A Survey of Aquatic Habitats, Fishes and other Aquatic Fauna of Elk Creek, Crescent City, California

Justin M. Garwood–*Environmental Scientist*
Anadromous Fisheries Resource and Assessment Program
California Department of Fish and Wildlife 5341 Ericson Way, Arcata, CA 95521
Justin.garwood@wildlife.ca.gov

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Top Photo: Mainstem Elk Creek in the CDFW Elk Creek Wetland Wildlife Area;
Bottom Photo: Upper Elk Creek Estuary in the Spring at low tide

Background

Elk Creek is a small (21.4 km^2) coastal watershed that drains most of the greater Crescent City and Elk Valley coastal plain (Figure 1). Prior to this study, limited information on Elk Creek salmonid occupancy and distributions were summarized in Garwood (2012a). Information on Elk Creek Coho Salmon (*Oncorhynchus kisutch*) habitats and ecological threats are broadly covered in the Elk Creek chapter of the Southern Oregon Northern California Coho Salmon Recovery Plan (NOAA 2014), though specific details regarding local threats to salmonid populations remain unclear. In response to a need for more refined restoration planning in Elk Creek, the Smith River Alliance developed an initial restoration strategy for the watershed (SRA 2017). I initiated this study in 2013 to determine current occupancy status and spatial distributions of salmonids, among other species, occurring in

Figure 1. Ariel photo of lower Elk Creek watershed looking west taken on April 7, 2016. Note the broad valley largely lacking human development and coniferous forest which is likely due to extensive wetland habitats. Much of the core watershed is buffered by dense stands of Coast Redwood and Sitka Spruce. *Photo: J. Garwood*

Elk Creek. This study should provide landowners, managers, and restoration groups better information on the aquatic species occurring in Elk Creek while identifying remaining information gaps. I used opportunistic field sampling focused on determining Coho Salmon, among other salmonids, presence annually from 2013 to 2018. In addition, I conducted a literature review focused on aquatic vertebrates of Elk Creek to determine what vertebrate aquatic fauna have been described using Elk Creek in the past. Collectively, these results will help inform future monitoring and management of this unique and biologically important watershed.

Study Area

The Estuary

The estuary of Elk Creek begins within the Crescent City Harbor and extends 380 meters to the US Highway 101 culvert. The estuary has been highly modified and realigned due to land development along the Crescent City coastline and the construction of the Crescent City Harbor. For example, based on an 1859 survey map, the lower Elk Creek channel appears to have been moved south east a few city blocks as Crescent City expanded (Figure 2). The current estuary channel width averages 53 meters at high tide and has a water surface area of 2.09 hectares. At low tide the estuary channel width averages 12 meters with water surface area 0.44 hectares. The estuary is largely composed of a

