Annual Project Performance Report

1. State: California

Grant number: F-137-R

Grant name: California Inland and Anadromous Sport Fish Management and Research

Project number and name: Project 67: Humboldt Bay Juvenile Salmonid Investigations

2. Report Period: July 1, 2009 through June 30, 2010
Report due date: September 30, 2010
Date prepared: August-September 2010

3. Location of work: Humboldt Bay, Humboldt County California, State Congressional District 1

4. Objectives:

1. To monitor the effects of marsh restoration projects in Wood and Salmon Creeks on juvenile salmonid use and basic water quality conditions, specifically in the newly created off channel ponds (contingent on successful grant application to FRGP).
2. Better describe use of entire Freshwater Creek stream-estuary ecotone by monitoring juvenile salmonid entry timing, movement, and use of Freshwater Creek Slough, Wood Creek, and Ryan Creek/Slough (contingent on successful grant application to FRGP).
3. To determine the proportion of the population of coho salmon smolts originating from the stream/estuary ecotone of Freshwater Creek (contingent on State's resumed payment to PSMFC to allow us to hire temporary field staff and DFG funding).
4. To describe the use of the tidal portion of smaller Humboldt Bay tributaries such as Martin Slough, Jacoby Creek/Gannon Slough, and Rocky Gulch by juvenile salmonids.

5. Part of Larger Project: This work is being augmented by California Fisheries Restoration Grant Program to pay for Pacific States Marine Fisheries Commission fishery technicians to conduct the field sampling and a small portion of O&E. Aid in Sport Fish Restoration funds are being used to pay for project biologist, O&E, and a small portion of temporary help for project field work.

This project is also collecting juvenile salmonid emigration timing and relative abundance data to document existing conditions prior to marsh restoration projects already ongoing or planned in the tidal portion of Freshwater Creek Slough, Salmon Creek estuary, Rocky Gulch, Wood Creek, Jacoby Creek, Gannon Slough, and Martin Slough by other government agencies and private and non-profit groups.

6. Describe how the objectives were met:

Introduction

California salmonid populations have declined considerably from historic levels (Brown et al. 1994, Weitkamp et al. 1995; Busby et al. 1996; Myers et al. 1998; CDFG 2002). Humboldt Bay tributary populations of coho salmon, *Oncorhynchus kisutch*, Chinook salmon, *O. tshawytscha*, and steelhead trout, *O. mykiss*, have been listed as threatened by NOAA Fisheries and coho salmon have been listed as threatened by the State of California. Humboldt Bay tributaries support some of the last significant populations of wild coho salmon remaining in California (Brown et al. 1994), as well as Chinook salmon, steelhead trout, and coastal cutthroat trout. Restoring estuary function for the benefit of coho salmon is a range wide recommendation in the State's coho recovery plan (CDFG 2004) and for Humboldt Bay in particular (HBWAC 2005). The Steelhead Restoration and Management Plan for California (CDFG 1996) also identified estuary function as a primary factor for the decline in steelhead productivity. Recent reports have documented a Pacific coast-wide pattern of juvenile coho salmon utilizing estuaries and have determined that this strategy increases their life history diversity and population resilience increasing the chance to recover these species (Koski 2009). This project aims to provide important juvenile salmonid life history information and assessments of restoration projects to resource managers and the restoration community to improve the design and implementation of estuarine habitat restoration projects.

