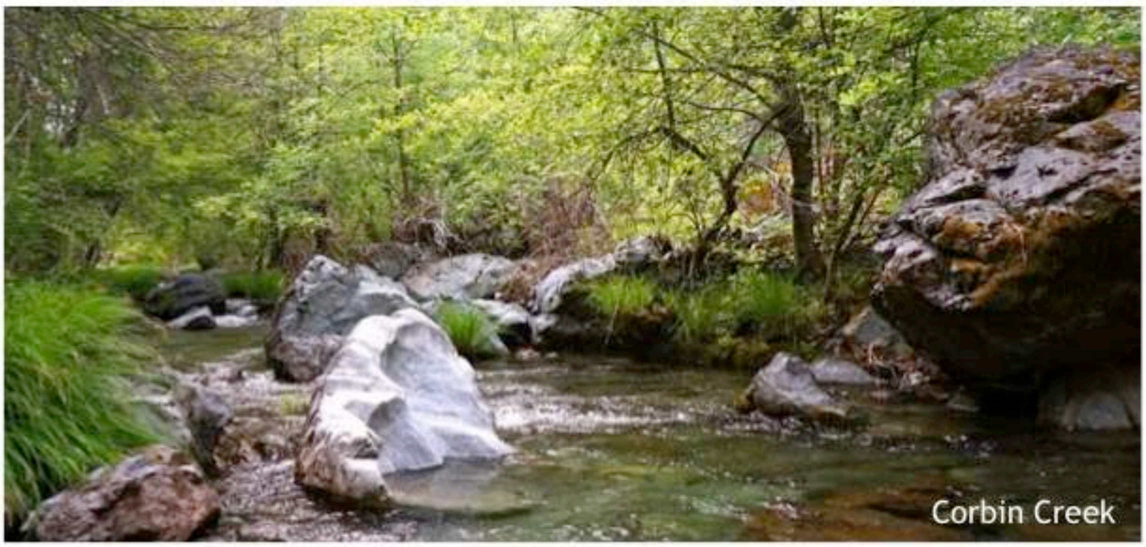
Native Fish Society

2015 & 2016 Upper Eel River Temperature Monitoring Report



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Native Fish Society
Upper Eel River Temperature Monitoring Report
Data from Years: 2015 & 2016

Report prepared by Jake Crawford, Southern Regional Manager, Native Fish Society

July 2017

Executive Summary

For the last two years, Native Fish Society staff, River Stewards and volunteers have placed fourteen digital temperature monitors in the upper mainstem of California's Eel River and its tributaries above Scott Dam/Lake Pillsbury. Our goal is to contribute a greater scientific understanding about the area's potential to serve the temperature-driven life history requirements of native fish in the upper Eel watershed including salmon, steelhead and trout.

To date, we have completed two years of water temperature data collection to learn whether the headwater tributaries of the Eel River flowing into the mainstem Eel River above Scott Dam would remain at temperatures suitable for salmonids during the warmest summer months, if in the future wild salmon and steelhead were to gain access to currently inaccessible but previously occupied headwater tributaries. While temperature monitoring has been conducted throughout the watershed by California Department of Fish and Wildlife, Pacific Gas and Electric (PG&E), University of California, Humboldt State University, and other public, private and community groups, no extensive multiyear monitoring has been done of the tributaries above Scott Dam to date. This report provides the most comprehensive set of temperature monitoring data in the Eel River's headwaters that we are aware of.

The Eel River has historically and is currently heavily impacted by anthropogenic and environmental changes, including agriculture, forestry, dams, irrigation diversions, road building and historic catastrophic flooding. It is unknown to what degree these changes have impacted the normal temperature thresholds in the river, but current observations have identified that each year some parts of the Eel River watershed often exceed temperatures suitable for salmonids (20°C/68°F). Past observations of the Eel River temperature regime have noted, "Over half of the mainstem and major tributary channels can be considered thermally lethal during some portion of the summer. This was probably true before significant human impact, yet huge salmon populations flourished" (Trush, 1992). As such, any cold, clean source of water accessible, or potentially accessible, to salmonids could be of great benefit to the recovery of threatened and sensitive populations and may be critical to their long-term survival as they search for cold water refugia given climate change projections over the next fifty to eighty years.

Analysis of our first two years of temperature monitoring data, collected from June – October in 2015 and 2016, shows that there is significant potential for upper Eel River tributaries to provide important cold water sources, offering both suitable and even optimal temperature for the life history requirements of salmonids during warm summer months, while the mainstem Eel River hovers at temperatures considered lethal for salmonids. According to the National Center for Environmental Information from the National Oceanic and Atmospheric Administration, 2015 and 2016 ranked as record (2015) and above average (2016) maximum temperatures for the 122 years that temperature data has been collected. Our temperature monitoring data demonstrates that cold-water sources suitable for salmonids exist above Scott Dam, and that the upper mainstem Eel is uniquely well suited to provide a buffer against dry and hot years, such as seen in 2015 and 2016. In addition, the modeled effects of a changing climate suggest that increased air temperatures have the potential to limit the quantity and quality of summer rearing habitat, making the cold water above Scott Dam increasingly important. The following report describes our methods, sampling sites, results and discussion for two years of temperature monitoring collection.

About Native Fish Society

Founded in 1995, the Native Fish Society utilizes the best-available science and our grassroots network of River Stewards to conserve and restore the Northwest's wild, native fish and safeguard their freshwater habitats. The Native Fish Society has 3,500 members and supports 90 volunteer River Stewards in Oregon, Washington, western Idaho and northern California.

Acknowledgements

The ongoing temperature-monitoring project would not be possible without the efforts of many organizations and individuals. Among them are: California Department of Fish and Wildlife, which has provided oversight and information about site locations; the California State Water Resources Control Board, which provided temperature monitors and invaluable assistance and input; Redwood Coast District Coordinaor Samantha Kannry who helped coordinate volunteers and identify site locations; and the numerous volunteers and partners working on behalf of the Eel River and its wild, native fish. In particular, we would like to thank River Steward Dustin Revel, River Steward Dane Downing, Bruce Hilbach-Barger, Jason Hartwick, Rose Dana, Shaun Thompson, Rich Zellman, Pat Higgins and the Eel River Recovery Project, Mary Lou Mileck and Bob Lashinski for their time, effort and guidance in conducting this project.

2015 Monitoring Crew

2016 Monitoring Crew

2015 Left to Right: Jason Hartwick, Samantha Kannry, Rose Dana, Mark Sherwood, Dustin Revel
2016 Left to Right: Rose Dana, Jake Crawford & Arrow, Samantha Kannry, Rich Zellman
Not Pictured: Dane Downing and Bruce Hilbach-Barger

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I. Introduction to the Eel River

The Eel River is a remarkable, diverse and expansive watershed. Numerous accounts of the Eel River have been written in environmental reports, scientific studies, and other literature that provide both historic and current characterizations of the river (see Kubicek, 1977; VTN Oregon, 1982; United States Forest Service and Bureau of Land Management, 1995; Becker & Reining, 2009; Yoshiyama & Moyle, 2010; National Marine Fisheries Service, 2014; Asarian, 2015; National Marine Fisheries Service, 2015). This report is limited to the rationale, methods, documentation and discussion of our multi-year temperature monitoring efforts, which identified and reported on cold-water sources in the upper mainstem Eel River and it's tributaries above Scott Dam and Lake Pillsbury.

a. Size and Location

California's Eel River is the third largest watershed in the state and encompasses a drainage of nearly 3,700 square miles of diverse and rugged terrain (Yoshiyama & Moyle, 2010). Four out of the five major forks of the Eel River's headwaters start out of the west side of the California Coast Range from wilderness areas in the Mendocino National Forest with elevations of 6,000 - 8,000 feet. Flowing northwest through three counties (Lake, Mendocino, and Glen), the Eel River eventually empties into the Pacific Ocean thirteen miles south of Eureka, California. Due to its Mediterranean like climate, almost all precipitation falls as rain or snow (at elevations above 5,000 feet) in the winter, and virtually no rain falls in the summer, which results in periods of low flow and warm water temperatures occurring from June to October (Yoshiyama & Moyle, 2010; Asarian, 2015).

b. Wild, Native Fish

Historically, the Eel River contained the third largest run of salmonids in California, behind the Sacramento and Klamath Rivers, collectively totaling over a million fish returning annually (Yoshiyama & Moyle, 2010). The Eel River is home to fall-run California Coast Chinook salmon (*Oncorhynchus tshawytscha*), Southern Oregon Northern California coho salmon (*O. kisutch)*, winter-run and summer-run North California Coast steelhead (*O. mykiss*), resident rainbow trout (*O. mykiss)*, anadromous coastal cutthroat trout (*O. clarkii*), Pacific Lamprey (*Entosphenus tridentatus*) and Green sturgeon (*Acipenser medirostris*). Of these populations, Chinook salmon, coho salmon and steelhead have all seen dramatic declines in historic populations and are currently listed as *threatened* under the federal Endangered Species Act (Yoshiyama & Moyle, 2010).

Populations of wild, native fish in the Eel River have declined as a result of both anthropogenic and biological changes that have occurred over the last century (NMFS, 2005; Yoshiyama & Moyle, 2010). These impacts include over-harvest by commercial fisheries, habitat degradation from road building and agriculture, catastrophic flooding, legal and illegal water diversions, competition and predation from piscivorous non-native species, and loss of access to historically available suitable habitat upstream of Lake Pillsbury, created by Scott Dam in 1922 (Yoshiyama & Moyle, 2010; NMFS, 2014).

Threatened populations in the upper mainstem Eel River include distinct population segments of North California Coast Steelhead with summer-run and winter-run life history components, and fall-run California Coast Chinook salmon (NMFS, 2011). The upper Mainstem Eel River steelhead population consists of the watershed area beginning at the confluence of Soda Creek (1.3 miles below Scott Dam) and encompasses the area above Scott Dam/Lake Pillsbury and its associated tributaries (NMFS, 2015). The Upper Eel River Chinook salmon population includes all fish spawning upstream of the South Fork Eel River confluence, and all major tributaries including the Middle Fork Eel River (NMFS, 2011). Historical reviews analyzing trends in population status of upper Eel River Chinook salmon and steelhead are varied in exact numbers; however, in general, with precautions in data interpretation, NFMS has identified that current population abundance is trending downward and are considered very low compared to historical estimates (NMFS, 2011).

c. Scott Dam and Lake Pillsbury

Situated in the upper reach of the Eel River Basin, Scott Dam and Cape Horn Dam represent the most significant dams in the Eel watershed and are part of the system that creates the Potter Valley Project (NMFS, 2014). Constructed in the early 20th century, Cape Horn Dam forms the 700 acre-foot storage reservoir Van Arsdale, and is located 11 miles below Scott Dam, which forms the 75,000 acre-foot storage reservoir Lake Pillsbury (NMFS, 2014). In total, the Potter Valley Project consists of the two dams and reservoirs, a tunnel and a powerhouse that provide the neighboring Russian River with water for irrigation and up to 9.4 megawatts of hydroelectric power to the nearby city of Ukiah (Potter Valley Water Irrigation District, 2016).

