FISH DIVISION
Oregon Department of Fish and Wildlife

Migration Patterns of Adult Bull Trout in the Metolius River and Lake Billy Chinook, Oregon
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ABSTRACT

Twenty-two maturing adfluvial bull trout *Salvelinus confluentis* were captured, implanted with radio transmitters, and released where the Metolius River enters Lake Billy Chinook between April and July of 1994. Fourteen of the surgeries were successful. Nine transmitters remained functional in live fish, and these fish were monitored through December 1994. Fish locations were determined biweekly using an airplane from April through December. During September, the primary spawning season, fish locations were determined weekly using a helicopter. Most bull trout remained near the mouth of the Metolius River until mid-July when they initiated their upstream migration. After migration commenced, most fish quickly moved up the Metolius River and resided near the mouth of the intended spawning tributary. Migration into the spawning tributary stream, spawning, and migration back to the mainstem Metolius River was usually accomplished within one month. Three fish migrated into Whitewater River where bull trout spawning previously had not been documented, and are presumed to have spawned there. The Whitewater River bull trout migrated upstream faster and earlier than fish spawning in other tributary streams. All nine bull trout with functioning transmitters migrated back to Lake Billy Chinook by December.

INTRODUCTION

Bull trout *Salvelinus confluentis* are a state and federal "sensitive" species, which have received considerable attention in recent years from fishery managers and anglers alike. The U.S. Fish and Wildlife Service determined that "listing" bull trout as threatened or endangered throughout their range was "warranted but precluded" in 1994 and 1995 due to higher priority species. The listing status of bull trout will be reviewed annually. This increased concern for bull trout has intensified the need to ensure that bull trout populations are adequately monitored.

An adfluvial population of bull trout exists in the Metolius River and Lake Billy Chinook in central Oregon. These bull trout spawn from mid-July to early October in small, cold water tributaries to the Metolius River (Ratiff 1992). Juvenile bull trout rear in their natal streams for two to three years before migrating to Lake Billy Chinook. After two to three years in the reservoir (Age 5 or 6), they migrate back up the Metolius River during April-July, and spawn during September in their natal tributary to complete the life cycle (Rishle et al., in press).

During recent years, a popular bull trout fishery has developed in Lake Billy Chinook because these fish have the potential to reach trophy size. Approximately 1,000 bull trout are harvested annually from Lake Billy Chinook (Thiesfeld et al. 1995). Redd counts in the known spawning areas have increased from 27 redds in 1986 to 330 in 1994 (Fies and Marx 1995), apparently due to increasingly restrictive angling regulations, and suggest that the population is increasing (Ratiff et al. 1994). However, mark and recapture population estimates suggested that more bull trout spawners existed than were accounted for by redd counts in the known spawning areas (Ratiff et al. 1994). To accurately assess the effects of harvest on the population, all major spawning areas needed to be identified. However, unsurveyed potential spawning areas in the Metolius River basin are in relatively inaccessible areas.
Bull trout spawning locations have been determined with radio telemetry in the North Fork Lewis River, Washington (M. Faler, U.S. Forest Service, Wind River Ranger District, Carson, Washington, personal communication), and other locations in the western United States (Schill et al. 1994) and Canada (McLeod and Clayton, in press; Golder and Associates 1994). Radio telemetry (1) appears especially well suited to studying spawning behavior of fluvial bull trout because their habitat is often widely dispersed in rugged, inaccessible areas (Schill et al. 1994), (2) has been used to document critical spawning habitats (McLeod and Clayton, in press), and (3) can help prioritize areas to conduct spawning ground counts (Golder and Associates 1994). Because of the inaccessibility of unsurveyed portions of the Metolius River basin, we decided to use radio telemetry to determine if additional spawning locations existed in the system. To accomplish this objective, adult bull trout preparing for their upstream migration were captured where the Metolius River enters Lake Billy Chinook, implanted with radio transmitters, and their movements monitored through the spawning season.

