (BR1) had a partial record (May 7–June 13, 2012). The receiver was lost and not recovered after June 13.

Habitat Measurements

A Yellow Springs Instrument (YSI) 6600 V2-4 multi-parameter water-quality sonde was used to measure numerous water quality field parameters. For this report, only depth, dissolved oxygen and water temperature are included to describe available habitat conditions for bull trout. The sonde was calibrated prior to each use. A National Institute of Standards and Technology thermometer was used to check field meters to ensure they were within 0.2°C. Instantaneous measurements of surface temperature at fish locations were made with a calibrated Orion model 122 conductivity meter.

Reservoir profiles were measured by Reclamation biweekly throughout the study period from May 9 to October 4, 2012, in each of the three strata. A Hydrolab DS5 meter was used for these measurements starting at 1 m below the surface and then at 2 m increments to 21 m below water surface. Below this depth, measurements were taken every 5 m to the bottom. Water quality profile data collected are summarized in appendix A.

Data Analysis

All spatial data were put into a Geographic Information System (GIS) ArcMap version 10.1 for analysis. A digital bathymetric map created by Ferrari (1998) for Reclamation was used for Arrowrock depth contours. To quantify the distribution of fish locations, the frequency of use of the three strata was determined by dividing the number of observations in each section by the total number of observations in the study area. The distance between successive locations of individual bull trout was measured using GIS ArcMap tools along the midline of Arrowrock. Mobile tracking error was estimated by using 14 detections of tag 60200 in stratum 3 that was determined to be a mortality or a shed tag (fig. 3). The Standard Distance tool (Environmental Systems Research Institute, Inc., 2012), which estimates dispersion of all detections around a centroid, provided a relative estimate of error in two-dimensional space for mobile tracking.

Acoustic Telemetry and Habitat Use

Bull trout were tagged to monitor their distribution and movement in Arrowrock; available habitat conditions and use were monitored during the study period. The MFB and SFB River conditions immediately upstream Arrowrock at two USGS streamgaging stations were also evaluated because streamflows and water temperature commonly are associated with migratory movement of bull trout (Fraley and Shepard, 1989).

Fifteen of the 18 bull trout (83 percent) implanted with acoustic tags were detected from April 10 to June 1, 2012 (table 2). Three of the tagged fish (tag numbers 59800, 60200, and 60900) were determined to have died or shed their tag, whereas three other fish tags (tag numbers 59900, 60300, 60700) were never detected by mobile tracking or at the three fixed receivers. The remaining 12 tagged fish provided the habitat utilization and movement information for the study.

Bull Trout Distribution and Movement

During 15 mobile boat tracking events, 91, 63, and 85 km were covered in strata 1, 2, and 3, respectively. On a few spring tracking periods, the upper end of stratum 2 was inaccessible because of large, floating woody debris that resulted from rising reservoir water levels.

Most bull trout detections and movement were recorded in stratum 1 (table 2). This is not surprising given that most of the bull trout capture and release locations were in stratum 1 (MFB arm). Only 2 of 16 detections were live fish in strata 2 and 3 after release (figs. 2 and 3). Stiefel and Dare (2006) also noted the importance of the MFB arm, particularly the transition area from lotic to lentic habitat, for fish staging to migrate upriver in spring. Migratory behavior and forage abundance in transition zones are likely reasons bull trout are found primarily in the MFB arm (Stiefel and Dare, 2006). The last acoustic tagged bull trout was detected on June 1; there was no subsequent detection of live bull trout between June 12 and August 21, 2012 (table 2). Beulah Reservoir, another highly regulated reservoir in east-central Oregon, also supports an adfluvial bull trout population that moves entirely out of the reservoir in summer (Bureau of Reclamation, 2004). This contrasts with findings for Lake Billy Chinook in central Oregon where bull trout (less than 450 mm, fork length) are assumed to remain in the reservoir (Beauchamp and Tassell, 2001).

Our tracking schedule was not frequent enough in each strata to provide fine resolution information on individual distances traveled. Based on GIS spatial analysis, individual horizontal distances traveled between detection times ranged from 0.1 to 11.8 km, with a mean distance of 5.2 km. The longest recorded movement was a fish (tag number 60800) that traveled from stratum 1 into stratum 2 between April 12 and May 10 (fig. 2).

Only two bull trout were detected at the fixed receiver sites (table 2). These include detections on May 10 in stratum 2 and on June 1 in stratum 1. Surprisingly, there were no detections in the deepest part of Arrowrock near the dam (BR3, stratum 3). This provides evidence that entrainment through Arrowrock Dam would be unlikely during spring to summer when discharge releases would be highest. Even though the fixed submersible acoustic receiver in the MFB arm (BR1) was lost in the latter stage of the study (that is, data recorded after June 12), it is unlikely there was a significant amount of data lost because the last fish detected by mobile tracking was on June 1. One limitation of using only one receiver at a location is that directionality cannot be determined. Future monitoring using this technology should consider having an array of at least two receivers so upstream or downstream movement can be determined. For future acoustic telemetry investigations in Arrowrock, it would be beneficial to target the MFB arm with a fixed array of receivers for the collection of continuous diel data on bull trout movement and habitat use.

Table 2. Bull trout detected during mobile tracking and fixed receivers BR1, BR2, and BR3, in Arrowrock Reservoir, Idaho, 2012.

[Shaded rows indicate fish mortalities or tags that had been shed. **Stratum:** 1, Middle Fork Arm, BR1; 2, South Fork Arm, BR2; 3, Dam Site, BR3. **Abbreviations:** NGVD 29, National Geodedic Vertical Datum of 1929; km, kilometer; °C, degrees celsius; m, meter; NA, not available]

Date	Stratum	Tracking distance (km)	Detection method	Tag No.	Time	Tag temperature (°C)	Tag depth (m)	Surface temperature (°C)	Water depth (m)	Reservoir altitude (m above NGVD 29)	Latitude	Longitude
04-10-12	1	14.2	Boat	59800	1135	5.2	8.2	6.0	10.7	975.37	43.649	-115.782
				59700	1228	4.4	14.3	6.0	18.7		43.640	-115.796
				61000	1340	6.0	0.0	6.5	28.2		43.624	-115.806
				60100	1408	4.4	16.3	7.0	19.8		43.623	-115.819
				61600	1500	5.2	6.1	9.0	8.1		43.613	-115.830
				60500	1602	5.2	8.2	9.5	42.6		43.607	-115.840
04-23-12	3	17.6	Boat	60000	1310	8.4	6.1	16.2	17.6		43.594	-115.885
				[1]60200	1158	5.2	38.8	13.8	39.0	972.37	43.605	-115.853
05-01-12	2	10.4	Boat	No detections								
05-09-12	1	16.9	Boat	59700	1054	7.6	0.0	7.4	8.2	975.80	43.650	-115.771
				59800	1145	7.6	8.2	8.6	8.0		43.647	-115.783
				61100	1200	7.6	0.0	8.6	10.5		43.647	-115.783
				61500	1305	10.0	2.0	12.2	20.0		43.635	-115.794
				61300	1402	9.2	6.1	15.2	22.6		43.620	-115.814
				60900	1535	6.0	24.5	13.8	25.0		43.610	-115.830
				60400	1600	11.6	0.0	13.8	19.5		43.610	-115.835
05-10-12	2	NA	Fixed receiver	60800	0351	13.2	0.0	NA	24.3	975.53	43.549	-115.799
05-15-12	2	15.7	Boat	No detections								
05-21-12	3	14.5	Boat	60200	0945	6.8	40.8	14.6	42.1	975.34	43.605	-115.854
05-30-12	1	21.6	Boat	59800	1047	9.2	10.2	11.3	14.3	977.98	43.647	-115.783
				60600	1115	10.8	0.0	11.4	11.8		43.643	-115.788
				60900	1452	8.4	26.5	14.4	40.5		43.608	-115.830
06-01-12	1	NA	Fixed receiver[2]	60600	0927	11.6	2.0	NA	38	978.06	43.621	-115.809
06-12-12	2	16.9	Boat	No detections								
06-18-12	3	17.4	Boat	60200	0951	8.4	44.9	17.5	43.8	978.94	43.605	-115.854
06-27-12	1	19.2	Boat	60900	1420	10.8	26.5	20.7	42.6	978.24	43.608	-115.831