Estuaries are important habitat for juvenile salmonids and other popular sport fish species. Numerous studies have documented extended estuarine residence by juvenile Chinook salmon (Healey 1991; Kjelson et al.1982; Healey 1982; Reimers 1971), coho salmon (Koski 2009; Wallace and Allen 2009; Miller and Sadro 2003; Nielsen 1994; Tschaplinski 1982), steelhead trout (Bond 2006), and sea-run coastal cutthroat trout (Trotter 1997; Northcote 1997). For salmonids other than coho salmon, faster growth in the estuary and larger size at ocean entrance has been shown to account for higher marine survival (Northcote 1997; Pearcy 1997; Trotter 1997). These survival benefits to coho salmon have largely been inferred from these studies, but coho salmon have substantially different life histories and estuary use patterns. Relatively few studies have identified the importance of the greater transition zone, or ecotone (Odum 1971), between fresh and brackish water to juvenile salmonids (Koski 2009; Wallace and Allen 2009; Wallace and Allen 2007; Miller and Sadro 2003; Tschaplinski 1982). Miller and Sadro (2003) defined this stream-estuary ecotone, and we adapted their definitions, to include the area of low gradient stream extending from stream entrance to the wide valley floor, through the upper limit of tidal influence downstream to the area where the channel becomes bordered by tidal mudflats. This definition of the ecotone 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.

Prior to CDFG's Natural Stocks Assessment Project (NSA) study virtually no salmonid sampling had been conducted in the stream-estuary ecotone of Humboldt Bay. On going studies by NSA in the tidal portions of Humboldt Bay tributaries showed that juvenile salmonids heavily utilize stream-estuary ecotone habitat and routinely rear there for months (Wallace and Allen 2009; Wallace and Allen 2007). CDFG's Anadromous Fisheries Research and Monitoring Program (AFRAMP) and NSA projects estimated that about 40% of coho salmon smolts and 80 to 90% of large steelhead smolts originated from the stream-estuary ecotone of Freshwater Creek in 2007 and 2008. These studies also showed that juvenile salmonids using this habitat experienced faster growth, obtained a larger size, and likely experienced increased marine survival over juvenile salmonids rearing in stream habitat (Wallace and Allen 2009; Wallace and Allen 2007; CDFG 2007; Wallace 2006; CDFG 2006 and 2005; CDFG unpublished data).

Based on data collected by CDFG's AFRAMP and NSA projects it appears that the stream-estuary ecotone habitat around Humboldt Bay provides extremely important over-winter rearing habitat for juvenile coho salmon and steelhead trout. Poor over-winter survival has been suggested as limiting production of juvenile salmonids in Freshwater Creek (Seth Ricker,

CDFG, personal communication), and in other watersheds throughout the Pacific coast of North America (Ebersole et al. 2006; Quinn and Petersen 1996; Nickelson et al. 1992). Numerous studies have concluded that low gradient habitats such as the stream-estuary ecotone, but also marshes, wetlands, off-channel pools, and beaver ponds throughout the watershed provides favorable over-winter habitat resulting in faster fish growth, higher over-winter survival rates, and larger sized smolts than other stream habitats (Ebersole et al. 2006; Miller and Sadro 2003; Quinn and Petersen 1996). Larger individuals at ocean entry also experience higher marine survival (Northcote 1997; Pearcy 1997; Trotter 1997). Subsequent surveys in the tidal portion of other Humboldt Bay tributaries such as Elk River Slough, Martin Slough, Salmon Creek estuary, Wood Creek, and Rocky Gulch showed that juvenile salmonids, especially coho salmon, rear in the stream-estuary ecotone of these streams for months at a time and are especially important over-winter habitat. Recent monitoring in the Klamath River has shown that juvenile coho salmon move great distances to seek over-winter habitat in lower basin tributaries (Dan Gale, USFWS, personal communication). Therefore, documenting increased growth and higher survival in the low gradient stream-estuary ecotone habitat has relevance to watersheds throughout California even if they don't have well developed estuaries.