STUDY AREA

The Metolius River starts as a large spring near the base of Black Butte and flows north and then east around Green Ridge approximately 45 km into Lake Billy Chinook at River Kilometer (RK) 20.6. The lower 20.6 km were inundated by the creation of Lake Billy Chinook with the construction of Round Butte Dam on the Deschutes River at RK 177 in 1964. A number of tributaries enter the Metolius River from the west. Progressing downstream from the start of the river, these are Lake (RK 64.0), Spring (RK 63.4), First (RK 60.0), Jack (RK 58.6), Canyon (RK 57.3), Abbot (RK 47.2), Candle (RK 46.7), and Jefferson (RK 46.4) creeks, and Whitewater River (RK 29.6; Figure 1). Of these, Spring, Jack, Canyon, Abbot, Candle, and Jefferson creeks are greatly influenced by cold water springs (~5°C). These springs contribute to the cool temperatures and relatively stable flows in the Metolius River. Whitewater River is a large, glacially influenced stream originating on the east slope of Mount Jefferson. It is generally more turbid and has a greater fluctuation in flows than the Metolius River and its spring fed tributaries. Gauging stations on the Metolius River (RK 20.6), Jefferson Creek (RK 0.8), and Whitewater River (RK 4.5) show the highest flows generally occur in June for all three streams.

Lake Billy Chinook has a surface area of 1,619 hectares and is located in the canyons of the Metolius, Deschutes, and Crooked rivers. The Deschutes River and Crooked River arms run parallel, north and south, whereas the Metolius River arm extends to the west. Lengths of these arms are 13 km, 10 km, and 21 km, respectively. Upstream and downstream passage for both anadromous and resident fish at the Pelton-Round Butte hydroelectric complex was terminated in 1968.

Native fish in the Metolius River and Lake Billy Chinook included bull trout, summer steelhead and rainbow trout Oncorhynchus mykiss, chinook salmon O. tshawytscha, sockeye salmon and kokanee O. nerka, mountain whitefish Prosopium williamsoni, largescale sucker Catostomus macrocheilus, bridgelip sucker C. columbianus, longnose dace Rhinichthys cataractae, northern squawfish Ptocholepis oregonensis, chiselmouth Acrocheilus alutaceus, shorthead sculpin Cottus confusus, torrent sculpin C. rotundus, slimy sculpin C. cognatus, and mottled sculpin C. bairdi (Fies and Robart 1988). Spring chinook, summer steelhead, and
sockeye salmon are no longer present because passage was terminated. Introduced species include brown trout Salmo trutta, brook trout S. fontinalis, largemouth bass Micropterus salmoides, smallmouth bass M. dolomieu, bluegill Lepomis macrochirus, black crappie Pomis nigromaculatus, and goldfish Carassius auratus.

Previous surveys have located spawning bull trout in Jack, Canyon, Candle, and Jefferson creeks, and to a lesser extent in the Metolius River near the mouth of Jack Creek (Ratliff 1992; Fies and Marx 1995; Riehle et al, in press). Bull trout have been observed in the Crooked and Deschutes rivers upstream of Lake Billy Chinook. However, no spawning or young-of-the-year bull trout have been observed in these areas, suggesting that these habitats are used only for rearing.

Figure 1. The Lake Billy Chinook and Metolius River system.
METHODS

Fish Collection and Surgery

Twenty-two bull trout (>560 mm fork length) were collected by angling near the mouth of the Metolius River (RK 20.6; Figure 1) from mid-April through June 1994. Generally, two adults were collected once weekly for transmitter implants and held in live cages in the river until surgery. Fish were anesthetized with Fintrol (105 mg/L) for surgery.

Radio transmitters (73 X 16 mm, 27 g, 150-151 Mhz) were surgically implanted through a 40-mm incision in the abdominal cavity posterior to and slightly dorsal to the pelvic fin, closely following the procedures outlined by Hart and Summerfelt (1975), except that an additional 5-mm incision was made 25 mm posterior to the main incision to allow for protrusion of the flexible wire antenna. Incisions were closed using non-absorbable nylon sutures. The antenna exit incision was closed with a single suture. A sequentially numbered Floy anchor tag was inserted near the base of the dorsal fin. “Radio tagged fish, please release” was printed on the anchor tags. Fork length was measured and the fish were released at the capture location after they had recovered from the anesthesia. Nineteen of the transmitters were manufactured by Advanced Telemetry Systems, while three were manufactured by Custom Telemetry Systems.

Monitoring

Fish locations were determined biweekly from an airplane from April through December 1994. During September, the primary spawning season, fish locations were determined weekly using a helicopter. Monitoring flights (~150 m above ground level) generally started near the capture location and proceeded up the Metolius River and each of the tributaries to locate radio-tagged fish. Individual radio frequencies were scanned for two-second intervals until a signal was identified. Fish locations were determined to be at the point of maximum signal strength and were recorded using a Loran. Additional ground monitoring occurred when time was available and to verify aerial results.