Table 2. Bull trout detected during mobile tracking and fixed receivers BR1, BR2, and BR3, in Arrowrock Reservoir, Idaho, 2012.—Continued

[Shaded rows indicate fish mortalities or tags that had been shed. **Stratum:** 1, Middle Fork Arm, BR1; 2, South Fork Arm, BR2; 3, Dam Site, BR3. **Abbreviations:** NGVD 29, National Geodedic Vertical Datum of 1929; km, kilometer; °C, degrees celsius; m, meter; NA, not available]

Date	Stratum	Tracking distance (km)	Detection method	Tag No.	Time	Tag temperature (°C)	Tag depth (m)	Surface temperature (°C)	Water depth (m)	Reservoir altitude (m above NGVD 29)	Latitude	Longitude
07-03-12	2	9.1	Boat	No detections								
07-17-12	3	17.1	Boat	60200	1028	11.6	38.8	22.1	37.3	972.20	43.605	-115.855
07-30-12	1	19.0	Boat	59800	1000	17.2	0	18.8	3.5	967.06	43.648	-115.783
				60900	1256	14.8	16.3	25.8	18.0		43.607	-115.831
08-09-12	2	11.0	Boat	No detections								
08-21-12	3	18.3	Boat	60200	1200	13.2	22.4	23.0	22.0	956.80	43.605	-115.854
			Mean[3]			7.3	6.7	10.1	18.1			

[1]Tag location was used to evaluate relative error expected from mobile boat tracking (see table 3 and figure 2).

[2]Only partial record for South Fork Arm stratum 1, from May 7 to June 13, record lost for remainder of time.

[3]Does not included mortalities, shed tags, or fixed receiver data.

Estimating Mobile Tracking Error

Accuracy of our acoustic telemetry methods is dependent on various environmental conditions including water temperature, water depth, specific conductivity, external noise, and substrate type (Pincock and Johnston, 2012). Error associated with mobile tracking was quantified using multiple detections of tag 60200, located in stratum 3 (table 3). Tag 60200 was useful for such quantification because it was in a fixed location, either because it was shed by the bull trout it was tagged to, or because the bull trout died. This tag was detected before or after each of 14 boat tracking events starting April 23 to ensure functionality of the equipment and to evaluate tracking error associated with changing environmental conditions (for example, thermal stratification) throughout the study period. Even though the exact tag location could not be determined and assuming no tag movement, the detection displayed in figure 2 displays the relative amount of horizontal error or dispersion associated with our field tracking methods. For this study, the relative error expected with tracking within a GIS generated polygon that contains 95 percent of the detections had a radius of 114 m. Arrowrock stratification caused by water density differences, which occurred by July at this location, did not seem to influence the tag detection. Future acoustic studies should include a similar approach to evaluate equipment functionality and accuracy. One other source of error that is difficult to quantify is fish movement while tracking. On a few occasions, acoustic tag signals were recorded from fish, but could not be verified due to their movement away from the boat.

Table 3. Mobile tracking locations for tag 60200, used to evaluate horizontal tracking error in Arrowrock Reservoir, Idaho, during the study period, April 23–August 21, 2012.

[See figure 2 for locations in stratum 3. **Abbreviations:** °C, degrees Celsius; m, meter]

Date	Tag temperature (°C)	Tag depth (m)	Surface temperature (°C)	Water depth (m)	Latitude	Longitude
04-23-12	5.2	38.8	13.8	39.0	43.605	-115.853
05-01-12	5.2	44.9	10.8	44.0	43.605	-115.854
05-09-12	6.0	42.8	12.4	44.0	43.605	-115.854
05-15-12	6.0	40.8	14.1	43.7	43.605	-115.854
05-21-12	6.8	40.8	14.6	42.1	43.605	-115.854
05-30-12	7.6	44.9	14.3	43.6	43.605	-115.854
06-12-12	8.4	44.9	17.2	49.3	43.604	-115.854
06-18-12	8.4	44.9	17.5	43.8	43.605	-115.854
06-27-12	9.2	44.9	22.3	47.0	43.605	-115.854
07-03-12	10.0	42.8	21.4	42.5	43.605	-115.854
07-17-12	11.6	38.8	22.1	37.3	43.605	-115.855
07-30-12	12.4	32.6	25.2	28.5	43.605	-115.854
08-09-12	13.2	28.6	24.1	30.4	43.604	-115.855
08-21-12	13.2	22.4	23.0	22.0	43.605	-115.854

Habitat Conditions and Use

In 2012, the Arrowrock drawdown was near normal at about 82 percent of the total volume of the reservoir (Bureau of Reclamation, 2012). This corresponded to a decrease in the water-surface elevation from about 980 to 948 m for the study period (fig. 4). Most of the decrease in Arrowrock water levels was after June 1 when bull trout were no longer detected. The complete departure of bull trout from Arrowrock was not anticipated based on assumptions that subadults likely would not migrate to spawn and that some adults would not migrate every year in response to energy availability and subsequent body condition (Thorpe, 1994). Additionally, other coldwater species such as rainbow trout and kokanee are found year-round in Arrowrock.

A radio telemetry study concurrent with this study provided similar findings. A fixed radio receiver located on the MFB River at the USGS Twin Springs streamgage recorded 24 radio tagged bull trout moving upriver from February to July 2012; no bull trout were detected after July. The highest number of bull trout (10) moving upriver was recorded in May (Dmitri Videgar, Bureau of Reclamation, written commun., 2012). This general spring movement pattern out of Arrowrock in the MFB River also has been noted by others (Flatter, 2000; Stiefel and Dare, 2006). Small sample size is one of the most common criticisms of telemetry studies. However, findings from this study and the concurrent radio telemetry study increase the confidence that results presented here represent the general spring movement pattern of bull trout out of Arrowrock.

Streamflows for water year 2012 contrast the MFB River at Twin Springs, which has natural or unimpaired flow, and the SFB River at Neal Bridge, which is regulated by Anderson Ranch Dam (fig. 5). Bull trout movement in the MFB arm and upriver out of Arrowrock by early to mid-June coincides with the descending limb of the MFB River hydrograph. So few fish were detected in the SFB arm (stratum 2) that no association to flow was discernible.

Daily water temperatures for both these sites are also different as the result of impoundment effects (figs. 6*A* and 6*B*). MFB River water temperatures are consistently colder in the winter and warmer in the summer than the SFB river. Summer water temperatures at the MFB site are consistently greater than 15°C, whereas SFB River sites are consistently less than 15°C. Maximum water temperatures for the MFB River were less than 15°C up until the last detection of bull trout in Arrowrock on June 1 and did not exceed this level consistently until the beginning of July (fig. 6*A*). Bull trout seasonal movement upstream in spring is generally associated with increasing water temperatures (Howell and others, 2010). Although colder water temperatures are available in the SFB river throughout the summer, the predominant movement patterns were in the MFB arm of Arrowrock, presumably to move upstream to spawn or live in the colder tributaries of the MFB River.

A comparison using mobile tracking temperatures indicate bull trout tag temperatures are lower by an average of almost 3.0°C than surface temperatures (table 2). Water surface temperatures at each fish detection ranged from 6.0 to 16.2°C with a mean of 10.1°C, whereas bull trout tag temperatures ranged from 4.4 to 11.6°C with a mean of 7.3°C. Bull trout were detected in deeper water habitat, ranging from 8.0 to 42.6 m, with a mean of 18.1 m (table 2). Actual fish depths were shallower ranging from 0.0 to 24.5 m with a mean of 6.7 m. Stiefel and Dare (2006) also determined that bull trout consistently use deep water habitats away from shore in a mean water depth of 14.7 m.

