Protecting Habitat for Coastal Cutthroat Trout through Reservations of Water in Southeast Alaska

Final Report for FWS Grant # F10AP00305

By

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Alaska Department of Fish and Game **Division of Sport Fish**

INTRODUCTION

Alaska water law is based on the doctrine of prior appropriation, giving the first appropriator of water from a given water source a priority of right over subsequent appropriators on a "first-in-time, first-in-right" basis. According to the rules of prior appropriation, the right to the requested amount of water is first given to the appropriator who has the earliest priority date to beneficially use the water. Senior water right holder have a legal standing to assert their right against conflicting uses of water from others who do not have a water right or who are junior in priority.

The State of Alaska Legislature amended the Alaska Water Use Act in 1980 to allow instream flows to be legally reserved by a private individual, group, or government agency in order to maintain specific flow rates in a river or volumes and water levels in a lake during specified time periods for one or a combination of four types of uses:

- Protection of fish and wildlife habitat, migration, and propagation;
- Recreation and parks purposes;
- Navigation and transportation purposes; and
- Sanitary and water quality purposes.

The Fish and Game Act requires the Alaska Department of Fish and Game, to "...manage, protect, maintain, improve, and extend the fishery resources of the state in the interest of the economy and general well-being of the state" (Alaska Statute 16.05.020; AS). One mechanism ADF&G uses to fulfill its mandate is to reserve water in rivers and lakes for fish and wildlife. An appropriation of water that remains within a river or lake is legally defined under Alaskan law (AS 46.15.145) and regulations (11 AAC 93.970) as a reservation of water (ROW). To reserve water an application with supporting data and analyses must be submitted to the Alaska Department of Natural Resources (DNR). A minimum of five years of mean daily stage data is recommended by DNR to quantify lake level requirements within an application.

In 2003, the Board of Fisheries and the Alaska Department of Fish and Game (ADF&G) prepared a policy for the management of sustainable wild trout fisheries (5 AAC 75.222) in recognition of the importance of coastal cutthroat trout and other wild trout and their ecosystems to the quality of life and economy of the state. The goal of the wild trout policy is to ensure conservation, sustainability, and optimal sustained yield of wild trout. To achieve this goal wild trout spawning, rearing, and migratory habitat should be protected. The policy further states wild trout habitat should not be perturbed beyond natural boundaries of variation and freshwater habitat should be protected on a watershed basis, including the appropriate management of water quantity. In managing these wild trout fisheries, ADF&G uses the precautionary approach involving the application of prudent foresight that takes into account the uncertainties in wild trout fisheries and habitat management, the biological, social, cultural, and economic risks, and the need to take action with incomplete knowledge should be applied to the regulation and control of harvest and other human-induced sources of wild trout mortality.

With the growing demand for resource development in Southeast Alaska (SEAK), potential threats to coastal cutthroat trout, *Oncorhynchus clarki clarki* (CCT) habitat continues to increase. The Western Native Trout Initiative (WNTI) Strategic Plan (WNTI 2008) identifies that native trout populations have been negatively impacted throughout their native range by habitat alteration. The WNTI strategic plan also identifies and emphasizes the importance of protecting existing watersheds with intact trout habitat. Furthermore, the National Fish Habitat (NFHAP) Action Plan (NFHAP 2013) mission and goal is to "protect and maintain intact and healthy aquatic systems". Before this project there were no ROW's for SEAK lakes -including lakes important to native CCT populations. Maintaining lake water levels near natural conditions is important to the protection of habitat for CCT, a species that has developed over time to thrive in these specific environments. Altering the natural hydrologic cycle, changing the littoral and riparian zones, or artificially raising and lowering lake levels can be problematic to cutthroat trout and many aquatic ecosystems (Burt 2002; Pusey 2003; Lytle and Poff 2004; and Harding 2011). Bangs and Harding (2005) identify one of the greatest long-term threats to coastal cutthroat populations in Alaska to be habitat degradation or destruction. Some of the potential causes of habitat alterations are road construction or insufficient maintenance of existing roads, mines, timber harvests, hydroelectric projects or other diversions of water, land development, and oil spills or other pollution.

There are 14 subspecies of cutthroat trout identified in the world. However, the CCT is the only subspecies found in Alaska and is also the only subspecies that can exhibit both resident and sea-run life history forms. The oldest and largest coastal cutthroat trout are of the resident lake life history form. These CCT have been known to live up to 15 years and weigh nearly eight pounds. These trophy-class coastal cutthroat trout are only found in large land-locked lakes in SEAK that contain populations of kokanee (*Oncorhynchus nerka*) (Elliott 2008). There are approximately 100 lakes in SEAK located above fish barriers that are known to contain populations of wild resident CCT. Thirteen of these lakes have been classified as trophy cutthroat lakes, meaning they produce cutthroat trout greater than or equal to 20 inches. These trophy cutthroat lakes are actively managed to maintain their unique fishery characteristics. The minimum size limit for legal harvest of cutthroat trout on a trophy classified lake is 25 inches with the exception of Turner Lake, which is catch and release only due to low abundance.

Of these 13 trophy cutthroat lakes, Turner Lake (Figure 1), Eagle Lake (Figure 2), and Orchard Lake (Figure 2) were selected for this project based on the criteria described in the study design section and recommendations from area management biologist and trout research staff. In 2010, ADF&G began a multi-year project to collect the hydrologic data necessary to file reservation of water applications to protect lake elevations, important to CTT, on each of these three lakes.

This project was initially funded through a Western Native Trout Initiative (WNTI) grant, using National Fish Habitat Action Plan funds, to collect three years (10/1/2010 to 12/30/2013) of lake elevation data. In 2012, the original grant was amended to include funding to collect the final two years (1/1/2014 to 12/31/2015) of lake elevation data. DNR typically recommends 5 complete years of data collection to substantiate a ROW application. This report serves as a final completion report summarizing the entire project from 10/1/2010 to 12/31/2015.

