MENDOCINO • HUMBOLDT
Redwood Companies

Class I Stream Aquatic Habitat Trends Monitoring

2021 Annual Report

June 30, 2022

Project Description:

Title: Class I Stream Aquatic Habitat Trends Monitoring

Purpose: Habitat Conservation Plan Aquatic Monitoring

Dates Initiated: February 1999 (HCP §6.3.5.3 Class I Aquatic Trend Monitoring Program; October 1999 (NCRWQCB Bear Creek Monitoring Plan, NCRWQCB North Fork Elk River Monitoring Plan)

Projected End Date: Ongoing

Project Manager: Keith Lackey

Executive Summary:

Long-term monitoring of fish-bearing (Class I) streams was initiated with adoption of the Habitat Conservation Plan (HCP) in 1999 with the goal to collect data to determine if salmonid habitat conditions across the property meet or are trending towards Aquatic Properly Functioning Conditions (APFC). The Pacific Lumber Company had an ongoing stream monitoring program when the HCP was adopted in 1999, and many of the existing sites were included in the newly created Aquatic Trends Monitoring (ATM) program. Sites were selected with the advice and approval of HCP signatory agencies and the North Coast Regional Water Quality Control Board (NCRWQCB). Representative stream reaches included in the ATM program were chosen for a variety of factors that included access, distribution, gradient, percentage of HCP coverage in the watershed, and watershed interest. Currently, habitat conditions are assessed at 44 sites and stream temperature is recorded at 50 sites.

This project is intended to monitor trends in stream conditions over time. Trend monitoring results may corroborate the findings of effectiveness monitoring but are also strongly influenced and constrained by inherent watershed conditions and processes, apart from management, including drainage area, geology and geomorphology, topography, vegetation, and climate. Due to improvements in timber harvest practices required by the California Forest Practice Rules and Humboldt Redwood Company's (HRC) HCP, recovery of aquatic habitat, where currently impaired, is expected to occur over time to the extent provided for by inherent watershed conditions. HRC's ATM program is designed to test this hypothesis as it tracks watershed trends over time.

ATM sites are distributed across HRC's ownership and situated in all eight (8) HCP-designated Watershed Analysis Units (WAU). Monitoring sites are currently more tightly clustered in three watersheds of special interest - Elk River, Freshwater Creek, and Bear Creek - to better understand conditions of impairment and trends. All three of these watersheds, listed as impaired water bodies under section 303(d) of the Federal Clean Water Act, provide important aquatic habitat for salmonids including coho, and are currently of particular interest to the NCRWQCB.

HRC simplifies the presentation of habitat status by taking a pass/fail approach to the APFC target criteria, resulting in habitat composite scores for each WAU. The following is a brief summary of survey results in 2021:

In the Yager/Lawrence Creek WAU, there were improvements in habitat composite scores for pool characteristics, LWD piece frequency, and canopy cover. However, the composite score for bed surface particle size was lower than the 2018 record. The 2021 water temperature score remained even with the 2018 record, yet higher than the baseline record.

In the Mattole River WAU, there were improvements in habitat composite scores for LWD and mid-channel canopy cover. In contrast, the composite score for bed surface particle size and pool characteristics declined in 2021. The 2021 water temperature score remained even with the 2018 record, yet higher than the baseline record.

In the Lower Eel River WAU, for Bear Creek, there were improvements in habitat composite scores for LWD and water temperature, while the composite score for bed surface particle size was lower than the 2020 record. 2021 pool characteristics and mid-channel canopy cover composite scores remained even with the 2020 records. Juvenile coho salmon were observed in Bear Creek in 2021, the first time since 2014.

In the Bear River WAU, there were improvements in habitat composite scores for pool characteristics and mid-channel canopy cover. However, the composite scores for bed surface particle size and water temperature were lower than the 2018 records. The 2021 LWD piece frequency composite score remained even with the 2018 and baseline records.

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INTRODUCTION

HRC manages approximately 211,000 acres of redwood and Douglas-fir forests in Humboldt County, California for long-term production of forest products. These timberlands, located in the erosive sedimentary terrain of the northern coast of California, have been extensively roaded and periodically logged since the 1860's. Intensive watershed and property-wide studies have documented ecological impacts from past management activities. One hundred and fifty years of management has increased sedimentation to streams and disturbed riparian forests as documented throughout the Pacific coast region. Streams within the timberlands are important freshwater spawning and rearing habitat for salmonids including coho (*Oncorhynchus kisutch*), Chinook (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*). These species (covered under the HRC HCP) have been federally listed as threatened within much of coastal northern California, including watersheds where HRC has ownership, due in part to impairment of freshwater habitat.

PROGRAM OVERVIEW

Beginning in 1999 with the establishment of a multi-species HCP, first the Pacific Lumber Company, and then HRC beginning in July of 2008, has managed the timberlands utilizing new sediment control and riparian forest management strategies to improve the aquatic habitat for covered species. HRC's current forest practices are designed to protect and restore aquatic habitats by reducing timber harvest-related erosion rates and sediment supply to the stream and to manage riparian forests to enhance their ecological values. Management activities are guided by the Aquatics Conservation Plan (ACP), part of the HCP (Section 6.3), developed with state and federal agencies, and through various permits issued by the NCRWQCB.

HRC has been steadily working to reduce sediment with a combination of state-of-the-art road construction practices, a commitment to reconstruction or decommissioning of older roads, and use limitations that prevent damage to roads and prevent sediment delivery to streams. Harvest-related sediment is controlled through geologic hazard identification and geologist field investigation during timber harvesting plan (THP) layout. Riparian forests are left relatively undisturbed to provide shade and large woody debris to streams. The company's silvicultural policies utilize uneven-aged silviculture and exclude harvest of any remaining large old growth trees on the property that meet HRC's Old Growth Tree Policy.

The primary goal of the ACP is to maintain, or achieve over time, a properly functioning aquatic habitat condition that will ensure the long-term viability of anadromous salmonids that utilize rivers and streams

on the property, many of which are considered keystone to regional recovery efforts. To assess progress towards this goal, an APFC matrix of habitat variables defining important freshwater habitat characteristics for salmonids compiled by the National Marine Fisheries Service (NMFS) is referenced in the HCP. APFC criteria were derived from laboratory and field research conducted throughout the Pacific Northwest, and while they define generalized target values, they have not been calibrated for HRC lands necessarily. Similar criteria have also been developed by the NCRWCB to meet requirements of the Clean Water Act (NCRWCB 2004).

MONITORING PROGRAM DESIGN

Long-term monitoring of fish-bearing (Class I) streams was initiated with adoption of the HCP in 1999 with the goal to collect data to determine if salmonid habitat conditions across the property meet, or are trending towards, APFC matrix target conditions during the 50-year span of the HCP (1999-2049). The basic design of this monitoring program is to repeatedly measure the habitat characteristics of stream reaches within the portion of watersheds utilized by anadromous salmonids. Permanent sites are located within "response reaches" that contain less than 4% gradient (Montgomery and Buffington, 1998) on fish-bearing streams (Class I streams, Figure 1). Sites are distributed throughout HRC property. All these streams currently or historically provided habitat for anadromous salmonids, including coho and Chinook salmon and steelhead trout, although species dominance has traditionally varied within the watersheds.

Figure 1. Class I stream, Elk River

A sampling site is a stream reach that is at least 30 channel widths long. The sampling length of most sites is approximately 200 to 400 meters (approximately 600 to 1200 feet) in length. The location of the sampling reach is permanently benchmarked to facilitate repeated measurement.

TREND MONITORING SITES

HRC's ownership includes land in nine major drainages including the Yager, Lawrence, Freshwater and Larabee Creeks, and the Bear, Elk, Eel, Van Duzen, and Mattole Rivers. Ownership is generally blocked within these basins. HRC owns most of the area in some watersheds while company ownership is a small

portion of others. To facilitate analysis of this extensive property, HRC has divided its ownership into eight WAUs. Watershed analysis has been completed on each of these areas, including Freshwater Creek, Elk River, Van Duzen River, Yager/Lawrence, Upper Eel, Lower Eel and Eel Delta, Bear River, and Mattole River watersheds. These WAUs were delineated, in part using the boundaries of the state of California's Planning Watersheds. A detailed description of the locations, physical characteristics, major watercourses, and dominant vegetation within each WAU can be found in the Watershed Analysis documents prepared for each watershed.

A site location map of currently active ATM sites is provided in Figure 2 which lists the active monitoring stations, organized by WAU and arranged by drainage area. Currently, there are 44 habitat monitoring sites and 50 temperature monitoring sites.

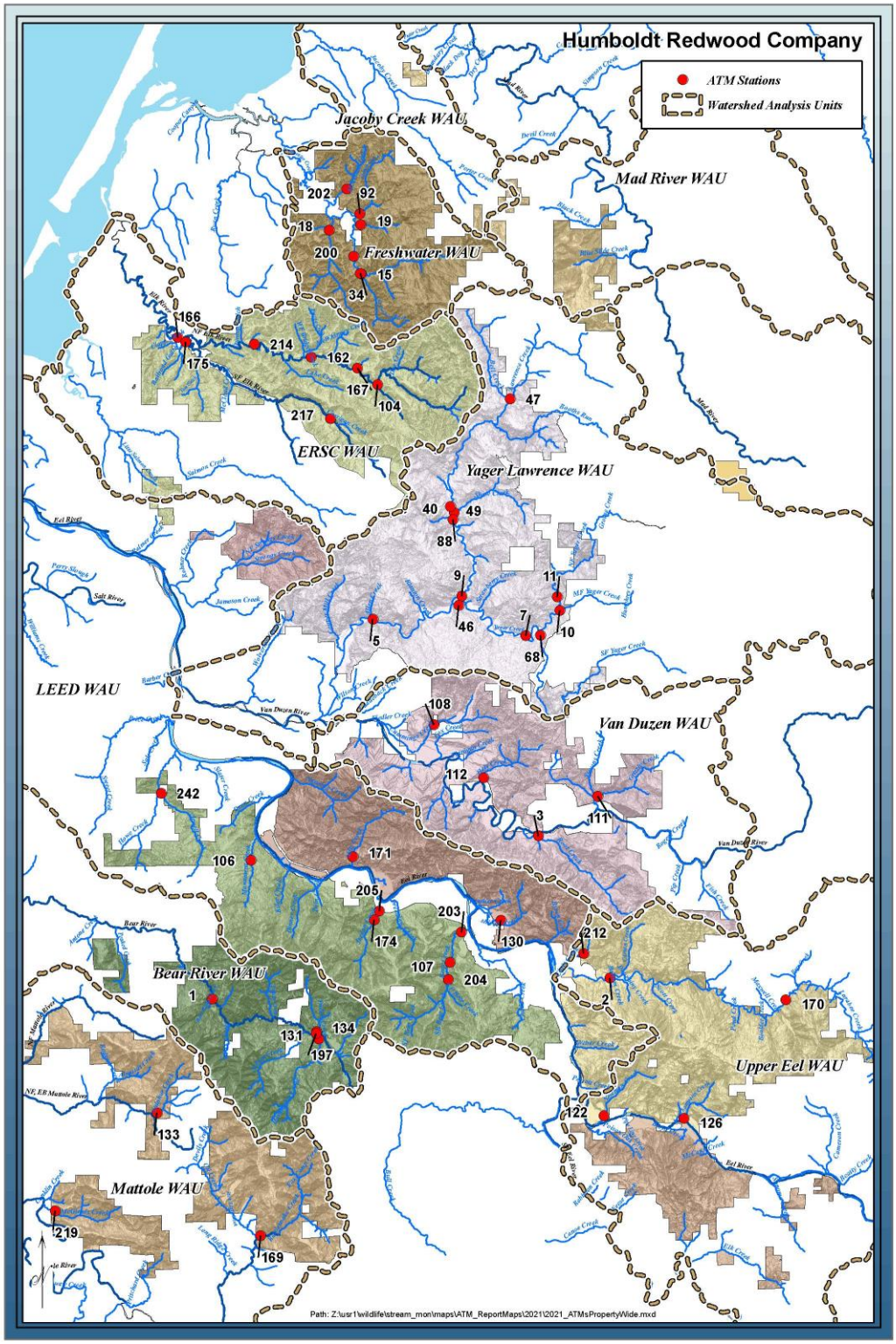

Figure 2. Location map of HRC ATM sites

Table 1. Site statistics and sampling rotation of active ATM sites. Cells marked with an "X" indicate current monitoring activities and rotation year in which monitoring will be conducted

Station ID	Stream Name	Upstream Watershed Acreage[1]	Upstream Area (mi^2)	Township Range Section	Reach Gradient (%)	Elevation (ft)	Temperature (Annual)	Stream Habitat Parameters	Rotation Schedule		
									2021	2022	2023
HUMBOLDT BAY WAU											
	Freshwater Creek Drainage										
34	Freshwater Creek	5,609	8.8	04N 01E 15	0.9	190	X (+Air)	X			X
15	South Fork Freshwater Creek	2,019	3.2	04N 01E 15	1.7	183	X	X			X
200	Freshwater Creek	7,911	12.4	04N 01E 10	0.4	134	X	X			X
19	Graham Gulch	1,588	2.5	04N 01E 03	1.4	95	X	X			X
92	Cloney Gulch	2,968	4.6	04N 01E 03	0.9	85	X	X			X
202	McCready Gulch	1,084	1.7	05N 01E 34	2.3	111	X	X			X
18	Little Freshwater Creek	2,980	4.7	04N 01E 04	0.8	65	X	X			X
	Elk River Drainage										
104	South Branch NF Elk River	1,207	1.9	04N 01E 35	2.8	360	every 9 years (next = 2023)				
167	North Fork Elk River	7,230	11.3	04N 01E 34	2.1	262	X	X			X
162	North Fork Elk River	8,738	13.7	04N 01E 28	0.6	134	X	X			X
214	North Fork Elk River	12,302	19.2	04N 01E 30	0.2	80	X	X			X
217	South Fork Elk River	4,030	6.4	03N 01E 3	1.6	510	X	X			X
175	South Fork Elk River	12,200	19.1	04N 01W 26	0.0	39	X	X			X
166	Elk River	26,393	41.2	04N 01W 26	0.1	39	X	X			X
YAGER WAU											
	Lawrence Creek Drainage										
47	Lawrence Creek	7,477	11.7	03N 02E 04	3.5	1111	X				
49	Lawrence Creek	18,332	28.6	03N 02E 19	1.1	587	X	X	X		
40	Shaw Creek	3,431	5.4	03N 02E 19	1.4	577	X	X	X		
88	Corner Creek	1,252	2.0	03N 02E 30	8.7	567	X				
9	Lawrence Creek	26,676	41.7	02N 02E 06	0.2	432	X (+Air)	X	X		
	Yager Creek Drainage										
11	North Fork Yager Creek	29,869	46.7	02N 02E 02	1.0	596	X				
10	Middle Fork Yager Creek	5,985	9.4	02N 02E 02	1.7	577	X				
68	South Fork Yager Creek	6,807	10.6	02N 02E 10	2.0	551	X (+Air)				
7	Yager Creek	44,060	68.8	02N 02E 10	0.8	511	X	X	X		
46	Yager Creek	48,394	75.6	02N 02E 06	0.5	429	X	X	X		
5	Yager Creek	80,623	126.0	02N 01E 11	1.3	246	X	X	X		
VAN DUZEN WAU											
111	Grizzly Creek	7,181	11.2	01N 02E 01	1.6	390	X (+Air)	X		X	
3	Root Creek	3,771	5.9	01N 02E 15	0.3	314	X	X		X	
112	Hely Creek	2,306	3.6	01N 02E 05	1.7	239	X	X		X	
108	Cummings Creek	1,894	3.0	02N 02E 30	2.5	383	X	X		X	

Table 1 (continued). Site statistics and sampling rotation of active ATM sites. Cells marked with an "X" indicate current monitoring activities and rotation year in which monitoring will be conducted

Station ID	Stream Name	Upstream Watershed Acreage[1]	Upstream Area (mi^2)	Township Range Section	Reach Gradient (%)	Elevation (ft)	Temperature (Annual)	Stream Habitat Parameters	*Rotation Schedule*		
									2021	2022	2023
EEL RIVER WAU											
	Upper Eel River Drainage										
126	Thompson Creek	2,463	3.8	01S 03E 29	4.1	154	X	X			X
122	Newman Creek	1,878	2.9	01S 02E 25	2.3	131	X	X			X
	Larabee Creek Drainage										
170	Larabee Creek	39,709	62.0	01S 03E 12	0.4	738	X	X			X
212	Chris Creek	835	1.3	01W 02E 35	0.9	180	X	X			X
2	Larabee Creek	53,633	83.8	01S 02E 01	0.9	137	X (+Air)	X			X
	Lower Eel River Drainage										
106	Middle Monument Creek	2,851	4.5	01N 01E 18	2.8	154	X	X		X	
174	Middle Jordan Creek	2,791	4.4	01N 01E 26	3.5	164	X	X		X	
205	Lower Jordan Creek	2,895	4.5	01N 01E 26	2.2	120		X		X	
130	Shively Creek	1,403	2.2	01N 02E 28	0.9	157	X	X		X	
	Bear Creek Drainage										
204	Bear Creek	4,302	6.7	01S 02E 06	3.8	320	X	X	X	X	X
107	Bear Creek	5,026	7.9	01N 02E 31	1.7	232	X (+Air)	X	X	X	X
203	Bear Creek	5,449	8.5	01N 02E 31	1.4	120	X	X	X	X	X
	Eel River Delta Drainage										
171	Stitz Creek	2,519	3.9	01N 01E 15	--	148	X				
242	Atwell Creek	2,747	4.3	01N 01W 3	1.5	170	X	X		X	
BEAR RIVER WAU											
131	Harmonica Creek	2,625	4.1	01S 01E 16	1.6	1302	X	X	X		
134	Pullen Creek	1,673	2.6	01S 01E 16	1.7	1302	X	X	X		
197	Bear River	1,935	3.0	01S 01E 16	1.4	1280	X (+Air)	X	X		
1	Bear River	15,103	23.6	01S 01W 12	1.0	924	X	X	X		
MATTOLE RIVER WAU											
133	Sulphur Creek	2,452	3.8	01S 01W 27	2.1	1105	X	X	X		
169	Upper NF Mattole River	5,507	8.6	02S 01E 19	2.2	596	X (+Air)	X	X		
	McGinnis Creek	3,789	5.9	02S 01W 35	1.2	135	X	X	X		

METHODS

Sampling Schedule

ATM sites in Bear Creek within the Lower Eel – Eel Delta (LEED) WAU have been sampled each year at the request of the NCRWQCB. Habitats at the remaining ATM sites are re-surveyed every three (3) years, except for ATM site 104 within the Elk River drainage, which will be monitored once every nine (9) years per verbal request from staff at California Department of Fish and Wildlife (Nick Simpson, pers comm, 2016). See Table 1 above for the general habitat monitoring schedule. Water temperature is monitored annually at nearly all ATM stations, including some stations where habitat sampling has been discontinued.

Habitat sampling frequency is increased following significant storm events. Out-of-sequence sampling is triggered by the occurrence of a 10-year flood in either the Eel River or the Van Duzen River as measured at USGS gages at Scotia (11477000) and Bridgeville (11478500), respectively. Monitoring may also be triggered by a 25-year recurrence precipitation event as recorded at National Weather Service weather stations at either Scotia or Eureka. Both flood and precipitation events were exceeded in Freshwater and Elk River in December 2002 and have not been observed since.

Sampling Methods

Table 2 lists the primary parameters reported in the ATM program, and references HRC's detailed measurement protocols (Standard Operating Protocols) for collecting data. Methods are summarized very briefly here.

Table 2. Parameters measured in the HRC ATM monitoring program

Characteristic	Measurement Parameters	Standard Operating Protocol
Channel dimensions	Channel gradient Channel width Cross-sectional area	SOP-15: *Aquatic trends monitoring site selection, monumenting and documentation* SOP-31: *Surveying with total station*
Particle-size distribution within bed surface substrate	Particle-size classes: (D_5, D_{16}, D_{50}, D_{84})	SOP-13: *Surface and sub-surface sediment sampling*
Pool dimensions and wood association	Pool area Pool spacing Residual pool depth % Pools associated with wood	SOP-14: *Stream Habitat Typing*
LWD frequency and distribution	Frequency (# pieces/100 ft.) Total piece count	SOP currently in progress
Water temperature	Maximum Weekly Average Temperature MWAT (˚C)	SOP-09: *Temperature instrumentation and deployment*
Riparian canopy cover	% Canopy cover over the stream (mid-channel canopy cover) % Canopy cover in the riparian forest (riparian overstory canopy cover)	SOP-12: *Stream and riparian canopy cover measurement*

Bed Surface Particle Size

Pebble count measurements collected at riffles are used to assess the APFC matrix target for D_{50} (diameter of the median [50th of 100] particle) and three additional parameters (D_5, D_{16}, D_{84}). These sediment measures can be tracked over time to determine whether bedload sediments in a watercourse are generally becoming coarser or finer, in response to in-channel erosion and changes in sediment loading rates from hillslope sources including cumulative effects from management activities.

Figure 3. Measuring particle size (mm) of the streambed surface

The first three (3) riffles are sampled within each monitoring reach by transecting back and forth over the entire riffle within the active channel. The intermediate axes of 200 pebbles are measured at each riffle (Figure 3). The median particle size is determined for each of the D parameters, although APFC target values have only been established for D_{50}. Results are reported as mean values within the APFC report card, as well as cumulative particle size frequency plots (Figure 4), which serve to provide a visual aid for improved interpretation. Over time, it is expected that trends will develop that will suggest an overall fining or coarsening of the channel substrate towards APFC target values to the extent provided for by inherent watershed conditions.

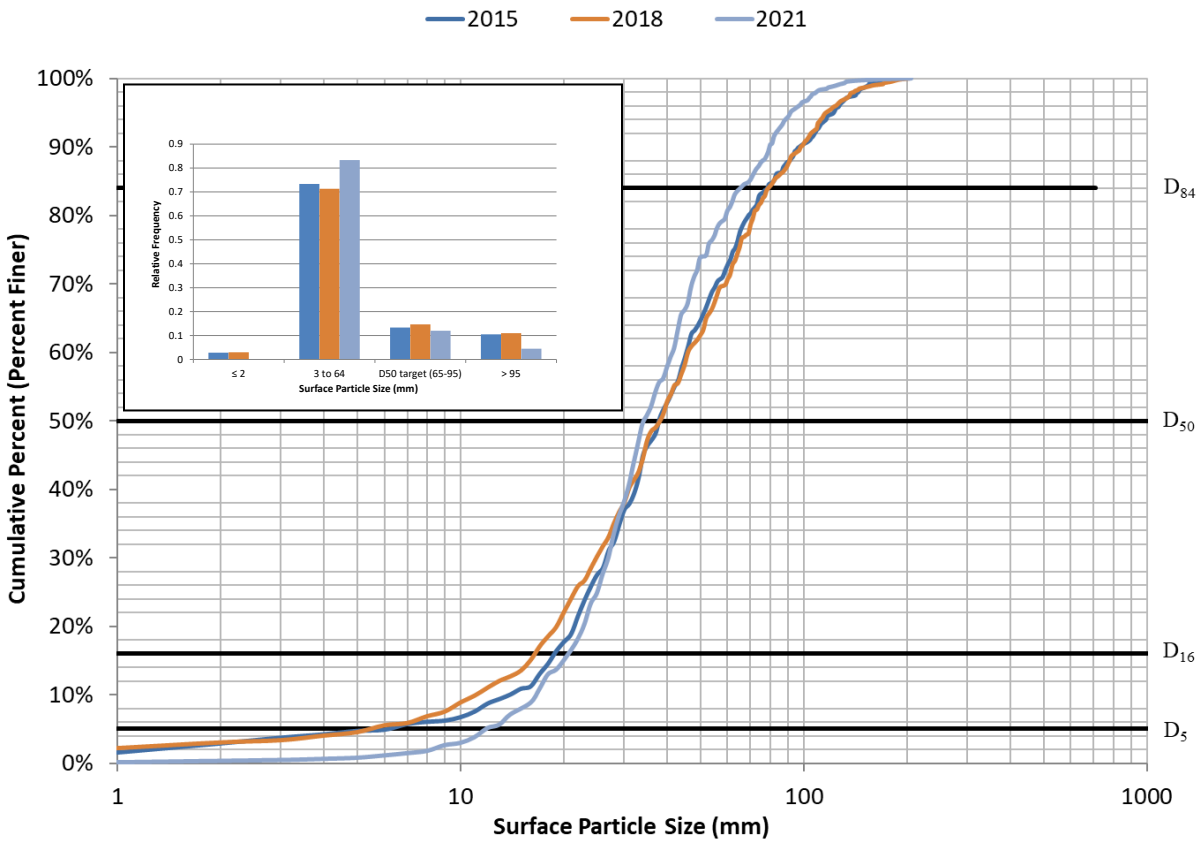

Figure 4. Example of a cumulative frequency (percent finer) plot of the mean surface particle sizes (mm) of three riffles measured within an ATM survey reach

Channel Dimensions

Cross-sectional streambed surveys are conducted to determine streambed elevation and area changes over time (Figure 5). Adjustments in channel dimensions may be sensitive to sediment and LWD loading within the stream channel and are expected to be correlated to habitat type characteristics. Streambed profiles indicate changes in channel dimensions and streambed scour or fill. Streambed topography is measured using standardized total station survey techniques (Topcon Positioning Systems, Inc.). This instrument was first deployed in 2003 to increase accuracy and repeatability of streambed surveys that had previously been measured with an auto level. Permanent critical points (left/right bank cross-section pins) are installed at each monitoring station as reference for the three-dimensional sampling grid encompassing the monitoring reach.

Each reach has a minimum of five (5) permanently benchmarked cross-sections that are measured in years when habitats are surveyed. The cross-sections are measured at each change in topography across

the channel. Cross-sectional area is determined below a reference elevation. This elevation is typically set at a channel feature associated with bank-full depth.

Data processing has been streamlined with electronic data collection, transfer, and processing. HRC has developed an Excel® spreadsheet to process cross-section data from x, y, z coordinates into standard measurements in the x-z plane. An additional spreadsheet computes channel area (m^2), width (m) and depth (m).

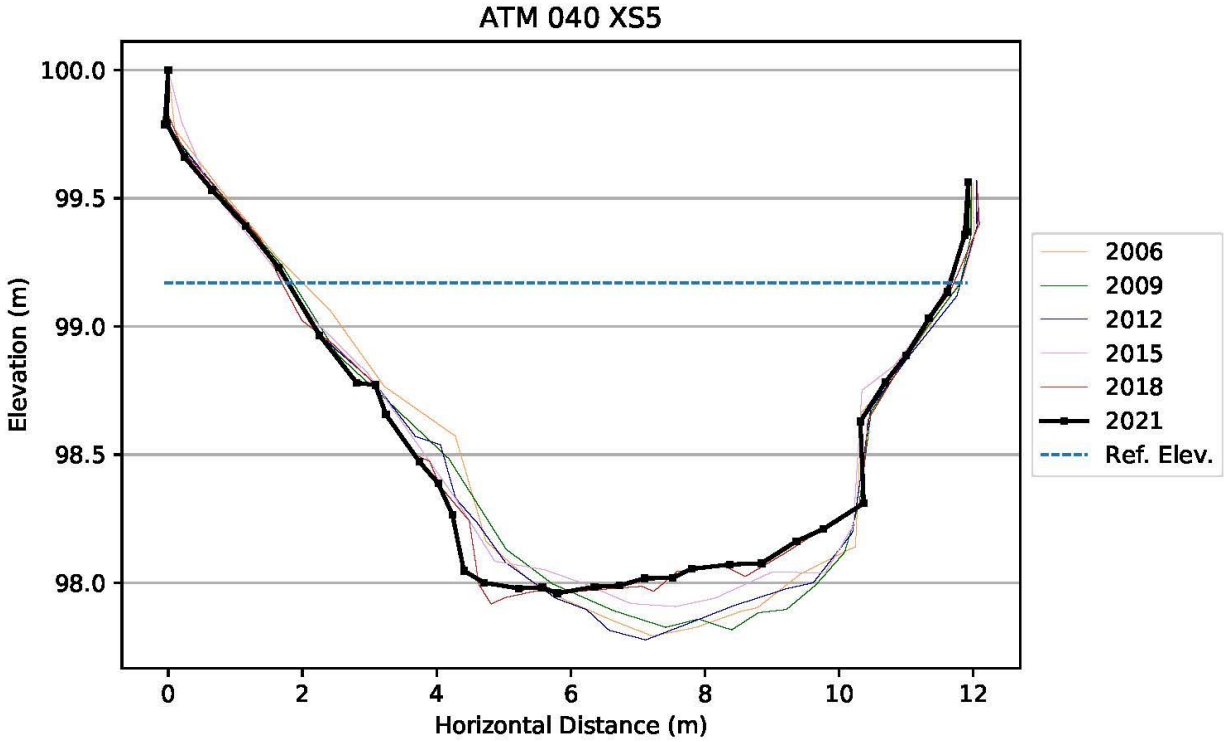

Figure 5. Example of a typical cross-sectional profile within an ATM survey reach

Large Woody Debris

LWD pieces within the bank-full stream channel of each ATM reach are counted to determine the total piece frequency of large wood available for creating fish habitat and molding channel morphology. To constitute a countable piece of LWD, individual pieces must be within the height of the bank-full channel and be a minimum of 20 cm in diameter and 2 meters in length. LWD data address APFC targets which are calculated from site-specific channel dimensions. The percent of pools associated with LWD parameter will continue to be collected as part of pool habitat measurements.

Pools

The primary rearing habitat parameters measured in the ATM program are pool characteristics. HRC conducts habitat typing on stream reaches to assess the frequency (i.e., the percentage of channel length composed of pools), size, and depth of pools. Measurements are performed at each habitat unit in the sampling reach. Habitat units are broken down to pool, riffle, or flat-water categories. Basic physical measurements such as length, width and residual depth are measured and observations of LWD influence are recorded.

Habitat typing addresses APFC matrix targets of pool-to-pool spacing based on bank-full channel width (CW), percent of surface area comprised of pool habitat, number of pools associated with LWD, and average residual pool depth. Residual pool depth is equal to the difference between maximum depth and pool tail crest depth.

Riparian Overstory

Canopy cover measurements (percent) are used to document growth and/or stability of riparian forests, as well as to identify streams that may be subject to higher thermal loading from sunlight. Canopy cover addresses the APFC matrix target for mid-channel canopy closure (Figure 6) and within the riparian forest (Figure 7). The mid-channel canopy cover is measured as an influence of the forest on maintaining cool water temperatures, taken mid-channel at 25m intervals throughout the sampling reach using a convex spherical densiometer (model A).

Figure 6. Pool habitat with overhead canopy

Figure 7. Redwood riparian forest overstory

Overstory canopy closure data in the riparian forest adjacent to the stream channel is also collected using the densiometer on a systematic grid pattern. While overstream canopy closure is measured every ATM survey cycle, beginning in 2015, no riparian forest canopy measurements are required in stands where ≥85% riparian forest closure was documented in the prior ATM survey *unless* significant disturbance (i.e. timber harvest, blow down, landslide, high mortality, fire) is evident.