The Potter Valley Project dams block historic spawning and rearing habitat upstream of Scott Dam, and have been identified as some of the most significant negative effects on salmon and steelhead for Upper Mainstem anadromous salmonid populations in the Eel River (NMFS, 2014; NMFS, 2015). Migrating fish are capable of reaching the habitat above the lower Cape Horn Dam/Van Aresdale Reservoir, however access was anthropogenically limited until renovations to the fish ladder were made in 1987 (Yoshiyama & Moyle, 2010). Combined with more recent amendments to stream flow management required by the Federal Energy Regulatory Commission (FERC) in 2004 these changes have resulted in improved conditions for migrating fish between the dams (NMFS, 2014; NMFS, 2015). Scott Dam is located immediately below the confluence of the Rice Fork Eel River, Salmon Creek, and Squaw Valley Creek and was built without fish passage. Depending on the source, Scott Dam blocks from 35 miles to over 200 miles of potential spawning and rearing habitat for anadromous salmonids (VTN, 1982; USFS and BLM, 1995; NMFS 2015). Moreover, to what extent resident *O. mykiss* utilize Lake Pillsbury for an adfluvial life history strategy is unknown (NMFS, 2015).

The Upper Eel Watershed above Scott Dam is an area primarily under the management of the United States Forest Service (USFS) Mendocino National Forest and consists of roughly 290 square miles, representing around 7.3 percent of the total Eel River watershed (NMFS, 2015). Scott Dam and the Potter Valley Project began relicensing discussions and preliminary scoping in 2017, and our project goal is to help contribute a better scientific understanding of the potential cold-water sources in the Upper Eel River as part of the FERC relicensing process.

II. Water Temperature and Salmonids

Of all the factors that affect salmonid biology, temperature is probably the most important environmental influence (Brannon, 1993; USEPA, 2001). Different salmonids have evolved to adapt to different temperature regimes based on local environmental conditions, and run-timing for anadromous salmonids is critically linked to water temperature in order to optimize survival strategies for migration, spawning, incubation, emergence and rearing (USEPA, 2001). Studies on the effects of temperature on salmonids are numerous, and have identified that water temperature can affect nearly every phase of their life histories, including their metabolisms, upstream and downstream migration, spawning, rearing, food ability, smoltification, swimming speed, result in direct and delayed mortality, cause increased disease, and alter the competitive dominance of other predators (USEPA, 2001; Carter, 2005; Kubicek, 1977; Elliot 1981). Moreover, the duration and severity of the time in which salmonids are exposed to thermal pressures can affect their long-term survival (Carter, 2005; Ligon et al., 1999).

III. Methods

In 2015 and 2016, Native Fish Society staff, River Stewards, and volunteers set fourteen remote digital temperature loggers in various creeks above Scott Dam/Lake Pillsbury that we believed had the potential to discharge a substantial amount of cold water throughout the summer and exhibit thermal refugia for salmonids. These locations were based on prior fieldwork for the California Department of Fish and Wildlife (CDFW) completed by one of our volunteer River Stewards, Samantha Kannry. Our hypothesis was that if accessible to anadromous fish, these areas were likely to sustain cold flows throughout the periods of low flow and warm water temperatures typical to the Eel watershed from June - October.

We used Onset Corporation temperature probes calibrated and set according to the criteria developed by the Stream Temperature Protocol outlined by the Forest Science Project, Humboldt State University (Lewis, 1999). Loggers were obtained in cooperation with the California Water Resources Control Board, as well as purchased from Onset Corporation by Native Fish Society. Each logger was calibrated according to National Institute of Standards and Technology (NIST) criteria, and set to record one reading every 30 minutes from the date of setting, running from the end of May to the first week of June, until they were retrieved the second week of October in 2015 and 2016. We utilized two types of Onset Hobo temperature probes, including the Hobo Tidbit V2 Temp Logger (UTBI-001) and Hobo Water Temp Pro V2 (U22-001). The Onset Tidbit UTBI-001 and Pro V2 U22 were selected because they are easy to use, measure temperatures over a wide temperature range (-40°C to 70°C), and have a ±0.2 °C accuracy (Onset, 2016). Probes were attached to postcard sized steel plates (3" x 6") with industrial strength plastic zip ties, and submerged under water out of direct sunlight. All monitor placement coordinates were recorded in WGS84, and raw data files and pictures of site locations are available upon request.

Onset Hobo Tidbit V2 Temp Logger (UTBI-001)

Onset Hobo Water Temp Pro V2 (U22-001)

Based on the United States Environmental Protection Agency's "Summary of Technical Literature Examining the Physiological Effects of Temperature on Salmonids" (EPA-910-D-01-005, 2001), we've highlighted two lines for graphical representation of our monitoring data, including "Suitable for Salmonids" with temperatures <20°C, and "Optimal for Salmonids" at temperatures <18°C. We drew the 20°C notation from Friedrichsen (1998), which offers:

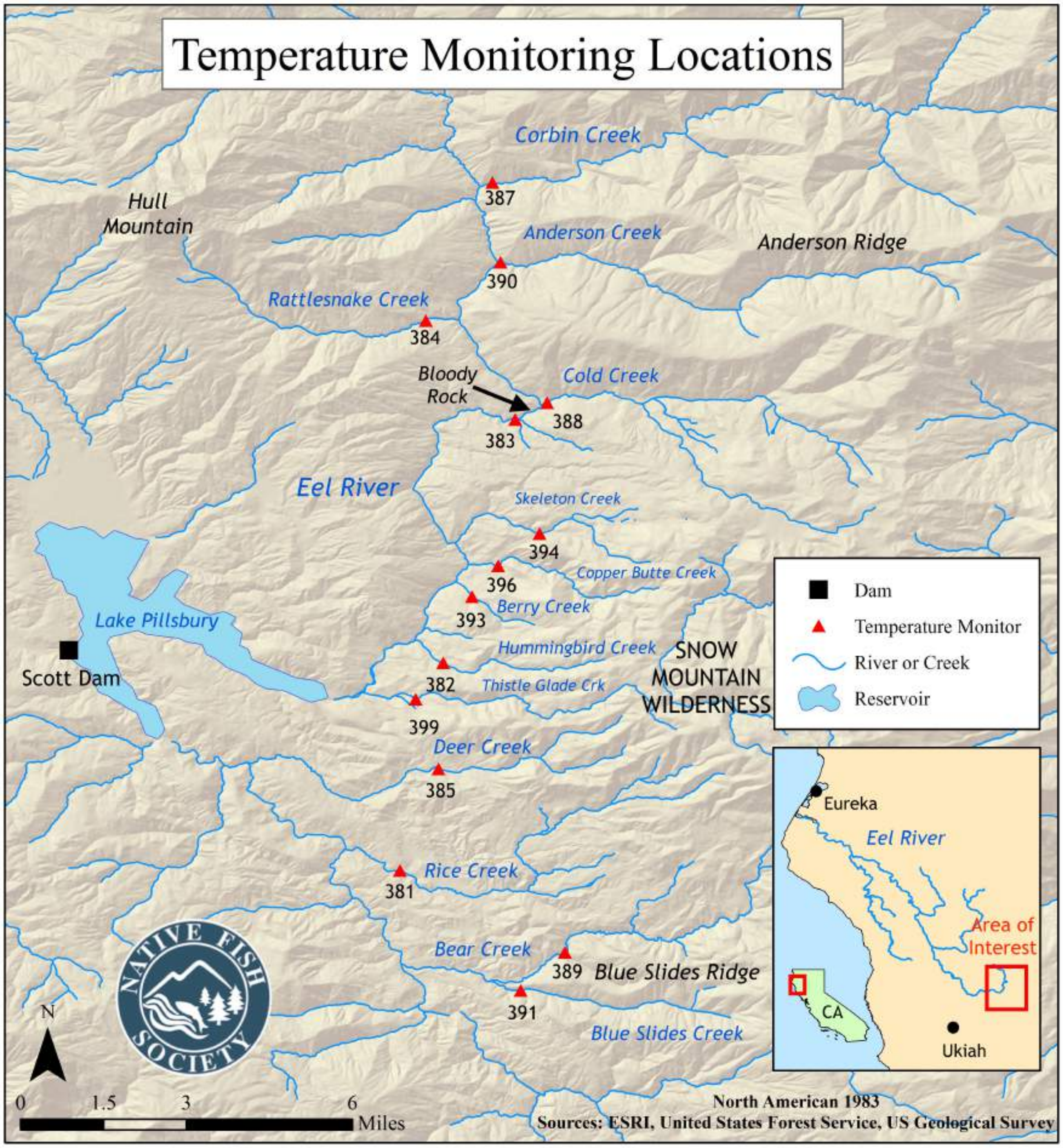
> "The figures denote 20°C as the threshold of stress for salmonids (Bjornn and Reiser, 1991). Although some species such as coho salmon may have a lower threshold for stress (Spence et al. 1996), the 20°C value presents a simple but useful reference point. Some comparison of maximum temperature between the field seasons of 1996 and 1997 are made with results from 1973 as measured by Kubicek (1977). These maximum weekly temperatures are not specifically relevant salmonid health in that they are momentary high points, however, they are useful for general discussion."

In summary, we recognize that these temperature thresholds vary between species, life history stages, and duration of exposure and should be used solely as visual references.

IV. Temperature Monitor Locations

We sought to collect data that would help determine if the tributaries above Scott Dam could provide suitable year round cold-water habitat and thermal refuge for salmonids. Site locations were selected based on their potential to discharge a substantial amount of cold water throughout the summer due to their size, location, and primarily snow fed sources. Preliminary surveys from field observations and information from local state agency staff helped inform decisions for temperature monitor placements. Temperature monitors were deployed during the last week of May and first week of June, and were retrieved the second week of October, in 2015 and 2016.

