# Goodman Off -Channel Pond Monitoring Report

**By Mid Klamath Watershed Council**

## Background and Introduction

The Goodman Off-Chanel Pond (OCP) is located approximately 2,000 feet up Middle Creek from its confluence with Horse Creek, tributary to the Klamath River (see figures 1 and 2).

This OCP was constructed in the fall of 2015 by MKWC and subcontractor ABC Logging. Funding for this project came from USFWS Partners for Fish and Wildlife and the PacifiCorp Coho Enhancement Fund. MKWC began project planning for the Goodman Pond in 2013. Post-construction monitoring funds are provided by PacifiCorp and the California Department of Fish and Wildlife.

Field reviews with the Karuk Tribe, landowner, Rocco Fiori (Fiori GeoSciences, Inc.), USFWS, CDFW, USFS and others helped to inform data collection needs prior to construction. MKWC performed a topographic survey of the project area, and conducted cross section topographical profiles throughout the proposed outlet channel and the pond. This site was chosen primarily for its favorable groundwater input and existing abandoned side channel feature. Before construction, MKWC staff located an active perennial spring at the project site which would provide an abundance of cold water input at the site and provide high quality rearing habitat for juvenile salmonids. These findings were confirmed through pre-project monitoring of one 10-foot-long ground water well installed at the site. Depth of groundwater was less than three and a half feet below ground level in the summer and groundwater temperatures ranged from 12-15 degrees Celsius.

With a perennial above ground spring located at the top of the project site as well as the nature of the vegetation in the area, we hypothesized that the feature would likely have good dissolved oxygen levels, ideal water temperature for rearing Coho salmon, and adequate volumes of water due to shallow ground water in the area. Prior to construction, all necessary permits were secured, including a 1602 permit from CDFW, 401 certification from the State Water Resources Control Board, NEPA concurrence Endangered Species Act coverage from USFWS and NMFS, and 404 permits from the Army Corps.

## Project Objectives

The Goodman OCP was constructed to augment limited winter rearing habitat for Coho salmon in Horse Creek. Off-channel habitats such as this provide juvenile Coho refuge from high stream flows in the winter, and most constructed habitats also provide refugia from potentially lethal Klamath River mainstem and tributary water temperatures in the summer and fall. Prior research from the Karuk and Yurok Tribes indicates that limited availability of slow-water habitats such as off-channel ponds, side-channels, backwaters, and alcoves during high flow periods can limit survival and production of juvenile Coho Salmon (Soto et al. 2014). Along with providing slow water habitat, off-channel ponds create thermal temperature refuges that provide warmer water in the winter and colder water in the summer, in comparison to their associated creek environments. These stable temperature regimes reduce environmental stress on juvenile fish during periods of optimal growth. While the Goodman OCP was constructed solely for winter rearing habitat,

ongoing water quality monitoring and population estimates show that large numbers of juvenile Coho utilize this pond for summer rearing.

## Construction

The wetted area of the constructed habitat is 2,700 square feet during summer base flow conditions. This habitat area increases by nearly 300 square feet during average winter flows. There is an ingress/egress channel at the downstream end of the pond, and the terminal end of the channel is approximately two feet wide during summer low flow conditions and approximately five feet wide during high flow conditions**.** Goodman Pond was excavated to a maximum depth of 10 feet during summer base flow conditions and averages 8 feet throughout habitat feature. The pond has a length of approximately 50 feet and average width of 45 feet as shown in figure 2 below. The bathymetry is varied to provide a diversity of depths for cover and forage habitat. Four large rootwad structures were installed along the length of the pond to provide cover habitat and a series of rootwads were buried at the downstream end of the egress channel to promote scour and assist with connectivity.

Immediately following construction, native grass seed and weed-free straw were spread to minimize erosion. Since then successive plantings with local schools and other partners have sped up the process of riparian vegetation establishment.

Photo 1: Goodman Pond 2019

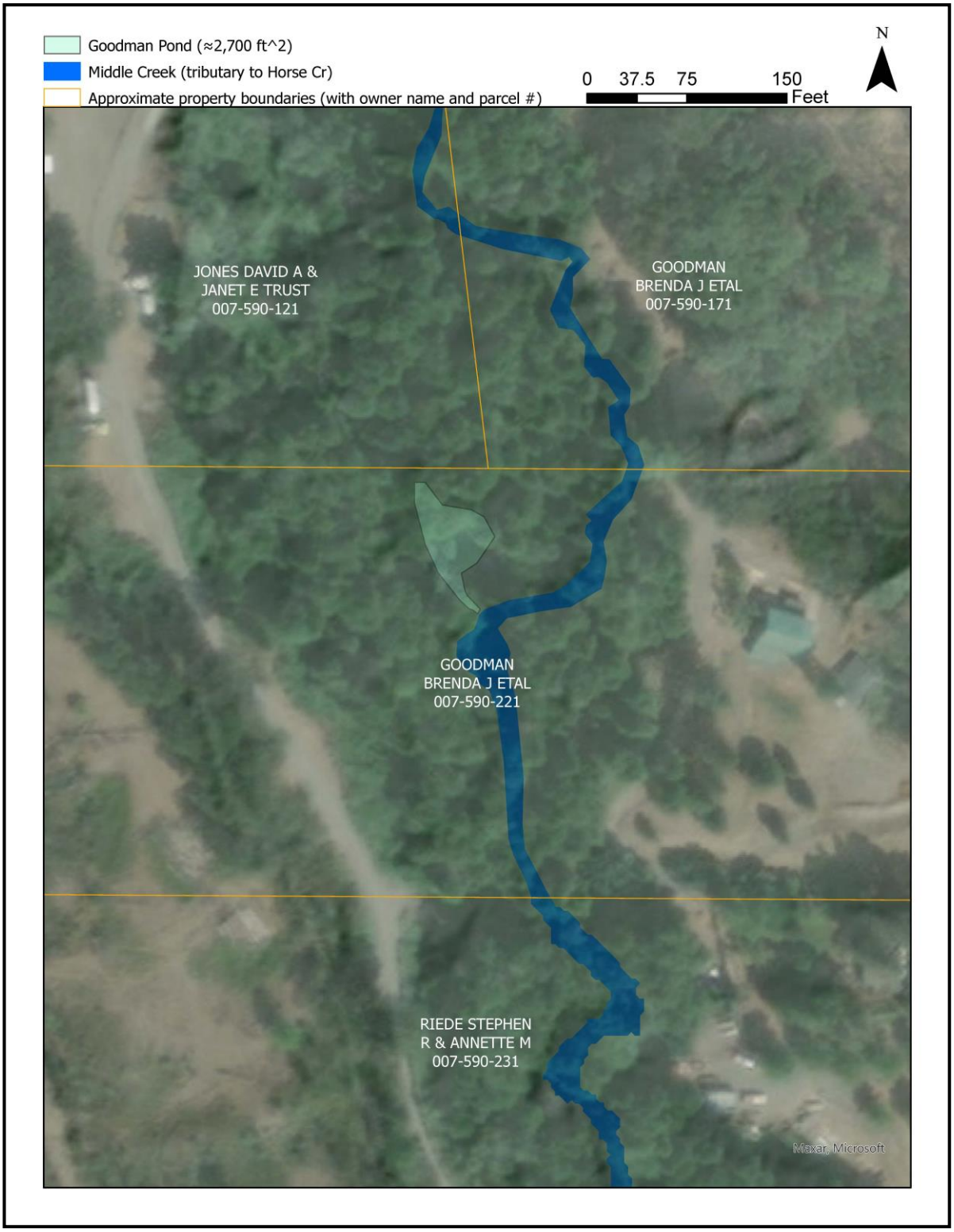



Figure 1: Plan view map of the Goodman off channel habitat feature on Middle Creek.

