JUVENILE SALMONID USE AND RESTORATION ASSESSMENT OF THE TIDAL PORTIONS OF SELECTED TRIBUTARIES TO HUMBOLDT BAY, CALIFORNIA, 2013-2015

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ABSTRACT

California Department of Fish and Wildlife and Pacific States Marine Fisheries Commission staff sampled the stream-estuary ecotone (SEE) of selected Humboldt Bay tributaries to document their use by juvenile salmonids and to assess estuarine habitat restoration projects. We sampled fish using seine nets and minnow traps baited with frozen salmon roe. Juvenile coho salmon (*Oncorhynchus kisutch*) was the most numerous salmonid captured but we also commonly captured Chinook salmon (*O. tshawytscha*), steelhead trout (*O. mykiss*), and cutthroat trout (*O.clarkii clarkii*). Sub-yearling coho salmon were present from April to December with peak catches occurring in the summer and fall. Their mean SEE residence time was one to two months but individual fish reared there for close to a year. Yearling-plus coho salmon were present primarily during the winter and spring. One group of Age 1+ coho arrived in the SEE in the fall and reared there throughout the winter and into the spring. A later group of Age 1+ coho emigrated through the SEE relatively quickly primarily during May. Juvenile Chinook salmon were present only in Freshwater Creek Slough in the late spring and early summer. Juvenile steelhead trout and cutthroat trout were captured throughout the year and some reared for months and possibly years in the SEE. Mean growth rates of juvenile salmonids in the ecotone were typically 0.15 to 0.25 mm/day which was higher than growth rates observed by other projects in stream habitats upstream of the SEE; however, juvenile salmonid growth rates in off channel ponds were usually higher. Juvenile salmonids sought out freshwater rather than brackish water habitat while rearing in the SEE. Juvenile salmonids, especially coho salmon, utilized newly constructed off channel ponds as soon as they were completed and fall/winter stream flow converted the ponds to fresh water habitat. Drought conditions from 2013 to 2015 affected SEE habitat in that higher water temperatures and salinities along with lower dissolved oxygen levels persisted for longer periods of time. Juvenile coho salmon delayed their fall arrival to the SEE, a higher than normal portion of yearling-plus coho salmon spent a second summer in SEE habitat, and juvenile salmonids were smaller and slower growing than most other years are all evidence that the drought altered juvenile salmonid behavior.

Introduction

Estuaries are important habitat for juvenile salmonids and other fish species. Numerous studies have documented extended estuarine residence by juvenile Chinook salmon *Oncorhynchus tshawytscha*, (Reimers 1971; Healey 1982; Kjelson et al.1982; Healey 1991), coho salmon *O. kisutch* (Tschaplinski 1982; Miller and Sadro 2003; Koski 2009), steelhead trout *O. mykiss*, (Bond et al. 2008), and sea-run coastal cutthroat trout *O.clarkii clarkii*, (Trotter 1997; Northcote 1997). Faster growth in the estuary and larger size at ocean entrance for estuarine rearing salmonids has been shown to account for higher marine survival (Nicholas and Hankin 1989; Northcote 1997; Pearcy 1997; Trotter 1997).

Studies on coho salmon have shown that larger individuals like those rearing in tidal habitat, experience greater over-winter survival in stream and estuary habitats (Ebersole et al. 2006; Roni et al. 2012). Studies have identified the importance of the greater transition zone, or ecotone (Odum 1971), between fresh and brackish water to juvenile coho salmon (Tschaplinski 1982; Miller and Sadro 2003; Koski 2009). Miller and Sadro (2003) defined this stream-estuary ecotone (SEE), and we adapted their definition. In our study, SEE was defined as the wetland area of low gradient stream extending from where the stream entered the tidal plain, through the upper limit of tidal influence on stream habitat, downstream to the channel bordered by tidal mudflats. This definition of the SEE includes all side channels, off channel ponds, tidal channels, and fringing marsh habitats that are accessible to fish for at least some portion of the tidal cycle.

In California, juvenile salmonid estuary studies have been conducted mostly in the Sacramento-San Joaquin Delta (Kjelson et al.1982; Sommer et al. 2001; Nobriga et al. 2005) or in coastal lagoons along the central coast (Bond et al. 2008; Hayes et al. 2008; Atkinson 2010). Some north-coast estuaries have also been studied such as the Klamath River (Wallace and Collins 1997), Mattole River (Zedonis 1992; Busby and Barnhart 1995) and Humboldt Bay tributaries (Wallace 2006; Wallace 2010; Wallace and Allen 2007, 2009, 2012, 2015). However, few studies have identified the importance of the SEE.

Recent studies conducted by Pacific States Marine Fisheries Commission (PSMFC) and California Department of Fish and Wildlife's (CDFW) Natural Stocks Assessment Project (NSA) in the tidal portions of Humboldt Bay tributaries have shown that juvenile salmonids heavily utilize SEE habitat and routinely rear there for months (Wallace 2006; Wallace and Allen 2007, 2009, 2012, 2015; CDFG 2009, 2010; Wallace et al. 2015). CDFW estimated that about 40% of coho salmon smolts and 80 to 90% of large steelhead trout smolts originated from the SEE of Freshwater Creek in 2007 and 2008 (Ricker and Anderson 2011). CDFW studies also have shown that juvenile salmonids using this habitat grew faster and obtained a larger size than juvenile salmonids rearing in stream habitat (Wallace and Allen 2007, 2009, 2012, 2015; Ricker and Anderson 2011; CDFG 2006, 2007, 2008; Wallace 2006; Wallace et al. 2015).

Multiple salmonid recovery plans encourage estuary and marsh habitat restoration projects around Humboldt Bay (CDFG 2004; HBWAC 2005; NMFS 2014). The majority of tidal wetlands around Humboldt Bay have been diked and converted to pasture land during the past 150 years (HBWAC 2005). Most of the Humboldt Bay sloughs are now contained between levees. Their adjacent marshes have been converted to pasture land and consequently the historic connectivity between slough channels and marsh habitat has been lost.

Currently, former marshlands around Humboldt Bay are being acquired by various public agencies for the purpose of habitat restoration. Willing private landowners are partnering with local land trusts and other non-profit groups to restore wetlands. The result is numerous SEE restoration projects are being planned and implemented in Humboldt Bay's tributaries and sloughs including constructing off channel ponds. CDFW/PSMFC monitored the effects of marsh restoration projects in Wood Creek, Salmon Creek, and Martin Slough on juvenile anadromous salmonid use and basic water quality conditions, specifically in the newly created off channel ponds.

The focus of this report is SEE sampling conducted during 2013- 2015 in Freshwater Creek and its tributaries Wood Creek and Ryan Creek, along with other Humboldt Bay tributaries including Salmon and Jacoby creeks (Figure 1). We also document the life history traits and use of SEE habitat by juvenile salmonids in addition to assessing the performance of estuarine habitat restoration projects.

STUDY AREA

Humboldt Bay is located 442 kilometers north of San Francisco, CA. and its watershed area is 57,756 hectares (HBWAC 2005). Its four largest tributaries are Freshwater Creek, Elk River, Salmon Creek, and Jacoby Creek (Figure 2). Numerous smaller tributaries, sloughs, and tidal streams also drain into Humboldt Bay (Figure 2).

Freshwater Creek Slough enters Humboldt Bay just north of Eureka via Eureka Slough. Freshwater Creek is a fourth order stream with a drainage area of approximately 9227 hectares. NSA observed tidal influence approximately nine kilometers upstream of the mouth of Eureka Slough at our sampling sites (Figure 3). The sampling area of Freshwater Creek Slough is characterized primarily by tidal freshwater habitat with dense stands of riparian vegetation, primarily in the form of willow (*Salix* spp.) and alder (*Alnus* spp.) trees. Brackish water up to 20 parts per thousand (ppt) occurs during the summer and fall in the lower portion of this area but further penetration of brackish water is usually blocked by the concrete base of the Humboldt Fish Action Council (HFAC) weir at river kilometer (rKm) 8.7 (Figure 3).

Wood Creek is a small tributary that enters Freshwater Creek Slough at approximately rKm seven and drains about 150 hectares (Figure 3). Brackish water up to 25 ppt occurs during the summer and fall in much of the sampling area but it is primarily

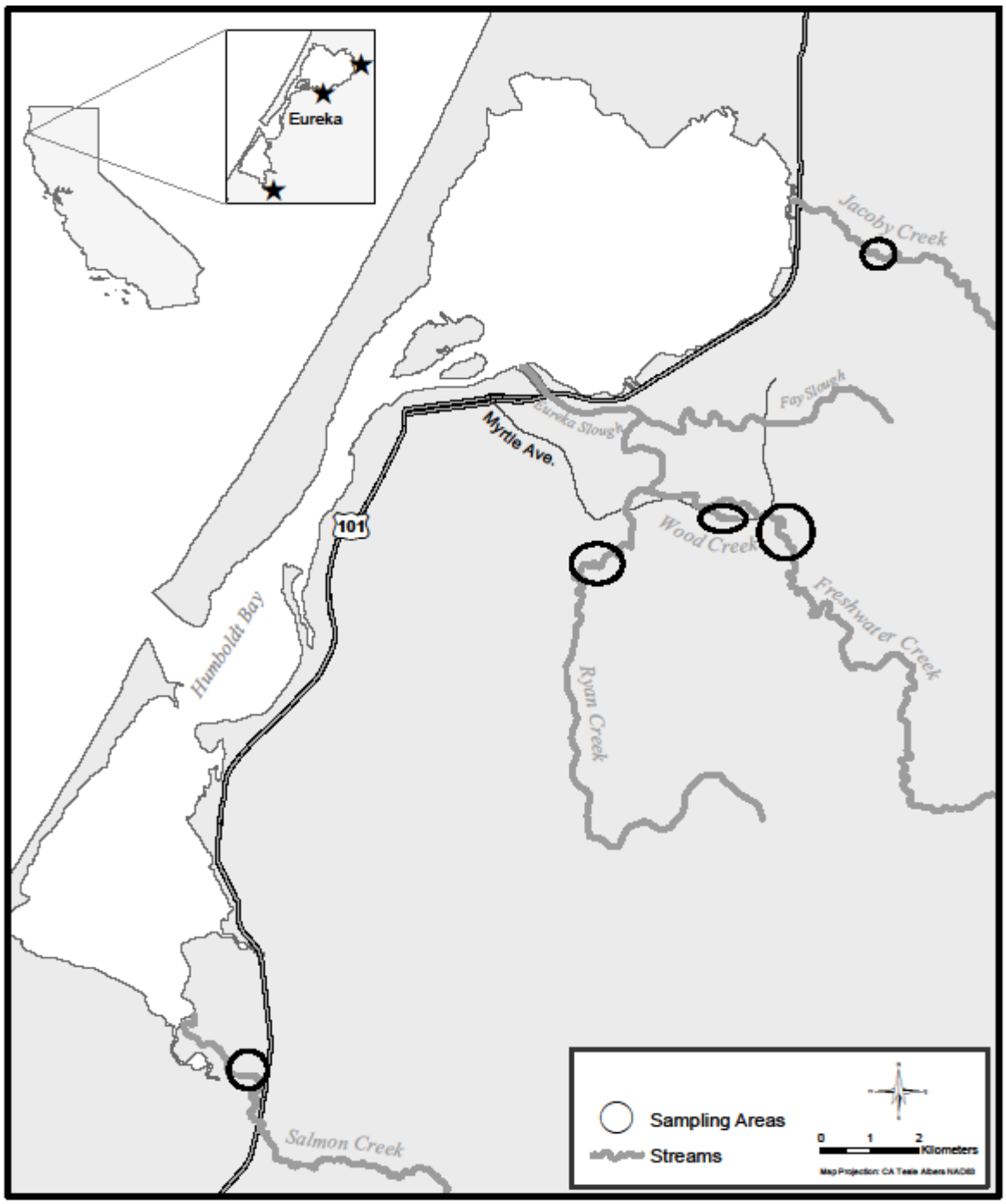

Figure 1. Sampling locations in the stream-estuary ecotone of Freshwater, Wood, Ryan, Salmon, and Jacoby creeks surveyed by Pacific States Marine Fisheries Commission and California Department of Fish and Wildlife from 2013 to 2015, Humboldt Bay, California.

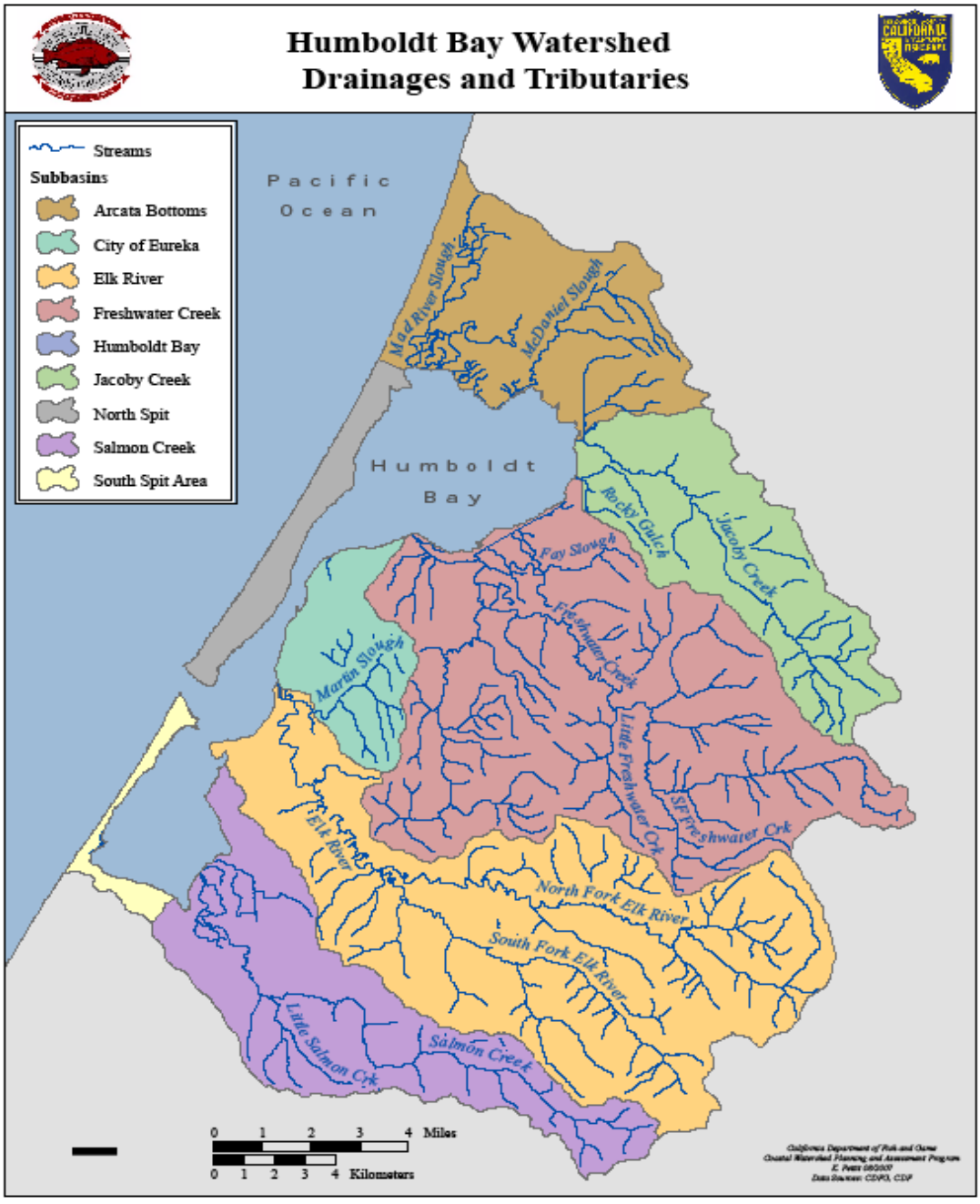

Figure 2. Map of Humboldt Bay, CA showing the names and locations of its largest tributaries.

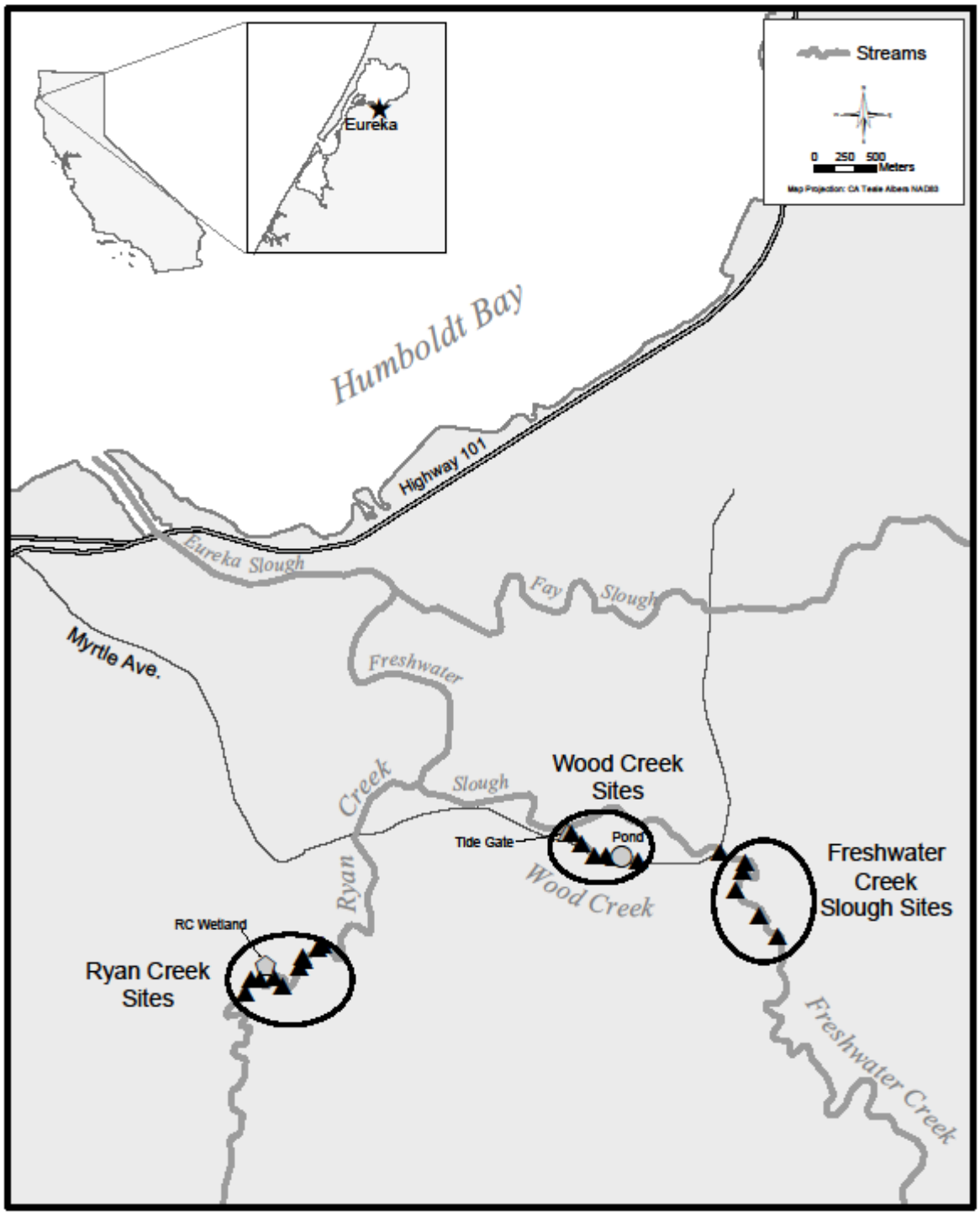

Figure 3. Sampling sites in the stream-estuary ecotone of Freshwater, Wood, and Ryan creeks surveyed by the California Department of Fish and Wildlife from 2013 to 2015.

freshwater during winter and early spring. The Northcoast Regional Land Trust planned and implemented an estuarine enhancement project on the lower 14 hectares of Wood Creek near its confluence with Freshwater Creek Slough. The project included the construction an off channel pond to increase rearing habitat for juvenile salmonids. Cattle continue to grave on part of the property, and the stream channel is low gradient, tidally influenced, and has limited riparian development.

Ryan Creek is the largest tributary of Freshwater Creek, and its slough enters Freshwater Creek Slough at about rKm six and drains about 3,315 hectares (Figure 3). The lower one kilometer of Ryan Creek is confined by levees and there is limited riparian development. The sampling area is owned by Green Diamond Resources Company (GDRC) and about 1/3 of the sampling sites experience brackish water up to 20 ppt during the summer and fall. The remaining sampling sites occur upstream in tidal freshwater habitat with dense stands of riparian vegetation, primarily in the form of alder and young coniferous trees. We also sampled a large wetland adjacent to Ryan Creek that is periodically flooded during the winter (Figure 3).

Salmon Creek enters the bay at the extreme southern end of Humboldt Bay via Hookton Slough (Figure 4), and drains approximately 5060 hectares (HBWAC 2005). The tidal portion of Salmon Creek is contained within the Humboldt Bay National Wildlife Refuge (Refuge). Cattail Creek and an old tidal meander at the mouth of Cattail Creek named Long Pond are adjacent to Salmon Creek and are part of the Refuge complex (Figure 4). New tide gates are located at the mouths of Salmon and Cattail creeks where they enter Hookton Slough. The tide gates allow for effective fish movement and mute tidal influence in both creeks. Brackish water up to 30 ppt occurs from late spring to late fall in much of the sampling area, but the upstream portion is mostly fresh water during the winter and early spring. The Refuge implemented a large habitat restoration project in 2011 that included relocating and enlarging both creeks' stream channels and constructing five off channel ponds on Salmon Creek to provide over winter habitat for juvenile salmonids.

