Enhancement of Salmonid Rearing Habitat in McGarvey Creek - Lower Klamath River

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Acknowledgements

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Introduction

The Yurok People have relied upon the Klamath River and coastal resources for their subsistence, cultural, and economic livelihood since time immemorial. Central to Yurok culture is harvest of anadromous fish. Runs of anadromous fish currently returning to spawn in Lower Klamath tributaries are depressed when compared with historical numbers. Extensive timber removal and road building activities have resulted in chronic sedimentation of streams and floodplains; a significant loss of channel-stored wood and riparian conifers; and a concomitant loss of habitat diversity and production potential in the sub-basin (Payne & Associates 1989; Gale and Randolph 2000; Beesley and Fiori 2007 & 2008; Voight and Gale 1998).

In the Klamath River, all runs of chinook salmon (*Oncorhynchus tshawytscha*), green sturgeon (*Acipenser medirostris*), and Pacific lamprey (*Lampetra tridentata*) are on the decline and coho salmon (*O. kisutch*) are listed as "threatened" under the Endangered Species Act. The Yurok Tribe is dedicated to rehabilitating degraded instream and riparian habitats to levels that support robust, self-sustaining populations of native anadromous fish. To help address this need, the Yurok Tribe's Fisheries (YTFP) and Watershed (YTWRD) programs have been conducting fisheries and watershed assessments, and implementing instream and upslope restoration activities in the Lower Klamath River Sub-basin since the late 1990s.

Initial restoration planning efforts included developing the Lower Klamath Sub-Basin Watershed Restoration Plan that prioritized upslope restoration and identified tributary specific restoration objectives for each Lower Klamath tributary (Gale and Randolph 2000). Sub-basin restoration objectives included: 1) reducing sediment inputs from upslope sources by treating high priority watershed road segments and stream crossings; 2) restoring native, conifer-dominated riparian forests; and 3) enhancing freshwater aquatic habitats. Since 2007, YTFP has been working with Rocco Fiori of Fiori GeoSciences (FGS) to design and implement innovative stream and floodplain enhancement projects in priority Lower Klamath tributaries. Treatments have included installation of constructed wood and engineered log jams (CWJs & ELJs) to facilitate formation and maintenance of productive fish habitats (e.g. spawning beds, deep pools with cover, slow velocity habitats), and enhancing off-channel habitats to increase salmonid rearing capacity (Gale 2008 & 2009; YTFP 2010; Hiner et al. 2011; Beesley and Fiori 2012a, 2012b, 2013a, 2013b, 2013c, 2014a, 2014b, 2014c, & 2016).

Project Area

McGarvey Creek is a third order watershed draining approximately 8.9 square miles (Figure 1). McGarvey Creek flows into the south side of the Lower Klamath River ~6.4 river miles upstream of the Pacific Ocean (Figure 1). The watershed supports anadromous populations of chinook and coho salmon, steelhead (*O. mykiss*), coastal cutthroat trout (*O. clarkii clarkii*), and multiple species of lamprey. The watershed also provides critically valuable rearing habitat for non-natal juvenile coho salmon and thermal refuge to fish migrating through the river during the low flow period (Beesley and Fiori 2007; YTFP 2009; Antonetti et al. 2012 & 2014). McGarvey Creek is located in the Klamath Glen Hydrologically Significant Area, which was given the highest priority rating in the Recovery Strategy for California Coho Salmon (CDFG 2004).

The McGarvey Creek watershed has been subjected to intense timber harvest and road building activities, including construction of the U.S. Highway 101 bypass through the headwaters in the

mid-1980's (Gale and Randolph 2000). Historic and ongoing land management activities have resulted in removal of old growth conifers from riparian habitats, substantial simplification of fisheries habitats, increased rates of channel sedimentation, and loss of large wood and naturally formed jams in fluvial habitats (Figures 2-4) (Gale and Randolph 2000; Beesley and Fiori 2007).

YTFP has been conducting physical and biological monitoring and implementing enhancement activities in McGarvey Creek since the late 1990s (Gale and Randolph 2000; Soto et al. 2008 & 2013; Gale 2008 & 2009; Hillemeier et al. 2009; Beesley and Fiori 2007, 2014a, & 2014b; YTFP 2009 & 2013; Fiori et al. 2009 & 2010; Antonetti et al. 2012 & 2014). Initial activities included assessments of historic land-use activities to further characterize changes in fish habitats through time, identifying factors that limit native salmonid populations, and prioritizing restoration. To address upslope sediment sources in McGarvey Creek, YTWRD completed a prioritized road assessment in the late 1990s. Since this time, they have decommissioned a majority of the high and medium priority road segments and stream crossings in the watershed. To improve forest conditions in the watershed, YTFP has been planting native conifers in riparian habitats and along decommissioned roads and stream crossings since the late 1990s.

Following treatment of a majority of the potential road related sediment sources in McGarvey Creek; YTFP began working closely with our technical restoration lead Rocco Fiori (California Licensed Geologist, Fiori GeoSciences - FGS) to plan, design, and implement comprehensive wood loading and floodplain enhancement efforts in the watershed. The first instream projects conducted with FGS included installing constructed wood jams (CWJs) in lower West Fork McGarvey Creek in 2007 and in mainstem McGarvey Creek upstream of West Fork in 2008 (Figure 5) (Gale 2008 & 2009; Fiori et al. 2009 & 2010). Given the need and scope of the opportunities available to restore critical low gradient and off-channel habitats in lower McGarvey Creek, YTFP and FGS coordinated Green Diamond Resource Company (GDRC – landowner) to develop a comprehensive stream and floodplain enhancement plan for the lower reaches of McGarvey Creek in 2009 (The Lower McGarvey Restoration Plan) (Figure 6).

Restoration priorities identified for lower McGarvey Creek were based on real time monitoring of fish use patterns in the watershed, assessment of geomorphic and hydrologic conditions, peer-reviewed research, previous experience, and landowner objectives. Specific objectives included: 1) increasing the amount of fluvial deposited wood and complex wood jams in stream and floodplain habitats; 2) increasing the quantity and quality of overwinter rearing habitat available to juvenile salmonids; and 3) removing riparian and floodplain roads that impair or threaten stream and floodplain function. These priorities were determined to be the most appropriate next step towards native salmon and trout recovery in McGarvey Creek.