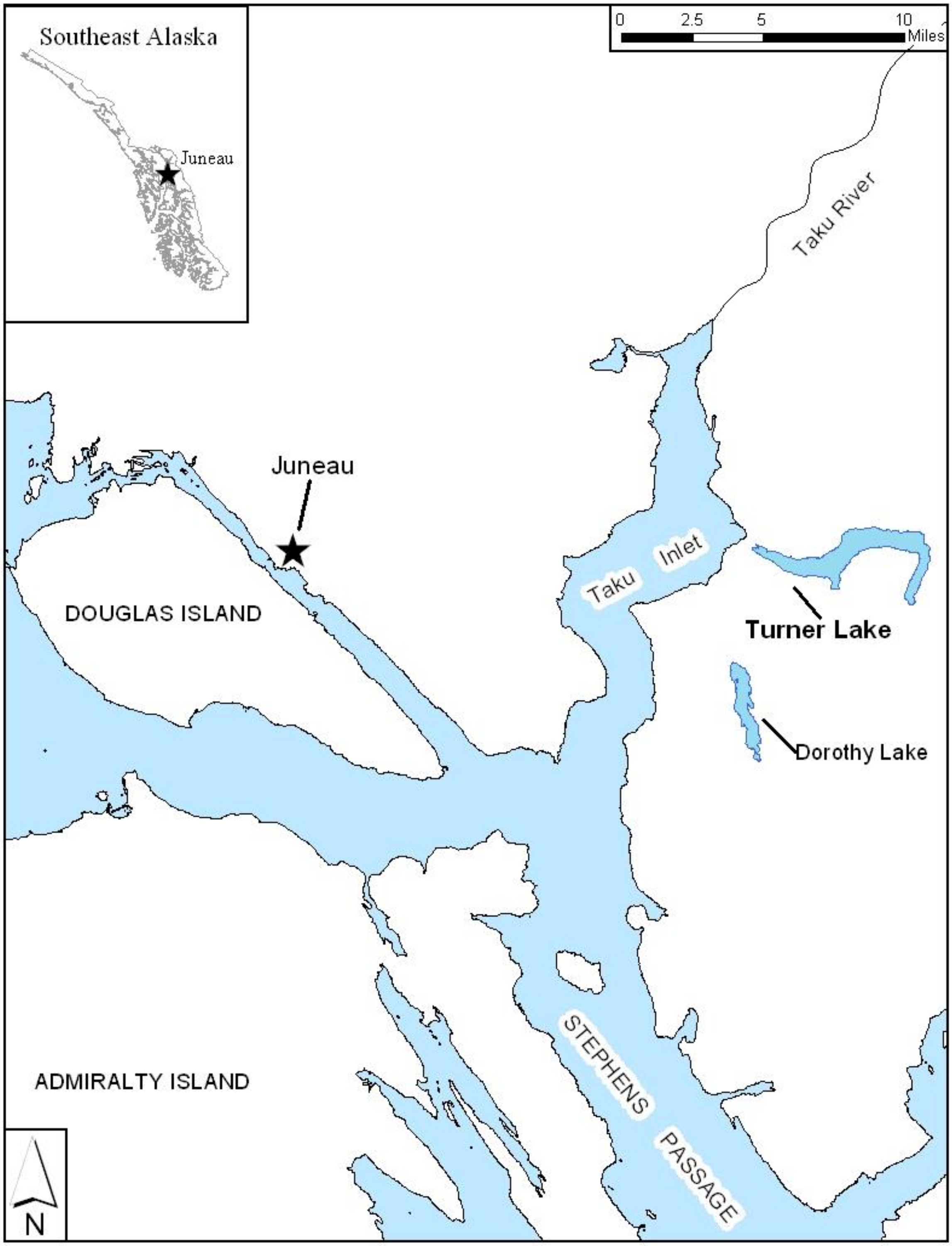


Figure 1.Turner Lake area map.