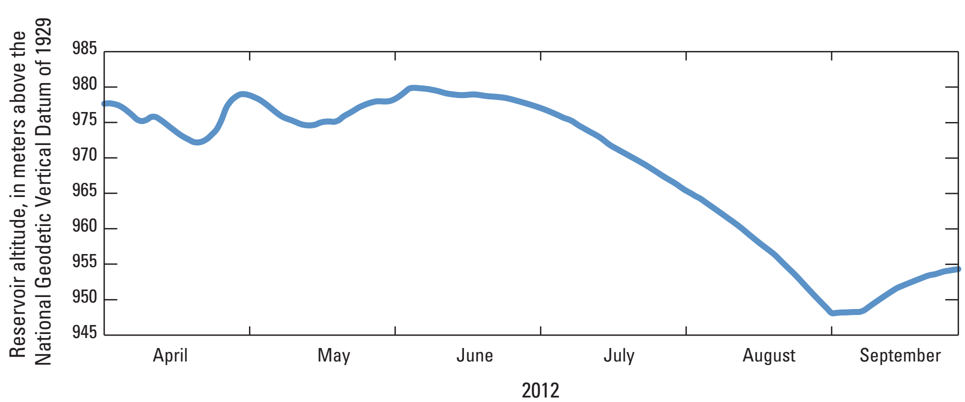

Figure 4. Altitude of Arrowrock Reservoir, Idaho, 2012 (Bureau of Reclamation, 2012).

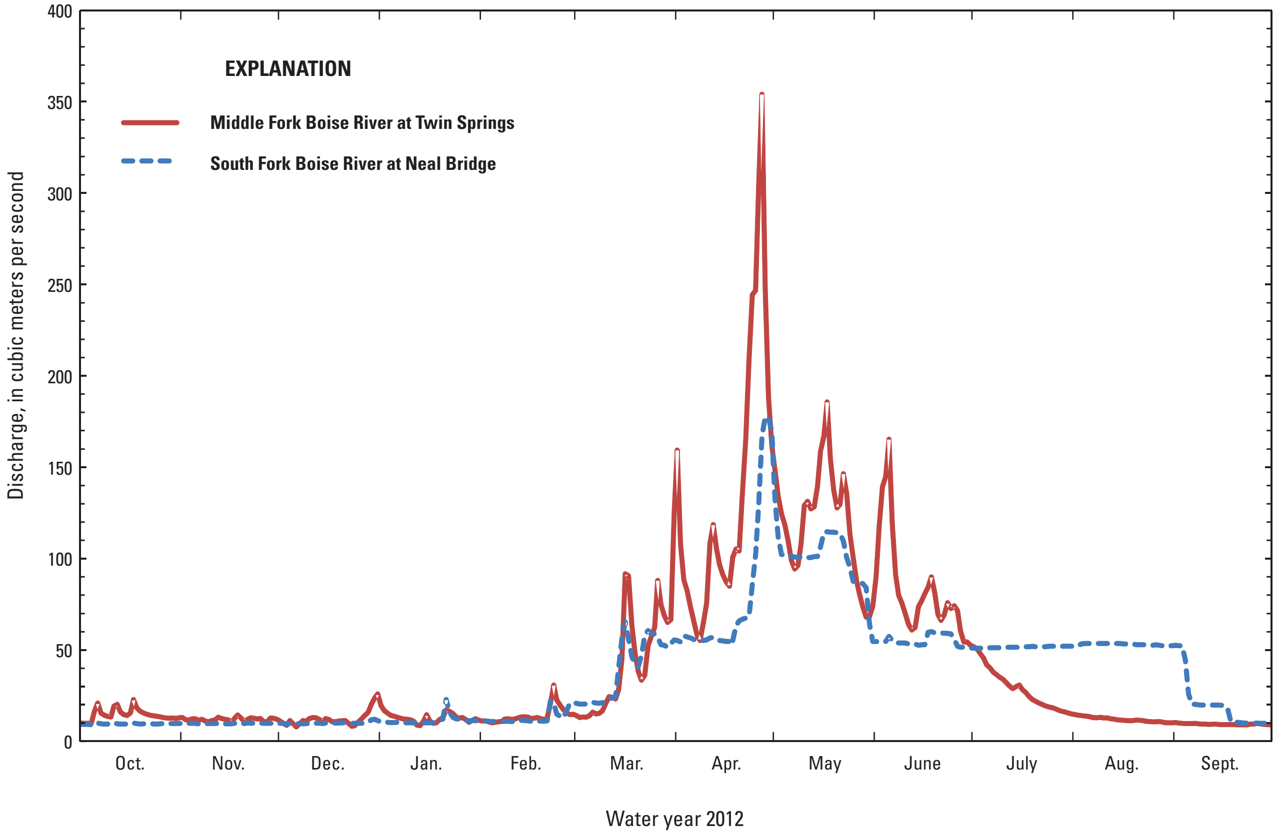

Figure 5. Daily mean discharge for Middle Fork Boise River at Twin Springs (13185000) and South Fork Boise River at Neal Bridge (13192200), Idaho, water year 2012.

Limnological data indicated that temperature and dissolved oxygen might be limiting factors on bull trout populations in Arrowrock, especially during warm summer months that coincide with low water levels. Thermal refuge during this study probably was limited based on availability of water temperatures 15°C and cooler. Water-quality profiles taken biweekly from May to October 2012 in each of the three Arrowrock strata provide a general characterization of available bull trout habitat as indicated by dissolved-oxygen concentrations and water temperatures (appendix A). Selected measurements from four periods were used to illustrate the changes in these parameters over the study period (fig. 7). The profiles indicate stratification had setup by at least May in each strata. However, dissolved oxygen and temperature were within suitable ranges for bull trout. Dissolved oxygen was greater than 6.5 mg/L and temperatures less than 15°C for much of the water column. These conditions seem to indicate that bull trout moved out of Arrowrock in response to seasonal migration cues rather than avoidance of high water temperatures and low dissolved-oxygen concentrations. However, by the first week in August through the latter part of September little if any suitable habitat remained in Arrowrock for bull trout, with most temperatures exceeding 15°C at all locations where water-quality profiles were measured. By mid-September, Arrowrock water levels had decreased where large parts of both the MFB at AR1 and SFB at AR2 had become lotic habitat (figs. 7*A* and 7*B*) as a result of summer water withdrawal. Some colder water habitat (less than 15°C) remained at the deepest Arrowrock site (dam site, AR3) in August and September (fig. 7*C*), but most dissolved-oxygen concentrations were less than 6.5 mg/L. See appendix A for all profile data.