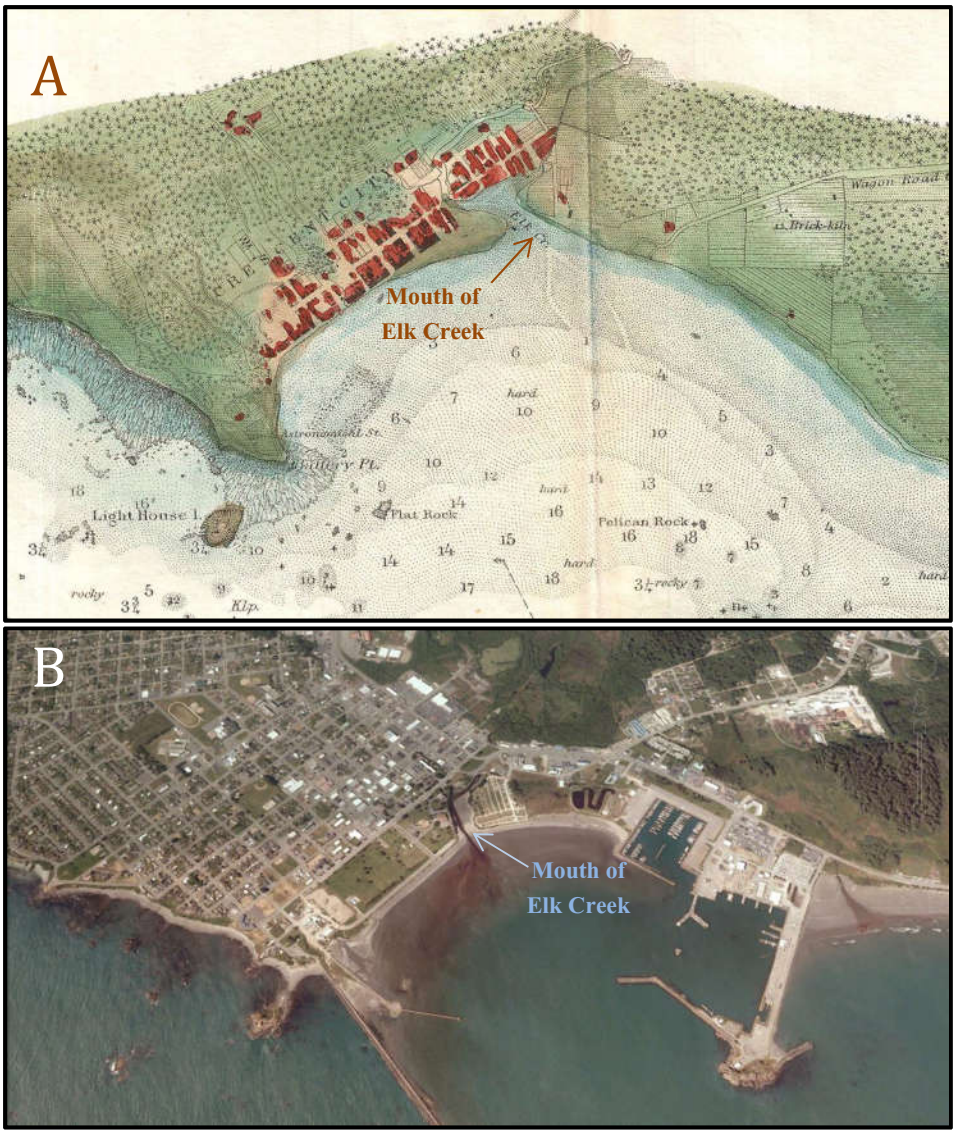


Figure 2. (A) Coast survey map of Crescent City and the lower portion of Elk Creek as interpreted in 1859. Note the lower stream and estuary channels were further west in 1859 than today. (B) Satellite image of Crescent City area and Crescent City Harbor from 2010.

simple sandy bottom with intermittent gravel and sediment deposits. The banks surrounding the estuary channel have been hardened with rip-rap with some locations having concrete construction waste as fill. The estuary abruptly ends at the outfall of a concrete culvert that extends 150 meters across Highway 101 and N Street.

The Lower Basin

Above the estuary, the main channel of Elk Creek flows through a broad floodplain valley containing an extensive freshwater marsh (Figure 1). The main channel in this wetland complex has been historically modified through channelization, channel straightening, and rerouting in several locations through secondary connecting channels. There are also several examples of historic channels currently severed from the modern stream channel at the lower portion of the valley. A portion of the lower basin was also historically developed into a lumber mill where a large log pond (~8 acres) was constructed. The upper portion of the valley appears to be largely unaltered having little evidence of historic channel modifications. Based on a lack of development encroachment, the lower two kilometers of Elk Creek represents one of the most substantial and intact relic coastal marshes in California. This is especially unique given its proximity to Crescent City, the most populated area in Del Norte County (Figure 1).

The main channel throughout the valley is approximately 4 kilometers in length and flows through a large open wetland complex with multiple channels and ponded areas. The channels through this section are flanked by a wide floodplain (150 – 300 meters) lacking both conifer forest and deciduous riparian tree cover (Figure 1). This wide valley lacking conifers indicates the lower watershed has substantial wetlands associated with the stream. This same area also has thick patches of reed canary grass (*Phalaris arundinacea*) which could be limiting native wetland plants and reducing water quality through oxygen demands from decaying biomass. Outside of this wide mesic floodplain, the entire inner watershed is flanked by thick stands of conifers dominated by Sitka spruce (*Picea sitchensis*) and Coast Redwood (*Sequoia sempervirens*). These forests currently provide a thick buffer between Elk Creek and the more developed portions of the outer watershed (Figure 1). Overall, the lower basin has very little gradient or elevation gain and has been modified by multiple large tsunami events depositing sand sheets throughout the lower watershed (Peterson et al. 2013).

The Upper Basin and Tributaries

The headwater forests of the eastern portion are dominated by old growth coast redwood in Jedediah Smith Redwoods State Park. Northern basin headwaters drain upper Elk Valley containing a mix forested rural residential properties and pasture. Western headwaters are composed of numerous forested low-elevation finger gullies in the coastal plain surrounded by a mix of urban and rural residential areas of Crescent City. The eastern flank of the watershed contains a mix of commercial, rural residential, pasture, and forested lands. Although little work has been done describing spawning habitat distribution in Elk Creek (*see* results section), the only likely spawning habitat of any value occurs in headwater tributaries having higher gradients and sorted gravel.

Literature Review and Sampling Methods

Literature Review

I obtained and reviewed raw data and reports that were associated with Elk Creek within the California Department of Fish and Wildlife's (CDFW) regional resource libraries. Much of these data and reports were already summarized in Garwood (2012a, 2012b), which document historic Coho Salmon distributions, in the California portion of the Southern Oregon Northern California (SONCC)

Evolutionary Significant Unit. The new literature review adds more fishes and other aquatic species known to occupy Elk Creek.

Fish Sampling Procedures

Minnow Traps— I used minnow traps to determine Coho Salmon occupancy throughout the small tributaries of Elk Creek. Minnow traps can be deployed across wide ranges of flow and turbidity during the winter months. To prevent trapping in areas having poor water quality for salmonids, I measured water quality at each sampling location prior to setting minnow traps. Thresholds for deploying traps were defined as dissolved oxygen >3.5 mg/L, salinity <5 ppt, and temperature <17 ˚C following studies by Ruggerone (2000) and Wallace and Allen (2009); *see* the water quality methods section below for a detailed description of collection methods. I used Gee ® brand minnow traps (Cuba Specialty Manufacturing Company, Fillmore, NY) composed of two interlocking inverted cone baskets of 6 mm mesh galvanized steel wire measuring 23 cm x 44 cm when assembled. An opening measuring 25 mm diameter located on each side the trap allowed for juvenile fish to enter the trap. I baited minnow traps with ~4 grams (one tablespoon) of sterilized salmon roe, procured by CDFW at the Trinity River Hatchery, contained in clear film canisters with 10 – 12 3.2 mm holes drilled into the sides to prevent captured individuals from consuming the bait. I deployed minnow traps on the substrate aligned parallel to flow (openings facing upstream and downstream) in areas having flow refuge. I secured the minnow traps to anchors using parachute cord and deployed individual traps for a period between 80 and 120 minutes.