## Monitoring

MKWC has coordinated with the Karuk Tribe to conduct biological and physical monitoring of the Goodman Pond and other constructed habitats from the time they were built to present. MKWC Fisheries staff monitors each off-channel project site monthly for dissolved oxygen and temperature. In addition, average monthly ocular fish counts approximate the number of fish utilizing each site (if funding is available).

A YSI 550A handheld dissolved oxygen/temperature meter is used to collect samples at predetermined locations at the off-channel site, including adjacent tributaries. At Goodman Pond, temperature and dissolved oxygen (DO) readings are taken at four separate locations with one to three readings at each location to capture effects from stratification. Limited continuous readings during January through August were collected with a U26 dissolved oxygen (DO) and temperature logger for the Goodman Pond as shown in figure 8. This logger is set to collect data at 30 minute intervals to chart daily fluctuation of these factors. The Karuk Tribe began PIT tagging juvenile Coho salmon in the pond in 2017 and conduct yearly Petersen mark/recapture studies on the pond to gather population estimates for this habitat.

MKWC senior technicians conducted monthly snorkel surveys from 2015-2018 and then bi-monthly surveys from 2019-2021 of the Goodman Pond to obtain ocular fish counts of fish utilizing the pond. Structural monitoring of the habitat, specifically riparian vegetation recruitment and pond/stream-connectivity-and invasive species monitoring occur concurrently with snorkel surveys.

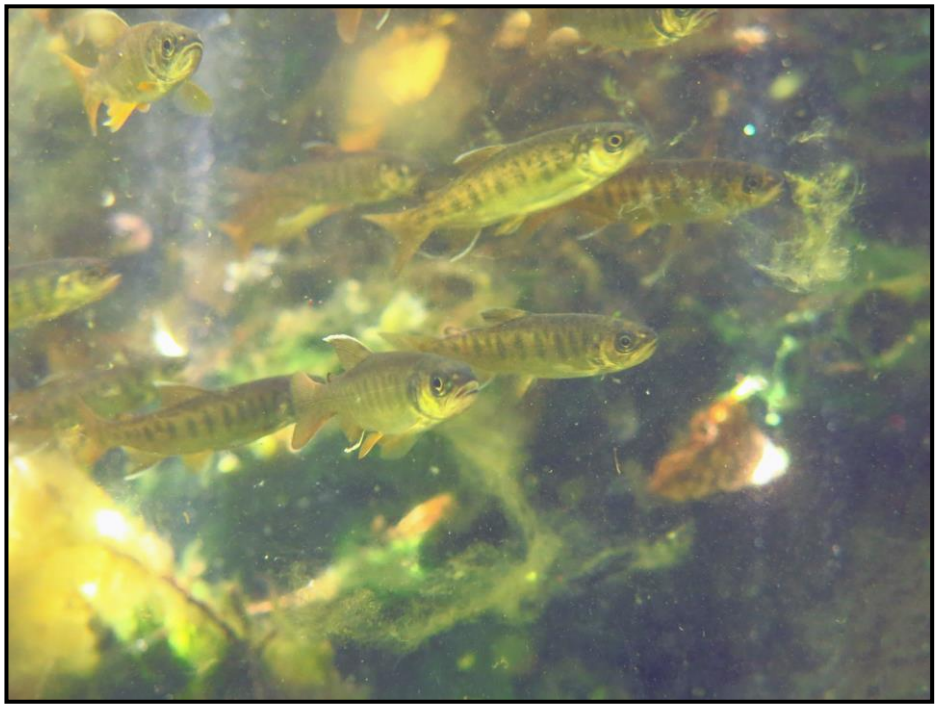


Photo 2: Juvenile Coho beneath undercut bank in Goodman Pond, 2019

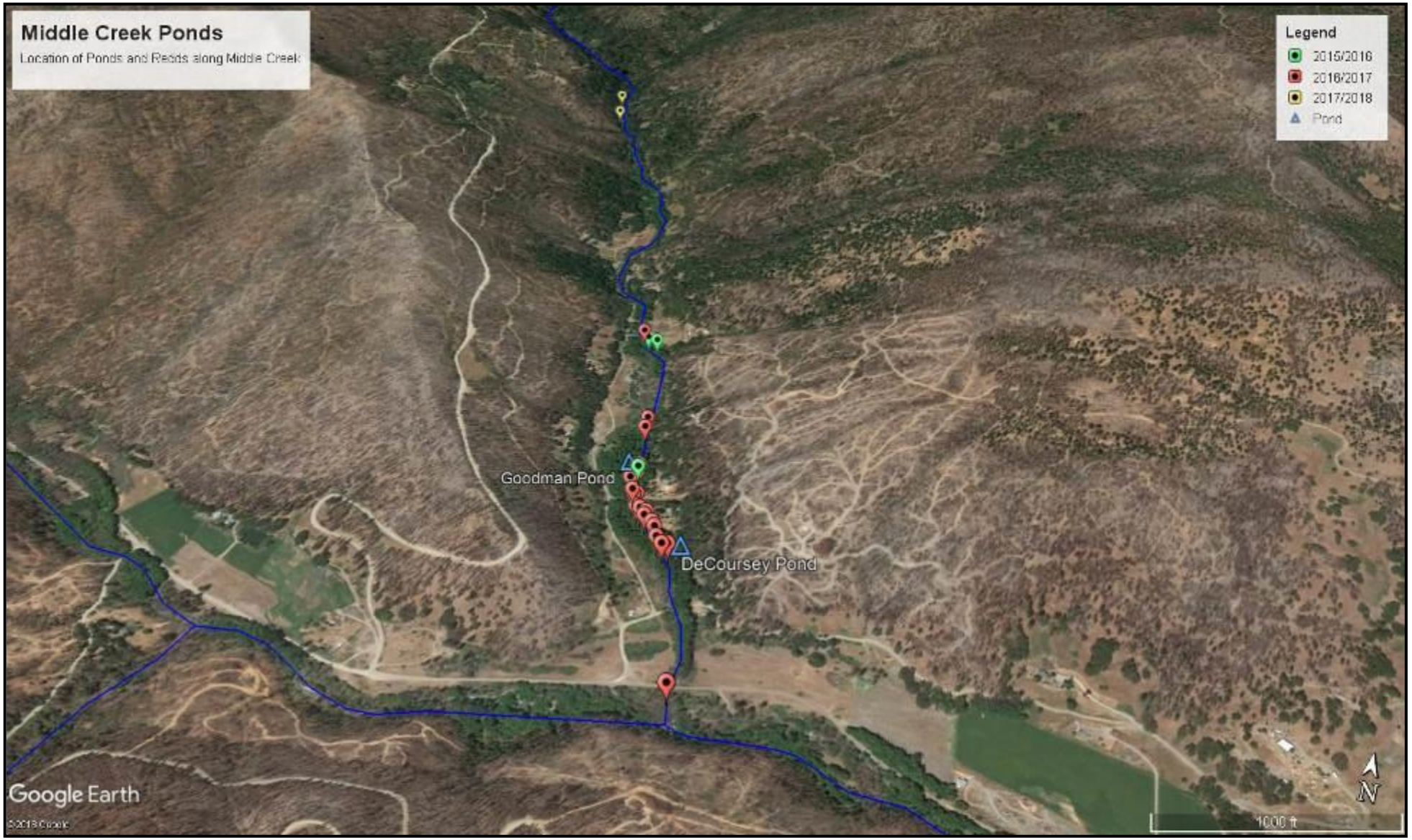



Figure 2: Topographic map of Middle Creek showing location of the two constructed off-channel ponds and three years of redd locations. In 2016/2017 22 redds were recorded on Middle Creek. Not featured on map, but in the winter of 2021/2022, 33 redds were documented in Middle Creek.