Water Temperature

Figure 8. Stream temperature logger with protective PVC case

Stream temperature (℃) is tracked during the warmest part of the year (typically June through September). Temperature is monitored with continuous recording data loggers (Onset HOBO® Water Temp Pro v2). Temperature data loggers are inserted into protective PVC cases (Figure 8) and placed in the stream at a location that meets requirements for sufficient mixing, adequate cover, and consistent flows during the summer months to ensure data integrity by reducing the likelihood of thermal stratification. Temperature data are used to calculate the maximum weekly average temperature (MWAT), or the average of the daily mean temperature measured during the warmest seven consecutive days each year. The APFC target value for MWAT at all ATM stations is ≤16.8℃. Figure 9 illustrates a typical temperature profile as measured at ATM stations property wide.

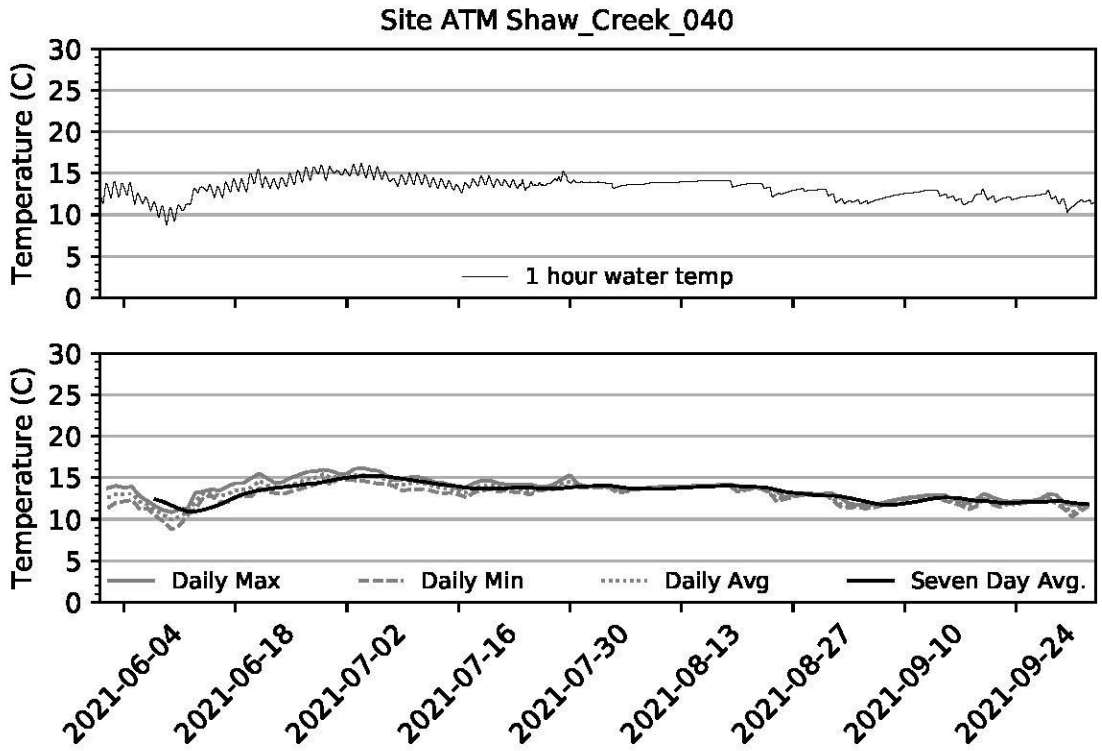

Figure 9. Example of a stream temperature profile generated from a continuously-recording temperature data logger deployed at most ATM stations annually

PROGRAM IMPLEMENTATION - 2021

In this section, we report on program implementation, including field and laboratory activity, program milestones, quality assurance, and methods implementation. The monitoring program objectives are:

- Complete all yearly scheduled measurement activities.
- Report trends relative to APFC criteria.
- Complete all field data collection procedures in an efficient and timely manner, following all applicable Standard Operating Protocols (SOP).
- Complete all QA/QC goals for each project within the monitoring program.
- Provide data summaries and periodic analyses to HCP Signatory Agencies, NCRWQCB and make publicly available.
- Provide habitat and channel morphology information to the HRC Watershed Analysis Process and THP cumulative effects analyses.

LOCATIONS OF FIELD MEASUREMENTS

Table 3 lists the field activity scheduled for 2021 and accomplishments against this plan. Pebble count, canopy closure, habitat typing, and streambed surveys were conducted at 16 stations in the Yager Creek, Lawrence Creek, Bear Creek, Bear River, and Mattole River drainages. Stream temperature loggers were deployed at 50 sites property wide. All fieldwork was completed within the scheduled period. All data collection occurred prior to any major storm events.

Table 3. 2021 measurement activity in the ATM Program

Watershed	Habitat		Temperature	
	Scheduled	Completed	Scheduled	Completed
Freshwater Creek	None	None	7	7
Elk River	None	None	7	7
Yager Creek	3	3	6	6
Lawrence Creek	3	3	5	5
Van Duzen River	None	None	4	4
Eel River Delta	None	None	2	2
Lower Eel Tributaries	None	None	3	3
Bear Creek	3	3	3	3
Upper Eel Tributaries	None	None	2	2
Larabee Creek	None	None	3	3
Mattole River	3	3	3	3
Bear River	4	4	4	4
Mad River	None	None	1	1
TOTAL	**16**	**16**	**50**	**50**

QUALITY ASSURANCE ACTIVITIES

QA/QC activities have been implemented in the ATM program to varying degrees since 2002. Many of these activities are described within pertinent SOP's. Three stations were revisited in 2021 for QA/QC purposes.

All instruments and equipment used for sampling were inspected and maintained daily. Any instrument repairs and/or calibrations were made either by the manufacturer or following manufacturer guidelines. Calibration of equipment was done on a regular schedule and upon any mishandling or questionable performance of the instrument.

QA/QC results are presented beginning on page 107 of this document.

PRESENTATION OF RESULTS

Current data derived from long-term stream habitat monitoring stations are provided and a simplified method for tracking habitat conditions and trends is presented below.

The basic compilation of data measured at each ATM station is provided in a "report card", an example of which is illustrated in Table 4. Each of the 44 active ATM stations have up to nine (9) APFC parameters with targets addressing habitat factors related to streambed substrate, pools, LWD, forest canopy and water temperature. The table cell is colored blue if the parameter met or exceeded the APFC target, white if it did not meet the target, green if there are no established APFC targets, and grey if there are no data associated with the parameter. These tables are used as the primary metric in which to evaluate current data collection. Parameters without assigned APFC target values will not be included in the total number of opportunities for success.

The report card groups ATM stations by WAU and provides the measured value for each of the nine parameters from each year of measurement. Previous measurements from WAUs not measured in 2021 can be found in previously submitted ATM annual reports.

Table 4. Example watershed report card

2021	Parameter	Target Value (# no target)	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8	Station 9	Station 10
Bed Surface	D_{84} (mm)	#	66	88	98	98	114	110	94	126	93	77
	D_{50} (mm)	65-95	30	38	28	42	46	56	39	68	65	31
	D_{16} (mm)	#	12	8	2	6	4	20	12	25	9	6
	D_5 (mm)	#	8	1	1	1	1	4	3	4	2	1
Pool Characteristics	Pool Area (%)	≥25	22	61	32	32	26	35	47	37	26	11
	Pool Spacing (CW/pool)	≤6.0	5.0	5.5	3.3	2.6	4.8	3.2	2.6	4.1	3.9	7.3
	Residual Pool Depth (m)	≥0.91	0.42	0.61	0.60	0.57	0.67	0.57	0.49	0.52	0.62	0.53
	Pools Assoc. w/wood (%)	≥50	100	100	100	100	100	100	85	88	100	100
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥5.1	12.9	12.7	6.2	6.3	5.6	7.3	4.7	4.7	8.6	7.4
	Total Piece Count	#	148	145	71	72	65	87	57	46	70	85
Water Temperature	MWAT (°C)	≤16.8		17.9	19.5	18.7	18.1	17.9	15.9	15.5	15.5	17.2
Riparian Overstory	Canopy Over Stream (%)	≥90	24	38	35	26	57	40	97	80	77	83
	Canopy of Rip Forest (%)	≥85	90	96	97	85				96	99	96

HRC synthesizes and simplifies presentation of habitat status by taking a pass/fail approach to the APFC target criteria. A "success" can be considered when a habitat parameter meets or exceeds APFC criteria. Each station/parameter combination is considered an opportunity for "success". If a certain WAU contains ten (10) stations, there are ten (10) opportunities for success for each individual parameter. If there are nine (9) parameters and 10 stations, there are 90 opportunities for success. Note that in Table 4 there are two (2) stations that do not have total LWD piece counts and four (4) stations that do not have riparian forest canopy measurements, reducing the total number of opportunities to 84.

The "Composite Habitat Score" is equal to the success rate, which is calculated as:

$$\text{Composite Habitat Score} = \frac{Number\ of\ Successes}{Number\ of\ Opportunities}$$

Within each WAU report card, the total number of blue cells equals the total number of successes documented for an individual year. This allows for a relatively standardized and streamlined approach to evaluate each watershed. In Table 4, there are 48 successes, yielding a watershed composite habitat score of 0.56 (out of 1.00) for the WAU's ten stations.

One of the benefits of this scoring approach is that there is a great deal of flexibility in computing the habitat score for any number of "groupings". A score can be computed for all parameters at an individual station, for all the stations in a WAU (as shown in Table 4) or for the entire HRC property. We can also create groups of the parameters related to key habitat factors. There is one (1) parameter related to bed surface substrate, four (4) related to pool characteristics, one (1) related to large woody debris, two (2) related to canopy cover, and one (1) related to water temperature. We combine the status of a habitat factor by grouping like-parameters. For example, we group all pool characteristics (n=4) and stations (n=10), providing (n= [4 x 10] = 40) opportunities for success for achieving pool-related goals in the watershed. This type of grouping allows progress in habitat factors to be tracked independently.

The habitat scoring method currently in use is a very flexible presentation of data. A composite score can be computed for any grouping of stations and parameters and the fundamental meaning does not change. This composite can be tracked through time to indicate improvement towards APFC targets. The goal is 100% success in meeting all habitat conditions at all stations or a composite score of 1.0, regardless of groupings.

In summary, the composite habitat score contains the following characteristics:

- The focus is on achieving salmonid habitat goals.
- Habitat status is simple to depict.
- Many parameters that are derived from unique measurement techniques can be considered together.
- All parameters are treated equally.
- The method is relatively insensitive to the different measurement dates for stations and parameters as well as sample size.
- The analysis is not heavily weighted by parameter values at the beginning of the data record or outliers within the data record.
- Large changes in one parameter in one year will have a minimal effect on the composite score**.** The bulk of parameters or all the sites must change to move the score, depending on groupings.
- Intermediate levels of progress may be missed.

The calculation and utilization of composite scoring helps satisfy the need to quantify progress towards achieving habitat goals, but it is not considered a replacement for future statistical analyses of individual parameters as the data record lengthens. We also note that there is likely to be ongoing debate over time as to the appropriateness of specific APFC targets currently in use as scientific information increases. As long as there are specific target levels identified, the method can be accommodated to report status relative to them.

WATERSHED HABITAT RESULTS

WEATHER IN 2021

Precipitation is calculated by the "hydrologic year" that runs from October 1 through September 30th and is numbered for the year in which it ends. Rainfall data collected at the Woodley Island National Weather Station (NWS) in Eureka, CA, indicate an average total annual rainfall of 39.12 inches[1] with roughly 90% of the annual precipitation falling as rain during the months of October through May. Rainfall amounts in hydrologic year 2021 (1 October 2020, to 30 September 2021) were substantially less than average throughout HRC property.

The Eureka long-term National Weather Service station is indicative of climate for HRC property north of the Van Duzen River. Total annual rainfall at the NWS station in Eureka was 25.77 inches, approximately 52% lower than the long-term average. Maximum daily rainfall was 1.76 inches, suggesting that peak flows may have been moderate in certain watersheds. The previous rainfall year that could be considered relatively large in Eureka was 2006, when rainfall was well above average (58.67 inches or 50% greater than the long-term average).

Total annual rainfall at the NWS station in Scotia, CA in HY2021 was 28.48 inches, which is approximately 65% lower than the long-term average (47.02) for this station. The maximum peak flow measured at the gaging station at the Eel River near Scotia equaled 30,100 cubic feet per second (cfs), with a corresponding maximum daily mean of 25,000 cfs occurring on February 2, 2021. The previous rainfall year that could be considered relatively large in Scotia was 2006, when rainfall was well above average (70.80 inches or 51% greater than the long-term average). Long-term annual precipitation records at the Woodley Island and Scotia NWS stations are shown in Figure 10.

Annual peak flows (cms) that represent the northern extent of HRC property are recorded at Graham Gulch (hydrologic monitoring station 505) in Freshwater Creek, and at Bear Creek (hydrologic monitoring station 530) which represent the southern extent of HRC property (Figure 11). Peak flow is expressed in cubic meters per second per unit area (cms/km^2) at HRC gaging stations. A value of 1 is approximately equal to a bank-full event. Along with rainfall distribution, peak flow magnitude is relatively variable across the range of HRC property.

[1] California Date Exchange Center (http://cdec.water.ca.gov/cgi-progs/profile?s=SCA&type=precip)

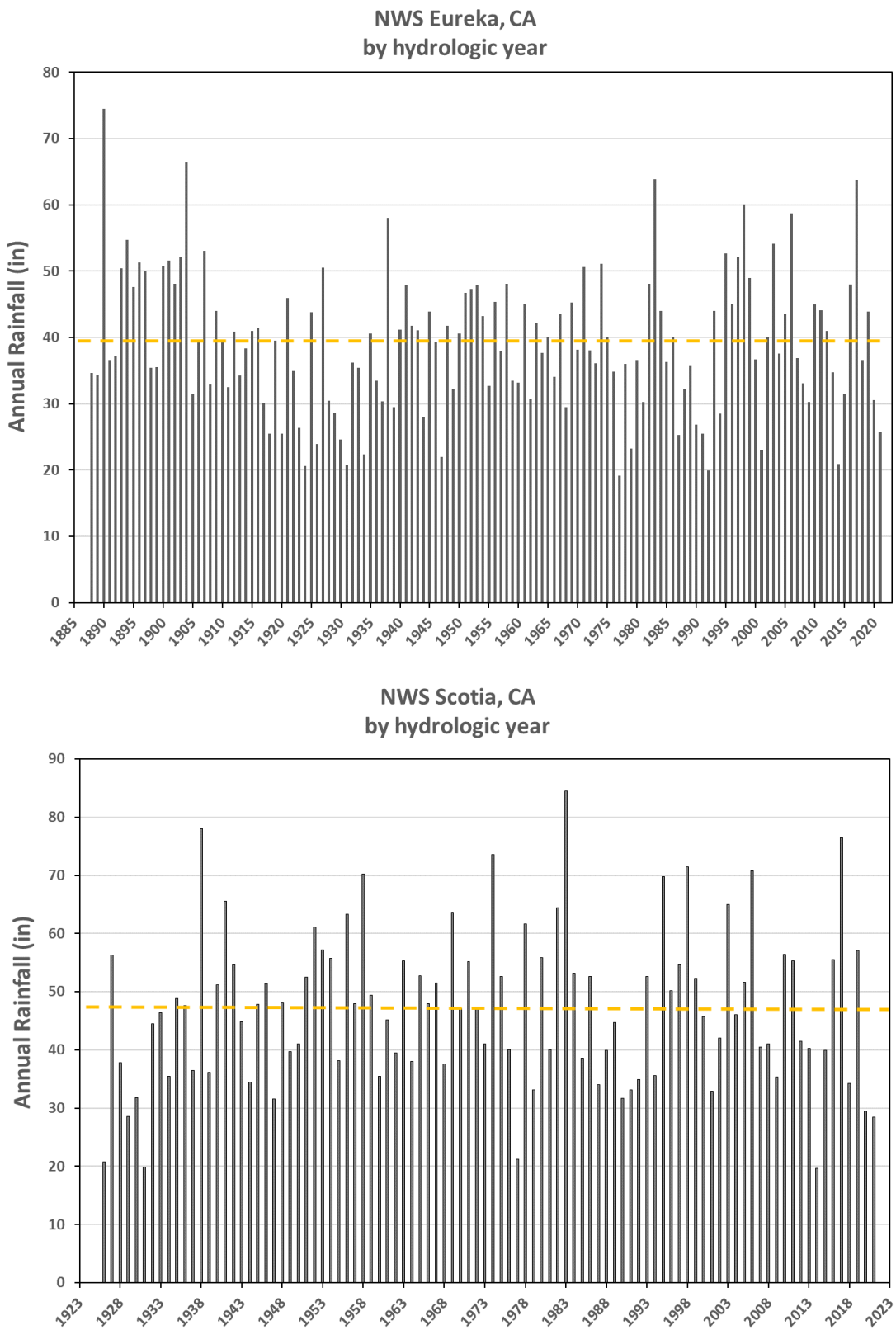

Figure 10. Annual rainfall by hydrologic year at Eureka and Scotia, CA. Dotted lines represent the running averages (all years)

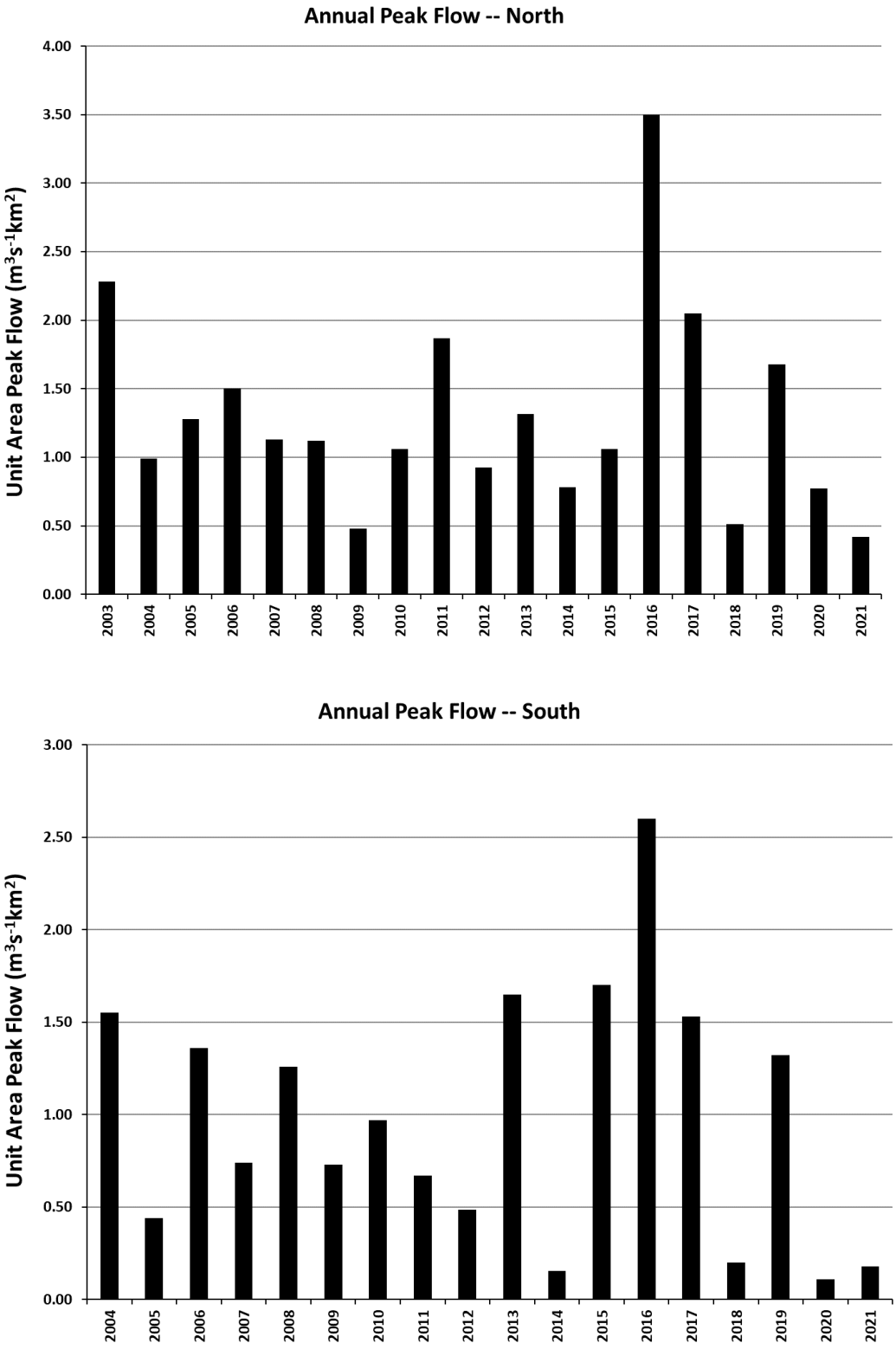

Figure 11. Reference streamflow sites are represented by Graham Gulch (site 505) in Freshwater Creek (north) and by Bear Creek (site 530) in the south

YAGER-LAWRENCE WAU

The Yager-Lawrence WAU is located northeast of the town of Carlotta, CA and drains an upstream area of approximately 96,472 acres or 150.7 square miles (Figures 12 & 13). Lawrence Creek is a 26, 932-acre (42 square mile) tributary that joins Yager Creek within the WAU area. Yager Creek flows into the Van Duzen River at approximately 5.0 miles from its confluence with the Eel River, which travels an additional 13.7 miles to the Pacific Ocean. The Yager-Lawrence WAU has elevations ranging from 80 feet at the mouth of Yager Creek to over 3,200 feet along the highest ridges.

Approximately 36% of the WAU is within HRC ownership, 63% is held by other private ownerships, and 1% is under public ownership. HRC's 34,605-acre ownership is concentrated in the tributary of Lawrence Creek, and along the mainstem of Yager Creek, extending only a short distance upstream of the Middle and North Forks.

The geology of the WAU is heavily dominated by the Yager and Franciscan assemblages with a small portion in the Wildcat formation. Ongoing rock uplift associated with tectonic plate interactions along the north coast of California produces a base level fall resulting in a regional pattern of fluvial incision over geologic timescales. Interpretations of existing historical channel conditions in the WAU should be broadly cast in the context of this incision. In the WAU, gradients associated with the mixed bedrock and alluvial stream network adjust to the alluvium they carry as well as the bedrock in which they incise.

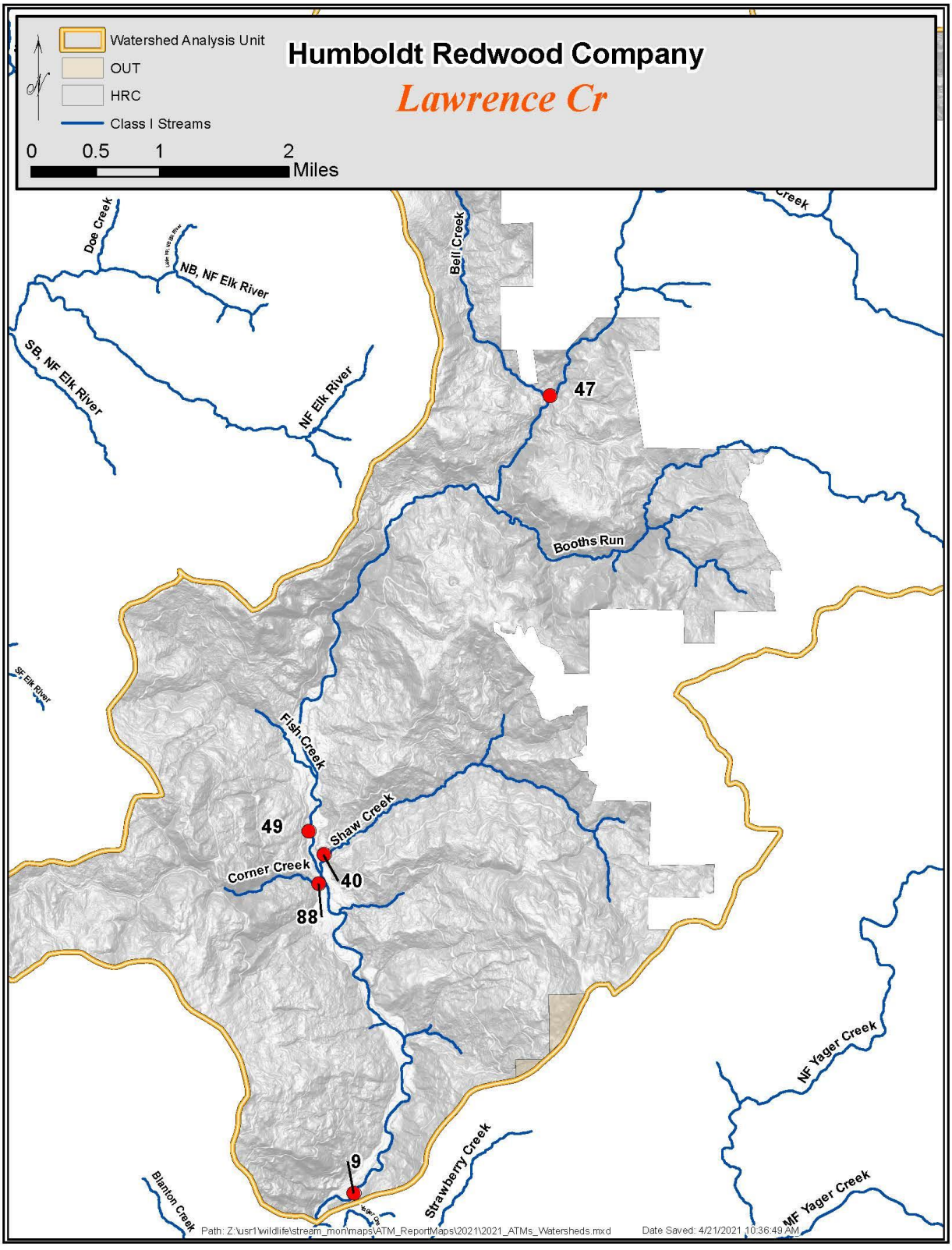

Figure 12. Location map of ATM sites in Lawrence Creek

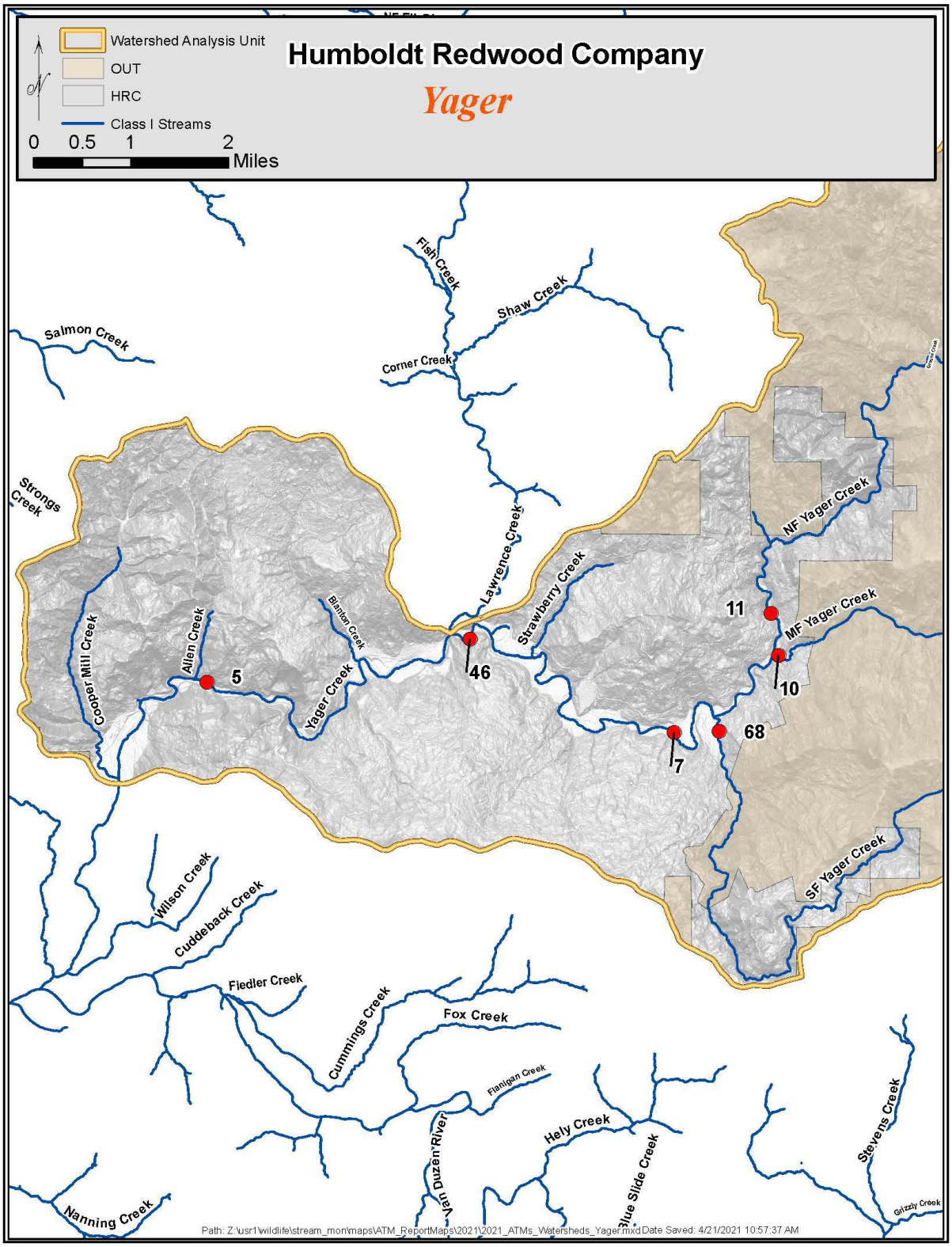

Figure 13. Location map of ATM sites in Lower Yager Creek

ATM 049 Lawrence Creek

ATM 040 Shaw Creek

ATM 009 Lawrence Creek

ATM 007 Yager Creek

ATM 046 Yager Creek

ATM 005 Yager Creek

Figure 14. ATM sites within the Yager/Lawrence Creek WAU

ATM Site 049 – Lawrence Creek [Coastal Belt: Yager Terrane (TKy)]

Data for all ATM parameters at site 049 (Figure 14) are summarized in the APFC report card (Table 5). D_{50} targets were met at this site in 2021, as data suggest a coarsening of the substrate particles across 3 of 4 size classes (Figure 15). Pool characteristics suggest a slight improvement in habitat conditions, as pool spacing met the target after narrowly placing short of it in 2018. Total LWD piece frequency met the target in 2021, increasing by 48% from 2018. Water temperature met the target in 2021, while mid-channel canopy cover increased substantially within the reach and met its target for the first time on record.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 2006 (see Appendix). Aggradation was observed at 3/5 cross-sections between survey years 2018 and 2021. The greatest degree of channel aggradation occurred at cross section 2 where the channel area decreased -0.56m^2. The greatest degree of channel scour occurred at cross-section 3 where the channel area increased +0.85m^2.