Beach Seine— To sample the broad open water portions of the Elk Creek estuary I used a 1.5 m x 9.1 x 7 mm stretched mesh seine attached to 1.5 m long wooden poles on each edge of the net. I made one to three passes at each sampling location depending on the size, depth, and water velocity. I typically sampled locations having more complexity with more than one pass.

Fish Processing and Marking Procedures

All salmonids captured during sampling with either a minnow trap or seine were identified to species (Chinook Salmon, Coho Salmon, trout spp., Coastal Cutthroat Trout), migrant stage (young-of-year, parr, smolt, adult), counted, measured, and weighted. All fork lengths of juvenile salmonids were measured to the nearest millimeter and weighed to the nearest hundredth of a gram. To assess growth rate, residence time, and movement, I fin clipped a sample group of Coho Salmon each week. I marked salmonids <70 mm captured on the first trapping period with a batch fin clip to explore relative site abundances and possible trap effects on back-to-back capture rates. This clip was made with small sharp scissors removing approximately three-square mm of the upper caudal fin. All other aquatic vertebrates observed during the various sampling events including fishes, amphibians, and mammals, were identified, aged, and counted.

Water Quality Sampling

I measured water quality at the upper Elk Creek estuary during multiple sampling periods in the spring of 2013. I used a Yellow Springs Instrument Professional Plus multi-parameter meter. Parameters measured included water temperature (°C) accuracy of ±0.2°, dissolved oxygen (mg/L) accuracy of ±0.2 mg/L, and salinity (ppt) accuracy of ±0.1 ppt.

Results and Discussion

Literature Review

I found eleven documents from 1966 to 2012 describing aquatic sampling results for Elk Creek (Table 1). Seven documents were field notes (Gastineau 1966, Rodgers 1974, Cobb 1987, Burgess 1999, Zeck 1999, Preston 2000, Burgess 2005, Holden 2009), two supported a historic data compilation that also included newer original field data (Garwood 2012a, Garwood 2012b), and one described sampling results in the Elk Creek estuary after an industrial spill violation (Weise 2003). Some of this information is also presented in the Elk Creek chapter of the NOAA Coho Salmon Recovery Plan (NOAA 2014). All studies were brief in their scopes and spatial distributions highlighting no comprehensive inventory has ever been carried out in Elk Creek despite being surrounded by a rural and urban interface.

Table 1. List of aquatic vertebrates documented to occur in Elk Creek, Crescent City, California.

Common Name	Scientific Name	Location	Source
	Fishes		
Coastal Cutthroat Trout	*Oncorhynchus clarki clarki*	*Estuary, Stream*	*Cobb (1987), Preston (2000), Burgess (2005), This study*
Steelhead Trout	*Oncorhynchus mykiss*	*Stream*	*Cobb (1987), Burgess (1999), Garwood (2012) Holden, B., III (2009)*
Coho Salmon	*Oncorhynchus kisutch*	*Estuary, Stream*	*Rodgers (1974), Cobb (1987), Burgess (1999), Burgess (2005), Preston (2000), Garwood (2012), This study*
Chinook Salmon	*Oncorhynchus tshawytscha*	*Estuary, Stream*	*(Zeck 1999, Burgess 1999) This study*
Three-spined Stickleback	*Gasterosteus aculeatus*	*Estuary, Stream*	*Gastineau (1966), Wiese (2003), This study*
Prickly Sculpin	*Cottus asper*	*Estuary, Stream*	*Wiese (2003), This study*
Coast Range Sculpin	*Cottus aleuticus*	*Stream*	*This study*
Pacific Staghorn Sculpin	*Leptocottus armatus*	*Estuary*	*Wiese (2003), This study*
Pacific Sandlance	*Ammodytes hexapterus*	*Estuary*	*This study*
Surfsmelt	*Hypomesus pretiosus*	*Estuary*	*This study*
Shiner Surfperch	*Cymatogaster aggregata*	*Estuary*	*Wiese (2003), This study*
Speckled Sanddab	*Citharichthys stigmaeus*	*Estuary*	*This study*
Starry Flounder	*Platichthys stellatus*	*Estuary*	*Wiese (2003), This study*
Unidentified Lamprey	*Petromyzonidae spp.*	*Stream*	*Cobb (1987), Garwood (2012)*
Unidentified Goby	*Gobiidae spp.*	*Estuary*	*Wiese (2003)*
Unidentified Smelt	*Osmeridae spp.*	*Estuary*	*Wiese (2003), This study*
	Amphibians		
Coastal Giant Salamander	*Dicamptodon tenebrosus*	*Stream*	*Holden, B., III (2009), This study*
Northern Red-legged Frog	*Rana aurora*	*Stream/ Pond*	*This study*
Northwestern Salamander	*Ambystoma gracile*	*Stream/Pond*	*This study*
	Mammals		
River Otter	*Lontra canadensis*	*Estuary*	*Weise (2003), This study*
American Beaver	*Castor canadensis*	*Stream*	*Preston (2000), This study*

Field Studies 2013-2018

I opportunistically sampled various locations throughout the Elk Creek Watershed from 2013 to 2018 to establish modern salmonid species occurrence and distributions. It is important to note these surveys were incidental in nature so broad spatial and temporal sampling gaps remain. I detected three species of salmonids including Coho Salmon, Chinook Salmon, Coastal Cutthroat Trout and a variety of resident freshwater fishes, estuarine fishes, and other aquatic species (Table 1).