Salmonid recovery plans encouraged numerous estuary and marsh habitat restoration projects around Humboldt Bay and the Eel River estuary (HBWAC 2005; CDFG 2004). The majority of tidal wetlands around Humboldt Bay have been diked and converted to pasture land during the past 150 years. Currently, historic pieces marshland habitat around Humboldt Bay are being acquired by various public agencies and non profit groups and numerous marsh restoration projects are being planned or implemented. NSA, by describing life history traits and habitat needs of juvenile salmonids in the stream-estuary ecotone of Humboldt Bay, has already played an important role by providing needed data to help in the design local estuarine habitat restoration projects. However, few if any of these projects have measured the response of salmonid use or water quality to their restoration measures. Specifically, ongoing restoration projects in Wood Creek and Salmon Creek, Humboldt Bay, CA have proposed to improve habitat by in part, constructing off channel ponds to increase the number, size, and survival of juvenile salmonids, especially during the winter months. Therefore, Pacific States Marine Fisheries Commission in cooperation with NSA has received a grant from Fisheries Restoration Grants Program (FRGP) to monitor the effects of marsh restoration projects in Wood and Salmon Creeks on juvenile salmonid use and basic water quality conditions, specifically in the newly created off channel ponds. We will submit our findings and recommendations to resource managers and the restoration community to assist in their planning, prioritization, and implementation of future estuary restoration projects.

During the duration of this contract period (2009-2010) NSA continued to sample the tidal portion of Freshwater Creek Slough and Salmon Creek estuary to document their use by juvenile salmonids. NSA also sampled smaller Humboldt Bay tributaries such as Jacoby Creek/Gannon Slough, Martin Slough, Rocky Gulch, and Wood Creek to determine if juvenile salmonids use these very small estuaries as rearing habitat or if they offer over wintering habitat during high stream flow events. By describing life history traits and habitat needs of juvenile coho salmon, Chinook salmon, steelhead trout, and sea-run coastal cutthroat trout this project will continue to provide important data to the restoration community to help restoration planning projects succeed. This project will provide "snapshots" of juvenile salmonid use of these areas before and after restoration projects.

Methods

When stream and weather conditions allowed NSA conducted bi-weekly sampling for juvenile salmonids in Freshwater Creek Slough and Salmon Creek (Figure 1). NSA used a 30 ft X 4 ft seine net to capture fish in Freshwater Creek and Salmon Creek Sloughs. NSA also continued monthly sampling in numerous smaller Humboldt Bay tributaries started in 2006 and 2007. We used a 100 ft X 5 ft seine net to capture fish in Martin Slough pond; a 30 ft X 4 ft seine to capture fish in sections of Jacoby Creek/Gannon Slough, Martin Slough and Rocky Gulch; and