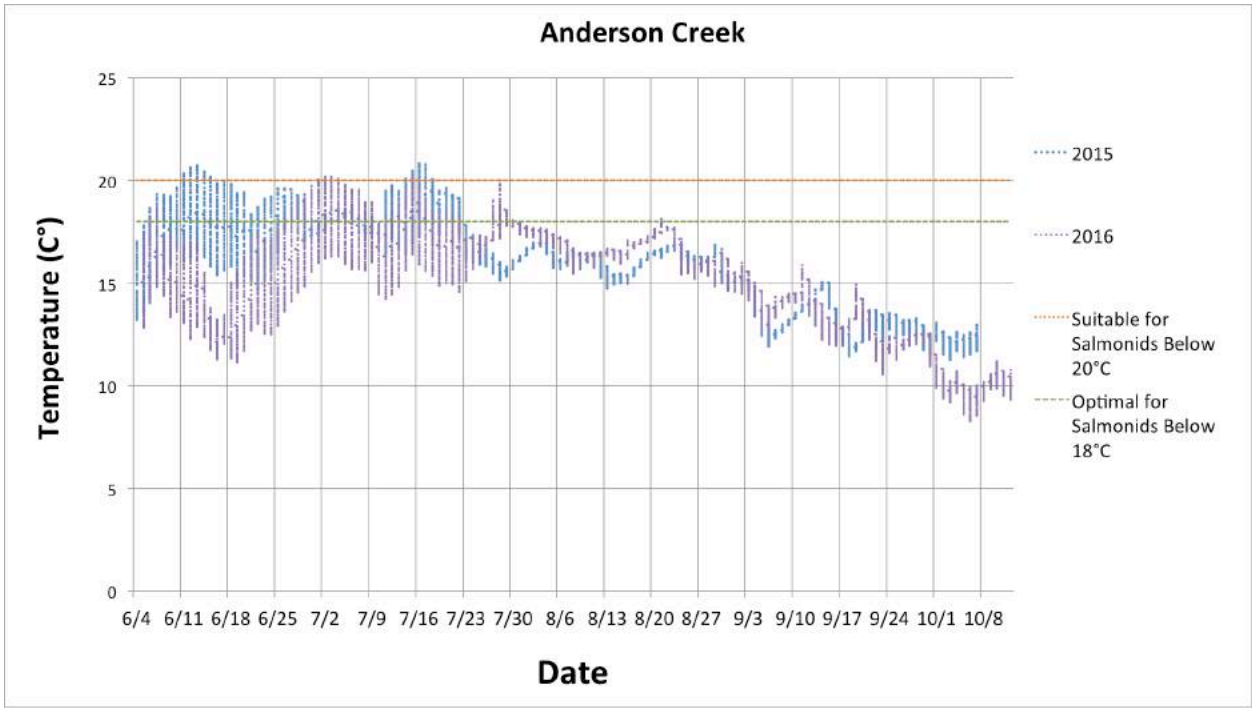
Figure 1. Map of Monitoring Locations.



Temperature Monitors:

Temperature Monitors:	390 – Anderson Creek	389 – Bear Creek
393 – Berry Creek	391 – Blue Slides Creek	388 – Cold Creek
396 – Copper Butte Creek	387 – Corbin Creek	385 – Deer Creek
382 – Hummingbird Creek	384 – Rattlesnake Creek	381 – Rice Creek
394 – Skeleton Creek	399 – Thistle Glade Creek	383 – Upper Eel, Bloody Rock Roughs

1. Anderson Creek

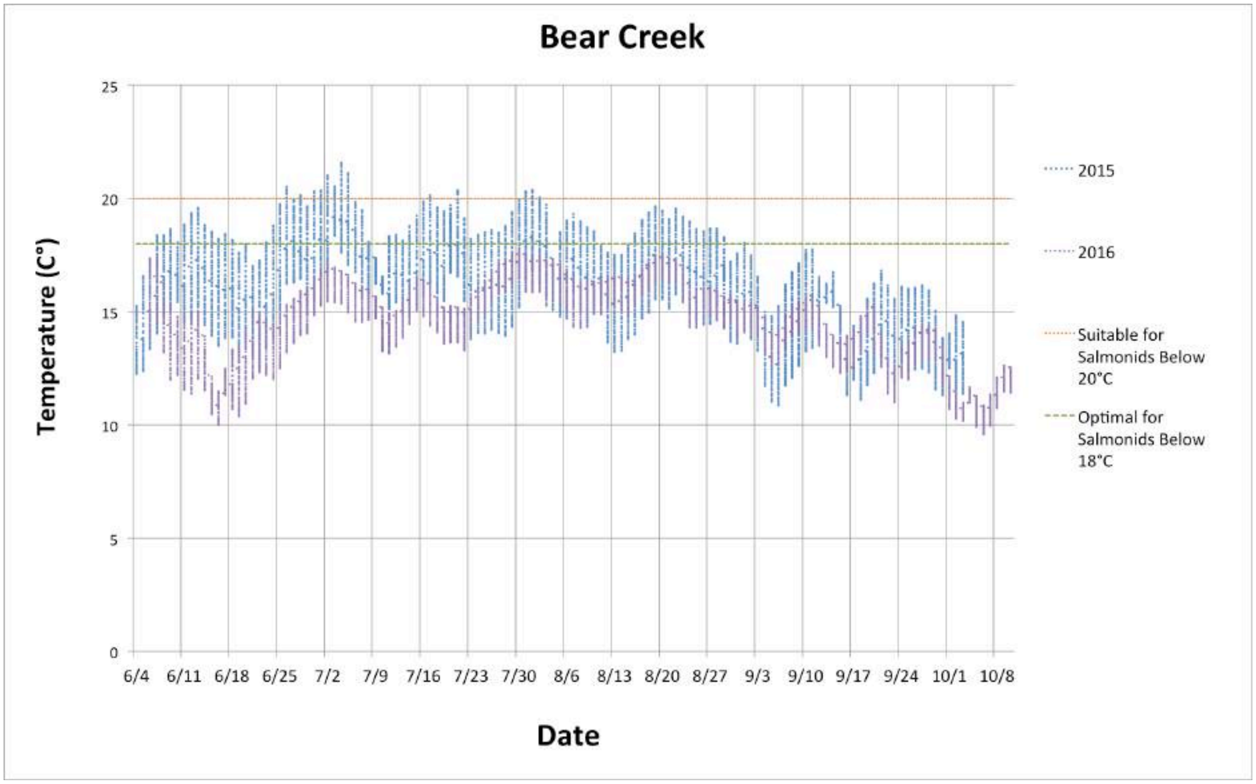


Details	2015	2016
Maximum Recorded	20.82°C on 7/16/15	20.20°C on 7/2/16
Location	39.50863 N, 122.84512 W	39.50863 N, 122.84512 W
Placed	6/1/15 at 2:45PM	6/4/16 at 11:10AM
Retrieved	10/9/15 at 4:40PM	10/12/16 at 4:45PM
Monitor Type	Tidbit V2 (UTBI-001)	Tidbit V2 (UTBI-001)

Notes

Anderson Creek starts at 5,400' on the north side of 6,500' Sheetiron Mountain and is a shorter tributary than Corbin Creek.

2. Bear Creek

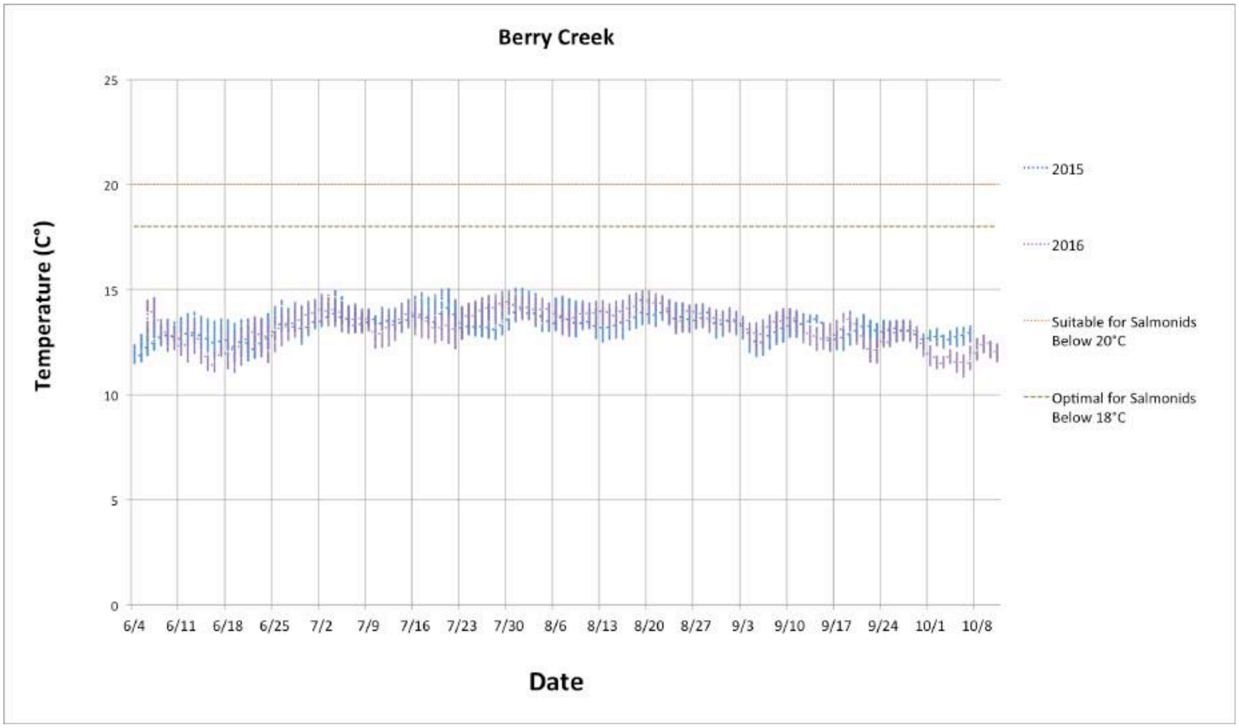


Details	2015	2016
Maximum Recorded	21.58°C on 7/4/15	17.80°C on 7/30/16
Location	39.32793, N 122.82825 W	39.32793, N 122.82825 W
Placed	6/2/15 at 1:00PM	6/5/16 at 6:15PM
Retrieved	10/8/15 at 10:00AM	10/12/16 at 5:30PM
Monitor Type	Tidbit V2 (UTBI-001)	Tidbit V2 (UTBI-001)

Notes

Bear Creek is the largest Rice Fork Eel River tributary that we monitored. We saw many *O. Mykiss* during placement and retrieval. The headwaters of Bear Creek are in the Snow Mountain Wilderness at nearly 6,500' on Snow Mountain.