RESULTS

Of the 22 bull trout implanted with radio transmitters, 13 radio-tagged bull trout migrated upstream into the Metolius River system. A 14th fish was harvested by an angler at the capture location before commencing its migration, and the radio transmitter was recovered. (Table 1 and Appendix A). Eight fish could not be tracked or did not move after surgery. These fish either shed the transmitter or the fish succumbed to the stress of surgery. Two of these eight fish were later recaptured without their transmitters and no information is available about their migration. One entered Jefferson Creek in September with its incision completely healed, apparently to complete the spawning cycle.
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<th>Freq. (MHz)</th>
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<td>Spawned Jack Creek</td>
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Of the 13 fish that we were able to track, three fish migrated to previously unknown spawning areas in Whitewater River. Six radio-tagged bull trout migrated to known spawning areas in Jack (2), Jefferson (2), Candle (1), and Canyon (1) creeks, although the fish that spawned in Canyon Creek was difficult to follow due to a weak radio signal. One fish was observed near the mouth of Jack Creek, but its exact spawning location was not determined. Three radio-tagged bull trout apparently were not able to complete their migrations. One fish migrated 24.5 km upstream and the signal was not located after 2 August. Two fish migrated 11.2 km upstream and stopped. Their transmitters were found later without carcasses, one up on the river bank. All three of these fish migrated past the mouth of Whitewater River and apparently were destined for the upper river spawning tributaries. We suspect these three fish were illegally harvested.

Most radio-tagged fish either remained near the tagging location or moved back into Lake Billy Chinook immediately after tagging. Fish remaining near the tagging location demonstrated very little movement. Some radio-tagged bull trout appeared to make false
starts on their spawning migration, moving upstream a short distance (<2 km), and then returning to the tagging location. Because our monitoring flights occurred biweekly, we were unable to determine the precise time between surgery and commencement of upstream migration. However, fish may have began their migration within 16 days and all fish had migrated by 102 days. The average time between surgery and commencement of the upstream migration was 66 days. One bull trout apparently initiated migration in May, one in June, seven in July, and three in August. There was no apparent trend between the date of surgery and the length of time before upstream migration commenced. Fish migrating into Whitewater River were all tagged before May 11 and had initiated their upstream migration by early July. Most fish migrating to the upper Metolius River tributaries initiated their migration between mid-July and mid-August (Table 2).

Table 2. The number of radio-tagged bull trout at specific locations in the Lake Billy Chinook/Metolius River system during 1994, indicating the general migration timing. One fish was located only intermittently.

<table>
<thead>
<tr>
<th>Month</th>
<th>Lake Billy Chinook/Mouth of Metolius R.</th>
<th>Metolius R.</th>
<th>Tributaries</th>
</tr>
</thead>
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<td>May</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>7</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>August</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>September 6th</td>
<td>6</td>
<td></td>
<td>4</td>
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<td>September 13th</td>
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<td></td>
<td>7</td>
</tr>
<tr>
<td>September 20th</td>
<td>4</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>September 29th</td>
<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>October</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>November</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>December</td>
<td>9</td>
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</table>

We observed three distinct migration patterns after commencement of migration for the nine fish monitored on a regular basis. In the first pattern, two bull trout quickly moved up the Metolius River and resided near the mouth of the intended spawning stream for one to four weeks. Migration into the spawning tributary stream, spawning, and migration back to the mainstem Metolius River was accomplished within two weeks. These fish then migrated back to Lake Billy Chinook in less than two weeks (Figure 2). Four fish followed a second pattern in which the upstream migration was similar to the first pattern. However, these fish took over a month to make the downstream journey to Lake Billy Chinook after spawning (Figure 3). Three fish followed a third pattern, which led to the documentation of additional spawning areas in Whitewater River. Fish spawning in Whitewater River migrated upstream to the spawning grounds faster than fish spawning in other tributary streams, held near the spawning area for up to two months, spawned, and then moved quickly back to Lake Billy Chinook (Figure 4).
Figure 2. Locations and dates of radio-tagged bull trout destined for the upper Metolius River tributaries to spawn. This migration pattern was exhibited by two of the radio-tagged bull trout. This bull trout was tagged on 10 May 1994 at the mouth of the Metolius River.
Figure 3. Locations and dates of radio-tagged bull trout destined for the upper Metolius River tributaries to spawn. This migration pattern was exhibited by four of the radio-tagged bull trout. This bull trout was tagged on 24 May 1994 at the mouth of the Metolius River.
Figure 4. Locations and dates of radio-tagged bull trout destined for Whitewater River to spawn. This migration pattern was exhibited by three of the radio-tagged bull trout. This bull trout was tagged on 26 April 1994 at the mouth of the Metolius River.
DISCUSSION