Jacoby Creek enters the northern end of Humboldt Bay. A seasonal off channel pond on Jacoby Creek occurs upstream of tidal influence and remains freshwater until it dries up in the late summer or fall (Figure 5). The pond is disconnected from Jacoby Creek except during the highest winter flows. The pond was modified in the summer/fall of 2015 by creating better connectivity between the pond and stream during the winter and spring flows (Love 2014), and a second pond was constructed approximately 0.5 kilometers upstream to provide over-winter rearing habitat for juvenile salmonids. The stream channel is bordered by dense stands of riparian vegetation, primarily in the form of willow and alder trees. The lower pond has little riparian vegetation due to past cattle grazing.

Martin Slough is a tributary of Elk River Slough and enters just east of Highway 101near rKm 2.5 (Figure 5). A new tide gate was just installed at the mouth of Martin Slough to replace an old failing tide gate that had been in place for decades. The tide gates allow for effective fish movement and mute tidal influence in Martin Slough. Brackish water

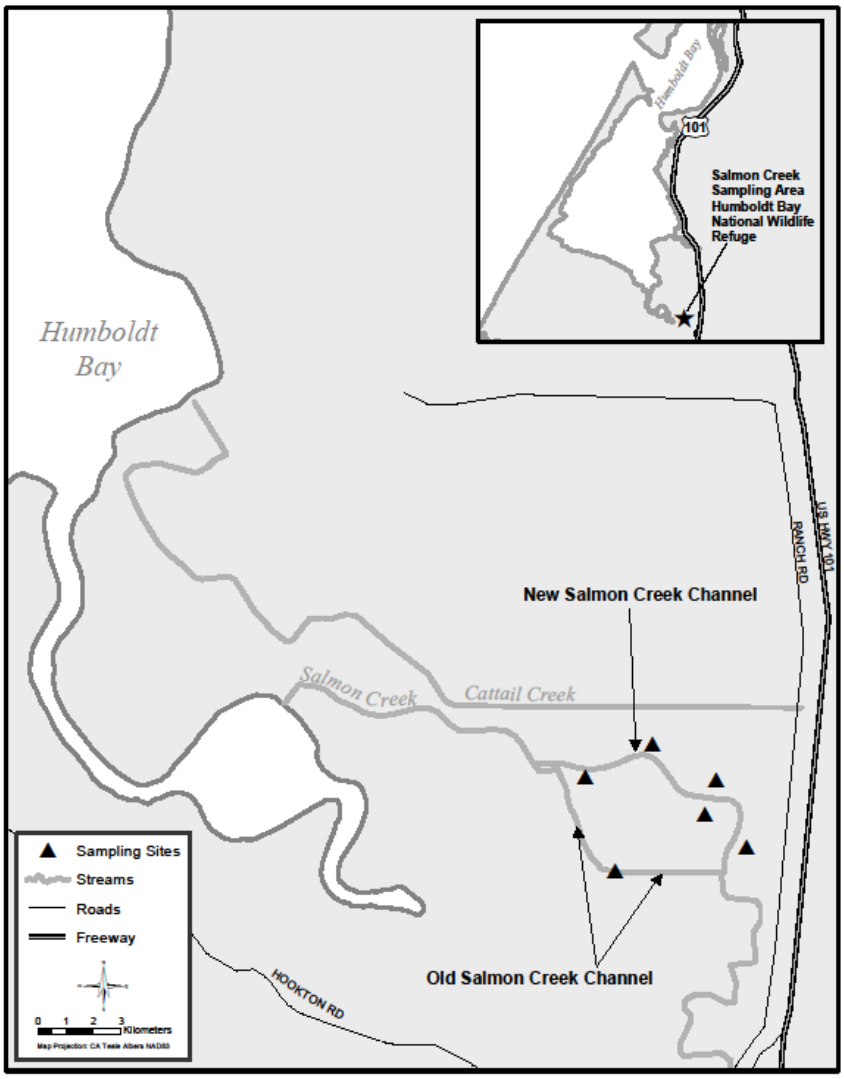

Figure 4. Sampling sites in the stream-estuary ecotone of Salmon Creek surveyed by California Department of Fish and Wildlife from 2013 to 2015.

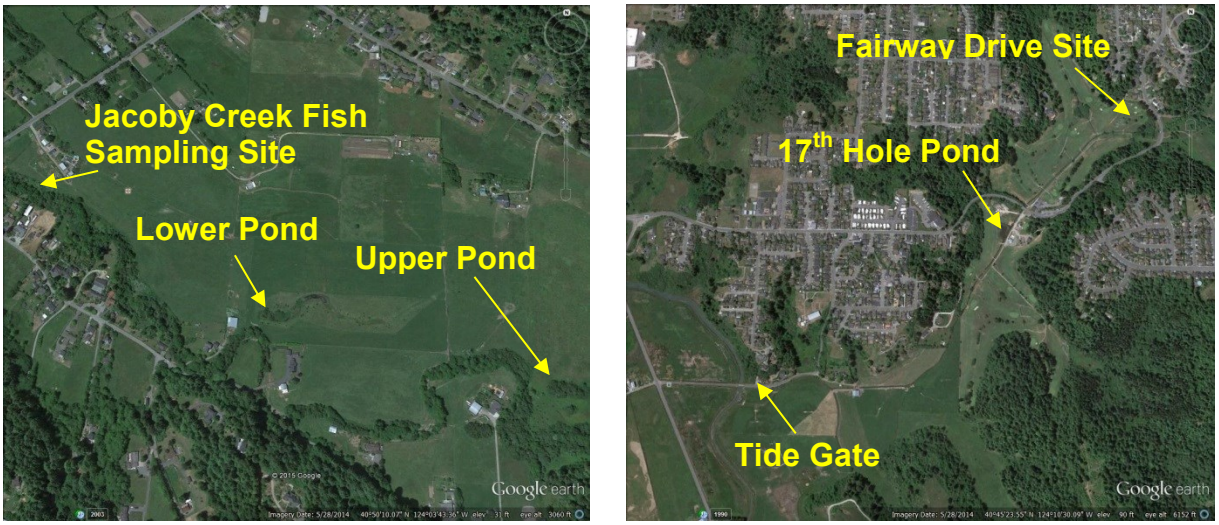

Figure 5. Approximate locations of fish and water quality sampling sites in Jacoby Creek (left) and Martin Slough (right).

up to 30 ppt is typically present from late spring to late fall near the tide gate and is also present at 5 to 15 ppt at the 17th hole off channel pond from mid-summer to late fall. Our sampling site at Fairway Drive remains fresh water throughout the year (Figure 5).

METHODS

From 2013 to 2015, we conducted bi-weekly sampling for juvenile salmonids in Freshwater, Ryan, and Salmon creeks, and the off channel pond in Wood Creek and monthly sampling in Martin Slough, Wood, Cattail, and Jacoby creeks and Jacoby Creek pond (Table 1). Crews used a 9.1 meter (m) X 1.2 m seine net to sample six sites in Freshwater Creek Slough, two sites in Martin Slough, and two sites in Cattail Creek; a 30.5 m X 1.5 m seine net to sample the off channel ponds on Wood Creek, Salmon Creek, and Martin Slough; and used minnow traps baited with frozen salmon roe to sample nine sites plus an adjacent wetland in Ryan Creek, six sites in Wood Creek, four sites in Cattail Creek, three sites in Martin Slough, one site in Jacoby Creek, and two sites in each of the constructed off channel ponds in Wood, Salmon, and Jacoby Creeks (Table 1). Minnow traps were used to sample heavily vegetated areas where we could not seine effectively.

Field crews anaesthetized, counted, and examined all juvenile salmonids for marks and tags. They also documented the life stage of each salmonid. Coho salmon were designated as “sub-yearling” or “yearling-plus” based on clear size differences between the smaller sub-yearling and larger yearling-plus fish. Coho salmon designated as sub-yearling fish prior to December 31 of each year were designated as yearling-plus fish starting January 1. For yearling-plus coho salmon, steelhead trout, and cutthroat trout, we also designated their development stage as parr (heavy parr marks present), pre-smolt (faded parr marks and silvery color), smolt (no parr marks visible and black fin

Table 1. The sampling methods, frequency, and duration for Freshwater, Wood, Ryan, Salmon, Cattail, and Jacoby creeks, Martin Slough, and Wood Creek and Jacoby Creek ponds sampled by California Department of Fish and Wildlife from 2013 to 2015.

Location	Method	Frequency	Duration
Freshwater Creek	9 m seine	bi-weekly	2013-2015
Wood Creek	minnow traps	monthly	2013-2015
Wood Cr Pond	30 m seine and minnow traps	bi-weekly	2013-2015
Ryan Creek	minnow traps	bi-weekly	2013-2015
Salmon Creek Ponds	30 m seine and minnow traps	bi-weekly	2013-2015
Cattail Creek	9 m seine and minnow traps	monthly	2013-2015
Martin Slough	30 and 9 m seines and minnow traps	monthly monthly	2014-2015 2014-2015
Jacoby Creek	minnow traps	monthly	2013-2015
Jacoby Cr Pond	minnow traps	monthly	2013-2015

edges), or adult. Crews also measured fork lengths (FL) to the nearest millimeter (mm), weights to the nearest 0.1 gram (g), and collected scales from the left side of all juvenile salmonids $\geq$ 50 mm except when the number of fish captured or environmental conditions made it dangerous to process the fish.

Passive Integrated Transponder (PIT) tags were applied to all healthy juvenile salmonids to gather residency, movement, and growth information while they were in the SEE. Per our NMFS 4(d) permit, the minimum size of fish tagged was $\geq$ 55 mm FL in 2013 and 2014 and $\geq$ 60 mm FL in 2015. The PIT tags were applied by making a small incision and inserting the tag into the body cavity. All fish $\geq$ 55 mm and $\leq$ 69mm FL received an 8.5 mm FDX tag and those $\geq$ 70 mm FL received an 11.5 mm HDX tag. Once processed, fish were allowed to recover and were released back into the sampling site. Fish already containing tags or marks were measured for FL, weighed, scale sampled on their right side, and their mark or tag number recorded. CDFW's Anadromous Fisheries Research and Monitoring Program (AFRAMP) and GDRC biologists applied PIT tags to juvenile salmonids in Freshwater Creek and Ryan Creek respectively. We kept records of all tag codes applied by our project and contacted AFRAMP and GDRC to identify all tag codes recovered.

The project maintained two paired PIT tag antenna arrays in Wood Creek; one at the entrance of the constructed off channel pond and one in the tide gate structure at the mouth of the creek (Figure 3). We also maintained one paired PIT tag antenna array at the opening of the second-most upstream pond in Salmon Creek (Figure 4) and at the midpoint of our sampling area in Ryan Creek (Figure 3). PIT tag detections were automatically stored on a data logger, and field staff downloaded these data every one to two weeks. The data were copied into Excel spreadsheets for future analyses.

We calculated the duration of estuarine residence for fish PIT-tagged in the SEE as the number of days between tagging and last capture or detection. For fish tagged outside the SEE (by other projects), we calculated estuarine residence as the number of days between first capture or detection in the SEE and last capture or detection. We calculated growth rates for fish PIT-tagged in the SEE as the change in FL between tagging and last capture divided by the number of days between tagging and last recapture. For fish tagged outside the SEE, growth rates were calculated as the change in FL between first and last captures in the SEE divided by the number of days between first and last captures.

We also conducted water quality sampling bi-weekly at the off channel ponds in Wood Creek and Salmon Creek, monthly in Wood Creek, and monthly in Jacoby Creek and off channel pond with YSI Professional Plus hand-held meters. Temperature, salinity, and dissolved oxygen data were collected in the ponds and adjacent slough habitat. Due to stratification between fresh and brackish water, water samples were collected at surface, mid, and bottom elevations when water depths $\geq$ 0.91 m, surface and bottom elevations when water depth was $\geq$ 0.46 m, and < 0.91 m, and bottom elevation when depths were < 0.46 m.

RESULTS

FRESHWATER CREEK SLOUGH

Freshwater Creek Slough 2013 to 2015

In 2013 the peak monthly catch-per-unit-effort (CPUE) for sub-yearling coho salmon was 4.13 fish/set in October (Table 2). Sub-yearling coho salmon monthly mean FL increased from 41 mm in April to 79 mm in September and then ranged from 64 to71 mm October to December (Table 3). In 2013, the peak monthly CPUE for yearling-plus coho salmon was 6.00 fish/set in April (Table 2). Yearling-plus coho salmon monthly mean FL increased from 75 mm in February to 126 mm in November (Table 3). Sub-yearling Chinook salmon were captured in May and June and their peak monthly CPUE was 0.32 fish/set in May (Table 2). Their monthly mean FL increased from 48 mm in May to 63 mm in June (Table 3). Juvenile steelhead trout were captured throughout the year with a peak monthly CPUE of 1.05 fish/set in May (Table 2). Their monthly mean FL ranged from 91 to 171 mm (Table 4). Cutthroat trout were captured throughout the year with a peak monthly CPUE of 0.71 fish/set in August (Table 2). Their monthly mean FL ranged from 127 to 224 mm (Table 4).

Table 2. Monthly effort (number of seine hauls) and catch-per-unit-effort (CPUE; number of fish per seine haul) of juvenile coho and Chinook salmon and steelhead and cutthroat trout captured by seine nets in Freshwater Creek Slough, 2013.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	29	0	0	0.03	0	0
February	24	0.04	0	0.08	0.04	0
March	22	1.82	0	0.09	0.05	0
April	22	6.00	0.32	0.41	0.32	0
May	22	4.77	1.00	1.05	0.27	0.32
June	24	1.83	3.33	0.38	0.25	0.08
July	36	0.31	2.97	0.25	0.22	0
August	24	0.13	1.63	0.46	0.71	0
September	24	0.13	2.00	0.17	0.42	0
October	24	0	4.13	0.17	0.13	0
November	24	0.04	3.42	0.51	0	0
December	20	0	1.05	0.08	0.20	0.15

Table 3. Number measured, mean fork-length (FL), and standard deviation (SD) of yearling-plus coho salmon (1+ coho), sub-yearling coho salmon (yoy coho), and sub-yearling Chinook salmon (yoy CH) captured by seine nets in Freshwater Creek Slough, 2013.

Month	No. 1+ Coho	Mean FL 1+ Coho	SD 1+ Coho	No. yoy Coho	Mean FL yoy Coho	SD yoy Coho	No. yoy CH	Mean FL yoy CH	SD yoy CH
January	-	-	-	-	-	-	-	-	-
February	1	75	-	-	-	-	-	-	-
March	40	89	10.4	-	-	-	-	-	-
April	73	98	16.2	7	41	3.1	-	-	-
May	105	94	10.0	22	54	6.0	7	48	5.0
June	44	103	6.0	81	56	10.6	2	63	6.4
July	10	105	4.4	107	68	8.7	-	-	-
August	3	108	12.7	39	77	6.7	-	-	-
September	3	106	11.7	48	79	7.6	-	-	-
October	-	-	-	99	64	11.6	-	-	-
November	1	126	-	82	71	12.6	-	-	-
December	-	-	-	21	66	7.4	-	-	-

Table 4. Number measured, mean fork-length (FL), and standard deviation (SD) of juvenile steelhead and cutthroat trout captured by seine nets in Freshwater Creek Slough, 2013.

Month	No. Steelhead Trout	Mean FL Steelhead Trout	SD Steelhead Trout	No. Cutthroat Trout	Mean FL Cutthroat Trout	SD Cutthroat Trout
January	1	171	-	-	-	-
February	2	164	15.6	2	188	24.7
March	2	123	54.4	1	127	-
April	9	91	12.9	6	158	54.8
May	23	106	23.4	4	131	29.8
June	8	122	33.6	6	187	44.6
July	5	121	46.3	6	194	29.7
August	8	154	26.7	14	198	29.6
September	3	112	32.3	10	224	38.5
October	1	129	-	3	200	36.6
November	8	112	49.6	-	-	-
December	3	121	67.5	3	180	22.3

In 2014, the peak monthly CPUE of 1.08 fish/set for sub-yearling coho salmon occurred in October (Table 5). Sub-yearling coho salmon monthly mean FL increased from 44 mm in May to 81 mm in November and December (Table 6). In 2014, we captured yearling-plus coho salmon every month of the year and their peak monthly CPUE of 6.95 fish/set occurred in April (Table 5). Their monthly mean FL increased from 70 mm in January to 115 mm in December (Table 6). The peak monthly CPUE of juvenile steelhead trout was 0.50 fish/set in October (Table 5). Their monthly mean FL ranged from 61 to 156 mm (Table 7). The peak monthly CPUE of cutthroat trout was 0.77 fish/set in May (Table 5). Their monthly mean FL ranged from 103 to 207 mm (Table 7). We did not capture any sub-yearling Chinook salmon in 2014 (Table 5).

In 2015, we captured sub-yearling coho salmon April to December and their peak monthly CPUE was 6.25 fish/set in July (Table 8). Sub-yearling coho salmon monthly mean FL increased from 41 mm in April to 76 mm in October and then were slightly smaller in November (Table 9). In 2015, we captured yearling-plus coho salmon February to November and their peak monthly CPUE was 1.59 fish/set in April (Table 8). Their monthly mean FL increased from 95 mm in February to 116 mm in November (Table 9). The peak monthly CPUE of juvenile steelhead trout was 0.63 fish/set in June (Table 8). Their monthly mean FL ranged from 100 to 158 mm except for one 53 mm individual captured in December (Table 10). The peak monthly CPUE of cutthroat trout was 0.39 fish/set in August (Table 8). Their monthly mean FL ranged from 167 to 231 mm except for one 242 mm individual captured in December (Table 7). We captured sub-yearling Chinook salmon in April and May and their peak catch of 0.23 fish/set

Table 5. Monthly effort (number of seine hauls) and catch-per-unit-effort (CPUE; number of fish per seine haul) of juvenile coho and Chinook salmon and steelhead and cutthroat trout captured by seine nets in Freshwater Creek Slough, 2014.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	24	1.75	0	0	0	0
February	22	6.27	0	0.36	0.05	0
March	24	5.42	0	0.25	0.04	0
April	21	6.95	0	0.14	0.38	0
May	22	5.72	0.27	0.23	0.77	0
June	24	1.33	0.42	0.21	0.29	0
July	36	0.36	1.00	0.44	0.31	0
August	24	0.46	0.88	0.33	0.25	0
September	24	0.46	0.92	0.38	0.29	0
October	24	0.29	1.08	0.50	0.29	0
November	24	0.46	0.79	0.04	0.25	0
December	22	0.14	0.64	0.05	0	-

Table 6. Number measured, mean fork-length (FL), and standard deviation (SD) of yearling-plus coho salmon (1+ coho), sub-yearling coho salmon (yoy coho), and sub-yearling Chinook salmon (yoy CH) captured by seine nets in Freshwater Creek Slough, 2014.

Month	No. 1+ Coho	Mean FL 1+ Coho	SD 1+ Coho	No. yoy Coho	Mean FL yoy Coho	SD yoy Coho	No. yoy CH	Mean FL yoy CH	SD yoy CH
January	42	70	8.51	-	-	-	-	-	-
February	138	80	10.32	-	-	-	-	-	-
March	130	86	11.81	-	-	-	-	-	-
April	146	94	11.72	-	-	-	-	-	-
May	126	96	9.61	6	44	4.76	-	-	-
June	32	99	7.71	10	60	4.47	-	-	-
July	13	106	6.76	36	68	5.03	-	-	-
August	11	104	6.03	21	69	4.76	-	-	-
September	11	104	8.15	22	74	7.27	-	-	-
October	7	106	5.94	26	79	4.73	-	-	-
November	11	111	9.97	19	81	5.53	-	-	-
December	3	115	18.52	14	81	10.86	-	-	-

Table 7. Number measured, mean fork-length (FL), and standard deviation (SD) of juvenile steelhead and cutthroat trout captured by seine nets in Freshwater Creek Slough, 2014.

Month	No. Steelhead Trout	Mean FL Steelhead Trout	SD Steelhead Trout	No. Cutthroat Trout	Mean FL Cutthroat Trout	SD Cutthroat Trout
January	-	-	-	-	-	-
February	8	80	24.39	1	195	-
March	6	139	36.77	1	103	-
April	3	87	7.51	3	169	77.91
May	5	126	45.47	17	147	52.96
June	5	98	23.40	7	135	51.03
July	16	119	33.82	11	172	26.73
August	7	156	24.19	6	187	22.80
September	9	129	33.96	7	186	29.99
October	12	127	30.93	7	192	24.54
November	1	128	-	6	207	41.83
December	1	61	-	-	-	-

Table 8. Monthly effort (number of seine hauls) and catch-per-unit-effort (CPUE; number of fish per seine haul) of juvenile coho and Chinook salmon and steelhead and cutthroat trout captured by seine nets in Freshwater Creek Slough, 2015.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	22	0	0	0	0	0
February	20	1.10	0	0.25	0.05	0
March	36	0.81	0	0.28	0.11	0
April	22	1.59	1.77	0.50	0.18	0.14
May	22	1.14	4.36	0.14	0.05	0.23
June	24	0.58	3.96	0.63	0.17	0
July	24	0.54	6.25	0.50	0.29	0
August	23	0.22	5.48	0.52	0.39	0
September	36	0.17	3.19	0.11	0.31	0
October	24	0.17	3.96	0.13	0.13	0
November	24	0.08	1.75	0.21	0.13	0
December	12	0	0.08	0.08	0.08	0

Table 9. Number measured, mean fork-length (FL), and standard deviation (SD) of yearling-plus coho salmon (1+ coho), sub-yearling coho salmon (yoy coho), and sub-yearling Chinook salmon (yoy CH) captured by seine nets in Freshwater Creek Slough, 2015.