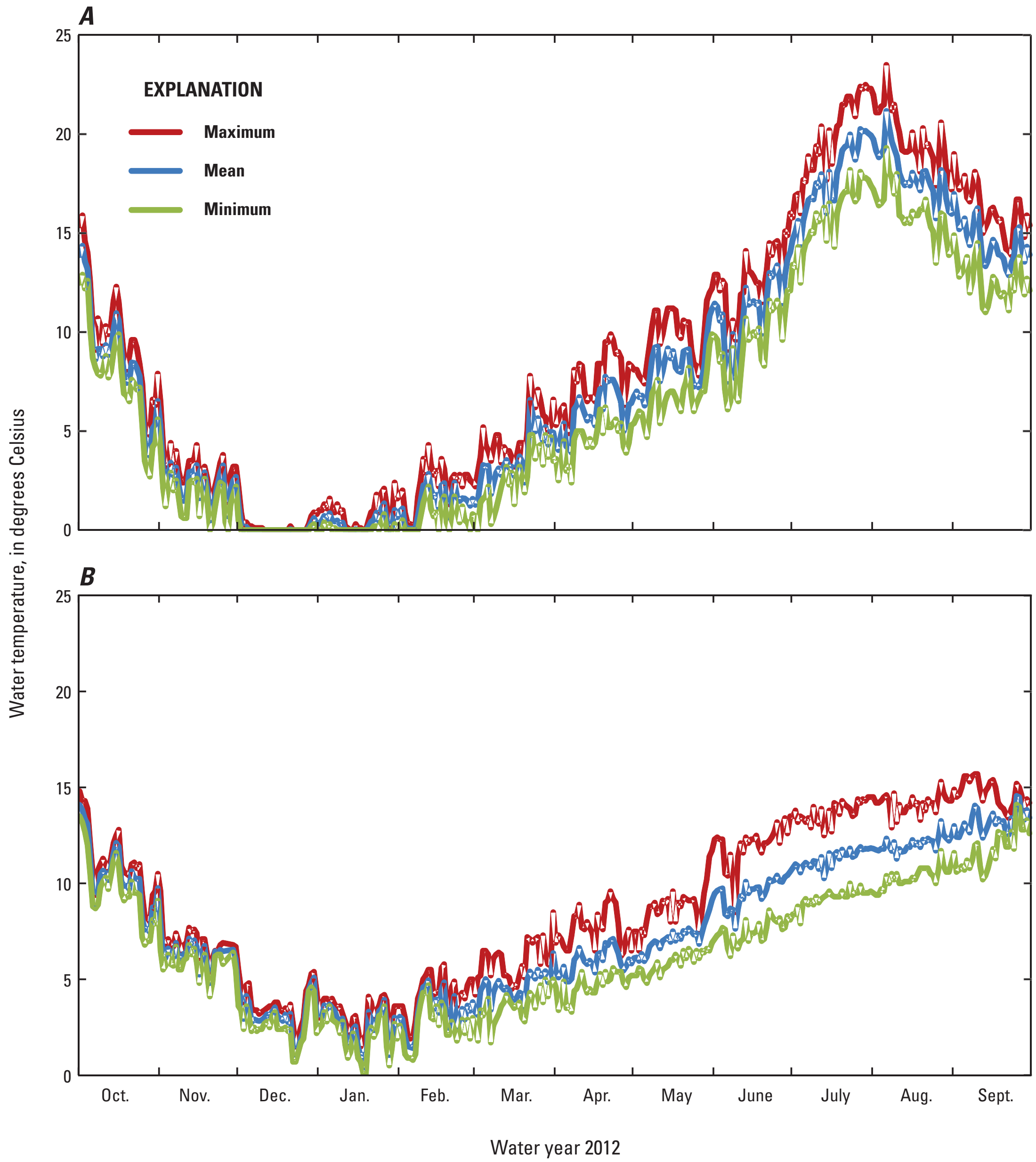

Figure 6. Daily maximum, mean, and minimum water temperatures for (*A*) Middle Fork Boise River at Twin Springs (streamgage 13185000), and (*B*) South Fork Boise River at Neal Bridge (streamgage 13192200), Idaho, water year 2012.

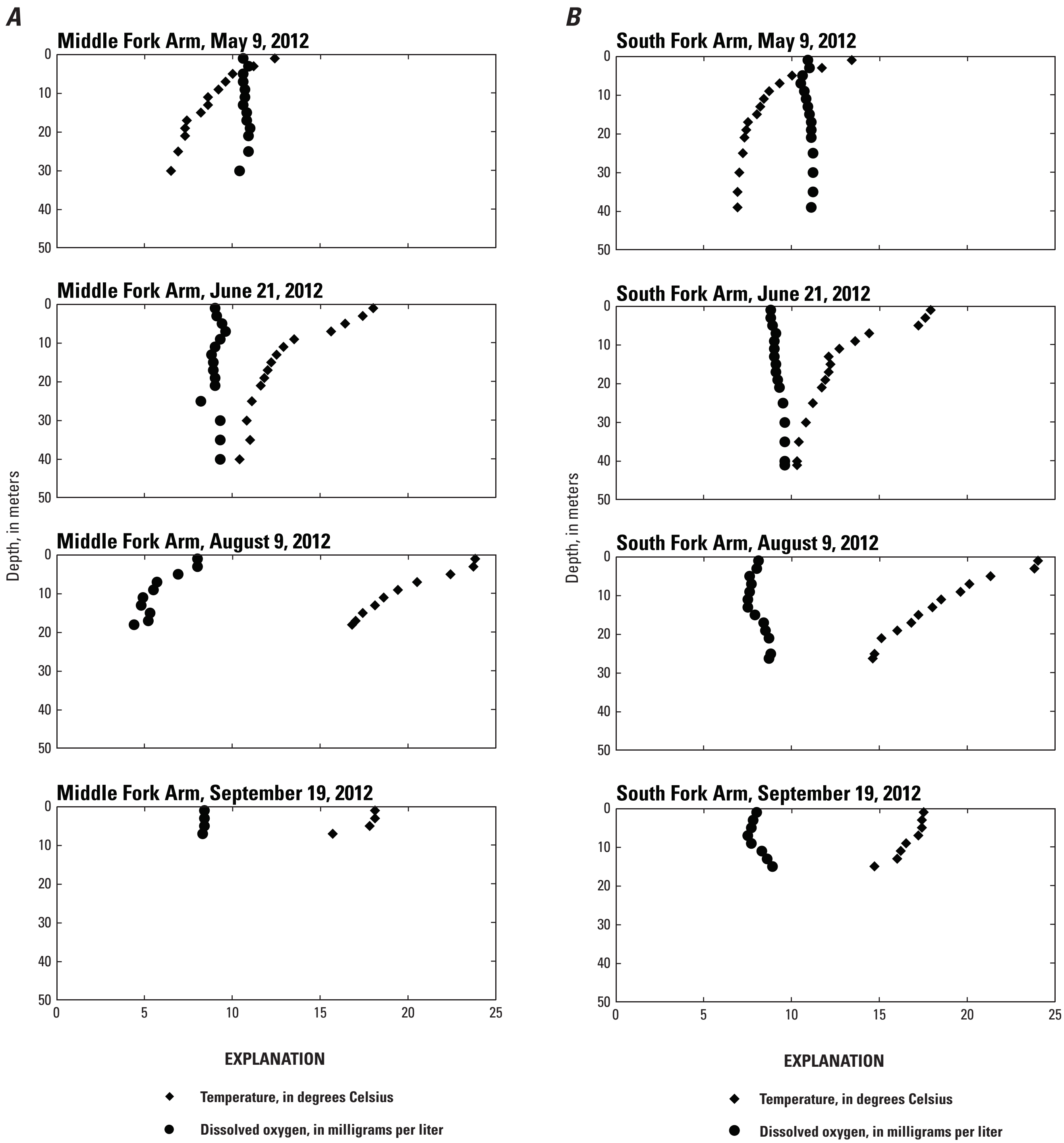

Figure 7. Temperature and dissolved oxygen profiles for (*A*) Middle Fork Arm (AR1), (*B*) South Fork Arm (AR2), and (*C*) Dam site (AR3), Arrowrock Reservoir, Idaho, 2012. See appendix A for all profile data.