3. Berry Creek

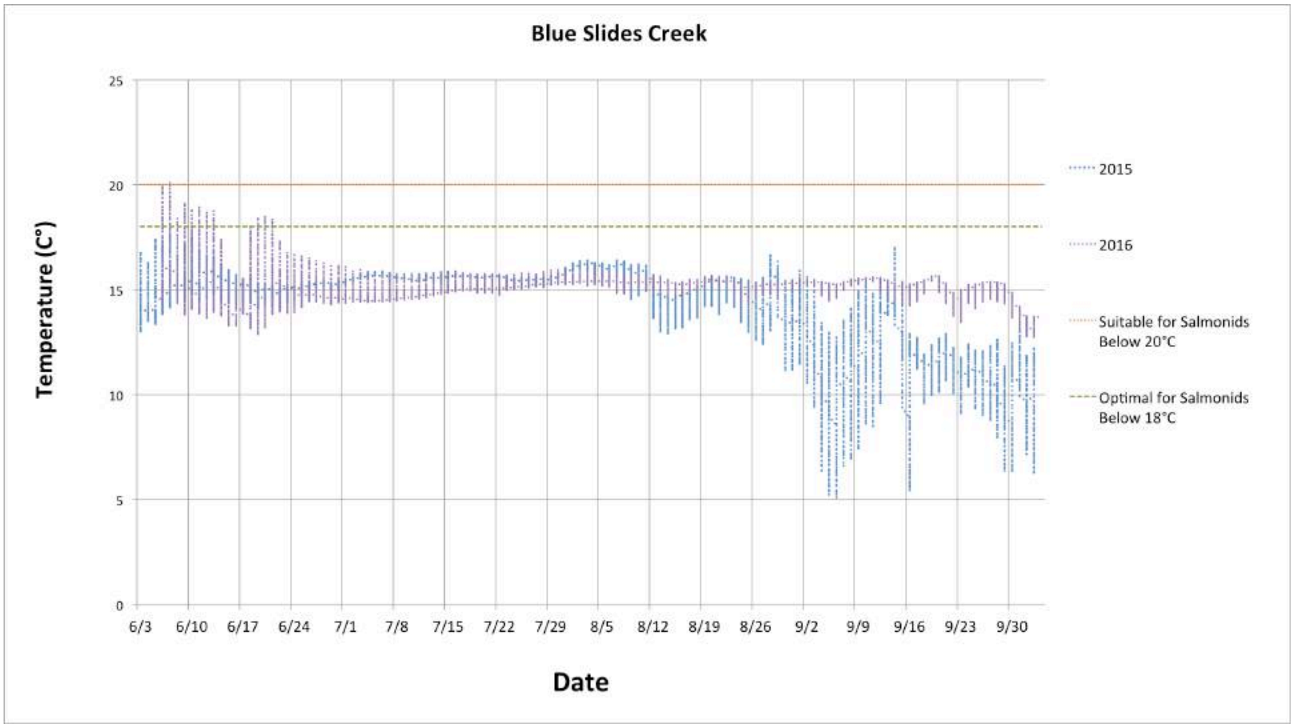


Details	**2015**	**2016**
Maximum Recorded	15.06°C on 7/31/15	14.91°C on 7/30/16
Location	39.42103, N 122.85258 W	39.42103, N 122.85258 W
Placed	6/3/15 at 10:00AM	6/5/16 at 1:30PM
Retrieved	10/8/15 at 6:00PM	10/12/16 at 3:00PM
Monitor Type	Water Temp Pro V2 (U22-001)	Water Temp Pro V2 (U22-001)

Notes

Berry Creek is a short tributary to the upper mainstem Eel River originating in the Snow Mountain Wilderness at 3,400'. The road M3 is certainly a barrier to fish, it is unknown if there are other barriers located lower in Berry Creek. In future studies, we hope to approach Berry Creek from the Eel River to monitor whether the creek creates a thermal refugia at the mouth and the uppermost extent of salmon and steelhead access in this tributary.

4. Blue Slides Creek

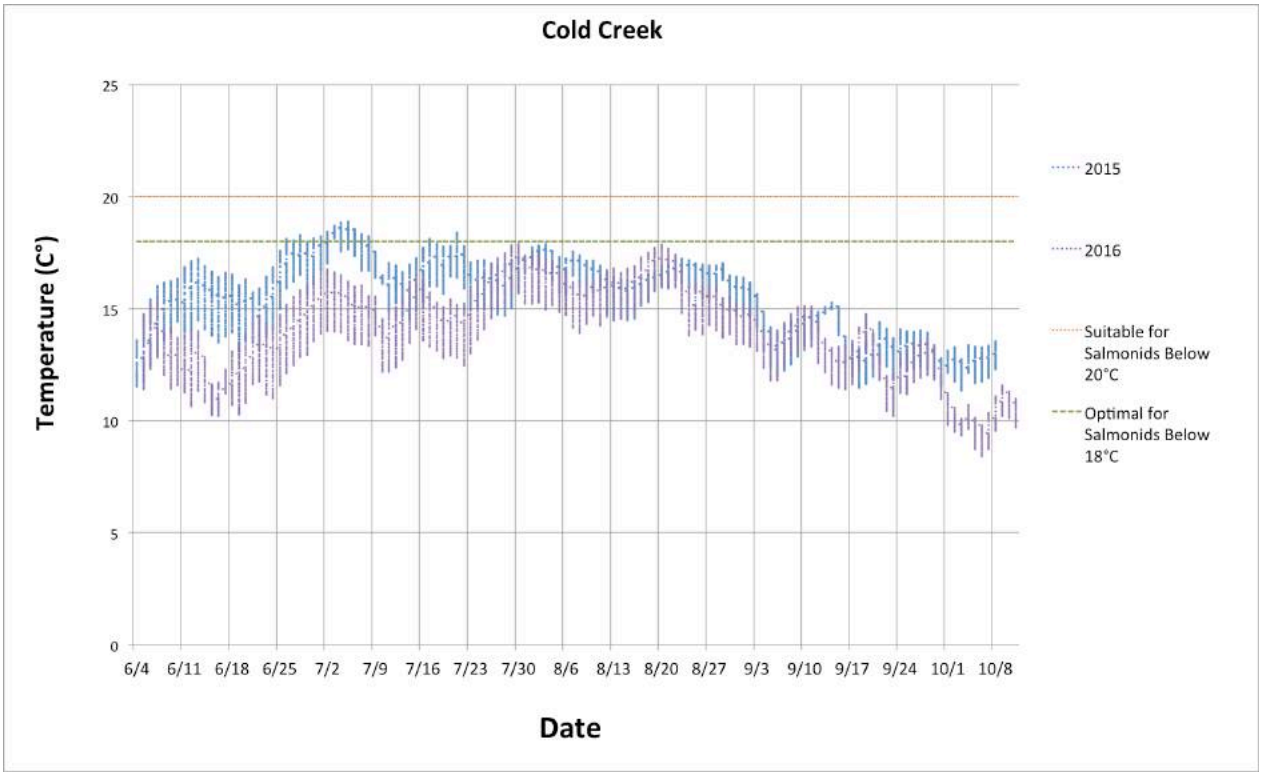


Details	2015	2016
Maximum Recorded	17.63°C on 6/7/15	20.08°C on 6/7/16
Location	39.31794 N, 122.83981 W	39.31794 N, 122.83981 W
Placed	6/2/15 at 11:10AM	6/5/16 at 7:00PM
Retrieved	10/9/15 at 1:40PM	10/12/16 at 6:00PM
Monitor Type	Tidbit V2 Temp Logger (UTBI-001)	Tidbit V2 Temp Logger (UTBI-001)

Notes

Blue Slides Creek is a tributary to Bear Creek, which flows into the Rice Fork Eel River. Its headwaters are at 4,000' and flows in part out of Blue Slides Lake. Blue Slides Creek was the only creek that was significantly drier when we returned in the fall.

5. Cold Creek

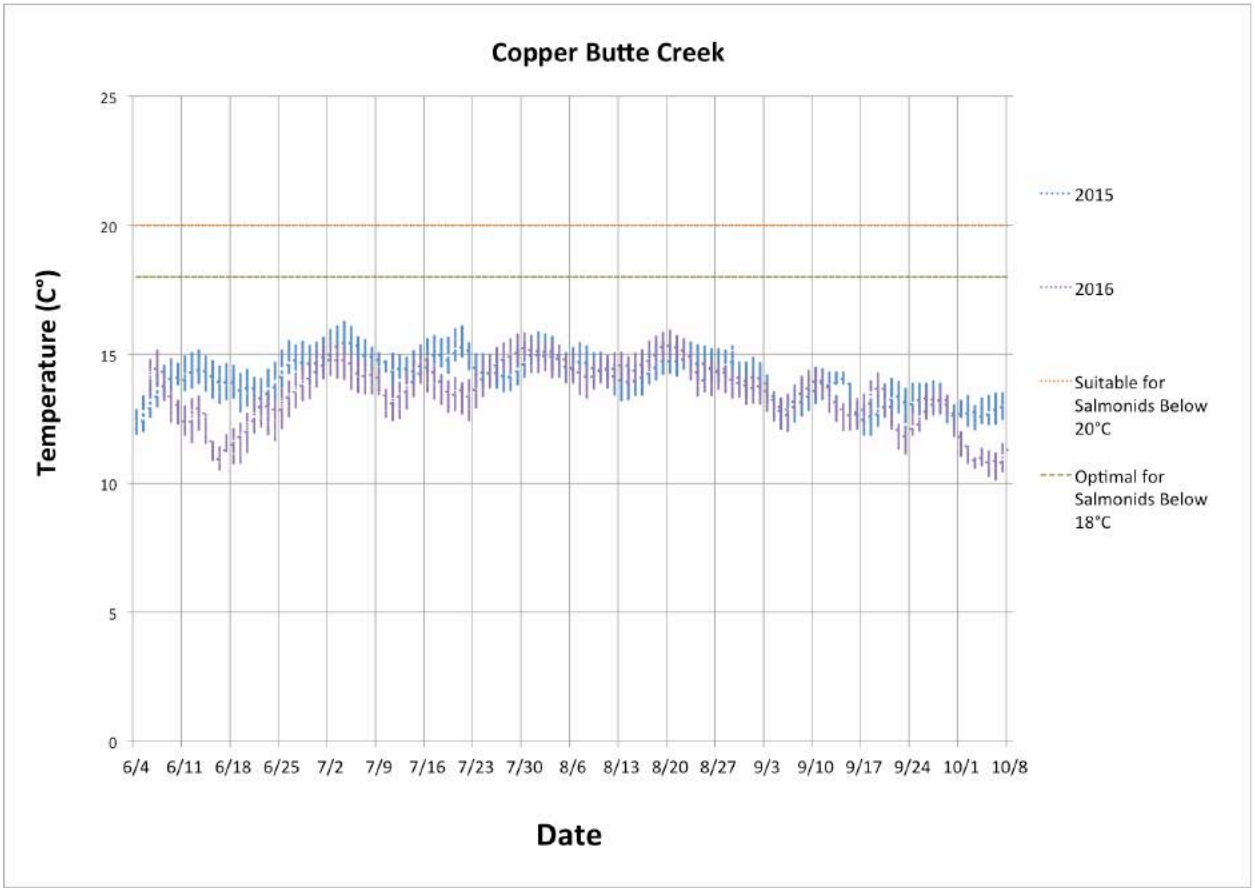


Details	2015	2016
Maximum Recorded	18.89°C on 7/5/15	17.92°C on 7/30/16
Location	39.47183 N, 122.83287 W	39.47183 N, 122.83287 W
Placed	6/1/15 at 5:30PM	6/4/16 at 3:45PM
Retrieved	10/9/15 at 1:40PM	10/13/16 at 12:00PM
Monitor Type	Tidbit V2 Temp Logger (UTBI-001)	Tidbit V2 Temp Logger (UTBI-001)

Notes

Cold Creek is another significant tributary that flows off of Sheetiron Mountain beginning at 5,000' and enters the Eel River from the east.