Month	No. 1+ Coho	Mean FL 1+ Coho	SD 1+ Coho	No. yoy Coho	Mean FL yoy Coho	SD yoy Coho	No. yoy CH	Mean FL yoy CH	SD yoy CH
January	-	-	-	-	-	-	-	-	-
February	22	95	12.3	-	-	-	-	-	-
March	29	103	7.8	-	-	-	-	-	-
April	35	105	11.3	39	41	2.4	3	52	2.3
May	26	109	17.6	96	49	5.9	5	62	5.8
June	15	105	11.5	95	62	7.2	-	-	-
July	13	106	8.8	149	69	6.6	-	-	-
August	6	107	6.4	126	72	5.9	-	-	-
September	6	112	5.5	115	73	6.0	-	-	-
October	5	112	4.1	94	76	6.6	-	-	-
November	2	116	4.2	42	74	10.3	-	-	-
December	-	-	-	1	53	-	-	-	-

Table 10. Number measured, mean fork-length (FL), and standard deviation (SD) of juvenile steelhead and cutthroat trout captured by seine nets in Freshwater Creek Slough, 2015.

Month	No. Steelhead Trout	Mean FL Steelhead Trout	SD Steelhead Trout	No. Cutthroat Trout	Mean FL Cutthroat Trout	SD Cutthroat Trout
January	0	-	-	-	-	-
February	5	111	36.1	1	198	-
March	10	137	46.2	4	196	29.3
April	11	100	12.7	4	220	13.8
May	3	135	27.5	0	-	-
June	15	112	27.5	4	181	52.8
July	12	116	23.3	7	211	42.7
August	12	141	25.3	9	201	43.8
September	4	131	55.9	11	211	57.6
October	3	158	46.5	3	167	22.6
November	5	153	36.4	3	231	61.0
December	1	53	-	1	242	-

occurred in May (Table 8). Their monthly mean FL increased from 52 mm in April to 62 mm in May (Table 10).

Recaptured PIT Tagged Fish 2013 to 2015

In 2013, PIT tags were applied to 201 sub-yearling coho salmon in Freshwater Creek Slough, and 99 fish (49.3%) were recaptured (Table 11). The mean length of estuarine residence for recaptured fish was 45 days and ranged from 6-140 days (Table 11[5]). The mean growth rate of recaptured sub-yearling coho was 0.20 mm/day and ranged from -0.07 to 0.86 mm/day (Table 11). PIT tags were applied to 222 yearling-plus coho salmon in 2013 and 49 fish (22.1%) were recaptured. The mean length of estuarine residence for recaptured fish was 32 days and ranged from 6-140 days (Table 11[6]). The mean growth rate for recaptured yearling-plus coho salmon was 0.30 mm/day and ranged from 0 to 0.58 mm/day (Table 11). We also recaptured six coho salmon that were tagged by AFRAMP in the Freshwater Creek basin; five in the fall of 2011 and one in the fall of 2010. We applied PIT tags to 62 juvenile steelhead trout in 2013 and recaptured 15 (24.2%) fish. They were at-large between 13-238 days and they grew 1 to 33 mm (0.05 to 0.42 mm/day) during that time. PIT tags were applied to 36 cutthroat trout in 2013, and eight (22.2%) were recaptured. Cutthroat trout were at-large between 13-118 days and they grew -2 to 14 mm (-0.05 to 0.34 mm/day) during that time. Our project also captured another two juvenile steelhead trout and three cutthroat trout that were tagged by other projects in other locations in the Freshwater Creek basin. It is likely that some of the cutthroat trout captured by our project were resident adult fish.

Table 11. Summarized information for sub-yearling coho salmon PIT tagged by Natural Stocks Assessment Project in Freshwater Creek Slough including number tagged, number and percent recaptured, mean and range of days at liberty (DAL) of recaptured fish, and mean and range of recaptured coho salmon growth rate (mm/day).

Year	No. Tagged	No. Recaptured	Percent Recaptured	Mean DAL	Range DAL	Mean Growth Rate	Range Growth Rate
2006	237	57	24.1	33	5-106	0.15	0.00-0.29
2007	65	12	18.5	68	6-167	0.17	0.12-0.45
2008	11	0	0	-	-	-	-
2009	152	69	45.4	60	13-175	0.20	0.00-0.68
2010	60	12	20.0	41	16-113	0.23	0.12-0.48
2011	520	74	14.2	52	12-165	0.25	0.00-0.93
2012	555	303	54.6	58	12-140	0.17	-0.07-0.63
2013	201	99	49.3	45	6-140	0.20	-0.07-0.86
2014	61	27	44.3	62	13-140	0.16	0.00-0.40
2015	252	120	47.6	71	13-152	0.08	0.00-0.27

[5] Table 11 includes PIT information from 2013, 2014, and 2015 and the previous seven years.
[6] Table 11 includes PIT information from 2013, 2014, and 2015 and the previous seven years.

In 2014, we applied PIT tags to 61 sub-yearling coho salmon in Freshwater Creek Slough and recaptured 27 (44.3%) fish (Table 11). The mean length of estuarine residence for recaptured fish was 62 days and ranged from 13-140 days (Table 11). The mean growth rate of recaptured sub-yearling coho salmon was 0.16 mm/day and ranged from 0 to 0.40 mm/day (Table 11). We applied PIT tags to 395 yearling-plus coho salmon and recaptured 91 (23.0%) fish. We also recaptured 26 yearling-plus coho salmon that were tagged by AFRAMP or by our project the previous year. The mean length of estuarine residence by all recaptured yearling-plus coho salmon was 40 days and ranged from 7-224 days. The mean growth rate of recaptured yearling-plus coho salmon was 0.31 mm/day and ranged from -0.08 to 0.71 mm/day. PIT tags were applied to 61 juvenile steelhead trout in 2014 and seven fish (11.5%) were recaptured. We also recaptured one steelhead trout that was tagged by AFRAMP or by our project the previous year. All recaptured steelhead trout were at-large for 14-98 days and grew 1 to 9 mm (0.02 to 0.24 mm/day) during that time. PIT tags were applied to 50 cutthroat trout in 2014, and eight fish (16.0%) were recaptured. We also recaptured two cutthroat trout that were tagged by AFRAMP or by our project in previous years. They were at-large for 14-210 days and grew -1 to 43 mm (-0.07 to 0.20 mm/day). It is likely that some of the cutthroat trout captured by our project were resident adult fish.

In 2015, we applied PIT tags to 252 sub-yearling coho salmon in Freshwater Creek Slough and recaptured 120 (47.6%) fish (Table 11). The mean length of estuarine residence for recaptured fish was 71 days and ranged from 13-152 days (Table 11). The mean growth rate of recaptured sub-yearling coho salmon was 0.08 mm/day and ranged from 0-0.27 mm/day (Table 11). We applied PIT tags to 87 yearling-plus coho salmon and recaptured 13 (14.9%) fish. We also recaptured one yearling-plus coho salmon that was tagged by NSA in 2014 and 25 that were tagged by AFRAMP in Freshwater Creek in the fall of 2014 or at the HFAC weir in 2015. The mean length of estuarine residence for all 39 recaptured yearling-plus coho salmon was 47 days and ranged from 1 to 287 days. The mean growth rate of recaptured yearling-plus coho salmon at large >13 days was 0.18 mm/day and ranged from 0 to 0.57 mm/day. PIT tags were applied to 55 juvenile steelhead trout in 2015 and 14 fish (25.5%) were recaptured. We also recaptured one steelhead trout that was tagged by our project the previous year. The 15 fish were at-large for 13 to 209 days and grew 1 to 41 mm (0.01 to 0.27 mm/day) during that time. We also recaptured one steelhead trout that was tagged by our project in Freshwater Creek Slough in August 2012 (1,141 days). It grew 146 mm (0.13 mm/day) while at large. PIT tags were applied to 25 cutthroat trout in 2015, and six fish (24.0%) were recaptured. We also recaptured six cutthroat trout that were tagged by our project in previous years. They were at-large for 13 to 716 days and grew -2 to 159 mm (-0.15 to 0.30 mm/day). It is likely that some of the cutthroat trout captured by our project were resident adult fish.

WOOD CREEK

Wood Creek 2013 to 2015

In 2013, juvenile coho salmon were the most abundant salmonids captured in Wood Creek and Wood Creek pond. We captured 140 yearling-plus coho salmon, 21 sub-yearling coho salmon, one steelhead trout, and two cutthroat trout during minnow trapping in Wood Creek (Table 12). In Wood Creek, yearling-plus coho salmon were captured from January to June, sub-yearling coho salmon from October to December, and the steelhead trout and cutthroat trout in March. Peak catches of yearling-plus and sub-yearling coho salmon occurred in April and December, respectively (Table 12). While seining Wood Creek pond, CPUE ranged from 0 to 2.25 fish/set for yearling-plus coho salmon and 0 to 3.00 fish/set for sub-yearling coho salmon with peak catches occurring in February and November, respectively (Table 13). Monthly mean FL for yearling-plus coho salmon varied from 71-85 mm (Table 14). Monthly mean FL for sub-yearling coho salmon varied from 61 to 95 mm (Table 14).

In 2014, juvenile coho salmon were the most abundant salmonids captured in Wood Creek and Wood Creek pond. We captured 195 yearling-plus coho salmon and three cutthroat trout in minnow traps in Wood Creek (Table 15). In Wood Creek, yearling-plus coho salmon were captured January to May and again in December, and cutthroat trout were captured in May and December (Table 15). Peak catches of yearling-plus coho salmon occurred in March (Table 15). In Wood Creek, monthly mean FL for yearling-plus coho salmon varied from 65-90 mm and sub-yearling coho salmon was 72 mm FL in December (Table 16). While seining Wood Creek pond, CPUE ranged from 0 to 1.00 fish/set for yearling-plus coho salmon and 0 to 0.50 fish/set for sub-yearling coho salmon (Table 17). Yearling-plus coho salmon were captured in the pond in March and April and sub-yearling coho salmon were captured in December (Table 17).

In 2015, juvenile coho salmon were the most abundant salmonids captured in Wood Creek and Wood Creek pond. We captured 94 yearling-plus coho salmon in minnow traps in Wood Creek (Table 18). In Wood Creek, yearling-plus coho salmon were captured January to May and their peak catches occurred in March (Table 18). Their monthly mean FL varied from 85-97 mm (Table 19). While seining Wood Creek pond, CPUE ranged from 0 to 0.50 fish/set for yearling-plus coho salmon and 0 to 8.00 fish/set for sub-yearling coho salmon (Table 20). Yearling-plus coho salmon were captured in the pond in January, February, and April and sub-yearling coho salmon were captured in April, July, and December (Table 20). Fork lengths ranged from 88 to 100 mm for yearling-plus coho salmon and 43 to 86 mm for sub-yearling coho salmon.

Recaptured PIT Tagged Fish 2013 to 2015

In 2013, we applied PIT tags to 156 yearling-plus coho salmon in Wood Creek and Wood Creek Pond and recaptured 22 (14.1%) fish. The recaptured fish were at large 4 to 59 days, and they grew 0 to 27 mm (0 to 0.85 mm/day) during that time. Ten of the recaptured yearling-plus coho were tagged and recaptured in the Pond $\geq$13 days later.

Table 12. Monthly effort (number of traps) and number of juvenile salmonids captured by minnow traps in Wood Creek, 2013.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	7	3	0	0	0	0
February	8	13	0	0	0	0
March	8	46	0	1	2	0
April	8	75	0	0	0	0
May	8	2	0	0	0	0
June	8	1	0	0	0	0
July	7	0	0	0	0	0
August	7	0	0	0	0	0
September	7	0	0	0	0	0
October	7	0	1	0	0	0
November	8	0	4	0	0	0
December	8	0	16	0	0	0
Total	**91**	**140**	**21**	**1**	**2**	**0**

Table 13. Monthly effort (number of seine hauls) and catch-per-unit-effort (CPUE; number of fish per seine haul) of juvenile salmonids captured by seine nets in Wood Creek pond, 2013.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	5	0	0	0	0	0
February	4	2.25	0	0	0	0
March	3	1.67	0	0	0	0
April	4	0	0	0	0	0
May	4	0	0	0	0	0
June	2	0	0	0	0	0
July	2	0	0	0	0	0
August	2	0	0	0	0	0
September	2	0	0	0	0	0
October	3	0	1.33	0	0	0
November	2	0	3.00	0	0	0
December	0	0	0	0	0	0

Table 14. Number measured, mean fork-length (FL), and standard deviation (SD) of yearling-plus coho salmon (1+ coho), sub-yearling coho salmon (yoy coho), and sub-yearling Chinook salmon (yoy CH) captured by minnow traps in Wood Creek, 2013.

Month	No. 1+ Coho	Mean FL 1+ Coho	SD 1+ Coho	No. yoy Coho	Mean FL yoy Coho	SD yoy Coho	No. yoy CH	Mean FL yoy CH	SD yoy CH
January	3	76	4.0	-	-	-	-	-	-
February	13	85	11.9	-	-	-	-	-	-
March	46	79	8.7	-	-	-	-	-	-
April	75	85	9.9	-	-	-	-	-	-
May	2	80	0.71	-	-	-	-	-	-
June	1	71	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-
August	-	-	-	-	-	-	-	-	-
September	-	-	-	-	-	-	-	-	-
October	-	-	-	1	61	-	-	-	-
November	-	-	-	4	95	9.0	-	-	-
December	-	-	-	16	76	18.1	-	-	-

Table 15. Monthly effort (number of traps) and number of juvenile salmonids captured by minnow traps in Wood Creek, 2014.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	8	10	0	0	0	0
February	12	4	0	0	0	0
March	7	142	0	0	0	0
April	8	34	0	0	0	0
May	8	4	0	0	1	0
June	7	0	0	0	0	0
July	7	0	0	0	0	0
August	7	0	0	0	0	0
September	7	0	0	0	0	0
October	7	0	0	0	0	0
November	7	0	0	0	0	0
December	8	1	0	0	2	0
Total	**93**	**195**	**0**	**0**	**3**	**0**

Table 16. Number measured, mean fork-length (FL), and standard deviation (SD) of yearling-plus coho salmon (1+ coho), sub-yearling coho salmon (yoy coho), and sub-yearling Chinook salmon (yoy CH) captured by minnow trap and seine in Wood Creek, 2014.

Month	No. 1+ Coho	Mean FL 1+ Coho	SD 1+ Coho	No. yoy Coho	Mean FL yoy Coho	SD yoy Coho	No. yoy CH	Mean FL yoy CH	SD yoy CH
January	10	95	9.3	-	-	-	-	-	-
February	4	60	5.5	-	-	-	-	-	-
March	143	72	9.9	-	-	-	-	-	-
April	38	85	13.0	-	-	-	-	-	-
May	4	94	7.1	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-
August	-	-	-	-	-	-	-	-	-
September	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-
December	-	-	-	2	72	4.2	-	-	-

Table 17. Monthly effort (number of seine hauls) and catch-per-unit-effort (CPUE; number of fish per seine haul) of juvenile salmonids captured by seine nets in Wood Creek pond, 2014.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	0	-	-	-	-	-
February	0	-	-	-	-	-
March	6	0.17	0	0	0	0
April	4	1.00	0	0	0	0
May	4	0	0	0	0	0
June	2	0	0	0	0	0
July	3	0	0	0	0	0
August	1	0	0	0	0	0
September	1	0	0	0	0	0
October	3	0	0	0	0	0
November	3	0	0	0	0	0
December	2	0	0.50	0	0	0

Table 18. Monthly effort (number of traps) and number of juvenile salmonids captured by minnow traps in Wood Creek, 2015.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	7	15	0	0	0	0
February	8	12	0	0	0	0
March	13	44	0	0	0	0
April	8	21	0	0	0	0
May	7	2	0	0	0	0
June	7	0	0	0	0	0
July	7	0	0	0	0	0
August	7	0	0	0	0	0
September	7	0	0	0	0	0
October	7	0	0	0	0	0
November	7	0	0	0	0	0
December	8	0	0	0	0	0
Total	**93**	**94**	**0**	**0**	**0**	**0**

Table 19. Number measured, mean fork-length (FL), and standard deviation (SD) of yearling-plus coho salmon (1+ coho), sub-yearling coho salmon (yoy coho), and sub-yearling Chinook salmon (yoy CH) captured by minnow trap and seine in Wood Creek, 2015.

Month	No. 1+ Coho	Mean FL 1+ Coho	SD 1+ Coho	No. yoy Coho	Mean FL yoy Coho	SD yoy Coho	No. yoy CH	Mean FL yoy CH	SD yoy CH
January	15	85	8.9	-	-	-	-	-	-
February	12	96	13.4	-	-	-	-	-	-
March	27	92	7.5	-	-	-	-	-	-
April	21	97	12.2	-	-	-	-	-	-
May	2	92	2.8	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-
August	-	-	-	-	-	-	-	-	-
September	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-

Table 20. Monthly effort (number of seine hauls) and catch-per-unit-effort (CPUE; number of fish per seine haul) of juvenile salmonids captured by seine nets in Wood Creek pond, 2015.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	4	0.25	0	0	0	0
February	4	0.25	0	0	0	0
March	3	0	0	0	0	0
April	4	0.50	0.25	0	0	0
May	3	0	0	0	0	0
June	2	0	0	0	0	0
July	3	0	0.25	0	0	0
August	2	0	0	0	0	0
September	2	0	0	0	0	0
October	4	0	0	0	0	0
November	2	0	0	0	0	0
December	1	0	8.00	0	0	0

These fish had mean growth rate of 0.39 mm/day (range 0 to 0.85 mm/day). Seven of the recaptured yearling-plus coho were tagged and recaptured at sites other than the Pond $\geq$13 days later and these fish had a mean growth rate of 0.28 mm/day (range 0.03 to 0.42 mm/day). We did not apply or recapture enough PIT tags from other species to calculate estuarine residence or growth rates.

In 2014, we applied PIT tags to 184 yearling-plus coho salmon in Wood Creek and recaptured eight fish (4.3%). We also recaptured five yearling-plus coho that were tagged in Wood Creek by our project in November and December 2013. The 13 recaptured yearling-plus coho salmon were at large 28 to 121 days, and they grew 1 to 28 mm (0.03 to 0.89 mm/day) during that time. We also PIT tagged two sub-yearling coho salmon and three cutthroat trout and did not recapture any of them.

In 2015, we applied PIT tags to 68 yearling-plus coho salmon in Wood Creek and recaptured seven (10.3%). We also recaptured three yearling-plus coho salmon that were tagged in Wood and Freshwater creeks by our project in 2014. All 10 recaptured yearling-plus coho salmon were at large 18 to 164 days, and they grew 0 to 21 mm (0 to 0.33 mm/day) during that time. We also PIT tagged five sub-yearling coho and did not recapture any of them.

PIT Tag Antenna Detections Wood Creek 2012/13 Season

From September 2012 to August 2013 the pond antenna detected 76 coho salmon. Individual coho salmon were first detected on November 30, 2012 and last detected on May 11, 2013, though most had left the pond by the end of March. The number of first detections peaked in December and March (n=32 and 29 respectively). Of the 76 coho salmon detected in the pond, 42 were tagged and released into the pond, 11 were NSA tagged fish from Wood Creek, six were tagged by NSA in Freshwater Creek Slough in the summer of 2012, 14 were tagged upstream in Freshwater Creek basin by AFRAMP during the fall of 2012, and three were tagged by NSA or Green Diamond Resource Company in Ryan Creek (Table 21). Thirty three of the 76 coho salmon were detected in the pond on more than one day. These fish had an average time between first and last detection (a surrogate for residence time) of 16 days (1 to 93 days).

From September 2012 to August 2013, the tide gate antenna detected 666 coho salmon, four juvenile steelhead trout, 16 cutthroat trout, and four Pacific lamprey. Individual coho salmon were first detected on September 13, 2012 and last detected on August 16, 2013. Most coho salmon were first detected in April (n=216) and May (n=185) 2013 corresponding with the traditional spring out-migration. Another first detection peak occurred in November (n=75) and December (n=83) illustrating that a

Table 21. Origin of PIT tagged juvenile coho salmon tagged in Freshwater Creek basin detected at Wood Creek pond antennas during January to September 2010, October 2010 to October 2011, October 2011 to July 2012, September 2012 through August 2013, and September 2013 through August 2014, and September 2014 to August 2015.

Fish Origin	**2010**	**10/11**	**11/12**	**12/13**	**13/14**	**14/15**
Stream Estuary Ecotone	7	1	-	1	0	1
Lower Mainstem Freshwater Creek	11	6	26	2	0	6
Middle Mainstem Freshwater Creek	-	11	16	1	1	4
Upper Mainstem Freshwater Creek	7	6	12	4	0	4
Little Freshwater Creek	12	-	-	-	-	-
Cloney Gulch	9	4	6	4	0	1
South Fork Freshwater Creek	-	0	10	2	0	1
Freshwater Creek (total)	46	28	70	14	1	17
Wood Creek Pond	74	8	199	42	5	2
Wood Creek	27	19	20	11	11	13
Ryan Slough/Creek	0	0	7	3	0	0
Freshwater Creek Slough	5	0	8	6	0	2
HFAC Weir	1	0	2	0	4	1
Estuary Ecotone (total)	107	27	236	62	20	18
Grand Total	153	55	306	76	21	35

large redistribution of juvenile coho salmon occurred in the fall after the first rains. Most individual fish were last detected in April/May and November/December, lending additional evidence that late fall and spring were the times of peak movement of coho salmon out of Freshwater Creek to the SEE. Of the 666 coho salmon detected at the tide gate antenna 236 were detected on more than one day. These fish had an average time between first and last detection (a surrogate for residence time) of 25 days (1 to 188 days). Overall, the tide gate antenna detected 546 coho salmon that were either tagged upstream of the SEE and then detected multiple times in the SEE, or were tagged in the SEE so that we could calculate a minimum SEE residence time for these fish. Their mean residence time in the SEE was 51 days (range 1 to 332 days).