Three adult bull trout migrated up Whitewater River demonstrating that bull trout are spawning in this previously undocumented area. Although our sample size was small, three of the 13 fish (23%) indicates a substantial proportion of the spawning population has been missed during previous redd counts. All three of the fish migrating into Whitewater River appear to have spawned between RK 17.1 and RK 20.0, probably because this location has a lower gradient (1.6%) than the first 17 km of Whitewater Creek (2.7%) and appears to have substantial spring input. Ground surveys conducted during early October 1994 confirmed spawning bull trout and redds in this reach.

Radio-tagged bull trout spent an average of 66 days at the confluence of the Metolius River and Lake Billy Chinook between surgery and initiation of their upstream migration. We are not sure whether this behavior was typical or an artifact of the surgery. Other bull trout have been recaptured in the same area up to 60 days after tagging with Floy anchor tags (Ratliff et al. 1994). If this behavior is typical, it suggests that these fish are extremely vulnerable to angling pressure, which occurs near the mouth of the Metolius River. Following these radio-tagged bull trout for an additional year may help determine whether bull trout typically spend such a long period near the mouth of the river.

Considerable variation in the timing of the upstream spawning migration has been observed in other locations, and the impetus for initiating the spawning migration is not clearly understood. Adult bull trout move upstream out of Flathead Lake, Montana, toward spawning tributaries as early as April, arriving in the North and Middle forks of the Flathead River in June and July (Fraley and Shepard 1989). In the Rapid River system, Idaho, fluvial bull trout migrated past a trapping site starting in late April with the entire run migrating past the facility by mid-July (Schill et al. 1994). McLeod and Clayton (in press) found similar timing for fluvial bull trout in the Athabasca River, Alberta. Adfluvial bull trout initiated their upstream migration out of Oldman Reservoir, Alberta, either by June, or in August and September (Golder and Associates 1994). Oliver (1979) reported upstream migration occurring from July to September in the Wigwam River, British Columbia. Our results show upstream migration occurred later than most other bull trout populations, possibly because of the relatively short distance traveled.

Radio-tagged bull trout in the Metolius River undergo shorter migrations than bull trout in other systems; the longest migration in this study was less than 40 km. Bjorn and Mallet (1964) reported fish movement of up to 325 km from original tagging sites in the Middle Fork Salmon River, Idaho. Schill et al. (1994) observed movements up to 100 km in Rapid River. Bull trout in the Flathead River system traveled between 88 km and 250 km to reach spawning tributaries (Fraley and Shepard 1989). The shorter migration distance may explain why Metolius River bull trout migrate later than bull trout in other systems.

Freshets and water temperature have also been suggested as the impetus to initiate upstream migration. McPhail and Murray (1979) found peak upstream movement to coincide with peak spring freshets and lower temperatures. In the Rapid River system, Elle and Thurow (1994) found that counts of upstream migrating bull trout peaked as day time high water temperatures increased to 10°C during the day and flow levels declined following a freshet. They were unable to determine if the causative factor was water temperature, water clarity, or flow. However, fish movement ceased when temperatures dropped below 10°C. Two peaks in
spawning runs have been recorded by Oliver (1979) and McPhail and Murray (1979), apparently due to age of the fish. The fish making up the earlier portion of the run were the smallest and youngest, and stayed in spawning tributaries or staging areas for the longest periods of time.

Water temperatures and flows in the Metolius River and its tributaries are remarkably stable (Riehle 1993) and probably do not influence bull trout movements. Water temperature in the Metolius River at RK 48.8 seldom exceeds 10°C between June and October. Water temperature drops slightly (~2°C) during early August, well after bull trout migrations have commenced. Canyon, Candle, Jack and Jefferson creeks, where bull trout spawn, also remain well below 10°C during this period, and often the mean daily temperature is below 8°C. As with the Metolius River, water temperatures typically cool by 1-2°C during early August.