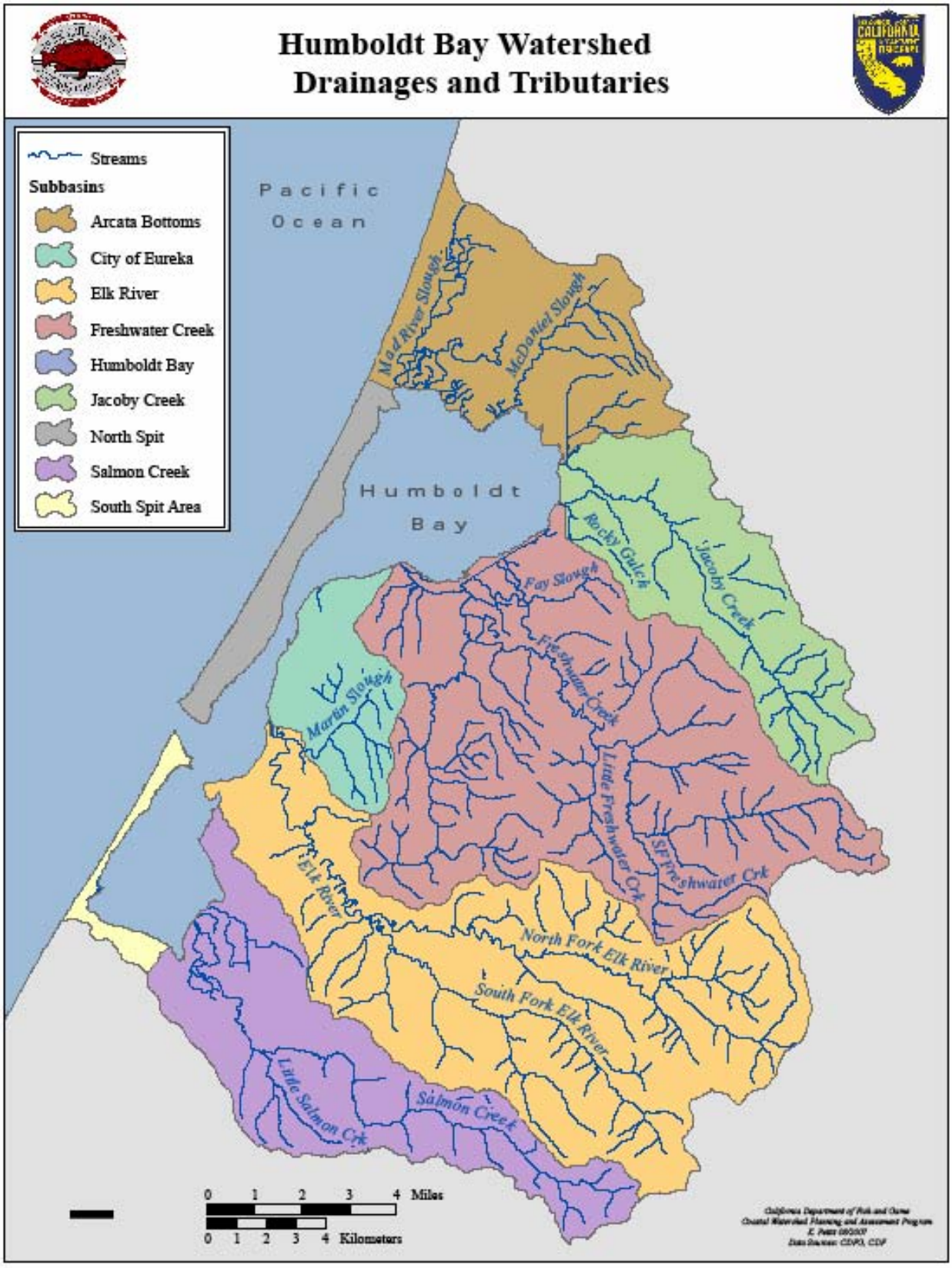

Figure 1. Map of Humboldt Bay tributaries.

minnow traps baited with frozen salmon roe in sections of Gannon Slough, Martin Slough, Rocky Gulch, and Wood Creek where we were unable to seine (Figure 1). In December 2009 NSA initiated sampling in Cattail Creek and Long Pond on the USFWS Humboldt Bay Refuge property to assess pre-project conditions prior to habitat restoration work on Salmon Creek estuary. In the winter of 2010 NSA installed two passive integrated transponder (PIT) tag antenna arrays in Wood Creek; one in a newly constructed off channel pond and one at the mouth of the creek. PIT tag detections were automatically stored on a data logger and NSA crew members downloaded this data every one to two weeks. This data was copied into Excel spreadsheets for future analysis back at the office. In the spring of 2010 NSA also assisted AFRAMP with the operation of a juvenile fish weir set up at the Humboldt Fish Action Council (HFAC) weir site in upper Freshwater Creek Slough to capture juvenile salmonid smolts emigrating from Freshwater Creek. This weir was supposed to be run in conjunction with another AFRAMP weir located about 3 km upstream in order to generate coho salmon and steelhead smolt production estimates passing each weir. Unfortunately a series of fiscal constraints conspired to make it impossible to run the upstream weir (See Question 7 in this report). NSA applied PIT tags to all healthy juvenile salmonids ≥55 mm FL to gather residency, movement, and growth information while they were in the stream-estuary ecotone.