Of the 666 coho salmon detected at the tide gate, 151 were tagged by AFRAMP upstream in Freshwater Creek basin during the fall of 2012 and two were tagged in the fall of 2011. These 153 coho salmon were comprised of 33 from Cloney Gulch, 31 from the middle mainstem Freshwater Creek, 29 from the lower mainstem, 26 from the upper mainstem, 23 from South Fork Freshwater Creek, and 11 from the SEE (Table 22). The remaining coho salmon were comprised of 221 fish tagged at the HFAC weir (220 tagged in 2013 and one tagged in 2012), 95 tagged in Ryan Creek (48 by GDRC biologists at their screw-trap, 10 by GDRC biologists in Ryan Creek during the fall of

Table 22. Origin of PIT tagged juvenile coho salmon tagged in Freshwater Creek basin detected at Wood Creek tide gate antennas during January to September 2010, October 2010 to October 2011, October 2011 to July 2012, September 2012 through August 2013, September 2013 through August 2014, and September 2014 to August 2015.

Fish Origin	**2010**	**10/11**	**11/12**	**12/13**	**13/14**	**14/15**
Stream Estuary Ecotone	9	30	-	11	16	3
Lower Mainstem Freshwater Creek	11	49	75	29	32	25
Middle Mainstem Freshwater Creek	-	79	51	31	43	16
Upper Mainstem Freshwater Creek	10	59	34	26	35	19
Little Freshwater Creek	13	-	-	-	-	-
Cloney Gulch	8	45	23	33	30	13
South Fork Freshwater Creek	-	13	31	23	16	10
Freshwater Creek (total)	51	275	214	153	172	86
Wood Creek Pond	33	3	138	22	5	2
Wood Creek	48	35	69	89	44	43
Ryan Slough/Creek	26	5	71	95	56	3
Freshwater Creek Slough	11	10	67	86	47	19
HFAC Weir	165	123	155	221	104	109
Estuary Ecotone (total)	283	176	501	513	256	176
Grand Total	334	451	715	666	428	262

2012, and 37 by NSA in Ryan Creek Slough), 89 tagged by NSA and released into Wood Creek (83 in 2013 and six in 2012), 86 tagged by NSA in Freshwater Creek Slough (12 in 2013 and 74 in 2012), and 22 fish tagged by NSA and released into Wood Creek pond (16 in 2013 and six in 2012) (Table 22).

The four steelhead trout detected at the tide gate were first detected on December 12, 2012 and last detected on August 12, 2013. Three were detected on only one day and the other was detected over a five day period. Two detected steelhead trout were tagged by NSA in Freshwater Creek Slough in 2012, one was tagged by NSA in Wood Creek in March 2013, and the other was tagged at the HFAC weir site in May 2013. Their length of SEE residence ranged from 16 to 228 days. The 16 cutthroat trout were detected from March to August 2013. Eleven were tagged in Ryan Creek (seven by NSA in Ryan Creek Slough and four by GDRC in Ryan Creek), two by NSA in Freshwater Creek Slough, two by AFRAMP at the HFAC weir, and one by NSA in Wood Creek. One cutthroat was tagged at the HFAC weir in April 2010 and was detected in August of 2013 (1,185 days). The remaining cutthroat trout were at large 1 to 400 days. The Pacific lamprey were detected at the tide gate in April 2013. Three were tagged by AFRAMP at the HFAC weir in April 2013 and were at large 11 to 17 days. One was tagged at the HFAC weir in April 2012 and was at large 373 days.

PIT Tag Antenna Detections Wood Creek 2013/14 Season

The Wood Creek tide gate antenna components were stolen near New Year's Day so we have no data from the tide gate location from December 18, 2013 to January 10, 2014. We moved the Pond antenna array to the tide gate location so we did not collect data at the Pond from January 7 to March 30, 2014, likely substantially reducing the number of detections at this site.

From September 2013 to August 2014 the pond antenna detected 21 coho salmon and one cutthroat trout. Coho salmon were first detected in the pond on December 3, 2013 and last detected on May 29, 2014. Six coho were first detected in December 2013 and the remaining 15 were first detected March through May 2014 with a peak of eight fish in April. These modest peaks corresponded with the redistribution of juvenile coho salmon in the fall after the first rains and the traditional smolt emigration in the spring. Of the 21 coho salmon detected in the pond, 11 were NSA tagged fish from Wood Creek (four in 2013 and seven in 2014), five were tagged and released into the pond by NSA (three in 2013 and two in 2014), four were tagged by AFRAMP at the HFAC weir in 2014, and one was tagged upstream in Freshwater Creek basin by AFRAMP during the fall of 2013 (Table 21). Twelve of the 21 coho salmon were detected in the pond on more than one day. These fish had an average time between first and last detection (a surrogate for residence time) of 24 days (1 to122 days).

The cutthroat trout was detected at the pond only on April 3. It was tagged by AFRAMP at the HFAC weir on March 20 and so it was at large in the SEE for 14 days.

From September 2013 to August 2014, the tide gate antenna detected 428 juvenile coho salmon, three adult coho salmon, six juvenile steelhead trout, three adult steelhead trout, 21 cutthroat trout, and one Pacific lamprey. Individual coho salmon were first detected on September 20, 2013 and last detected on July 4, 2014.

For the first time in the five year operation of the tide gate antenna we did not detect a fall redistribution of juvenile coho salmon from Freshwater Creek downstream to the SEE. Only nine juvenile coho salmon were detected from September 2013 through January 2014 and all of these fish were tagged in the SEE. Most coho salmon were first detected at the tide gate in February 2014 (n=151), the month with the first substantial rainfall of the season. February was also the first month where we detected PIT tagged coho salmon from Freshwater Creek. We detected 248 coho salmon from March through May corresponding with the time of traditional smolt emigration in the spring. This illustrates that a large redistribution of juvenile coho salmon occurs with the first large rain and stream flow events of the season regardless of whether they occur in the fall or later in the winter.

Of the 428 juvenile coho salmon detected at the tide gate 172 (40.1%) were comprised of fish tagged by AFRAMP upstream of the SEE in Freshwater Creek basin (171 tagged in 2013 and 1 in 2012). These 172 coho were comprised of 43 fish from the middle mainstem Freshwater Creek, 35 from the upper mainstem, 32 from the lower mainstem, 30 from Cloney Gulch, 16 from the South Fork Freshwater Creek, and 16 from the SEE (Table 22). The remaining coho salmon were comprised of 104 fish tagged by AFRAMP at the HFAC weir (103 tagged in 2014 and 1 in 2013), 56 tagged in Ryan Creek (35 by GDRC in 2014, 12 by GDRC in 2013, one by GDRC in 2012, and eight by NSA in the stream-estuary ecotone), 47 tagged by NSA in Freshwater Creek Slough (25 tagged in 2014 and 22 tagged in 2013), 44 tagged and released into Wood Creek by NSA (38 tagged in 2014 and six tagged in 2013), and five tagged and released by NSA into Wood Creek pond (one tagged in 2014 and four tagged in 2013) (Table 22).

The six steelhead trout detected at the tide gate were first detected on October 3, 2013 and last detected on May 20, 2014. All six steelhead were detected on only one day at the tide gate antenna. Three detected steelhead trout were tagged by NSA in Ryan Creek Slough (two in 2013 and one in 2012), one was tagged by NSA in Freshwater Creek Slough in February 2014, and the other two were tagged by GDRC in Ryan Creek (one at the screw trap in 2014 and one upstream of the SEE in 2013. Their length of SEE residence ranged from 0 to 360 days. The 21 cutthroat trout were first detected on September 5, 2013 and last detected on July 19, 2014. Thirteen were tagged in Ryan Creek (seven by NSA in Ryan Creek Slough and six by GDRC in Ryan Creek), six by NSA in Freshwater Creek Slough, one at the HFAC weir, and one by NSA in Wood Creek. The cutthroat trout were detected at the tide gate antenna for 0 to 212 days but were at large in the SEE 1 to 599 days. All three adult coho salmon were detected at the tide gate antenna in January 2014. Two were tagged by GDRC, one at the Ryan Creek screw trap in 2012 and one in Ryan Creek upstream of the SEE in 2011. The other coho salmon was tagged at the HFAC weir in June 2012. The adult steelhead trout were detected January and February 2014. Two were originally tagged

at the HFAC weir (one in 2012 and one in 2010) and the other was tagged by GDRC in Ryan Creek in 2011.

PIT Tag Antenna Detections Wood Creek 2014/15 Season

The tide gate antenna malfunctioned from December 31, 2014 to January 15, 2015 and January 29 to February 1, 2014.

From September 2014 to August 2015 the pond antenna detected 35 coho salmon and one cutthroat trout. Coho salmon were first detected in the pond on October 17, 2014 and last detected on May 4, 2015. December 2014 was the month with the most first detections with 12, and corresponded with the fall redistribution of juvenile coho salmon downstream to the SEE after the first large rains and stream flow events. The remaining 23 were first detected October 2014 through May 2015 with a peak of six fish in April. Of the 35 coho salmon detected in the pond, 16 were tagged upstream in Freshwater Creek basin by AFRAMP during the fall of 2014, 13 were NSA tagged fish from Wood Creek (12 in 2015 and one in 2014), two were tagged and released into the pond by NSA in the 2014-15 season, three were tagged by NSA and AFRAMP in the SEE (two in 2014 and one in 2013), and one was tagged by AFRAMP at the HFAC weir in 2014 (Table 21). Twelve of the 35 coho salmon were detected at the pond on more than one day. These fish had an average time between first and last detection (a surrogate for residence time) of 18 days (1 to 73 days).

The cutthroat trout was detected at the pond only on April 22. It was tagged by NSA in Freshwater Creek Slough on March 31 and so it was at large in the SEE for 22 days.

From September 2013 to August 2014, the tide gate antenna detected 262 juvenile coho salmon, one adult coho salmon, one steelhead trout, 13 cutthroat trout, one unidentified trout, and seven Pacific lamprey. Individual coho salmon were first detected on September 29, 2014 and last detected on August 12, 2015. Most coho salmon were first detected in May (n=94) and June (n=47) 2015 corresponding with the traditional spring out-migration. Another first detection peak occurred in December (n=35) and November (n=22) 2014 illustrating that a large redistribution of juvenile coho salmon occurred in the fall after the first rains. Of the 262 coho salmon detected at the tide gate antenna 120 were detected on more than one day. These fish had an average time between first and last detection at the Wood Creek antennas (a surrogate for residence time) of 40 days (1 to 208 days). Overall, the tide gate antenna detected 221 coho salmon that were either tagged upstream of the SEE and then detected multiple times in the SEE, or were tagged in the SEE so that we could calculate a minimum SEE residence time for these fish. Their mean residence time in the SEE was 53 days (range 1 to 609 days).

Of the 262 juvenile coho salmon detected at the tide gate 86 (32.8%) were comprised of fish tagged by AFRAMP upstream of the SEE in Freshwater Creek basin (85 tagged in 2014 and one in 2013). These 86 coho were comprised of 25 fish from the lower mainstem Freshwater Creek, 19 from the upper mainstem, 16 from the middle mainstem, 13 from Cloney Gulch, 10 from the South Fork Freshwater Creek, and three

from the SEE (Table 22). The remaining coho salmon were comprised of 109 fish tagged by AFRAMP at the HFAC weir, 43 tagged and released into Wood Creek by NSA, 19 tagged by NSA in Freshwater Creek Slough, three tagged in Ryan Creek, and two tagged and released by NSA into Wood Creek pond (Table 22).

The steelhead trout was detected at the tide gate between April 9 and June 20, 2015. It was also detected at the Ryan Creek antenna on May 5, 2015 indicating it was moving over a large area of the SEE. It was tagged by NSA in Ryan Creek Slough on August 19, 2013, and so was at large 670 days. The 13 cutthroat trout were detected from September 2014 to August 2015. Seven were tagged by NSA in Freshwater Creek Slough (one in 2015 and six in 2014), four were tagged by NSA in Ryan Creek Slough (two in 2014 and two in 2013), and two were tagged by AFRAMP at the HFAC weir in 2015. The cutthroat trout mean length of SEE residence was 250 days (range 22 to 766 days). The Pacific lamprey were detected at the tide gate from April to June 2015. All were tagged by AFRAMP at the HFAC weir from March to May 2015 and were at large 11 to 61 days.

RYAN CREEK SLOUGH

Ryan Creek Slough 2013 to 2015

In 2013, yearling-plus coho salmon were the most abundant salmonids captured in Ryan Creek Slough and the adjacent wetland (Table 23). NSA captured 644 yearling-plus coho salmon, 99 sub-yearling coho salmon, 43 juvenile steelhead trout, and 65 cutthroat trout (Table 23). NSA captured yearling-plus coho salmon January to September and sub-yearling coho salmon from June to December with peak catches occurring in April and November, respectively (Table 23). Steelhead trout peak catch occurred in May and cutthroat trout peak catch occurred in June (Table 23).

Monthly mean FL for yearling-plus coho salmon increased from 82 in January to102 mm in September (Table 24). Yearling-plus coho salmon captured in the adjacent wetland were smaller than those captured in Ryan Creek. From January to May 2013, the months coho salmon were captured in the wetlands, the mean FL's of coho salmon was 77 $\pm$ 11 mm (n=183) from the wetland and 93 $\pm$ 11 mm (n=442) from the stream. The monthly mean FL of sub-yearling coho salmon increased from 66 mm in June to 89 mm in September and then dropped to 68 to 78 mm October to December (Table 24). Monthly mean FL varied from 88 to 147 mm for steelhead trout and 115 to 137 mm for cutthroat trout (Table 25).

In 2014, juvenile coho salmon were the most abundant salmonids captured in Ryan Creek Slough and the adjacent wetland. NSA captured 375 yearling-plus coho salmon, four sub-yearling coho salmon, 29 steelhead trout, and 98 cutthroat trout (Table 26). NSA captured yearling-plus coho salmon January to December and sub-yearling coho in November and December with peak catches occurring in April and November, respectively (Table 26). Peak catches occurred in July for steelhead trout and June for cutthroat trout (Table 26).

Table 23. Effort (number of traps) and number of juvenile salmonids captured by minnow traps in Ryan Creek Slough, 2013.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	22	124	0	4	5	0
February	22	124	0	2	4	0
March	22	134	0	3	4	0
April	33	201	0	3	8	0
May	22	46	0	9	6	0
June	22	9	2	4	11	0
July	22	4	3	2	6	0
August	22	1	7	4	5	0
September	22	1	12	5	5	0
October	33	0	28	4	5	0
November	22	0	46	3	6	0
December	11	0	1	0	0	0
Total	**275**	**644**	**99**	**43**	**65**	**0**

Table 24. Number measured, mean fork-length (FL), and standard deviation (SD) of yearling-plus coho salmon (1+ coho), sub-yearling coho salmon (yoy coho), and sub-yearling Chinook salmon (yoy CH) captured by minnow traps in Ryan Creek Slough, 2013.

Month	No. 1+ Coho	Mean FL 1+ Coho	SD 1+ Coho	No. Yoy Coho	Mean FL Yoy Coho	SD Yoy Coho	No. Yoy CH	Mean FL Yoy CH	SD Yoy CH
January	124	82	12.1	0	-		0	-	-
February	124	83	12.5	0	-		0	-	-
March	134	85	12.0	0	-		0	-	-
April	201	95	11.8	0	-		0	-	-
May	42	100	11.3	0	-		0	-	-
June	9	100	10.1	2	66	2.1	0	-	-
July	4	100	13.9	3	76	1.2	0	-	-
August	1	101	-	7	85	5.3	0	-	-
September	1	102	-	12	89	4.6	0	-	-
October	0	-	-	28	77	12.9	0	-	-
November	0	-	-	46	78	14.6	0	-	-
December	0	-	-	1	68	-	0	-	-

Table 25. Number measured, mean fork-length (FL), and standard deviation (SD) of juvenile steelhead and cutthroat trout captured by minnow traps in Ryan Creek Slough, 2013.

Month	No. Steelhead Trout	Mean FL Steelhead Trout	SD Steelhead Trout	No. Cutthroat Trout	Mean FL Cutthroat Trout	SD Cutthroat Trout
January	4	121	20.2	5	128	21.7
February	2	130	4.9	4	132	20.7
March	3	126	6.0	4	127	26.1
April	3	88	13.4	8	115	17.1
May	9	117	19.2	6	123	33.1
June	4	126	16.4	11	123	13.1
July	2	111	8.5	6	120	6.2
August	7	119	7.13	5	127	4.1
September	4	117	28.0	5	126	10.5
October	5	143	13.8	5	134	15.1
November	4	147	21.0	6	137	15.0
December	3	139	9.2	0	-	-

Table 26. Monthly effort (number of traps) and number of juvenile salmonids captured by minnow traps in Ryan Creek Slough, 2014.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	22	20	0	1	2	0
February	22	22	0	1	3	0
March	22	79	0	0	8	0
April	33	148	0	3	13	0
May	22	64	0	2	13	0
June	20	10	0	4	16	0
July	22	6	0	10	13	0
August	22	8	0	4	8	0
September	33	7	0	2	14	0
October	22	3	0	2	4	0
November	22	7	3	0	3	0
December	22	1	1	0	1	0
Total	**284**	**375**	**4**	**29**	**98**	**0**

Monthly mean FL for yearling-plus coho salmon increased from 79 mm in January to 123 mm in December (Table 27). Yearling-plus coho salmon captured in the adjacent wetland were smaller than those captured in Ryan Creek. In March and April 2014, the months coho salmon were captured in the wetlands, the mean FL's of coho salmon was 78 ± 10 mm (n=30) from the wetland and 93 ± 12 mm (n=190) from the stream. The FL of sub-yearling coho salmon ranged from 55 to 85 mm. Monthly mean FL varied from 98 to 144 mm for steelhead trout and 111 to 147 mm for cutthroat trout (Table 28).

In 2015, juvenile coho salmon were the most abundant salmonids captured in Ryan Creek Slough and the adjacent wetland. NSA captured 92 yearling-plus coho salmon, 33 sub-yearling coho salmon, three steelhead trout, and 21 cutthroat trout (Table 29). NSA captured yearling-plus coho salmon January to July and sub-yearling coho May to December except for July. Peak catches occurred in January for yearling-plus coho salmon and August for sub-yearling coho salmon (Table 29). Juvenile steelhead trout were captured in January, June, and July and cutthroat trout were captured March to November, except for August (Table 29).

Monthly mean FL for yearling-plus coho salmon increased from 97 mm in January to 113 mm in May and then was comprised by smaller individuals in June and July (Table 30). We only captured one yearling-plus coho salmon in the adjacent wetland this year. It was captured in February and was 96 mm FL. The monthly mean FL of sub-yearling coho salmon increased from 44 mm in May to 100 mm in November (Table 30). The

Table 27. Number measured, mean fork-length (FL), and standard deviation (SD) of yearling-plus coho salmon (1+ coho), sub-yearling coho salmon (yoy coho), and sub-yearling Chinook salmon (yoy CH) captured by minnow traps in Ryan Creek Slough, 2014.

Month	No. 1+ Coho	Mean FL 1+ Coho	SD 1+ Coho	No. yoy Coho	Mean FL yoy Coho	SD yoy Coho	No. yoy CH	Mean FL yoy CH	SD yoy CH
January	20	79	12.1	-	-	-	-	-	-
February	22	84	10.3	-	-	-	-	-	-
March	79	89	11.5	-	-	-	-	-	-
April	141	92	13.7	-	-	-	-	-	-
May	64	96	9.2	-	-	-	-	-	-
June	10	100	9.5	2	54	7.78	-	-	-
July	6	108	10.9	14	67	4.42	-	-	-
August	8	98	9.0	37	73	7.27	-	-	-
September	7	102	8.8	93	75	6.63	-	-	-
October	3	102	8.1	98	83	7.61	-	-	-
November	7	104	6.3	44	80	10.42	-	-	-
December	1	123	-	26	78	11.57	-	-	-

Table 28. Number measured, mean fork-length (FL), and standard deviation (SD) of juvenile steelhead and cutthroat trout captured by minnow traps in Ryan Creek Slough, 2014.

Month	No. Steelhead Trout	Mean FL Steelhead Trout	SD Steelhead Trout	No. Cutthroat Trout	Mean FL Cutthroat Trout	SD Cutthroat Trout
January	1	136	-	2	147	26.9
February	1	141	-	3	134	20.5
March	0	-	-	8	111	16.6
April	3	98	11.3	13	118	16.3
May	2	101	4.9	13	126	14.5
June	4	116	4.3	16	126	15.2
July	10	119	8.2	13	137	12.8
August	4	124	12.3	8	129	15.5
September	2	144	18.4	14	132	11.3
October	2	133	38.2	4	128	5.8
November	0	-	-	3	139	9.0
December	0	-	-	1	136	-

Table 29. Monthly effort (number of traps) and number of juvenile salmonids captured by minnow traps in Ryan Creek Slough, 2015.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	22	44	0	1	0	0
February	22	15	0	0	0	0
March	33	8	0	0	3	0
April	22	8	0	0	5	0
May	22	7	1	0	5	0
June	33	3	3	1	3	0
July	22	7	0	1	2	0
August	22	0	13	0	0	0
September	22	0	6	0	1	0
October	22	0	6	0	1	0
November	22	0	3	0	1	0
December	22	0	1	0	0	0
Total	**286**	**92**	**33**	**3**	**21**	**0**

Table 30. Number measured, mean fork-length (FL), and standard deviation (SD) of yearling-plus coho salmon (1+ coho), sub-yearling coho salmon (yoy coho), and sub-yearling Chinook salmon (yoy CH) captured by minnow traps in Ryan Creek Slough, 2015.