A snorkel survey on 9/1/2021 identified juvenile coho salmon and trout of various size classes in all 5 pools sampled (Figure 16).

Table 5. Individual site report card for ATM 049, Lawrence Creek

Site 049 Lawrence Creek	Parameter	Target Value (# no target)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bed Surface	D_{84} (mm)	#	306	207		204			223			220			120			139			158
	D_{50} (mm)	65-95	128	53		75			98			96			65			73			76
	D_{16} (mm)	#	16	12		10			20			15			21			31			29
	D_5 (mm)	#	2	3		1			8			3			9			9			12
Pool Characteristics	Pool Area (%)	≥25	32	58		43			58			34			51			54			59
	Pool Spacing (CW/pool)	≤6.0	7.5	4.3		5.8			6.4			6.0			4.3			6.1			5.1
	Residual Pool Depth (m)	≥0.91	0.69	0.72		0.70			0.91			0.87			0.79			0.95			0.92
	Pools Assoc. w/wood (%)	≥50	100	86		100			100			100			100			100			100
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥4.0							4.2			3.2			2.7			2.7			4.0
	Total Piece Count	#							47			39			40			41			61
Water Temperature	MWAT (°C)	≤16.8	18.7	19.4		19.8	17.6		17.7	16.0	16.7	16.5	17.5	17.4	17.9	16.8	17.8	16.6	16.6	17.0	16.6
Riparian Overstory	Canopy Over Stream (%)	≥84	46	34		19			67			74			77			73			96
	Canopy of Rip Forest (%)	≥85	79	100		98						97									

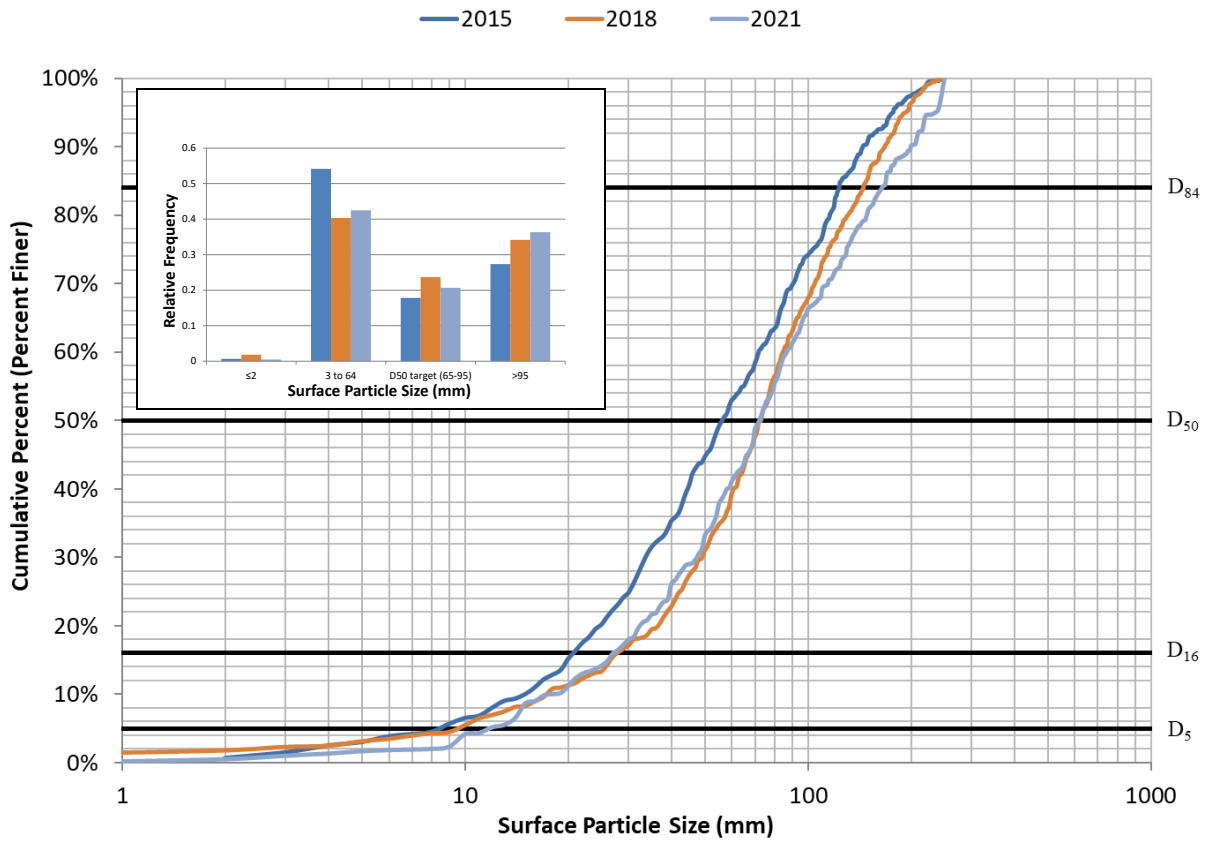

Figure 15. Cumulative frequency plot of the mean surface particle size of three riffles measured within the Lawrence Creek ATM 049 monitoring reach

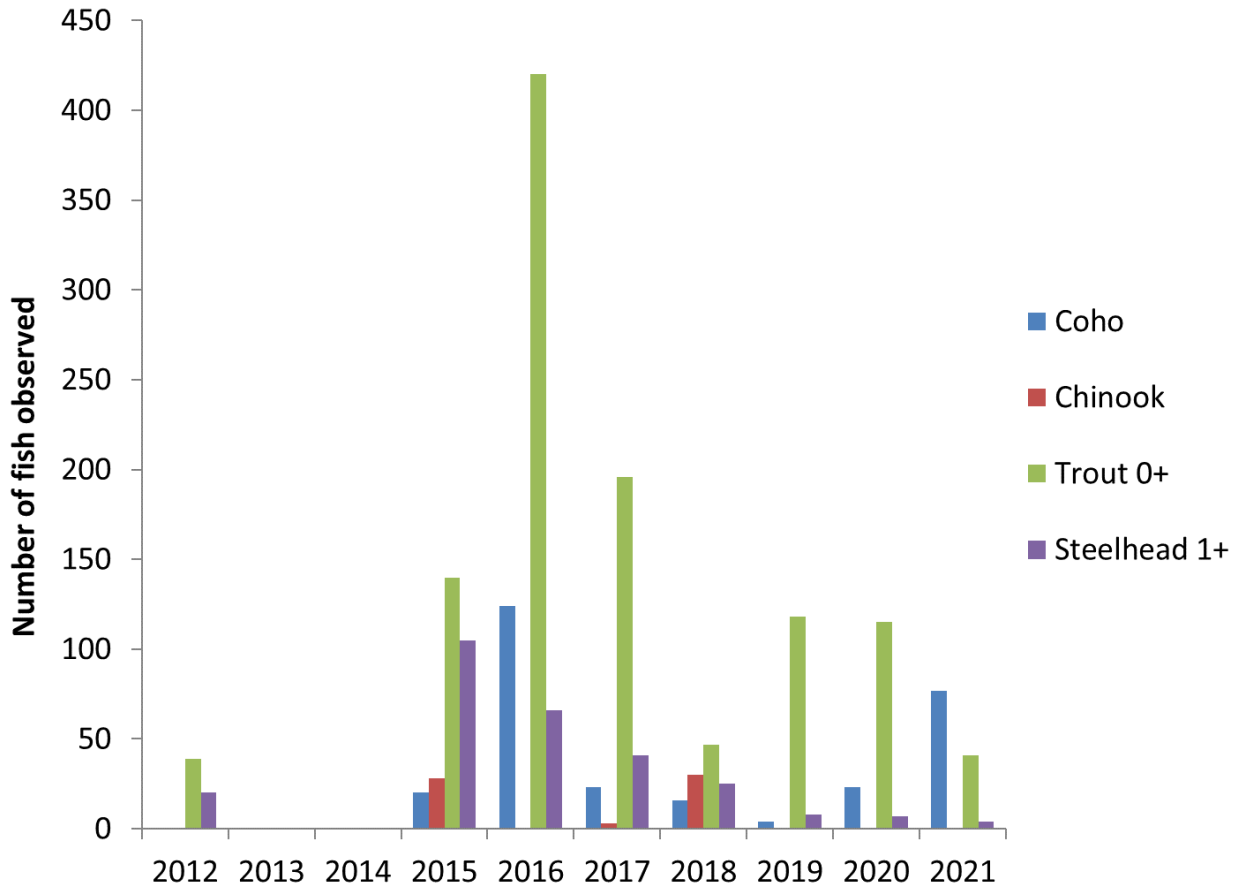

Figure 16. Results of annual snorkel survey fish counts of the first 5 pools within the Lawrence Creek ATM 049 monitoring reach (2012, 2015-2021)

ATM Site 040 – Shaw Creek [Coastal Belt: Yager Terrane (TKy)]

Data for all ATM parameters at site 040 (Figure 14) are summarized in the APFC report card (Table 6). Bed surface remained below targets as data suggest very little change in the D_{50} value since 2018 (Figure 17). Pool habitat characteristics scored the same as in 2018, with 3 of the 4 parameters meeting their targets. LWD total piece frequency did not meet the target for the eighth consecutive survey year, even as data suggest an increase in the total number of pieces counted. Stream temperature and over stream canopy cover each met their targets in 2021.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 1998 (see Appendix). Channel scour was observed at one cross-section between survey years 2018 and 2021, where channel area increased +0.01m^2. The greatest degree of channel aggradation occurred at cross-section 3, where channel area decreased -0.86 m^2.

A snorkel survey on 7/8/2021 identified juvenile coho salmon and trout of various size classes in all 5 pools sampled (Figure 18).

Table 6. Individual site report card for ATM 040, Shaw Creek

Site 040 Shaw Creek	Parameter	Target Value (# no target)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bed Surface	D_{84} (mm)	#	79	71		102			114			89			79			83			66
	D_{50} (mm)	65-95	31	23		34			45			33			39			39			37
	D_{16} (mm)	#	14	8		4			11			11			20			16			21
	D_5 (mm)	#	5	1		1			3			2			7			6			13
Pool Characteristics	Pool Area (%)	≥25	46	56		52			57			38			54			56			73
	Pool Spacing (CW/pool)	≤6.0	5.2	4.7		2.7			2.8			5.1			3.8			4.0			3.2
	Residual Pool Depth (m)	≥0.91	0.53	0.58		0.52			0.56			0.39			0.59			0.61			0.63
	Pools Assoc. w/wood (%)	≥50	100	100		0			80			100			88			100			80
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥9.0	4.0	7.3		5.7			5.3			5.2			4.1			6.6			7.4
	Total Piece Count	#							55			46			32			53			57
Water Temperature	MWAT (°C)	≤16.8	15.4		15.2	16.0	15.2	14.8	13.8	13.8	14.7	14.5			15.8	14.9	16.5	15.1	15.4	16.1	15.2
Riparian Overstory	Canopy Over Stream (%)	≥92	92	98		95			97			96			100			97			100
	Canopy of Rip Forest (%)	≥85	93	91		100						98									

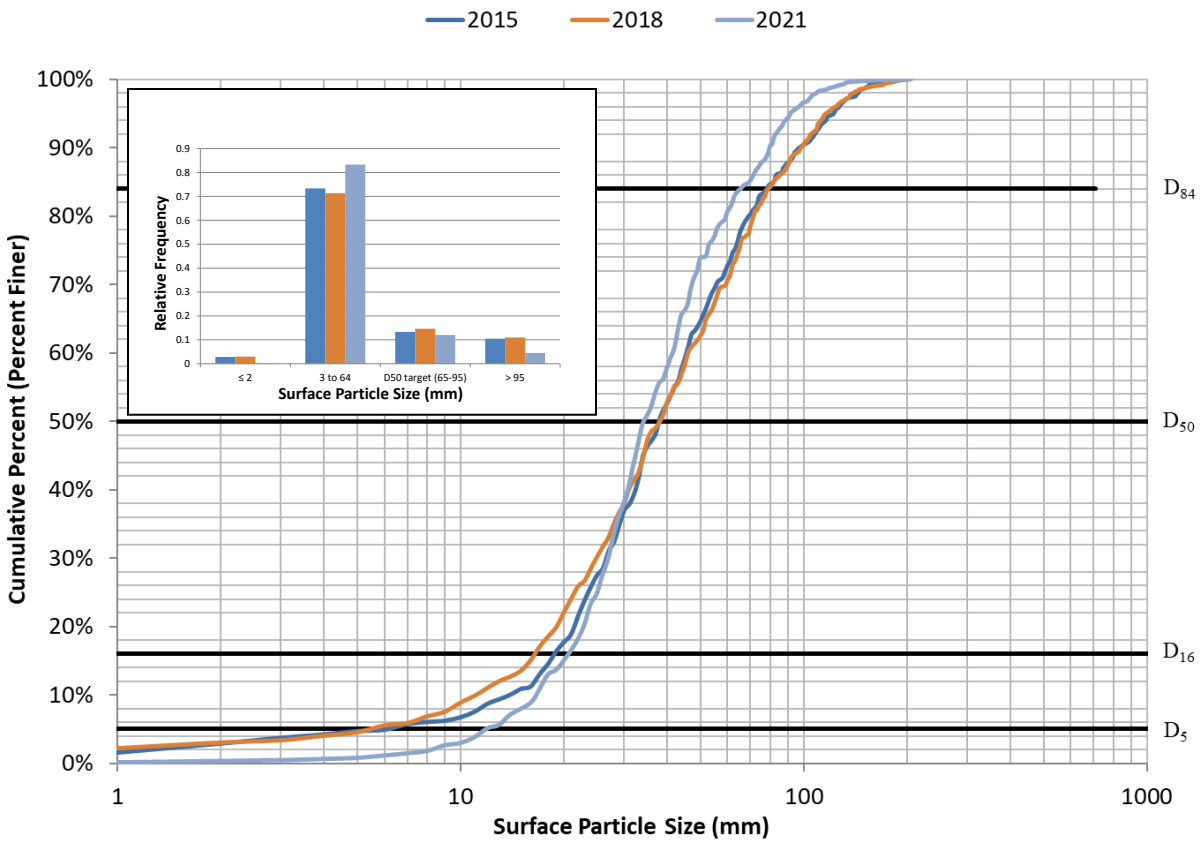

Figure 17. Cumulative frequency plot of the mean surface particle sizes of three riffles measured within the Shaw Creek ATM 040 monitoring reach

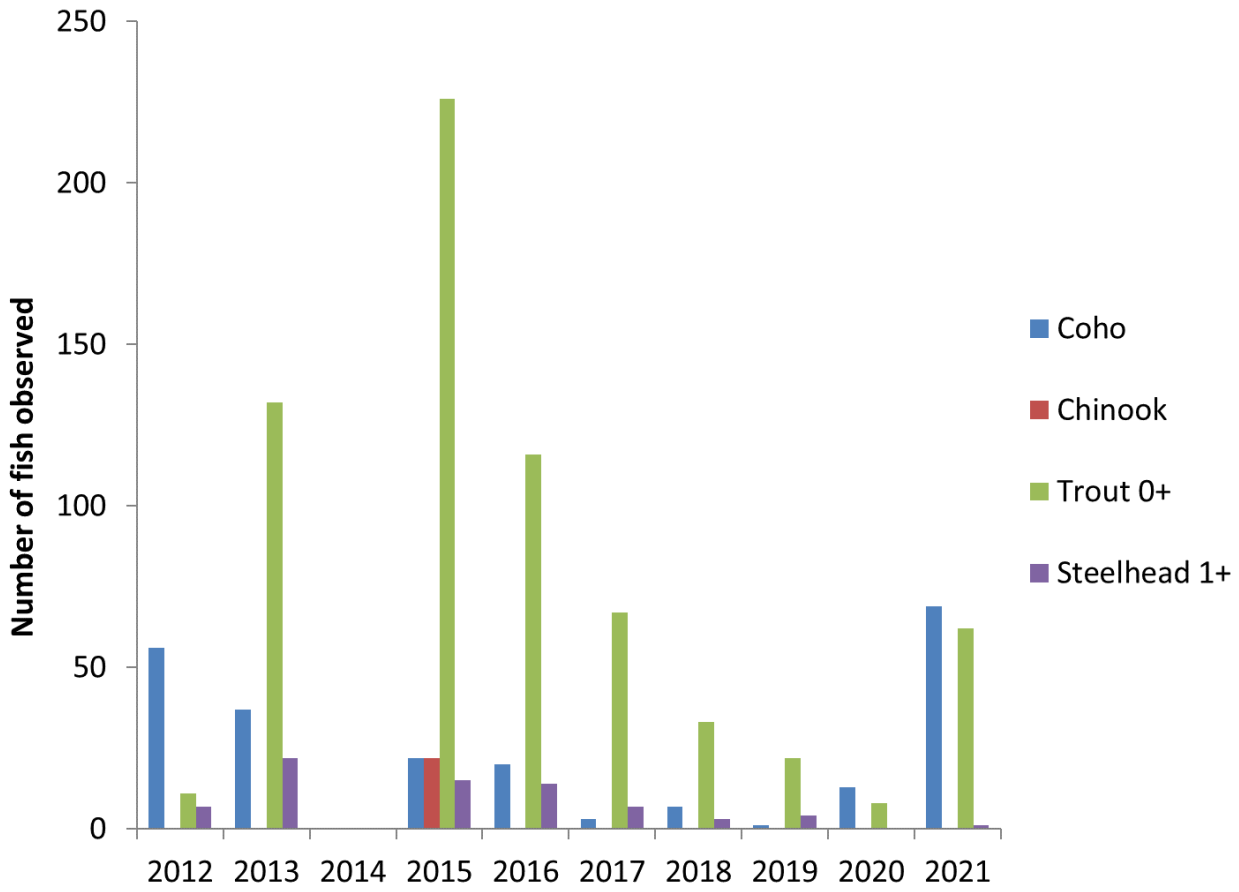

Figure 18. Results of annual snorkel survey fish counts of the first 5 pools within the Shaw Creek ATM 040 monitoring reach (2012, 2013, 2015-2021)

ATM Site 009 – Lawrence Creek [Coastal Belt: Yager Terrane (TKy)]

Data for all ATM parameters at site 009 (Figure 14) are summarized in the APFC report card (Table 7). Bed surface parameters met the D_{50} target even as the data suggest a slight fining across all substrate particle size classes (Figure 19). Pool area, pool spacing, and percent pools associated with wood each met their targets in 2021, while residual pool depth did not. LWD piece frequency met its target for the first time since 2006. Over stream canopy cover met its target in 2021 for the first time on record, while stream temperature did not meet its target for the eleventh straight survey year.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 1998 (see Appendix). Aggradation was observed at 3/5 cross-sections between survey years 2018 and 2021. The greatest degree of channel aggradation occurred at cross-section 2, where channel area decreased -0.84m^2. Scour occurred at 2 cross-sections, the greatest degree of which at cross section 3 where channel area increased +0.32m^2.

A snorkel survey on 9/1/2021 identified trout of various age classes in 4 of the 5 pools sampled (Figure 20).

Table 7. Individual site report card for ATM 009, Lawrence Creek

Site 009 Lawrence Creek	Parameter	Target Value (# no target)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bed Surface	D_{84} (mm)	#	198	117		158			150			90			130			151			150
	D_{50} (mm)	65-95	95	32		30			57			50			45			86			80
	D_{16} (mm)	#	16	3		2			16			14			18			42			36
	D_5 (mm)	#	5	1		1			4			4			4			20			15
Pool Characteristics	Pool Area (%)	≥25	84	50		33			75			56			62			64			73
	Pool Spacing (CW/pool)	≤6.0	12.0	5.1		7.2			3.9			2.9			3.7			4.3			3.1
	Residual Pool Depth (m)	≥0.91	0.90	0.87		0.93			0.89			0.69			0.35			0.78			0.81
	Pools Assoc. w/wood (%)	≥50	67	67		33			60			60			78			86			100
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥3.2	0.7	2.4		4.3			2.1			2.7			3.1			2.7			3.7
	Total Piece Count	#							25			24			58			50			69
Water Temperature	MWAT (°C)	≤16.8	19.1	19.9		19.7	18.3	18.0	18.2	16.6	17.5	16.9	18.2	17.9	18.9	17.8	18.8	17.9	17.8	18.1	18.1
Riparian Overstory	Canopy Over Stream (%)	≥92	33	47		56			58			80			89			83			97
	Canopy of Rip Forest (%)	≥85	81	86		96						91									

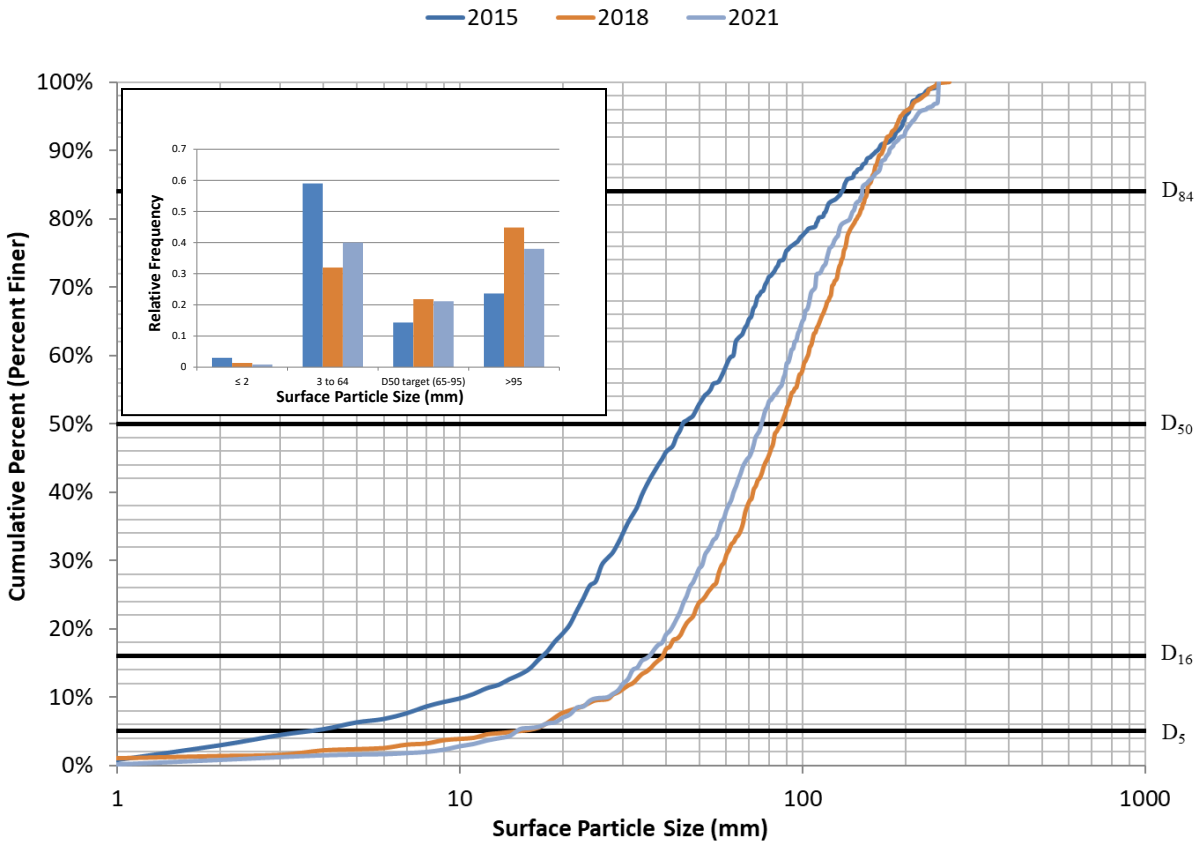

Figure 19. Cumulative frequency plot of the mean surface particle sizes of three riffles measured within the Lawrence Creek ATM 009 monitoringt reach

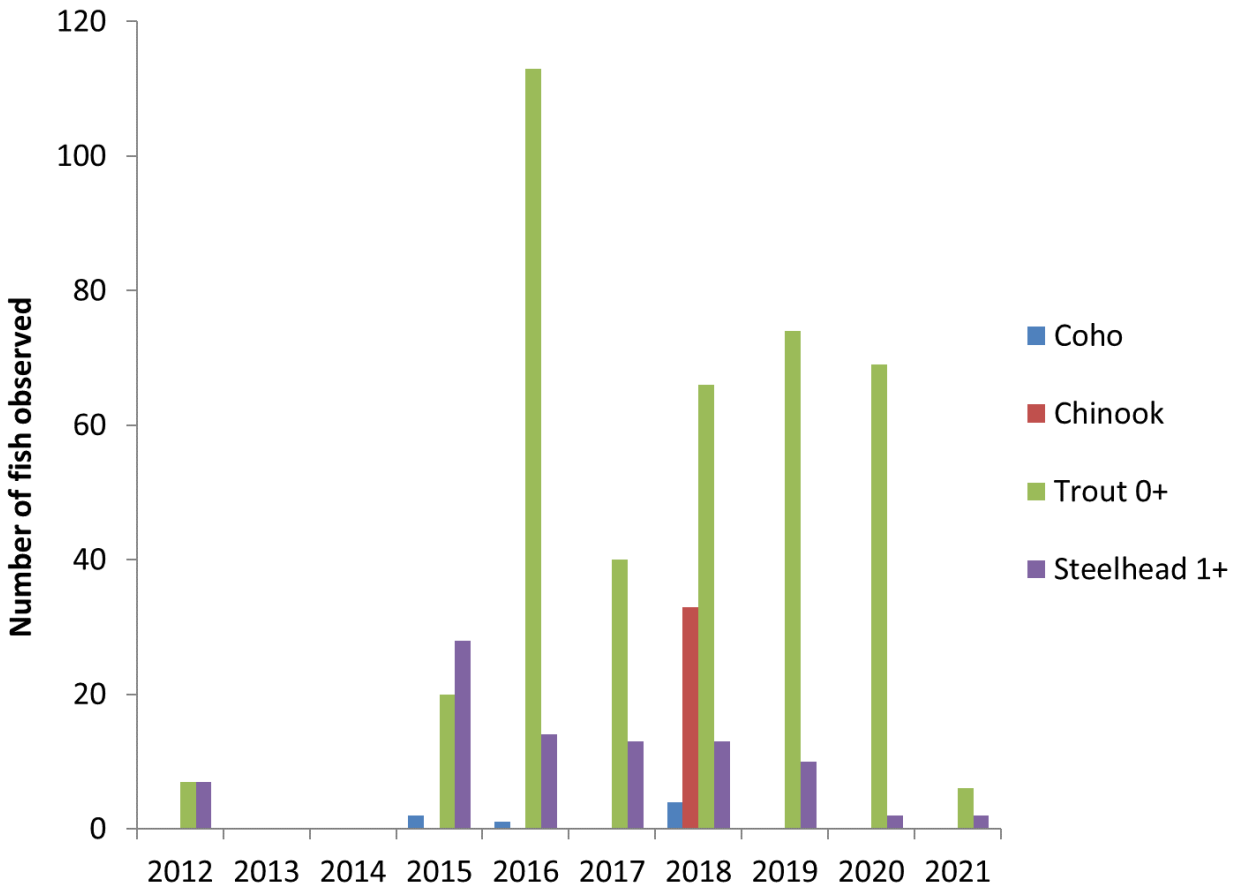

Figure 20. Results of annual snorkel survey fish counts of the first 5 pools within the Lawrence Creek ATM 009 monitoring reach (2012, 2015-2021)

ATM Site 007 – Yager Creek [Coastal Belt: Yager Terrane (TKy)]

Data for all ATM parameters at site 007 (Figure 14) are summarized in the APFC report card (Table 8). Bed surface parameters met the D_{50} target in 2021, as the data suggest a coarsening across most particle size classes (Figure 21). Pool area, pool spacing, and percent pools associated with wood met their respective APFC targets, while residual pool depth did not. LWD piece frequency did not meet the target in 2021, as the total number of LWD pieces increased only slightly since 2018. Water temperature decreased slightly, but still did not meet the target value. Over stream canopy met its target for the first time on record, while riparian canopy did not meet the target value for the seventh consecutive survey year.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 1998 (see Appendix). Channel scour was observed at 2/5 cross-sections between survey years 2018 and 2021. The greatest degree of channel scour occurred at cross-section 3, where channel area increased +1.65m^2. Aggradation occurred at 3 cross-sections, the greatest degree of which happened at cross-section 5 where the channel decreased in area -6.44m^2.

A snorkel survey on 9/1/2021 identified age 0+ trout in 3 of 5 pools sampled. Other observed species include California roach (*Lavinia symmetrics*) (Figure 22).