Photo 3: Goodman Pond project site before construction 2014

Photo 4: Outlet channel was re-enforced with root wads at its connection point

Photo 5: Goodman Pond winter of 2015

Photo 6: Groundwater flowing into the upstream end of Goodman Pond spring 2016. The groundwater provides significant input to the pond and flows even when the creek dries up in very low flow years.

Photo 7: Groundwater flow into Goodman Pond August of 2016

# Results

## Fish Population Estimates/Dive Counts

Goodman Pond provides optimal conditions for both summer and winter refuge for Coho juveniles. Like other constructed off-channel ponds MKWC has constructed, Goodman Pond provides extremely stable temperatures throughout the year, with a yearly fluctuation of around six degrees Celsius. This is likely attributed to the perennial ground water input to the pond and the riparian forest surrounding the feature. We hypothesize that all of the fish using the Goodman Pond are natal to Middle Creek because of an old, rusted culvert crossing near the mouth of the creek. MKWC and other partners are working on replacing this culvert that can be an adult barrier in low flow years and seems to be a barrier to upstream juvenile migration during most of the year. This hypothesis is based off the presence/absence counts collected by MWKC staff. Figure 4 illustrates a trend where young of the year are documented moving into the ponds in May and June followed by outmigration events in late fall and early spring. Several tagged Coho have been found rearing in the pond for almost two years. Ocular fish counts were collected by senior MKWC staff during snorkel surveys and population estimates were generated from the Karuk Tribal Fisheries Program.