Month	No. 1+ Coho	Mean FL 1+ Coho	SD 1+ Coho	No. yoy Coho	Mean FL yoy Coho	SD yoy Coho	No. yoy CH	Mean FL yoy CH	SD yoy CH
January	44	97	11.3	0	-	-	0	-	-
February	14	108	10.0	0	-	-	0	-	-
March	18	110	11.3	0	-	-	0	-	-
April	8	112	10.3	0	-	-	0	-	-
May	7	113	11.0	1	44	-	0	-	-
June	1	106	-	4	66	5.3	0	-	-
July	3	89	3.6	0	-	-	0	-	-
August	0	-	-	13	86	6.5	0	-	-
September	0	-	-	6	94	4.8	0	-	-
October	0	-	-	6	95	10.0	0	-	-
November	0	-	-	3	100	2.6	0	-	-
December	0	-	-	1	51	-	0	-	-

FL's of steelhead trout varied from 100-141 mm. Monthly mean FL's varied from 129-151 mm for cutthroat trout (Table 31).

Recaptured PIT Tagged Fish 2013 to 2015

In 2013, NSA applied PIT tags to 75 sub-yearling coho salmon in Ryan Creek Slough and recaptured 21 (28.0%). Of the 21 recaptured fish 14 were collected in November. The recaptured sub-yearling coho salmon had a mean residence time of 24 days and were at-large 13 to 84 days. They grew 0 to16 mm and their mean growth rate was 0.19 mm/day (0 to 0.36 mm/day). NSA applied PIT tags to 439 yearling-plus coho salmon in Ryan Creek Slough of which 108 (24.6%) were recaptured. We also recaptured 23 yearling-plus coho multiple times in Ryan Creek Slough that were tagged by our project throughout the SEE in 2012 and 2013. The mean length of estuarine residence in Ryan Creek Slough of all 131 recaptured yearling-plus coho salmon was 58 days and ranged from 13 to 252 days. They grew -1 to 39 mm and their mean growth rate was 0.19 mm/day (-0.08 to 0.57 mm/day).

In 2013 we applied PIT tags to 25 juvenile steelhead trout and recaptured six (24.0%). We also recaptured nine steelhead trout that were tagged by our project throughout the SEE in 2012 and 2013. The mean length of SEE residence of all 15 recaptured steelhead trout was 144 days and they were at large 14 to 378 days. They grew 0 to 60 mm and their mean growth rate was 0.19 mm/day (0 to 0.38 mm/day). NSA applied PIT

Table 31. Number measured, mean fork-length (FL), and standard deviation (SD) of juvenile steelhead and cutthroat trout captured by minnow traps in Ryan Creek Slough, 2015.

Month	No. Steelhead Trout	Mean FL Steelhead Trout	SD Steelhead Trout	No. Cutthroat Trout	Mean FL Cutthroat Trout	SD Cutthroat Trout
January	1	119	-	0	-	-
February	0	-	-	0	-	-
March	0	-	-	4	131	16.8
April	0	-	-	5	129	10.6
May	0	-	-	5	127	21.9
June	1	100	-	3	151	13.9
July	1	115	-	6	146	5.1
August	0	-	-	0	-	-
September	1	141	-	0	-	-
October	0	-	-	1	145	-
November	0	-	-	1	147	-
December	0	-	-	0	-	-

tags to 38 cutthroat trout and recaptured 11 (28.9%). We also recaptured seven cutthroat trout that were tagged by our project or GDRC in Ryan Creek Slough in 2012 and 2013. The 18 recaptured cutthroat trout had a mean residence time of 106 days and were at large 13 to 350 days. They grew -3 to 75 mm, and their mean growth rate was 0.18 mm/day (-0.20 to 0.41 mm/day).

In 2014, NSA applied PIT tags to four sub-yearling coho salmon in Ryan Creek Slough and did not recapture any of them. NSA applied PIT tags to 254 yearling-plus coho salmon and recaptured 52 (20.5%). We also recaptured 29 yearling-plus coho salmon that were tagged by AFRAMP, GDRC, or by our project throughout the SEE in 2013 and 2014. The mean length of estuarine residence in Ryan Creek Slough of all 81 recaptured yearling coho salmon was 63 days and ranged from 13 to 266 days. They grew -1 to 40 mm and their mean growth rate was 0.27 mm/day (-0.04 to 0.79 mm/day).

In 2014 NSA applied PIT tags to 18 juvenile steelhead trout and recaptured six (33.3%). We also recaptured one steelhead trout that was tagged by our project in Ryan Creek Slough in 2013. The seven recaptured steelhead trout were at-large 14 to 112 days. They grew 0 to 40 mm and their growth rates ranged from 0 to 0.43 mm/day. NSA applied PIT tags to 54 cutthroat trout and recaptured 23 (42.6%). We also recaptured one cutthroat trout that was tagged by our project in Ryan Creek Slough in 2013. The 24 recaptured cutthroat trout had a mean residence time of 76 days and were at large 14 to 238 days. They grew 3 to 42 mm and their mean growth rate was 0.24 mm/day (0.07-0.61 mm/day).

In 2015, we applied PIT tags to 72 yearling-plus coho salmon and recaptured 11 (15.3%). We also recaptured five yearling-plus coho salmon that were tagged by AFRAMP in Freshwater Creek in 2014, two tagged by NSA in Ryan Creek Slough in 2014, and two tagged by NSA in Wood Creek in 2015. The mean length of estuarine residence by all 20 recaptured yearling-plus coho salmon was 71 days and ranged from 14 to 273 days. They grew 6 to 58 mm while at large and their mean growth rate of was 0.42 mm/day and ranged from 0.21 to 0.62 mm/day. We applied PIT tags to 27 sub-yearling coho salmon in Ryan Creek Slough and recaptured six (22.2%). They were at large from 14 to 98 days. While at large they grew 2 to14 mm (0.06 to 0.43 mm/day). PIT tags were applied to three juvenile steelhead trout in 2015 and one fish was recaptured. It was at-large for 28 days and grew 5 mm (0.18 mm/day) during that time. PIT tags were applied to 18 cutthroat trout and five (27.8%) were recaptured. They were at-large for 15 to 112 days and grew 3 to 22 mm (0.03 to 0.80 mm/day). It is likely that some of the cutthroat trout captured by our project were resident adult fish.

PIT Tag Antenna Detections Ryan Creek Slough 2012/13 Season

NSA installed and began operating a PIT tag antenna array in Ryan Creek Slough on February 19, 2013. From February to August 2013 the antenna detected 638 coho salmon, 31 juvenile steelhead trout, 47 cutthroat trout, and one adult steelhead trout. Individual coho salmon were first detected on March 7 and last detected on June 7. However, our antenna's time/date function malfunctioned beginning June 21 and we detected 15 additional coho salmon sometime between June 21 and July 10. The number of first detections peaked in May (n=368) and corresponded with peak coho salmon smolt emigration from Ryan Creek. Of the 638 coho salmon detected at the antenna 572 were detected greater than one day after tagging or first observation in the SEE. These fish had an average time between first and last detection (a surrogate for residence time) of 32 days (1 to 362 days). However, most of the fish detected were tagged at the GDRC screw trap during the smolt emigration and were actively emigrating from the system. So if we consider only the other 137 coho salmon (not tagged at the screw trap) their mean residence time was 106 days (2 to 348 days).

Of the 638 coho salmon detected at the antenna, 441 (69.1%) were tagged by GDRC at their Ryan Creek screw trap (438 in 2013 and three in 2012), 134 (21.0%) were tagged by NSA in Ryan Creek Slough (96 in 2013 and 38 in 2012), 32 were tagged by GDRC in Ryan Creek upstream of the SEE in the fall of 2012, 15 were tagged by NSA in Freshwater Creek Slough (14 in 2012 and one in 2013), 12 were tagged upstream of the SEE in Freshwater Creek by AFRAMP during the fall of 2012, three were tagged by AFRAMP at the HFAC weir on Freshwater Creek Slough in 2013, and one was tagged by NSA in Wood Creek in 2013 (Table 32).

Individual steelhead trout were first detected on February 25 and last detected on May 9, 2013. Twenty two detected steelhead trout were tagged by NSA in Ryan Creek Slough (19 in 2012 and three in 2013) and nine were tagged by GDRC at their Ryan Creek screw trap in 2013. The mean length of SEE residence was 207 days (70 to 314 days) for fish tagged by NSA in Ryan Creek Slough and four days (2 to 12 days) for fish

Table 32. Origin of PIT tagged juvenile coho salmon detected at Ryan Creek Slough antennas during February to August 2013, September 2013 through August 2014, and September 2014 through August 2015.

Fish Origin	**12/13**	**13/14**	**14/15**
Stream Estuary Ecotone	-	3	2
Lower Mainstem Freshwater Creek	6	5	14
Middle Mainstem Freshwater Creek	3	14	17
Upper Mainstem Freshwater Creek	-	9	10
Little Freshwater Creek	-	-	-
Cloney Gulch	-	2	2
South Fork Freshwater Creek	3	1	13
Freshwater Creek (total)	12	34	58
Green Diamond Resources Fall Tagging	32	42	4
Wood Creek Pond	-	-	-
Wood Creek	1	2	4
Ryan Slough/Creek	134	131	90
Freshwater Creek Slough	15	14	9
HFAC Weir	3	16	36
Green Diamond Resources Screw Trap	441	448	51
Estuary Ecotone (total)	594	611	190
Grand Total	638	687	252

tagged by GDRC at their screw trap. Cutthroat trout were detected from March 8 to August 15, 2013. Twenty five were tagged in Ryan Creek Slough by NSA (19 in 2012 and six in 2013), 21 by GDRC in Ryan Creek in 2013, and one by NSA in Freshwater Creek Slough in 2012. The cutthroat trout tagged by NSA had a mean residence time of 159 days (1 to 327 days) while the ones tagged by GDRC at the screw trap had a mean residence time of 16 days (2 to 72 days). The adult steelhead trout was detected on May 7, 2013. It was originally tagged in June 2011 in Ryan Creek Slough and had been at large 679 days between tagging and recapture.

PIT Tag Antenna Detections Ryan Creek Slough 2013/14 Season

From September 2013 to August 2014 the antenna detected 687 juvenile coho salmon, 16 juvenile steelhead trout, one adult steelhead trout; and 41 cutthroat trout. However, the antennas were off-line from October 12 to November 4, 2013 and February 18 to March 4, 2014 so we did not collect any data during these time periods. Individual coho salmon were first detected on September 6, 2013 and last detected on August 5, 2014. The number of first detections peaked in May (n=490) and corresponded with peak coho salmon smolt emigration from Ryan Creek.

Just as we observed at the Wood Creek tide gate antenna, we did not detect a fall redistribution of juvenile coho salmon from Freshwater and Ryan creeks downstream to the SEE. Only 16 juvenile coho salmon were detected from September 2013 through January 2014 and all but one of these fish was tagged in the SEE. Most coho salmon from Freshwater Creek were first detected at the tide gate in February 2014 (n=14), the month with the first substantial rainfall of the season. The modest peak of upper basin coho salmon we detected in February along with the large number of coho we detected in May is consistent with the coho salmon emigration patterns we've observed in past years in Humboldt Bay. Typically there is a fall redistribution of coho salmon moving from stream habitat downstream to the SEE. This year's observations at Ryan and Wood creeks illustrates that a large redistribution of juvenile coho salmon occurs with the first large rain and stream flow events of the season regardless of whether they occur in the fall or later in the winter.

Of the 687 coho salmon detected at the antenna 650 were detected greater than one day after tagging or first observation in the SEE. These fish had an average time between first and last detection (a surrogate for residence time) of 42 days (1-478 days) in the SEE. However, most of the fish detected were tagged at the GDRC screw trap during the smolt emigration, so if we consider only the other 176 coho salmon (those not tagged at the screw trap) their mean residence time was 87 days (1-478 days).

Of the 687 coho salmon detected at the antenna, 448 (65.2%) were tagged by GDRC at their Ryan Creek screw trap (430 in 2014 and 18 in 2013), 131 (19.1%) were tagged by NSA in Ryan Creek Slough (88 in 2014 and 43 in 2013), 42 were tagged by GDRC in Ryan Creek upstream of the SEE (41 in 2013 and one in 2012), 31 were tagged upstream of the SEE in Freshwater Creek by AFRAMP (30 in 2013 and one in 2012), 17 were tagged by NSA and AFRAMP in Freshwater Creek SEE (six in 2014 and 11 in 2013), 16 were tagged by AFRAMP at the HFAC weir on Freshwater Creek Slough in 2014), and two were tagged by NSA in Wood Creek, one each in 2014 and 2013 (Table 32).

Individual steelhead trout were first detected on September 21, 2013 and last detected on July 29, 2014. Fourteen detected steelhead trout were tagged by NSA in Ryan Creek Slough (four in 2014, nine in 2013, and one in 2012) and two were tagged by GDRC (one at Ryan Creek screw trap in 2014 and one in Ryan Creek in 2013). The mean length of SEE residence was 189 days (12-366 days) for fish tagged by NSA in Ryan Creek Slough and the two juvenile steelhead tagged by GDRC resided 2 and 12 days in the SEE. Cutthroat trout were detected from September 28, 2013 to July 24, 2014. Thirty nine were tagged in Ryan Creek Slough by NSA (21 in 2014, 17 in 2013, and one in 2012), one by GDRC at the Ryan Creek screw trap in 2013, and one in Ryan Creek in 2011. The cutthroat trout tagged by NSA had a mean residence time of 158 days (2-482 days) while the one tagged by GDRC at the screw trap was at large 473 days. The adult steelhead trout was tagged by GRDC in Ryan Creek in 2011. It was recaptured at the GDRC screw trap on April 6, 2013 and then detected at the Ryan Creek antenna between January 30 and February 14, 2014. It was also detected at the Wood Creek tide gate antenna on January 30, 2014.

PIT Tag Antenna Detections Ryan Creek Slough 2014/15 Season

From September 2014 to August 2015 the antenna detected 247 juvenile coho salmon, 10 adult coho salmon, 11 juvenile steelhead trout, one adult steelhead trout, 43 cutthroat trout, and two Pacific lamprey. GDRC discontinued PIT tagging juvenile salmonids in Ryan Creek which resulted in fewer PIT tag detections at our antenna in 2014/15 compared to past years (Table 32). Individual coho salmon were first detected on September 3, 2014 and last detected on July 31, 2015. The number of first detections peaked in April and May (n=83 and 60 respectively) and corresponded with peak coho salmon smolt emigration from Ryan Creek. A smaller peak occurred in December (n=21) illustrating the fall redistribution of coho salmon downstream to the SEE. The 10 adult coho salmon were detected from November 22, 2014 to April 19, 2015. Of the 247 juvenile coho salmon detected at the antenna 210 were detected greater than one day after tagging or first observation in the SEE. These fish had an average time between first and last detection (a surrogate for residence time) of 169 days (1-397 days).

Of the 247 coho salmon detected at the antenna, 88 (35.6%) were tagged by NSA in Ryan Creek Slough (60 in 2015 and 28 in 2014), 56 (22.7%) were tagged upstream of the SEE in Freshwater Creek by AFRAMP (57 in 2014 and one in 2013), 51 (20.6%) were tagged by GDRC at their Ryan Creek screw trap (49 in 2014 and two in 2013), 35 (14.2%) were tagged by AFRAMP at the HFAC weir on Freshwater Creek Slough (27 in 2015 and eight in 2014), eight were tagged by NSA and AFRAMP in Freshwater Creek SEE (one in 2015 and seven in 2014), four were tagged by GDRC in Ryan Creek upstream of the SEE in 2013, four were tagged by NSA in Wood Creek in 2015, and one contained a tag of unknown origin (Table 32). Six of the detected adult coho salmon were tagged at the Ryan Creek screw trap by GDRC in 2013, three were tagged by NSA in Ryan Creek Slough in 2013, and one was tagged by NSA in Freshwater Creek Slough in the fall of 2012.

Individual juvenile steelhead trout were first detected on September 16, 2014 and last detected on May 4, 2015. Ten of them were tagged by NSA in Ryan Creek Slough (one in 2015 and nine in 2014) and one was tagged by GDRC at the Ryan Creek screw trap in 2014. The mean length of SEE residence was 223 days (70-397 days) for fish tagged by NSA in Ryan Creek Slough and the juvenile steelhead tagged by GDRC resided 281 days in the SEE. Cutthroat trout were detected from September 4, 2014 to August 24, 2015. Thirty nine were tagged in Ryan Creek Slough by NSA (nine in 2015, 25 in 2014, three in 2013, and two in 2012) and four in Freshwater Creek Slough (three in 2014 and one in 2013) by NSA. The cutthroat trout had a mean residence time of 285 days (1-921 days). The adult steelhead trout was tagged by NSA in Ryan Creek Slough in 2013. It was detected at the Ryan Creek antenna on May 5, 2015 and detected at the Wood Creek tide gate antenna between April 9 and June 1, 2015. We detected two Pacific lamprey at the Ryan Creek Slough antenna site, one from March 23 to March 26, 2015 and the other on April 30, 2015. They were tagged on March 21 and April 15 respectively at the HFAC weir on Freshwater Creek Slough.

SALMON CREEK

Salmon Creek 2013 to 2015

During 2013, we captured 13 yearling-plus coho salmon and two juvenile steelhead trout seining the new ponds. We captured coho salmon from March to May and their monthly CPUE ranged from 0 to 0.42 fish/set with peak catches occurring in May (Table 33). We captured one steelhead trout each in April and October (Table 33). We did not capture any juvenile salmonids in minnow traps this year. The mean for yearling-plus coho salmon in 2013 was 97 mm (range 73 to 117). The FL's for steelhead trout were 97 and 185 mm (Table 34).

In 2014, we captured 16 yearling-plus coho salmon and 42 juvenile steelhead trout seining the new ponds. We captured coho salmon in March, May, and June, and CPUE ranged from 0 to 0.80 fish/set with peak catches occurring in March (Table 35). We captured steelhead trout February through May, with a peak CPUE of 2.50 fish/set in March. We also minnow-trapped two yearling-plus coho salmon and eight juvenile steelhead trout in the new off-channel ponds and they were captured in March and April (Table 35). The monthly mean FL varied from 88 to 120 mm for yearling-plus coho salmon and 85 to 130 mm for steelhead trout (Table 36).

Table 33. Monthly effort (number of seine hauls) and catch-per-unit-effort (CPUE; number of fish per seine haul) of juvenile salmonids captured by seine nets in Salmon Creek ponds, 2013.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	14	0	0	0	0	0
February	14	0	0	0	0	0
March	12	0.25	0	0	0	0
April	13	0.15	0	0.08	0	0
May	19	0.42	0	0	0	0
June	5	0	0	0	0	0
July	18	0	0	0	0	0
August	12	0	0	0	0	0
September	13	0	0	0	0	0
October	13	0	0	0.08	0	0
November	12	0	0	0	0	0
December	6	0	0	0	0	0

Table 34. Number measured, mean fork-length (FL), and standard deviation (SD) of yearling-plus coho salmon (1+ coho), sub-yearling coho salmon (yoy coho), and steelhead trout (SH) captured by seine in Salmon Creek estuary, 2013.

Month	No. 1+ Coho	Mean FL 1+ Coho	SD 1+ Coho	No. yoy Coho	Mean FL yoy Coho	SD yoy Coho	No. SH Trout	Mean FL SH Trout	SD SH Trout
January	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-
March	3	83	8.9	-	-	-	-	-	-
April	2	105	4.2	-	-	-	1	97	-
May	8	100	9.7	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-
August	-	-	-	-	-	-	-	-	-
September	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	1	185	-
November	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-

Table 35. Monthly effort (number of seine hauls) and catch-per-unit-effort (CPUE; number of fish per seine haul) of juvenile salmonids captured by seine nets (S) in Salmon Creek estuary, 2014. Minnow trap (MT) catch and effort (# fish captured) is included for months when salmonids were captured by this method.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	12	0	0	0	0	0
February	12	0	0	1.17	0	0
March (S)	10	0.80	0	2.50	0	0
March (MT)	24	2	0	7	0	0
April (S)	9	0	0	0.44	0	0
April (MT)	24	0	0	1	0	0
May	12	0.25	0	0.25	0	0
June	10	0.10	0	0	0	0
July	12	0	0	0	0	0
August	11	0	0	0	0	0
September	12	0	0	0	0	0
October	11	0	0	0	0	0
November	19	0	0	0	0	0
December	6	0	0	0	0	0

Table 36. Number measured, mean fork-length (FL), and standard deviation (SD) of yearling-plus coho salmon (1+ coho), sub-yearling coho salmon (yoy coho), and steelhead trout (SH) captured by seine and minnow traps in Salmon Creek estuary, 2014.