Project Overview

YTFP and FGS began implementing the Lower McGarvey Restoration Plan in 2009 and concluded in 2016. Funding to implement the plan was provided by the U.S. Fish and Wildlife Service (USFWS – Partners for Fish and Wildlife Program), the U.S. Bureau of Reclamation (BOR – Klamath Basin Restoration & Native American Affairs Programs), the National Fish and Wildlife Foundation (NFWF – PacifiCorp's Klamath River Coho Enhancement Fund), and the California Department of Fish and Wildlife (CDFW – Fisheries Restoration Grant Program).

Since 2009, YTFP and FGS have installed 33 CWJs, constructed four off-channel habitat features (Alcoves I-IV), and planted 921 native trees in riparian habitats (Figures 5-6).

Lower McGarvey Creek Project objectives included:

- Increasing salmonid spawning and rearing habitat complexity in McGarvey Creek and reducing water quality impacts in the watershed by installing numerous constructed wood jams, creating off-channel habitat features, and planting native trees in riparian habitats;
- Evaluating project effectiveness to facilitate adaptive management of the project area; and
- Creating high quality, resource-based employment opportunities for Yurok tribal members.

The original scope of work proposed for this phase of the Lower McGarvey Restoration Plan was construction of the third alcove, installation of ~19 CWJs, and to plant a minimum of 50 native trees in riparian habitats. Additional funding allowed us to accomplish the following:

1) Overall stream length affected: 1,100 feet
2) Stream length planted or protected (with fence): 1,100 feet planted
3) Riparian zone to be planted or protected (length x width): 1,100 ft x 30 ft
4) Total feet of fencing: NA
5) Trees to be planted (number, by species): 365
   - 203 Coastal Redwood
   - 31 Port Orford Cedar
   - 131 Western Red Cedar
6) Non-native vegetation removed (length x width): NA
7) Stream bank restoration sites (number, length of stream, and technique): NA
8) In-stream habitat structures to be installed (number, type):
   - Constructed Wood Jams: 12 Mainstem Jams, 7 Alcove Jams
   - Constructed Alcoves: 2
9) Road stream crossings removed/upgraded: NA
10) Number fish barriers removed: NA
    a. Length of upstream habitat made accessible: NA

Restoration and monitoring activities conducted from 2009 through March 2014 are documented in the following reports: Beesley and Fiori 2014a & 2014b. This report summarizes work conducted on the Lower McGarvey Restoration Plan from March 2014 through September 2016.

Driving Directions & Project Location

The project is located on property owned by GDRC (Contact: Ryan Bourque – Senior Environmental Scientist – 619 2nd Street, Eureka CA, 95501). Heading south from the town of Klamath on U.S. Highway 101, travel across the Klamath River. Take the first exit immediately after crossing the river (Klamath Beach Road - Exit 768). Turn right at the stop sign. Proceed under the highway and upriver ~one mile. Turn right onto the M10 road. A GDRC key is required to pass through the gate located on the M10. Follow the M10 for ~1.5 miles to the bridge crossing McGarvey Creek. The project reach can be accessed by hiking downstream for ~1,800 feet on the M600 (Figures 5-6). The project coordinates are: Downstream BND: Lat. 41.500; Long. -123.997; Upstream BND: Lat. 41.492; Long. -124.006 (Figures 5-6).

Habitat Enhancement

In summer 2014, YTFP and FGS constructed the fourth off-channel habitat feature (McGarvey Alcove IV) in the Lower McGarvey Creek Project Reach (Figures 7-10; Appendix A). McGarvey Alcove IV was constructed on the western side of the valley within the 2009 wood loading reach (Figures 6-11). The alcove was sited in this location to take advantage of ground water inputs and rain driven surface flows derived from the historic Den Creek channel located along the western valley wall. The alcove was excavated within this former channel and was tied into the existing outlet channel that drains to mainstem McGarvey Creek (Figures 6-10). Several key pieces of wood were placed in Alcove IV to increase salmonid rearing habitat complexity and to provide sites for native amphibians to lay eggs (Figures 9-10).

Topographic Surveys

YTFP conducted a baseline 3-D topographic survey of the McGarvey Alcove IV project area and established permanent benchmarks during summer 2014. All surveys were conducted using an optical total station and a hand-held data collector. Data was collected in meters using the following coordinate systems: projected coordinate system NAD_1983_UTM Zone_10N; geographic coordinate system GCS North American 1983. End points for the longitudinal profile survey and cross sections were marked using rebar with end caps and georeferenced using the optical total station. YTFP tied all project surveys to YTFP's long-term channel monitoring survey located within the watershed to expand and enhance our physical monitoring program. Following alcove construction in 2014, YTFP conducted repeat topographic surveys in October 2014 to document as-built habitat conditions and in July 2015 to document post-winter conditions (Figure 12). The post-winter survey shows the upper portion of the alcove filled slightly (~0.8 to 1.0 ft) with sediment. This aggradation was the result of winter storms that caused McGarevy Creek to flow into the alcove and deposit channel derived sediments in the upper portion of the constructed feature (Figure 11). We had anticipated this would occur given the low floodplain elevations relative to mainstem thalweg elevations in this reach. Currently, the feature serves as a backwater alcove during most of the year but acts more like a side channel during overbank flows with both conditions providing vitally important habitat for native fish.

Photo-Monitoring

YTFP established a network of photographic monitoring sites within the project reach to help characterize habitat conditions and document changes over time (Beesley and Fiori 2014a & 2014b). Photo-monitoring location information was collected using a hand-held Garmin GPS Map 78s unit (Latitude, Longitude -decimal degrees, geographic coordinate system, WGS 84). We established one primary photo-point (McGAlcoveIV_1) to document habitat conditions at McGarvey Alcove IV and obtained photographs throughout the project's duration (Appendix A).

Water Quality & Fish Use Monitoring

YTFP has been assessing fish use and water quality conditions within the constructed alcoves of McGarvey Creek to improve our understanding of restoration performance and effectiveness, and to use the information gained to inform and improve future designs and fish recovery actions (Beesley and Fiori 2014a, YTFP 2013; YTFP Unpublished Data). Alcove water quality and fish use data collected from 2010 through 2013 was summarized in Beesley and Fiori 2014a. In February 2015, YTFP used two data sondes to collect water quality data from sites in McGarvey Alcove III and Alcove IV. Two sites (Upper & Lower) were monitored in Alcove IV during the

period: 02/12/15 – 02/19/15 (Figure 13). The sondes were then moved to two sites (Upper & Lower) within Alcove III and operated for the period: 02/19/24 – 02/24/15 (Figure 14).