Table 8. Individual site report card for ATM 007, Yager Creek

Site 007 Yager Creek	Parameter	Target Value (# no target)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bed Surface	D_{84} (mm)	#	168	123		107			112			100			103			123			123
	D_{50} (mm)	65-95	68	57		25			51			75			52			77			82
	D_{16} (mm)	#	13	19		1			20			14			15			41			50
	D_5 (mm)	#	1	5		1			7			2			3			18			26
Pool Characteristics	Pool Area (%)	≥25	37	39		18			31			20			27			33			76
	Pool Spacing (CW/pool)	≤6.0	4.5	5.6		2.3			2.5			5.2			10.4			10.7			4.3
	Residual Pool Depth (m)	≥0.91	0.80	0.76		0.68			0.62			0.76			0.78			1.36			0.90
	Pools Assoc. w/wood (%)	≥50	100	100		100			100			100			60			100			86
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥1.8	1.7	2.3		1.0			1.8			3.0			1.5			0.6			1.4
	Total Piece Count	#							18			28			39			19			44
Water Temperature	MWAT (°C)	≤16.8					21.7	21.9	22.4	20.7	20.4	19.8		21.6	19.8	21.0	22.6	21.6	19.4	19.2	18.5
Riparian Overstory	Canopy Over Stream (%)	≥47	10	19		28			30			38			25			32			54
	Canopy of Rip Forest (%)	≥85	29	42		60						44			62			66			74

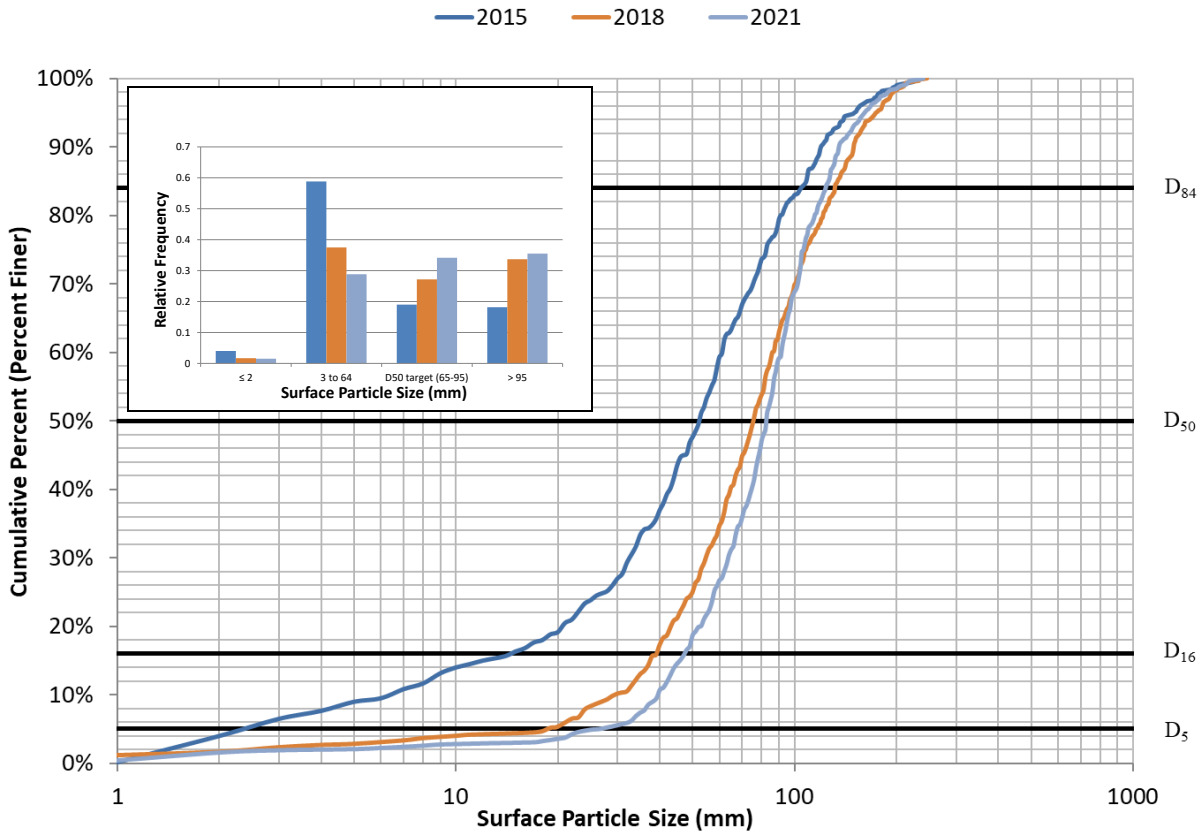

Figure 21. Cumulative frequency plot of the mean surface particle sizes of three riffles measured within the Yager Creek ATM 007 monitoring reach

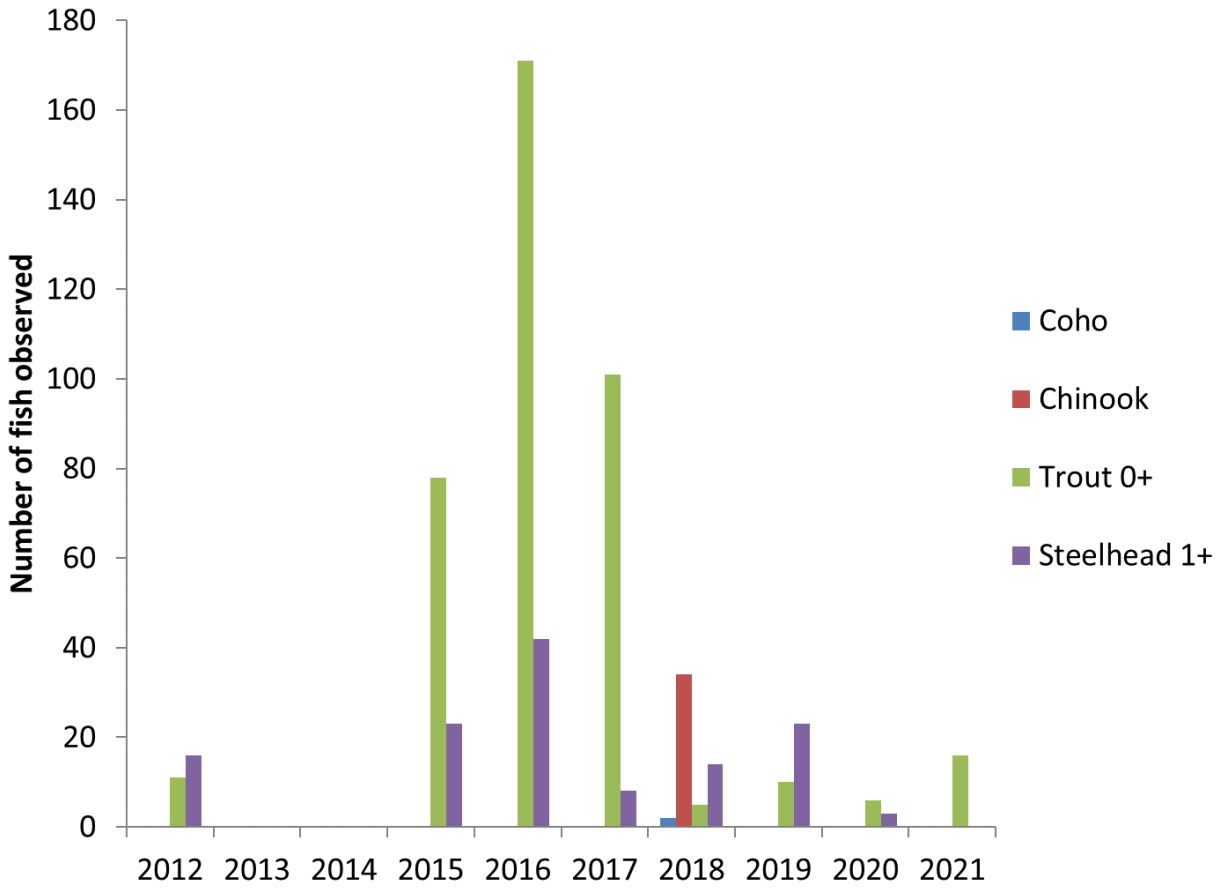

Figure 22. Results of annual snorkel survey fish counts of the first 5 pools within the Yager Creek ATM 007 monitoring reach (2012, 2015-2021)

ATM Site 005 – Yager Creek [Coastal Belt: Yager Terrane (TKy)]

Data for all ATM parameters at site 005 (Figure 14) are summarized in the APFC report card (Table 9). The D_{50} particle size class remained well short of APFC targets in 2021, even as all particle size classes showed a slight coarsening (Figure 23). Pool characteristics suggest a slight improvement in habitat quality, as pool area met the target value in 2021. LWD piece frequency remained well below the targets in this reach for the eight consecutive survey year. Both stream temperature and over stream canopy cover did not meet their respective targets.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 1997 (see Appendix). Channel scour was observed at 3/5 cross-sections between survey years 2018 and 2021. The greatest degree of channel scour occurred at cross-section 3, where channel area increased $+13.58m^2$. The greatest degree of aggradation occurred at cross-section 4, where channel area decreased $-0.74m^2$.

A snorkel survey on 9/1/2021 identified trout of various size classes in all 5 pools sampled. Other observed species include threespine stickleback (*Gasterosteus aculeatus*) and California roach (Figure 24).

Table 9. Individual site report card for ATM 005, Yager Creek

Site 005 Yager Creek	Parameter	Target Value (# no target)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bed Surface	D_{84} (mm)	#	746	413		404			322			344			113			72			74
	D_{50} (mm)	65-95	262	52		52			46			52			33			44			46
	D_{16} (mm)	#	12	4		2			8			8			8			18			26
	D_5 (mm)	#	1	1		1			3			2			3			5			13
Pool Characteristics	Pool Area (%)	≥25	36	30		31			65			25			42			23			35
	Pool Spacing (CW/pool)	≤6.0	3.8	6.7		6.3			2.2			5.3			4.3			7.6			6.1
	Residual Pool Depth (m)	≥0.91	1.59	2.19		1.81			1.00			2.01			1.11			2.11			2.21
	Pools Assoc. w/wood (%)	≥50	50	33		0			0			0			14			75			60
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥2.3	0.2	0.3		1.1			0.2			0.3			0.3			0.3			0.3
	Total Piece Count	#							3			4			6			7			8
Water Temperature	MWAT (°C)	≤16.8	21.7	22.7	20.9	22.1	21.2	21.1	21.4	19.8	20.1	19.7		22.3		20.8	21.4	21.4	21.0	21.1	21.9
Riparian Overstory	Canopy Over Stream (%)	≥74	13	23		7			27			13			25			54			69
	Canopy of Rip Forest (%)	≥85	89	98		98						93									

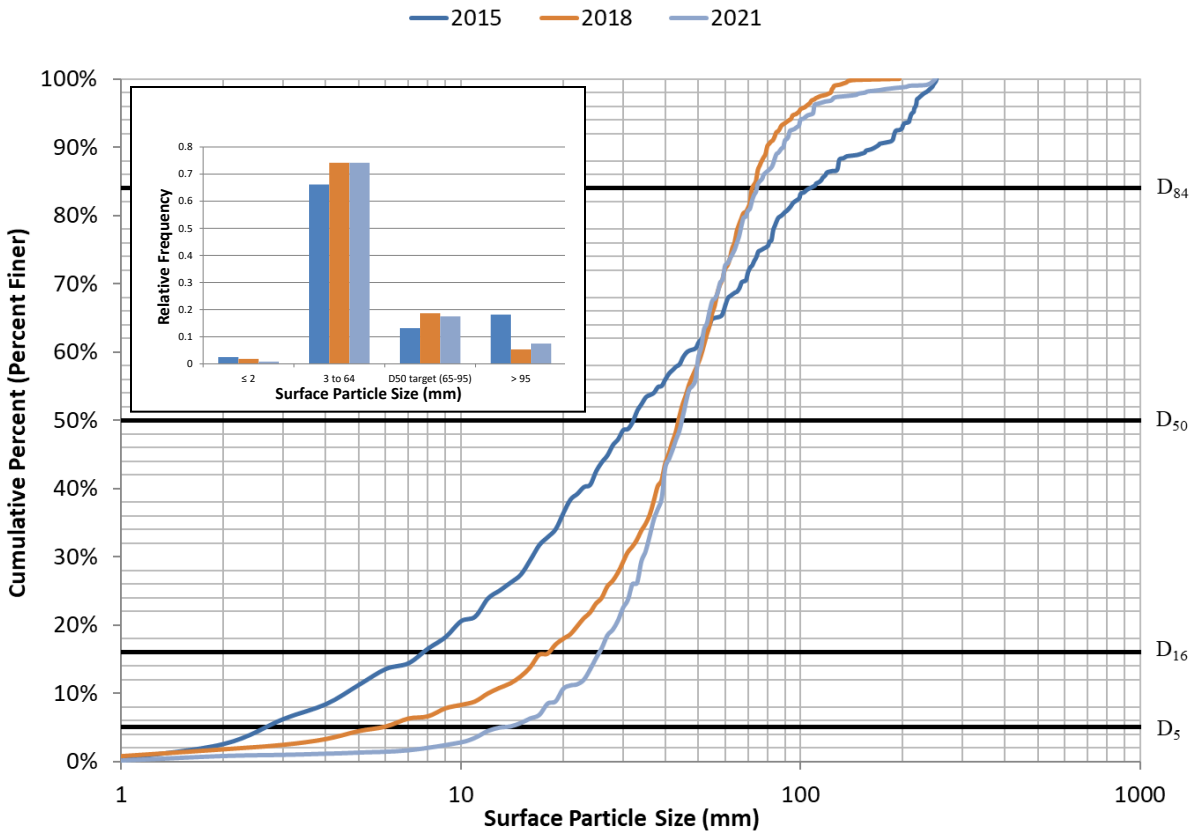

Figure 23. Cumulative frequency plot of the mean surface particle sizes of three riffles measured within the Yager Creek ATM 005 monitoring reach

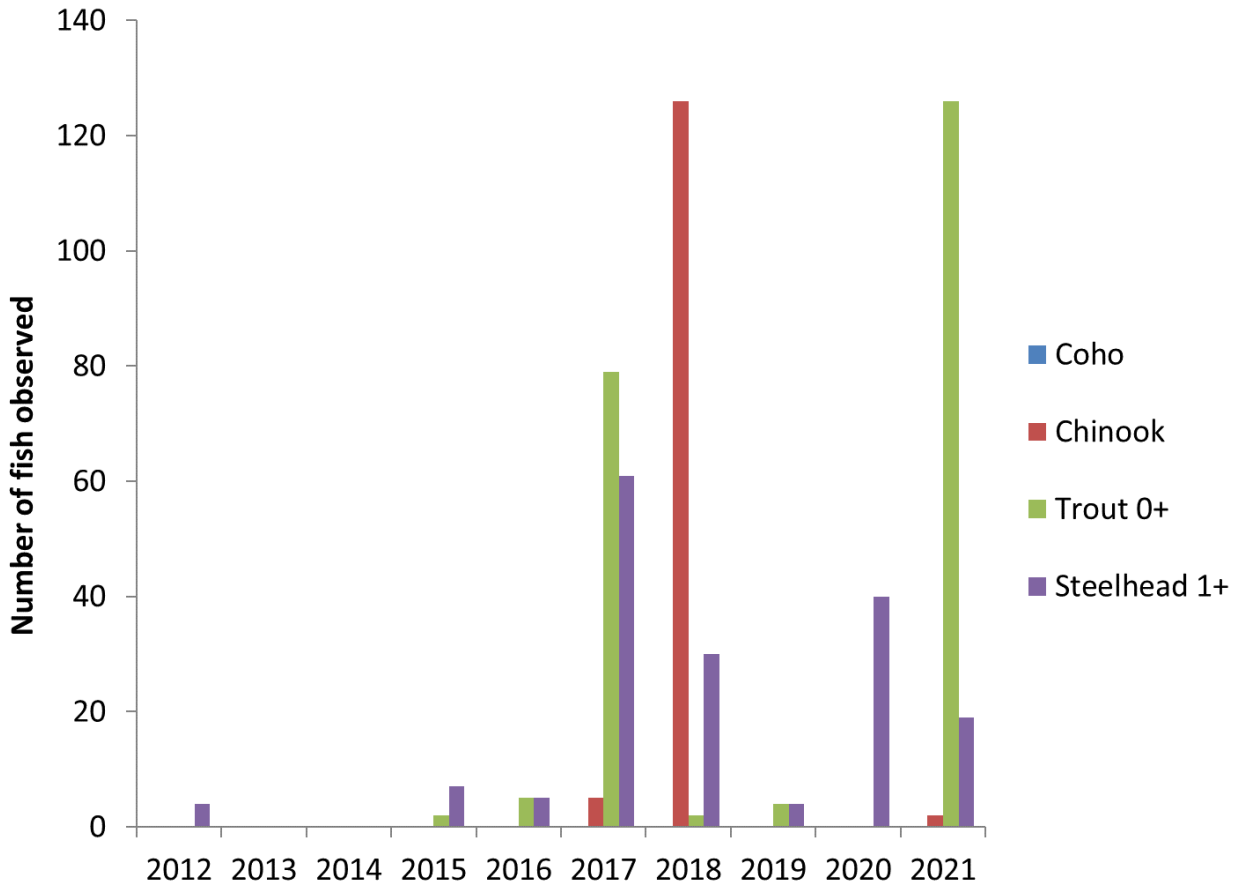

Figure 24. Results of annual snorkel survey fish counts of the first 5 pools within the Yager Creek ATM 005 monitoring reach (2012, 2015-2021)

ATM Site 046 – Yager Creek [Coastal Belt: Yager Terrane (TKy)]

Data for all ATM parameters at site 046 (Figure 14) are summarized in the APFC report card (Table 10). The D_{50} particle size class met the bed surface target for a second straight survey year, as the data suggest relative stability across all size classes (Figure 25). Pool measurements suggest favorable habitat conditions, while only pools associated with wood fell below target in 2021. LWD piece frequency met its target in 2021, as the total number of pieces increased nearly threefold since 2018. Over stream canopy also met the target, as stream temperature exceeded 20℃ for the seventeenth consecutive year.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 1998 (see Appendix). Channel aggradation was observed at 2/5 cross-sections between survey years 2018 and 2021. The greatest degree of channel aggradation occurred at cross-section 1, where channel area decreased -0.83m^2. The greatest degree of channel scour was observed at cross-section 2 where channel area increased +1.55m^2.

A snorkel survey on 9/1/2021 identified juvenile trout of various size classes in all 5 pools sampled. Other observed species include California roach and Sacramento pike minnow (*Ptychocheilus grandis*) (Figure 26).

Table 10. Individual site report card for ATM 046, Yager Creek

Site 046 Yager Creek	Parameter	Target Value (# no target)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bed Surface	D_{84} (mm)	#	122	156		110			105			104			96			108			106
	D_{50} (mm)	65-95	47	69		38			53			40			52			69			68
	D_{16} (mm)	#	11	27		7			20			9			25			39			40
	D_5 (mm)	#	1	7		1			6			2			8			24			22
Pool Characteristics	Pool Area (%)	≥25	58	67		69			80			31			42			60			60
	Pool Spacing (CW/pool)	≤6.0	6.3	5.0		4.3			3.5			3.7			4.2			4.4			4.3
	Residual Pool Depth (m)	≥0.91	1.26	1.16		0.81			0.92			1.37			1.09			1.06			1.08
	Pools Assoc. w/wood (%)	≥50	75	75		0			33			50			57			100			29
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥1.7	2.7	2.4		1.8			1.1			3.1			1.4			1.1			2.8
	Total Piece Count	#							12			48			43			35			90
Water Temperature	MWAT (°C)	≤16.8			21.5	22.0	21.0	21.1	20.7	20.5	20.1	20.1	21.9	20.3	20.2	20.4	21.5	21.1	21.1	20.3	21.3
Riparian Overstory	Canopy Over Stream (%)	≥64	32	45		42			61			40			69			62			85
	Canopy of Rip Forest (%)	≥85	73	87		98						81			86						

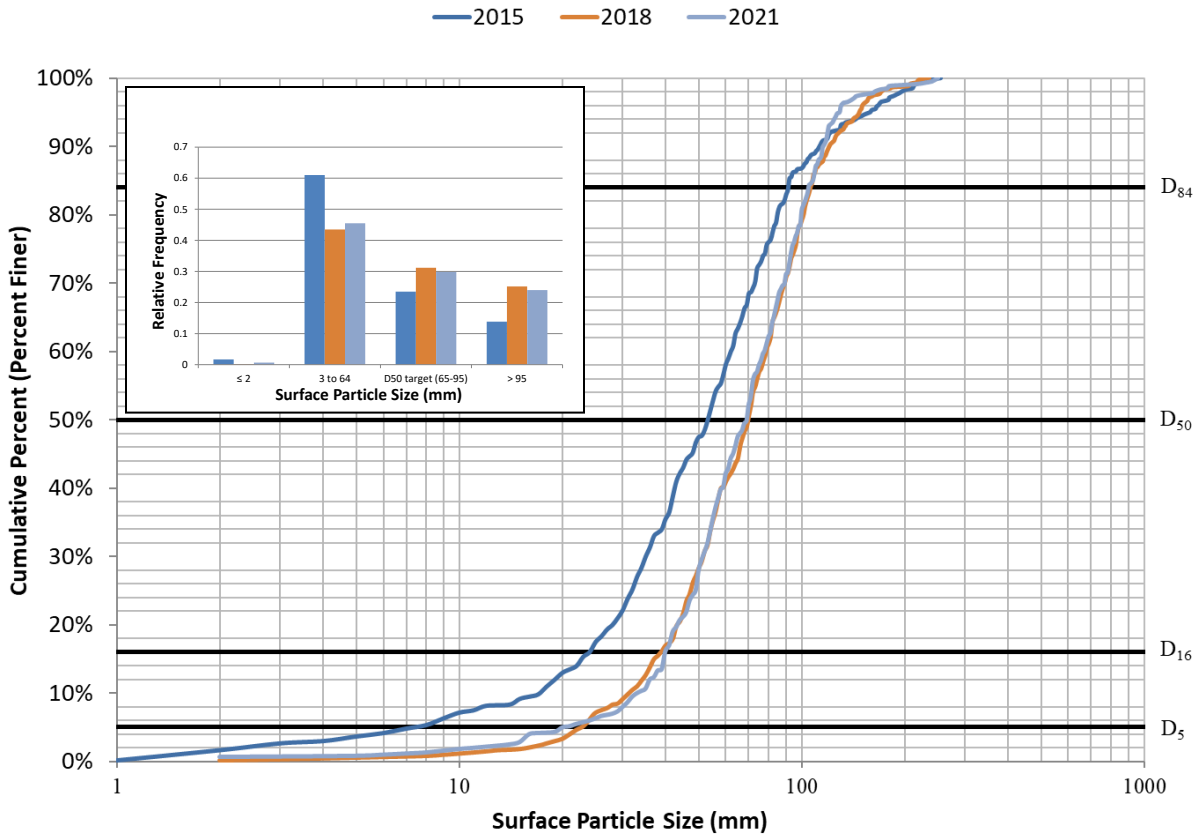

Figure 25. Cumulative frequency plot of the mean surface particle sizes of three riffles measured within the Yager Creek ATM 046 monitoring reach

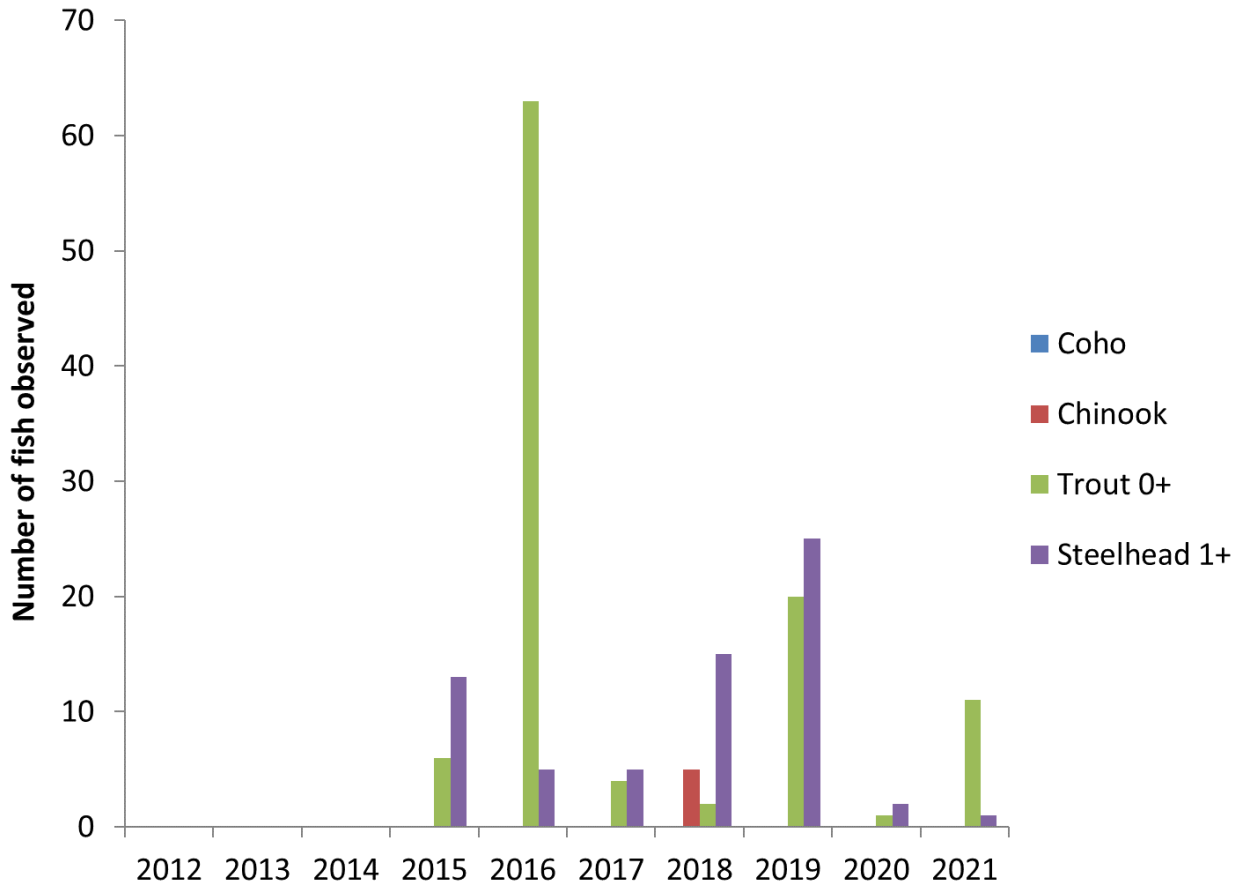

Figure 26. Results of annual snorkel survey fish counts of the first 5 pools within the Yager Creek ATM 046 monitoring reach (2015-2021)

Summary of ATM Trends in the Yager/Lawrence WAU

A summary of Yager/Lawrence habitat characteristics from 2021 are summarized in the APFC report card (Table 11). Results of habitat composite scores from 2021 and 2018 are compared to baseline (2003) data (Figure 27). Overall, the greatest improvements were observed in pool characteristics, LWD piece frequency, and canopy cover. Overall bed surface scores fell in 2021 while stream temperature scores remained stable.

Table 11. The most recent habitat measures for the Yager/Lawrence WAU

Current Status	Parameter	Target Value (# no target)	049 Lawrence Creek	040 Shaw Creek	009 Lawrence Creek	007 Yager Creek	005 Yager Creek	046 Yager Creek
Bed Surface	D_{84} (mm)	#	158	66	150	123	74	106
	D_{50} (mm)	65-95	76	37	80	82	46	68
	D_{16} (mm)	#	29	21	36	50	26	40
	D_{5} (mm)	#	12	13	15	26	13	22
Pool Characteristics	Pool Area (%)	≥25	59	73	73	76	35	60
	Pool Spacing (CW/pool)	≤6.0	5.1	3.2	3.1	4.3	6.1	4.3
	Residual Pool Depth (m)	≥0.91	0.92	0.63	0.81	0.90	2.21	1.08
	Pools Assoc. w/wood (%)	≥50	100	80	100	86	60	29
Large Woody Debris	Total Piece Frequency (#/100 ft)	f(CW)	4.0	7.4	3.7	1.4	0.3	2.8
	Total Piece Count	#	61	57	69	44	8	90
Water Temperature	MWAT (°C)	≤16.8	16.6	15.2	18.1	18.5	21.9	21.3
Riparian Overstory	Canopy Over Stream (%)	f(CW)	96	100	97	54	69	85
	Canopy of Rip Forest (%)	≥85						
Watershed Area	Upstream Acreage	#	18,333	3,430	26,675	44,059	80,623	48,393
Reach Gradient	Reach Gradient (%)	#	1.1	1.3	0.5	0.8	1.0	0.6

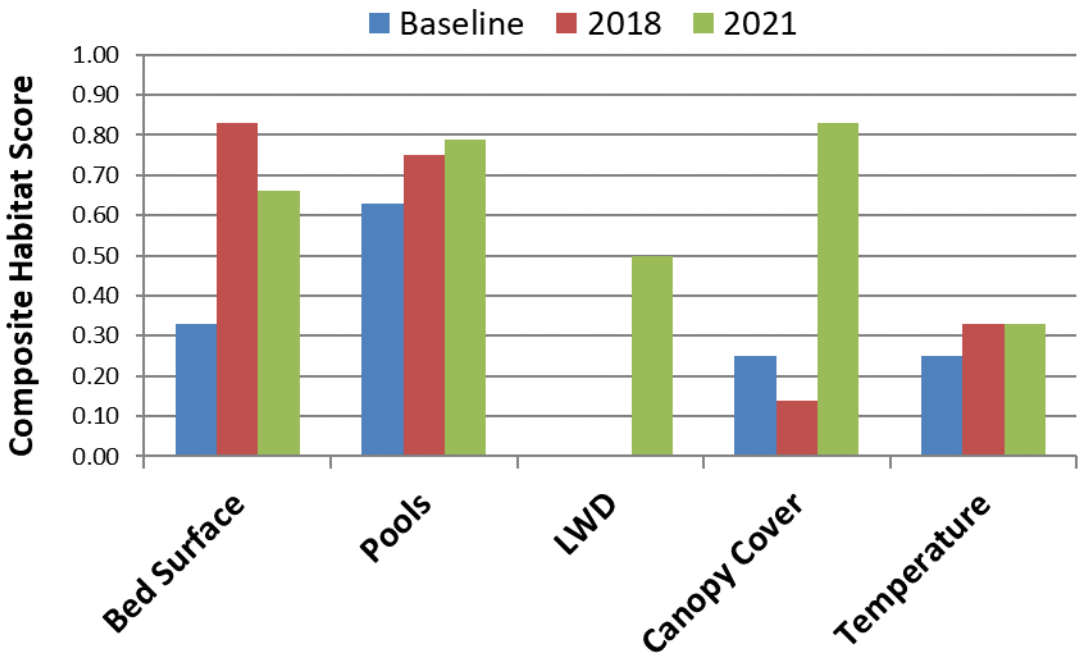

Figure 27. The composite scores for habitat characteristics in the Yager/ Lawrence WAU in 2018 and 2021 relative to baseline (2003) data

MATTOLE RIVER WAU

The Mattole River is located along the northern coast of California within western Humboldt and northern Mendocino Counties and drains an area of 286 square miles (~190,000 acres). Climate is characterized by high intensity rainfall in the winter and dry summers. Annual rainfall averages 60 inches near Petrolia and 115 inches on eastern ridges. The Mattole watershed contains a mixture of dense Douglas-fir forests, deciduous forests (tan oak), and grasslands. The Mattole River WAU encompasses approximately 62,000 acres, of which HRC owns approximately 20%. The WAU is comprised of the major tributary basins: 1) Lower North Fork Mattole River; 2) East Branch North Fork Mattole River and its tributaries (Alwardt and Sulphur Creeks); 3) McGinnis and Pritchard Creek; and 4) Upper North Fork Mattole River that includes Oil Creek and its tributaries and Rattlesnake Creek and its tributaries (Figure 28). Bedrock in the Mattole watershed is dominated by mélange of the Franciscan Coastal rocks that is comprised of pervasively sheared argillite and sandstone (i.e., soft rocks). Due to naturally high erosion rates and the history of logging that severely increased erosion, the EPA in 1994 listed the Mattole River as "impaired" (303d listing).