Month	No. 1+ Coho	Mean FL 1+ Coho	SD 1+ Coho	No. yoy Coho	Mean FL yoy Coho	SD yoy Coho	No. SH Trout	Mean FL SH Trout	SD SH Trout
January	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	14	96	62.5
March	10	88	10.7	-	-	-	27	101	32.2
April	4	113	10.6	-	-	-	1	85	-
May	3	106	7.1	-	-	-	3	130	15.9
June	1	120	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-
August	-	-	-	-	-	-	-	-	-
September	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-

In 2015, we captured 23 yearling-plus coho salmon and 10 juvenile steelhead trout seining the off channel ponds and did not capture any salmonids with minnow traps. We captured coho salmon February to May and their CPUE ranged from 0 to 1.06 fish/set with peak catches occurring in April (Table 37). We captured steelhead trout in April and December with a peak CPUE of 0.35 fish/set in April (Table 37). In the spring fork lengths varied from 98 to 131 mm for yearling-plus coho salmon and 93 to 165 mm for steelhead trout, but the following winter captured steelhead trout were much smaller (Table 38) ranging from 48 to 56 mm. We did not capture any salmonids with any sampling method in Cattail Creek.

Recaptured PIT Tagged Fish 2013 to 2015

In 2013, we applied PIT tags to 12 yearling-plus coho salmon and recaptured one (8.3%). It was tagged and recaptured in the most upstream pond (Pond 0). It was at-large 27 days and grew 22 mm (0.81 mm/day). We also applied PIT tags to two juvenile steelhead trout and did not recapture either one.

In 2014, we applied PIT tags to 17 yearling-plus coho salmon and recaptured one (5.9%). It was tagged in the second most upstream pond (Pond 1) and recaptured in the third most upstream pond (Pond 2). It was at-large 31 days and grew 27 mm (0.87 mm/day). We applied PIT tags to 48 juvenile steelhead trout and recaptured one (2.1%). It was tagged in Pond 2 and recaptured in Pond 1. It was at large 12 days and grew 2 mm (0.17 mm/day). We also recaptured one steelhead that was tagged by NSA

Table 37. Monthly effort (number of seine hauls) and catch-per-unit-effort (CPUE; number of fish per seine haul) of juvenile salmonids captured by seine nets in Salmon Creek estuary, 2015.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	12	0	0	0	0	0
February	12	0.08	0	0	0	0
March	12	0.08	0	0	0	0
April	17	1.06	0	0.35	0	0
May	9	0.33	0	0	0	0
June	7	0	0	0	0	0
July	7	0	0	0	0	0
August	5	0	0	0	0	0
September	6	0	0	0	0	0
October	11	0	0	0	0	0
November	6	0	0	0	0	0
December	13	0	0	0.31	0	0

Table 38. Number measured, mean fork-length (FL), and standard deviation (SD) of yearling coho salmon (1+ coho), sub-yearling (yoy) coho salmon (yoy coho), and steelhead trout (SH) captured by seine in Salmon Creek estuary, 2015.

Month	No. 1+ Coho	Mean FL 1+ Coho	SD 1+ Coho	No. yoy Coho	Mean FL yoy Coho	SD yoy Coho	No. SH Trout	Mean FL SH Trout	SD SH Trout
January	0	-	-	0	-	-	0	-	-
February	1	75	-	0	-	-	0	-	-
March	1	98	-	0	-	-	0	-	-
April	18	116	11.7	0	-	-	6	113	27.1
May	3	108	5.1	0	-	-	0	-	-
June	0	-	-	0	-	-	0	-	-
July	0	-	-	0	-	-	0	-	-
August	0	-	-	0	-	-	0	-	-
September	0	-	-	0	-	-	0	-	-
October	0	-	-	0	-	-	0	-	-
November	0	-	-	0	-	-	0	-	-
December	0	-	-	0	-	-	4	51	3.5

in October 2012. It was tagged and recaptured in Pond 1, at large for 133 days, and increased in size from 185 mm in October to 286 mm FL in February (0.76 mm/day).

In 2015, we applied PIT tags to 22 yearling-plus coho salmon and recaptured one (4.5%). It was tagged in Pond 0 on February 5 and recaptured in Pond 0 on March 6. It was at-large 29 days and grew 23 mm (0.79 mm/day) during that time. We applied PIT tags to six juvenile steelhead trout and did not recapture any of them.

PIT Tag Antenna Detections 2012/13 Season

Between September 2012 and August 2013, NSA detected one coho salmon and one steelhead trout at the antenna site. The coho salmon was detected on March 14, 2013. It was tagged in Pond 1 on March 7 and was at large seven days. The steelhead trout was detected from April 5-9. It was tagged in Pond 2 on April 3 and was at large six days.

PIT Tag Antenna Detections 2013/14 Season

Between September 2013 and August 2014, NSA detected five coho salmon and 11 steelhead trout at the antenna site. The coho salmon were first detected on March 12 and last detected on May 26. Three of the coho salmon were tagged in Pond 1 and two were tagged in Pond 2. They were at large for 2-19 days. The steelhead trout were first detected on February 28 and last detected on May 22. Five were tagged in Pond 1, five in Pond 2, and one in Pond 0. Their mean residence time was 21 days and ranged from 2-60 days.

PIT Tag Antenna Detections 2014/15 Season

Between September 2014 and August 2015, NSA detected 19 coho salmon and four steelhead trout at the antenna site. The coho salmon were first detected on February 11 and last detected on June 3. Eighteen of the coho salmon were tagged in Pond 1 and one was tagged in Pond 0. Twelve of the coho salmon were detected on more than one day and these fish had a mean residence time of nine days (range 1-67 days). The steelhead trout were first detected on April 29 and last detected on June 23. All were tagged in Pond 1 and they were at large for 0-55 days.

JACOBY CREEK POND

Jacoby Creek and Off Channel Pond 2013 to 2015

In 2013 we sampled Jacoby Creek pond monthly with minnow traps from January to July and did not capture any fish. The pond was dry from August to December so we did not sample during those months. We also conducted monthly fish sampling in a reference site in Jacoby Creek and captured two yearling-plus coho salmon, 57 yoy coho salmon, and 18 juvenile steelhead trout (Table 39). We captured both yearling-

Table 39. Monthly effort (number of traps) and number of juvenile salmonids captured by minnow traps in Jacoby Creek, 2013.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	1	0	0	0	0	0
February	1	0	0	2	0	0
March	1	0	0	0	0	0
April	1	0	0	0	0	0
May	1	2	0	3	0	0
June	1	0	0	0	0	0
July	1	0	6	5	0	0
August	1	0	9	5	0	0
September	1	0	2	2	0	0
October	1	0	11	1	0	0
November	1	0	28	0	0	0
December	1	0	1	0	0	0
Total	**12**	**2**	**57**	**18**	**0**	**0**

plus coho salmon in May and they were 116 and 101 mm FL. We captured yoy coho salmon July to December with a peak catch of 28 in November. Their monthly mean FL increased from 70 mm in July to 81 mm in December. We captured steelhead trout February to October with 13 of the 18 captured in May, July, and August. Their mean FL was 110 mm and ranged from 86 to 149 mm.

We applied PIT tags to 50 yoy and two yearling-plus coho salmon in 2013 and recaptured six (12.0%) yoy coho salmon. Their residence time ranged from 35 to 90 days and they grew 1 to 10 mm (0.03 to 0.11 mm/day) while at large. We applied PIT tags to 11 steelhead trout and recaptured four (36.4%). Their residence time ranged from 28 to 92 days and they grew 1 to 11 mm (0.02 to 0.12 mm/day) while at large.

In 2014 we sampled Jacoby Creek pond monthly with minnow traps from February to July and again in November and December and did not capture any fish. The pond was dry from August to October so we did not sample during those months. We also conducted monthly fish sampling in a reference site in Jacoby Creek and captured 32 yearling-plus coho salmon, four yoy coho salmon, 19 juvenile steelhead trout, and one cutthroat trout (Table 40). We captured yearling-plus coho salmon January to April and then one in July with a peak catch of 22 in January. Their monthly mean FL increased from 79 mm in January to 101 mm in July. We captured yoy coho salmon in July, September, and November. Their FL's ranged from 66 to 88 mm. We captured small numbers of steelhead trout throughout the year with a peak catch of five in July (Table

40. Monthly effort (number of traps) and catch-per-unit-effort (CPUE; number of fish per trap) of juvenile salmonids captured by minnow traps in Jacoby Creek, 2014.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	1	22	0	4	0	0
February	1	2	0	0	0	0
March	1	2	0	1	0	0
April	1	5	0	1	1	0
May	1	0	0	0	0	0
June	1	0	0	2	0	0
July	1	1	1	5	0	0
August	1	0	0	2	0	0
September	1	0	1	1	0	0
October	1	0	0	0	0	0
November	1	0	2	2	0	0
December	1	0	0	1	0	0
Total	**12**	**32**	**4**	**19**	**1**	**0**

40). Their mean FL was 109 mm and ranged from 68 to 147 mm. We captured one cutthroat trout in April (Table 40) and it was 131 mm FL.

We applied PIT tags to 20 yearling-plus coho salmon and recaptured one (5.0%). We also recaptured nine fish that we marked as you coho salmon in 2013. All 10 fish were at large 64 to 272 days and grew 2 to 33 mm (0.03 to 0.25 mm/day) while at large. We PIT tagged four yoy coho salmon and did not recapture any of them. We PIT tagged 13 steelhead trout and we recaptured one (7.7%). We also recaptured two steelhead trout that we tagged in 2013. All three fish were at large 97 to 363 days and grew 9-46 mm (0.09 to 0.13 mm/day) while at large. We applied a PIT tag to the cutthroat trout and did not recapture it.

In 2015 we sampled Jacoby Creek pond monthly with minnow traps from January to July and again in November and December and did not capture any fish. The pond was dry from August to October so we did not sample during those months. We also conducted monthly fish sampling in a reference site in Jacoby Creek every month but April, November, and December and captured seven yearling-plus coho salmon, 12 yoy coho salmon, 16 juvenile steelhead trout, and one cutthroat trout (Table 41). We captured yearling-plus coho salmon in January and March with a peak catch of four in March (Table 41). Their FL's ranged from 98 to 123 mm. We captured yoy coho salmon August to October with a peak catch of six in October (Table 41). Their FL's ranged from 65 to 85 mm. We captured steelhead trout January to March and June to

Table 41. Monthly effort (number of traps) and catch-per-unit-effort (CPUE; number of fish per trap) of juvenile salmonids captured by minnow traps in Jacoby Creek, 2015.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
January	1	3	0	1	0	0
February	1	0	0	2	0	0
March	1	4	0	1	0	0
April	0	-	-	-	-	-
May	1	0	0	0	0	0
June	1	0	0	5	0	0
July	1	0	0	2	1	0
August	1	0	4	2	0	0
September	1	0	2	2	0	0
October	1	0	6	1	0	0
November	0	-	-	-	-	-
December	0	-	-	-	-	-
Total	**9**	**7**	**12**	**16**	**1**	**0**

October with a peak catch of five in June (Table 41). Their FL's ranged from 89 to 131 mm. We captured one cutthroat trout in July (Table 41) and it was 124 mm FL.

We applied PIT tags to six yearling-plus coho salmon and recaptured one (16.7%). It was at large 56 days and grew 5 mm (0.09 mm/day) while at large. We PIT tagged eight yoy coho salmon and recaptured three (37.5%). They were at large for 55 days and grew 1 to 2 mm (0.02 to 0.04 mm/day). We PIT tagged 14 steelhead trout and recaptured one (7.1%). It was at large 56 days and grew 13 mm (0.23 mm/day) while at large. We applied a PIT tag to the cutthroat trout and did not recapture it.

Jacoby Creek and Off Channel Pond Water Quality 2013 to 2015

In 2013 Jacoby Creek provided good water quality conditions for juvenile salmonids the entire year while the off channel pond provided good water quality on only a seasonal basis and was essentially dry from August to December. Jacoby Creek had dissolved oxygen (DO) levels >8 mg/l in all months but August and September while the pond DO levels were adequate for juvenile salmonids from January to March 2013, marginal in April and inadequate by May (Table 42). Water temperatures in the pond were higher than in Jacoby Creek in all months they were both sampled (Table 42).

In 2014 Jacoby Creek provided good water quality conditions for juvenile salmonids the entire year while the off channel pond did not provide good water quality at any time during the year and was essentially dry in January and August to October (Table 43).

Table 42. Water quality measurements collected in Jacoby Creek and the off channel pond, 2013.

Water Quality Date	Water Quality Site	Time	Water Temperature (° C)	Conductivity (uS/cm)	Dissolved Oxygen (mg/l)
January 16	Jacoby Creek	1015	4.6	71.8	12.76
	Jacoby Pond	1055	5.1	78.6	7.78
February 13	Jacoby Creek	1115	6.8	95.5	8.42
	Jacoby Pond	1050	9.7	101.4	6.07
March 12	Jacoby Creek	1100	8.3	96.0	11.15
	Jacoby Pond	1150	12.1	84.5	6.33
April 17	Jacoby Creek	1200	9.1	108.4	12.00
	Jacoby Pond	1230	14.5	9.2	4.79
May 15	Jacoby Creek	1015	11.6	135.8	9.81
	Jacoby Pond	1040	14.5	91.6	1.50
June 20	Jacoby Creek	1030	12.9	146.2	8.97
	Jacoby Pond	1055	14.8	85.3	0.19
July 18	Jacoby Creek	1135	14.0	168.5	8.12
	Jacoby Pond	1150	15.8	111.6	1.67
August 15	Jacoby Creek	0945	16.1	190.3	6.10
	Jacoby Pond	-	-	-	-
September 11	Jacoby Creek	1010	15.8	194.5	4.89
	Jacoby Pond	-	-	-	-
October 10	Jacoby Creek	1205	11.1	151.1	8.51
	Jacoby Pond	-	-	-	-
November 13	Jacoby Creek	1225	11.5	162.4	8.00
	Jacoby Pond	-	-	-	-
December 18	Jacoby Creek	1130	6.1	135.5	10.71
	Jacoby Pond	-	-	-	-

Table 43. Water quality measurements collected in Jacoby Creek and the off channel pond, 2014.

Water Quality Date	Water Quality Site	Time	Water Temperature (° C)	Conductivity (uS/cm)	Dissolved Oxygen (mg/l)
January 16	Jacoby Creek	1200	5.9	132.9	10.85
	Jacoby Pond	-	-	-	-
February 20	Jacoby Creek	1115	7.8	92.9	11.77
	Jacoby Pond	1150	11.2	104.9	2.74
March 21	Jacoby Creek	1000	8.4	118.3	10.63
	Jacoby Pond	1030	13.1	112.2	1.67
April 16	Jacoby Creek	0920	10.7	131.2	9.47
	Jacoby Pond	0945	15.6	123.3	1.66
May 14	Jacoby Creek	0920	12.3	127.5	9.47
	Jacoby Pond	0945	18.4	132.3	2.70
June 13	Jacoby Creek	1020	13.4	165.0	8.04
	Jacoby Pond	1045	15.0	126.1	0.44
July 16	Jacoby Creek	1050	15.2	200.1	7.18
	Jacoby Pond	1135	17.1	226.2	0.51
August 13	Jacoby Creek	0950	15.1	212.9	5.14
	Jacoby Pond	-	-	-	-
September 18	Jacoby Creek	0940	14.9	223.1	5.59
	Jacoby Pond	-	-	-	-
October 16	Jacoby Creek	1225	13.5	201.2	7.86
	Jacoby Pond	-	-	-	-
November 20	Jacoby Creek	0920	11.6	160.5	9.11
	Jacoby Pond	1005	11.4	256.8	3.83
December 18	Jacoby Creek	1055	10.9	92.0	9.85
	Jacoby Pond	1155	10.5	120.3	3.00

Jacoby Creek had (DO) levels >7 mg/l in all months but August and September, while the pond DO levels peaked at 3.83 mg/l in November and were $\leq$3 mg/l the remaining months when water was in the pond (Table 43). Water temperatures in the pond were higher than in Jacoby Creek in all months they were both sampled except for November and December (Table 43).

In 2015 Jacoby Creek provided good water quality conditions for juvenile salmonids January to July and marginal conditions July to October (Table 44). Habitat restoration work was completed in November to provide better connection between Jacoby Creek and the existing off channel pond (lower pond) and construct a new off channel pond (upper pond) approximately 0.5 km upstream of the lower pond. The lower pond had good water quality conditions in April and December and marginal water quality in February and March (Table 44). Conditions in the lower pond improved in December after the restoration project was completed but it was essentially dry August to October (Table 44). Jacoby Creek had DO levels >7 mg/l January to May and then DO varied from 3.43 to 5.89 July to October (Table 44). From January to November the pond DO levels peaked at 6.30 mg/l in April, were slightly > 4 mg/l in February and March, and were <4 mg/l the remaining months (Table 44). However, after the habitat restoration project was completed in November we measured DO > 8mg/l in both ponds. Water temperatures in the ponds were higher than in Jacoby Creek in all months where ponds and creek were both sampled (Table 44).

MARTIN SLOUGH

From August to December 2014 we captured 16 yearling-plus coho salmon, two yoy coho salmon, and six cutthroat trout in Martin Slough. All of the fish were captured at our most upstream site except for five cutthroat trout which were captured in the off channel pond. We captured yearling-plus coho salmon in August, September, and December and their peak catch of nine occurred in August (Table 45). Their mean FL was 106 mm and ranged from 92-137 mm. We captured two yoy coho salmon in December and their FL's ranged from 65-69 mm. We captured six cutthroat trout, all but one captured in the pond in September. Their FL's ranged from 169-214 mm.

In 2014 we applied PIT tags to 14 yearling-plus coho salmon and recaptured four (28.6%). All four fish were recaptured in September after our initial tagging in August. They were at large 35 days and grew -1 to 1 mm (-0.03 to 0.03 mm/day) during this period. We PIT tagged six cutthroat trout and did not recapture any of them.

In 2015 we captured we captured 113 yearling-plus coho salmon, seven yoy coho salmon, three juvenile steelhead trout and five cutthroat trout in Martin Slough. All but one fish was captured by seining and 97 (86.6%) of the seined fish were captured in the off channel pond. We captured yearling-plus coho salmon in August, September, and December 2014 and January to May 2015 and their peak catch of 9.25 fish/set occurred in May 2015 (Table 45). Their monthly mean FL's were 124 to 144 mm (Table 46) and their individual FL's ranged from 95-176 mm. The juvenile coho salmon in Martin Slough were larger than the ones we captured in other Humboldt Bay tributaries. Also, the yearling-plus coho salmon we captured in the pond were larger (138 $\pm$ 15.1 mm; n=73) than those captured in other parts of Martin Slough (127 $\pm$ 20.2; n=16). We captured yoy coho salmon in December 2014 and July, November, and December 2015 (Table 45). Their FL's ranged from 79-122 mm. We captured juvenile steelhead trout in April, May, and November 2015 (Table 45) and their FL's ranged from 150 to 229 mm.

Table 44. Water quality measurements collected in Jacoby Creek and the off channel ponds, 2015.

Water Quality Date	Water Quality Site	Time	Water Temperature (° C)	Conductivity (uS/cm)	Dissolved Oxygen (mg/l)
January 14	Jacoby Creek	1230	8.7	129.6	10.94
	Jacoby Pond	1255	11.0	140.7	2.75
February 10	Jacoby Creek	0920	9.7	85.2	10.70
	Jacoby Pond	0950	12.4	112.5	4.10
March 11	Jacoby Creek	1050	10.1	133.8	10.59
	Jacoby Pond	1205	12.9	142.5	4.17
April 7	Jacoby Creek	-	-	-	-
	Jacoby Pond	1015	10.8	94.4	6.30
May 13	Jacoby Creek	1010	11.2	149.0	9.37
	Jacoby Pond	1045	15.0	128.0	2.47
June 17	Jacoby Creek	1005	12.9	174.7	7.89
	Jacoby Pond	1025	14.8	145.0	2.91
July 16	Jacoby Creek	0955	15.2	193.9	3.43
	Jacoby Pond	1015	16.2	198.1	1.57
August 20	Jacoby Creek	0945	15.2	210.7	5.89
	Jacoby Pond	-	-	-	-
September 21	Jacoby Creek	1145	15.0	215.3	5.44
	Jacoby Pond	-	-	-	-
October 14	Jacoby Creek	0930	13.6	216.4	5.34
	Jacoby Pond	-	-	-	-
November 19	Jacoby Creek	-	-	-	-
	Jacoby Pond	1005	11.4	256.8	3.83
December 15	Jacoby Creek	-	-	-	-
	Jacoby Lower Pond	1025	6.9	121.8	8.49
	Jacoby Upper Pond	0900	8.5	101.8	8.25

Table 45. Monthly effort (number of seine hauls) and catch-per-unit-effort (CPUE; number of fish per seine haul) of juvenile salmonids captured by seine nets in Martin Slough, 2014 and 2015.

Month	Effort	Yearling Coho Salmon	Sub-yearling Coho Salmon	Steelhead Trout	Cutthroat Trout	Sub-yearling Chinook Salmon
August	4	2.25	0	0	0.50	0
September	5	1.20	0	0	1.00	0
October	5	0	0	0	0	0
November	5	0	0	0	0	0
December	5	0.20	0.40	0	0	0
January	5	2.60	0	0	0	0
February	5	1.80	0	0	0	0
March	5	3.20	0	0	0	0
April	5	7.40	0	0.44	0	0
May	4	9.25	0	1.00	0.25	0
June	5	0	0	0	0	0
July	5	0	0.20	0	0	0
August	5	0	0	0	0	0
September	5	0	0	0	0	0
October	5	0	0	0	0	0
November	5	0	0.40	0.40	0.20	0
December	5	0	0.80	0	0	0

We captured cutthroat trout in August and September 2014, and May and November 2015 (Table 45). Their FL's ranged from 158-268 mm.