6. Copper Butte Creek

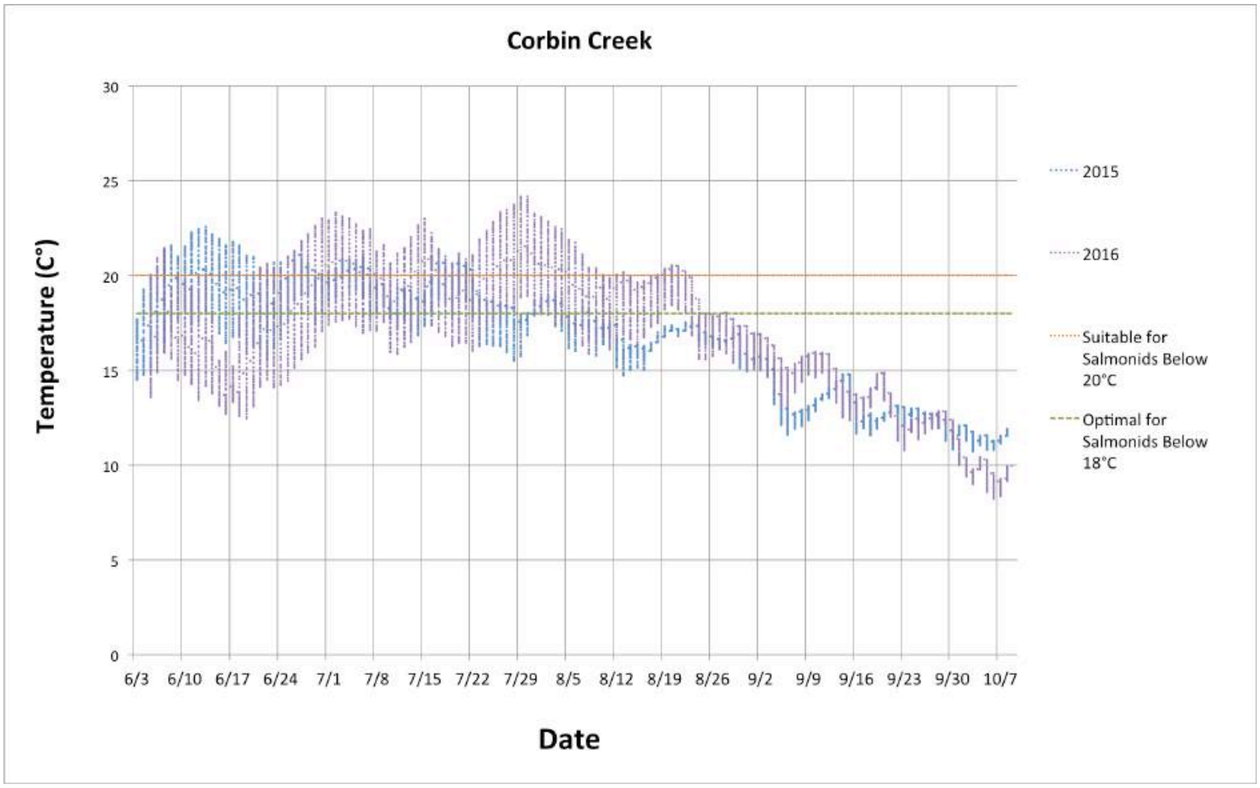


Details	2015	2016
Maximum Recorded	16.27°C on 7/4/15	15.92°C on 8/20/16
Location	39.42914 N 122.84573 W	39.42914 N 122.84573 W
Placed	6/3/15 at 9:30AM	6/5/16 at 12:50PM
Retrieved	Retrieved: 10/8/15 at 5:15PM	10/12/16 at 2:45PM
Monitor Type	Water Temp Pro V2 (U22-001)	Water Temp Pro V2 (U22-001)

Notes

Copper Butte Creek begins at 5,000' in the Snow Mountain Wilderness. The road M3 is a barrier to upstream migration of fish in the creek.

7. Corbin Creek

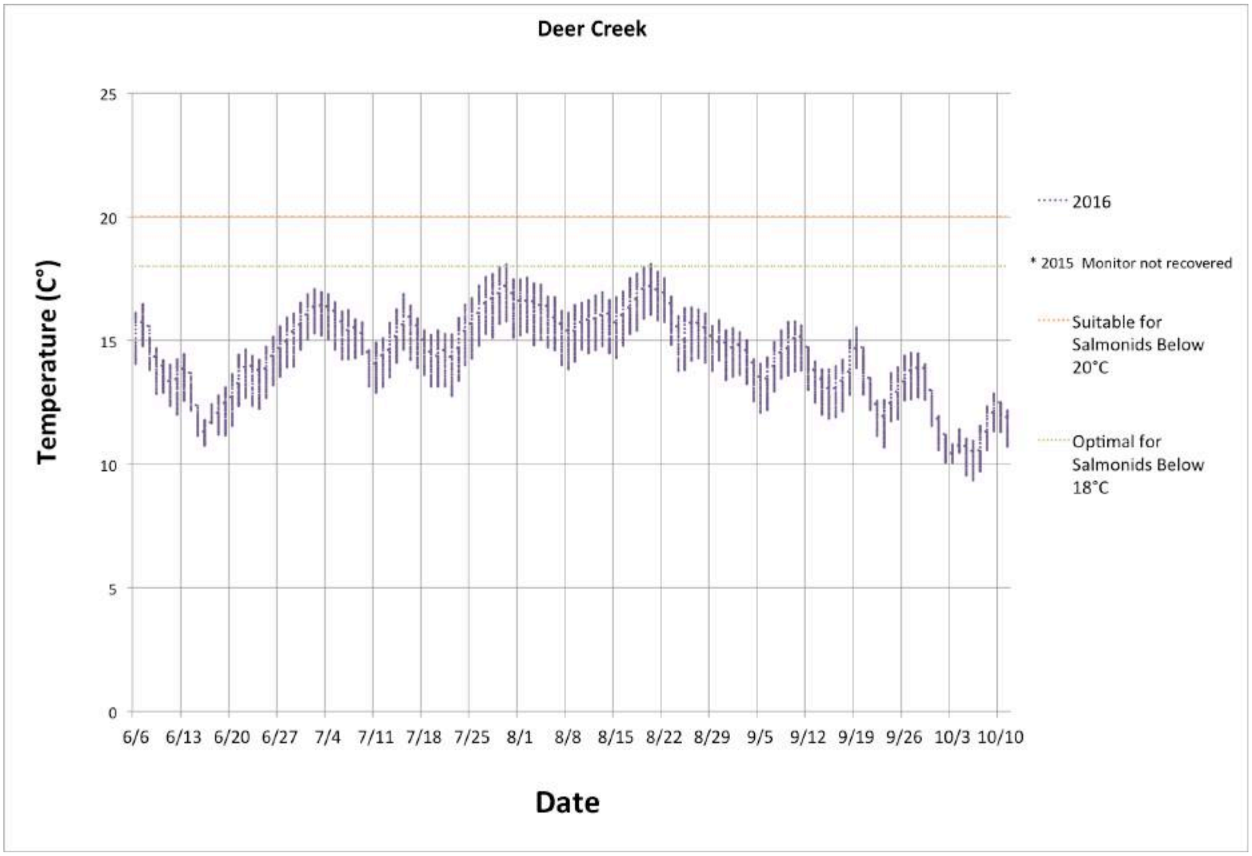


Details	2015	2016
Maximum Recorded	22.51°C on 6/13/15	24.17°C on 7/29/16
Location	39.52950 N, 122.84721 W	39.52950 N, 122.84721 W
Placed	6/1/2015 at 1:30PM	6/4/16 at 9:45AM
Retrieved	10/9/2015 at 6:00PM	10/13/16 at 10:15AM
Monitor Type	Water Temp Pro V2 (U22-001)	Tidbit V2 Temp Logger (UTBI-001)

Notes

Corbin Creek is a significant tributary to the upper mainstem Eel River. It begins at nearly 5,400' elevation on Felkner Hill and joins the North Fork Corbin Creek and Wescott Creek on its way to the Eel River. Both the North Fork and Wescott creeks are significant waterways in their own right and each begins at over 5,000' with Wescott near 6,000' on Summit Springs Hill.