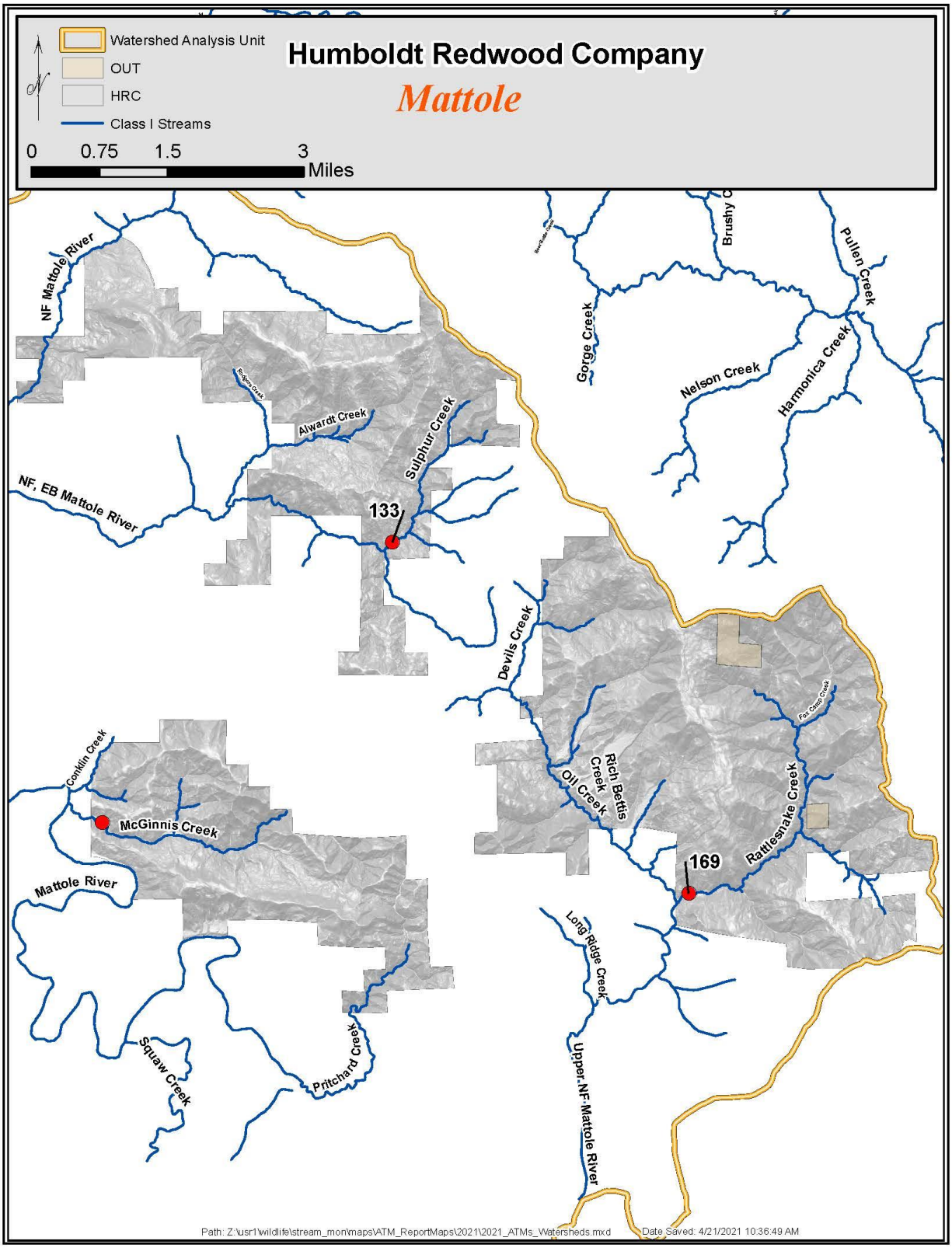

Figure 28. Location map of ATM sites within the Mattole River WAU

ATM 133 Sulphur Creek

ATM 169 Rattlesnake Creek

ATM 219 McGinnis Creek

Figure 29. ATM sites within the Mattole River WAU

ATM 133 - Sulphur Creek [Coastal Belt: Coastal Terrane (TKfs)]

Data for all ATM parameters at site 133 (Figure 29) are summarized in the APFC report card (Table 12). The bed surface D_{50} target was not met in 2021, as the data suggest a fining of the substrate across most particle size classes (Figure 30). Pool characteristics remained stable with 3 of 4 measured parameters meeting their target values. LWD piece counts in 2021 rose slightly but did not meet the target for the eighth consecutive survey year. Canopy cover and stream temperature each met their target values four survey years in a row.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 1998 (see Appendix). Channel scour was observed at 2/5 cross-sections between survey years 2018 and 2021. The greatest degree of channel scour occurred at cross-section 4, where channel area increased $+0.44m^2$. The highest degree of aggradation occurred at cross-section 2, where channel area decreased $-3.1m^2$.

A snorkel survey on 7/9/2021 identified trout of various size classes in all 5 pools sampled (Figure 31).

Table 12. Individual site report card for ATM 133, Sulphur Creek

Site 133 Sulphur Creek	Parameter	Target Value (# no target)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bed Surface	D_{84} (mm)	#	147	131		110			138			144			84			120			111
	D_{50} (mm)	65-95	71	44		38			69			57			42			67			59
	D_{16} (mm)	#	8	13		4			21			10			14			23			21
	D_5 (mm)	#	1	1		1			7			3			3			6			8
Pool Characteristics	Pool Area (%)	≥25	14	17		22			31			17			8			38			31
	Pool Spacing (CW/pool)	<6.0	11.0	8.2		5.5			3.4			5.7			5.0			3.7			3.8
	Residual Pool Depth (m)	≥0.91	0.46	0.49		0.49			0.47			0.47			0.31			0.52			0.68
	Pools Assoc. w/wood (%)	≥50	67	75		67			86			50			17			100			50
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥4.4	4.1	3.8		3.6			3.1			1.7			3.4			1.1			1.8
	Total Piece Count	#							33			18			46			15			25
Water Temperature	MWAT (°C)	≤16.8	19.0	17.9		19.6	16.3	16.5	16.1	15.4	15.4	15.6	16.4	16.2	16.7	16.6	17.2	16.4	15.8	16.7	16.2
Riparian Overstory	Canopy Over Stream (%)	≥87	48	60		18			80			87			95			94			96
	Canopy of Rip Forest (%)	≥85	83	71		86						94									

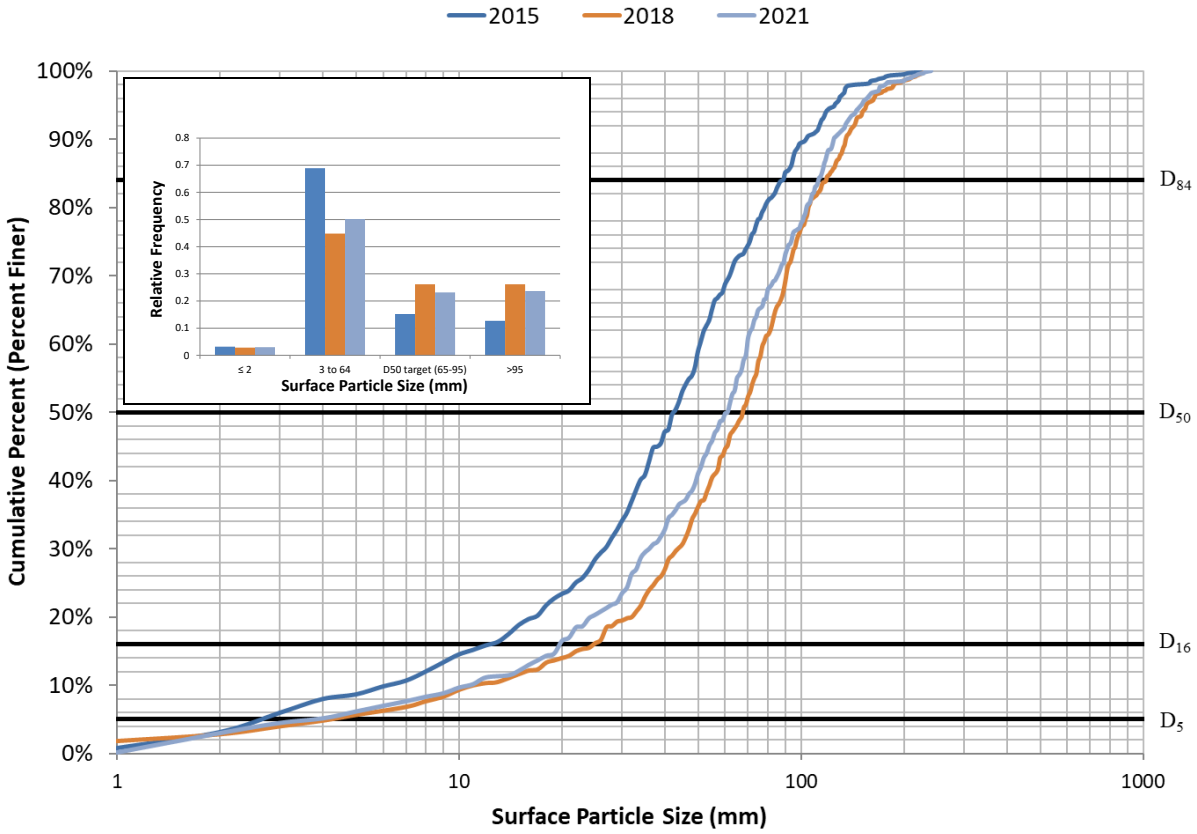

Figure 30. Cumulative frequency plot of the mean surface particle sizes of three riffles measured within the Sulphur Creek ATM 133 monitoring reach

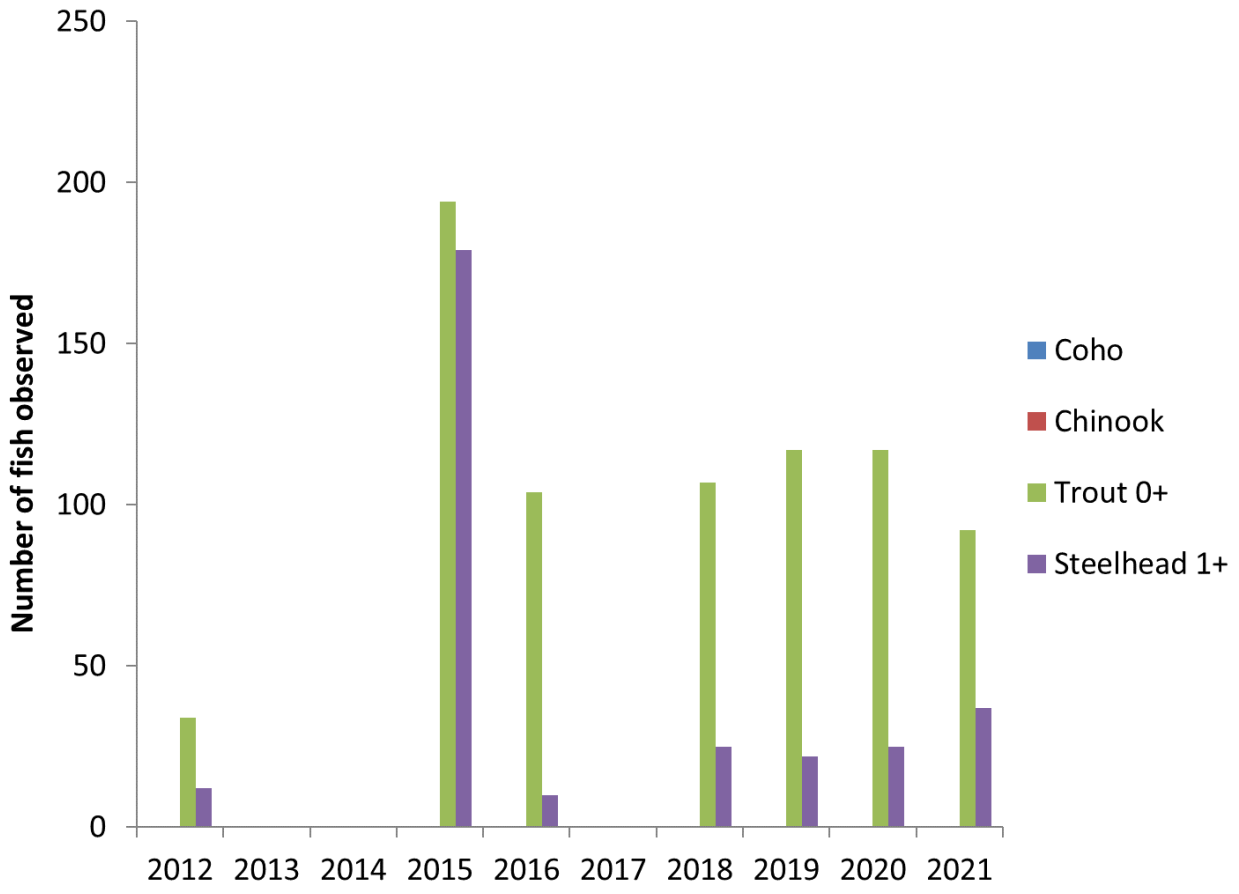

Figure 31. Results of annual snorkel survey fish counts of the first 5 pools within the Sulphur Creek ATM 133 monitoring reach (2012, 2015, 2016, 2018-2021)

ATM 169 – Rattlesnake Creek [Coastal Belt: Coastal Terrane (TKfs)]

Data for all ATM parameters at site 169 (Figure 29) are summarized in the APFC report card (Table 13). The bed surface D_{50} target was not met in 2021, even as the data suggest a coarsening of the substrate across most particle size classes (Figure 32). Pool characteristics suggest a slight decline in habitat conditions in 2021, with only half the parameters meeting the target values. LWD frequency has been historically very low in this reach, with parameters measuring well below target each survey year. Stream temperature continued to place short of the target for the tenth consecutive survey year, despite over stream and riparian canopy cover showing improvements in 2021.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 2004 (see Appendix). Channel scour was observed at 3/5 cross-sections between survey years 2018 and 2021. The greatest degree of channel scour occurred at cross-section 3, where channel area increased $+1.0m^2$. The greatest degree of channel aggradation occurred at cross-section 4 where channel area decreased -1.27. No change in channel area occurred at cross-section 2 between 2018 and 2021.

A snorkel survey was not conducted in 2021 due to excessive animal pollution (Figure 33).

Table 13. Individual site report card for ATM 169, Rattlesnake Creek

Site 169 Upper NF Mattole River	Parameter	Target Value (# no target)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bed Surface	D_{84} (mm)	#	228	177		203			172			257			135			124			121
	D_{50} (mm)	65-95	89	61		58			78			83			64			58			64
	D_{16} (mm)	#	12	10		8			17			10			24			17			30
	D_5 (mm)	#	1	1		1			7			3			9			6			13
Pool Characteristics	Pool Area (%)	≥25	22	33		28			26			22			45			35			31
	Pool Spacing (CW/pool)	<6.0	5.5	3.5		5.7			4.7			5.1			2.3			3.4			4.0
	Residual Pool Depth (m)	≥0.91	0.55	0.55		0.45			0.49			0.54			0.81			0.49			0.61
	Pools Assoc. w/wood (%)	≥50	83	56		0			0			0			39			100			25
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥5.7	1.7	2.8		1.9			0.5			1.1			1.3			0.4			0.8
	Total Piece Count	#	20						5			10			13			4			9
Water Temperature	MWAT (°C)	≤16.8	20.3	20.6		21.7	18.3		18.0	16.3	16.3	16.9	17.8	18.5	18.3	18.0	18.3	17.6	16.9	17.9	17.7
Riparian Overstory	Canopy Over Stream (%)	≥89	13	15		85			57			73			72			91			95
	Canopy of Rip Forest (%)	≥85	17	34		57						68			19			46			62

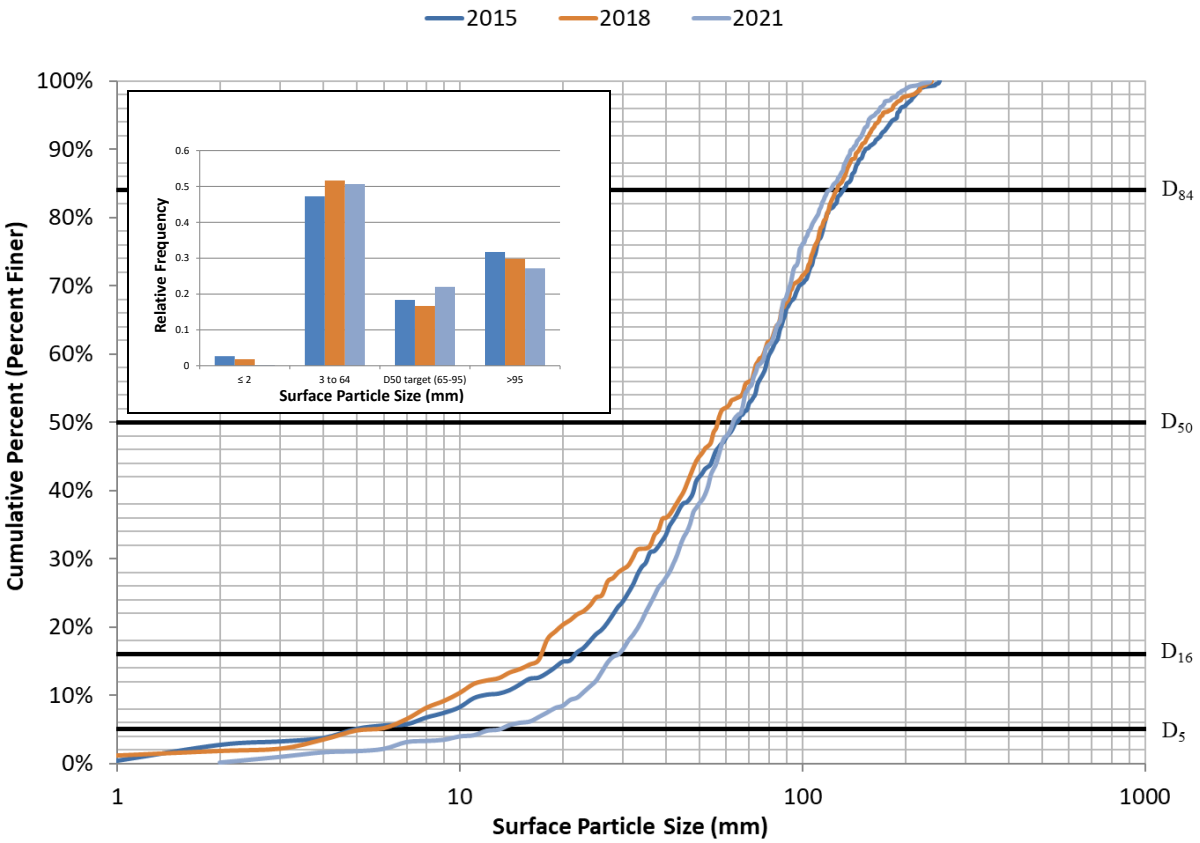

Figure 32. Cumulative frequency plot of the mean surface particle sizes of three riffles measured within the Rattlesnake Creek ATM 169 monitoring reach

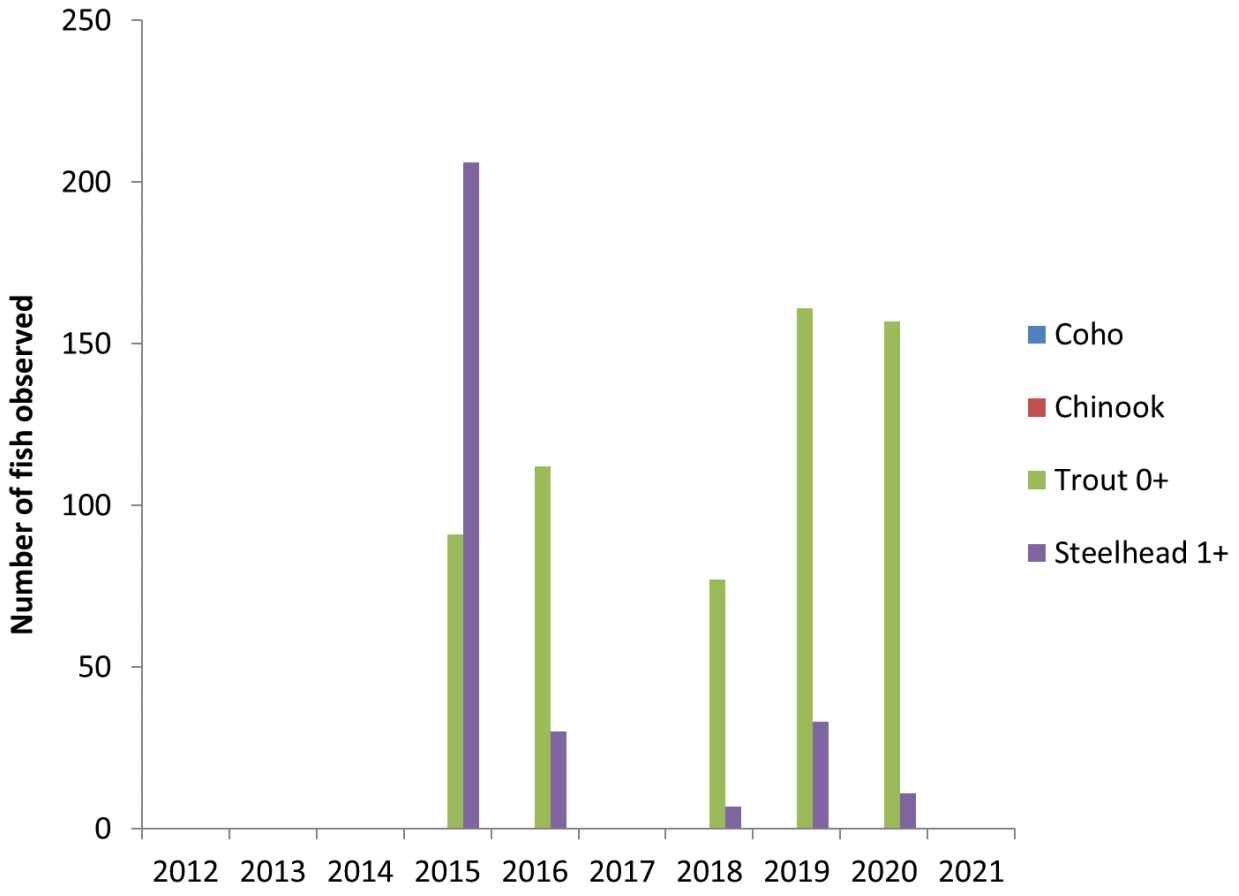

Figure 33. Results of annual snorkel survey fish counts of the first 5 pools within the Rattlesnake Creek ATM 169 monitoring reach (2015, 2016, 2018-2020)

ATM 219 – McGinnis Creek [Undifferentiated Wildcat Group (QTw)]

Data for all ATM parameters at site 219 (Figure 29) are summarized in the APFC report card (Table 14). The bed surface D_{50} target was not met in 2021, as the data suggest a fining of the substrate across all particle size classes (Figure 34). Pool characteristics suggest stability in habitat conditions, with 3 of 4 parameters meeting their target values in 2021. LWD piece frequency met its target in 2021 for the first time on record, nearly tripling the number of pieces that were in the reach during the last survey year. Over stream canopy cover sufficiently met the target, as stream temperature missed the target for the third year in a row.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 2006 (see Appendix). Channel aggradation was observed at 2/5 cross-sections between survey years 2018 and 2021. The greatest degree of channel aggradation occurred at cross-section 1, where channel area decreased -7.21m^2. The greatest degree of channel scour occurred at cross-section 3, where channel area increased +5.88m^2.

A snorkel survey on 7/19/2021 identified trout of various size classes in all 5 pools sampled (Figure 35). Foothill yellow-legged frogs were also observed in the reach.

Table 14. Individual site report card for ATM 219, McGinnis Creek

Site 219 McGinnis Creek	Parameter	Target Value (# no target)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bed Surface	D_{84} (mm)	#				69			101			105			69			113			91
	D_{50} (mm)	65-95				33			47			56			29			74			55
	D_{16} (mm)	#				13			15			22			10			41			28
	D_5 (mm)	#				10			4			7			3			22			16
Pool Characteristics	Pool Area (%)	≥25				28			32			13			15			29			40
	Pool Spacing (CW/pool)	<6.0				4.5			2.9			8.1			4.3			3.8			3.8
	Residual Pool Depth (m)	≥0.91				0.47			0.51			0.68			0.38			0.56			0.57
	Pools Assoc. w/wood (%)	≥50				83			50			33			86			100			100
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥4.58							2.2			4.3			1.8			4.2			11.5
	Total Piece Count	#							23			47			23			56			156
Water Temperature	MWAT (°C)	≤16.8			17.1	19.0	17.9	17.4	16.2	15.2	15.8	15.7	17.9	16.0	16.9	16.2	17.9	16.5	17.6	17.5	17.5
Riparian Overstory	Canopy Over Stream (%)	≥88							95			81			91			95			90
	Canopy of Rip Forest (%)	≥85					78					95									

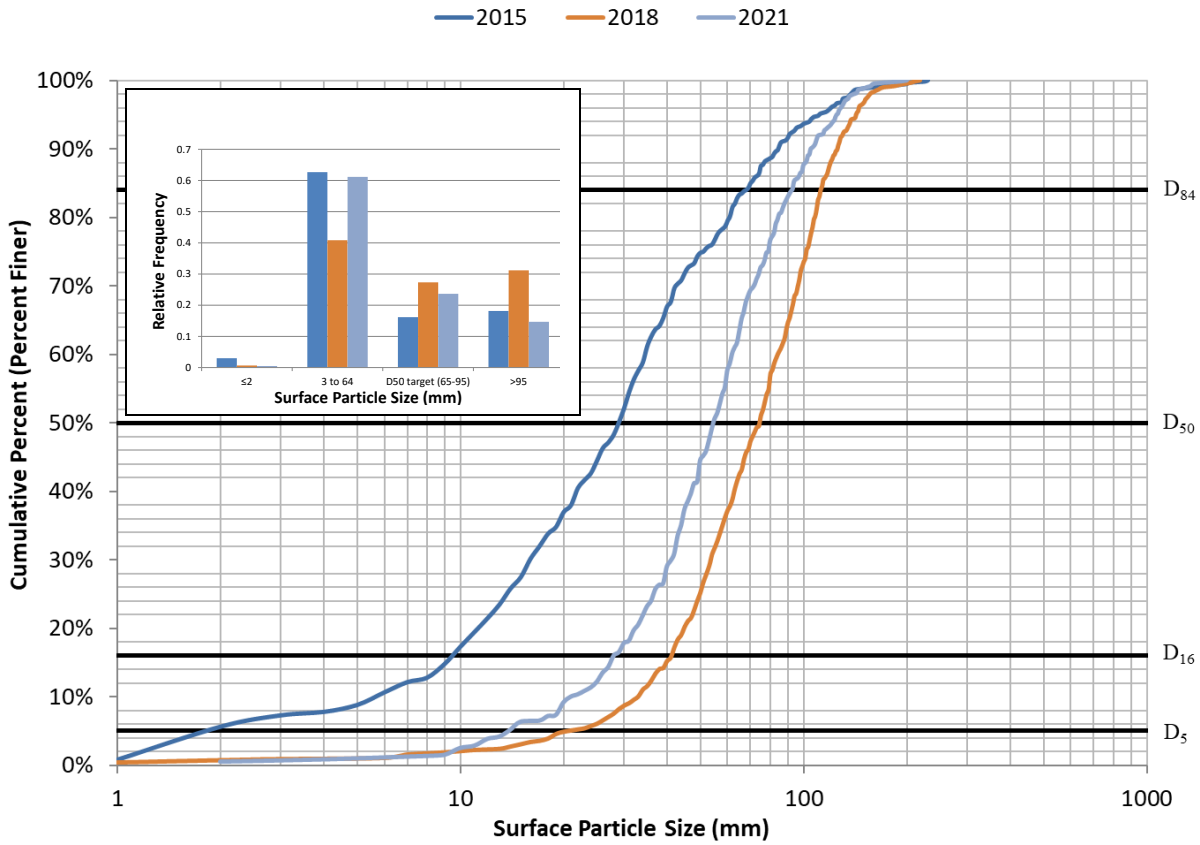

Figure 34. Cumulative frequency plot of the mean surface particle sizes of three riffles measured within the McGinnis Creek ATM 219 monitoring reach

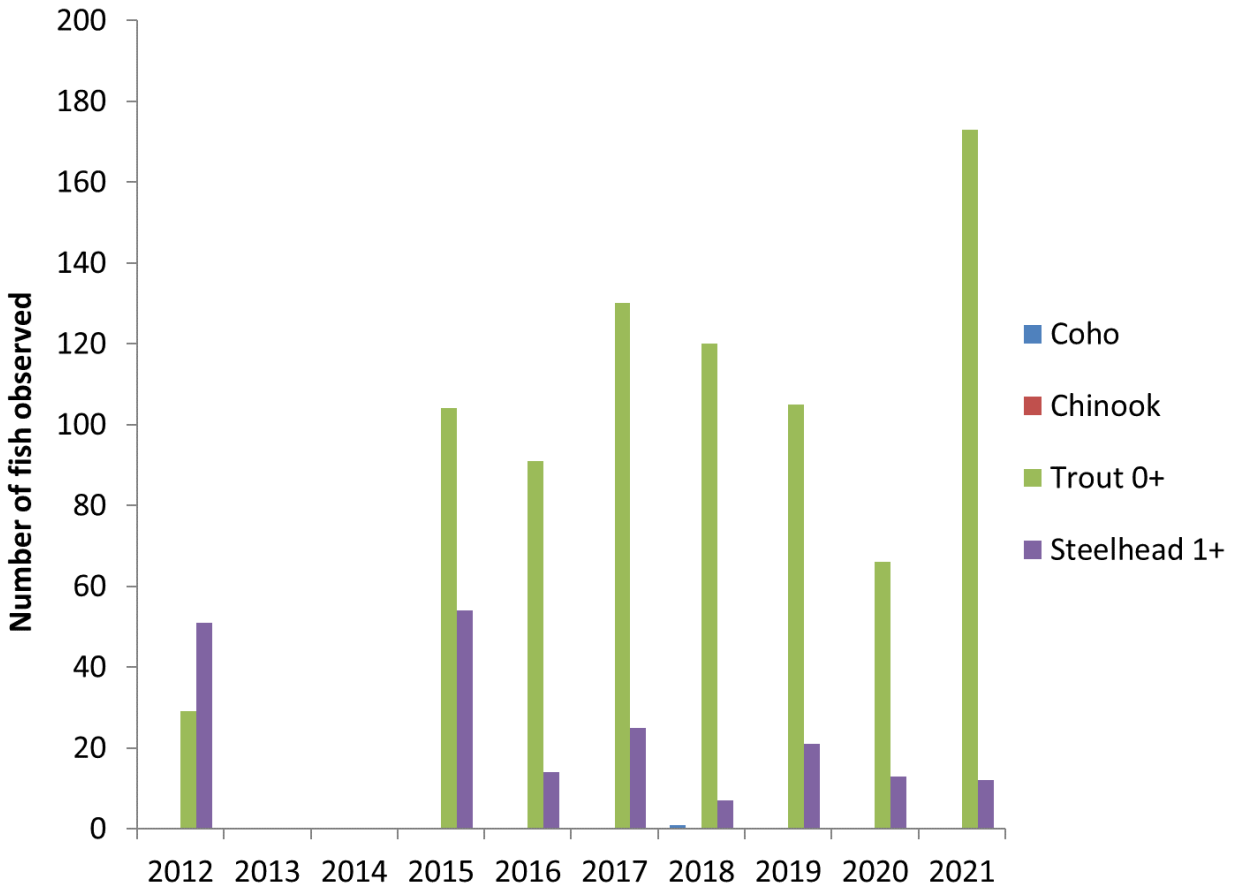

Figure 35. Results of annual snorkel survey fish counts of the first 5 pools within the McGinnis Creek ATM 2019 monitoring reach (2012, 2015-2021)

Summary of ATM Trends in the Mattole River WAU

A summary of the Mattole habitat characteristics from 2021 is provided in the APFC report card (Table 15). Results of habitat composite scores from 2021 and 2018 are compared to baseline (2003) (Figure 36). Overall, the greatest improvements in habitat composite scores were observed in LWD piece frequency and canopy cover. D_{50} substrate particle size showed the greatest overall habitat deficiency, while overall stream temperatures remained stable, although warmer than ideal.