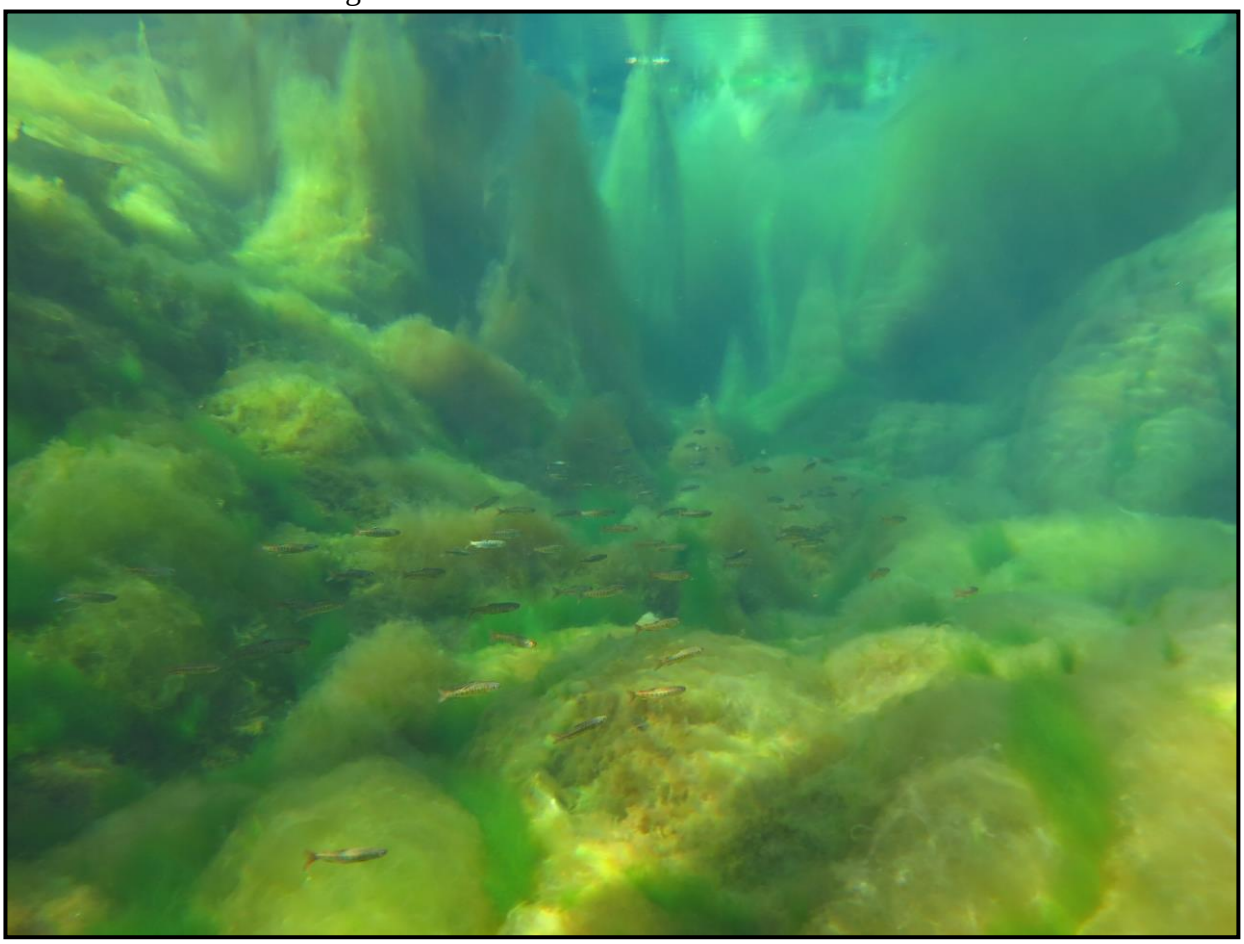


Photo 8: School of juvenile Coho rearing in Goodman Pond

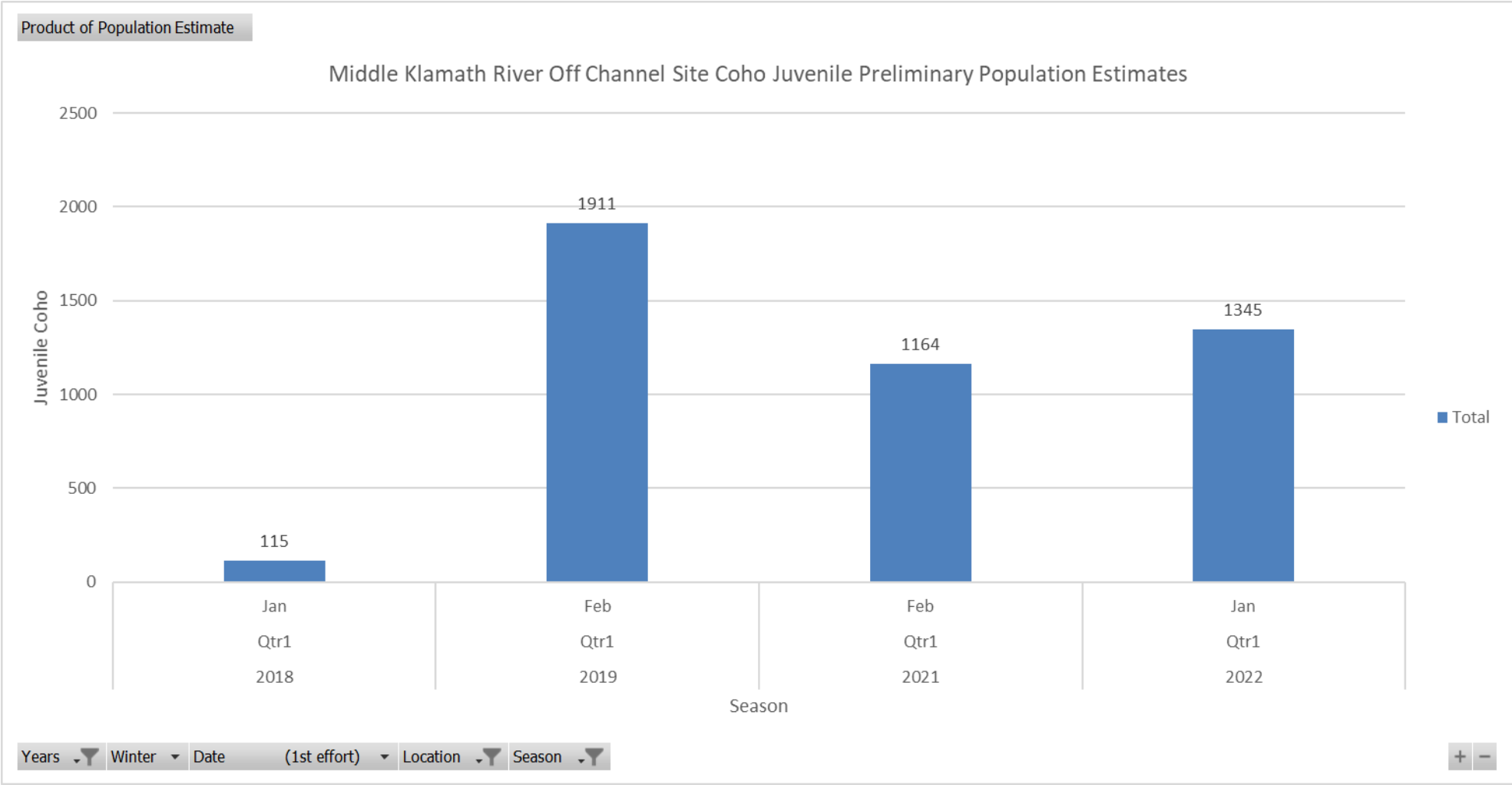



Figure 3: Preliminary population estimates from KTFP for Goodman Pond. The KTFP began Petersen mark/recapture events in the winter of 2018 on the Goodman Pond. No population estimate was conducted in 2020.

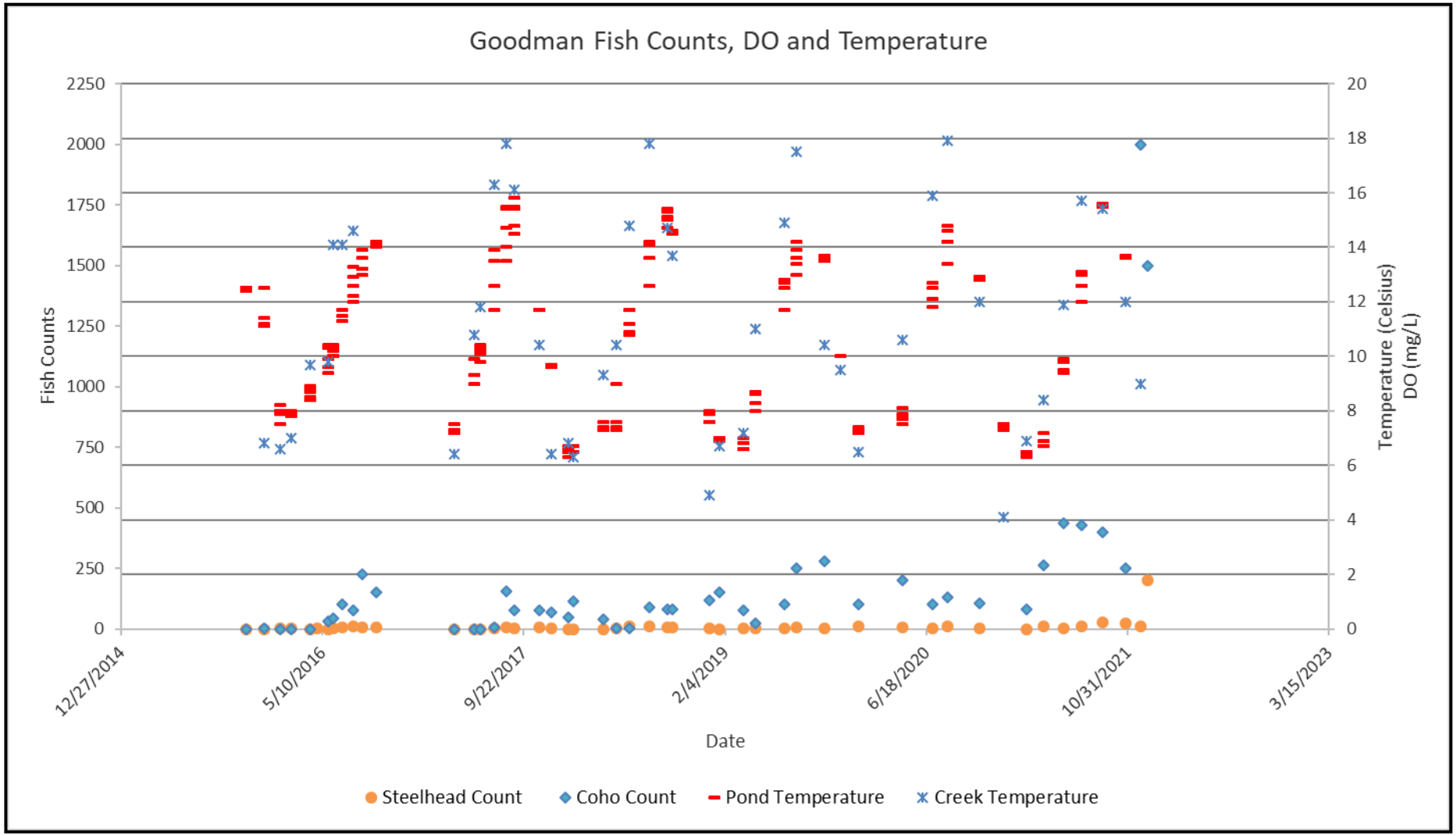



Figure 4: Ocular fish counts collected during snorkel surveys and spot temperature readings at various locations around the pond. Creek temperature taken just upstream of pond egress channel.

Photo 9: Culvert crossing on Middle Creek during high water event in December 2016

Photo 10: Culvert during low flows in December of 2015

Photo 11: Dry creek channel in July of 2015

## Water Quality Sampling

Goodman Pond is heavily influenced by ground water which translates to very stable temperatures with small daily diel temperature fluctuations throughout the year (Figures 5, 6,7 and 8). One HOBO temperature logger is deployed at a depth of six feet near the upstream end of the pond. Along with the temp logger, an Onset U26 temperature and DO logger was deployed along the center line of the pond at a depth of 3.5 feet for years 2016-2018. The average daily temperature over three years of monitoring is 10.8 degrees Celsius with a three year minimum temperature of 3.22 degrees Celsius and a three year maximum temp of 15.15 degrees Celsius (taken from HOBO temp logger). Average daily temp fluctuation in the pond is .56 degrees Celsius (based off of three years of monitoring). This stable temperature regime provides excellent growth conditions for juvenile salmonids rearing in the pond throughout the year. This type of thermal stability is a common characteristic of habitats with strong groundwater connections.