Water temperatures measured in Alcove IV during the February 2015 monitoring period ranged from 9.42 to 11.22 °C at the upper site and from 9.74 to 12.04 °C at the lower site (Figure 13). Dissolved oxygen (DO) measured in Alcove IV during the February 2015 monitoring period were highly variable with values ranging from 0.00 to 6.03 mg/L at the upper site and from 4.48 to 6.97 mg/L at the lower site (Figure 13). DO at the lower monitoring site were much less variable and favorable to native fish relative to values measured at the upper monitoring site.

Water temperatures measured in Alcove III during the February 2015 monitoring period ranged from 10.06 to 11.16 °C at the upper site and from 9.41 to 11.69 °C at the lower site (Figure 14). Dissolved oxygen (DO) measured in Alcove III during this monitoring period ranged from 5.57 to 7.11 mg/L at the upper site and from 6.12 to 8.18 mg/L at the lower site (Figure 14).

In March-April, 2016, YTFP monitored water quality in all four of the McGarvey Creek alcoves. McGarvey Alcove III and Alcove IV were monitored for the period: 03/22/16 – 03/30/16 while Alcove I and Alcove II were monitored for the period: 03/31/16 – 04/11/16 (Figures 15-16).

Water temperatures measured during the March 2016 monitoring period ranged from 9.60 to 11.77 °C in Alcove III and from 6.73 to 13.46 °C in Alcove IV (Figure 15). DO values measured during this monitoring period ranged from 6.42 to 11.47 mg/L in Alcove III and from 6.42 to 11.18 in Alcove IV (Figure 15). DO patterns observed in Alcove IV during the March 2016 period were quite odd relative to the data collected in this alcove during February 2015. We are unsure if there was an issue with the DO probe during this deployment. The equipment was calibrated prior to this monitoring event and re-calibrated before deploying it in Alcove I. Calibration operations performed indicated that particular sonde was functioning properly so we can only assume the values measured in Alcove IV during March 2016 reflect actual conditions. DO may have been influenced by fluctuating water levels and surface and ground water inputs.

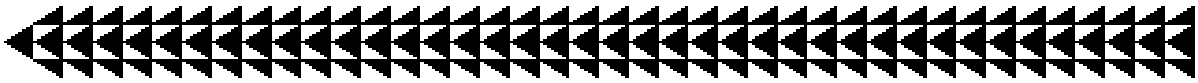
Water temperatures measured during the March 2016 monitoring period ranged from 10.29 to 12.59 °C in Alcove I and from 9.80 to 10.76 °C in Alcove II (Figure 16). DO values measured during this monitoring period ranged from 0.62 to 4.80 mg/L in Alcove I and from 6.81 to 8.47 in Alcove II (Figure 16). Water quality patterns observed in the four alcoves during March 2016 support our hypothesis that Alcoves II and III are highly influenced by tributary water inputs while Alcoves I and IV are more influenced by local ground water conditions.

To document fish use within the constructed alcoves, YTFP has been conducting mark-recapture population estimates using the Chapman modification of the Petersen estimator (Ricker 1975). Juvenile coho salmon abundance data for the four constructed alcoves in McGarvey Creek are presented in Figure 17. Although coho abundance estimates vary within and among the four sites during the monitoring period, the data indicates consistent use of these constructed features. These monitoring efforts also indicate significant use of these features by native amphibians (YTFP Unpublished Data). Since construction in 2014, YTFP has documented relatively high and consistent use of Alcove IV by juvenile coho with estimates ranging from a low of 133 individuals in February 2016 to a high of 170 individuals in July 2016 (Figure 17).

Discussion

The Yurok Tribe has been conducting watershed restoration and monitoring in McGarvey Creek since the late 1990s. YTFP and FGS have added a substantial amount of large wood to instream habitats as well as created four off-channel habitats to increase habitat complexity and floodplain connectivity (Figures 5-10). Physical habitat and fish use data collected since 2008 indicates that these actions have resulted in increased habitat complexity and salmonid rearing capacity. Fish and amphibian response to off-channel habitat construction in McGarvey has been very positive with consistent year-round use of these features by juvenile natal and non-natal coho (Fiori and Beesley 2014a; YTFP 2013; YTFP Unpublished Data) (Figure 17). However, studies conducted in a beaver pond located in West Fork McGarvey indicate these ponded features provide significant, high quality rearing habitats for juvenile coho and may result in higher growth rates and survival relative to off-channel habitats (YTFP Unpublished Data).

Based on published research, Yurok led coho ecology studies in the Lower Klamath, and the increased need for the ecosystem services that beaver dams provide, YTFP and FGS are currently working with various partners to fund and permit a series of beaver dam analogues (BDAs) in lower McGarvey Creek. Anticipated benefits of the proposed BDAs include 1) increasing the amount of summer rearing habitat by storing surface waters and recharging ground water tables, 2) improving winter rearing conditions in McGarvey Creek by increasing the amount of slow velocity refuge areas, and 3) increasing rearing habitat resiliency to environmental perturbations such as drought and potential future climate change impacts.