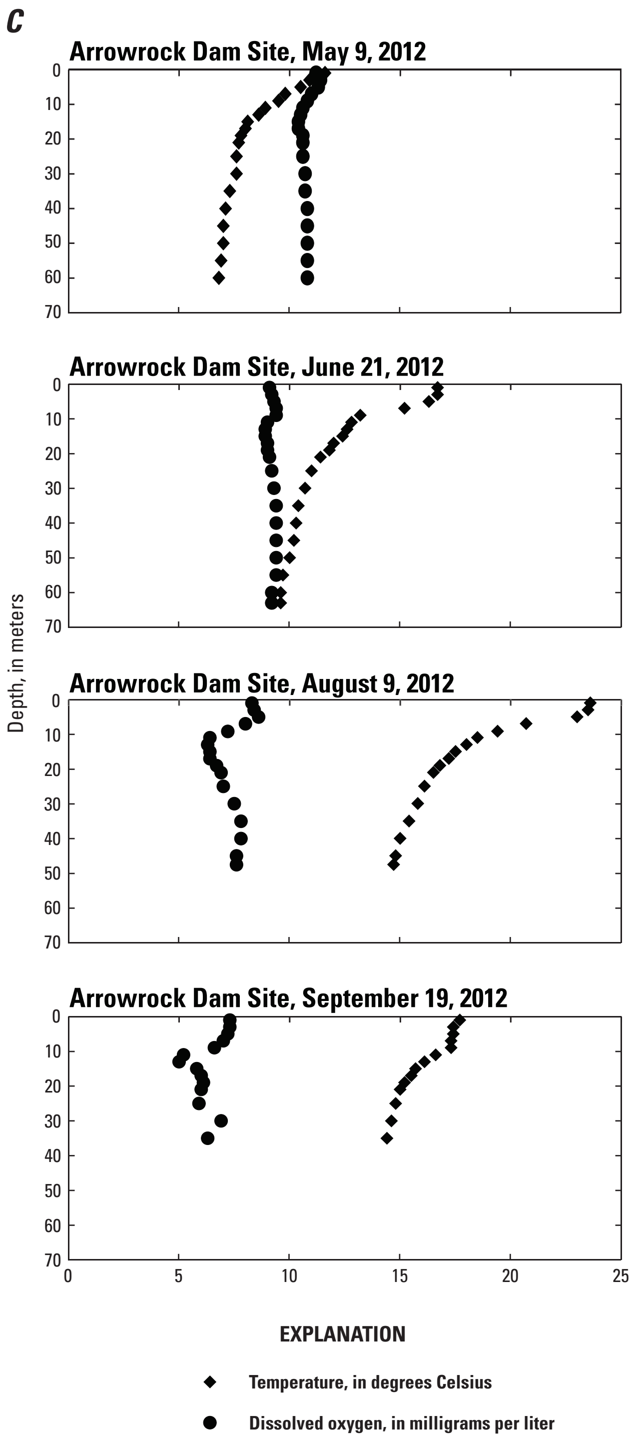

Figure 7.—Continued.

Summary

The acoustic telemetry study was designed to examine movement patterns and habitat use of bull trout residency during spring to summer (April–August) in Arrowrock Reservoir (Arrowrock), a highly regulated reservoir in southern Idaho. Acoustic telemetry technology, including mobile tracking and stationary receivers, was used to collect spatial data throughout Arrowrock during 2012. Temperature and depth sensors on tagged fish, along with periodic measures of Arrowrock water-temperature and dissolved-oxygen profiles, provided information on reservoir water-quality conditions during the study period.

The upper Boise River Basin (upstream of Arrowrock Dam) is in southwestern Idaho. The basin is about 5,700 square kilometers with altitude ranging from 930 to 3,230 meters (m). Arrowrock, a narrow canyon reservoir, typically has about 86 percent of its maximum annual volume depleted annually, equating to a lower water-surface elevation of about 945 m. The Middle Fork Boise (MFB) River is an unregulated river, whereas the South Fork Boise (SFB) River is regulated downstream of Anderson Ranch Dam and is free-flowing about 43.5 kilometers (km) before it enters Arrowrock. These two large tributaries create areas in the upper sections of Arrowrock where the rivers transition into lentic waters where bull trout are commonly found.

Mobile tracking of acoustic-tagged fish occurred from April 10 to August 21, 2012. The study area was broken up into three strata that were designated stratum 1, stratum 2, and stratum 3. Five tracking events were completed in each of the three strata. One fixed site LOTEK submersible acoustic receiver was placed in each stratum from May 7 to September 5, 2012 to record fish movements between Arrowrock and its two major tributaries, the MFB and SFB Rivers. Of the 18 bull trout implanted with acoustic tags, 15 (83 percent) were detected from April 10 to June 1, 2012. Most bull trout detections and movements were recorded in stratum 1. Only 2 of 16 detections were of live fish in strata 2 and 3 after release. The last acoustic-tagged bull trout was detected on June 1.

Based on GIS spatial analysis, the individual horizontal distances that bull trout traveled between detection times ranged from 0.1 to 11.8 km, with a mean of 5.2 km. Only two different bull trout were detected at the fixed receiver sites. There were no detections in the deepest part of Arrowrock near the dam, which is evidence that entrainment through Arrowrock Dam would be unlikely during spring to summer, when discharge releases would be highest. The relative error expected with our tracking within a GIS-generated polygon that contains 95 percent of the detections had a radius of 114 m. Reservoir stratification caused by water density differences, which occurred by July at this location, did not seem to influence the tag detection.

The complete departure of bull trout from Arrowrock was not anticipated based on assumptions that subadults probably would not migrate to spawn, and some adults would not migrate every year in response to energy availability and subsequent body condition. Bull trout movement in the MFB arm and upriver out of Arrowrock by early to mid-June coincides with the descending limb of the MFB River hydrograph. Most decline in Arrowrock water levels occurred after June 1, when bull trout were no longer detected. There were so few fish detections in the SRB arm (stratum 2) that no association to flow was discernible.

Daily water temperatures for both of these sites are also different because of impoundment effects. MFB river water temperatures are consistently colder in the winter and warmer in the summer than the SFB river. Summer water temperatures at the MFB River site are consistently greater than 15°C, whereas SFB River sites are consistently less than 15°C. Although colder water temperatures are available in the SFB River throughout the summer, the predominant movement patterns were in the MFB arm of Arrowrock, presumably to move upstream to spawn or live in the colder tributaries of the MFB River. A comparison using mobile tracking temperatures indicates that the actual temperatures of bull trout are lower than Arrowrock surface temperatures by an average of 3.0°C. Water surface temperatures at each fish detection ranged from 6.0 to 16.2°C, with a mean of 10.1°C, whereas bull trout body temperatures ranged from 4.4 to 11.6°C, with a mean of 7.3°C.

Detected bull trout were over deep water habitat ranging from 8.0 to 42.6 m, with a mean of 18.1 m. Actual fish depths were shallower, ranging from 0.0 to 24.5 m, with a mean of 6.7 m. Limnological data indicated that temperature and dissolved oxygen might be limiting factors on bull trout populations in Arrowrock, especially during warm summer months that coincide with lower water levels resulting from water withdrawals. Thermal refuge during this study appeared to be limited based on availability of water 15°C and cooler. From the first week of August through the latter part of September, little if any suitable habitat remained for bull trout, with most temperatures exceeding 15°C at all locations where water-quality profiles were measured.

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Appendix A. Biweekly Water-Quality Profiles at Three Locations in Arrowrock Reservoir, Idaho, May–October 2012

[From Megan Hacket, Bureau of Reclamation Pacific Northwest Laboratory Information Management System, written commun., 2012, Boise, Idaho. **Site No.:** AR1, Middle Fork Arm, latitude 43.62000°, longitude -115.82099°; AR2, South Fork Arm, latitude 43.58397°, longitude -115.82899°; AR3, Dam Site, (main reservoir), latitude 43.59194°, longitude -115.91700°. **Abbreviations:** °C, degrees Celsius; mg/L, milligram per liter; m, meter; NA, no data]

Date	Sample time	Temperature (°C)	Dissolved oxygen (mg/L)	Depth (m)
		ARI		
05-09-12	13:22	12.4	10.6	1
05-09-12	13:24	11.2	10.9	3
05-09-12	13:25	10.0	10.6	5
05-09-12	13:27	9.6	10.6	7
05-09-12	13:29	9.2	10.7	9
05-09-12	13:30	8.6	10.7	11
05-09-12	13:34	8.6	10.6	13
05-09-12	13:35	8.2	10.8	15
05-09-12	13:37	7.4	10.8	17
05-09-12	13:38	7.3	11.0	19
05-09-12	13:40	7.3	10.9	21
05-09-12	13:42	6.9	10.9	25
05-09-12	13:44	6.5	10.4	30
05-24-12	10:31	13.6	9.9	1
05-24-12	10:31	13.2	10.0	3
05-24-12	10:32	13.1	9.9	5
05-24-12	10:32	12.8	9.9	6
05-24-12	10:33	10.9	10.0	7
05-24-12	10:34	10.3	10.1	9
05-24-12	10:34	10.1	10.1	11
05-24-12	10:35	9.7	10.1	13
05-24-12	10:35	9.5	10.1	15
05-24-12	10:36	9.3	10.2	17
05-24-12	10:36	9.3	10.3	19
05-24-12	10:37	9.2	10.3	21
05-24-12	10:37	9.0	10.3	25
05-24-12	10:38	8.8	10.4	30
05-24-12	10:39	8.7	9.9	31.4
06-08-12	12:39	15.6	9.3	1
06-08-12	12:40	15.2	9.3	3
06-08-12	12:41	14.2	9.4	5
06-08-12	12:43	13.5	9.3	7
06-08-12	12:44	12.5	9.4	9
06-08-12	12:46	11.8	9.5	11
06-08-12	12:47	11.0	9.6	13
06-08-12	12:48	10.6	9.8	15
06-08-12	12:50	10.4	9.8	17
06-08-12	12:51	10.0	10.0	19
06-08-12	12:53	9.9	10.1	21
06-08-12	12:56	9.6	10.1	25
06-08-12	12:58	9.3	10.3	30
06-08-12	13:00	9.2	10.3	35
06-21-12	12:59	18.0	9.0	1
06-21-12	13:02	17.4	9.1	3
06-21-12	13:03	16.4	9.4	5
06-21-12	13:04	15.6	9.6	7
06-21-12	13:06	13.5	9.3	9