Coho Salmon Distributions

Previously, I documented five sequential Coho Salmon year classes occupying Elk Creek, with brood years spanning 1998 to 2002 based on available reports, field notes, and snorkel surveys targeting salmonid distributions (Table 1) (Garwood 2012a and Garwood 2012b). With this current study, I found seven additional sequential year classes of juvenile Coho Salmon in Elk Creek with brood years spanning from 2011 to 2017 (Table 2). Results from both periods demonstrate Elk Creek is used consistently by Coho Salmon for spawning and rearing. Although I did not conduct spawner surveys, the presence of Coho Salmon parr throughout the watershed provides evidence that adults consistently migrate into this watershed each winter. Previous surveys describe adult Coho Salmon migrating and spawning in small tributaries located in the upper watershed in 1999 (Burgess 1999) and in 2005 (Burgess 2005) (Figure 3). Although I did not sample systematically throughout the entire watershed, I did find Coho Salmon were easily detected and widely distributed across a variety of sampling sites (Figure 3, Appendix A). Most detections were made at road crossings along Elk Valley Road and Highway 101. I also found Coho Salmon throughout the lower valley and at one location in the upper valley of mainstem Elk Creek. I was unable to sample in the middle valley section, which likely contains abundant rearing habitats for juvenile Coho Salmon.

Table 2. Summary of juvenile Coho Salmon, juvenile Chinook Salmon, and Coastal Cutthroat Trout captures from 2013 to 2018, Elk Creek, Crescent City, CA. Sampling intensity varied across years so capture numbers do not represent indices of annual abundance. A total of seven consecutive Coho Salmon year classes (2011-2017), and three consecutive Chinook Salmon year classes (2015-2017) were identified.

		Coho Salmon			Chinook	Chinook	Coastal	Coastal
	Coho	Young	Yearlings		Salmon	Salmon	Cutthroat	Cutthroat
Date	Year Class	of Year	Parr	Smolt	parr	Yearlings	Parr	Adult
3/8/2013	2011	0	0	9	0	0	0	0
3/14/2013	2011, 2012	17	0	1	0	0	0	0
3/21/2013	2011, 2012	5	0	96	0	0	4	2
3/28/2013	2011, 2012	4	1	44	0	0	3	0
4/5/2013	2011, 2012	30	0	41	0	0	0	0
4/6/2013	2011	0	0	1	0	0	4	0
4/11/2013	2011, 2012	91	0	5	0	0	0	0
4/18/2013	2011, 2012	15	0	29	0	0	3	0
4/23/2013	2011, 2012	28	0	15	0	0	3	0
5/2/2013	2011, 2012	32	0	21	0	0	0	0
5/15/2013	2011, 2012	6	0	3	0	0	0	0
5/23/2013	2011, 2012	10	0	1	0	0	0	0
5/30/2013	2011	0	0	1	0	0	0	0
6/5/2013	2012	13	0	0	0	0	0	0
3/30/2015	2014	10	0	0	0	0	0	0
4/24/2015	2014	24	0	0	0	0	0	0
4/29/2015	2013, 2014	1	0	3	0	0	0	0
12/9/2015	2014	2	0	0	0	0	0	0
3/8/2016	2014	0	2	0	0	0	3	0
4/22/2017	2015	0	0	3	3	0	0	0
6/6/2017	2016	3	0	0	2	1	7	0
4/20/2018	2017	25	0	0	7	0	0	0