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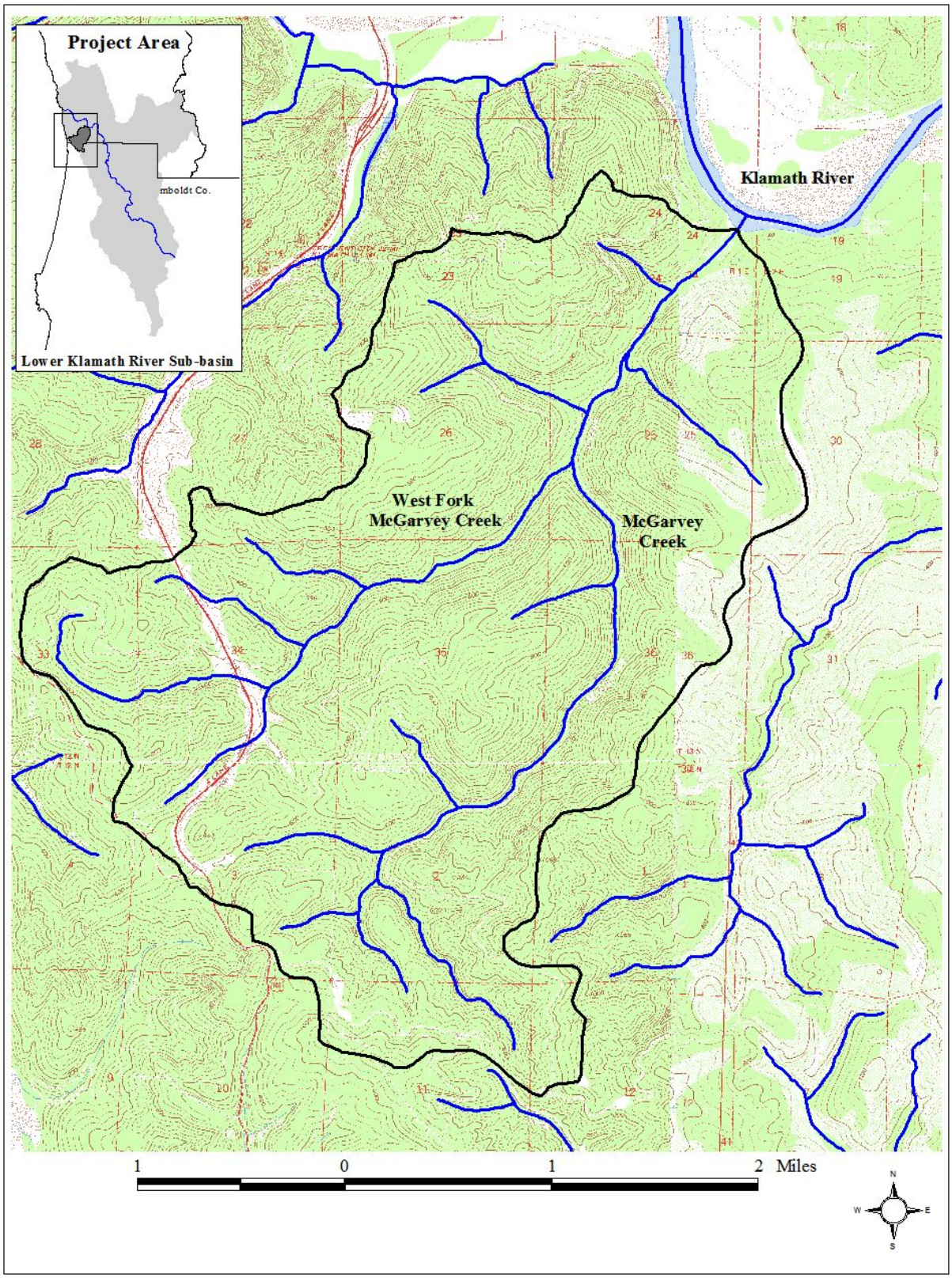

Figure 1. Map depicting the project location in lower McGarvey Creek, Lower Klamath River.

Figure 2. Photographs of a reach in upper McGarvey Creek prior to wood loading activities (Note: wood jams are lacking in the channel and mature alders dominate riparian habitats).

Figure 3. Photographs of a typical reach in lower McGarvey Creek where complex wood jams are lacking and mature conifers have been virtually eliminated from riparian recruitment zones.

Figure 4. Photograph of a typical floodplain in lower McGarvey Creek (Note: mature conifers have been eliminated from riparian recruitment zones and mature alders dominate the forests).

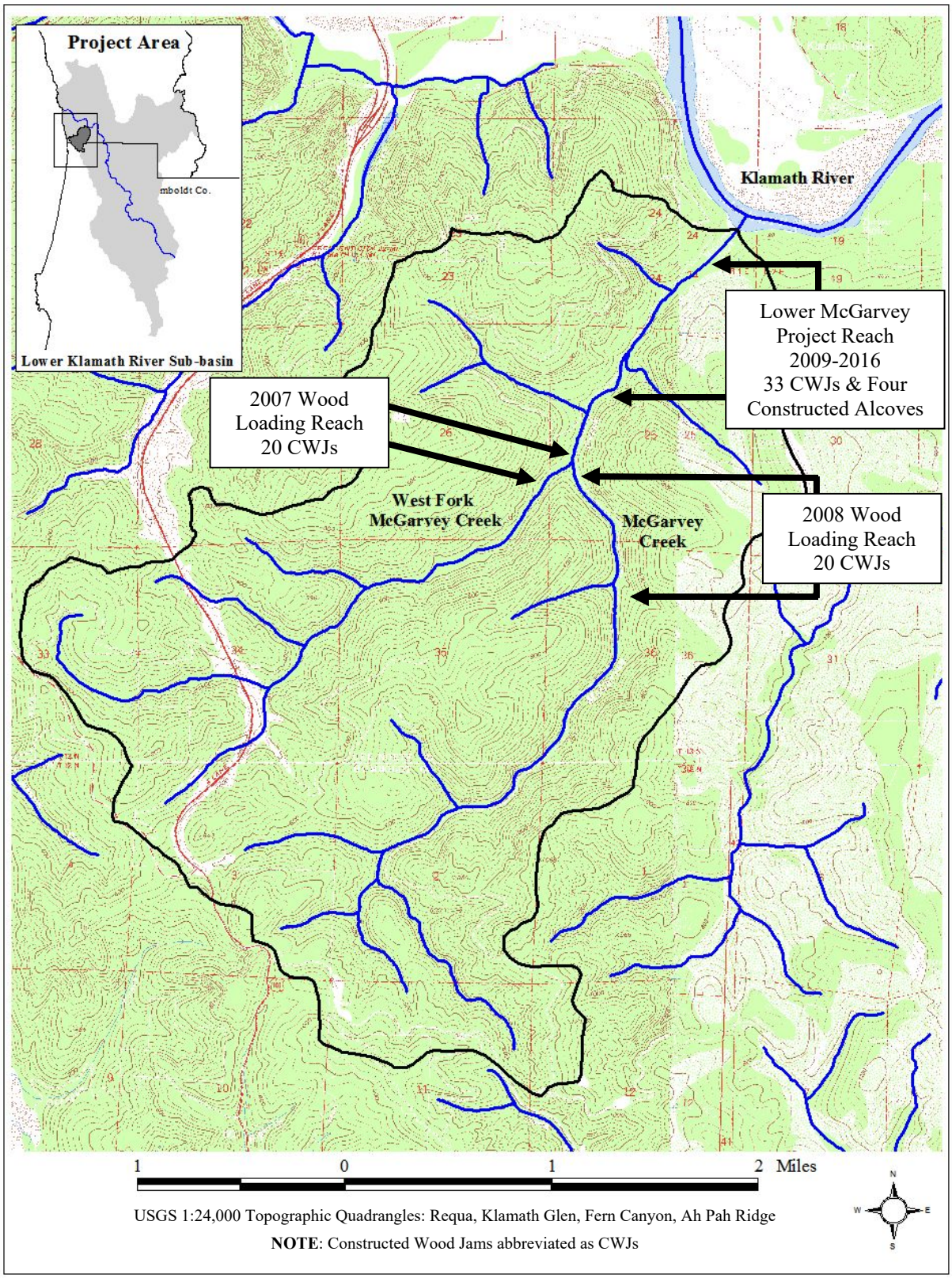

Figure 5. Map depicting restoration project locations in McGarvey Creek, Lower Klamath River.