In 2015 we applied PIT tags to 82 yearling-plus coho salmon and recaptured six (7.3%). We also recaptured one yearling-plus coho salmon we marked in Martin Slough in 2014. The seven fish were at large 30-160 days and grew 11-42 mm (0.21 to 0.72 mm/day) during this time period. We PIT tagged six sub-yearling coho salmon in 2015 and recaptured one. It was at large 28 days and grew 8 mm (0.29 mm/day). We PIT tagged three juvenile steelhead trout and five cutthroat trout in 2015 and did not recapture any of them.

Wood Creek and Salmon Creek Off Channel Pond Water Quality

We found similar water quality patterns in off-channel ponds in Wood and Salmon creeks (Tables 47, 48, and 49). The off channel ponds contained brackish water up to 33 ppt in Salmon Creek and 25 ppt in Wood Creek during the summer and fall of 2013 (Table 47). Due to the drought in 2013/14, resulting in little rain and low stream flows, salinities remained elevated in the Wood and Salmon Creek ponds in the winter of

Table 46. Number measured, mean fork-length (FL), and standard deviation (SD) of yearling coho salmon (1+ coho), sub-yearling (yoy) coho salmon (yoy coho), and steelhead trout (SH) captured by seine in Martin Slough, August 2014 through 2015.

Month	No. 1+ Coho	Mean FL 1+ Coho	SD 1+ Coho	No. yoy Coho	Mean FL yoy Coho	SD yoy Coho	No. SH Trout	Mean FL SH Trout	SD SH Trout
August	9	104	8.1	0	-	-	0	-	-
September	6	107	15.8	0	-	-	0	-	-
October	0	-	-	0	-	-	0	-	-
November	0	-	-	0	-	-	0	-	-
December	1	110	-	2	67	2.8	0	-	-
January	13	145	19.7	0	-	-	0	-	-
February	9	124	24.0	0	-	-	0	-	-
March	16	130	18.8	0	-	-	0	-	-
April	13	137	11.2	0	-	-	0	-	-
May	37	138	11.7	0	-	-	1	150	-
June	1	128	-	0	-	-	0	-	-
July	0	-	-	1	79	-	0	-	-
August	0	-	-	0	-	-	0	-	-
September	0	-	-	0	-	-	0	-	-
October	0	-	-	0	-	-	0	-	-
November	0	-	-	2	111	4.9	0	-	-
December	0	-	-	4	109	13.0	2	213	22.6

2013/14 until February 2014. During November to January of most years the ponds are often fresh water or at least have a layer of freshwater near the surface. However, this year salinities in Wood Creek were 21-22 ppt in November, 6 to 20 ppm in December 2013, and 20 to 26 ppt in January 2014. In Salmon Creek the salinities were 18 to 30 ppt in November, 18 to 29 ppt in December 2013, and 14 to 30 ppt in January 2014.

Beginning in mid-February 2014 modest rain and stream flow events lowered pond surface salinities from February to April to 1 to 11 ppt in Wood Creek and <5ppt in Ponds 0, 1, and 2 in Salmon Creek. However, by June 2014 pond salinities had risen to 11-14 ppt in Wood Creek and 24 to 38 ppt in Salmon Creek and they remained high throughout the summer and early fall until late November 2014 (Table 48). Water salinity tended to be higher and more persistent in the more downstream ponds on Salmon Creek (Tables 47, 48, and 49). Water temperatures in the ponds also followed a seasonal pattern in that they were cool (i.e. 10-15°C) in the winter and spring but became too warm (i.e. >17°C) to support juvenile salmonids in the summer. DO was often either extremely low in the warm brackish layer of the pond during the year, or highly variable with very low or super-saturated DO levels (Tables 47, 48, and 49). In 2015 water quality returned to normal patterns where rearing conditions in the off channel ponds on Wood and Salmon creeks were good during the winter and spring but

Table 47. Typical differences in water temperature, salinity in parts per thousand (ppt), and dissolved oxygen in milligrams per liter (mg/l) in Salmon Creek in winter (February 20, 2013) and summer (July 24, 2013) stream flows and in Wood Creek at winter (March 4, 2013) and summers (August 1, 2013) stream flows.

Salmon Creek February 20, 2013 **Water Quality Site**	**Depth** **(feet)**	**Water Temperature** **(° C)**	**Salinity** **(ppt)**	**Dissolved Oxygen** **(mg/l)**
Pond 0 (time 1140 hrs)				
West Transect				
surface	0.5	8.3	0.3	9.04
bottom	2.0	10.7	1.1	8.60
Pond 1 (time 1045 hrs)				
West Transect				
surface	0.5	6.6	0.3	7.97
middle	2.0	6.5	0.4	7.98
bottom	4.0	10.8	15.9	5.71
Pond 2 (time 1030 hrs)				
West Transect				
surface	0.5	6.9	0.3	7.75
middle	1.5	6.9	0.3	8.28
bottom	3.0	6.8	0.3	8.63
Salmon Creek July 24, 2013 **Water Quality Site**	**Depth** **(feet)**	**Water Temperature** **(° C)**	**Salinity** **(ppt)**	**Dissolved Oxygen** **(mg/l)**
Pond 0 (time 1315 hrs)				
West Transect				
surface	0.5	24.1	23.2	7.01
middle	-	-	-	-
bottom	2.0	22.3	24.6	9.84
Pond 1 (time 1150 hrs)				
West Transect				
surface	0.5	20.0	29.3	6.92
middle	-	-	-	-
bottom	2.0	20.2	31.1	5.26
Pond 2 (time 1130 hrs)				
West Transect				
surface	0.5	20.0	27.9	17.14
middle	-	-		-
bottom	1.5	21.1	30.8	13.36
Wood Creek March 4, 2013 **Water Quality Site**	**Depth** **(feet)**	**Water Temperature** **(° C)**	**Salinity** **(ppt)**	**Dissolved Oxygen** **(mg/l)**
surface	0.5	11.0	0.8	10.94
middle	1.5	13.7	2.6	6.14
bottom	3.0	13.1	3.2	0.07
Wood Creek August 1, 2013 **Water Quality Site**	**Depth** **(feet)**	**Water Temperature** **(° C)**	**Salinity** **(ppt)**	**Dissolved Oxygen** **(mg/l)**
surface	0.5	24.9	15.4	18.00
middle	1.5	28.0	22.3	15.14
bottom	3.0	27.5	24.4	2.20

Table 48. Typical differences in water temperature, salinity in parts per thousand (ppt), and dissolved oxygen in milligrams per liter (mg/l) in Salmon Creek in winter (February 12, 2014) and summer (July 23, 2014) stream flows and in Wood Creek at winter (March 27, 2014) and summers (July 31, 2014) stream flows.

Salmon Creek February 12, 2014 **Water Quality Site**	**Depth** **(feet)**	**Water Temperature** **(° C)**	**Salinity** **(ppt)**	**Dissolved Oxygen** **(mg/l)**
Pond 0 (time 1015 hrs)				
West Transect				
surface	0.5	10.2	0.8	9.11
middle	1.5	10.6	1.5	8.09
bottom	3.0	11.9	27.1	1.10
Pond 1 (time 1130 hrs)				
West Transect				
surface	0.5	10.9	2.2	9.39
middle	2.3	11.7	20.7	5.65
bottom	4.5	11.7	24.7	4.54
Pond 2 (time 0920 hrs)				
West Transect				
surface	0.5	10.1	1.7	9.57
middle	1.5	10.3	3.7	7.99
bottom	3.0	11.5	18.0	5.74
Salmon Creek July 23, 2014 **Water Quality Site**	**Depth** **(feet)**	**Water Temperature** **(° C)**	**Salinity** **(ppt)**	**Dissolved Oxygen** **(mg/l)**
Pond 0 (time 1000 hrs)				
West Transect				
surface	0.5	21.1	35.4	3.56
middle	-	-	-	-
bottom	2.0	21.1	35.6	3.68
Pond 1 (time 1200 hrs)				
West Transect				
surface	0.5	21.2	36.5	4.22
middle	2.0	21.1	36.6	4.27
bottom	4.0	20.9	37.1	5.58
Pond 2 (time 1100 hrs)				
West Transect				
surface	0.5	20.9	36.6	3.99
middle	1.5	20.7	36.9	4.71
bottom	3.0	20.7	37.0	5.71
Wood Creek March 27, 2014 **Water Quality Site**	**Depth** **(feet)**	**Water Temperature** **(° C)**	**Salinity** **(ppt)**	**Dissolved Oxygen** **(mg/l)**
surface	0.5	11.6	0.3	7.38
middle	1.5	12.5	1.5	11.32
bottom	3.0	18.1	9.5	4.69
Wood Creek July 31, 2014 **Water Quality Site**	**Depth** **(feet)**	**Water Temperature** **(° C)**	**Salinity** **(ppt)**	**Dissolved Oxygen** **(mg/l)**
surface	0.5	30.1	15.9	14.01
middle	1.3	31.1	22.6	15.45
bottom	2.5	29.3	24.9	9.46

Table 49. Typical differences in water temperature, salinity in parts per thousand (ppt), and dissolved oxygen in milligrams per liter (mg/l) in Salmon Creek in winter (February 12, 2014) and summer (July 23, 2014) stream flows and in Wood Creek at winter (March 27, 2014) and summers (July 31, 2014) stream flows.

Salmon Creek February 19, 2015 **Water Quality Site**	**Depth** **(feet)**	**Water Temperature** **(° C)**	**Salinity** **(ppt)**	**Dissolved Oxygen** **(mg/l)**
Pond 0 (time 1005 hrs)				
West Transect				
surface	0.5	12.1	1.1	9.23
middle	-	-	-	-
bottom	2.0	13.9	3.7	7.43
Pond 1 (time 1050 hrs)				
West Transect				
surface	0.5	11.5	0.2	9.27
middle	1.5	11.4	0.3	9.10
bottom	3.0	11.5	0.4	7.71
Pond 2 (time 1130 hrs)				
West Transect				
surface	0.5	11.6	0.2	9.77
middle	-	-	-	-
bottom	2.5	11.5	0.3	8.88
Salmon Creek July 29, 2015 **Water Quality Site**	**Depth** **(feet)**	**Water Temperature** **(° C)**	**Salinity** **(ppt)**	**Dissolved Oxygen** **(mg/l)**
Pond 0 (time 0930 hrs)				
West Transect				
surface	0.5	24.9	31.2	4.98
middle	-	-	-	-
bottom	1.5	25.5	34.9	13.55
Pond 1 (time 1045 hrs)				
West Transect				
surface	0.5	22.2	35.6	4.97
middle	1.5	22.4	35.4	7.92
bottom	3.0	22.0	36.6	4.62
Pond 2 (time 0950 hrs)				
West Transect				
surface	0.5	21.4	35.7	3.77
middle	-	-	-	-
bottom	1.5	21.7	36.1	6.04
Wood Creek March 19, 2015 **Water Quality Site**	**Depth** **(feet)**	**Water Temperature** **(° C)**	**Salinity** **(ppt)**	**Dissolved Oxygen** **(mg/l)**
surface	0.5	15.7	2.1	9.11
middle	2.0	16.0	6.1	8.49
bottom	4.0	15.7	7.3	4.99
Wood Creek July 24, 2015 **Water Quality Site**	**Depth** **(feet)**	**Water Temperature** **(° C)**	**Salinity** **(ppt)**	**Dissolved Oxygen** **(mg/l)**
surface	0.5	26.6	12.7	15.55
middle	1.8	33.0	22.3	23.25
bottom	3.5	32.4	25.5	16.64

became inhospitable to juvenile salmonids during the summer and fall (Table 49) and had begun converting to freshwater again in November and December 2015.

Meromixis, the warming and depletion of oxygen in the brackish layer of the water column, is often seen in lagoons along the California coast (Zedonis et al. 2007; Atkinson 2010). In general, the off channel ponds provide good water quality during the winter and spring and support juvenile salmonids rearing over winter in the SEE but become too warm and brackish with low dissolved oxygen during much of the summer and fall.

Past studies in the SEE of Humboldt Bay found that juvenile coho salmon preferred freshwater habitat with water temperatures ≤17°C (Wallace 2006; Wallace and Allen 2007, 2009, 2012). Bjornn and Reiser (1991) reported that preferred water temperatures were 12-14°C for Chinook and coho salmon and 10-13°C for steelhead trout and that conditions become life-threatening when temperatures exceeded 23-25°C. They also reported that salmonids function without impairment at DO levels near 8mg/l and were probably limited by levels <5mg/l. In the SEE of Humboldt Bay, juvenile coho salmon do not appear to rear in water >17°C while juvenile steelhead and cutthroat trout are often captured in areas as warm as 21°C (Wallace 2006; Wallace and Allen 2007, 2009, 2012). These same studies also typically captured juvenile salmonids in areas where DO levels were 5-7mg/l and often captured juvenile coho salmon in areas as low as 3.5 to 5mg/l. Ruggerone (2000) reported that juvenile coho salmon tolerated lower DO levels than other salmonids, often as low as 4mg/l.

DISCUSSION

This paper presents three years of data from an on-going 12 year study of juvenile salmonid use of the SEE of Humboldt Bay. In Freshwater Creek Slough, where CDFW has its longest continuous juvenile salmon data set in Humboldt Bay, NSA captured relatively large numbers of sub-yearling coho salmon in 2015, and relatively few in 2014 compared to past years (Table 30). The CPUE of sub-yearling coho salmon in 2015 was the second highest recorded by our project (Table 30), but their mean monthly FL was smaller compared to most other years (Figure 6). In 2012 we observed the highest sub-yearling coho salmon CPUE of our study (Table 30) coupled with the smallest monthly mean FL of our study (Figure 6) suggesting high sub-yearling coho salmon density inhibits their growth in the SEE. Also, from 2006 to 2010 and again in 2015, June and July were the months of peak CPUE for sub-yearling coho salmon; however, from 2011 to 2014 the monthly CPUE peaked in August to December possibly the result of low stream flows during the drought forcing fish to move downstream. PIT tagged sub-yearling coho salmon mean residence times of 45 and 62 days and growth rates of 0.20 and 0.16 mm/day in the SEE of Freshwater Creek Slough in 2013 and 2014 respectively, were similar to past years (Table 11). However, in 2015 their mean residence time was 71 days, which was the longest recorded during our study, and their mean growth rate was 0.08 mm/day, which was the slowest recorded during our study (Table 11).

Table 30. Effort, number captured, and catch-per-unit-effort of sub-yearling coho salmon in Freshwater Creek Slough during June-September, 2006-2015.

Year	Effort (No. Seine Hauls)	No. Fish Captured	Catch-per-unit-effort (No. fish/haul)
2006	204	420	2.06
2007	168	101	0.60
2008	188	11	0.06
2009	104	247	2.38
2010	87	73	0.84
2011	108	264	2.44
2012	101	1,340	13.27
2013	108	274	2.54
2014	108	89	0.82
2015	107	486	4.54

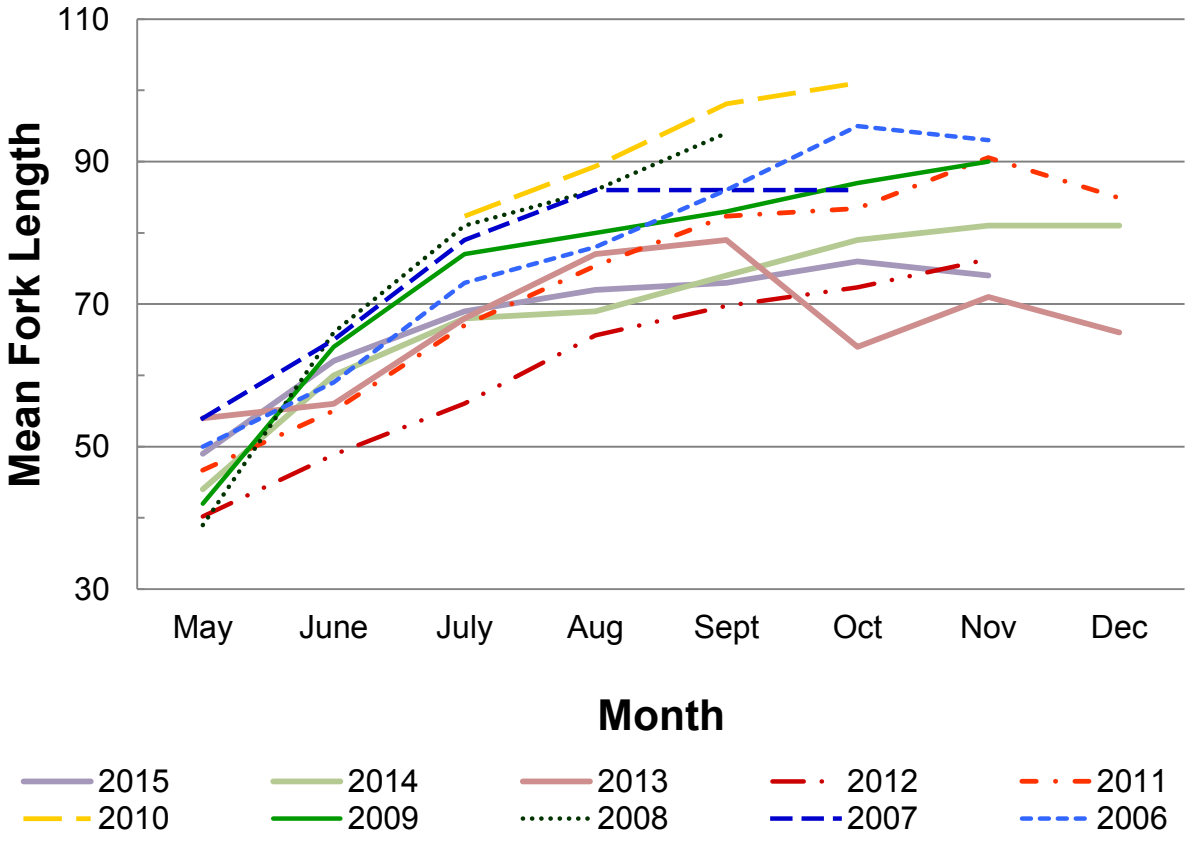

Figure 6. Mean monthly fork lengths of sub-yearling coho salmon captured in Freshwater Creek Slough, 2006-2015.

In all three years of this study NSA found that juvenile salmonids were also rearing in the SEE of Wood and Ryan creeks and that fish would move throughout the entire Freshwater-Wood-Ryan SEE. Residence times of PIT tagged juvenile coho salmon ranged from 6 to 287 days in Freshwater Creek Slough, 4 to 164 days in Wood Creek, and 13 to 273 days in Ryan Creek (Appendix 1). Residence times of PIT tagged juvenile steelhead trout ranged from 13 to 238 days in Freshwater Creek and 14 to 378 days in Ryan Creek (Appendix 1). PIT tagged cutthroat trout were at-large for 13 to 716 days in Freshwater Creek Slough and 13 to 350 days in Ryan Creek. We detected tagged juvenile salmonids from throughout the Freshwater and Ryan Creek basins at our PIT tag antennas on Wood Creek (Tables 21 & 22) and Ryan Creek Slough (Table 32). These observations demonstrate that juvenile salmonids rear and move throughout the entire Freshwater-Wood-Ryan SEE. Therefore, it is important to maintain and enhance connectivity between the streams entering the SEE.

This and earlier studies by NSA (Wallace 2006; Wallace and Allen 2007, 2009, 2012, 2015; Wallace et al. 2015) showed that sub-yearling and yearling-plus coho salmon, as well as a wide size range of juvenile steelhead trout routinely reared in the SEE for months. There appears to be at least three basic life history strategies exhibited by juvenile coho salmon in Humboldt Bay tributaries (Wallace 2006; Wallace and Allen 2007, 2009, 2012, 2015; Wallace et al. 2015). One strategy is sub-yearling coho salmon move to the SEE during spring and reside there throughout the summer and fall with at least some continuing to rear in the SEE throughout the winter and into the spring. The second strategy is as stream flow increase in the fall or winter, there is a large-scale redistribution of coho salmon from stream habitat downstream to the SEE of Humboldt Bay tributaries. The third strategy is stream-reared coho salmon smolt and emigrate quickly through the SEE in the spring. The “fall redistribution” of coho salmon into winter habitat has been observed by other researchers throughout the Pacific Northwest (Koski 2009). Wallace et al. 2015 cited studies showing it occurs in California rivers such as the Smith River, Klamath River, Redwood Creek, Eel River, and Russian River. Also the SEE provides rearing habitat for a large portion of juvenile salmonids in Humboldt Bay tributaries. CDFW estimated that about 40% of coho salmon smolts and 80-90% of large steelhead trout smolts originated from the SEE of Freshwater Creek in 2007 and 2008 (Ricker and Anderson 2011). Our studies also showed that juvenile salmonids using this habitat experienced faster growth, obtained a larger size, and therefore likely were larger when entering the marine environment (Wallace 2006; Wallace and Allen 2007, 2009, 2012; CDFG 2006, 2007, 2008, 2009, 2010).

However, there does appear to be density dependent growth in at least Freshwater Creek Slough. This study found that monthly mean FL of sub-yearling coho salmon was negatively correlated to their June-September CPUE (Table 30 and Figure 6). This suggests that in summers of high sub-yearling coho salmon abundance in the SEE, growth rate is muted compared to lower abundance years. Restoring and increasing SEE habitat could result in greater numbers of juvenile coho salmon rearing in the ecotone or at least lowering the density of rearing coho salmon resulting in larger sized fish entering the winter season.