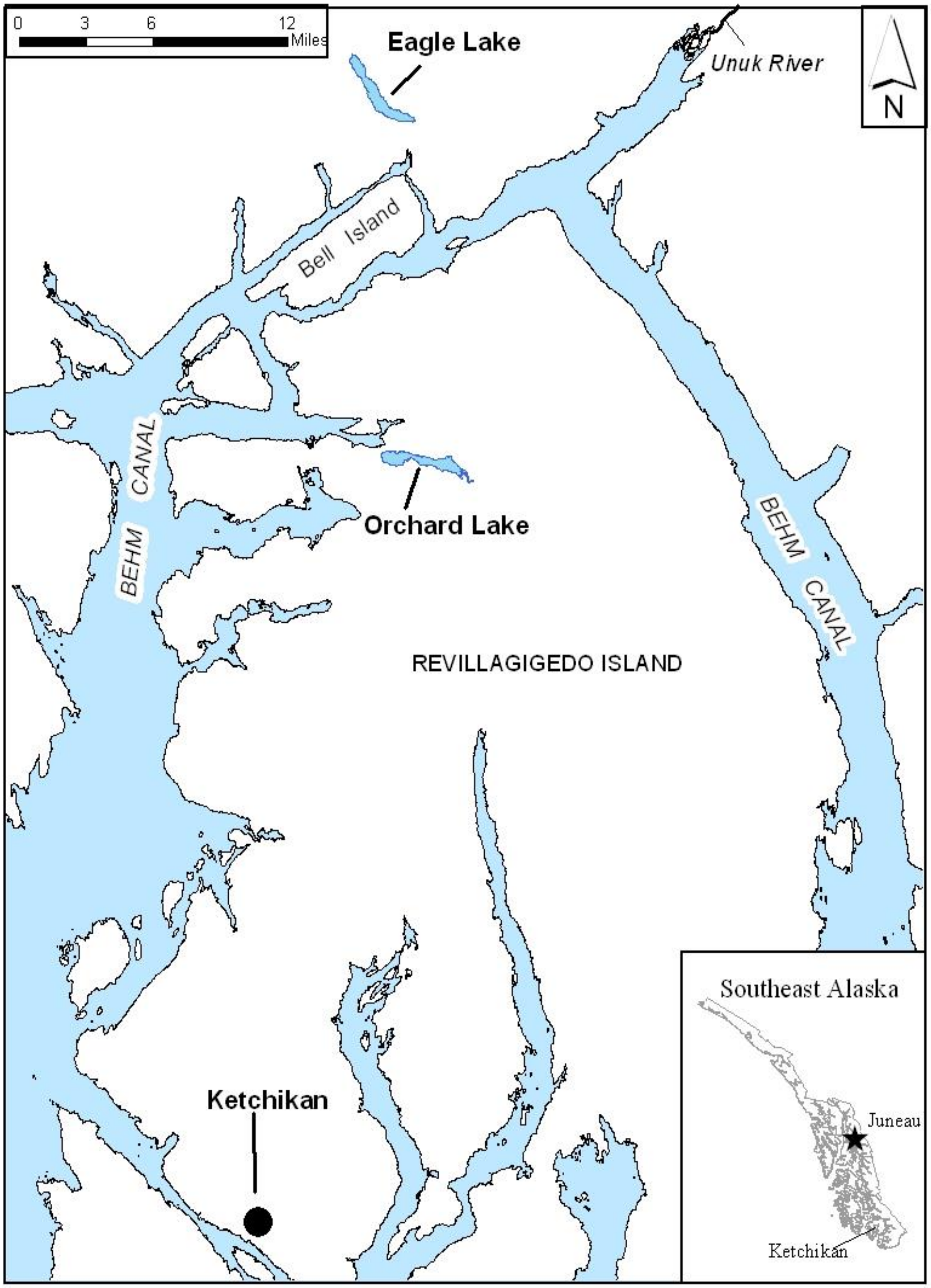


Figure 2. Eagle and Orchard lakes area map.

Study Area

All three study lakes (Turner, Eagle, and Orchard) are located in SEAK. This region of Alaska is characterized by steep mountains, rocky coastline, and a temperate coastal rainforest. The climate consists of cold snowy winters and cool wet summers. The three study lakes are within the Tongass National Forest. A United States Forest Service (USFS) recreation cabin is available for public use at each lake.

Turner Lake is located in the upper portion of the Taku Inlet, 16 miles east of Juneau. The lake is 8.6 miles long and a surface area of approximately 1,270 hectares. The lake is very steep sided and has a maximum depth of 706 feet. The lake outlet flows about one mile to Taku Inlet and is blocked to upstream fish passage by a barrier falls just below the lake (Harding 2009).

Eagle Lake is located 48 miles south of the town of Wrangell. The lake has a surface area of 435 hectares and a maximum depth of 148 feet. Most of the shoreline is low gradient with lots of large woody debris. Eagle Lake is blocked to upstream fish passage by a vertical falls located 4.5 miles downstream of the lake outlet. An electric transmission line runs along the west side of the watershed.

Orchard Lake is located 35 miles north of the town of Ketchikan. The lake has a surface of 390 hectares and an estimated maximum depth of 200 feet. The lake is accessible from saltwater via a one mile trail from Shrimp Bay. Much of the shoreline consists of steep sided bedrock cliffs. Orchard Lake is blocked to upstream fish passage by a barrier falls just below the lake.

Study Design

Objectives

The primary objective of this project is to collect the hydrologic data necessary to file reservation of water applications to reserve lake levels for CCT habitat, migration, and propagation within Turner, Eagle, and Orchard lakes. Specific objectives of this project included:

1. Install and operate lake level gages to collect 5 years of lake level data at Turner, Eagle, and Orchard lakes;
2. Collect lake inlet stream water temperatures;
3. Survey thalweg elevations of inlet streams; and
4. Complete and file ROW applications to protect CCT habitat, migration, and propagation in Turner, Eagle, and Orchard lakes.

Study Lake Selection

Many trophy cutthroat lakes in SEAK are generally protected from immediate habitat threats. Four are located within Misty Fjords National Monument and four more are located on Admiralty Island National Monument. Of the five remaining lakes, we chose Turner, Eagle, and

Orchard lakes. These three lakes were the most cost effective to travel to and met the criteria below.

The three study lakes were selected based on the following criteria:

1) Contain resident only populations of CCT;
2) Are located outside USFS designated wilderness areas;
3) Are classified and managed by ADF&G as a trophy cutthroat trout lake;
4) Have at least one USFS recreation cabin available; and
5) Could reasonably be developed for hydroelectric power (i.e. within close proximity to existing electric transmission lines), water export, or other out of stream water uses.

A reconnaissance trip was made during June 2010 to each of the lakes to find suitable sites for the gages and to take photos and GPS coordinates of the proposed gage sites. These photos and coordinates were sent to the appropriate USFS Ranger Districts to gain approval to install the lake gages at the proposed locations. The respective USFS Ranger Districts sent letters granting approval and offered to assist as needed.

Prior to this project, no lake level data had been collected at any of these lakes. To meet DNR data recommendations, ADF&G operated lake level gages, year-round, at each lake for 5 years. Each lake level gage collected lake level data every 15 minutes on the quarter hour. These recorded lake levels are the lakes water surface elevation relative to an established benchmark near each gage site. At the end of each water year the 15 minute lake level data was analyzed and summarized into mean daily lake levels (Figures 6-8), mean monthly lake levels, and mean annual lake levels. The lake level gages were installed in October 2010 and remained in operation until October 2015.

ADF&G surveyed the thalweg longitudinal profile at the downstream end of three inlet streams important to cutthroat spawning at each of the three study lakes. Water temperature data was also collected at each of these inlet streams using water temperature loggers.

Data Collection

Lake levels

Two lake level gages were installed independently of each other at each lake during October 2010 to record lake levels and water temperatures. Each lake level gage was located on a steep bedrock shoreline within easy access of the USFS cabins but out of view from most cabin users. The Turner Lake level gage was located along the northern shoreline, one mile east of the Turner Lake West cabin, at 58°18’32.6” North, 133°56’17.4” West (Figure 3 and Picture 1). The Eagle Lake level gage was located along the northern shoreline, three miles southeast of the Eagle Lake cabin, at 56°01’54”N, 131°25’07”W (Figure 4 and Picture 2), and the Orchard Lake level gage was located along the northern shoreline, 0.5 mile east of the Plenty Cutthroat cabin, at 55°49’32”N, 131°26’25”W (Figure 5 and Picture 3).