Flow in the Metolius River is very stable. The minimum flow occurs in October (~38 m³/s) and is 83% of the peak flow, which occurs in June (~46 m³/s). Typically, freshets do not occur because most of the system is greatly influenced by springs. Thus, neither decreasing water temperature, nor changes in flow appear to be key factors prompting bull trout migrations in the Metolius River. Future water temperature and flow monitoring, and continued monitoring of these radio-tagged bull trout may explain whether warming water temperature or flows are a causative factor in the commencement of the upstream migration.

A major difference was observed in the timing and pattern of upstream migration exhibited by fish migrating into Whitewater River versus those fish destined for upper river tributaries. Whitewater River bull trout migrated upstream farther, an average of 19 km versus 2 km, and migrated closer to the peak of the hydrograph than did fish migrating into upper river tributaries. For example, a typical fish migrating up Whitewater River entered the stream in early July, while a typical Jefferson Creek fish entered the stream in early September (Figure 5). Although flows in the Metolius River, Jefferson Creek and Whitewater River all peak in June, the decline in flow through the summer is proportionally higher in Whitewater River. In Whitewater River, August flow is approximately 65% of the June flow, while in Jefferson Creek, August flow is approximately 73% of the June flow. Elevation gain may also be a factor in determining migration timing. Whitewater River bull trout gained 482 m of elevation, while Jefferson Creek bull trout gained 171 m of elevation. We propose that Whitewater River bull trout migrate earlier than upper Metolius River bull trout because their migration is longer, they gain more elevation, and the decline in flow is more extreme.

The two different upstream migration patterns are similar to the migration patterns exhibited by bull trout in Swift Reservoir (M. Faler, U.S. Forest Service, Wind River Ranger District, Carson, Washington, personal communication). Bull trout spawning in Pine Creek migrated upstream quickly and resided near their intended spawning area throughout the summer. Bull trout spawning in Rush Creek held in the mainstem Lewis River near the mouth of Rush Creek until late summer, then migrated upstream quickly to spawn. Faler speculates that these patterns are in response to temperature differences in the streams rather than flow differences. Both of these streams are snow melt/rain event dominated, with peaks in the hydrographs occurring in winter or late spring. Water temperature in Pine Creek peaks at 16°C at the mouth during midsummer, but reaches only 8°C in the area where bull trout hold throughout the summer. The high temperature at the mouth probably represents a thermal barrier to upstream migration. Water temperature in Rush Creek peaks at 11°C near the mouth and 9°C near the spawning area.
Figure 5. Migration of radio tagged-bull trout into Jefferson Creek and Whitewater River during 1994, and mean monthly flows in Jefferson Creek and Whitewater River.
Other authors have offered different hypotheses for the differential timing of entry into the tributary streams. Fraley and Shepard (1989) reported that adfluvial bull trout migrating out of Flathead Lake into the Flathead River remained at the mouths of spawning tributaries for two to four weeks during which time feeding was thought to be limited. They speculated that bull trout formed pairs at this time because most bull trout entered upstream migrant traps in pairs. However, McPhail and Murray (1979) suggested that bull trout pair bonding occurred during upstream migration and before reaching full maturity in spawning tributaries.

While bull trout migrating to the upper Metolius River tributaries held near the tributary mouth for two to four weeks, their entry into the stream, spawning, and migration out generally took less than two weeks. Bull trout in the Flathead River system were usually not in spawning condition when they entered spawning tributaries, but held in the tributaries for up to a month or more in deeper holes or near log or debris cover. This pattern was more similar to the pattern exhibited by Whitewater River bull trout. Bull trout migrating into Whitewater River were also among the earliest fish tagged. This fact, along with the different migration patterns, and the different hydrological characteristics of Whitewater River (glacial input), may indicate that these fish represent a distinct subpopulation or genetic group. Bull trout were collected from the upper Metolius River tributaries and Whitewater River in the summer of 1995 to determine if genetic differences exist.

The quick migration rate back to the reservoir exhibited by most fish in this study appears to be similar to bull trout populations elsewhere. Oliver (1979) and Shepard et al. (1984) suggested that females may head back to wintering areas immediately after egg deposition. Unfortunately, we were not able to sex our fish during surgery to examine this hypothesis. McLeod and Clayton (in press) observed that fluvial bull trout in the Athabasca River system, Alberta, commenced their downstream migration shortly after spawning and returned to their overwintering area by the end of October. Golder and Associates (1994) found that adfluvial bull trout in the Oldman River system, Alberta, migrated back to Oldman Reservoir shortly after spawning.