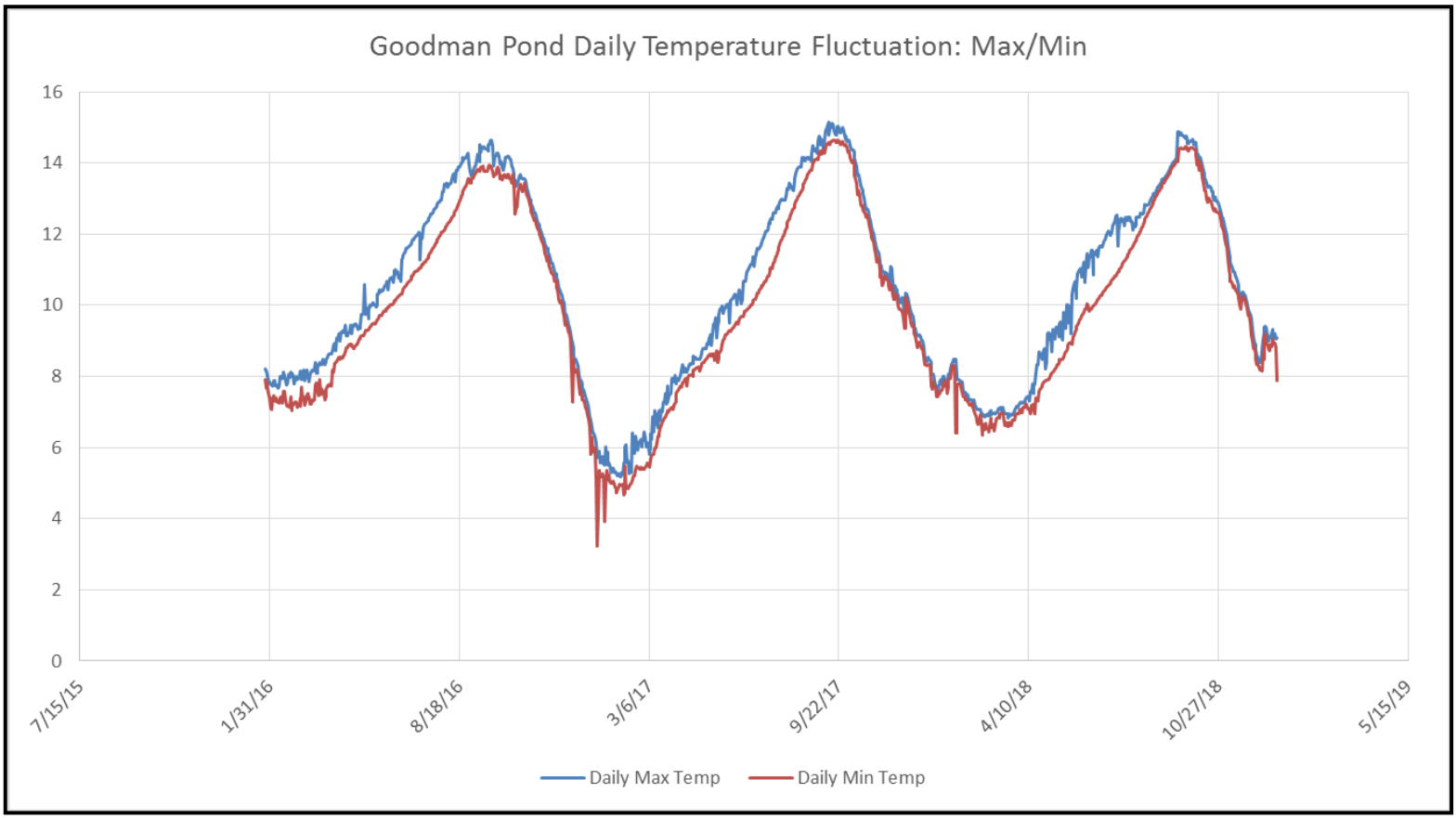



Figure 5: Daily maximum and daily minimum temperature collected by HOBO temperature logger in Goodman Pond. Average daily temperature fluctuation in the pond is approximately .56 degrees Celsius over three years.

## Dissolved Oxygen

Dissolved oxygen measurements were taken at the pond using two different methods. An Onset U26 dissolved oxygen (DO) and temperature logger was deployed along the mid line of the pond at an approximate depth of three and a half feet deep. This logger recorded DO reading every half hour throughout the year to track DO trends (Figure 8). Spot readings were taken at three to four locations around the pond with a handheld YSI 550A temperature/dissolved oxygen meter. These readings were taken to measure DO and temperature readings at various depths throughout the pond to track physiological and biological differences within the habitat. As shown in Figures 7 and 8, dissolved oxygen (DO) in the pond ranged from a minimum of 1.51 mg/L to a max of 8.75 mg/L over four years of monitoring. DO in the pond begins to stratify starting in the early summer months and tends to be more evenly mixed during the winter and spring months (see figure.7) Average summer DO ranges are 1 mg/L to 4mg/L and average winter range is 5 mg/L to 8 mg/L. Mean DO measurement in the pond is 4.8 mg/L throughout the four years of monitoring, which is within a healthy range for juvenile Coho rearing. According to a study by the California North Coast Reginal Water Quality Board, DO ranges of greater than 4 mg/L and temperatures of less than 18 degrees Celsius are ideal for optimum salmonid growth and health (Carter 2005). While Goodman Pond drops below this DO threshold a few times a year, these events tend to be short lived and are commonly seen in slow water habitats during summer months. Even at low ranges of DO, juvenile Coho were observed using the pond (Figure 7). For example, on August 1$^{st}$ 2019, DO range in the pond was 1.5 mg/L to 2.8 mg/L and MKWC staff counted 250 Coho using the pond. Since there is no connectivity issue at the Goodman Pond, Coho can move between the pond and creek to find what habitat they find most suitable. MKWK, NOAA, The Yurok Tribe and other partners have also observed juvenile Coho rearing in low DO conditions in slow water habitats in northern CA as long as temperature is below their stressful tolerance and food is available. The following figures summarize the water quality sampling results for the Goodman Pond.