8. Deer Creek

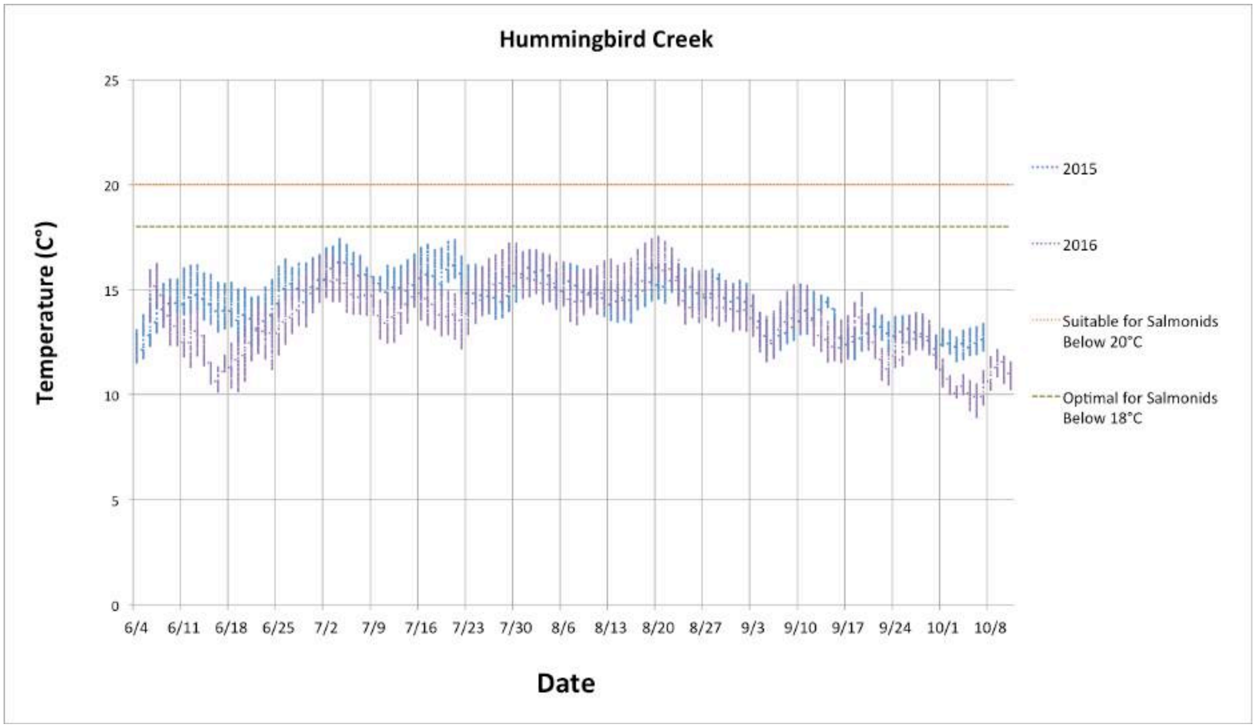


Details	2015	2016
Maximum Recorded	NOT RECOVERED	18.06°C on 7/30/16
Location	39.37597 N, 122.86132 W	39.37597 N, 122.86132 W
Placed	6/3/15 at 8:30AM	6/5/16 at 4:30PM
Retrieved	NOT RECOVERED	10/12/16 at 4:00PM
Monitor Type	Tidbit V2 Temp Logger (UTBI-001)	Water Temp Pro V2 (U22-001)

Notes

Deer Creek is a significant tributary to the Rice Fork Eel River, flowing out of the Snow Mountain Wilderness at over 5,000'. This is the first creek on the M3, where the road crossing creates an upstream barrier to fish.

9. Hummingbird Creek

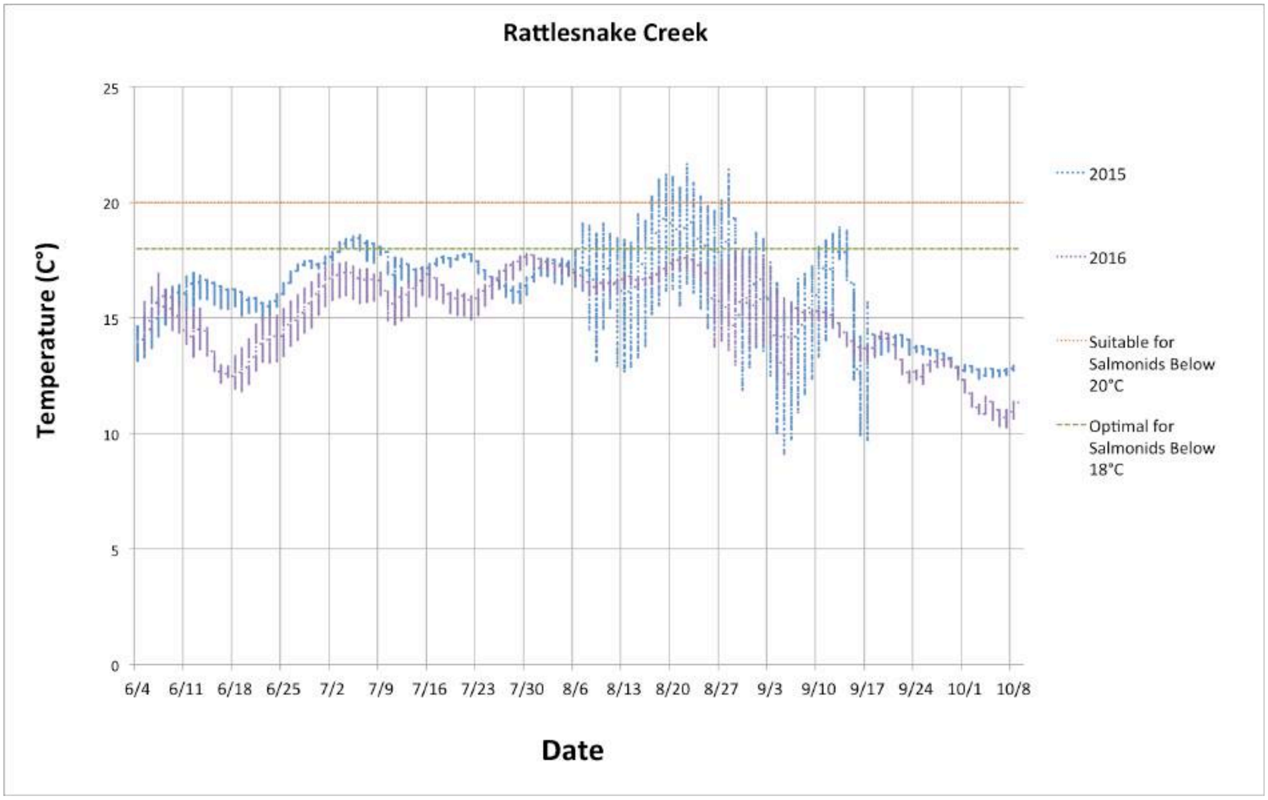


Details	2015	2016
Maximum Recorded	17.44°C on 7/4/15	17.51°C on 8/20/16
Location	39.40374 N 122.86013 W	39.40374 N 122.86013 W
Placed	6/3/15 at 10:30AM	6/5/16 at 3:15PM
Retrieved	10/8/15 at 5:55PM	10/12/16 at 3:15PM
Monitor Type	Water Temp Pro V2 (U22-001)	Tidbit V2 Temp Logger (UTBI-001)

Notes

Hummingbird Creek is a short tributary to the upper mainstem Eel River. It originates at 4,500' in the Snow Mountain Wilderness. The creek is very steep and road M3 is certainly a barrier to fish, it is unknown if there are other barriers lower in Hummingbird Creek. We hope to approach Hummingbird Creek from the Eel River in future efforts to monitor whether the creek creates a thermal refugia and the uppermost extent of salmon and steelhead access in this tributary.

10. Rattlesnake Creek

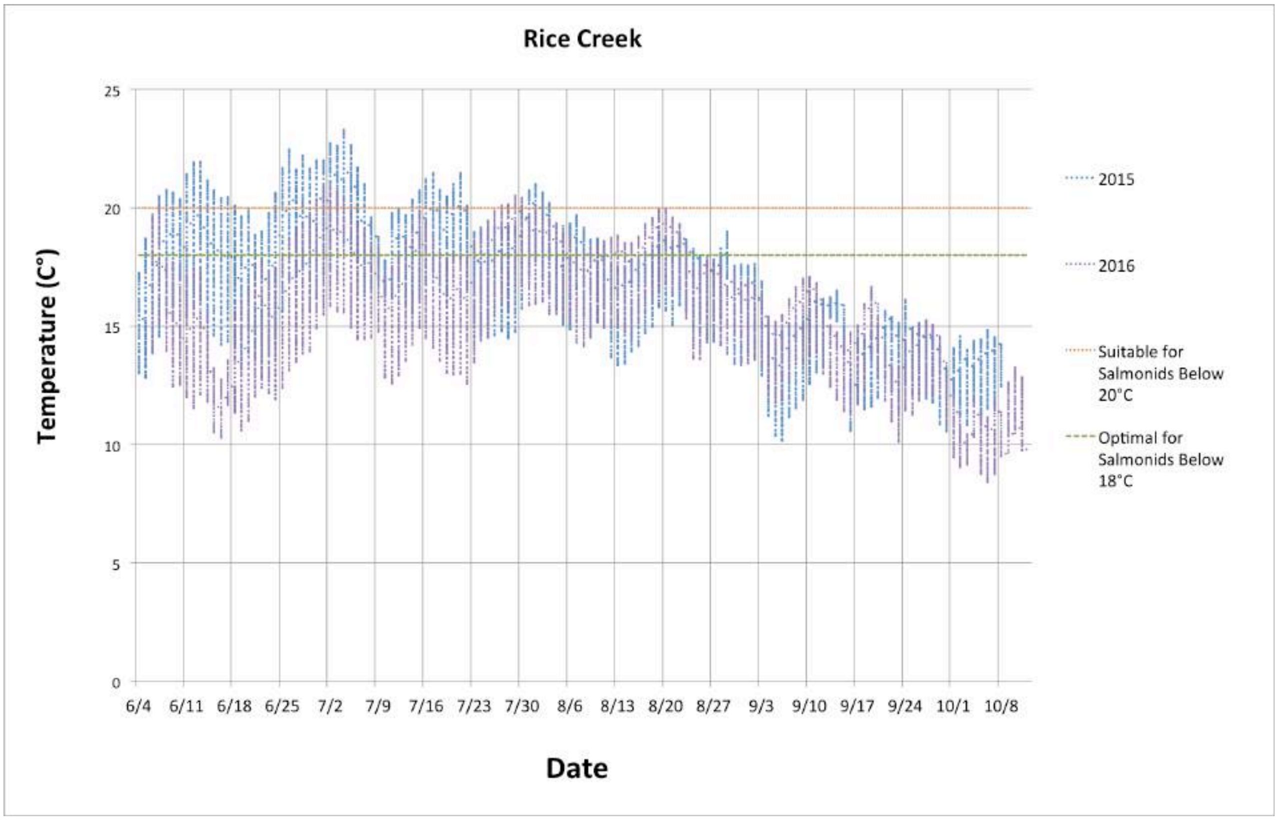


Details	2015	2016
Maximum Recorded	21.65°C on 8/22/15	17.99°C on 8/30/16
Location	39.49332 N, 122.86465 W	39.49332 N, 122.86465 W
Placed	6/1/15 at 4:35PM	6/4/16 at 12:25 PM
Retrieved	10/9/15 at 3:45PM	10/12/16 at 4:15PM
Monitor Type	Tidbit V2 Temp Logger (UTBI-001)	Tidbit V2 Temp Logger (UTBI-001)

Notes

Rattlesnake Creek is the first tributary we monitored that joins the upper mainstem Eel River from the west. Similar in length to Anderson Creek, Rattlesnake Creek begins on 6,800' Hull Mountain.