Date	Sample time	Temperature (°C)	Dissolved oxygen (mg/L)	Depth (m)
		ARI—Continued		
06-21-12	13:07	12.9	9.0	11
06-21-12	13:09	12.5	8.8	13
06-21-12	13:10	12.2	8.9	15
06-21-12	13:11	12.0	8.9	17
06-21-12	13:13	11.8	9.0	19
06-21-12	13:14	11.6	9.0	21
06-21-12	13:16	11.1	8.2	25
06-21-12	13:17	10.8	9.3	30
06-21-12	13:18	11.0	9.3	35
06-21-12	13:20	10.4	9.3	40
07-06-12	10:54	20.8	NA	1
07-06-12	10:55	20.3	NA	3
07-06-12	10:56	19.7	NA	5
07-06-12	10:57	16.8	NA	6
07-06-12	10:58	16.2	NA	7
07-06-12	10:59	15.1	8.4	9
07-06-12	11:00	14.5	8.6	11
07-06-12	11:01	14.0	8.7	13
07-06-12	11:02	13.6	8.7	15
07-06-12	11:03	13.4	8.8	17
07-06-12	11:04	13.1	8.8	19
07-06-12	11:06	12.8	8.7	21
07-06-12	11:08	12.5	8.6	25
07-06-12	11:09	12.1	8.7	30
07-06-12	11:10	12.0	8.6	31.5
07-26-12	09:30	23.1	7.8	1
07-26-12	09:49	23.1	7.8	3
07-26-12	09:50	22.5	7.7	5
07-26-12	09:51	22.3	7.2	7
07-26-12	09:52	18.3	6.8	9
07-26-12	09:52	17.5	7.0	11
07-26-12	09:53	16.8	7.0	13
07-26-12	09:53	16.2	7.1	15
07-26-12	09:54	15.7	6.6	17
07-26-12	09:54	15.4	6.8	19
07-26-12	09:55	15.1	7.0	21
07-26-12	09:57	14.6	6.8	23.8
08-09-12	12:49	23.8	8.0	1
08-09-12	12:50	23.7	8.0	3
08-09-12	12:51	22.4	6.9	5
08-09-12	12:51	20.5	5.7	7
08-09-12	12:54	19.4	5.5	9
08-09-12	12:55	18.6	4.9	11
08-09-12	12:55	18.1	4.8	13
08-09-12	12:56	17.4	5.3	15
08-09-12	12:57	17.0	5.2	17
08-09-12	12:58	16.8	4.4	18

Appendix A. Biweekly water-quality profiles at three locations in Arrowrock Reservoir, Idaho, May–October, 2012.—Continued

[From Megan Hacket, Bureau of Reclamation Pacific Northwest Laboratory Information Management System, written commun., 2012, Boise, Idaho. **Site No.:** AR1, Middle Fork Arm, latitude 43.62000°, longitude -115.82099°; AR2, South Fork Arm, latitude 43.58397°, longitude -115.82899°; AR3, Dam Site, (main reservoir), latitude 43.59194°, longitude -115.91700°. **Abbreviations:** °C, degrees Celsius; mg/L, milligram per liter; m, meter; NA, no data]

Date	Sample time	Temperature (°C)	Dissolved oxygen (mg/L)	Depth (m)
ARI—Continued				
08-24-12	09:33	21.5	7.7	1
08-24-12	09:34	21.4	7.5	3
08-24-12	09:35	20.9	6.6	5
08-24-12	09:36	20.0	5.6	7
08-24-12	09:37	19.4	4.7	9
08-24-12	09:38	19.2	4.1	10.4
09-05-12	11:32	20.4	7.0	1
09-05-12	11:33	17.0	7.2	3
09-19-12	09:45	18.1	8.4	1
09-19-12	09:47	18.1	8.4	3
09-19-12	09:49	17.8	8.4	5
09-19-12	09:50	15.7	8.3	7
10-04-12	13:06	16.7	9.1	1
10-04-12	13:07	16.5	9.1	3
10-04-12	13:08	16.4	9.0	5
100-4-12	13:08	16.3	9.0	7
10-04-12	13:09	15.6	9.1	9
10-04-12	13:10	12.8	9.2	9.5
AR2				
05-09-12	14:02	13.4	10.9	1
05-09-12	14:03	11.7	11.0	3
05-09-12	14:05	10.0	10.6	5
05-09-12	14:06	9.3	10.5	7
05-09-12	14:08	8.7	10.7	9
05-09-12	14:09	8.4	10.8	11
05-09-12	14:10	8.2	10.9	13
05-09-12	14:13	8.0	11.0	15
05-09-12	14:14	7.5	11.1	17
05-09-12	14:17	7.4	11.1	19
05-09-12	14:18	7.3	11.1	21
05-09-12	14:20	7.2	11.2	25
05-09-12	14:21	7.0	11.2	30
05-09-12	14:36	6.9	11.2	35
05-09-12	14:37	6.9	11.1	39
05-24-12	10:08	13.1	9.9	1
05-24-12	10:09	13.0	9.9	3
05-24-12	10:09	13.0	9.9	5
05-24-12	10:09	12.9	9.8	7
05-24-12	10:10	12.4	9.8	9
05-24-12	10:11	10.5	10.1	11
05-24-12	10:11	10.1	10.2	13
05-24-12	10:12	10.0	10.3	15
05-24-12	10:12	9.6	10.3	17
05-24-12	10:13	9.4	10.4	19
05-24-12	10:13	9.3	10.4	21
05-24-12	10:14	9.0	10.4	25
05-24-12	10:14	8.8	10.5	30
05-24-12	10:15	8.8	10.4	35
05-24-12	10:16	8.6	10.4	39.2

Date	Sample time	Temperature (°C)	Dissolved oxygen (mg/L)	Depth (m)
AR2—Continued				
06-08-12	13:40	15.2	9.4	1
06-08-12	13:42	15.2	9.4	3
06-08-12	13:45	15.3	9.4	5
06-08-12	13:47	14.6	9.4	7
06-08-12	13:49	12.9	9.3	9
06-08-12	14:09	12.1	9.4	11
06-08-12	14:10	11.4	9.5	13
06-08-12	14:12	11.2	9.5	15
06-08-12	14:14	10.8	9.5	17
06-08-12	14:15	10.6	9.6	19
06-08-12	14:16	10.3	9.7	21
06-08-12	14:18	10.1	9.7	25
06-08-12	14:19	9.6	9.9	30
06-08-12	14:21	9.4	9.9	35
06-08-12	14:22	9.3	9.8	40
060-8-12	14:24	9.2	9.5	42.4
06-21-12	12:09	17.9	8.8	1
06-21-12	12:11	17.6	8.8	3
06-21-12	12:13	17.2	8.9	5
06-21-12	12:14	14.4	9.1	7
06-21-12	12:15	13.6	9.0	9
06-21-12	12:16	12.7	9.0	11
06-21-12	12:17	12.1	9.0	13
06-21-12	12:18	12.2	9.1	15
6-21-12	12:19	12.1	9.1	17
6-21-12	12:19	11.9	9.2	19
6-21-12	12:20	11.7	9.3	21
6-21-12	12:22	11.2	9.5	25
6-21-12	12:23	10.8	9.6	30
6-21-12	12:24	10.4	9.6	35
6-21-12	12:26	10.3	9.6	40
6-21-12	12:27	10.3	9.6	41
07-06-12	11:32	21.9	8.2	1
07-06-12	11:33	21.6	8.2	3
07-06-12	11:34	20.7	8.4	4
07-06-12	11:35	19.9	8.6	5
07-06-12	11:36	18.0	9.0	6
07-06-12	11:37	16.7	8.9	7
07-06-12	11:38	15.9	8.8	8
07-06-12	11:39	15.5	8.6	9
07-06-12	11:40	14.9	8.3	11
07-06-12	11:41	14.6	8.3	13
07-06-12	11:42	14.2	8.5	15
07-06-12	11:43	13.8	8.6	17
07-06-12	11:44	13.6	8.7	19
07-06-12	11:45	13.3	8.8	21
07-06-12	11:46	12.8	9.0	25
07-06-12	11:48	12.5	9.1	30
07-06-12	11:50	12.0	9.2	35