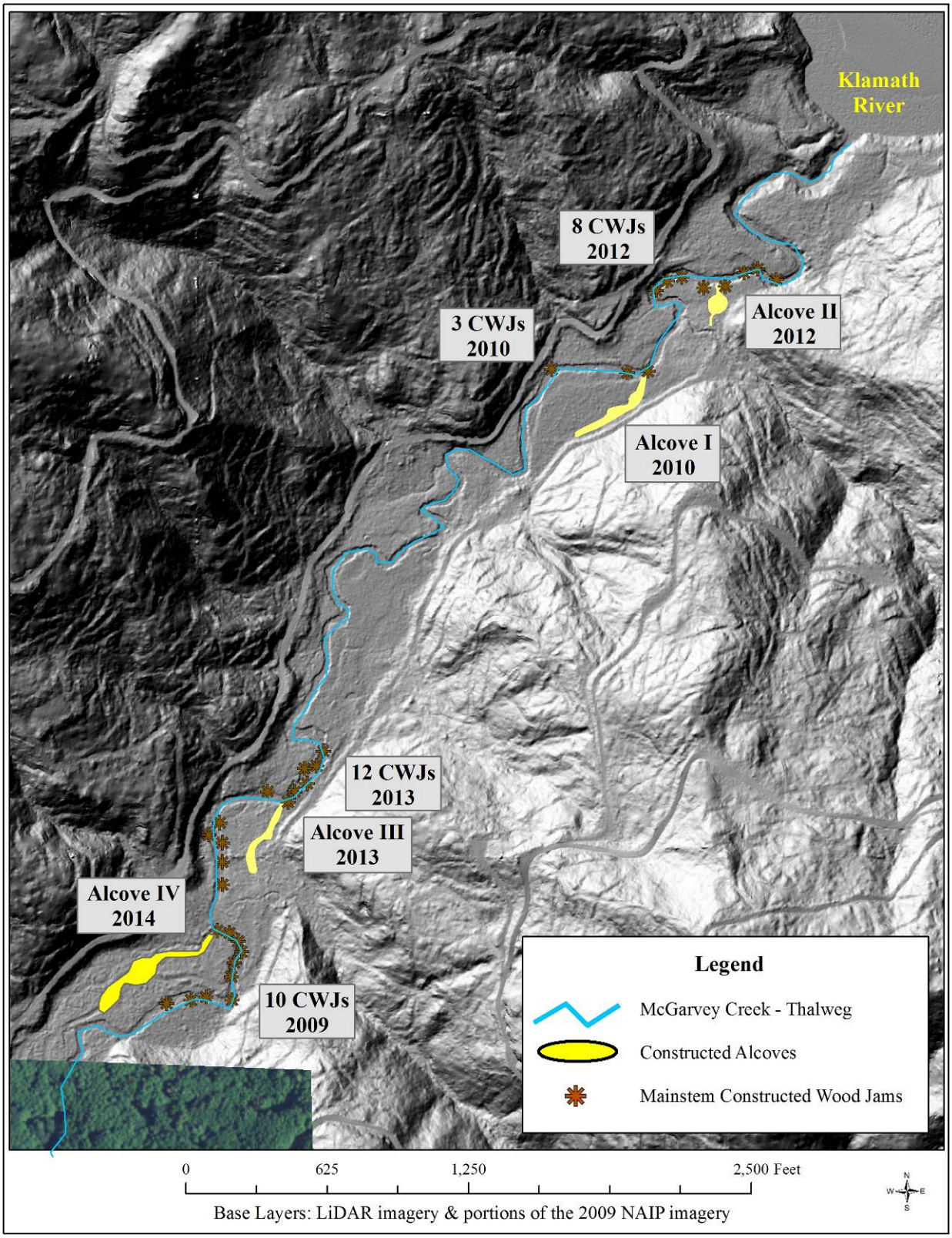

Figure 6. Map depicting a multi-phased approach to rehabilitating stream and floodplain habitats in lower McGarvey Creek, Lower Klamath River Sub-basin, California (Note: Alcove CWJs not depicted).