InSitu Level Troll 500 pressure transducers were installed to measure and record water level (accuracy of +/- 0.1%) and temperature (accuracy of +/- 0.1° C). Transducers were housed in galvanized 1-1/4" pipes secured to bedrock with custom pipe brackets and 5/8" galvanized expansion bolts. The total length of the transducers, cable and desiccant was approximately 16 feet. The transducer and approximately 10 feet of cable are below the water surface, the remaining cable and desiccant are above the water surface. Each pressure transducer was assigned a unique station number. Transducers 13201 and 13202 were installed in Turner Lake, transducers 13301 and 13302 were installed in Eagle Lake, and transducers 13401 and 13402 were installed in Orchard Lake.

Galvanized expansion bolts (5/8" x 6") secured into the bedrock near the two transducers were used to measure lake level independent of the two transducers (Picture 4). This bolt, herein referred to as reference mark 1 (RM1), was assigned an arbitrary elevation of 10 ft. and serves as the primary reference point for lake level measurements. The vertical distance between RM1 and the water surface elevation (WSE) was measured using a surveyor's leveling rod graduated in 1/100 ft. increments. This distance was subtracted from the elevation of RM1 (10ft.) to determine the current lake level. Each pressure transducer was programmed to read the current respective lake level and to measure and store a lake level and water temperature reading every fifteen minutes on the quarter hour. During each site visit, the WSEs measured from RM1 was compared with each pressure transducer reading to determine if the real-time lake level is being accurately recorded by the transducers

Two additional RMs (RM2 and RM3) were established near each gage site to monitor for quality control. These RM's are large galvanized expansion bolts installed in surrounding bedrock. The differences in the elevations of these RM's in relation to RM1 were measured using standard differential surveying techniques following United States Geological Survey (USGS) protocols (Kennedy 1990). The RM elevations were surveyed once a year and also at the time of gage removal.

The three study lakes were visited at least two times per year during the gages operational period to download the transducer data, measure the current lake level in relation to RM1, take pictures of site conditions, and to perform routine maintenance and repairs. These gage site visits took place shortly after the lakes are free of ice in late spring and again in late fall. In addition to the spring and fall visit, Turner Lake was also visited in March 2012. Insufficient ice cover prevented additional winter visits to the lakes. Lake level and water temperature data was transferred from the transducers to a Rugged Reader© Pocket PC, after measuring the lake level relative to RM1.

Back in the office setting the fifteen minute transducer lake level and water temperature data was downloaded from the Rugged Reader© Pocket PC to a desktop computer using the Win-Situ 5© and Win-Situ Sync© software and saved in the appropriate station folder. Transducer recorded lake level and water temperature data, along with measured lake level data in relation to RM1, was converted in Microsoft Excel to comma delimited text files and imported into the Water Information System Kisters Inc. (WISKI) hydrologic software[1] for storage and analysis. Electronic copies of field notes, gage height corrections spreadsheet, photographs, and lake level summary records is being stored in folders associated with the gaging station name and number on the WISKI dedicated server.

Upon completion of data collection, the fifteen minute lake level data was converted from an elevation relative to the arbitrary “10 feet” assigned to RM1 to a true elevation above mean sea-level. To accomplish this, the true elevation of RM1 needed to be determined. Using a Thales Z-Max differential GPS, set up on a beach near a calm part of the lake, we first determined the elevation of a stable benchmark (rebar or brass cap) beneath the GPS. Next, the current lake level was surveyed relative to the elevation of this stable benchmark. This surveyed difference was **subtracted** from the elevation of RM1. Now the difference between the current elevation, as determined in the previous survey and RM1 was measured. This measured difference was **added** to the current lake elevation to determine the true elevation of RM1 (Table 1). This elevation data was post processed through the Online Positioning User Service (OPUS) software.

Table 1. Example spreadsheet of RM1 true elevation survey.

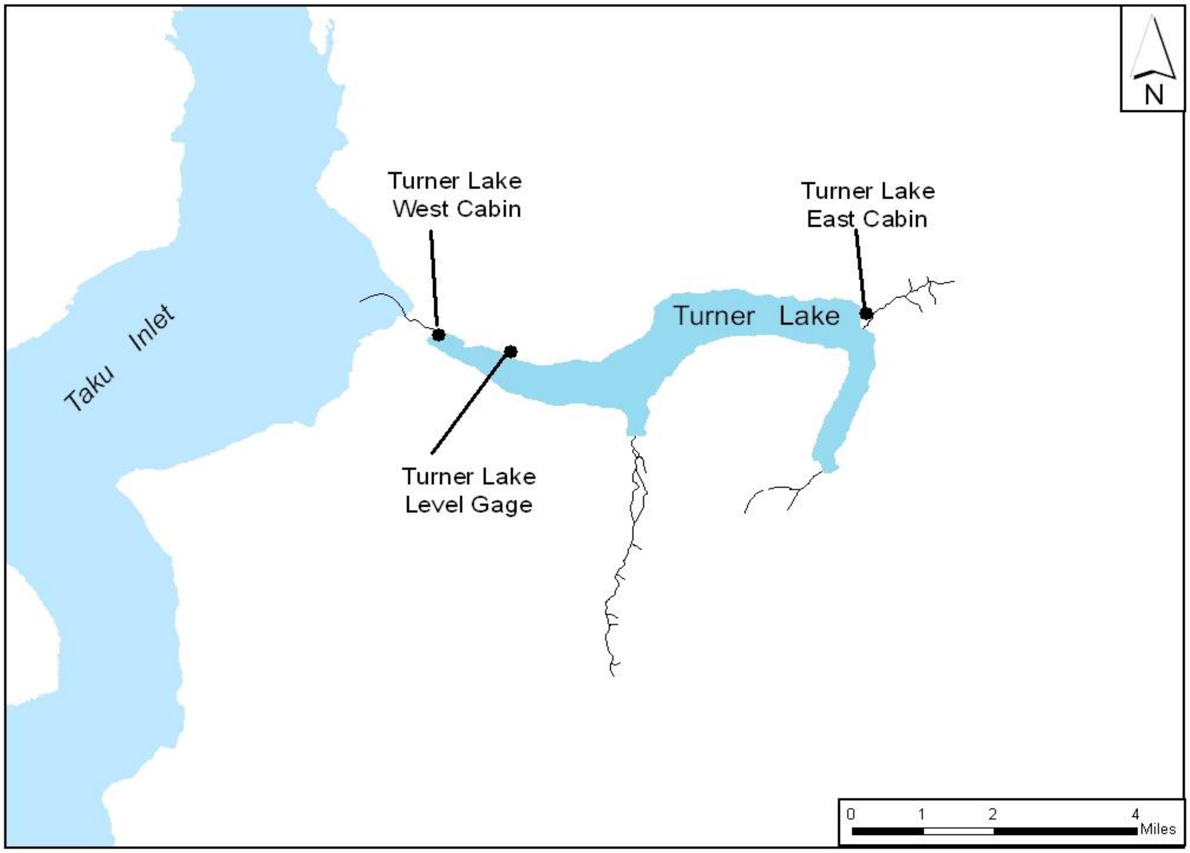
Elevation of Brass Cap	92.995 feet
Difference between brass cap and lake level	8.716 feet
Current lake elevation (92.995' - 8.716')	84.279 feet
Difference between lake level and RM1	1.100 feet
Elevation of RM1 (84.279' + 1.100')	85.379 feet