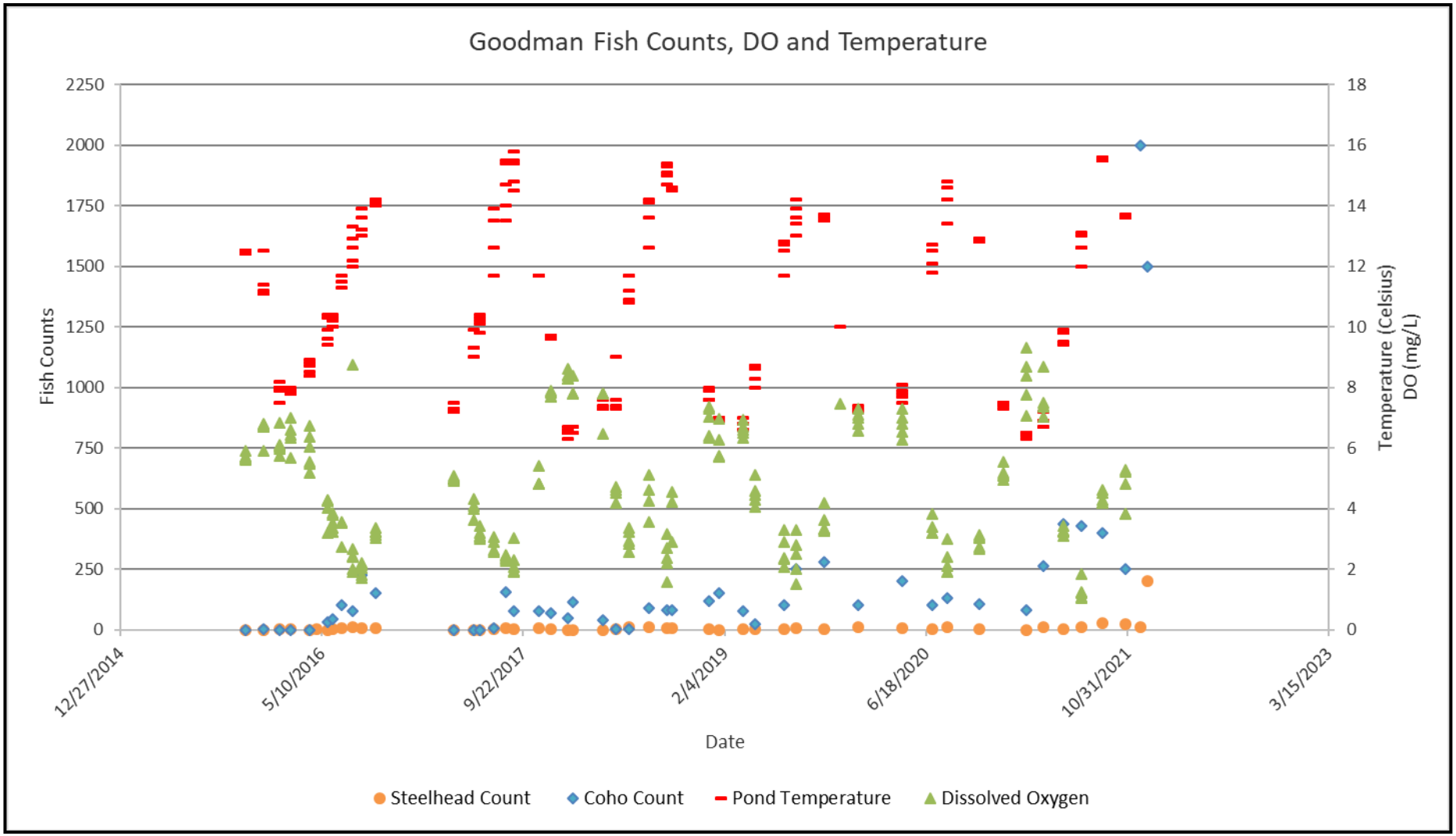



Figure 6: Temperature and dissolved oxygen readings taken during field visits. Temperatures in the pond are several degree warmer all winter than temperature in the adjacent creek. DO levels become heavily stratified during summer months and more evenly mixed in the winter.

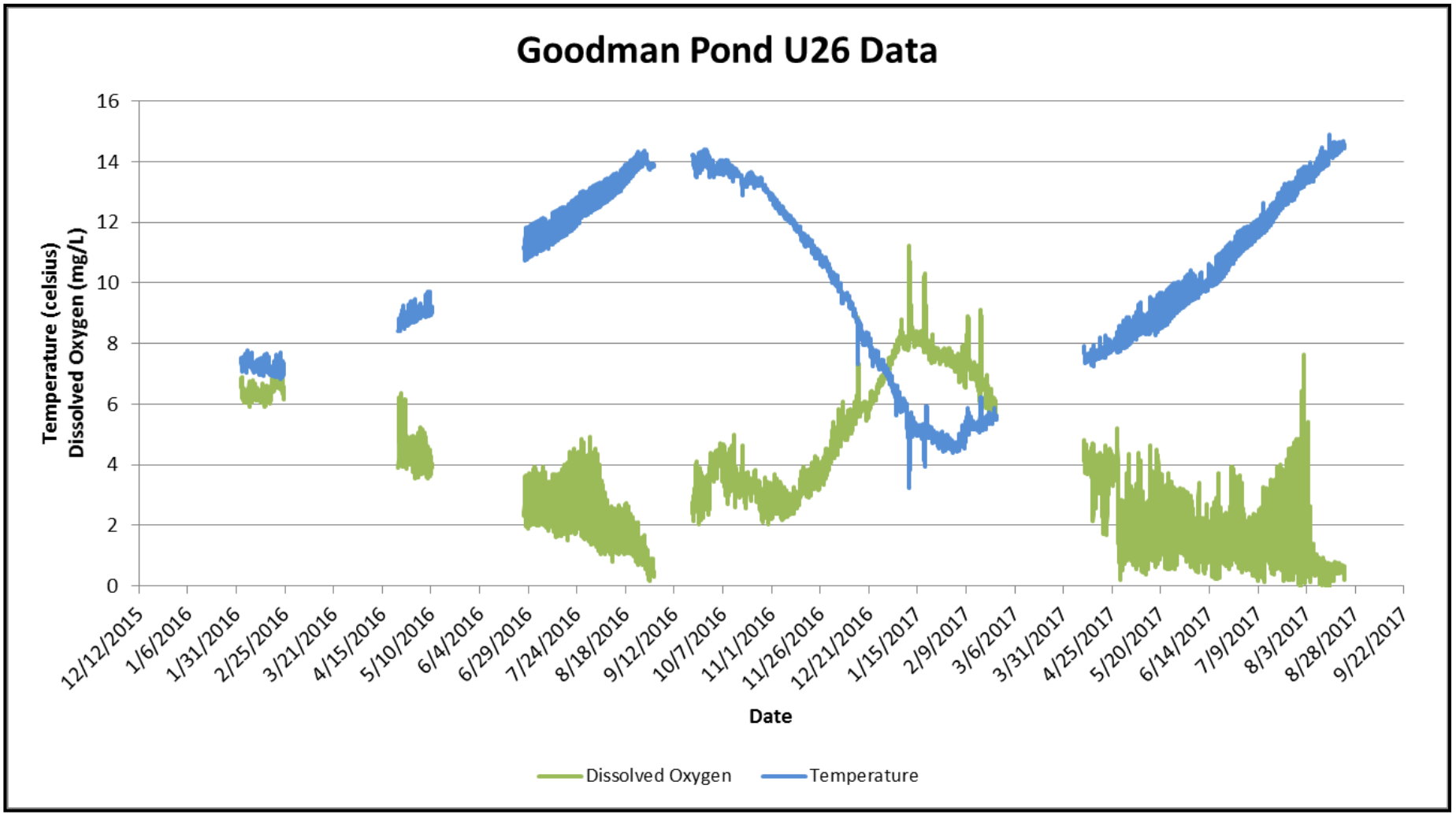



Figure 7: Dissolved oxygen and temperature reading collected by an Onset U26 temperature and DO logger. This logger was deployed at an average depth of 3.5 feet near the upstream end of the pond. Juvenile Coho were observed throughout the year rearing in the pond even during periods of low DO. Logger was set to take readings every half an hour during deployment periods.