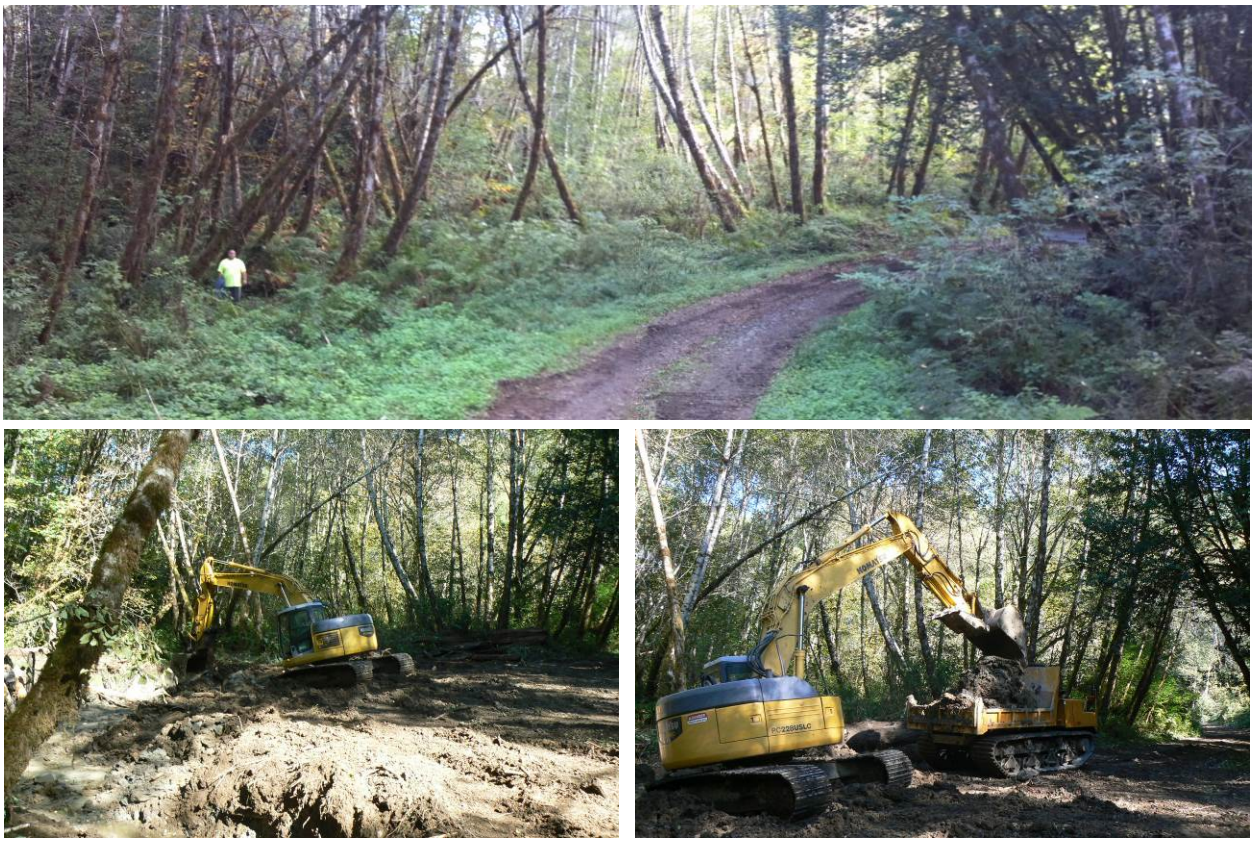

Figure 7. McGarvey Creek Alcove IV construction photographs (Top – Looking downstream at alcove site prior to excavation 10/08/14; Bottom – Alcove excavation 10/08/14).

Figure 8. Placement of erosion control hay at McGarvey Creek Alcove IV following construction (Left – Looking downstream 10/13/14; Right – Looking upstream 10/13/14).

Figure 9. McGarvey Creek Alcove IV following construction and the first flow event (10/31/14).

Figure 10. McGarvey Creek Alcove IV during the first winter post-construction (02/12/15).

Figure 11. McGarvey Creek during an overbank flow event (note: flows onto M600 road 02/12/15).

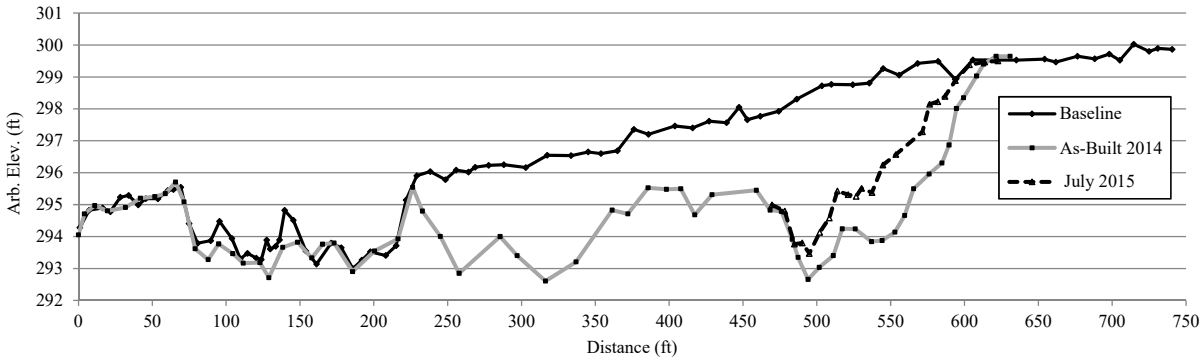

Figure 12. Longitudinal profile plots of McGarvey Creek Alcove IV prior to construction (Baseline), as-built (2014), and following the first winter post-construction (July 2015).

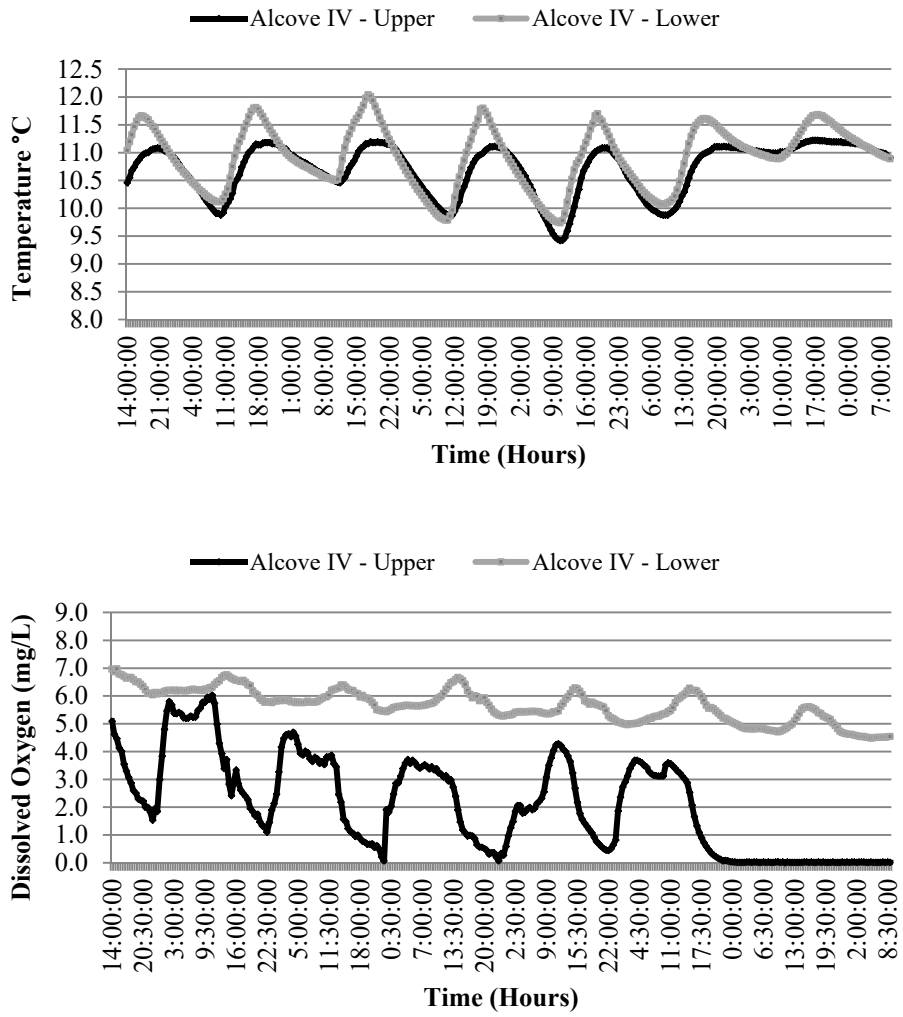

Figure 13. Water quality data collected in McGarvey Creek Alcove IV during the period: 02/12/15 – 02/19/15 (Top – Water Temperature; Bottom – Dissolved Oxygen).