Appendix A. Biweekly water-quality profiles at three locations in Arrowrock Reservoir, Idaho, May–October, 2012.—Continued

[From Megan Hacket, Bureau of Reclamation Pacific Northwest Laboratory Information Management System, written commun., 2012, Boise, Idaho. **Site No.:** AR1, Middle Fork Arm, latitude 43.62000°, longitude -115.82099°; AR2, South Fork Arm, latitude 43.58397°, longitude -115.82899°; AR3, Dam Site, (main reservoir), latitude 43.59194°, longitude -115.91700°. **Abbreviations:** °C, degrees Celsius; mg/L, milligram per liter; m, meter; NA, no data]

Date	Sample time	Temperature (°C)	Dissolved oxygen (mg/L)	Depth (m)
AR2—Continued				
07-06-12	11:52	11.6	9.1	39.3
07-26-12	10:26	23.5	7.9	1
07-26-12	10:29	23.3	8.0	3
07-26-12	10:30	21.4	7.9	5
07-26-12	10:30	19.3	8.0	7
07-26-12	10:32	18.2	7.9	9
07-26-12	10:32	17.3	7.5	11
07-26-12	10:33	16.6	7.7	13
07-26-12	10:34	16.2	8.0	15
07-26-12	10:34	15.8	8.2	17
07-26-12	10:35	15.4	8.4	19
07-26-12	10:36	15.0	8.6	21
07-26-12	10:37	14.4	8.8	25
07-26-12	10:37	13.4	9.0	30
07-26-12	10:38	13.3	9.0	31.8
08-09-12	13:15	24.0	8.1	1
08-09-12	13:16	23.8	8.0	3
08-09-12	13:17	21.3	7.6	5
08-09-12	13:17	20.1	7.7	7
08-09-12	13:18	19.6	7.6	9
08-09-12	13:19	18.5	7.5	11
08-09-12	13:19	18.0	7.5	13
08-09-12	13:20	17.2	7.9	15
08-09-12	13:21	16.8	8.4	17
08-09-12	13:22	16.0	8.5	19
08-09-12	13:22	15.1	8.7	21
08-09-12	13:23	14.7	8.8	25
08-09-12	13:24	14.6	8.7	26.2
08-24-12	08:58	21.2	8.0	1
08-24-12	08:59	21.2	7.9	3
08-24-12	09:00	21.2	8.0	5
08-24-12	09:00	20.0	4.6	7
08-24-12	09:01	19.2	4.9	9
08-24-12	09:02	18.6	6.2	11
08-24-12	09:03	16.8	7.8	13
08-24-12	09:04	15.4	8.4	15
08-24-12	09:06	15.2	8.4	17
08-24-12	09:07	15.1	8.4	18.3
09-05-12	10:42	19.5	7.3	1
09-05-12	10:43	19.4	7.3	3
09-05-12	10:44	19.4	7.2	5
09-05-12	10:45	18.1	7.5	7
09-05-12	10:46	15.1	8.3	9
09-05-12	10:47	14.7	8.5	11
09-19-12	11:12	17.5	8.0	1
09-19-12	11:13	17.4	7.8	3
09-19-12	11:14	17.4	7.7	5
09-19-12	11:15	17.2	7.5	7
09-19-12	11:16	16.5	7.7	9
09-19-12	11:17	16.2	8.3	11
09-19-12	11:18	16.0	8.6	13
09-19-12	11:19	14.7	8.9	15
10-04-12	11:23	16.1	8.7	1
10-04-12	11:24	16.1	8.7	3
10-04-12	11:25	16.0	8.7	5
10-04-12	11:25	16.1	8.6	7
10-04-12	11:26	16.0	8.7	9
10-04-12	11:27	16.0	8.6	11
10-04-12	11:27	16.0	8.7	13
10-04-12	11:28	15.6	8.8	15
10-04-12	11:29	15.4	9.0	16
10-04-12	11:30	13.4	9.1	17
10-04-12	11:31	13.4	9.1	17.9
AR3				
05-09-12	10:29	11.6	11.2	1
05-09-12	10:30	10.9	11.4	3
05-09-12	10:32	10.5	11.3	5
05-09-12	10:35	9.8	11.0	7
05-09-12	10:37	9.5	10.8	9
05-09-12	10:40	8.9	10.6	11
05-09-12	10:42	8.6	10.5	13
05-09-12	10:44	8.1	10.4	15
05-09-12	10:47	8.0	10.4	17
05-09-12	10:49	7.8	10.6	19
05-09-12	10:50	7.7	10.6	21
05-09-12	10:52	7.6	10.6	25
05-09-12	10:54	7.6	10.7	30
05-09-12	10:57	7.3	10.7	35
05-09-12	10:59	7.1	10.8	40
05-09-12	11:01	7.0	10.8	45
05-09-12	11:04	7.0	10.8	50
05-09-12	11:06	6.9	10.8	55
05-09-12	11:08	6.8	10.8	60
05-24-12	08:51	10.4	10.1	1
05-24-12	08:53	10.3	10.1	3
05-24-12	08:54	10.3	10.2	5
05-24-12	08:55	10.3	10.1	7
05-24-12	08:56	10.1	10.1	9
05-24-12	08:57	10.0	10.0	11
05-24-12	09:10	10.0	10.0	13
05-24-12	09:10	9.8	10.0	15
05-24-12	09:11	9.5	10.0	17
05-24-12	09:12	9.5	10.0	19
05-24-12	09:13	9.4	10.0	21
05-24-12	09:13	9.2	10.1	25
05-24-12	09:14	9.1	10.1	30
05-24-12	09:15	9.0	10.2	35

Appendix A. Biweekly water-quality profiles at three locations in Arrowrock Reservoir, Idaho, May–October, 2012.—Continued

[From Megan Hacket, Bureau of Reclamation Pacific Northwest Laboratory Information Management System, written commun., 2012, Boise, Idaho. **Site No.:** AR1, Middle Fork Arm, latitude 43.62000°, longitude -115.82099°; AR2, South Fork Arm, latitude 43.58397°, longitude -115.82899°; AR3, Dam Site, (main reservoir), latitude 43.59194°, longitude -115.91700°. **Abbreviations:** °C, degrees Celsius; mg/L, milligram per liter; m, meter; NA, no data]