After the true elevation of each RM1 was determined, a data correction within WISKI was made to all the lake level data to convert it to a true elevation above mean sea-level (AMSL).

The fifteen minute lake level data was also corrected at the end of each water year to account for transducer drift or movement. These data corrections were based on the differences between the observed (measured) lake level and the transducers recorded lake level. Any erroneous, ice affected, or missing data was also corrected; and the primary transducer chosen at the end of each water year.

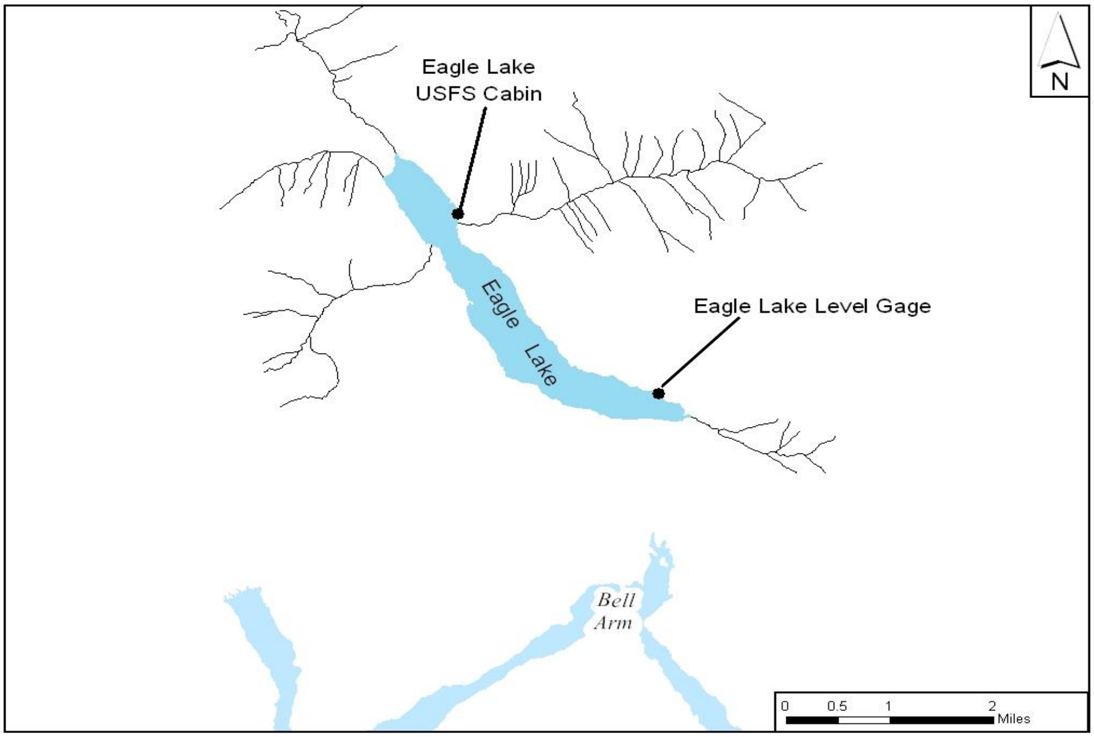
[1] Product name is included for complete description of process, and does not constitute product endorsement.

Figure 3. Locations of key features on Turner Lake.



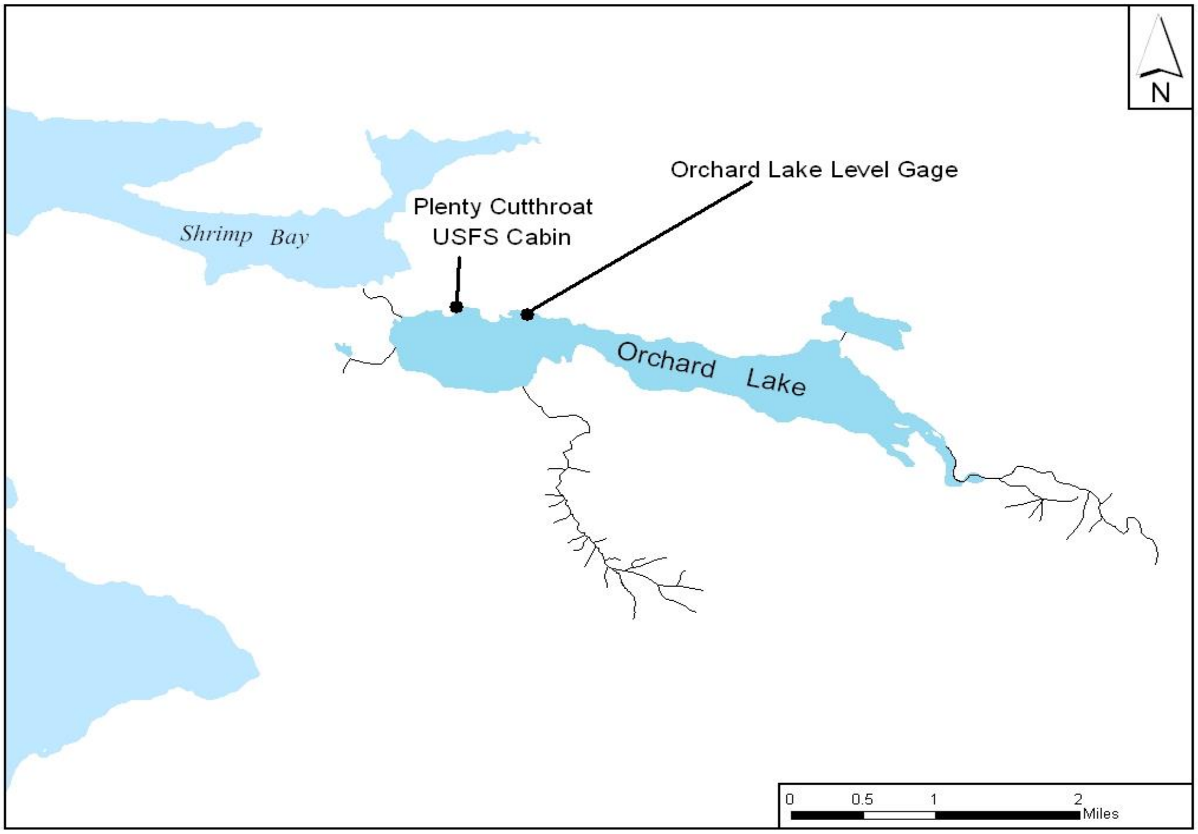
Picture 1. Turner Lake transducers and RM1 (circled in red). Lake level at 8.32 feet on September 30, 2010.