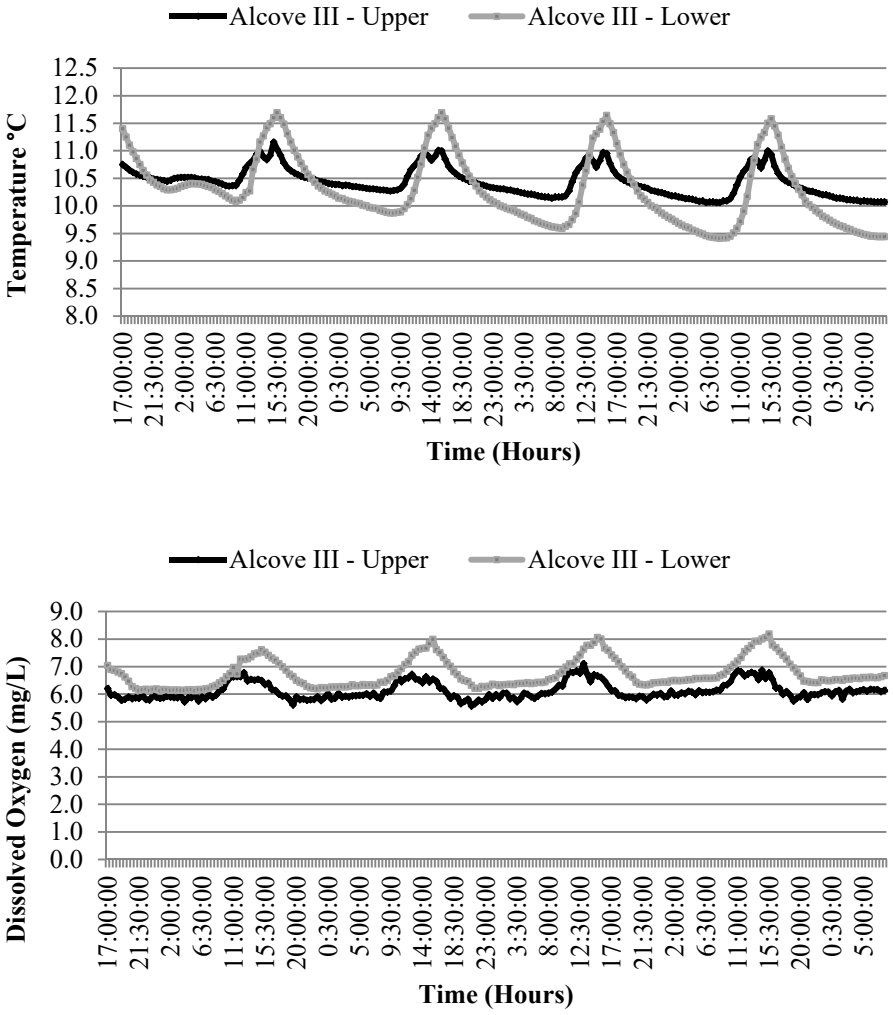

Figure 14. Water quality data collected in McGarvey Creek Alcove III during the period: 02/19/15 – 02/24/15 (Top – Water Temperature; Bottom – Dissolved Oxygen).

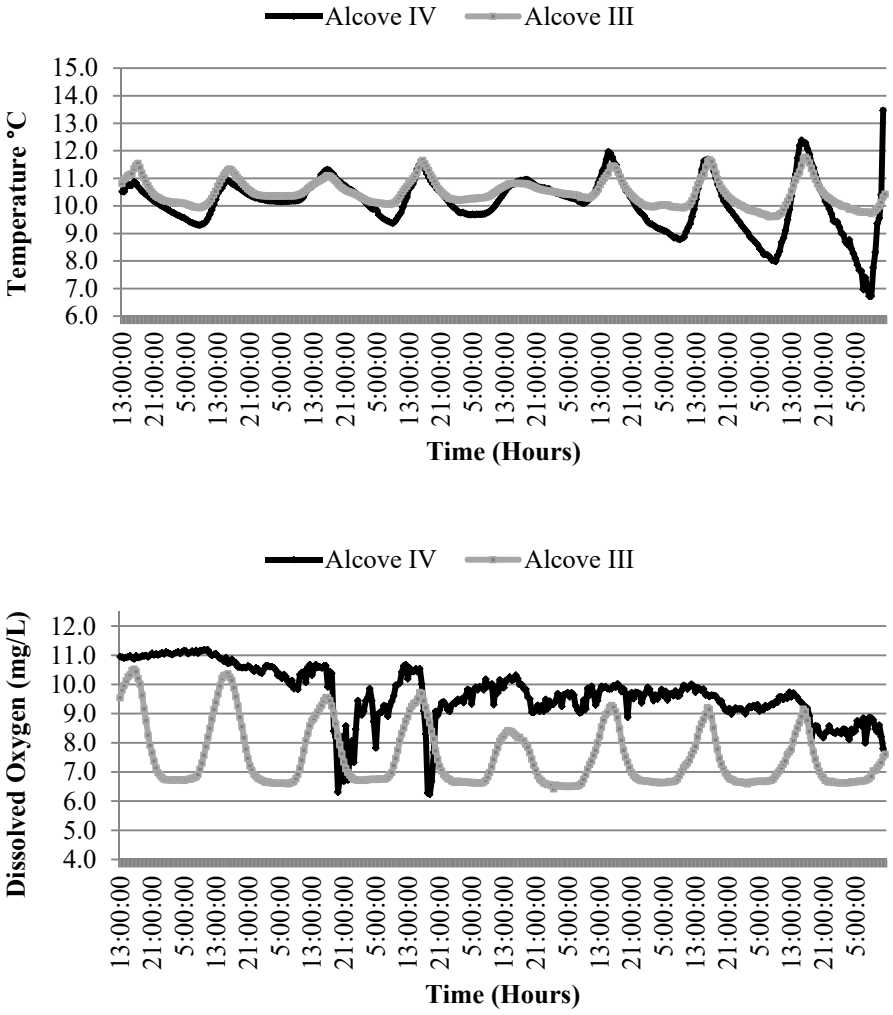

Figure 15. Water quality data collected in McGarvey Creek Alcove III & IV during the period: 03/22/16 – 03/30/16 (Top – Water Temperature; Bottom – Dissolved Oxygen).