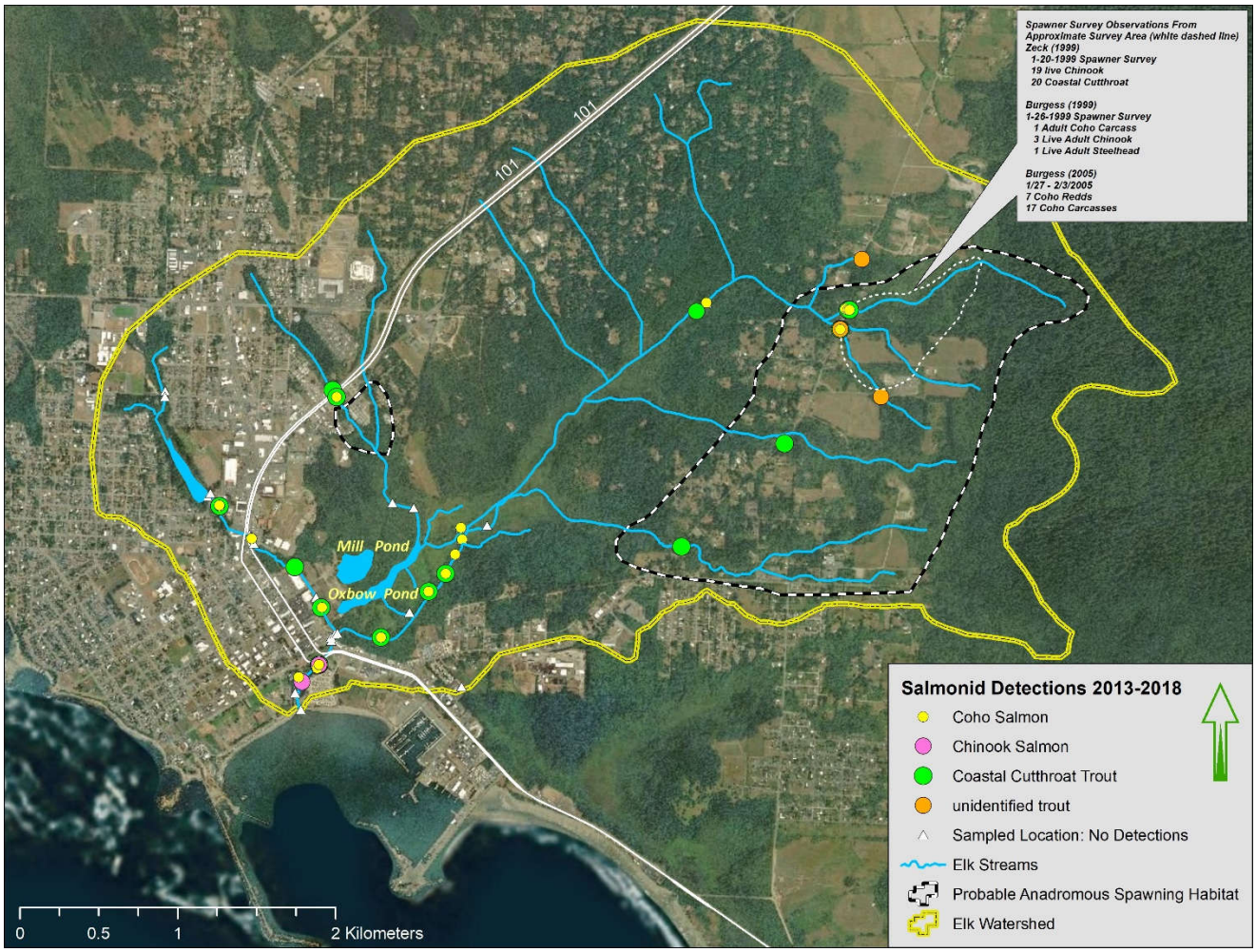


Figure 3. Map of sampling effort, salmonid observations, and stream habitats in the Elk Creek Watershed, Crescent City, Del Norte County, CA. Sampling occurred from 2013 to 2018. Some locations were sampled on multiple occasions so individual markers could represent multiple species observations on separate dates.

Perhaps the most surprising detections were in two northwest drainages of Elk Creek that occur in the urban city limits of Crescent City. The first and westernmost tributary occurs directly behind the Safeway and Crescent City Cinema shopping center as a straightened ditch that is intermittently confined to culverts from Second Street up to 7th Street where it enters a riparian area flanked by Highway 101 to the west and the Del Norte County Fairgrounds to the right. I captured Coho Salmon in the ditched portion behind the shopping center between 3rd and 5th Streets (Figure 3). Further upstream, I captured Coho Salmon directly below the Highway 101 culvert at the western edge of the fairgrounds parking lot. From here the stream flows through a 145-meter-long culvert under Highway 101 and a large parking lot to the northwest where it opens into a short riparian zone for 165 meters. I captured the uppermost Coho Salmon in a small daylighted section of stream in the middle of the Del Norte County Road Department parking lot (Figure 3). Upstream of this section the stream flows through a culvert for approximately 90 meters to its lentic origin, a large wetland above East Cooper Avenue that extends up to Del Norte High School. I sampled the lower end of this wetland and the crossing at West Harding Avenue and did not capture any salmonids. The second noteworthy location where I captured juvenile Coho Salmon was at another unnamed northwest tributary east of the one previously described just downstream of Highway 101 near the intersection of Highway 101

and A Drive (Figure 3). This tributary extends north of Highway 101, beyond Washington Boulevard, though I did not sample in that area. Future sampling is needed in this region, especially the tributaries east of this area that cross Parkway Drive and Highway 101.

Coho Salmon in the Elk Creek Estuary

I seined a single estuarine site, directly downstream of Highway 101 at the pedestrian trail bridge, on multiple occasions from 2013 to 2018 to investigate estuarine use and migration timing of juvenile Coho Salmon. In the spring of 2013, I sampled this location almost weekly across 13 occasions from March 8 to June 5 to investigate smolt (yearlings) migration timing and fry (young-of -the-year [YOY]) emergence and estuarine use. I sampled this location close to low tide to avoid high salinity concentrations and to take advantage of smaller and shallower habitats. All sampling periods had favorable water quality conditions for capturing juvenile salmonids (Table 3). I captured 516 Coho

Table 3. Water quality parameters of the upper Elk Creek estuary salmonid sampling location throughout the spring of 2013. Sampling largely occurred during an outgoing/ low tide interval to avoid excessive salinities and water depths.