Date	Sample time	Temperature (°C)	Dissolved oxygen (mg/L)	Depth (m)
AR3—Continued				
05-24-12	09:16	8.8	10.3	40
05-24-12	09:16	8.6	10.4	45
05-24-12	09:17	8.5	10.4	50
05-24-12	09:18	8.4	10.4	55
05-24-12	09:18	8.4	10.4	60
05-24-12	09:20	8.3	10.0	61.8
06-08-12	16:00	15.5	9.5	1
06-08-12	16:01	15.1	9.6	3
06-08-12	16:02	14.1	9.9	5
06-08-12	16:03	13.7	9.9	7
06-08-12	16:04	12.4	9.9	9
06-08-12	16:07	11.5	9.7	11
06-08-12	16:08	11.0	9.8	13
06-08-12	16:09	10.8	9.7	15
06-08-12	16:11	10.5	9.6	17
06-08-12	16:12	10.1	9.6	19
06-08-12	16:13	10.0	9.6	21
06-08-12	16:14	9.7	9.6	25
06-08-12	16:16	9.6	9.7	30
06-08-12	16:18	9.4	9.8	35
06-08-12	16:19	9.2	9.8	40
06-08-12	16:20	9.2	9.8	41.8
06-21-12	08:21	16.7	9.1	1
06-21-12	08:23	16.7	9.2	3
06-21-12	08:46	16.3	9.3	5
06-21-12	08:47	15.2	9.4	7
06-21-12	08:48	13.2	9.4	9
06-21-12	08:49	12.8	9.0	11
06-21-12	08:50	12.6	8.9	13
06-21-12	08:51	12.4	8.9	15
06-21-12	08:52	12.0	9.0	17
06-21-12	08:52	11.8	9.0	19
06-21-12	08:53	11.4	9.1	21
06-21-12	08:54	11.0	9.2	25
06-21-12	08:55	10.7	9.3	30
06-21-12	08:56	10.4	9.4	35
06-21-12	08:57	10.3	9.4	40
06-21-12	08:58	10.2	9.4	45
06-21-12	08:59	10.0	9.4	50
06-21-12	09:00	9.7	9.4	55
06-21-12	09:02	9.6	9.2	60
06-21-12	09:03	9.6	9.2	63
07-06-12	12:24	21.6	8.5	1
07-06-12	12:25	21.3	8.4	3
07-06-12	12:26	20.9	8.5	5
07-06-12	12:27	19.8	8.8	7
07-06-12	12:28	17.8	9.3	8
07-06-12	12:29	16.2	9.4	9
07-06-12	12:30	15.4	9.1	10

Date	Sample time	Temperature (°C)	Dissolved oxygen (mg/L)	Depth (m)
AR3—Continued				
07-06-12	12:31	15.0	8.9	11
07-06-12	12:32	14.7	8.8	13
07-06-12	12:33	14.3	8.7	15
07-06-12	12:34	13.9	8.6	17
07-06-12	12:35	13.6	8.5	19
07-06-12	12:36	13.5	8.5	21
07-06-12	12:37	13.1	8.4	25
07-06-12	12:38	12.4	8.5	30
07-06-12	12:39	12.2	8.5	35
07-06-12	12:40	12.1	8.6	40
07-06-12	12:41	11.8	8.7	45
07-06-12	12:42	11.7	8.8	50
07-06-12	12:43	11.4	8.6	55
07-06-12	12:44	11.2	8.5	60
07-06-12	12:45	11.2	8.4	60.8
07-26-12	11:46	23.9	8.1	1
07-26-12	11:46	23.5	8.2	3
07-26-12	11:47	22.7	8.3	5
07-26-12	11:49	20.2	7.8	7
07-26-12	11:50	18.2	7.6	9
07-26-12	11:51	17.1	7.4	11
07-26-12	11:52	16.4	7.6	13
07-26-12	11:53	16.0	7.8	15
07-26-12	11:53	15.6	7.9	17
07-26-12	11:54	15.3	8.0	19
07-26-12	11:55	15.0	8.0	21
07-26-12	11:56	14.8	8.0	25
07-26-12	11:57	14.5	7.9	30
07-26-12	11:58	14.4	8.0	35
07-26-12	11:59	14.1	8.1	40
07-26-12	11:59	13.9	8.0	45
07-26-12	12:00	13.6	7.8	50
08-09-12	11:58	23.6	8.3	1
08-09-12	12:00	23.5	8.4	3
08-09-12	12:01	23.0	8.6	5
08-09-12	12:03	20.7	8.0	7
08-09-12	12:04	19.4	7.2	9.2
08-09-12	12:04	18.5	6.4	11
08-09-12	12:06	18.0	6.3	13
08-09-12	12:07	17.5	6.4	15
08-09-12	12:08	17.2	6.4	17
08-09-12	12:08	16.8	6.7	19
08-09-12	12:09	16.5	6.9	21
08-09-12	12:10	16.1	7.0	25
08-09-12	12:11	15.8	7.5	30
08-09-12	12:12	15.4	7.8	35
08-09-12	12:13	15.0	7.8	40
08-09-12	12:14	14.8	7.6	45
08-09-12	12:16	14.7	7.6	47.5

Appendix A. Biweekly water-quality profiles at three locations in Arrowrock Reservoir, Idaho, May–October, 2012.—Continued

[From Megan Hacket, Bureau of Reclamation Pacific Northwest Laboratory Information Management System, written commun., 2012, Boise, Idaho. **Site No.:** AR1, Middle Fork Arm, latitude 43.62000°, longitude -115.82099°; AR2, South Fork Arm, latitude 43.58397°, longitude -115.82899°; AR3, Dam Site, (main reservoir), latitude 43.59194°, longitude -115.91700°. **Abbreviations:** °C, degrees Celsius; mg/L, milligram per liter; m, meter; NA, no data]

Date	Sample time	Temperature (°C)	Dissolved oxygen (mg/L)	Depth (m)
AR3—Continued				
08-24-12	10:38	21.0	8.0	1
08-24-12	10:39	20.9	8.0	3
08-24-12	10:40	20.9	7.9	5
08-24-12	10:41	19.8	5.6	7
08-24-12	10:42	19.3	5.4	9
08-24-12	10:42	18.9	5.4	11
08-24-12	10:43	18.4	5.4	13
08-24-12	10:44	18.0	5.5	15
08-24-12	10:45	17.6	5.0	17
08-24-12	10:46	17.4	5.1	19
08-24-12	10:46	17.3	5.4	21
08-24-12	10:47	16.6	6.3	25
08-24-12	10:48	16.2	6.9	30
08-24-12	10:50	15.4	7.1	35
08-24-12	10:50	15.0	7.2	40
09-05-12	12:14	19.8	6.4	1
09-05-12	12:15	19.2	6.5	3
09-05-12	12:16	19.1	6.4	5
09-05-12	12:17	18.9	5.1	7
09-05-12	12:17	18.4	3.3	9
09-05-12	12:18	17.9	3.6	11
09-05-12	12:19	17.5	4.5	13
09-05-12	12:19	17.0	4.9	15
09-05-12	12:20	16.5	5.8	17
09-05-12	12:21	16.1	6.2	19
09-05-12	12:21	15.6	6.6	21
09-05-12	12:22	15.3	6.9	25
09-05-12	12:23	14.9	7.1	30
09-05-12	12:24	14.6	6.8	33
09-19-12	12:53	17.7	7.3	1
09-19-12	12:54	17.4	7.3	3
09-19-12	12:55	17.4	7.2	5
09-19-12	12:56	17.3	7.0	7
09-19-12	12:56	17.3	6.6	9
09-19-12	12:57	16.6	5.2	11
09-19-12	12:58	16.1	5.0	13
09-19-12	12:58	15.7	5.8	15
09-19-12	12:59	15.5	6.0	17
09-19-12	12:59	15.2	6.1	19
09-19-12	13:00	15.0	6.0	21
09-19-12	13:01	14.8	5.9	25
09-19-12	13:02	14.6	6.9	30
09-19-12	13:04	14.4	6.3	35
10-04-12	09:03	15.8	6.9	1
10-04-12	09:04	15.8	6.8	3
10-04-12	09:05	15.8	6.8	4
10-04-12	09:06	15.8	6.8	5
10-04-12	09:06	15.8	6.8	7
10-04-12	09:07	15.8	6.9	8
10-04-12	09:08	15.8	6.9	9
10-04-12	09:09	15.7	6.6	11
10-04-12	09:09	15.5	5.7	13
10-04-12	09:10	15.4	5.6	15
10-04-12	09:10	15.2	5.7	17
10-04-12	09:11	15.1	5.8	19
10-04-12	09:11	15.1	5.7	20
10-04-12	09:12	15.0	5.9	21
10-04-12	09:13	14.8	6.2	25
10-04-12	09:13	14.6	6.7	30
10-04-12	09:14	14.3	6.2	35
10-04-12	09:15	14.0	3.3	39.2

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