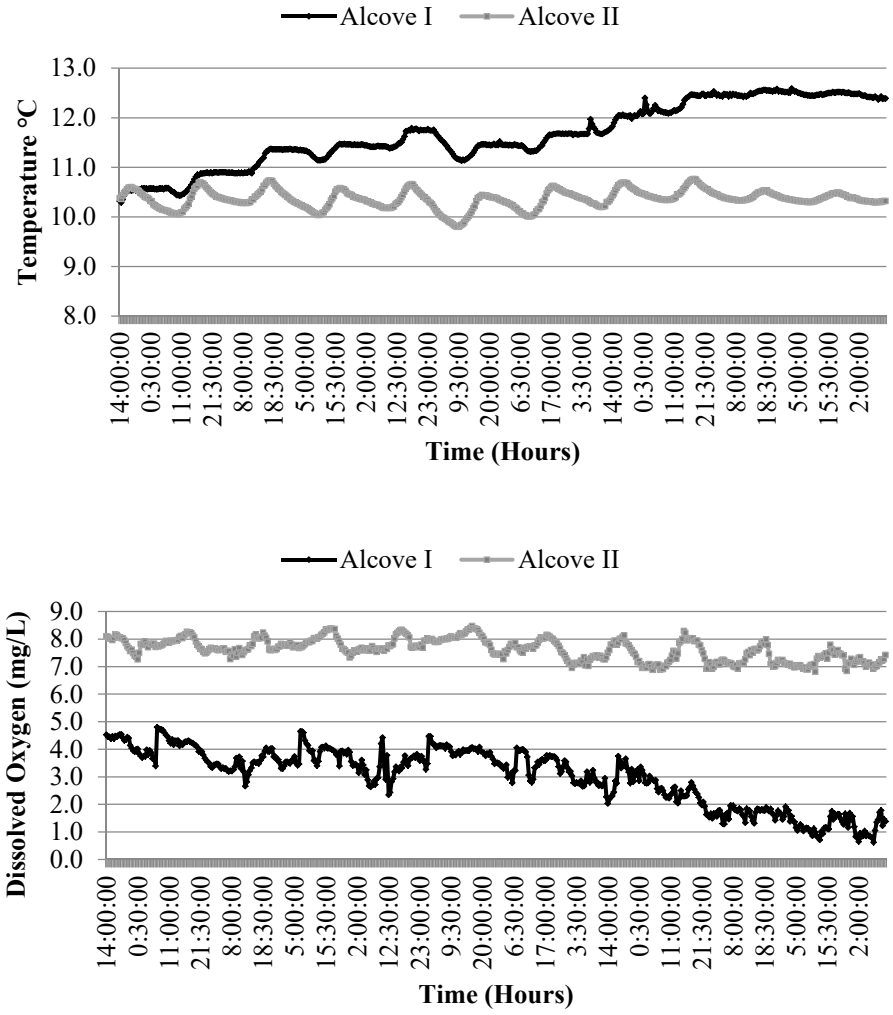

Figure 16. Water quality data collected in McGarvey Creek Alcove I & II during the period: 03/31/16 – 04/11/16 (Top – Water Temperature; Bottom – Dissolved Oxygen).

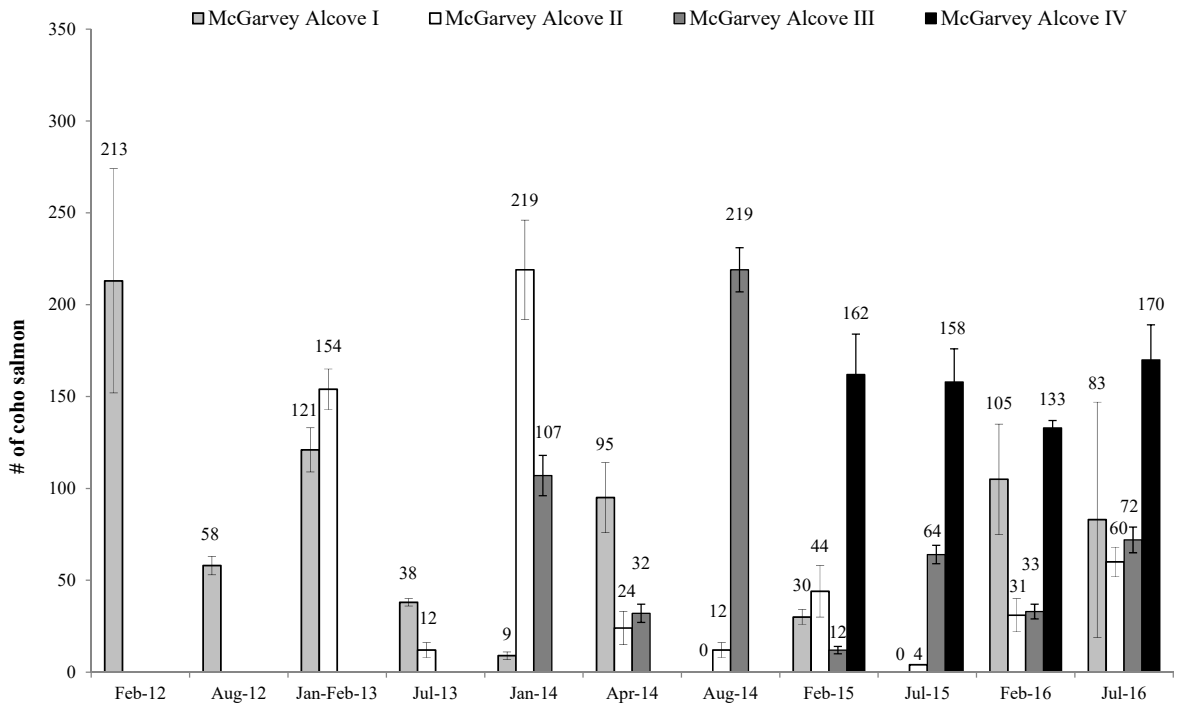

Figure 17. Mark-recapture population estimates for juvenile coho in McGarvey Creek alcoves.

Appendix A. Photo-Monitoring of McGarvey Alcove IV

Photo-Site McGAlcoveIV_1: McGarvey Creek Alcove IV prior to construction (10/08/2014).

Photo-Site McGAlcoveIV_1: McGarvey Creek Alcove IV during construction (10/12/2014).

Photo-Site McGAlcoveIV_1: McGarvey Creek Alcove IV during construction (10/13/2014).

Photo-Site McGAlcoveIV_1: McGarvey Creek Alcove IV during construction (10/14/2014).

Photo-Site McGAlcoveIV_1: McGarvey Creek Alcove IV post-construction (10/31/2014).

Photo-Site McGAlcoveIV_1: McGarvey Creek Alcove IV first winter post-construction (02/12/15).