Date	Salinity (ppt)	Dissolved Oxygen (mg/L)	Water Temperature (C)
3/8/2013	0.10	8.43	10.8
3/14/2013	0.10	9.01	10.7
3/28/2013	0.12	8.98	11.0
4/5/2013	0.07	7.21	11.7
4/18/2013	0.10	10.58	9.8
4/23/2013	0.14	9.90	12.7
5/2/2013	0.11	9.98	13.5

Salmon across seven consecutive year classes (2011 to 2017) of Coho Salmon in the Elk Creek Estuary from 2013 to 2018 (Table 2, Figure 4). On most occasions (10 of 15) I captured both YOY and yearlings (Figure 4) indicating consistent use by these stages in the upper estuary. I only had one occasion each where I did not capture either YOY or yearlings (Table 2). During the weekly sampling in 2013, I captured the most yearling smolts from March 21 to May 5 with a peak of 89 captured on March 21 (Table 2, Figure 5). In contrast, I captured most YOY Coho Salmon between April 5 and May 2 with a peak of 91 on April 11 (Table 2, Figure 5). I fin clipped 123 Coho Salmon smolts across the season with a weekly batch mark to obtain a minimum estimate of individual rearing tenure in the upper estuary prior to ocean entry. I recaptured at least 11 marked smolts a minimum of 5 to 14 days (mean: 10 days) after their first capture indicating some smolts reside in the estuary for weeks prior to ocean entry. During the spring of 2013, fork lengths of Coho Salmon YOY averaged 39 mm (range: 32- 49 mm) while smolts averaged 103 mm (Range: 78-198 mm) (Figure 6). Both YOY and Smolt Coho Salmon generally increased in size during the spring of 2013 (Figure 6).

Figure 4. Large coho salmon smolt captured in the Elk Creek Estuary, 5-22-2017

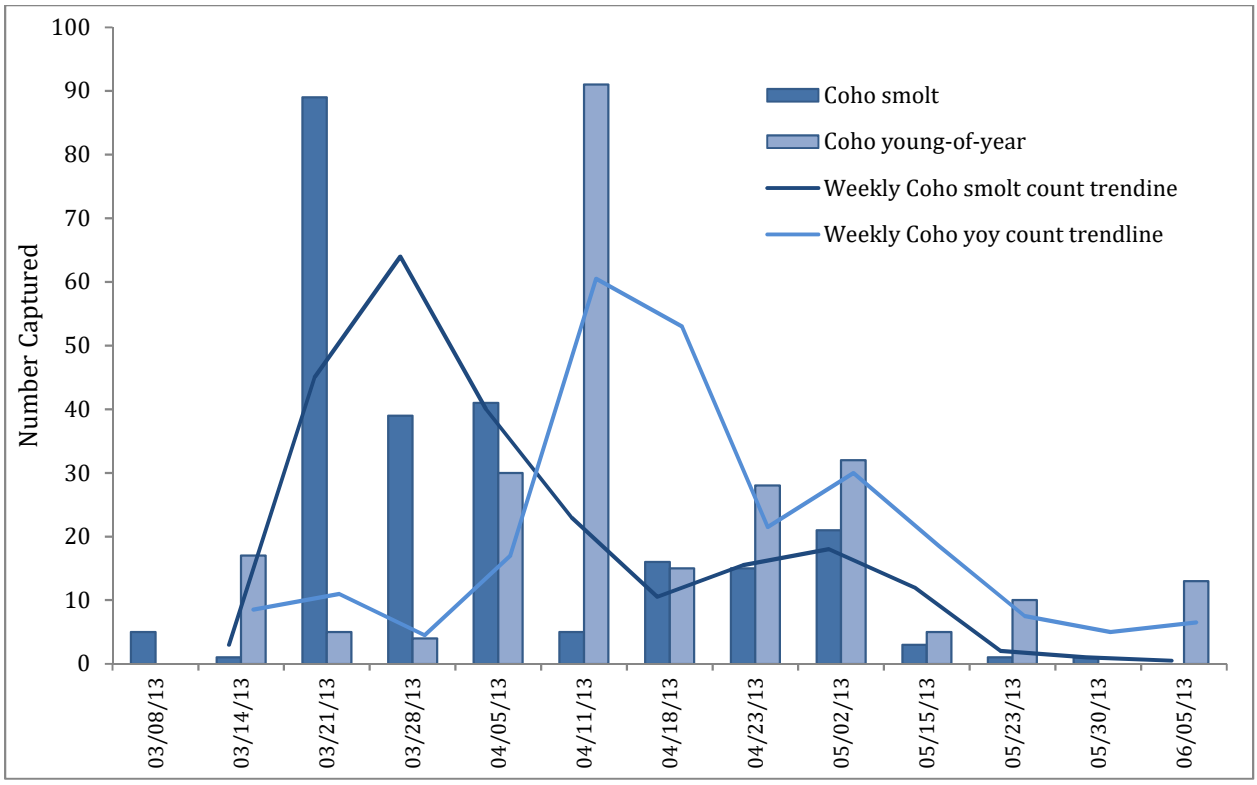
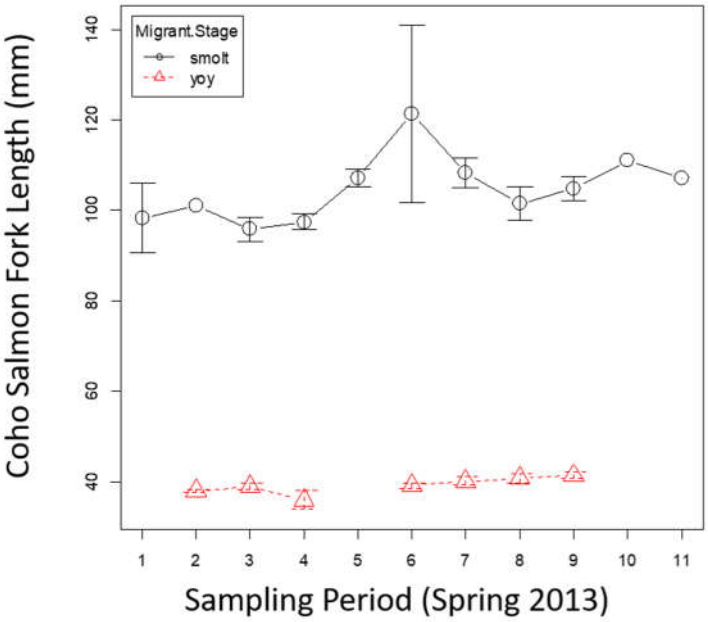


Figure 5. Juvenile Coho Salmon seine captures by date and age class from Elk Creek estuary, downstream of the Highway 101 culvert at the pedestrian footbridge, during the spring of 2013, Crescent City, CA.