Table 15. The most recent habitat measures for the Mattole River WAU

Current Status	Parameter	Target Value (# no value)	133 Sulphur Creek	169 Rattlesnake Creek	219 McGinnis Creek
Bed Surface	D_{84} (mm)	#	111	121	91
	D_{50} (mm)	65-95	59	64	55
	D_{16} (mm)	#	21	30	28
	D_5 (mm)	#	8	13	16
Pool Characteristics	Pool Area (%)	≥25	31	31	40
	Pool Spacing (CW/pool)	≤6.0	3.8	4.0	3.8
	Residual Pool Depth (m)	≥0.91	0.68	0.61	0.57
	Pools Assoc. w/wood (%)	≥50	50	25	100
Large Woody Debris	Total Piece Frequency (#/100 ft)	f(CW)	1.8	0.8	11.5
	Total Piece Count	#	25	9	156
Water Temperature	MWAT (°C)	≤16.8	16.2	17.7	17.5
Riparian Overstory	Canopy Over Stream (%)	f(CW)	96	95	90
	Canopy of Rip Forest (%)	≥85			
Watershed Area	Upstream Acreage	#	2,451	5,508	3,788
Reach Gradient	Reach Gradient (%)	#	2.1	2.2	1.2

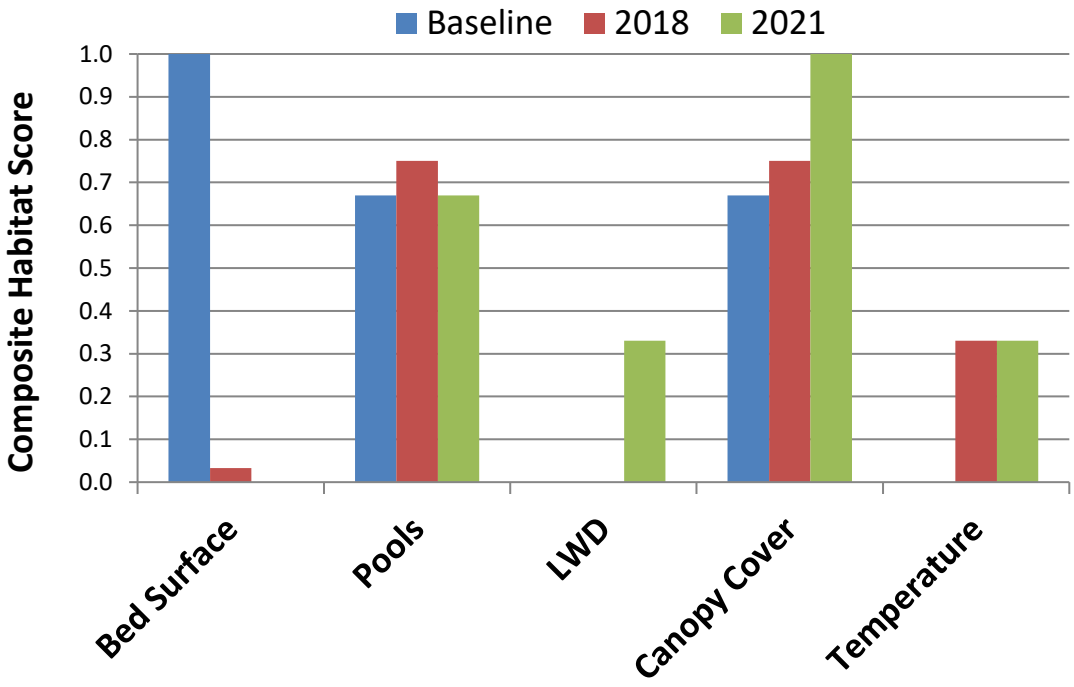

Figure 36. The composite scores for habitat characteristics in the Mattole River WAU in 2018 and 2021 relative to baseline (2003) data

BEAR CREEK – LOWER EEL WAU

HRC ownership encompasses both major and minor Eel River tributaries that span its confluence with the Pacific Ocean to approximately 40 miles south (upstream of the confluence with Devil's Elbow Creek). Within this reach, HRC owns approximately 17% of the total watershed, an area of which is divided into two distinct sections: The Lower and Upper Eel River WAUs. The Lower Eel River WAU includes HRC ownership within tributaries to the Eel River south of the Van Duzen River to Perrott Creek and encompasses both Jordan and Bear Creek (Figure 37). This WAU also includes a region termed the Eel River Delta which encompasses several tributaries that drain into the Eel River nearer to its confluence with the Pacific Ocean. Sediments within Bear Creek are derived primarily from the Coastal Belt of the Franciscan Complex with a small segment of the lower portion of the watershed (near the confluence with the Eel River) underlain by the Wildcat Group.

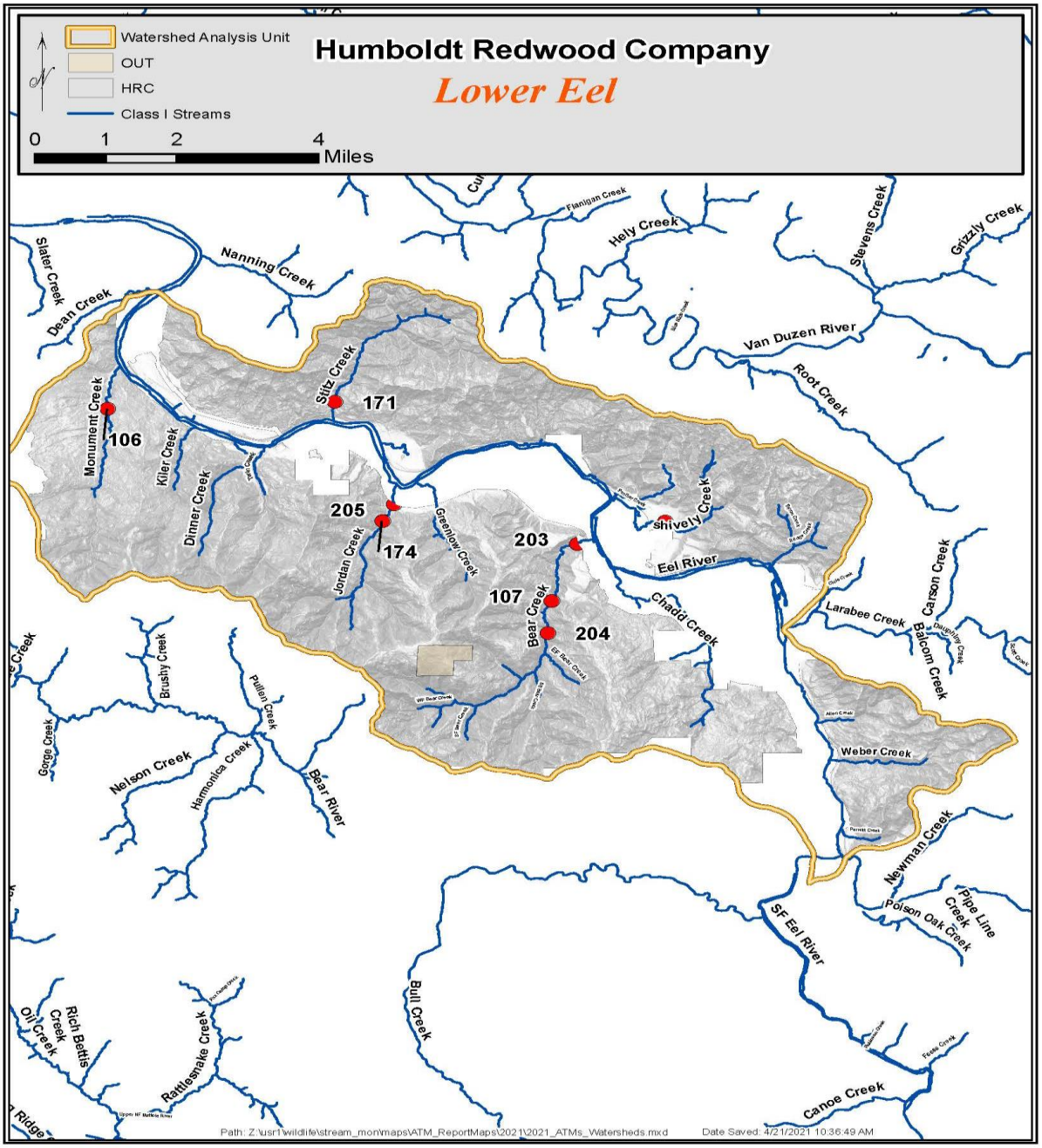

Figure 37. Location map of ATM sites within the Bear Creek/Lower Eel WAU

ATM 204 Bear Creek

ATM 203 Bear Creek

ATM 107 Bear Creek

Figure 38. ATM sites within the Bear Creek/Lower Eel WAU

ATM Site 203 – Lower Bear Creek [Alluvium (Qal) underlain by Undifferentiated Wildcat Group (Qtw)]

Data for all ATM parameters at site 203 (Figure 38) are summarized in the APFC report card (Table 16). The bed surface D_{50} target was not met in 2021, as the data suggest a fining of the substrate across most particle size classes (Figure 39). Pool characteristics suggest stable habitat conditions, with 3 of 4 parameters meeting the target values. LWD piece frequency met the target in 2021, after briefly placing short of it in 2020. Over stream canopy cover met its target in 2021, while stream temperature met the target for the first time since 2016.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 2004 (see Appendix). Channel aggradation was observed at 3/5 cross-sections between survey years 2018 and 2021. The greatest degree of channel aggradation occurred at cross-section 1, where channel area decreased -1.48m^2. The greatest degree of channel scour occurred at cross-section 5, where channel area increased +0.68m^2.

A snorkel survey on 6/29/2021 identified trout of various size classes in all 5 pools sampled, and juvenile coho salmon in 2 of the 5 pools (Figure 40). Also observed in the reach were rough-skinned newts.

Table 16. Individual site report card for ATM 203, Lower Bear Creek

Site 203 Bear Creek	**Parameter**	**Target Value** (# no target)	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Bed Surface	D_{84} (mm)	#	66	88	98	98	114	110	94	126	93	77	83	45	110	94	110	108	109	111
	D_{50} (mm)	65-95	30	38	28	42	46	56	39	68	65	31	33	19	66	48	66	66	65	58
	D_{16} (mm)	#	12	8	2	6	4	20	12	25	9	6	7	6	38	14	40	29	33	28
	D_5 (mm)	#	8	1	1	1	1	4	3	4	2	1	2	2	19	2	27	12	14	9
Pool Characteristics	Pool Area (%)	≥25	22	61	32	32	26	35	47	37	26	11	13	17	32	30	25	40	34	39
	Pool Spacing (CW/pool)	≤6.0	5.0	5.5	3.3	2.6	4.8	3.2	2.6	4.1	3.9	7.3	7.5	3.3	3.0	2.7	3.1	1.9	2.4	1.9
	Residual Pool Depth (m)	≥0.91	0.42	0.61	0.60	0.57	0.67	0.57	0.49	0.52	0.62	0.53	0.60	0.42	0.55	0.61	0.56	0.52	0.54	0.55
	Pools Assoc. w/wood (%)	≥50	100	100	100	100	100	100	85	88	100	100	100	100	100	82	100	100	100	94
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥5.1	12.9	12.7	6.2	6.3	5.6	7.3	4.7	4.7	8.6	7.4	7.1	8.1	11.3	6.8	6.4	5.8	4.44	9.9
	Total Piece Count	#	148	145	71	72	65	87	57	46	70	85	112	128	178	108	102	92	70	156
Water Temperature	MWAT (°C)	≤16.8		17.9	19.5	18.7	18.1	17.9	15.9	15.5	15.5	17.2	17.2	17.7	16.8	17.6	17.1	17.1	18.4	16.6
Riparian Overstory	Canopy Over Stream (%)	≥90	24	38	35	26	57	40	97	80	77	83	83	70	87	85	79	83	91	93
	Canopy of Rip Forest (%)	≥85	90	96	97	85				96	99	96	91							

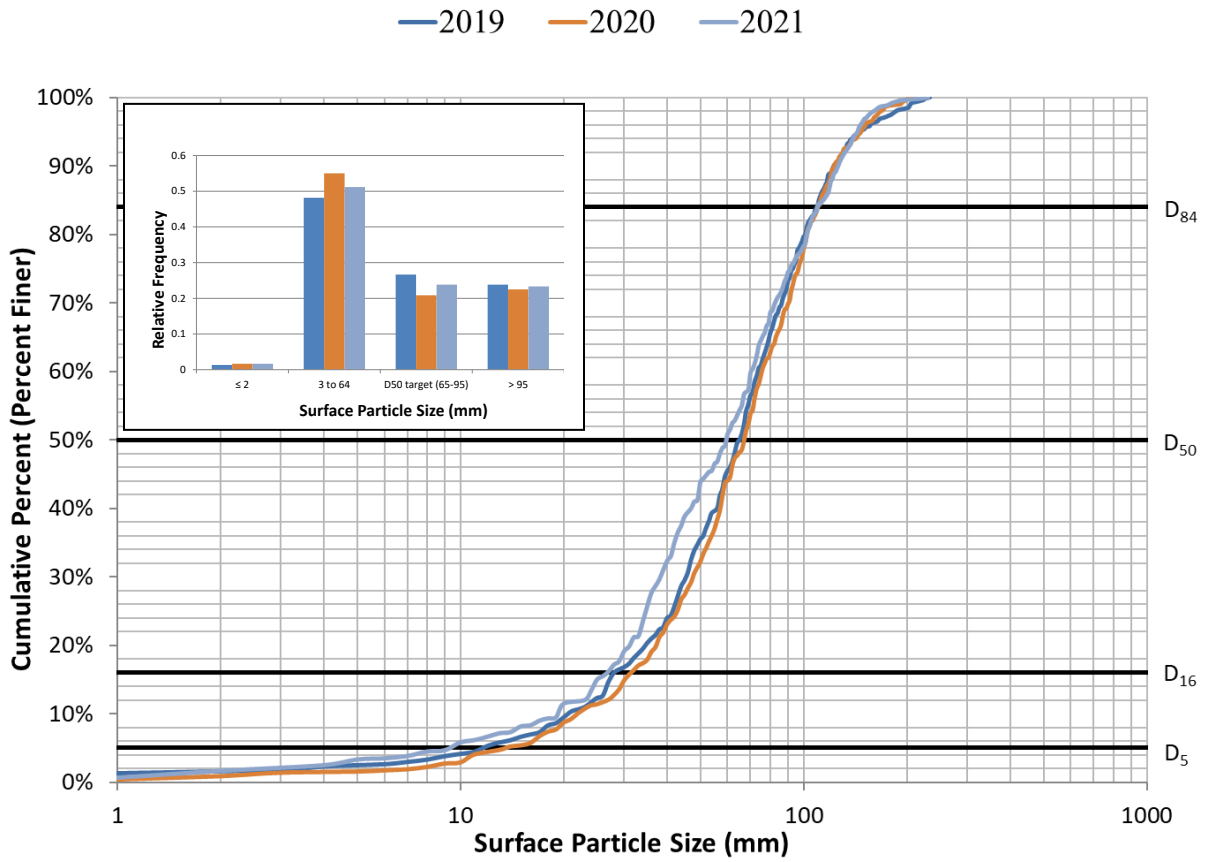

Figure 39. Cumulative frequency plot of the mean surface particle sizes of three riffles measured within the Bear Creek ATM 203 monitoring reach

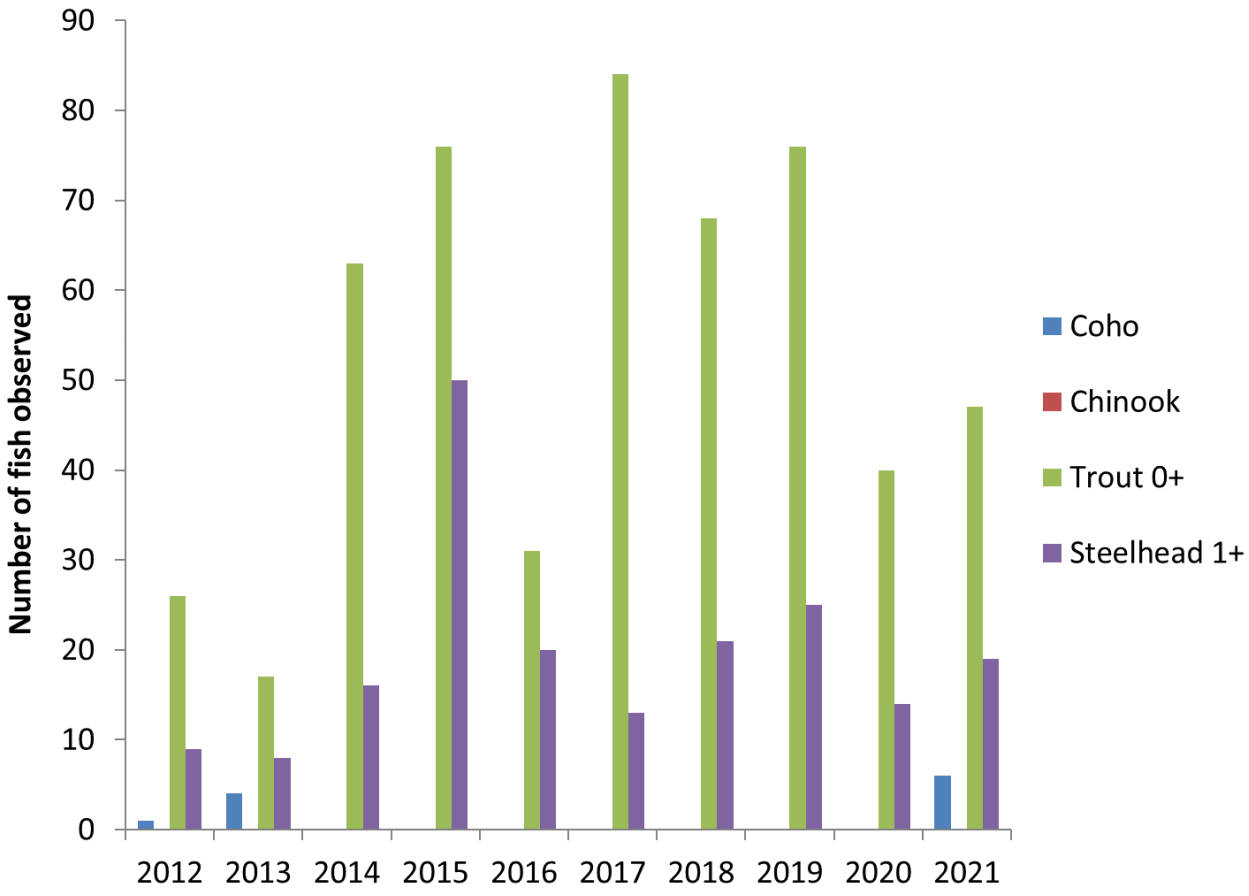

Figure 40. Results of annual snorkel survey fish counts of the first 5 pools within the Bear Creek ATM 203 monitoring reach (2012-2021)

ATM Site 107 – Middle Bear Creek [Coastal Belt: Coastal Terrane (TKfs)]

Data for all ATM parameters at site 107 (Figure 38) are summarized in the APFC report card (Table 17). The bed surface D_{50} target was not met in 2021, as the data suggest a fining of the substrate within the two larger particle size classes (Figure 41). Pool characteristics suggest stable habitat conditions, with 3 of 4 parameters meeting the target values. LWD piece frequency met the target in 2021, as total pieces within the reach increased substantially. Over stream canopy cover met the target in 2021, as did stream temperature for the fourth year in a row.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 1998 (see Appendix). Channel aggradation was observed at 3/6 cross-sections between survey years 2018 and 2021. The greatest degree of channel aggradation occurred at cross-section 3, where channel area decreased -2.07m^2. The greatest degree of channel scour occurred at cross-section 6, where channel area increased +1.12m^2.

A snorkel survey 8/31/2021 identified trout of various size classes in all 5 pools sampled (Figure 42).

Table 17. Individual site report card for ATM 107, Mid-Bear Creek

Site 107 Bear Creek	**Parameter**	**Target Value** (# no target)	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Bed Surface	D_{84} (mm)	#	113	110	100	110	109	160	129	124	154	131	116	104	79	116	123	127	116	130	115
	D_{50} (mm)	65-95	46	44	42	30	36	67	62	57	69	37	43	43	34	68	66	73	66	68	63
	D_{16} (mm)	#	9	10	8	3	7	14	22	19	16	5	11	7	10	36	24	37	28	27	35
	D_{5} (mm)	#	1	1	1	1	1	1	5	3	2	1	2	2	3	14	7	20	11	11	18
Pool Characteristics	Pool Area (%)	≥25	9	23	50	19	14	22	16	20	25	45	19	27	7	28	29	28	35	43	44
	Pool Spacing (CW/pool)	≤6.0	11.3	3.8	7.9	4.1	4.4	4.6	5.1	4.5	4.9	2.6	7.4	4.3	10	3.4	3.4	3.0	2.7	2.2	2.3
	Residual Pool Depth (m)	≥0.91	0.72	0.54	0.50	0.52	0.45	0.48	0.45	0.33	0.61	0.56	0.56	0.45	0.39	0.42	0.63	0.61	0.51	0.49	0.59
	Pools Assoc. w/wood (%)	≥50	100	100	100	100	100	100	100	100	100	89	67	86	100	100	89	100	100	100	85
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥5.1	9.2	15.2	12.8	6.7	8.5	3.2	7.1	11.3	15.1	8.9	6.1	5.9	3.9	9.2	7.7	7.5	7.1	4.36	6.2
	Total Piece Count	#	129	213	179	94	119	76	75	115	49	95	85	83	55	129	122	106	99	61	88
Water Temperature	MWAT (°C)	≤16.8	18.7	19.6	17.5	18.8	18.0	17.9	17.3	15.2	15.1	14.8	16.6	16.8		16.2	16.9	16.1	16.1	16.3	16.1
Riparian Overstory	Canopy Over Stream (%)	≥90	31	42	31	26	28	56	53	97	90	83	79	77	54	78	88	65	76	91	97
	Canopy of Rip Forest (%)	≥85	73	86	90	73	81				98	99	90	89							

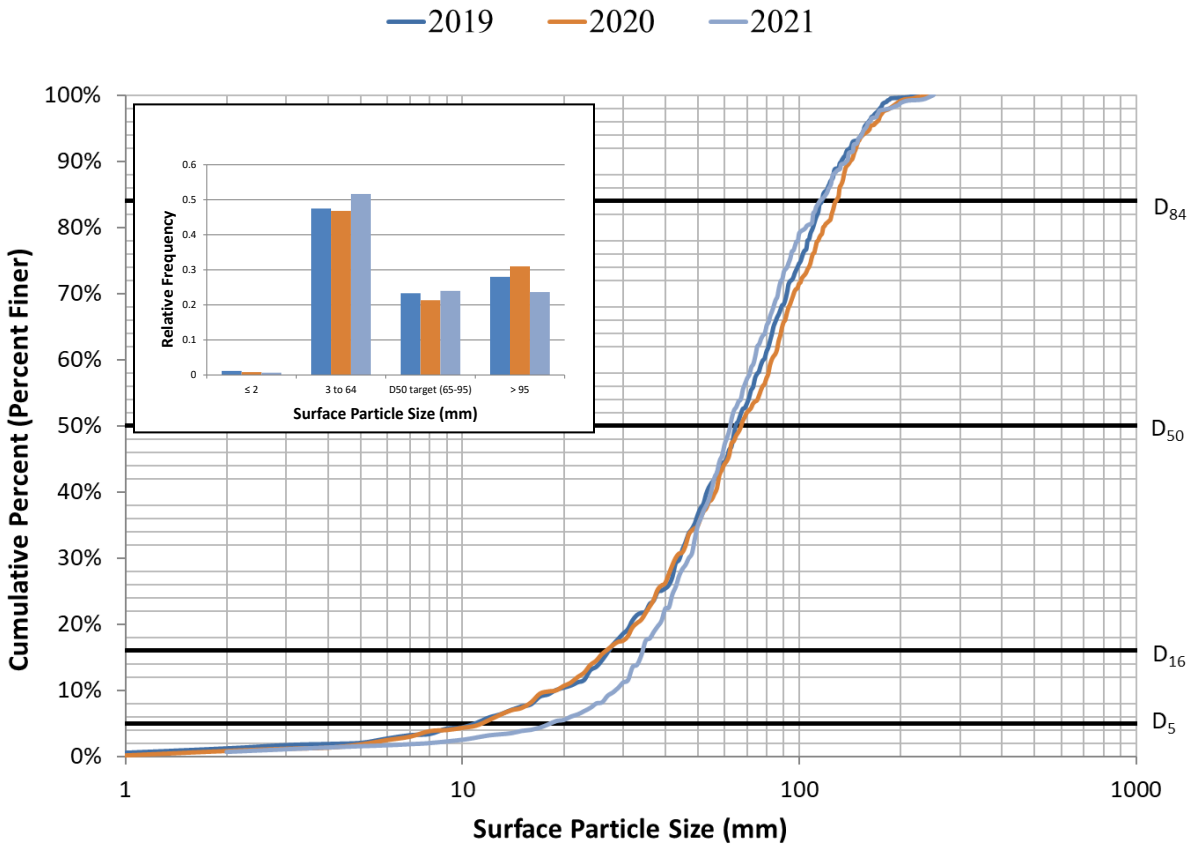

Figure 41. Cumulative frequency plot of the mean surface particle sizes of three riffles measured at the Bear Creek ATM 107 monitoring reach

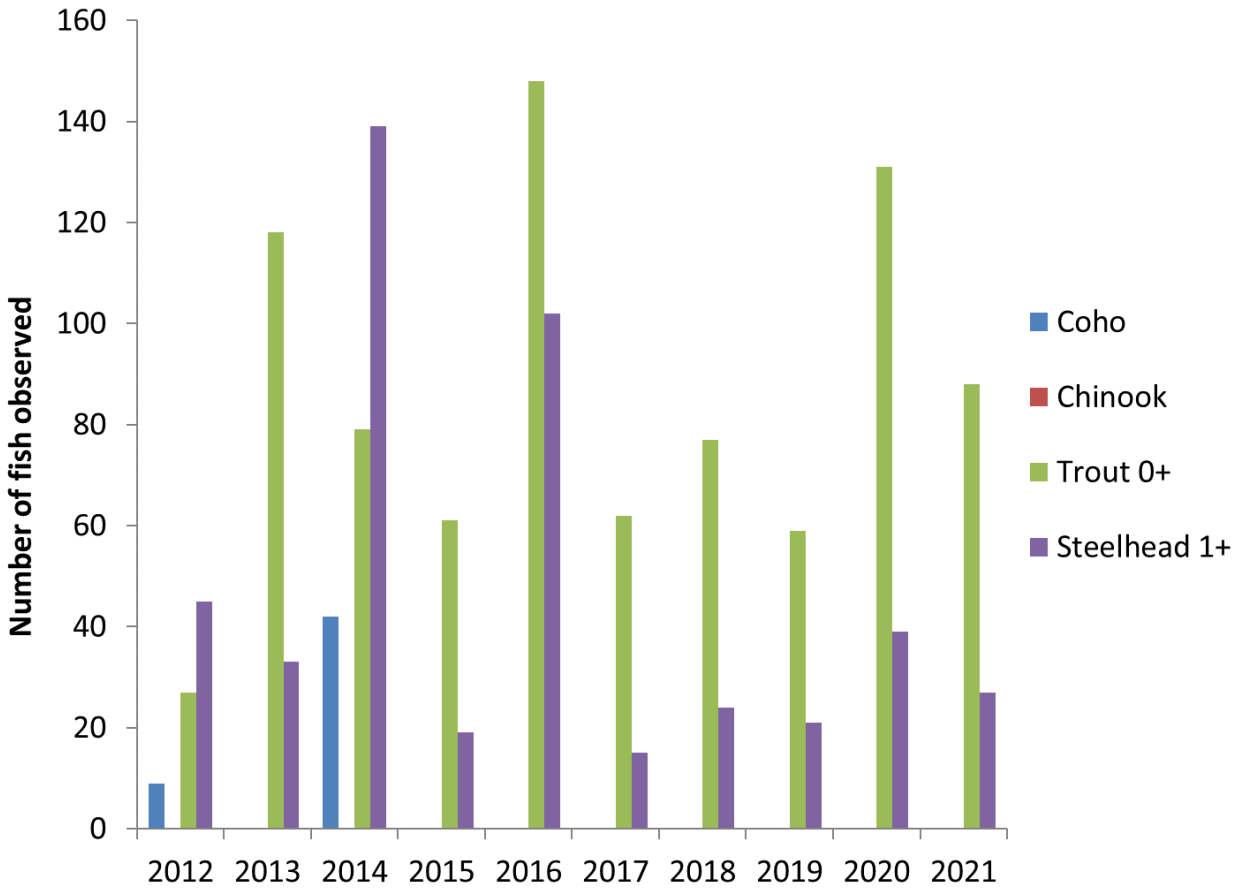

Figure 42. Results of annual snorkel survey fish counts of the first 5 pools within the Bear Creek ATM 107 monitoring reach (2012-2021)

ATM Site 204 – Mid-Upper Bear Creek [Coastal Belt: Coastal Terrane (TKfs)]

Data for all ATM parameters at site 204 (Figure 38) are summarized in the APFC report card (Table 18). The bed surface D_{50} target was not met in 2021, as the data suggest a fining of the substrate within the two larger particle size classes (Figure 43). Pool characteristics suggest stable habitat conditions, with 3 of 4 parameters meeting their targets. LWD piece frequency met the target for the seventh consecutive year. Over stream canopy cover met its target for the second straight year, as stream temperature also met the target for the sixth year in a row.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 2004 (see Appendix). Channel aggradation was observed at 2/5 cross-sections between survey years 2018 and 2021. The greatest degree of channel aggradation occurred at cross-section 2, where channel area decreased -0.38m^2. The greatest degree of channel scour occurred at cross-section 4, where channel area increased +1.73m^2.

A snorkel survey on 8/31/2021 identified juvenile coho salmon and trout of various size classes in all 5 pools sampled (Figure 44).