Figure 4. Location of USFS cabin and lake gage site on Eagle Lake.



Picture 2. Eagle Lake transducers. Lake level at 7.13 feet on October 20, 2010.

Figure 5. Location of USFS cabin and lake gage site on Orchard Lake.



Picture 3. Orchard Lake transducers. Lake level at 7.13 feet on October 21, 2010.

Inlet Stream Thalweg Longitudinal Profiles

To determine the gradient of inlet streams important for spawning cutthroat the thalweg longitudinal profile were measured at three inlet streams to each lake during the spring 2012 site visit. The streams selected were identified by trout research staff as having suitable habitat for spawning CCT.

To conduct the thalweg profile surveys differential leveling, protocols as described in Harrelson et al (1994) were followed. The lake level relative to RM1 was measured and associated time recorded prior to beginning the survey. This lake level was the known elevation that all streambed elevations were related to. The auto level was setup in a location so that the lake and as much of the reach as possible is visible. To start the survey a stadia rod reading (backsight) was taken at the current lake level to establish the height of instrument (HI). All subsequent stadia rod readings (foresights), herein referred to as stations, from this auto level set up location are subtracted from the HI to obtain the elevation of the thalweg relative to the lake level. Rod readings were taken at the thalweg correlated to changes in habitat types (i.e. riffle, pools, run/glide). Using a tape measure or range finder, distances between each station was measured. A photograph was taken and the habitat type and a GPS coordinate of each station was also recorded. As the survey proceeded upstream the level operator calculated elevations at each station. At most streams become necessary to establish turning points if the rod cannot be seen from the auto levels current location. In this the case the auto level moved to a location where the last station with a known elevation could be seen. A backsight reading is taken at this station and the HI relative to this stations elevation was calculated.

The survey continued upstream until the highest lake level elevation recorded at the lake level gage was reached. Thalweg elevations were measured into the lake as far as it is possible to identify the stream thalweg. After the survey was complete a lake level reading in relation to RM1 was measured and the associated time recorded.

All thalweg longitudinal profile data was transferred from field notes into an Excel worksheet and stored in the corresponding lakes gaging folder. Each tributary's thalweg longitudinal profile worksheet contains the GPS coordinates of each station, the elevation (relative to RM1) at each station, the distance between this station and the next station, and the percent gradient between stations. The percent gradient between stations was calculated as the difference in elevation between subsequent stations divided by the distance between these stations multiplied by 100. The gradient of the entire reach was also calculated as the difference in elevations between the downstream and upstream stations divided by the sum of all distances between stations multiplied by 100. Longitudinal profile maps for each surveyed inlet tributary will be created and published in an ADF&G Fisheries Data Series (FDS) report.

Inlet Stream Water Temperature

Inlet stream water temperature was collected in three inlet streams at each lake to determine the timing of CCT spawning migrations. Stream temperatures of about 3 to 6°C may initiate spawning activity and actual spawning typically occurs when daily maximum water temperatures reach 6 to 9°C (Behnke 1992).

In October 2010, Hobo water temperature loggers were installed in the same inlet streams that the thalweg gradient worked occurred. The Hobos were installed mid-depth near the middle of the stream and programed to record water temperatures every 2 hours. During the spring site visits the Hobos were retrieved and replaced with another Hobo. Once back in the office setting, the water temperature data from the retrieved Hobo was downloaded and stored in an Excel file. Once completely summarized, this data will be stored in the same WISKI database that holds the lake level data and reported in an the aforementioned ADF&G FDS report. All summarized water temperature data will also be entered into the Alaska Online Aquatic Temperature Site database.

Results

Five complete water years of lake level data have now been collected on each of the three study lakes. Lake level Gage 13201 operated continuously on Turner Lake from September 30, 2010 until October 5, 2015. Lake Level Gage 13301 operated continuously on Eagle Lake from October 20, 2010 until October 22, 2015. Lake Level Gage 13401 operated continuously on Orchard Lake from October 21, 2010 until October 21, 2015.

Mean daily lake elevations on Turner Lake ranged from a high of 86.22 ft. AMSL recorded on August 22, 2011 to a low of 78.41 ft. AMSL recorded on April 6, 2012. Eagle Lake mean daily lake elevations ranged from a high of 305.59 ft. AMSL recorded on September 13, 2012 to a low of 300.11 ft. AMSL recorded on March 6, 2014. Orchard Lake elevations ranged from a high of 150.59 ft. AMSL recorded on October 10, 2015 to a low of 141.19 ft. AMSL recorded on March 6, 2014.