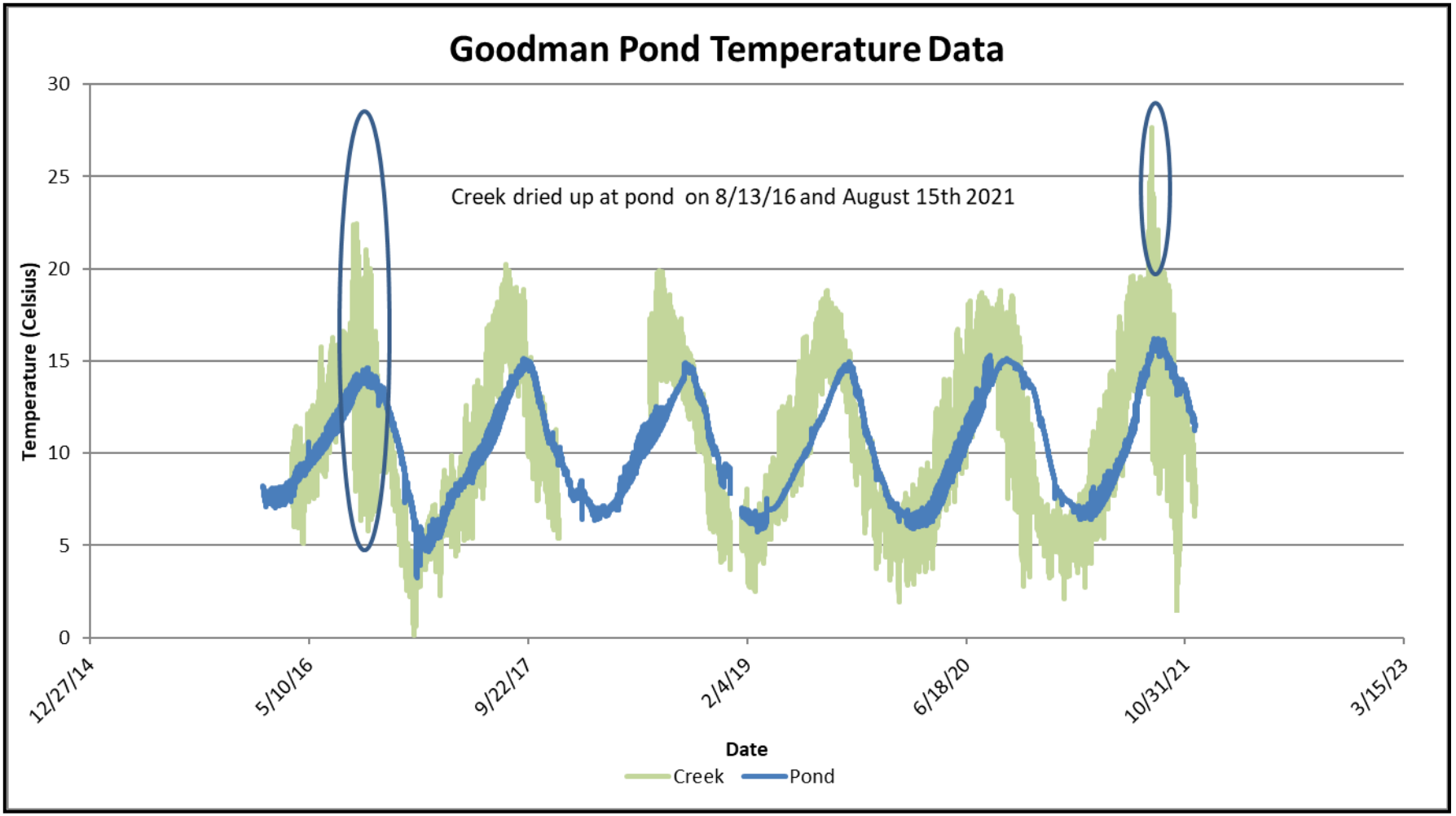



Figure 8: Temperature data collected by Hobo temperature logger. Logger was set to log temperature once and hour. Logger is deployed at an average depth of 5 feet.

## Habitat Condition Comparison

Using data collected by KTFP technicians during PIT tagging and mark recapture events, MKWC has synthesized preliminary fish sampling comparisons for several constructed off-channel ponds along Horse Creek and Seiad Creek. In 2018, Coho using Goodman Pond had the largest average fork length as well as largest average weight per fish in comparison to four other ponds in the area. Average fork length was 98 mm and average weight was 10.48 grams of sampled fish. Figure 9 below compares population estimates, average fork lengths and average weight of juvenile Coho captured in various off-channel ponds. N-value for sampling events was: Goodman= 323, Upper Lawrence= 165, Durazo=35, Alexander= 136, May= 157.

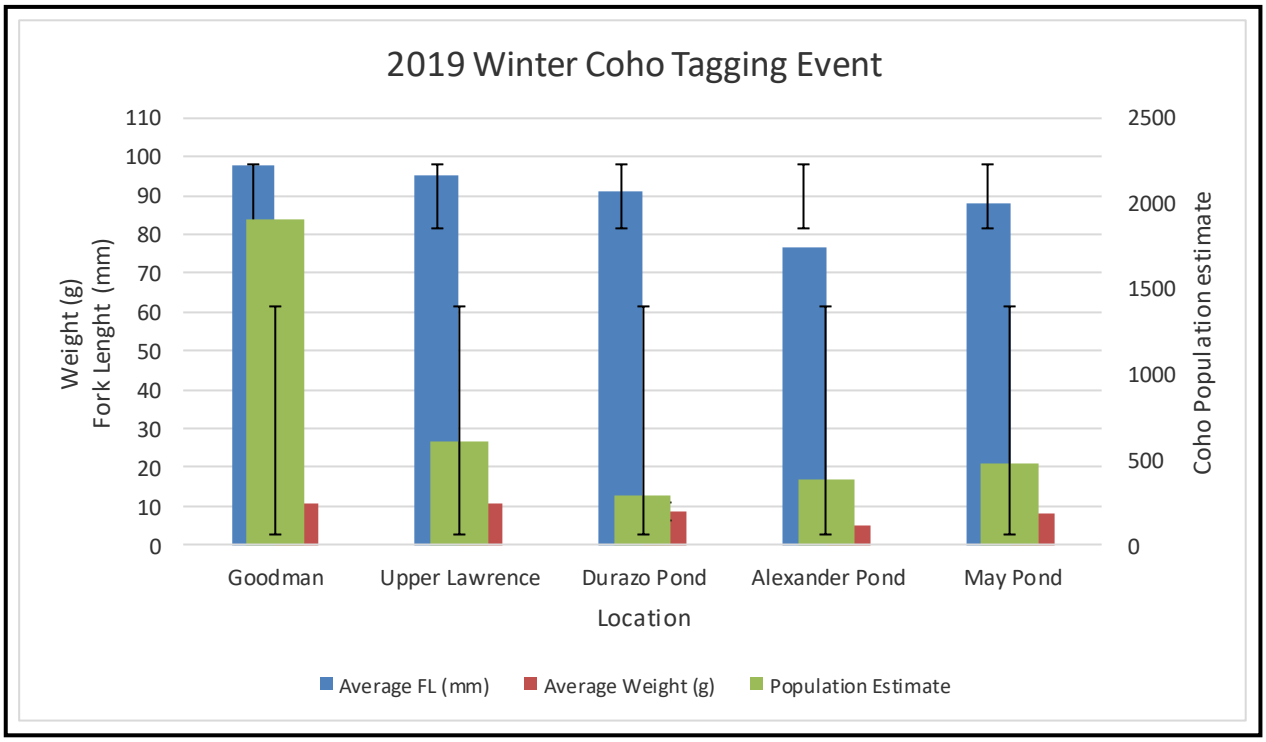



Figure 9: Average weight of juvenile Coho captured in off-channel ponds during February 2019. Goodman and Lawrence Ponds are located in the Horse Creek watershed while Durazo, Alexander, and May Ponds are all located along Seiad Creek.

Photo 12-13: Various year classes of Coho rearing in Goodman Pond.

## Natal and non-natal coho use: Passive Integrated Transponder (PIT tag) info

Tagging events at the Goodman Pond began in 2017. Tagging efforts typically coincide with population estimates. Over 500 tags have been implanted into fish found rearing in this pond. In the winter of 2016, MKWC staff recorded an adult female Coho in the pond and during the 2018 season MKWC staff discovered a jack Coho carcass at the egress of the pond. These adults did not have PIT tags but MKWC hopes that as tagging events continue, MKWC staff will be able to detect PIT tagged live adults or carcasses during winter Coho surveys on Middle Creek. The Karuk Tribe installed a PIT tag reader array at the mouth of Middle Creek and the mainstem Horse Creek in the spring of 2022. No PIT tagged fish from other locations have been detected in the pond to date. Recaptured fish tagged during KTFP sampling/tagging events have shown many fish using the pond for overwintering habitat since its construction.