Table 18. Individual site report card for ATM 204, Mid-Upper Bear Creek

Site 204 Bear Creek	**Parameter**	**Target Value** (# no target)	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Bed Surface	D_{84} (mm)	#	118	135	108	143	161	133	128	170	173	123	120	101	116	142	142	115	117	97
	D_{50} (mm)	65-95	37	51	24	53	54	62	51	76	64	52	47	45	69	66	80	67	61	60
	D_{16} (mm)	#	4	14	2	8	7	17	13	28	14	15	11	11	35	15	32	35	25	33
	D_5 (mm)	#	1	1	1	3	1	5	4	11	3	1	2	3	16	5	14	11	10	13
Pool Characteristics	Pool Area (%)	≥25	23	39	21	38	22	16	28	38	27	21	36	14	28	31	28	34	34	30
	Pool Spacing (CW/pool)	≤6.0	7.7	9.9	3.1	2.7	6.7	5.1	10.8	4.4	3.9	4.1	3.8	4.9	3.8	3.0	3.1	3.4	2.7	3.9
	Residual Pool Depth (m)	≥0.91	0.39	0.39	0.67	0.70	0.66	0.45	0.47	0.61	0.62	0.61	0.58	0.44	0.53	0.49	0.46	0.54	0.49	0.55
	Pools Assoc. w/wood (%)	≥50	100	100	100	100	100	100	83	100	83	86	75	67	88	80	100	100	100	100
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥4.4	7.6	11.4	10.9	9.0	3.4	7.1	9.4	3.3	5.8	6.5	3.5	5.6	12.1	5.3	5.4	8.1	4.8	6.2
	Total Piece Count	#	105	158	151	124	71	62	130	33	63	85	49	78	170	74	77	113	66	89
Water Temperature	MWAT (°C)	≤16.8						17.3							15.1	16.3	15.2	15.5	15.6	15.4
Riparian Overstory	Canopy Over Stream (%)	≥90	7	10	34	11	23	53	73	79	51	75	63	64	85	90	79	80	93	96
	Canopy of Rip Forest (%)	≥85	79	77	90	85				96	93	94	90	96						

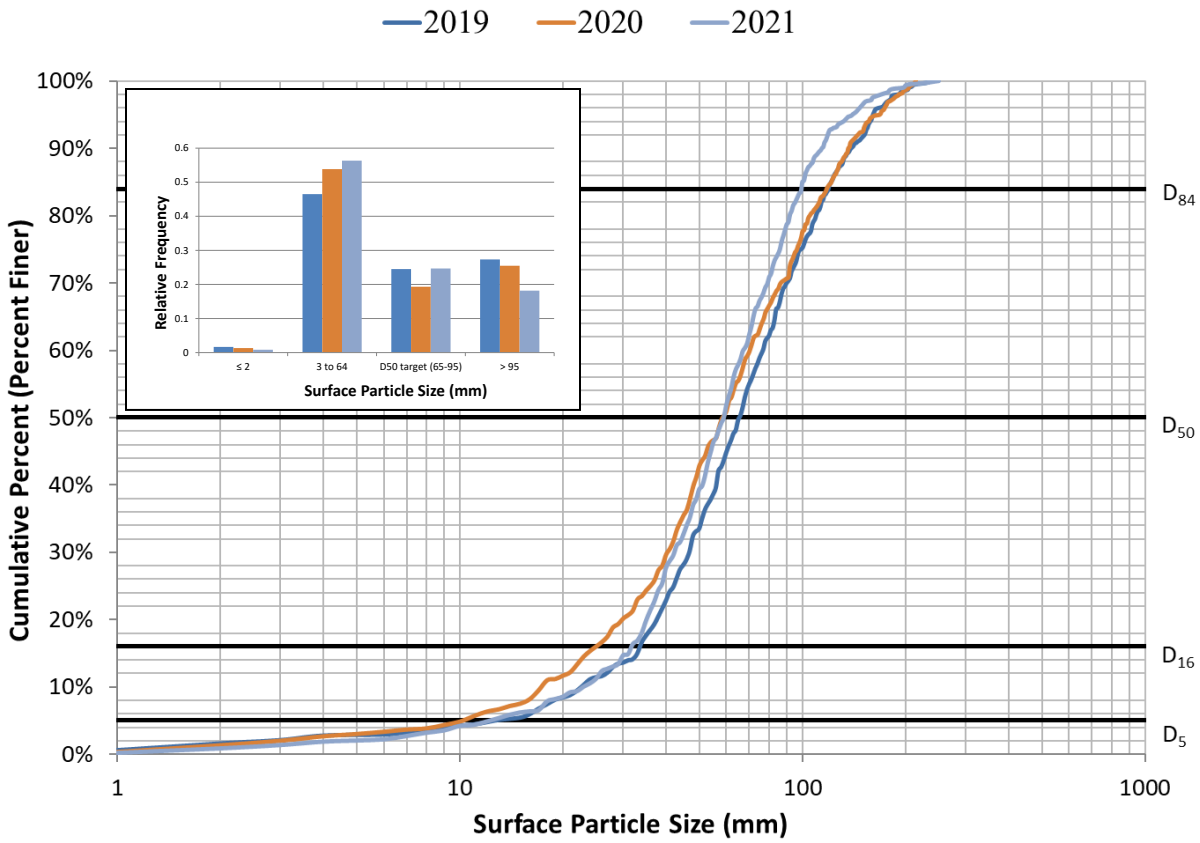

Figure 43. Cumulative frequency plot of the mean surface particle sizes of three riffles measured at the Bear Creek ATM 204 monitoring reach

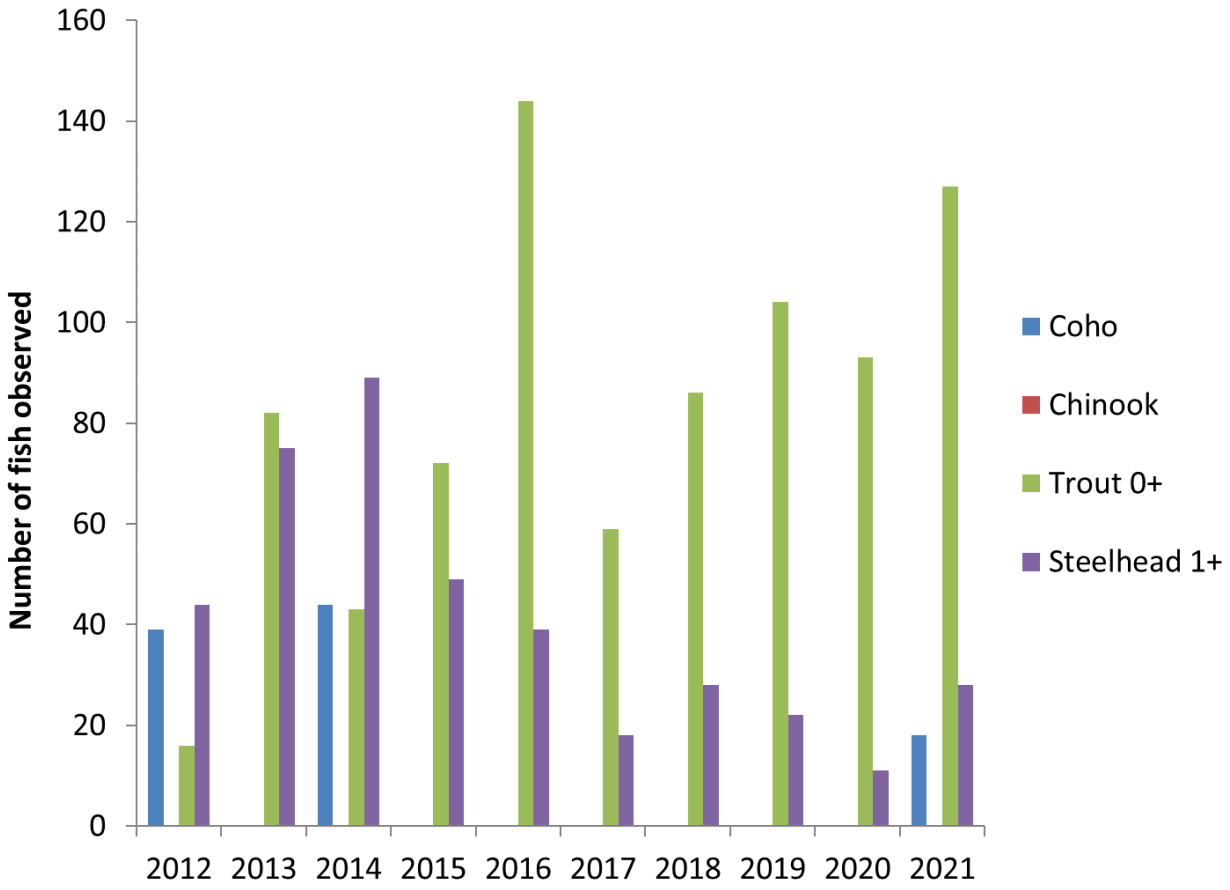

Figure 44. Results of annual snorkel survey fish counts of the first 5 pools within the Bear Creek ATM 204 monitoring reach (2012-2021)

Summary of ATM Trends for Bear Creek in the Lower Eel WAU

A summary of the Bear Creek habitat characteristics from 2021 is provided in the APFC report card (Table 19). Results of habitat composite scores from 2020 and 2021 are compared to baseline (2004) data (Figure 45). Overall, the greatest improvements were made in LWD piece frequency and stream temperature. Bed surface D_{50} results suggest a decline in substrate size within the watershed. Pool characteristics and over stream canopy cover remained the most stable parameters in 2021.

Table 19. The most recent habitat measures for Bear Creek in the Lower Eel WAU

Current Status	Parameter	Target Value (# no target)	203 Lower Bear Cr	107 Mid-Bear Cr	204 Mid-Upper Bear Cr
Bed Surface	D_{84} (mm)	#	111	115	97
	D_{50} (mm)	65-95	58	63	60
	D_{16} (mm)	#	28	35	33
	D_5 (mm)	#	9	18	13
Pool Characteristics	Pool Area (%)	≥25	39	44	30
	Pool Spacing (CW/pool)	≤6.0	1.9	2.3	3.9
	Residual Pool Depth (m)	≥0.91	0.55	0.59	0.55
	Pools Assoc. w/wood (%)	≥50	94	85	100
Large Woody Debris	Total Piece Frequency (#/100 ft)	f(CW)	9.9	6.2	6.2
	Total Piece Count	#	156	88	89
Water Temperature	MWAT (°C)	≤16.8	16.6	16.1	15.4
Riparian Overstory	Canopy Over Stream (%)	f(CW)	93	97	96
	Canopy of Rip Forest (%)	≥85			
Watershed Area	Upstream Acreage	#	5,449	5,026	4,302
Reach Gradient	Reach Gradient (%)	#	1.6	1.8	3.8

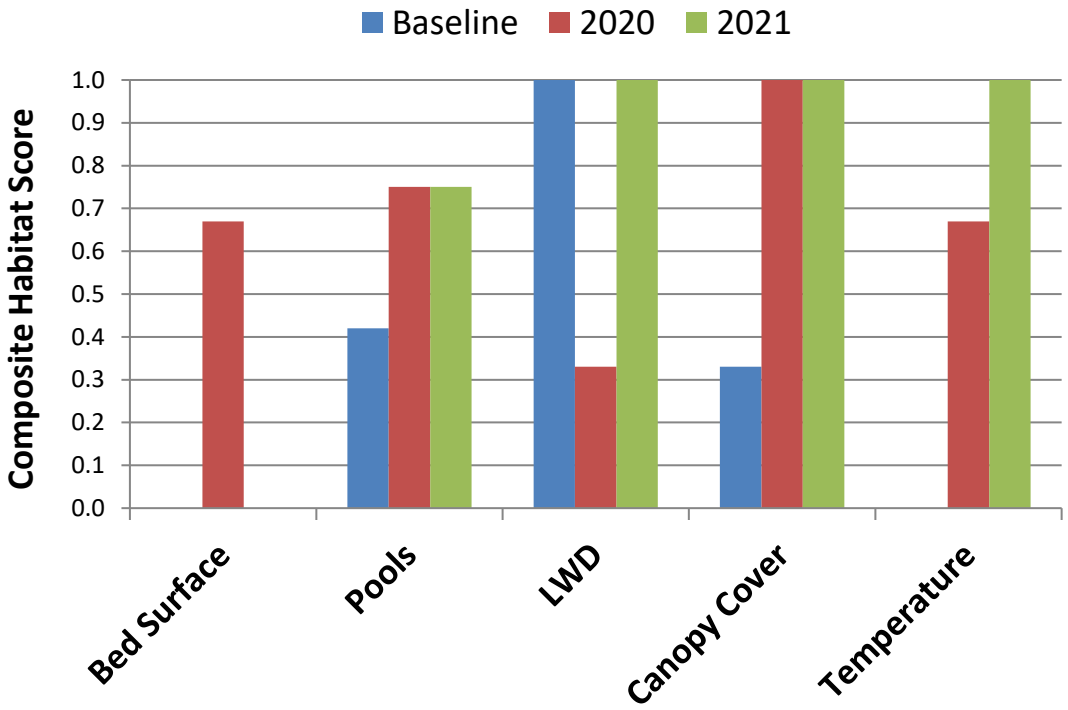

Figure 45. The composite scores for habitat characteristics in the Lower Eel WAU in 2020 and 2021 relative to baseline (2004) data

BEAR RIVER WAU

HRC ownership is based primarily in the upper portion of the Bear River watershed (ownership = 16,537 acres, 31% of total basin) between the headwaters and the confluence with Peaked Creek. Major tributaries within HRC property include Harmonica Creek, Pullen Creek, Nelson Creek, Brushy Creek, Gorge Creek, and Beer Bottle Creek (Figure 46).

The Bear River watershed lies in a tectonically active region of the coast range characterized by very steep terrain and deeply incised drainage basins. Tectonic uplift has caused rapid incision of the Bear River system resulting in steep hillslopes and deep canyons. Steep slopes composed of sheared bedrock materials, which are often prone to landslides, in combination with high rainfall and intense seismic activity results in high rates of natural sediment production.

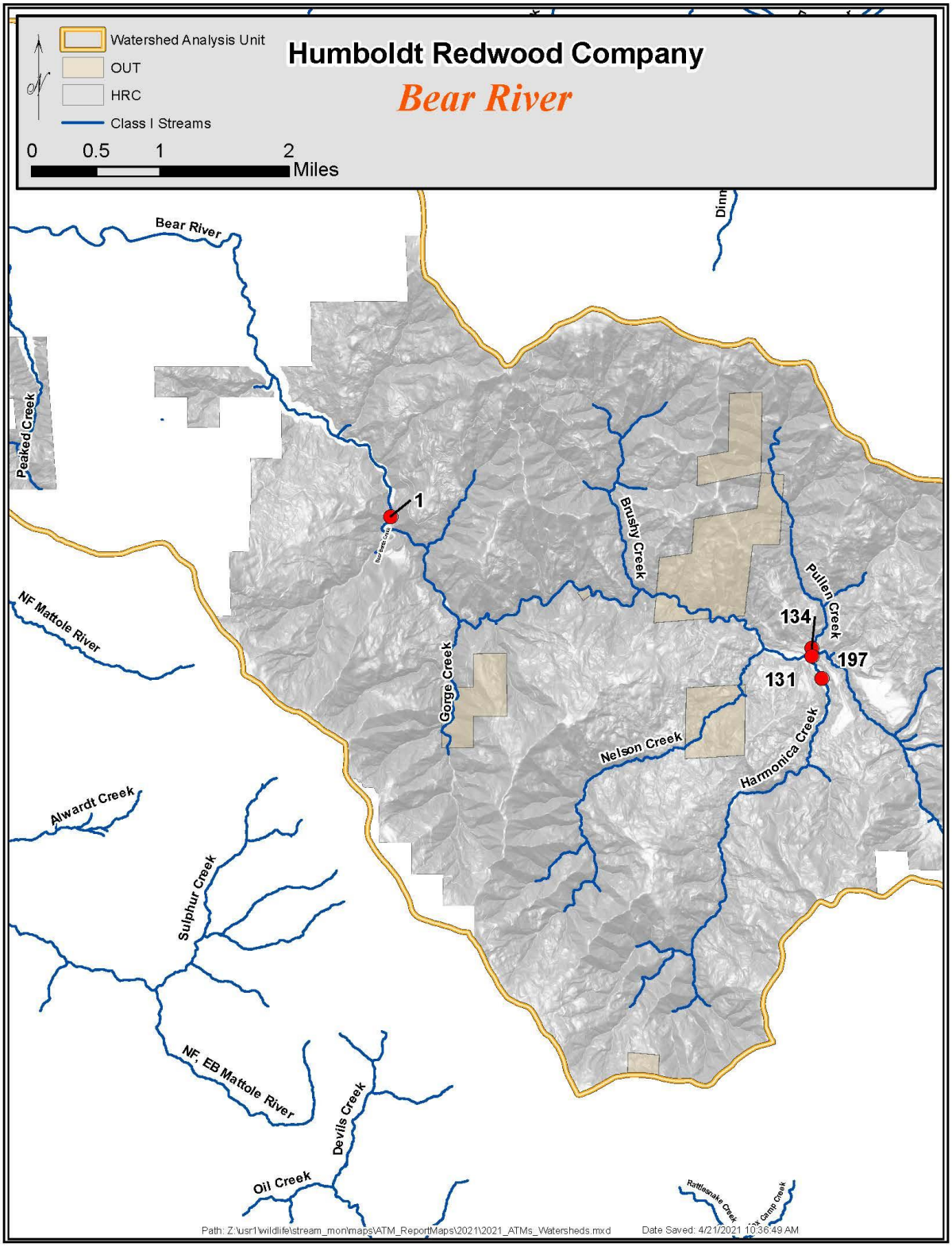

Figure 46. Location map of ATM sites in Bear River

ATM 131 Harmonica Creek

ATM 134 Pullen Creek

ATM 197 Upper Bear River

ATM 001 Lower Bear River

Figure 47. ATM sites within the Bear River WAU

ATM Site 131 – Harmonica Creek [Coastal Belt: Yager Terrane (TKy)]

Data for all ATM parameters at site 131 (Figure 47) are summarized in the APFC report card (Table 20). The bed surface D_{50} target was met in 2021, as the data suggest stability within the substrate across all particle size classes (Figure 48). Pool characteristics remained stable, yet still suggest deficiencies in habitat conditions with only 1 parameter meeting the target value. LWD piece frequency did not meet the target for the eighth consecutive survey year. Over stream canopy cover did not meet the target but riparian canopy cover did for the first time since 2006. Stream temperature narrowly missed the target in 2021 by 0.1° C.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 1997 (see Appendix). Channel scour was observed at 3/5 cross-sections between survey years 2018 and 2021. The greatest degree of channel scour occurred at cross-section 1, where channel area increased $+0.22m^2$. The greatest degree of channel aggradation occurred at cross-section 2, where channel area decreased $-0.31m^2$.

A snorkel survey on 8/31/2021 identified trout of various size classes in all 5 pools sampled (Figure 49).

Table 20. Individual site report card for ATM 131, Harmonica Creek

Site 131 Harmonica Creek	Parameter	Target Value (# no target)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bed surface	D_{84} (mm)	#	141	101		101			131			141			99			112			110
	D_{50} (mm)	65-95	65	35		32			59			60			51			67			68
	D_{16} (mm)	#	24	9		6			15			9			20			40			39
	D_5 (mm)	#	8	4		2			6			2			6			22			22
Pool Characteristics	Pool Area (%)	≥25	8	12		17			29			9			30			13			18
	Pool Spacing (CW/pool)	≤6.0	12.9	8.1		3.5			7.7			13.7			10.0			11.2			6.4
	Residual Pool Depth (m)	≥0.91	0.66	0.41		0.42			0.53			0.62			0.51			0.54			0.69
	Pools Assoc. w/wood (%)	≥50	50	100		80			80			67			67			67			80
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥7.4	5.7	4.8		4.3			3.5			3.5			2.3			5.0			1.8
	Total Piece Count	#							37			43			14			44			17
Water Temperature	MWAT (°C)	≤16.8			16.7	19.0	16.7	16.9	17.0	15.0	14.7	15.5	16.3		17.0	16.7	16.5	15.3	16.1	16.5	16.9
Riparian Overstory	Canopy Over Stream (%)	≥91	32	39		37			44			70			65			77			89
	Canopy of Rip Forest (%)	≥85	60	70		92						84						82			89

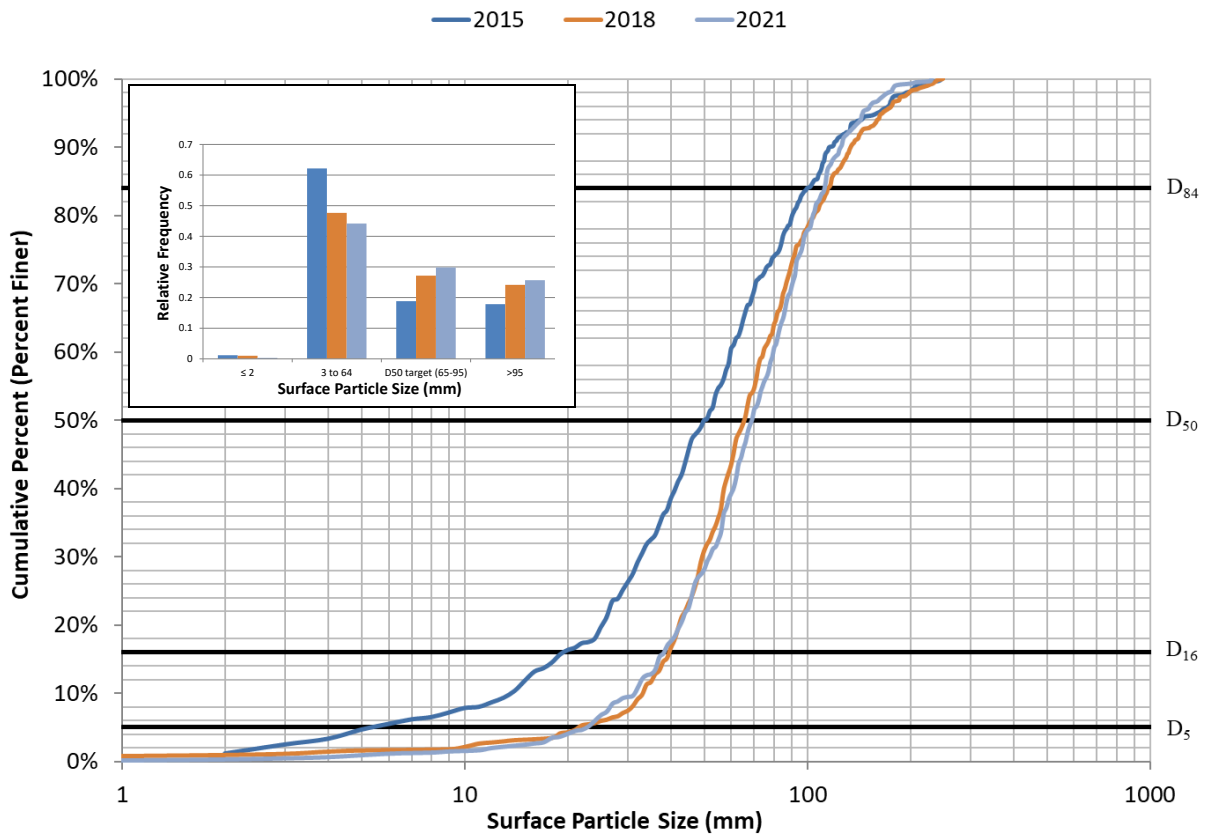

Figure 48. Cumulative frequency plot of the mean surface particle sizes of three riffles measured within the Harmonica Creek ATM 131 monitoring reach

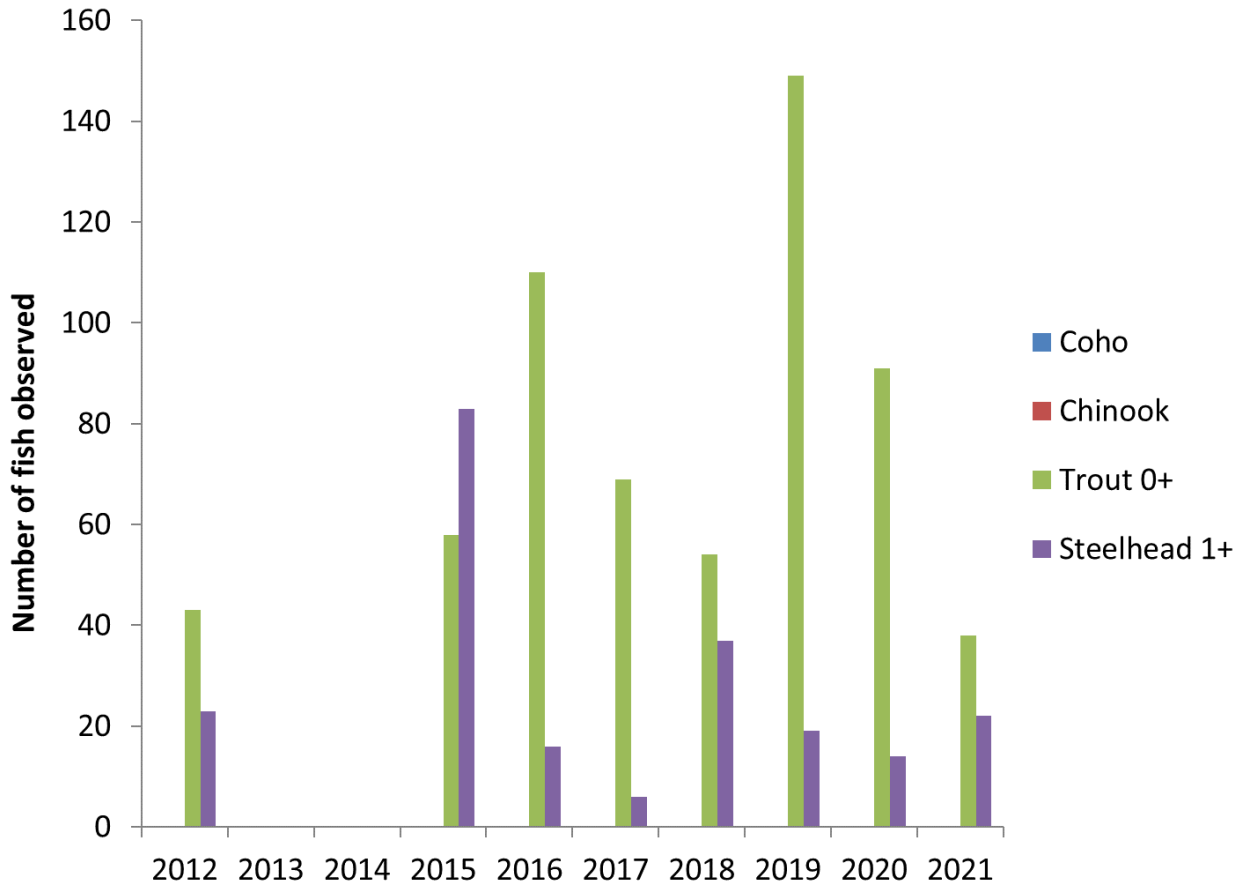

Figure 49. Results of annual snorkel survey fish counts of the first 5 pools within the Harmonica Creek ATM 133 monitoring reach (2012, 2015-2021)

ATM Site 134 – Pullen Creek [Coastal Belt: Yager Terrane (TKy)]

Data for all ATM parameters at site 134 (Figure 47) are summarized in the APFC report card (Table 21). The bed surface D_{50} target was not met in 2021, as the data suggest a fining of the substrate across all particle size classes (Figure 50). Pool characteristics suggest stable habitat conditions, with only half of the parameters meeting target values. LWD piece frequency did not meet the target for the fifth consecutive survey year. Over stream canopy cover in 2021 easily met the target with a recorded 100% closure, while stream temperature met the target in 2021 for the twelfth year in a row.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 2006 (see Appendix). Channel scour was observed at 2/5 cross-sections between survey years 2018 and 2021. The greatest degree of channel scour occurred at cross-section 1, where channel area increased $+0.39m^2$. The greatest degree of channel aggradation occurred at cross-section 5, where channel area decreased $-0.39m^2$.

A snorkel survey on 8/31/2021 identified trout of various size classes in all 5 pools sampled (Figure 51).