Poor over-winter survival has been suggested as limiting production of juvenile salmonids in Freshwater Creek (Ricker and Anderson 2011) and coho salmon in other watersheds throughout the Pacific Coast of North America (Nickelson et al. 1992; Quinn and Petersen 1996; Ebersole et al. 2006). Ricker and Anderson (2011) speculated that many fish moved downstream to the SEE in the fall and winter prior to installation of smolt traps in March.

Numerous studies have concluded that low gradient habitats such as the SEE, as well as marshes, wetlands, off-channel pools, and beaver ponds provide favorable over-winter habitat resulting in faster fish growth in coho salmon, higher over-winter survival rates, and larger sized smolts than other stream habitats (Quinn and Petersen 1996; Miller and Sadro 2003; Ebersole et al. 2006; Ricker and Anderson 2011). Ricker and Anderson (2011) found over-winter survival in low-gradient reaches 2-6 times higher than the other sampled reaches. In addition, increasing aquatic habitat connectivity between rearing habitats can increase survival and the resiliency of populations (Bisson et al. 2009). In tributaries entering Humboldt Bay, most of the low-gradient over-winter habitat appears to occur in the SEE (Wallace 2006; Wallace and Allen 2007, 2009, 2012; Ricker and Anderson 2011), with the best examples being non-natal tidal tributaries that are connected to streams containing “source” populations of salmonids (e.g. non-natal Wood Creek connected to source population in Freshwater Creek).

Generally, SEE habitat restoration projects appear to be successful at providing over-winter habitat for juvenile salmonids. During this study we assessed off channel pond construction and tide gate replacement/modification completed in Wood and Salmon creeks, pre and the beginning of post project sampling of tide gate replacement in Martin Slough, and pre project sampling prior to off channel pond construction in Jacoby Creek. Most years the off channel ponds in Wood and Salmon creeks were occupied by juvenile salmonids from around December to May, but due to high water temperature and salinities and often low DO they were unsuitable for salmonids June to November.

Relatively large numbers of juvenile salmonids, especially coho salmon, were captured in the restored habitat. In Salmon Creek, off-channel ponds were constructed in 2011, and we captured more juvenile coho salmon in the ponds the first year after they were constructed than the previous seven pre-project years combined. We have captured hundreds of juvenile coho salmon in Wood Creek, Martin Slough, and (beginning in the first few months of 2016) Jacoby Creek.

Fish growth could be quite high in the ponds, especially in the spring. In Wood Creek from February to April 2013 we found yearling-plus coho salmon that were tagged and recaptured in the pond had a mean growth rate of 0.40 mm/day (range 0-0.85 mm/day; n=11) while those tagged and recaptured in the main channel of Wood Creek had a mean growth rate of 0.22 mm/day (range 0.03-0.42 mm/day; n=7). In 2015 we recaptured one yearling-plus coho salmon tagged in the pond and it grew 1.29 mm/day. In the Salmon Creek ponds we recaptured one yearling-plus coho salmon tagged in the ponds during each of the three years of our study and their growth rates were 0.79 to 0.87 mm/day (Appendix 1). In Martin Slough during 2015 we found yearling-plus coho

salmon tagged and recaptured in the off channel pond had a mean growth rate of 0.48 mm/day (range 0.33-0.72; n=5) while the single yearling coho tagged and recaptured in the main channel of Martin Slough grew 0.21 mm/day. Finally, preliminary data from the newly constructed upper Jacoby Creek pond showed that from January to March 2016 yearling-plus coho salmon had a mean growth rate of 0.27 mm/day (range 0.08-0.50 mm/day) while the annual mean monthly growth rates of PIT tagged yearling-plus coho salmon from the main channels of Freshwater Creek Slough, Ryan Creek Slough, and Jacoby Creek was 0.25 mm/day (range 0.12 to 0.42 mm/day).

The drought from 2013 to 2015 appeared to effect habitat conditions and fish behavior in the SEE. We noted that in 2013/14 heavy rains and increased stream flows that typically begin in November or December did not begin until February 2014 and that the fall redistribution of juvenile coho salmon that usually occur in November and December was delayed until March 2014. We also noted a much higher number of juvenile coho salmon holding over a second summer in the SEE. Growth rates of sub-yearling coho salmon in Freshwater Creek Slough during the summers of 2014 and especially 2015 are among the slowest on record (Table 11). We speculated the increased holdover was due to drought conditions reducing growth rates of juvenile coho salmon in stream and SEE habitat, coupled with a shortened window for emigration in the spring resulting in the earlier than normal occurrence of warm brackish water in the sloughs entering Humboldt Bay. Impaired habitat conditions in the SEE due to the drought were also evident. We noted the growth of heavy mats of filamentous algae in most off channel ponds during the summer and in many cases it persisted into the winter (Figure 7). The heavy algae growth limited our ability to seine off channel ponds in Wood and Salmon creeks and Martin Slough. We hypothesize that the lack of rain and low flows resulted in less than normal water circulation and flushing in the pond during the winter and spring and the usual dry weather and low stream flows during the summers exacerbated the poor conditions in the pond. Finally we also noted warm brackish water persisted for a longer period of time in the tidal off channel ponds in Wood and Salmon creeks during the drought and noted hypersaline conditions in the Salmon Creek estuary with summer water salinity reaching 34 to 38 ppt (Wallace 2014).

Recent reports have documented a coast-wide pattern of juvenile coho salmon utilizing estuaries (Miller and Sadro 2003; Koski 2009; Jones et al. 2014) and have determined that movement to the estuary or other off-channel habitats increases their life history diversity and population resilience increasing the chance to recover these species (Koski 2009). Since the ability to restore complex estuarine ecosystem functions is contingent upon a landscape perspective to restoration planning (Simenstad et al. 2000) and will likely not be achieved through isolated manipulation of individual elements (National Research Council 1992), fishery managers and restoration scientists will need to take several actions.

The actions include gauging the relative success of these restoration projects, developing appropriate habitat criteria targets, determining which restoration techniques work best, and determining how these restoration projects ties into the greater ecosystem functions. By first recognizing, and then understanding the role of the entire

Figure 7. Comparison of algae levels in Wood Creek pond in February 2014 (left) versus February 2013 (right).

estuarine rearing stage in juvenile salmonid life history, we will be better able to form effective restoration and management practices to help recover anadromous salmonids.

The SEE surrounding Humboldt Bay is important to juvenile salmonids, especially coho salmon, because 1) it supports multiple life stages; 2) juvenile salmonids rear in the ecotone for significant periods of time; 3) a significant portion of the populations utilizes the ecotone; and 4) salmonids rearing in the ecotone grow faster and larger than their cohorts rearing upstream in stream habitat.

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LITERATURE CITED

Atkinson, K.A. 2010. Habitat conditions and steelhead abundance and growth in a California lagoon. Master's Thesis. San Jose State University, San Jose, California.

Bisson, P.A., J.B. Dunham, and G.H. Reeves. 2009. Freshwater ecosystems and resilience of Pacific salmon: habitat management based on natural variability. Ecology and Society 14(1): 45. [online] URL: http://www.ecologyandsociety.org/vol14/iss1/art45/

Bjornn, T.C. and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publication 19: 83-138.

Bond, M.H, S.A. Hayes, C.V. Hanson, and R.B. MacFarlane. 2008. Marine survival of steelhead (*Oncorhynchus mykiss*) enhanced by a seasonally closed estuary. Canadian Journal of Fisheries and Aquatic Sciences 65: 2242-2252.

Busby, M.M. and R.A. Barnhart. 1995. Potential food sources and feeding ecology of juvenile fall Chinook salmon in California's Mattole River lagoon. California Department of Fish and Game Bulletin. 81 (4): 136-146.

California Department of Fish and Game. 2004. Recovery Strategy for California Coho Salmon. Report to the California Fish and Game Commission. February 2004.

California Department of Fish and Game. 2006. Humboldt Bay juvenile salmonids investigations. Annual Performance Report. Federal Aid in Sport Fish Restoration Act. Grant Number F-51-R-16. Project No. 67.

California Department of Fish and Game. 2007. Humboldt Bay juvenile salmonids investigations. Annual Performance Report. Federal Aid in Sport Fish Restoration Act. Grant Number F-51-R. Project No. 67.

California Department of Fish and Game. 2008. Humboldt Bay juvenile salmonids investigations. Annual Performance Report. Federal Aid in Sport Fish Restoration Act. Grant Number F-122-R. Project No. 67.

California Department of Fish and Game. 2009. Humboldt Bay juvenile salmonids investigations. Annual Performance Report. Federal Aid in Sport Fish Restoration Act. Grant Number F-122-R. Project No. 67.

California Department of Fish and Game. 2010. Humboldt Bay juvenile salmonids investigations. Annual Performance Report. Federal Aid in Sport Fish Restoration Act. Grant Number F-137-R. Project No. 67.

Ebersole, J.L., P.J. Wigington Jr., J.P. Baker, M.A. Cairns, M.R. Church, B.P. Hansen, B.A. Miller, H.R. La Vigne, J.E. Compton, and S. G. Leibowitz. 2006. Juvenile coho salmon and survival across stream network seasonal habitats. Transactions of the American Fisheries Society 135: 1681-1697

Hayes, S.A., M.H. Bond, C.V. Hanson, E.V. Freund, J.J. Smith, E.C. Anderson, A.J. Amman, and R.B. MacFarlane. 2008. Steelhead growth in a small central California watershed: upstream and estuarine rearing patterns. Transactions of the American Fisheries Society 137: 114-128.

Healey, M.C. 1982. Juvenile Pacific salmon in estuaries: the life support system. Pages 315-341 *in:* V. Kennedy editor. Estuarine comparisons. Academic Press, New York. New York, USA.

Healey, M.C. 1991. Life history of Chinook salmon (*Oncorhynchus tshawytscha*). Pages 311-393 *in:* C. Groot and L. Margolis editors. Pacific salmon life histories. UBC Press, Vancouver, British Columbia, Canada.

Humboldt Bay Watershed Advisory Committee. 2005. Humboldt Bay Watershed Salmon and Steelhead Conservation Plan. Prepared for California Department of Fish and Game and the California Coastal Conservancy by the Humboldt Bay Watershed Advisory Committee and the Natural Resources Services Division of Redwood Community Action Agency.

Jones, K.K., T.J. Cornwell, D.L. Bottom, L.A. Campbell, and S. Stein. 2014. The contribution of estuary-resident life histories to the return of adult *Oncorhynchus kisutch*. Journal of fish biology 85(1): 52-80.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life history of fall-run juvenile Chinook salmon, *Oncorhynchus tshawytscha*, in Sacramento-San Joaquin Estuary, California. Pages 393-411; *in*: V. Kennedy, editor. Estuarine comparisons. Academic Press, New York, New York, USA.

Koski, K.V. 2009. The fate of coho salmon nomads: the story of an estuarine-rearing strategy promoting resilience. Ecology and Society 14 (1): 4.

Love, M. 2014. Jacoby Creek off channel habitat restoration. Preliminary Design Report. Prepared for Pacific Coast Fish, Wildlife, and Wetlands Restoration Association, Jacoby Creek Land Trust, and California Department of Fish and Wildlife by Michael Love and Associates. 143pp.

Miller, B.A. and S. Sadro. 2003. Residence time and seasonal movements of juvenile coho salmon in the ecotone and lower estuary of Winchester Creek, South Slough, Oregon. Transactions of the American Fisheries Society 132(3): 546-559.

National Marine Fisheries Service. 2014. Recovery Plan for Southern Oregon/Northern California Coast Coho Salmon (*Onchorynchus kisutch*). National Marine Fisheries Service. Arcata, CA.

National Research Council. 1992. Restoration of aquatic ecosystems: science, technology and public policy. National Academy Press. Washington D.C.

Nicholas, J.W. and D.G. Hankin. 1989. Chinook salmon populations in Oregon coastal river basins: Description of life histories and assessment of recent trends in run strengths. Oregon Department of Fish and Wildlife. No. EM 8402, March 1989. Oregon State University Extension Service, Corvallis, Oregon, USA.

Nickelson, T.E., J.D. Rogers, S.L. Johnson, and M.F. Solazzi. 1992. Seasonal changes in habitat use by juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49: 783-789.

Nobriga, M.L., F. Feyrer, R.D. Baxter, and M. Chotkowski. 2005. Fish community ecology in an altered river delta: Spatial patterns in species composition, life history strategies, and biomass. Estuaries 28 (5): 776-785.

Northcote, T.G. 1997. Why sea-run? An exploration into the migratory /residency spectrum of coastal cutthroat trout. Pages 20-26 *in* J.D. Hall, P.A. Bisson, and R.E. Gresswell, editors. Sea-run cutthroat trout: biology, management, and future conservation. Oregon Chapter, American Fisheries Society, Corvallis.

Odum, E.P. 1971. Fundamentals of ecology. 3rd edition. Saunders. Philadelphia.

Pearcy, W.G. 1997. Sea-run cutthroat trout: life history profile. Pages 29-34 *in* J.D. Hall, P.A. Bisson, and R.E. Gresswell, editors. Sea-run cutthroat trout: biology, management, and future conservation. Oregon Chapter, American Fisheries Society, Corvallis.

Quinn, T.P. and N.P. Peterson. 1996. The influence of habitat complexity and fish size on over winter survival and growth of individually marked juvenile coho salmon (*Oncorhynchus kisutch*) in Big Beef Creek, Washington. Canadian Journal of Fisheries and Aquatic Sciences 53: 1555-1564.

Reimers, P.E. 1971. The length of residence of juvenile fall Chinook salmon in Sixes River, Oregon. Ph. D., Oregon State University, Corvallis.

Ricker, S.J. and C.W. Anderson. 2011. Freshwater Creek Salmonid Life Cycle Monitoring Station. Annual Report. California Department of Fish and Game, Anadromous Fisheries Resource Assessment and Monitoring Program, 50 Ericson Ct., Arcata, CA 95521.

Roni, P., T. Bennett, R. Holland, G. Pess, K. Hanson, R. Moses, M. McHenry, W. Ehinger, and J. Walter. 2012. Factors affecting migration timing, growth, and survival of juvenile coho salmon in two coastal Washington watersheds. Transactions of American Fisheries Society 141 (4): 890-906.

Ruggerone, G.T. 2000. Differential survival of juvenile sockeye and coho salmon exposed to low dissolved oxygen during winter. Journal of Fish Biology 56: 1013-1016.

Simenstad, C.A., W.G. Hood, R.M. Thom, D. A. Levy, and D. L. Bottom. 2000. Landscape structure and scale constraints on restoring estuarine wetlands for pacific coast juvenile fishes. Pages 597-630 *in* M.P. Weinstein and D.A. Kreeger, editors. Concepts and controversies in tidal marsh ecology. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Sommer, T.R., M.L. Nobriga, W.C. Harrell, W. Batham, and W.J. Kimmerer. 2001. Floodplain rearing of juvenile Chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58: 325-333.

Trotter, P.C. 1997. Sea-run cutthroat trout: life history profile. Pages 7-15; *in* J.D. Hall, P.A. Bisson, and R.E. Gresswell, editors. Sea-run cutthroat trout: biology, management, and future conservation. Oregon Chapter, American Fisheries Society, Corvallis, OR.

Tschaplinski, P.J. 1982. Aspects of the population biology of estuary-reared juvenile coho salmon in Carnation Creek: a summary of current research. Pages 289-307; *in* G.F. Hartman, editor. Proceedings of the Carnation Creek Workshop: a ten-year review. Malaspina College, Nanaimo, British Columbia.

Wallace, M. 2006. Juvenile salmonid use of Freshwater Slough and tidal portion of Freshwater Creek, Humboldt Bay, California. 2003 Annual Report. Inland Fisheries Administrative Report No. 2006-04.

Wallace, M. 2010. Response of juvenile salmonids and water quality to habitat restoration in Humboldt Bay estuaries. California Department of Fish and Game; Available from: https://nrmsecure.dfg.ca.gov/FileHandler.ashx?DocumentID=36268.

Wallace, M. 2014. Drought monitoring stressor case study: Extended periods of brackish and hyper-saline conditions in the stream-estuary ecotone of Salmon Creek, Humboldt Bay 2014. Available from: https://www.wildlife.ca.gov/Conservation/Inland-Fisheries/Projects/Salmon-Creek.

Wallace, M. and S. Allen. 2007. Juvenile salmonid use of the tidal portions of selected tributaries to Humboldt Bay, California. Final Report California Department of Fish and Wildlife, Fisheries Restoration Grants Program Grant P0410504.

Wallace, M. and S. Allen. 2009. Juvenile salmonid use of the tidal portions of selected tributaries to Humboldt Bay, California. Final Report California Department of Fish and Wildlife, Fisheries Restoration Grants Program Grant P0610522.

Wallace, M. and S. Allen. 2012. Juvenile salmonid use of the tidal portions of selected tributaries to Humboldt Bay, California. Final Report California Department of Fish and Wildlife, Fisheries Restoration Grants Program Grant P0810517.

Wallace, M. and S. Allen. 2015. Juvenile salmonid use and restoration assessment of the tidal portions of selected tributaries to Humboldt Bay, California, 2011-2012. Fisheries Administrative Report No. 2015-02.

Wallace, M., and B.W. Collins. 1997. Variation in use of the Klamath River estuary by juvenile Chinook salmon. California Fish and Game 83(4):132-143.

Wallace, M., S. Ricker, J. Garwood, A. Frimodig, and S. Allen. 2015. Importance of the stream-estuary ecotone to juvenile coho salmon (*Oncorhynchus kisutch*) in Humboldt Bay, California. California Fish and Game 101(4): 241-266; 2015.

Zedonis, P. 1992. The biology of juvenile steelhead (*Oncorhynchus mykiss*) in the Mattole River estuary/lagoon. Master's Thesis. Humboldt State University, Arcata, CA.

Zedonis, P, R. Turner, N. Hetrick. 2007. Water quality dynamics of the Mattole River Lagoon and suitability for rearing salmonids in 2006. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Technical Series Report Ts 2008-01, Arcata, Califiornia.

Appendix 1- Summary of residence time and growth rates of PIT tagged sub-yearling (SY) coho salmon, yearling-plus (1+) coho salmon, and juvenile steelhead trout (SH) from Freshwater Creek Slough (FW), Wood Creek, Ryan Creek Slough, Salmon Creek, Jacoby Creek, and Martin Slough, 2013-2015.

	Year	No. Tagged	No. Recap	Percent Recap	Mean DAL	Range DAL	Mean Growth Rate	Range Growth Rate
Coho								
FW	2013	201	99	49.3	45	6-140	0.20	-0.07-0.86
SY	2014	61	27	44.3	62	13-140	0.16	0.00-0.40
	2015	252	120	47.6	71	13-152	0.08	0.00-0.27
FW	2013	222	49	22.1	32	6-140	0.30	0.00-0.58
1+	2014	395	91	23.0	40	7-224	0.31	-0.08-0.71
	2015	87	13	14.9	47	1-287[a]	0.18	0.00-0.57[a]
Wood	2013	156	22	14.1	27	4-59	0.32	0.00-0.85
1+	2014	184	8	4.3	-	28-121	-	0.03-0.89
	2015	68	7	10.3	-	18-164	-	0.00-0.33
Ryan	2013	75	21	28.0	24	13-84	0.19	0.00-0.36
SY	2015	27	6	22.2	-	14-98	-	0.06-0.43
Ryan	2013	439	108	24.6	58	13-252	0.19	-0.08-0.57
1+	2014	254	52	20.5	63	13-266	0.27	0.04-0.79
	2015	72	11	15.3	71	14-273	0.42	0.21-0.62
Salmon	2013	12	1	8.3	-	27	-	0.81
1+	2014	17	1	5.9	-	31	-	0.87
	2015	22	1	4.5	-	29	-	0.79
Jacoby	2013	50	6	12.0	-	35-90	-	0.03-0.11
SY	2015	8	3	37.5	-	55-55	-	0.02-0.04
Jacoby	2014	20	1	5.0	-	64-272[a]	-	0.03-0.25[a]
1+	2015	6	1	16.7	-	56	-	0.09
Martin	2015	6	1	16.7	-	28	-	0.29
SY								
Martin	2014[b]	14	4	28.6	-	35-35	-	-0.03-0.03
1+	2015	82	6	7.3	-	30-160	-	0.21-0.72

Appendix 1 (con't)- Summary of residence time and growth rates of PIT tagged sub-yearling (SY) coho salmon, yearling-plus (1+) coho salmon and juvenile steelhead trout (SH) from Freshwater Creek Slough (FW), Wood Creek, Ryan Creek Slough, Salmon Creek, Jacoby Creek, and Martin Slough, 2013-2015.

	Year	No. Tagged	No. Recap	Percent Recap	Mean DAL	Range DAL	Mean Growth Rate	Range Growth Rate
SH								
FW	2013	62	15	24.2	-	13-238	-	0.05-0.42
	2014	61	7	11.5	-	14-98	-	0.02-0.24
	2015	55	14	25.5	-	13-209	-	0.01-0.27
Ryan	2013	25	6	24.0	-	14-378	-	0.00-0.38
	2014	18	6	33.3	-	14-112	-	0.00-0.43
Salmon	2014	48	1	2.1	-	12-133[a]	-	0.17-0.76[a]
Jacoby	2014	13	1	7.7	-	97-363[a]	-	0.09-0.13[a]
	2015	14	1	7.1	-	56	-	0.23

[a] *Includes captured fished tagged in previous year*
[b] *Sampling started in August 2014*