11. Rice Creek

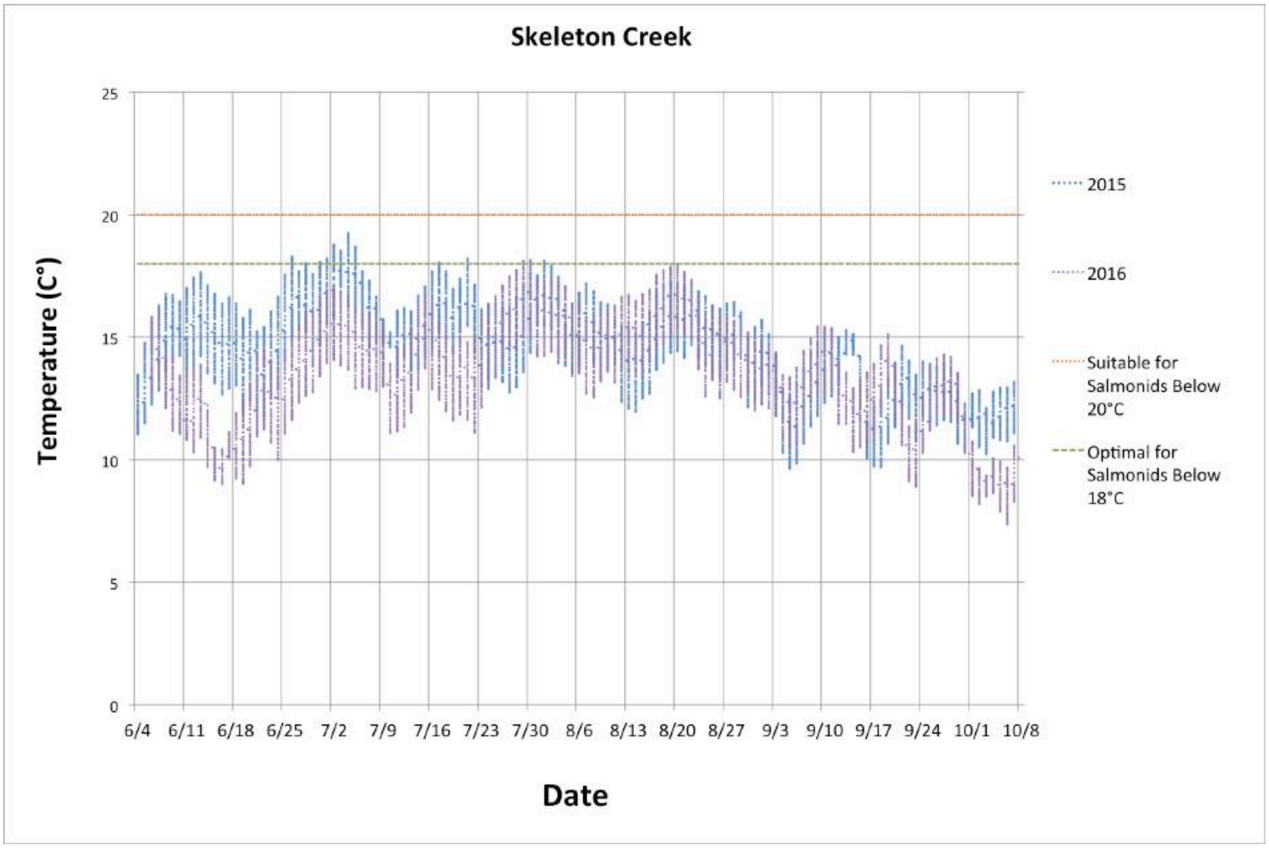


Details	2015	2016
Maximum Recorded	23.30°C on 7/4/15	20.96°C on 7/2/16
Location	39.34936, N 122.87143 W	39.34936, N 122.87143 W
Placed	6/2/15 at 3:45PM	6/5/16 at 5:15PM
Retrieved	10/8/15 at 4:10PM	10/12/16 at 4:30PM
Monitor Type	Tidbit V2 Temp Logger (UTBI-001)	Tidbit V2 Temp Logger (UTBI-001)

Notes

Rice Creek is a significant tributary to the Rice Fork Eel River. It originates in the Snow Mountain Wilderness at 6,000'. *O. Mykiss* were sighted both in June and in October at the M3 road crossing. This road crossing is not a barrier to fish wishing to migrate upstream.

12. Skeleton Creek

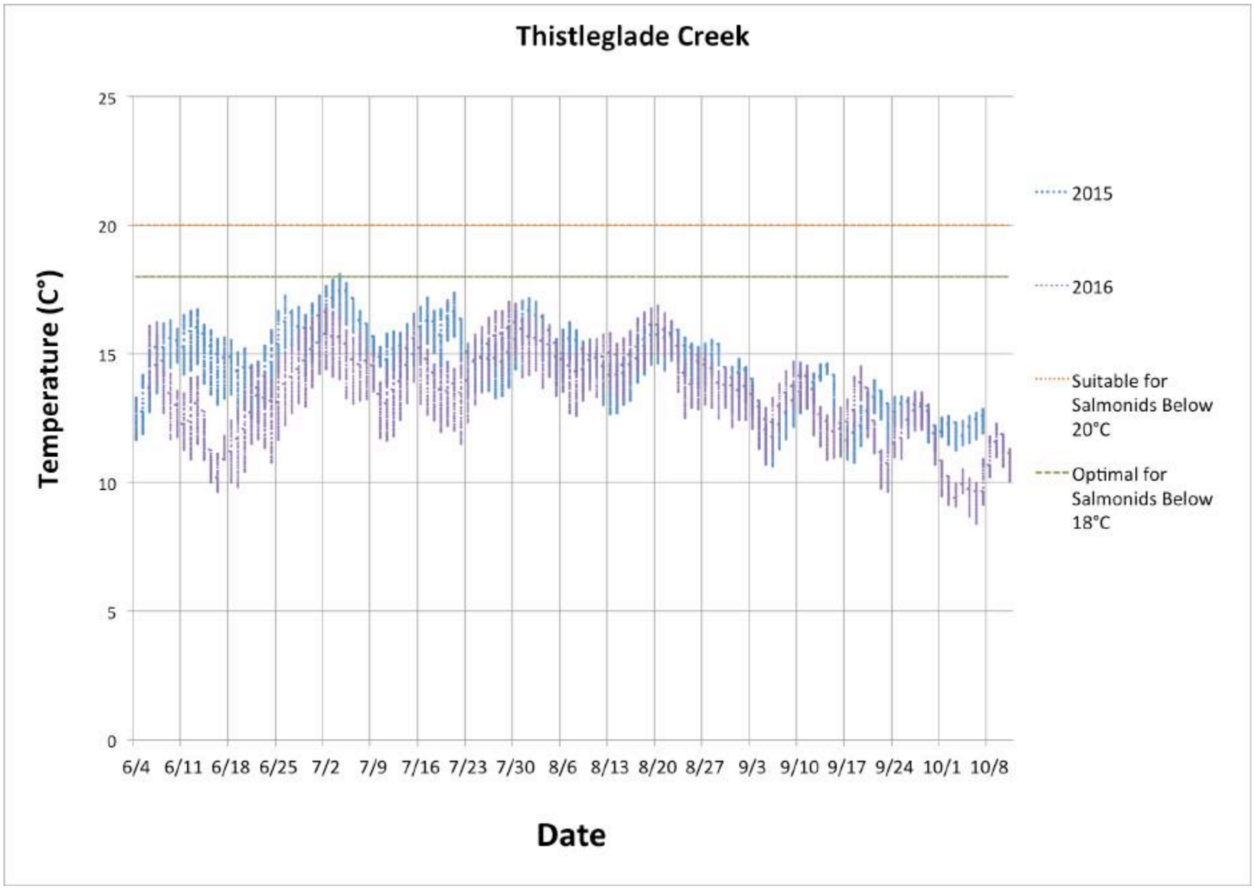


Details	2015	2016
Maximum Recorded	19.25°C on 7/4/15	18.15°C on 7/30/16
Location	39.43758 N, 122.83488 W	39.43758 N, 122.83488 W
Placed	6/3/15 at 9:00AM	6/5/16 at 12:15PM
Retrieved	10/8/15 at 5:00PM	10/12/16 at 2:30PM
Monitor Type	Water Temp Pro V2 (U22-001)	Water Temp Pro V2 (U22-001)

Notes

Skeleton Creek is likely the most significant of the five Snow Mountain Wilderness originating tributaries to the upper mainstem Eel River in terms of size and flow. The temperature probe was set in the pool just downstream of the M3 crossing. During most flows the culvert appears to be a significant barrier to upstream migrating salmonids.

13. Thistle Glade Creek

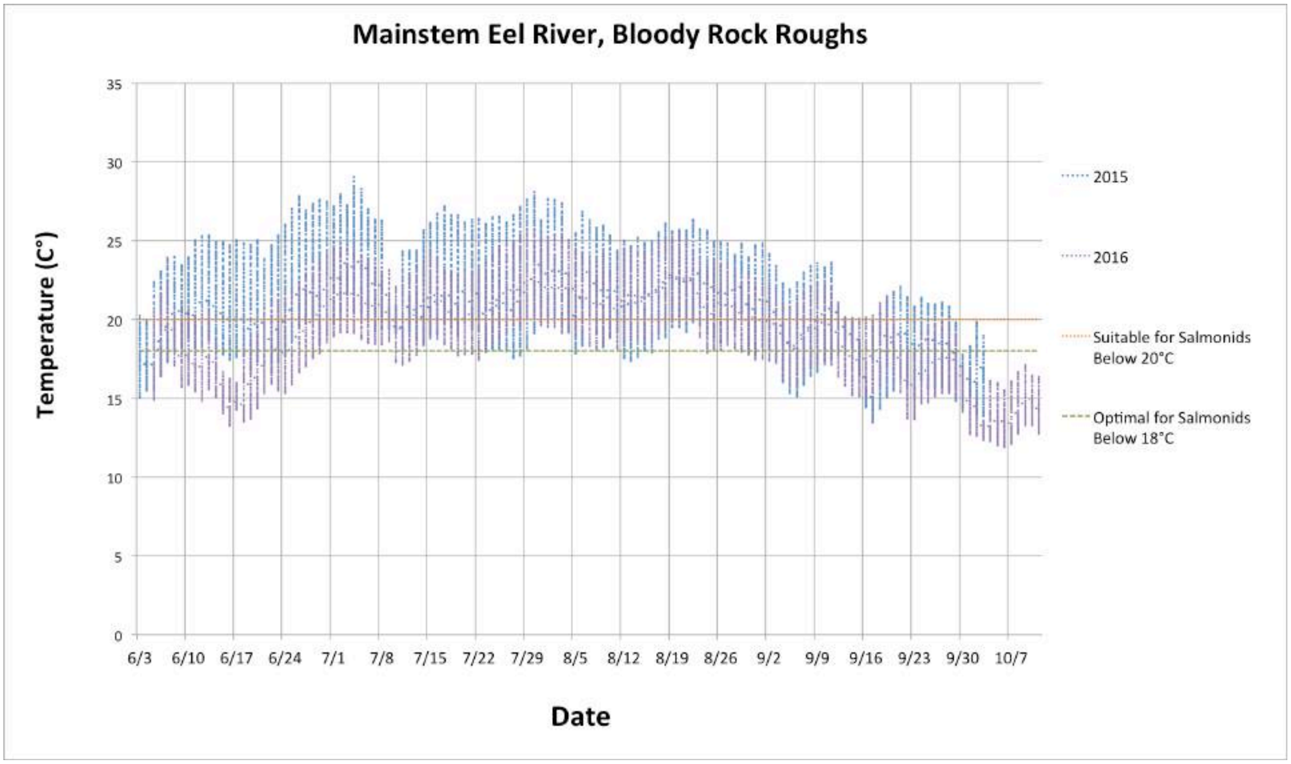


Details	2015	2016
Maximum Recorded	18.01°C on 7/4/15	17.01°C on 7/29/16
Location	39.39419, N 122.86727 W	39.39419, N 122.86727 W
Placed	6/3/15 at 9:25AM	6/5/16 at 3:45PM
Retrieved	10/8/15 at 5:40PM	10/12/16 at 3:45PM
Monitor Type	Water Temp Pro V2 (U22-001)	Water Temp Pro V2 (U22-001)