Results

Freshwater Creek Slough

July-December 2009 During 2009 we observed a modest rebound in our catches of young-of-the-year (yoy) coho (Table 1). The peak weekly catch of yoy coho salmon was 4.25 fish/set and it occurred in mid October. In past years, peak yoy coho CPUE's usually occurred in late July (CDFG 2008 & 2007). Their FL's were similar to past years. Their monthly mean FL increased from 77 mm in July to 90 mm in November (Table 2). Based on the recapture of PIT tagged fish, yoy coho salmon resided in the tidal freshwater portion of Freshwater Creek Slough throughout the summer. Most project tagged yoy coho salmon were recaptured at the same site where they were originally marked indicating that they moved very little while residing in the slough. We did not capture any yoy Chinook salmon in July through December 2009 (Table 2). We captured two yearling coho salmon, both in August (Table 2). Their mean FL was 106 mm. We also commonly captured juvenile steelhead trout throughout the sampling season (Table 2). Their peak weekly catch of 0.75 fish/set occurred in mid August. We captured cutthroat trout from mid July to late November (Table 2) and their peak weekly catch was 0.50 fish/set in mid August and early November.

PIT Tag Results for 2009. Many of the yoy coho salmon PIT tagged by NSA resided in the tidal freshwater portion of Freshwater Creek Slough throughout the summer and into the fall. We applied PIT tags to 152 yoy coho in 2009 and recaptured 69 (45.4%) of them (Table 3). Yoy coho mean length of residence was 60 days in 2009 (Table 3). Their mean residence times were 68 days in 2007 and 33 days in 2006 (CDFG 2008 & 2007). The mean growth rate of

Table 1. Effort, number captured, and catch-per-unit-effort of young-of-the-year coho salmon in upper Freshwater Creek Slough during June, 2003-2010.

Year	# Seine Hauls	# Caught	CPUE (fish/set)
2003	48	478	9.96
2004	60	335	5.58
2005	59	447	7.58
2006	48	161	3.35
2007	48	64	1.33
2008	44	4	0.09
2009	34	106	3.12
2010	10	2	0.20

Table 2. Monthly catch-per-unit-effort (CPUE) and fork length (FL) in millimeters of young-of-the-year (yoy) Chinook salmon, yoy coho salmon, yearling and older coho salmon, juvenile steelhead trout, and cutthroat trout in upper Freshwater Creek Slough, July-December 2009. CPUE is number of fish per seine haul.

		YOY Chinook			YOY Coho			Yearling Coho			Steelhead			Cutthroat		
	No.		Mean			Mean			Mean			Mean			Mean	
Month	Sets	CPUE	FL	Range	CPUE	FL	Range	CPUE	FL	Range	CPUE	FL	Range	CPUE	FL	Range
July	24	0	-	-	1.58	77	66-90	0	-	-	0.25	124	67-170	0.33	189	157-218
Aug	24	0	-	-	1.75	80	63-94	0.08	106	96-115	0.46	127	73-166	0.25	204	153-232
Sept	24	0	-	-	2.50	83	71-95	0	-	-	0.25	131	105-156	0.17	185	143-232
Oct	20	0	-	-	2.25	86	45-99	0	-	-	0.40	144	96-200	0.10	190	157-222
Nov	24	0	-	-	0.67	90	70-103	0	-	-	0.08	112	98-125	0.29	220	179-270
Dec	12	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-

Table 3. Summary of residence times of young-of-the-year (yoy) coho salmon, yearling and older coho salmon, juvenile steelhead trout, and cutthroat trout based on Passive Integrated Transponder (PIT) tag data in Freshwater Creek Slough, January-December 2009. Mean days at liberty (DAL) were not calculated for fish species/life stage with sample sizes less than 10 individuals. Growth rates are millimeters per day and mean growth rates were calculated for fish at large ≥13 days except where noted.