Table 21. Individual site report card for ATM 134, Pullen Creek

Site 134 Pullen Creek	Parameter	Target Value (# no target)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bed Surface	D_{84} (mm)	#	185	124		129			140			131			89			118			109
	D_{50} (mm)	65-95	69	39		30			60			42			42			71			58
	D_{16} (mm)	#	21	9		2			12			8			16			35			22
	D_5 (mm)	#	1	1		1			4			2			6			12			8
Pool Characteristics	Pool Area (%)	≥25	5	14		18			34			17			13			14			16
	Pool Spacing (CW/pool)	≤6.0	10.1	12.9		3.9			5.0			3.6			7.7			5.1			4.5
	Residual Pool Depth (m)	≥0.91	0.39	0.34		0.42			0.43			0.32			0.41			0.40			0.35
	Pools Assoc. w/wood (%)	≥50	100	100		75			89			64			75			100			57
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥7.5							4.3			7.3			3.3			4.2			5.4
	Total Piece Count	#							53			84			29			38			50
Water Temperature	MWAT (°C)	≤16.8	15.9	15.1	14.7	16.5	14.0	14.5	17.5	13.6	13.6	14.5	16.4	15.3	15.6	14.9	16.1	15.1	14.8	15.2	15.7
Riparian Overstory	Canopy Over Stream (%)	≥53	87	99	99	85			93			100			99			99			100
	Canopy of Rip Forest (%)	≥85	89	87		92						99									

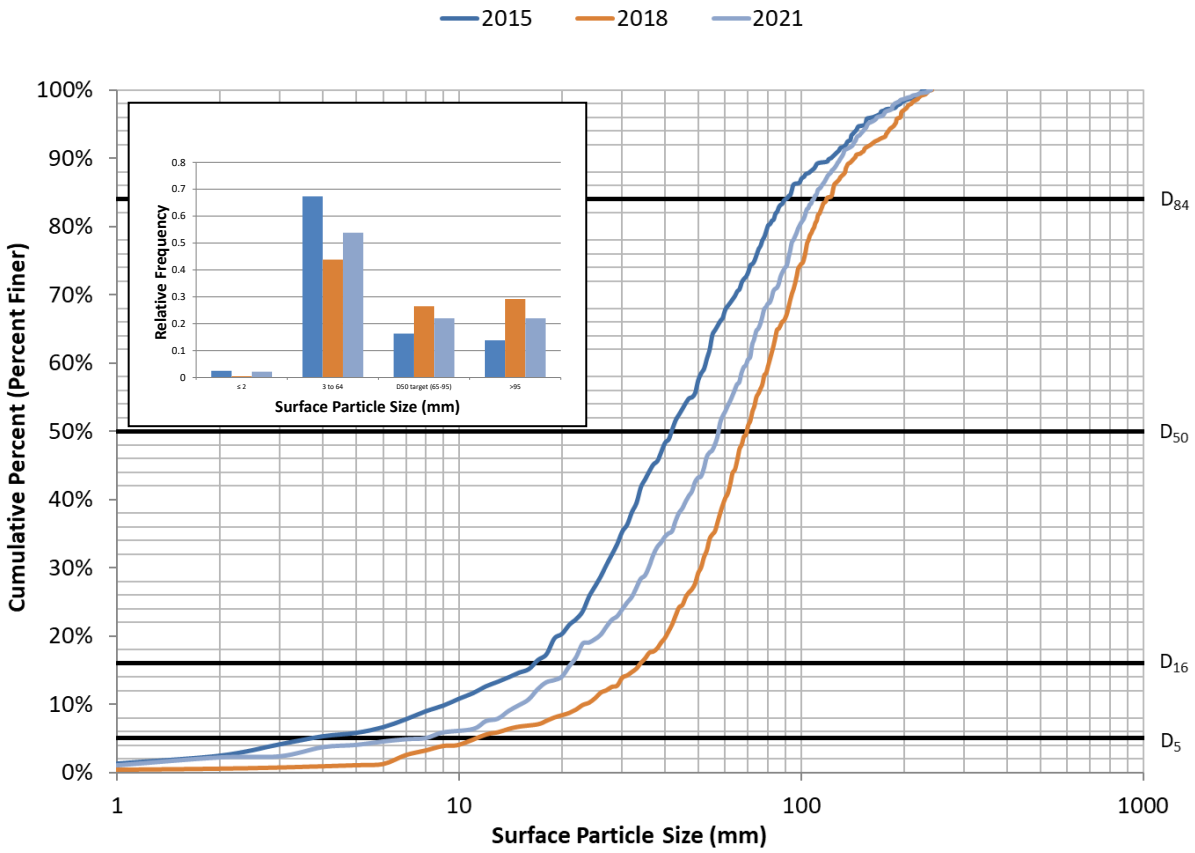

Figure 50. Cumulative frequency plot of the mean surface particle sizes of three riffles measured within the Pullen Creek ATM 134 monitoring reach

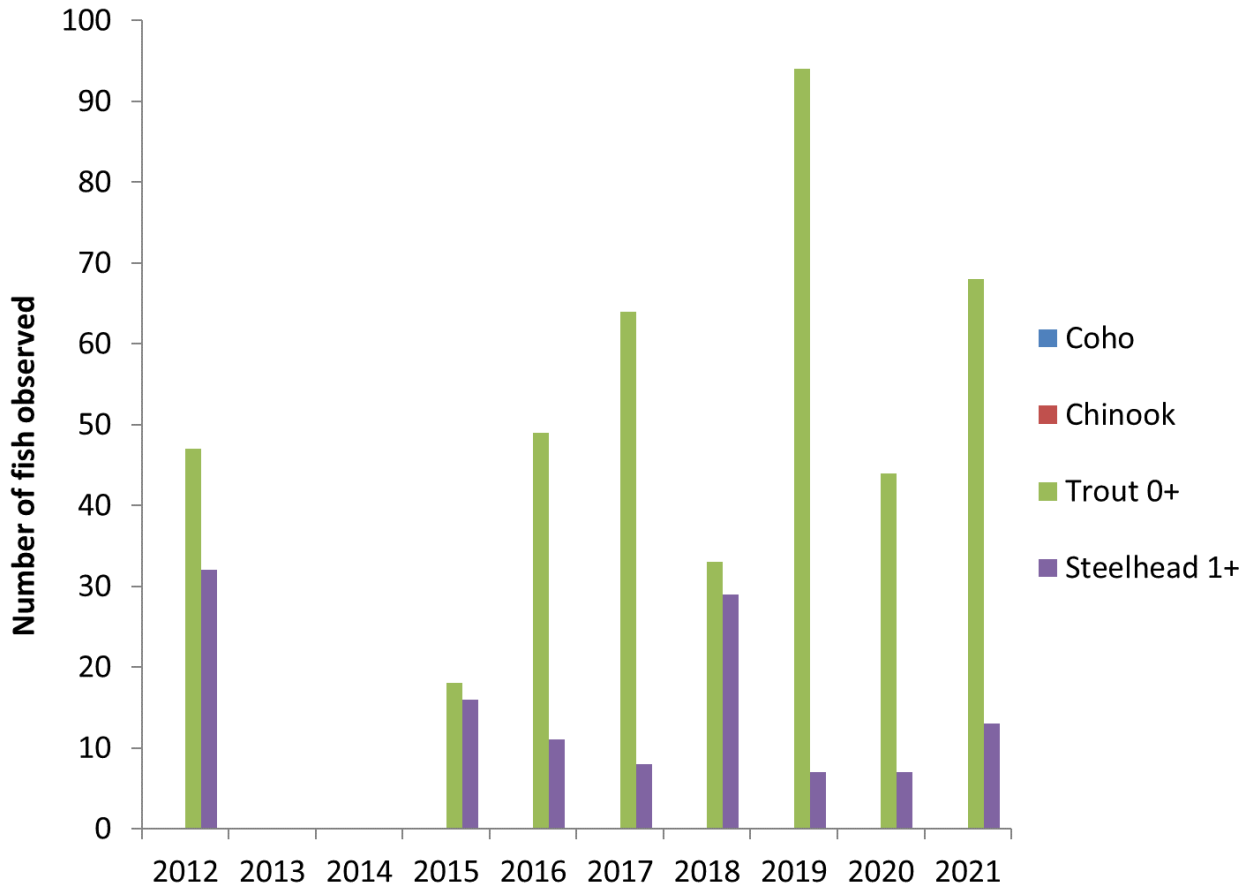

Figure 51. Results of annual snorkel survey fish counts of the first 5 pools within the Pullen Creek ATM 134 monitoring reach (2012, 2015-2021)

ATM Site 197 – Upper Bear River [Coastal Belt: Coastal Terrane (TKfs)]

Data for all ATM parameters at site 197 (Figure 47) are summarized in the APFC report card (Table 22). The bed surface D_{50} target was met in 2021, as the data suggest stability within all substrate particle size classes (Figure 52). Pool characteristics suggest stable habitat conditions, with 3 of 4 parameters meeting their targets in 2021. LWD piece frequency did not meet the target for the third survey year in a row. Over stream canopy cover in 2021 met the target for the fourth survey year in a row, as stream temperature met the target for the eighth survey year in a row.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 2006 (see Appendix). Channel scour was observed at 3/5 cross-sections between survey years 2018 and 2021. The greatest degree of channel scour occurred at cross-section 5, where channel area increased $+0.94m^2$. The greatest degree of channel aggradation occurred at cross-section 2, where channel area decreased $-0.59m^2$.

A snorkel survey on 8/31/2021 identified trout of various size classes in all 5 pools sampled (Figure 53).

Table 22. Individual site report card for ATM 197, Upper Bear River

Site 197 Bear River	Parameter	Target Value (# no target)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bed Surface	D_{84} (mm)	#							90			101			94			116			105
	D_{50} (mm)	65-95							44			44			44			68			66
	D_{16} (mm)	#							16			12			18			37			40
	D_5 (mm)	#							7			3			3			25			25
Pool Characteristics	Pool Area (%)	≥25							35			18			37			45			39
	Pool Spacing (CW/pool)	≤6.0							3.9			4.1			5.0			3.2			4.9
	Residual Pool Depth (m)	≥0.91							0.49			0.56			0.54			0.45			0.54
	Pools Assoc. w/wood (%)	≥50							89			75			57			70			50
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥6.3							7.7			8.1			3.8			5.9			3.6
	Total Piece Count	#							86			90			39			50			37
Water Temperature	MWAT (°C)	≤16.8										14.9		14.9	16.1	15.1	16.3	15.8		15.8	16.4
Riparian Overstory	Canopy Over Stream (%)	≥92	80	89		82			85			98			98			94			99
	Canopy of Rip Forest (%)	≥85	86	79		99						98									

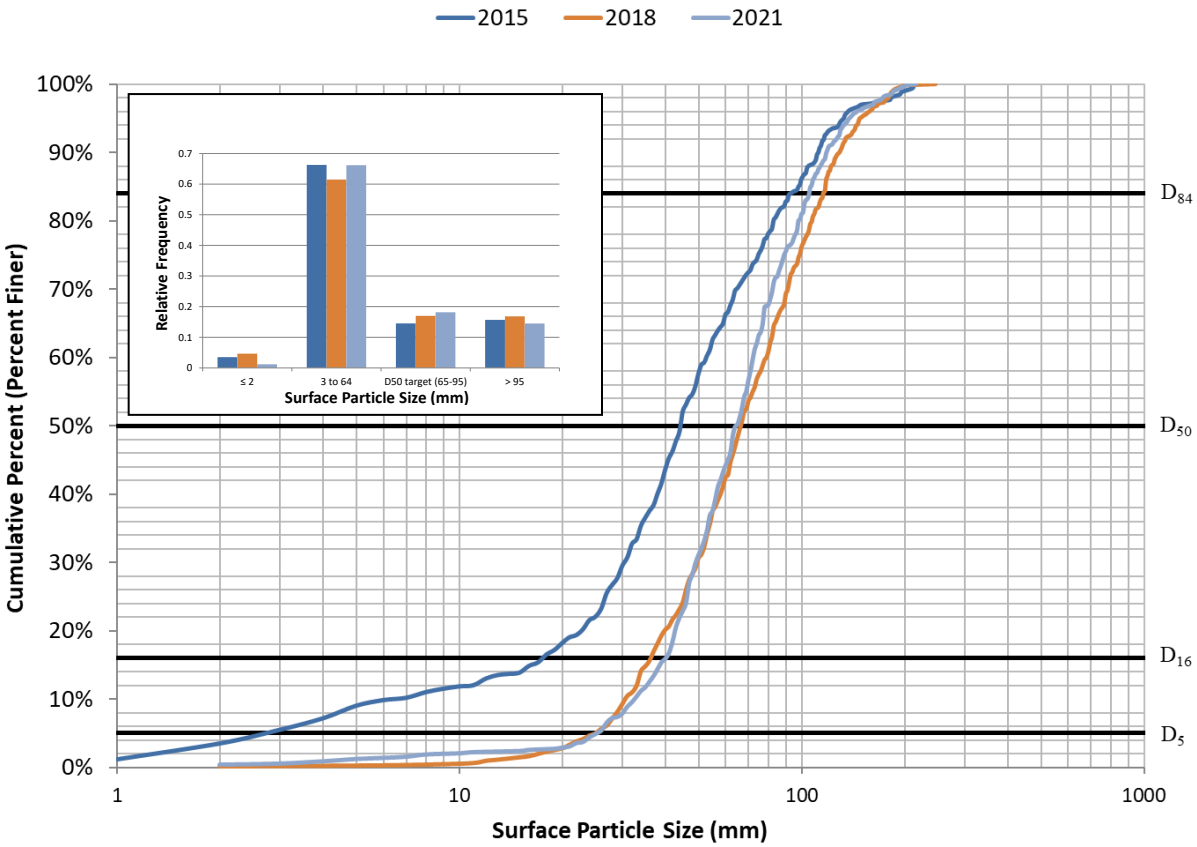

Figure 52. Cumulative frequency plot of the mean surface particle sizes of three riffles measured within the Bear River ATM 197 monitoring reach

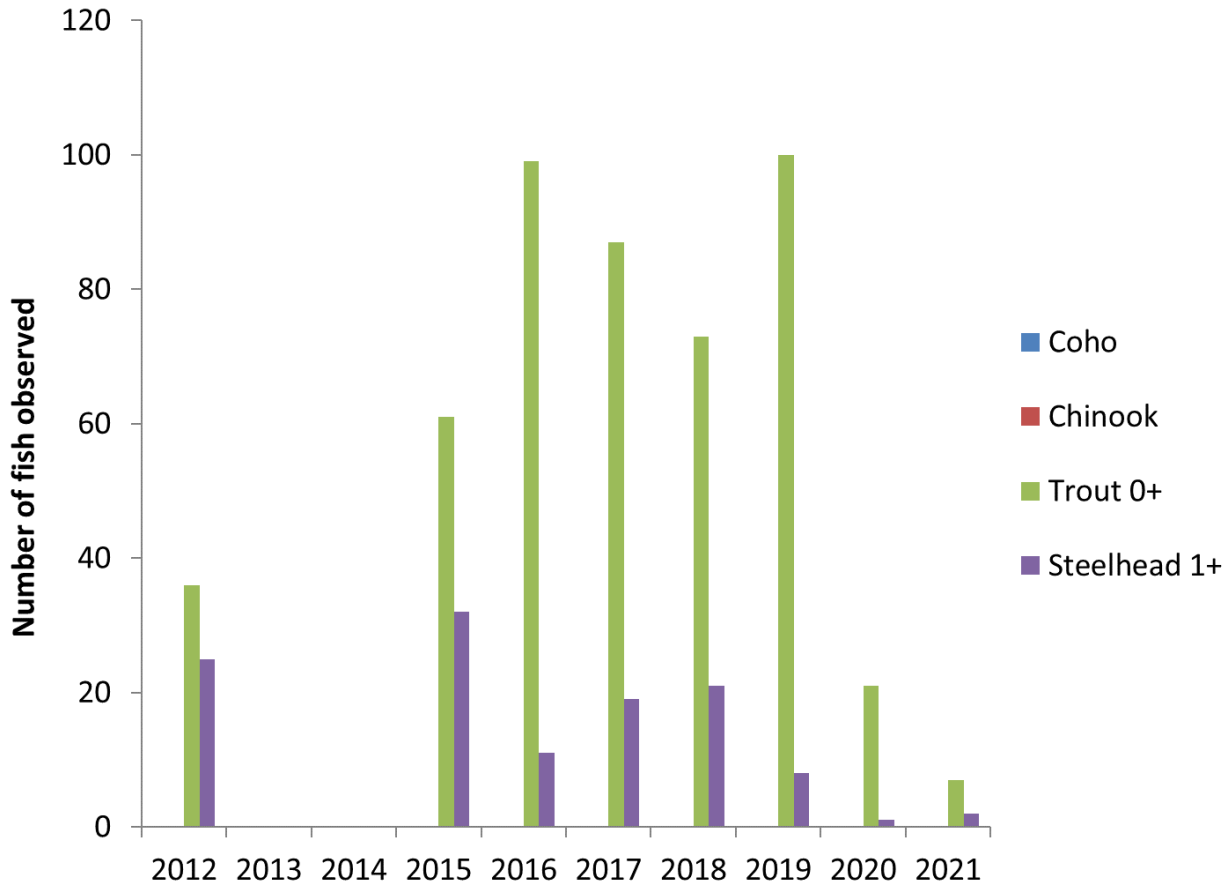

Figure 53. Results of annual snorkel survey fish counts of the first 5 pools within the Bear River ATM 197 monitoring reach (2012, 2015-2021)

ATM Site 001 – Lower Bear River [Coastal Belt: Coastal Terrane (TKfs)]

Data for all ATM parameters at site 001 (Figure 47) are summarized in the APFC report card (Table 23). The bed surface D_{50} target was not met in 2021, as the data suggest a fining of the substrate within the two larger particle size classes (Figure 54). Pool characteristics suggest stable habitat conditions, with only half of the parameters meeting their targets. LWD piece frequency did not meet the target for the eighth consecutive survey year. Over stream canopy cover met the target value in 2021 for the third survey year in a row, while stream temperature did not meet the target in 2021 for the second straight year.

Cross-section data suggest varying degrees of channel aggradation and scour since surveys were instituted in 2006 (see Appendix). Channel aggradation was observed at 2/4 cross-sections between survey years 2018 and 2021. The greatest degree of channel aggradation occurred at cross-section 4, where channel area decreased -0.34m^2. The greatest degree of channel scour occurred at cross-section 3, where channel area increased +1.16m^2.

A snorkel survey on 8/31/2021 identified trout of various size classes in all 5 pools sampled (Figure 55).

Table 23. Individual site report card for ATM 001, Lower Bear River

Site 001 Bear River	Parameter	Target Value (# no target)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bed surface	D_{84} (mm)	#	222	176		183			187			152			110			136			108
	D_{50} (mm)	65-95	65	43		40			85			39			44			73			58
	D_{16} (mm)	#	11	9		4			21			5			21			30			32
	D_5 (mm)	#	1	2		1			6			2			6			12			15
Pool Characteristics	Pool Area (%)	≥25	21	26		33			32			22			13			26			47
	Pool Spacing (CW/pool)	≤6.0	6.8	5.3		4.7			2.7			4.5			6.5			3.3			3.3
	Residual Pool Depth (m)	≥0.91	1.05	0.82		0.64			0.75			0.85			0.86			0.52			0.69
	Pools Assoc. w/wood (%)	≥50	50	40		25			17			0			14			33			22
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥3.1	1.9	1.6		1.6			1.1			1.7			1.2			1.3			2.0
	Total Piece Count	#							11			19			20			25			39
Water Temperature	MWAT (°C)	≤16.8		19.1		19.5	17.2	16.8	17.5	15.8	15.9	16.5	17.3	17.7	17.9	17.3	17.9	17.3	16.4	17.1	17.1
Riparian Overstory	Canopy Over Stream (%)	≥61	40	34		35			35			47			78			81			93
	Canopy of Rip Forest (%)	≥85	86	91		100						98									

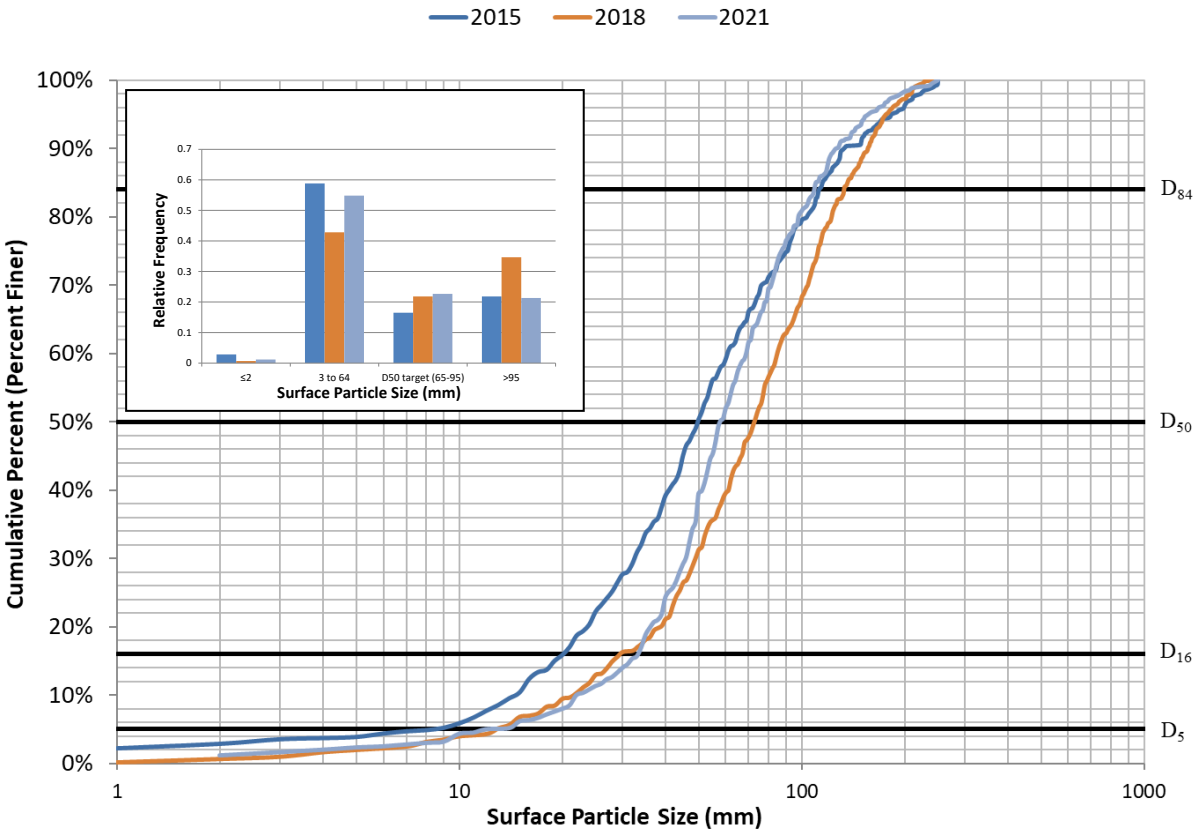

Figure 54. Cumulative frequency plot of the mean surface particle sizes of three riffles measured within the Bear River ATM 001 monitoring reach

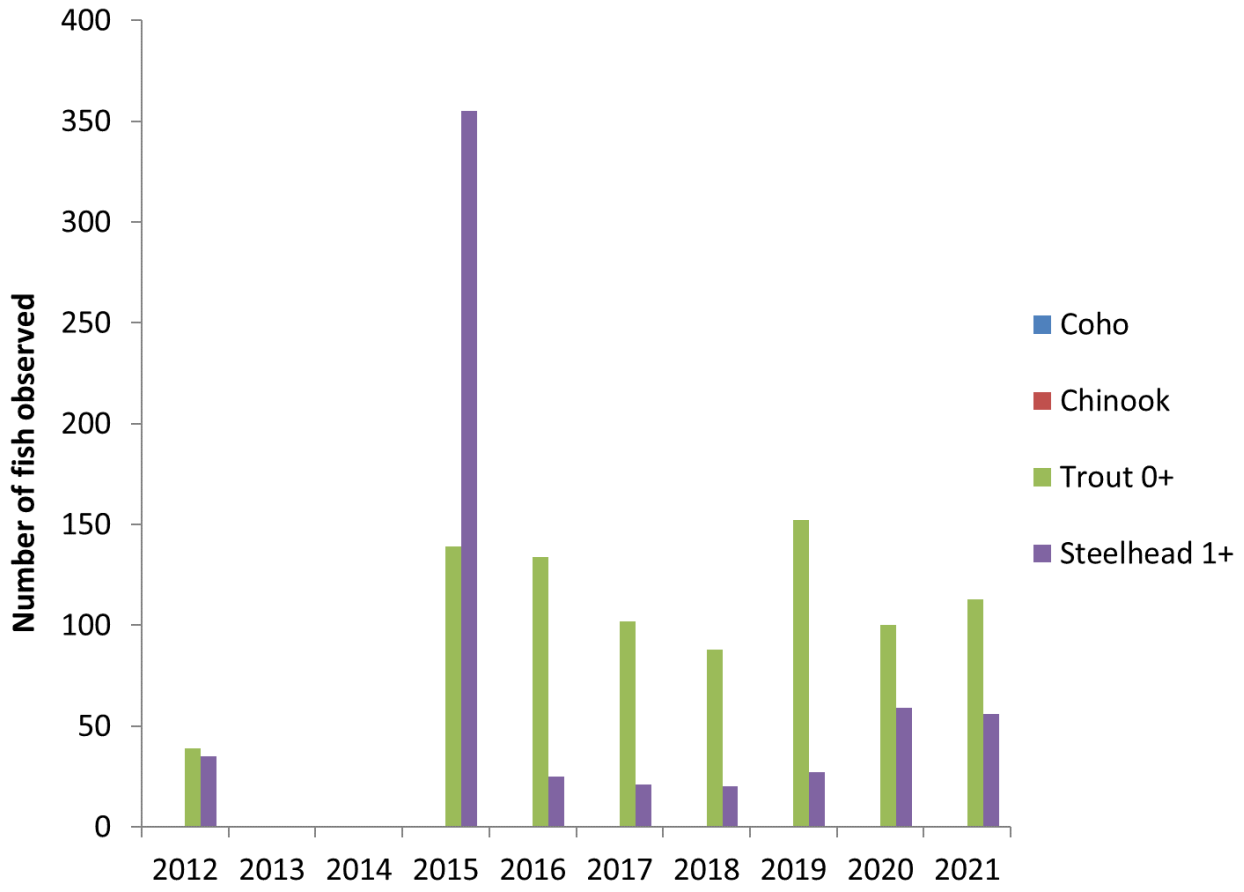

Figure 55. Results of annual snorkel survey fish counts of the first 5 pools within the Bear River ATM 001 monitoring reach (2012, 2015-2021)

Summary of ATM Trends in the Bear River WAU

A summary of the Bear River habitat characteristics from 2021 is provided in the APFC report card (Table 24). Results of habitat composite scores from 2018 and 2021 are compared to baseline (2003) data (Figure 56). Overall, the greatest improvements in habitat composite scores were observed in pool characteristics, and over stream canopy cover. Bed surface particle size and stream temperature scores declined in 2021, while LWD piece frequency remained the most deficient habitat parameter within the watershed.

Table 24. The most recent habitat measures for the Bear River WAU

Current Status	Parameter	Target Value (# no target)	131 Harmonica Creek	134 Pullen Creek	197 Bear River	001 Bear River
Bed Surface	D_{84} (mm)	#	110	109	105	108
	D_{50} (mm)	65-95	68	58	66	58
	D_{16} (mm)	#	39	22	40	32
	D_{5} (mm)	#	22	8	25	15
Pool Characteristics	Pool Area (%)	≥25	18	16	39	47
	Pool Spacing (CW/pool)	≤6.0	6.4	4.5	4.9	3.3
	Residual Pool Depth (m)	≥0.91	0.69	0.35	0.54	0.69
	Pools Assoc. w/wood (%)	≥50	80	57	50	22
Large Woody Debris	Total Piece Frequency (#/100 ft)	f(CW)	1.8	5.4	3.6	2.0
	Total Piece Count	#	17	50	37	39
Water Temperature	MWAT (°C)	≤16.8	16.9	15.7	16.4	17.1
Riparian Overstory	Canopy Over Stream (%)	f(CW)	89	100	99	93
	Canopy of Rip Forest (%)	≥85				
Watershed Area	Upstream Acreage	#	2,624	1,673	1,935	15,103
Reach Gradient	Reach Gradient (%)	#	1.6	2.0	1.4	0.8

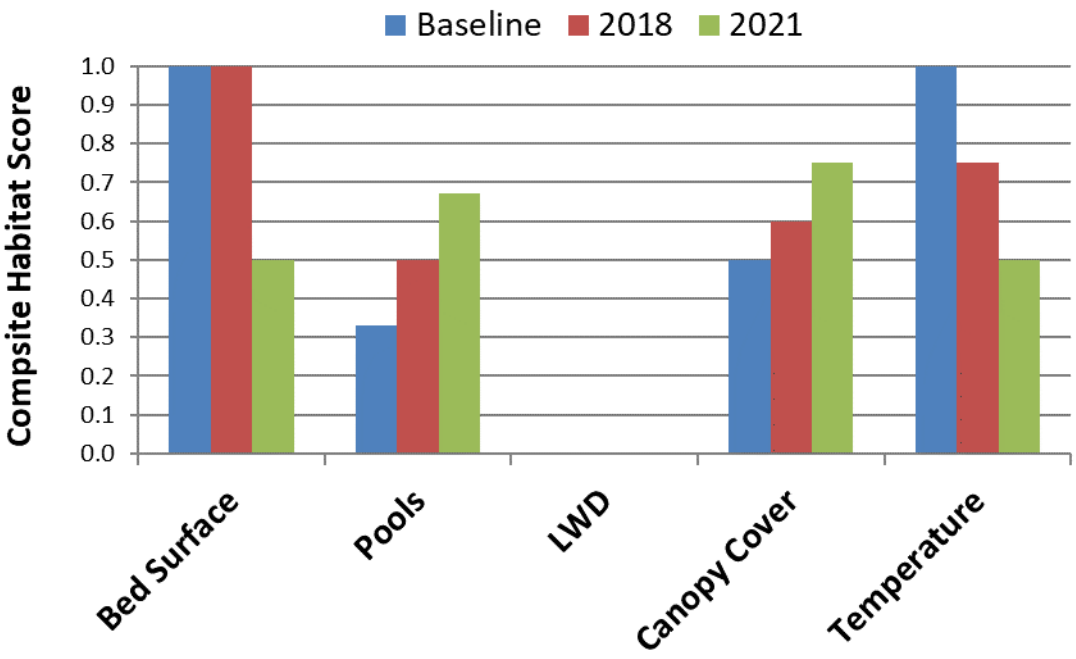

Figure 56. The composite scores for habitat characteristics in the Bear River WAU in 2018 and 2021 relative to baseline (2003) data

QUALITY ASSURANCE / QUALITY CONTROL

Three of the sixteen (3/16) ATM sites measured in 2021 were re-measured to assess the quality and reproducibility of ATM data collection. Data collection at all 16 sites was conducted by the same one-to-three-person field crew in 2021. Three QA/QC sites were re-measured within 2 weeks of the initial measurement date. The number of pools surveyed during the QA/QC visit at each site also remained consistent with the original survey and surface substrate (pebble count) re-measurements took place at the same locations at each site. Results of the 2021 QA/QC are shown in the APFC report card (Table 25).

Initial vs. QA/QC surface sediment measurements were highly consistent at ATM stations 131, 134, and 197 (standard deviation of the mean (+/-) 1.5mm, 1.0mm, 2.0mm, respectively). Pool characteristic comparisons were consistent at all three sites, resulting in identical pass/fail scores in all but one pool habitat parameter at one station. LWD counts were also highly consistent, resulting in identical pass/fail scores of initial vs. QA/QC counts. Mid-channel and riparian canopy cover QA/QC measurements reflect consistent, repeatable results utilizing the current data collection methods. All current data collection methods in 2021 have demonstrated the ability to produce reliable results, highlighting the flexibility of the pass/fail approach to the APFC score card rating system currently utilized in this report.

Table 25. QA/QC data collection measures for three (3) ATM stations in 2021

2021 QA/QC	Parameter	Target Value (# no target)	Harmonica 131	Harmonica 131.1	Pullen 134	Pullen 134.1	Bear River 197	Bear River 197.1
Bed Surface	D_{84} (mm)	#	110	108	109	99	105	112
	D_{50} (mm)	65-95	68	65	58	56	66	70
	D_{16} (mm)	#	39	40	22	27	40	44
	D_5 (mm)	#	22	26	8	8	25	30
Pool Characteristics	Pool Area (%)	≥25	18	24	16	19	39	37
	Pool Spacing (CW/pool)	≤6.0	6.4	6.1	4.5	5.1	4.9	4.5
	Residual Pool Depth (m)	≥0.91	0.69	0.54	0.35	0.34	0.54	0.47
	Pools Assoc. w/wood (%)	≥50	80	40	57	83	50	71
Large Woody Debris	Total Piece Frequency (#/100 ft)	f(CW)	1.8	3.1	5.4	4.2	3.6	3.7
	Total Piece Count	#	17	28	50	37	37	38
Water Temperature	MWAT (°C)	≤16.8	16.9		15.7		16.4	
Riparian Overstory	Canopy Over Stream (%)	f(CW)	89	76	100	99	99	96
	Canopy of Rip Forest (%)	≥85	89	88				

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APPENDICES

Appendix A Cross-section Plots (on CD)