Turner Lake exhibits a glacial melt hydrograph (Figure 6) with the lake becoming free of ice and lake levels quickly rising beginning around mid-May. Increasing air temps continue to melt snow and ice within the watershed through summer and into the fall months, with lake elevations typically peaking around September.

Eagle and Orchard lakes share very similar rainfall driven hydrographs (Figures 7 and 8). Due to the lack of glaciers within these watersheds Eagle and Orchard lake elevations are driven by melting snow in the spring and rely on rainfall in the summer and fall months. Rainfall on snow, in the lower elevations of the watersheds, continues to keep the lakes full throughout the winter months.

Tributary thalweg gradients were collected on 2 tributaries to Orchard Lake and three tributaries on both Turner and Eagle lakes. Mean gradients, within the littoral zone, between and elevation of 78 ft. AMSL and 89 ft. AMSL ranged from 0.4% to 4.1%, on Turner lake. On Eagle Lake, mean gradients were collected between 297 ft. AMSL and 317 ft. AMSL and ranged from 2.2% to 3.7%. On Orchard Lake, mean gradients were collected between 140 ft. AMSL and 154 ft. AMSL and ranged from 3.3% to 7.5%.

Water temperatures were collected on 3 inlet tributaries to each of the three study lakes. Daily maximum water temperatures typically reached 6-9°C around late May through early July. These are the approximate times when CCT spawning activity will typically occur in these inlet tributaries and lake margins (Behnke 1992 and R. Harding, Fishery Biologist, Juneau, 2011 personal communication).

After one year of lake level data was collected, ROW applications were completed for each of the three study lakes. These applications were completed using only the initial one year of lake level data. ROW applications included the following components: 1) maps and legal descriptions describing the lake and gage locations; 2) the hydrologic data collected on the respective lake; 3) description and justification of the method used to quantify the lake level ROW requests; 4) fish species periodicity chart; and 5) the lake level requested by time period for the respective lake. These ROW applications were accepted by DNR (LAS numbers 28656, 28772, and 28771) and given priority dates 8/2/2012 (Turner Lake) and 11/19/2012 (Eagle and Orchard lakes).

At the completion of data collection new ROW applications were completed for each lake using updated lake level data for the entire, five year, period of record. These new ROW applications were accepted by DNR (LAS numbers 31214, 31215, and 31219) and given a priority date of June 15, 2016.

Figure 6. Mean daily lake elevations (10/1/2010-9/30/2015) and ROW requested elevations for Turner Lake.

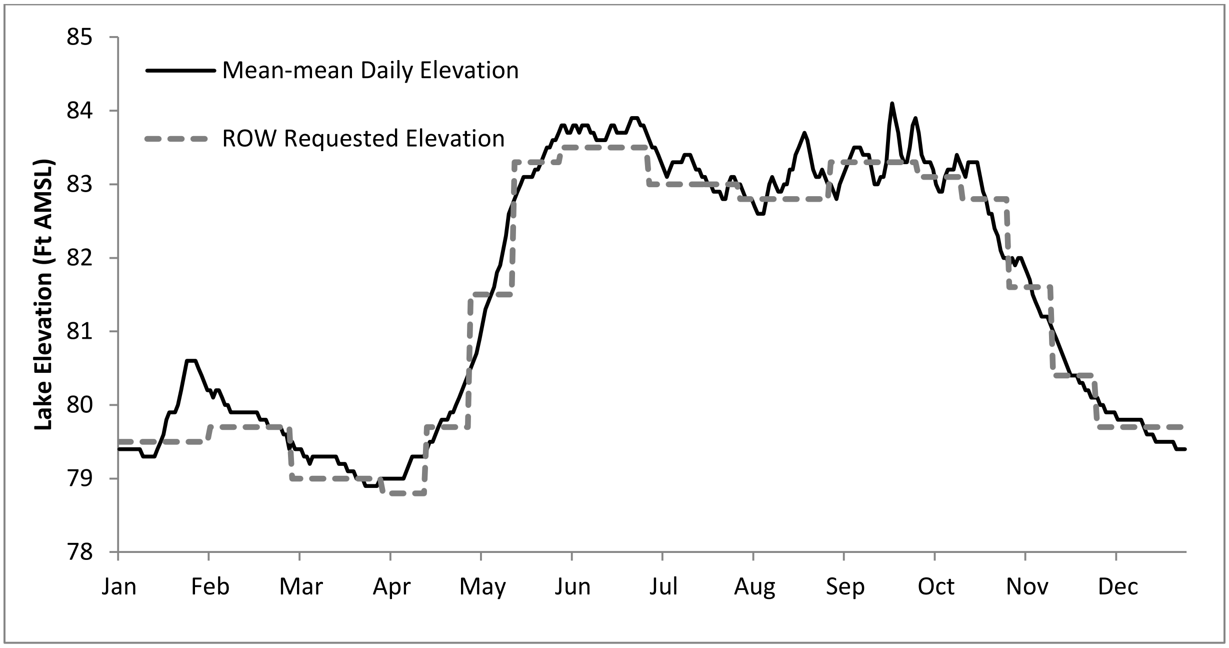


Figure 7. Mean daily lake elevations (10/1/2010-9/30/2015) and ROW requested elevations for Eagle Lake.