Species	Number Tagged	Number Recaptured	Percent Recaptured	Mean DAL	Range DAL	Percent Recap at Same Site	Number With DAL >13 Days	Mean Growth Rate	Range Growth Rate
Yoy Coho	152	69	45.4	60	13-175	94	69	0.20	0-0.68
1+ Coho	27	0	0	-	-	-	-	-	-
Steelhead	49	12	24.5	30	13- 69	100	12	0.18	0-0.50
Cutthroat	17	4	23.5	-	29-119	100	4	-	0-0.41

recaptured yoy coho was 0.20 mm/day and ranged from 0 to 0.68 mm/day (Table 3). We applied PIT tags to 27 yearling coho in 2009 and recaptured none of them (Table 3). However, we did recapture one yearling coho we tagged the previous summer. We tagged it on August 29, 2008 and recaptured it on April 24, 2009 (238 days) at the same site where we tagged it. We also captured eight yearling coho between April and August that were tagged by DFG's AFRAMP project in the Freshwater Creek basin. Six were tagged at a downstream migrant trap about four kilometers upstream of our sampling area and two were tagged in the fall of 2008 in the upper mainstem and south fork of Freshwater Creek. We applied PIT tags to 49 juvenile steelhead in 2009 and recaptured 12 (24.5%) of them (Table 3). They were at large for 13 to 69 days. All 12 of the steelhead were recaptured at the same site where they were marked. Their mean growth rate was 0.18 mm/day and ranged from 0 to 0.50 mm/day (Table 3). We also recaptured one juvenile steelhead tagged by our project in 2007. It was at large from 8/10/07 to 8/11/09 (731 days). While at large its' FL increased from 73 mm to 166 mm and its growth rate was 0.12 mm/day. Its' body weight increased from 4.7 g to 49.6 g (an average of 1.31% of its initial body weight per day). Finally, we captured another eight juvenile steelhead that were tagged by CDFG's AFRAMP project in the Freshwater Creek basin. All of these fish were tagged at the HFAC weir site. The three largest steelhead (173-183 mm FL) were recaptured by NSA downstream of the HFAC weir, but the remaining five smaller steelhead (81-101 mm FL) were recaptured by NSA upstream of the HFAC weir site. These smaller fish reared in Freshwater Creek Slough for 29 to 139 days. We applied PIT tags to 17 cutthroat trout in 2009 and recaptured four (23.5%) of them (Table 3). They were at large from 29 to 119 days and their growth rates ranged from 0 to 0.41 mm/day (Table 3). All four fish were recaptured at the same site where they were marked. We also recaptured three cutthroat trout tagged by our project in 2008. They were at large from 439 to 502 days and their growth rates ranged from 0.12 to 0.20 mm/day. Finally, we captured another four cutthroat trout that were tagged by AFRAMP in the Freshwater Creek basin. Three were tagged at the HFAC weir site and one was tagged in the lower mainstem of Freshwater Creek. Their days at liberty ranged from 86 to 359 days and their growth rates ranged from 0.18 to 0.49 mm/day. One of the AFRAMP tagged cutthroat was detected at our PIT tag antenna at the mouth of Wood Creek between May 23 and June 8, 2010. It is likely that some of the cutthroat trout captured by our project were resident adult fish.

January-June 2010. During January to June 2010 we were rarely able to sample Freshwater Creek Slough due to high stream flows; in fact, we were unable to conduct any sampling between February 18 and June 21 (Table 4). Yearling coho salmon were the most common salmonid captured in upper Freshwater Creek Slough (Table 4). Due to the limited amount of sampling we were able to complete we are unable to compare catch and size information to previous years. We are still analyzing PIT tag information for 2009 and these results will be reported in our project's 2009/10 SFRA Annual Report.

Downstream Migrant Weir. Due to lack of funds AFRAMP and NSA were not able to construct and fish the downstream migrant trap at Howard Heights in the spring of 2010. However, NSA did assist AFRAMP in running the HFAC downstream migrant trap. Without operating both traps we were unable to estimate the portion of Freshwater Creek coho salmon and steelhead trout smolts originating from the stream estuary ecotone.