Notes

Thistle Glade Creek is the lowest tributary to the upper mainstem Eel River that we monitored. It begins at 5,600' on Snow Mountain in the Snow Mountain Wilderness. The road M3 blocks upstream migration and it is likely that there is some barrier to upstream migration downstream of the monitoring site. For future studies, we hope to monitor the confluence of Thistle Glade Creek and the Eel River to determine if thermal refugia is created and how far upstream fish are able to swim.

14. Mainstem Eel River, Downstream of Bloody Rock Roughs



Details	2015	2016
Maximum Recorded	29.09°C on 7/4/15	25.70°C on 7/29/16
Location	39.42103, N 122.85258 W	39.42103, N 122.85258 W
Placed	6/1/15 at 6:40PM	6/4/16 at 2:10PM
Retrieved	10/9/15 at 2:25PM	10/13/16 at 12:30PM
Monitor Type	Tidbit V2 Temp Logger (UTBI-001)	Tidbit V2 Temp Logger (UTBI-001)

Notes

Corbin, Anderson, Rattlesnake and Cold Creek are all found upstream of the hydrological/geological maze known as the Bloody Rock Roughs. Massive boulders impossibly wedged in a narrow chasm immediately downstream of Cold Creek create these roughs.
Our temperature monitor was set nearly a mile below the actual roughs and registered high mid-summer water temperatures.

V. Results

<u>2015 Maximum Temperatures Recorded</u>

Monitor Location	2015 Maximum Temperature
Berry Creek	15.06°C on 7/31/15
Copper Butte Creek	16.27°C on 7/4/15
Hummingbird Creek	17.44°C on 7/4/15
Blue Slides Creek	17.63°C on 6/7/15
Thistle Glade Creek	18.01°C on 7/4/15
Cold Creek	18.89°C on 7/5/15
Skeleton Creek	19.25°C on 7/4/15
Anderson Creek	20.82°C on 7/16/15
Bear Creek	21.58°C on 7/4/15
Rattlesnake Creek	21.65°C on 8/22/15
Corbin Creek	22.51°C on 6/13/15
Rice Creek	23.30°C on 7/4/15
Mainstem Eel, Bloody Rock Roughs	29.09°C on 7/4/15
Deer Creek	Not Recovered

In 2015, our monitors recorded Berry, Blue Slides, Copper Butte, Hummingbird, and Thistle Glade Creeks with temperatures that remained at "Optimal for Salmonids Below 18°C" throughout the entire summer. Similarly, Cold and Skeleton Creeks both stayed at or below temperatures considered "Suitable for Salmonids Below 20°C" throughout the summer. While Anderson, Bear, Corbin, Rattlesnake and Rice Creeks reached temperatures above 20°C at some point during the summer, those durations were brief and were repeatedly followed by diurnal cooling and temperatures below 18°C within the same 24 hour period.

Comparatively, the temperature monitor downstream of the Bloody Rock Roughs in the mainstem Eel River recorded the warmest average temperature readings throughout the summer, and temperatures often stayed above 20°C. In addition, the Bloody Rock Roughs monitor recorded temperatures that fluctuated up to ten degrees within 24-hour periods and dropped below the "Suitable for Salmonids" within 24-hour periods on all but three occasions (July 3 - 5; August 1 - 2; August 29 - 30).

The majority of monitors recorded their maximum temperatures on 7/4/15, with seven gauges (Bloody Rock Roughs, and Bear, Copper Butte, Hummingbird, Rice, Skeleton, and Thistle Glade Creeks) all reaching their maximum recorded temperature on this same day.

2016 Maximum Recorded Temperatures

Monitor Location	2016 Maximum Temperature
Berry Creek	14.91°C on 7/30/16
Copper Butte Creek	15.92°C on 8/20/16
Thistle Glade Creek	17.01°C on 7/29/16
Hummingbird Creek	17.51°C on 8/20/16
Bear Creek	17.80°C on 7/30/16
Rattlesnake Creek	17.99°C on 8/30/16
Deer Creek	18.06°C on 7/30/16
Skeleton Creek	18.15°C on 7/30/16
Cold Creek	19.92°C on 7/30/16
Blue Slides Creek	20.08°C on 6/7/16
Anderson Creek	20.20°C on 7/2/16
Rice Creek	20.96°C on 7/2/16
Corbin Creek	24.17°C on 7/29/16
Mainstem Eel, Bloody Rock Roughs	25.70°C on 7/29/16

In 2016, overall the recorded temperatures of each creek were cooler, with an increased number of creeks recording temperatures that had maximum recorded temperatures below "Optimal Temperatures for Salmonids (<18°C)" for the entire duration of the summer, including Bear, Berry, Cold, Copper Butte, Hummingbird, Rattlesnake and Thistle Glade. Similarly, those creeks that did exceed optimal temperatures, just barely exceeded Optimal (<18°C) and Suitable (<20°C) levels and for limited duration; whereas Deer Creek reached a maximum temperature of 18.06°C, Skeleton Creek reached 18.15°C, Blue Slides reached 20.08°C, and Rice Creek reached 20.96°C. The two warmest recorded temperatures were Corbin Creek at 24.17°C and the Mainstem Eel at Bloody Rock Roughs at 25.70°C. It should be noted that in 2016 the mainstem Eel River at Bloody Rock Roughs had a maximum temperature at 3.39°C less than in 2015.

In general, the majority of creeks reached their maximum temperatures later in the summer and 8 of the 14 monitors reached peak maximum temperatures within the same two-day period on 7/29 (n=3) and 7/30 (n=5). Overall, these trends demonstrated that the summer of 2016 could be characterized as cooler than 2015, and that the maximum recorded temperatures were reached later.

VI. Summary

The results of our 2015 & 2016 temperature monitoring efforts identified that almost all of the upper Eel River tributaries we monitored above Scott Dam (excluding the mainstem Eel River downstream of Bloody Rock Roughs, and the lowest reach of Corbin Creek) remained at temperatures suitable for salmonids throughout the warm summer months, and that in those instances where monitors recorded maximum temperatures that exceeded "Suitable for Salmonids <20°C", those temperatures were brief and closely followed by periods of diurnal cooling with temperatures below 20°C within a 24 hour period.

While the scope of our study did not measure the habitat suitability of these creeks, our findings do suggest that water temperatures would likely not be a limiting factor for salmonids if they were to regain access to potentially suitable habitat upstream of Scott Dam in these locations. Future studies will need to consider whether there are any downstream barriers from our monitoring locations, the extent to which habitat is available upstream of monitor locations, whether flows remain adequate to support the different life history requirements of salmonids throughout the year, and whether additional creeks and tributaries are able to sustain suitable temperatures for salmonids in the upper Eel River watershed.

VII. Discussion

Climate change poses one of the most significant threats to salmon resiliency, and will remain a significant obstacle to recovering California's anadromous salmonids (Bisson, 2008; Moyle et al., 2008). In California, over 60 percent of the state's salmonids have been identified as especially vulnerable to future climate change predictions (Moyle et al., 2013). Consequently, habitats that currently support salmonids may not be suitable in the future. As a result of a changing climate it is likely the Eel River will experience a reduction in its overall viable salmonid habitat or a shift to habitat in increasing elevations, as air and water temperatures increase and late summer and fall flows decrease along with annual snow pack (Hanak et al., 2011; Mastrandrea & Luers, 2012). Considerations about future environmental conditions suggest that we favor prioritizing the reintroduction of California Coastal Chinook (CC) salmon and Northern Coastal (NC) steelhead into the high altitude habitats found above Scott Dam. These areas are likely to continue to provide critical cold-water refugia for the upper Eel River's threatened salmonids despite climate change predictions in the rest of the region. The many tributaries flowing out of the Snow Mountain Wilderness and the geomorphic conditions which keep them flowing and cool today, are less likely to change in the future due to anthropogenic alterations.

Furthermore, a 2011 NMFS status review of the NC steelhead population suggested the Upper Eel river population is likely at a high risk of extinction due to the loss of majority historical stream habitat (NMFS, 2011). Given the results of this year's monitoring efforts, NC Steelhead (*O. mykiss*), which spend a longer duration of their life in freshwater habitat (including migration, spawning, and rearing during the warm summer months), the cold-water habitat above Scott Dam is likely to most greatly benefit the population if they are to regain access in the future. Additionally, these benefits would likely extend to CC Chinook salmon as they seek out cold-water refugia while moving freely through the upstream available habitat.

It is critically important to the resiliency and long-term survival of salmonids in the Eel River that we look at the habitat suitability of the area above Scott Dam with respect to the other areas of the watershed. The loss of salmonid habitat upstream of Scott Dam has resulted in a reduction of available habitat that can serve as refugia for salmon and steelhead, particularly in conditions that include periods of extended drought (Yoshiyama and Moyle, 2010). Rising temperatures will affect the overall distribution of the species and impact their persistence over time, and these effects will be exacerbated under predicted scenarios from the effects of climate change (Poff et al. 2002; Mote et al. 2003). Given the results of our 2015 temperature monitoring efforts, as future discussions develop around relicensing of Scott Dam and the Potter Valley Project, further analysis on habitat suitability and availability in the Upper Mainstem Eel River watershed is warranted.

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