Period	Date	Fork Length (mm) Smolt	YOY
1	8-Mar	98.3	-
2	14-Mar	101.0	38.0
3	21-Mar	95.8	39.0
4	28-Mar	97.4	36.0
5	5-Apr	107.2	-
6	11-Apr	121.4	39.2
7	18-Apr	108.3	40.2
8	23-Apr	101.5	40.8
9	2-May	104.9	41.4
10	15-May	111.0	-
11	23-May	107.0	-

Figure 6. Juvenile Coho Salmon fork lengths, by date and age group (yoy= young-of-the-year; smolt= yearling) from the Elk Creek estuary during the spring of 2013. Sampling location was downstream of the Highway 101 culvert at the pedestrian footbridge, Elk Creek, Crescent City, CA. Error bars represent standard error around the mean. The large error bar on period 6 smolts was caused by a 198 mm long smolt that likely spent two winters in Elk Creek before smolting.

Chinook Salmon

I captured YOY Chinook Salmon in the upper Elk Creek estuary on three occasions in two consecutive years (Table 2, Figure 3, Figure 7, Appendix A). In 2017, I captured three YOY Chinook Salmon on April 22 and two on June 6, one of which had strong visual smolting coloration. The fish pictured in Figure 7 is a Chinook Salmon parr captured on April 22, 2017; *note* squared off anal fin. On April 20, 2018 I captured seven YOY Chinook Salmon. Last, on April 22, 2017 I captured a yearling Chinook Salmon smolt with a fork length of 107 mm. Yearling Chinook Salmon are typically rare, however, it's important to define all potential life history expressions in a population. Fork lengths for YOY Chinook Salmon ranged from 42-81 mm. Although Chinook Salmon were only captured in two of the seven survey years, I documented three consecutive year classes (2016-2018). Spawner surveys in Elk Creek during 1999 documented 19 adult Chinook Salmon (Zeck 1999) (Figure 3) and three adult Chinook Salmon (Burgess 1999) (Figure 3) indicating they are reproducing in the watershed. Spawner surveys are needed to understand the current adult population size of Elk Creek.

Figure 7. Chinook Salmon YOY observed in Elk Creek, 5-22-2017.

Coastal Cutthroat Trout

I captured a total of 29 Coastal Cutthroat Trout across 12 different locations from 2013 to 2017 (Table 2, Figure 3, Appendix A). Coastal Cutthroat Trout were the most widely distributed salmonid in the watershed, occurring in a wide range of habitats from the estuary to many of the smaller headwater tributaries occurring upstream of Highway 101 and Elk Valley Road (Figure 3). A total of 27 individuals were juveniles having parr marks (mean size: 121 mm; Range: 91 mm to 141 mm). The two remaining individuals were of adults lacking parr marks (sizes: 139 mm and 145 mm). The capture size limitations of minnow traps likely reduced the number Coastal Cutthroat Trout available for capture and may have reduced my ability to detect them on some occasions at specific locations.

Rainbow Trout/ Steelhead

I could not always distinguish juvenile Coastal Cutthroat Trout from juvenile Rainbow Trout (including steelhead forms) making it difficult to understand Rainbow Trout distributions. However, I captured four juvenile trout *spp.* at three locations (Figure 3, Appendix A) that were likely Rainbow Trout based on color/-spot patterns, lack of red cut lines, and short maxillary bones. Other studies have identified juvenile Rainbow Trout in the past (Table 1), though only one has documented adult anadromous steelhead on a spawner survey (Burgess 1999) (*see* Figure 3 inset). Spawner surveys are needed to understand the current adult population size of Elk Creek.

Future work and Recommendations

Aquatic Faunal Inventories

Salmonid monitoring should focus on defining anadromous and resident salmonid distribution extents throughout the Elk Creek Watershed, especially in reaches where sampling has not occurred such as the three northwest tributaries that intersect Highway 101 and the two large ponds (Mill and Oxbow [Figure 3]). Furthermore, spawning habitats for various salmonids need to be spatially

inventoried given their suspected rarity and likely strong influence on overall basin-wide salmonid productivity. For example, all documented spawning locations have been restricted to a few small tributaries in the southeastern portion of the watershed upstream of Elk Valley Road. This general region has been locally defined as Nunes Creek though details on specific tributaries is confusing (*see* dotted polygon *in* Figure 3 for general confirmed spawning reaches). Further study on the spatial patterns of salmonids, especially rearing juveniles and adult Coastal Cutthroat Trout, would help define critical habitats, core space use, and potential proximal habitats visible in satellite imagery but currently severed through diking, levees and abandoned channels.