In 2008, AFRAMP estimated that 38% of the coho salmon smolt production passing the HFAC weir originated from the lower 3 km (11.5% of habitat) of the basin (Seth Ricker, CDFG, personal communication). In 2007, AFRAMP estimated 41% of the coho smolt production originated in the lower 3 km of habitat (CDFG 2007). AFRAMP also estimated that 82% of the steelhead smolts originated in the lower 3 km in 2008, and >90% originated from this area in 2007 (Seth Ricker, CDFG, personal communication). These findings illustrate the importance of the estuarine/freshwater ecotone to juvenile salmonids. Freshwater Creek/Slough in this area is confined within a narrow channel bordered by steep banks. It has a low gradient with slow

Table 4. Monthly catch-per-unit-effort (CPUE) and fork length (FL) in millimeters of young-of-the-year (yoy) Chinook salmon, yoy coho salmon, yearling and older coho salmon, juvenile steelhead trout, and cutthroat trout in upper Freshwater Creek Slough, January-June 2010. CPUE is number of fish per seine haul.

		YOY Chinook			YOY Coho			Yearling Coho			Steelhead			Cutthroat		
	No.		Mean			Mean			Mean			Mean			Mean	
Month	Sets	CPUE	FL	Range	CPUE	FL	Range	CPUE	FL	Range	CPUE	FL	Range	CPUE	FL	Range
Jan	8	0	-	-	0	-	-	0	-	-	0.25	156	141-171	0	-	-
Feb	20	0	-	-	0	-	-	0.10	97	94-99	0	-	-	0	-	-
Mar	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apr	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
June	10	0.30	77	71-81	0.20	66	65-67	1.00	102	73-121	0.40	130	110-156	0.10	-	-

stream velocity and is relatively deep with ample small woody debris cover. The low stream velocity coupled with highly productive habitat found along the lower valley floor of Freshwater Creek and slough probably provides good over-wintering habitat for juvenile salmonids during moderate flows. Low velocity habitats such as off channel ponds, side channels, sloughs, and wetlands often produce high survival and growth of juvenile coho salmon (Quinn 2005; Jones and Moore 2000; Sandercock 1991). However, there is very little off channel habitat in this section of stream so there is little refuge from high flow events in winter. AFRAMP estimated the total number of coho salmon smolts passing the HFAC weir to be 6,453 in 2009, 4,945 in 2008, and 5,888 in 2007 (Seth Ricker, CDFG, personal communication).

Martin Slough

July-December 2009. Juvenile coho salmon were the most abundant salmonids captured in Martin Slough (Table 5). Based on their size and appearance most were probably yoy fish but we did not examine scales to confirm this. On average the coho we captured in Martin Slough were larger than those captured in any other Humboldt Bay tributary. Their monthly mean FL increased from 97 mm in July to 121 in November and individual FL's ranged from 73-164 mm (Table 5). We also caught 16 cutthroat trout and their FL's ranged from 179 to 279 mm (Table 5). We also captured numerous larger adult cutthroat trout.

We captured a total of six invasive Sacramento pikeminnow in Martin Slough in 2008. The first was captured in August and the other five were captured in October and November. CDFG and other cooperating agencies conducted a number of pikeminnow eradication sampling efforts culminating with a large effort in November 2008 that included draining a pond where five of the six were found (CDFG 2008a). In addition to our normal monthly sampling, NSA periodically conducted additional sampling in Martin Slough and upstream in Martin Creek in 2009 and 2010 specifically to look for pikeminnow. As of the end of June 2010 we have captured no additional pikeminnow.

January-June 2010. Juvenile coho salmon were by far the most abundant salmonids captured in Martin Slough (Table 5). Based on their size and appearance most were probably yearling and older fish but we did not examine scales to confirm this. We did capture a few of what were probably yoy fish in April. On average the coho we captured in Martin Slough were larger than those captured in any other Humboldt Bay tributary (Table 5). Our juvenile coho catches remained high throughout the winter and into spring indicating coho were using Martin Slough primarily as over-winter habitat. Their monthly mean FL's increased from 82 mm in January to 120 mm in June and individual FL's ranged from 61-150 mm (Table 5). We again observed that smaller sized coho appeared in Martin Slough and many of our other sample sites around Humboldt Bay, February through March, after winter storms increased stream flows. This suggests that coho which had been rearing upstream in Elk River moved to the stream estuary ecotone of Elk River and Martin Slough. Also, four of the tagged coho recaptured in Martin Slough in 2009 were originally tagged by our project in upper Elk River Slough in 2008 (see below). We also captured four cutthroat trout, three of them in June.