## Connectivity

Goodman Pond has a perennial connection to Middle Creek because of its strong ground water through flow. Little to no maintenance has been required to date due to the placement of a small root wad structure at the confluence of the outlet channel and the creek. This root wad structure serves as a hard point for the creek to scour against, resulting in a year round pool at the pond outlet/creek confluence. A minimum amount of work has helped to create a stable connection from the creek to the pond. The creek has gone subsurface on two separate occasions since the construction of the pond in 2015. These events occurred in 2016 and 2021 and likely saved many fish from

Egress Channel before construction

Egress Channel after construction


Egress Channel winter of 2016


Egress Channel July 2018

## Non-native/Invasive presence

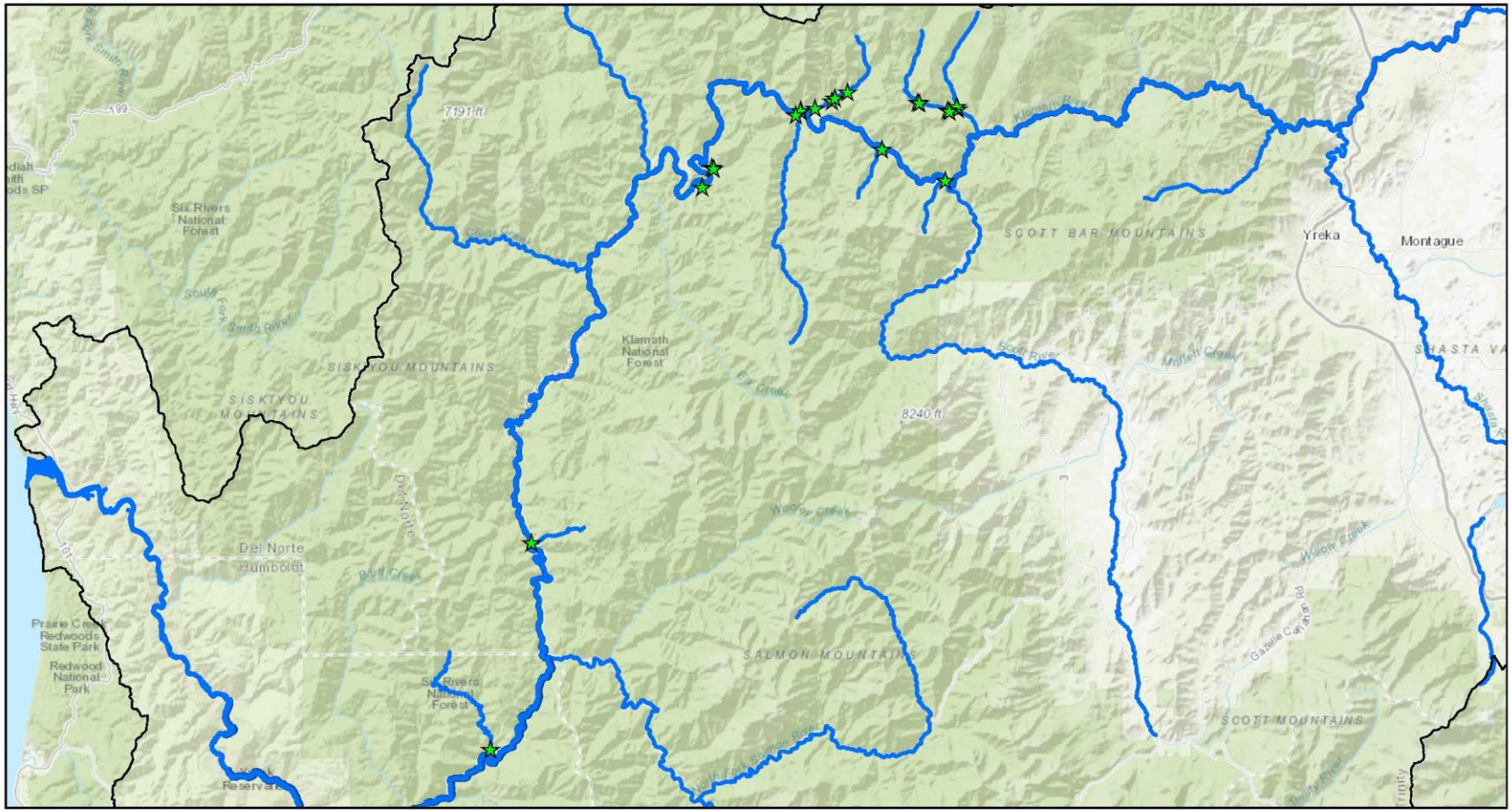
No non-native fish or amphibian species have been detected within the Goodman Pond. This could be attributed to the general temperature profiles of the creek and pond, which on average stay much cooler than other tributaries of the Klamath that have large amounts of invasive aquatic species. The culvert crossing Middle Creek might also prevent migration of non-native species, or that the pond is located several miles from the Klamath River mainstem. While aquatic animal species are not present, several species of prevalent invasive plants are located around the pond, these include Himalayan Blackberry, Poison Hemlock, Eurasian Nettle (stinging nettle) and several non-native grasses yet to be identified. These plants were present before construction and are widespread within the Horse Creek valley. MKWC is currently working on a plan to help manage these plant species around the pond and encourage native plant growth. Several tree plantings have taken place since construction and a large scale channel reconfiguration project of Middle Creek is in the planning stages of development. This project has a large scale native planting plan built into the design.

## Lessons learned/Next Steps

Lessons learned from the construction and monitoring of Goodman OCP include: 1) gathering information about subsurface groundwater and stratigraphy conditions are important to inform the design process., This information should come from multiple sources including information from locals and information gained from installing and monitoring groundwater wells, 2) Slow water habitat in Horse Creek is lacking and can benefit from more off-channel habitat features, as indicated by the extremely high numbers of juvenile Coho utilizing this site (around 1 fish per 1.5 square feet)., and 3) Even though there were low dissolved oxygen levels observed during the hottest days of summer, Coho juveniles still use this site, even when they have easy access out of the habitat if they choose,. This observation indicates that we should continue to build these features even if there are narrow timeframes of what appears to be undesirable dissolved oxygen levels, as long as the temperatures are tolerable (<18 C) for Coho during these months. This type of behavior has been documented in many other off-channel habitats along the Klamath River

and Northern CA and supports the theory that Coho appear to be temperature intolerant but are more hypoxia tolerant as a species as long as the temperatures remain cool.

# Addendum A: Off-Channel Pond Location Map of the Mid Klamath Sub-basin



## Citation/References:

J.R. Brett and, J. M. Blackburn (1981)
**"Oxygen Requirements for Growth of Young Coho (Oncorhynchus kisutch) and Sockeye (O. nerka) Salmon at 15 °C"**

Hillemeier, D., Silloway, S.,Soto, T., Corum, A., Kleeman, M.,
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**"The Role Of The Klamath River Mainstem Corridor In The Life History And Performance Of Juvenile Coho Salmon (*Oncorhynchus kisutch*)"**

Carter, K. (2005) California Regional Water Quality Control Board, North Coast Region
"The Effects of Dissolved Oxygen on Steelhead Trout, Coho Salmon, and Chinook Salmon Biology and Function by Life Stage."