In general, very little is known about the aquatic community in Elk Creek. For example, one unidentified juvenile lamprey was noted in Garwood (2012) (Table 1) and various unidentified smelts were noted by Weise (2003) (Table 1). It would not be surprising to document spawning populations of longfin smelt (*Spirinchus thaleichthys*) (California ESA Threatened Species) or resident populations of Tidewater Goby (*Eucyclogobius newberryi*) (Federal ESA Endangered Species) in Elk Creek given its year-round connectivity to the Crescent City harbor and low-gradient freshwater channels available for spawning and rearing habitats. A study using eDNA could help determine if these rare and cryptic species occur in Elk Creek. However, a recent study by Sutter (2018) did not detect Tidewater Goby in Elk Creek using eDNA methods.

Figure 8. beaver-felled alder in Elk Creek, 2017.

Virtually nothing is known about aquatic amphibian and reptile populations potentially occurring in Elk Creek despite the watershed having extensive potential habitats. Both Western Pond Turtle (*Emys marmorata*) and Northern Red-legged Frog (*Rana aurora*) are California Species of Special Concern and use primarily lentic habitats. A population of Western Pond Turtles reside at Dead Lake in Tolowa Dunes State Park, just north of the Elk Creek Watershed. Elk Creek has similar ponded habitats, including the Mill Pond and Oxbow Pond (Figure 3), which should be surveyed for Western Pond Turtles and breeding Northern Red-legged Frogs. The headwaters of Elk Creek, Especially the northeast tributaries should be surveyed for Coastal Tailed Frogs (*Ascaphus truei*) and Southern Torrent Salamanders (*Rhyacotriton variegatus*), two headwater stream amphibians that are both California Species of Special Concern.

Last, because American Beavers (*Castor canadensis*) can have profound influences on characterizing and maintaining wetlands, a survey of their general distributions and influences on Elk Creek would provide managers details on their role in Elk Creek. Figure 8 illustrates a beaver-felled red alder was from the pond above Cooper Avenue that drains into Elk Creek. Beavers dammed up the pond outlet culvert that was later replaced due to a rusted out failing section. The beaver clogged culvert was pulled during culvert replacement to avoid flooding at Cooper Avenue.

Monitoring, Planning, and Restoration Considerations

- In addition to general faunal inventories, surveys of life stage-based habitat availability for salmonids would provide a detailed assessment of potential salmonid habitat bottlenecks and restoration opportunities. For example, some historic channels throughout lower Elk Creek appear

to be disconnected from the main channel through diking and channel reconfiguration. Additionally, the two ponds (Mill and Oxbow ponds [Figure 3]) should be assessed for salmonid habitat and their connectivity to Elk Creek given salmonids have been detected near these ponds in the past (Ecology and Environment 2001).

- Because of its proximity to the coast, Elk Creek is likely not temperature impaired. Since Coho Salmon were regularly detected in the upper Elk Creek estuary during the spring to early summer, future detailed water quality measurements would provide information regarding the seasonal salt wedge distribution as well as seasonal habitat availability to salmonids.

- The entire watershed should be thoroughly inspected for passage barriers to juvenile and adult salmonids under different discharge scenarios. For example, Highway 101 crosses Elk Creek at least three locations. These three culverts extend for 150 meters, 125 meters, and 50 meters respectively, making them some of the longest culverts in a coastal northern California Coho Salmon stream. All three of these crossings had juvenile Coho Salmon either above or below the culverts. Furthermore, given spawning gravel distribution is restricted to the higher gradient portions of the watershed, barriers impeding adult migration to spawning grounds are likely the most important passage issue, due to adult reproduction being a major limiting factor for salmonid productivity. This is especially important for the stream crossings along and above Elk Valley Road.

- Elk Creek receives considerable storm water runoff from the greater Crescent City area, measures to reduce direct runoff through low impact development designs would reduce flood amplitudes, improve low-flow conditions, improve water quality, and protect infrastructure.

- Because so little is known about the status of the Elk Creek watershed, better management of its natural resources would result from a stakeholder-based planning effort. Challenging issues such as habitat fragmentation from urbanization, habitat corridors connecting Elk Creek to Crescent City Marsh and Jedediah Smith State Park, legacy pollution from historic mill sites, sea-level rise, homeless encampments, etc., requires an organized and inclusive planning process.

Elk Creek meets the Pacific Ocean

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Appendix A. Fish sampling locations throughout the Elk Creek watershed (Crescent City, CA) from 2013 to 2018. Spatial coordinates were collected in UTM, NAD 83, Zone 10. Some coordinates are in close proximity representing the same general locations from separate visits and are thus not likely separate sites.

Location		Species Detected			
UTME	UTMN	Chinook Salmon	Coastal Cutthroat Trout	Coho Salmon	trout spp.
400247	4623966			x	
400249	4623959		x	x	
400458	4623760			x	
400737	4623588		x		
400783	4622891			x	
400803	4622861	x			
400897	4622950			x	
400908	4622974	x	x	x	
400909	4622971	x			
400911	4623335		x		
400916	4623338			x	
400942	4624719		x		
400969	4624675		x	x	
401296	4623159		x	x	
401588	4623458		x	x	
401693	4623576		x	x	
401749	4623700			x	
401779	4623869			x	
401790	4623796			x	
403180	4623793		x		
403290	4625345			x	
403787	4626945		x		
403811	4624466		x		
404142	4625202		x	x	x
404170	4625332			x	
404186	4625327		x	x	
404187	4625327		x	x	
404197	4625327		x	x	
404265	4625651				x
404412	4624781				x