Natural mortality during the spawning migration appears to have been zero for radio-tagged bull trout. Three fish did not complete their migration. However, we believe their loss was due to illegal harvest, rather than natural mortality. No mortality was recorded for radio-tagged bull trout which apparently spawned. No radio-tagged bull trout from Swift Reservoir, Washington, which make relatively short migrations into the Lewis River system, suffered mortality (M. Faler, U.S. Forest Service, Wind River Ranger District, Carbon, Washington, personal communication). Schill et al. (1994) reported a spawning migration mortality rate in 1992 of 67% for Rapid River bull trout, where spawning migrations may be 100 km. Elle and Thurow (1994) reported a mortality rate of 47% for all upstream migrating bull trout. Bull trout larger than 450 mm suffered a mortality rate of 58%. It appears the combination of relatively short migrations, stable streamflows, and high water quality allows for a high survival rate for bull trout spawning in the Metolius River basin. With the apparent low spawning mortality shown in this study, an increased number of larger, older adults may be possible in this population with protection from excessive angler harvest and illegal harvest.

Eight of the surgeries were unsuccessful. These fish either did not undergo migrations into the Metolius River or they moved downstream into Lake Billy Chinook and the radio signal was not recorded again. Two fish were recaptured without the transmitter, one of which
successfully migrated upstream to spawn in Jefferson Creek with the incision completely healed. We suspect the six other fish also shed the radio transmitter or died. All three fish that received the transmitters manufactured by Custom Telemetry Systems migrated back into Lake Billy Chinook and shed the transmitter or died. During surgery, we noticed that an unidentified black substance came off these transmitters, which indicated that the transmitters were not encased with an inert material as requested. We believe this substance may have adversely effected the bull trout implanted with these tags.

ACKNOWLEDGMENTS

We would like to thank the Oregon Department of Fish and Wildlife, the Confederated Tribes of the Warm Springs Reservation of Oregon, Portland General Electric Company, the Ochoco National Forest, the Prineville District of the Bureau of Land Management, Trout Unlimited, and the National Fish and Wildlife Foundation which provided financial support for this project. We thank Eric Schulz, who completed much of the monitoring; Roy "Murdoch" Panter of the Oregon State Police, who piloted us on most of our flights; Bill "Is this close enough?" Griffiths, our helicopter pilot from Portland General Electric Company; the Wizard Falls Fish Hatchery crew, who provided us with practice specimens; Mark Healy, who provided us with flow data; and Doug and Mo Calvin, who weathered a weekly horde of biologists and interested parties at the capture location. We thank Mike Faler and Flip Shively, who graciously shared their surgical techniques, skills and knowledge with a couple of novice fish surgeons. Finally, we also thank Jim Griggs, Dave Buchanan, and Beth Stewart, who provided helpful comments that improved the manuscript.
REFERENCES


The following table lists the locations of the radio-tagged bull trout by month:

<table>
<thead>
<tr>
<th>Date</th>
<th>FLK</th>
<th>FLK</th>
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</thead>
</table>

Appendix A

Conversion: Temperature in °C = °F - 32 / 1.8.

Variables used in the table:
- CR = Crooked River
- Am = Arbutus Creek
- LW = Little Willow Creek
- P = Painter Creek
- F = Falls Creek
- RV = Rainbow Valley
- TK = Taylor Creek
- LN = Long Creek
- CA = Canadian Creek
- Y = Yellow Creek
- M = Myrtle Creek
- IL = Indian Lake
- LY = Little York Creek
- CV = Cottonwood Creek
- A = Alsea River
- VI = Vida Creek
- NL = North Fork
- FL = French Creek
- BC = Boiler Creek
- XM = Xanadu Creek

Note: Locations corresponding to FLK are indicated as follows: V = Willow Creek, E = East Fork, W = White River, R = Red River, P = Proctor Creek, A = Alsea River, and B = Boiler Creek.
Table A-1. Expected fish locations in river mile so the reader can easily identify locations on USGS maps. Readid tags are expected to tag fish from 1.00 to 1.10 am. Am of Lake Billy Chinook.

<table>
<thead>
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<th>Frequency</th>
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<td>1/27</td>
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<td>4:29</td>
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<tr>
<td>4:29</td>
<td>5/12</td>
<td>1/27</td>
</tr>
</tbody>
</table>

Appendix Table A-2. Location of radio tagged bull trout by river mile (RM) in the Metolius River. This table is essentially the same as Appendix.