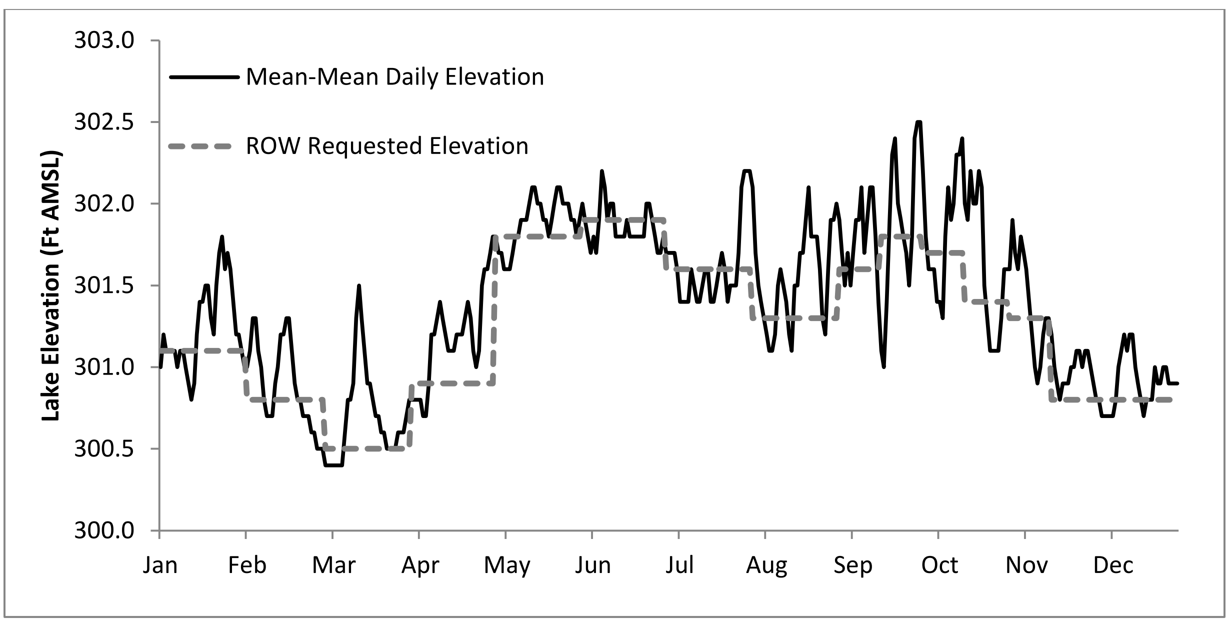
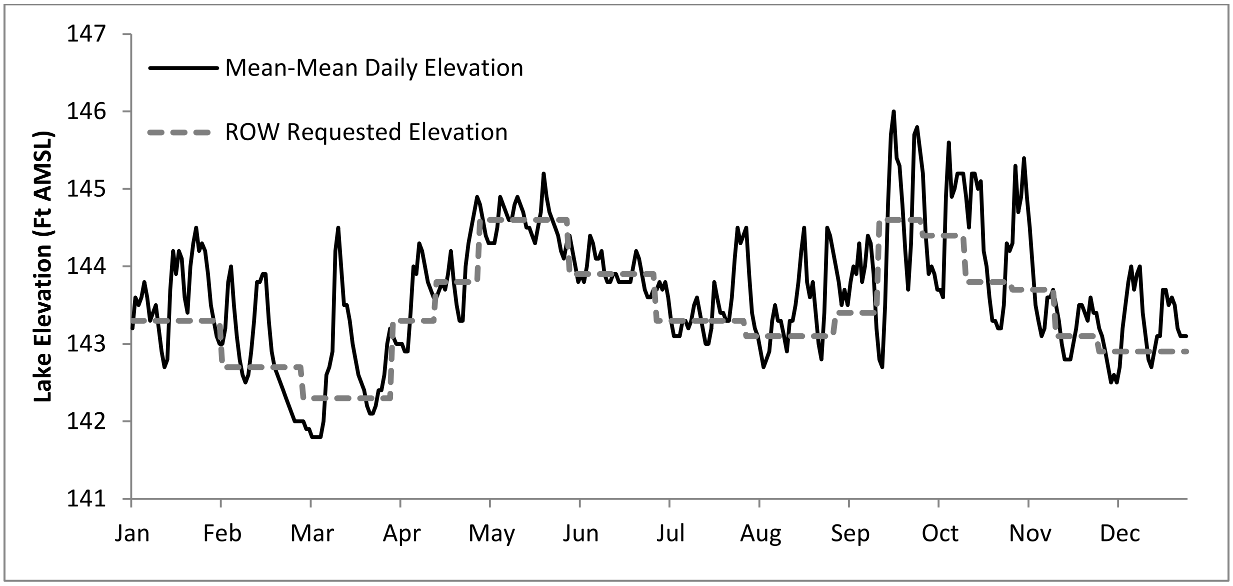


Figure 8. Mean daily lake elevations (10/1/2010-9/30/2015) and ROW requested elevations for Orchard Lake.



Discussion

A petition for listing CCT under the Endangered Species Act was denied in 1999. After a status review of the CCT from Washington, Oregon, and California the National Marine Fisheries Service concluded that "there is insufficient evidence to demonstrate that CCT are at a significant risk of extinction" as well as "there is insufficient evidence to demonstrate that CCT are *not* at significant risk of extinction" (Johnson et al. 1999). The review goes on to acknowledge there are stock concerns within much of southern end of the CCT range. These stock concerns are due most commonly to habitat alteration caused by hydroelectric dams and diversions, agriculture, mining, urbanization, and logging.

In Southeast Alaska, there are still very healthy populations of CCT, especially in some of the large lake systems. These same large lake systems are also attractive to water development projects and other anthropogenic activities. One mechanism to protect these lakes for CCT habitat, migration, and propagation is to apply for reservations of water.

This project, funded through WNTI and NFHP, collected the 5 years of lake elevation data necessary to apply for ROW's for Turner, Eagle, and Orchard lakes, in SEAK. These ROW's were completed and have been submitted to DNR.

Lake elevations were requested to attempt to mimic the natural seasonal patterns of lake levels. All requested lake elevations were near the median lake elevation for the requested time periods.

To maintain seasonal uses of habitats by each life history stage, we recommend maintaining a lake elevation regime that mimics the magnitude and timing of the natural lake elevation regime. Maintaining lake elevations near natural conditions is important to the protection of habitat for cutthroat trout, a species that has developed over time to thrive in these specific environments.

The ROW applications have not yet been adjudicated by the DNR. Once adjudicated and certificates of water have been issued, ADF&G will be the senior water right holder on Turner, Eagle, and Orchard lakes. These water rights will protect the littoral zone habitat important to the native coastal cutthroat trout.

At this time there are no water withdraws, impoundments, or diversions on these three lakes. All ADF&G gaging equipment and temperature loggers have been removed. Only the associated reference marks remain. If required ADF&G gage datum could be reestablished using these reference marks.

While water development projects in SEAK increase, so does the threat to habitat important to fish and other aquatic resources. Applying for additional reservations of water is one method to help protect and maintain this habit.

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