During the entire year we also captured adult cutthroat trout, tidewater goby, threespine stickleback, prickly sculpin, Pacific staghorn sculpin, red legged frog, tree frog, Northwest salamander, and rough skin newt in Martin Slough.

PIT Tag Results for 2009. We applied PIT tags to 416 yearling and older coho salmon and recaptured 32 (7.7%) of them. Additionally, we captured five coho that we marked in Martin Slough in 2008. The yearling coho were at large for an average of 56 days (range 23-238). We captured five of the 32 (16%) recaptured coho at different sites from where we originally marked them. This is a higher rate of movement compared to our observations of yoy coho in Freshwater Creek and Elk River Sloughs. We captured an additional four tagged coho in Martin Slough that were originally tagged by NSA in upper Elk River Slough. All these fish were marked in 2008, two in mid July and two in early December, and were at large 67 to 270 days.

Table 5. Number and fork length (FL) of juvenile salmonids captured in Martin Slough, Rocky Gulch, Wood Creek, and numbers only for Gannon Slough, and Jacoby Creek, July 2009 through June 2010 (MT=minnow trap).

Martin Slough

Date	Coho Salmon			Steelhead/RT			Cutthroat Trout		
	No.	FL	Range	No.	FL	Range	No.	FL	Range
7-09-09	20	97	73-131	0	-	-	2	179	172-186
8-06-09	11	104	90-125	0	-	-	1	189	189
9-10-09	3	130	105-148	0	-	-	7	216	204-230
10-8-09	1	164	164	0			3	249	222-279
11-12-09	14	121	92-154	0	-	-	3	243	238-250
12-08-09	1	120	120	0	-	-	0	-	-
1-12-10	10	82	62-113	0	-	-	0	-	-
2-11-10	128	100	66-150	0	-	-	1	-	-
3-10-10	60	99	76-130	0	-	-	0	-	-
4-13-10	51	110	61-133	0	-	-	0	-	-
5-11-10	28	117	104-132	0	-	-	0	-	-
6-15-10	4	120	109-127	0	-	-	3	-	-

Rocky Gulch

Date	Coho Salmon			Steelhead/RT			Cutthroat Trout		
	No.	FL	Range	No.	FL	Range	No.	FL	Range
7-15-09	0	-	-	0	-	-	10	122	96-142
9-06-09	0	-	-	0	-	-	8	117	98-149
10-16-09	0	-	-	0	-	-	5	144	115-157
11-19-09	0	-	-	0	-	-	6	117	84-131
12-15-09	1	84	84	0	-	-	1	129	129
1-14-10	15	74	62-95	0	-	-	0	-	-
2-16-10	25	85	74-101	0	-	-	1	142	142
3-17-10	36	94	77-110	0	-	-	0	-	-
4-14-10	28	102	83-114	1	138	138	1	160	160
5-21-10	10	119	111-124	0	-	-	3	127	117-140
6-22-10	0	-	-	0	-	-	2	138	130-145

Wood Creek

Date	Coho Salmon			Steelhead/RT			Cutthroat Trout		
	No.	FL	Range	No.	FL	Range	No.	FL	Range
7-08-09	0	-	-	0	-	-	0	-	-
8-14-09	1	76	76	0	-	-	1	137	137
9-08-09	3	85	73-103	0	-	-	0	-	-
10-07-09	2	94	83-105	0	-	-	2	132	125-139
11-05-09	1	89	89	0	-	-	0	-	-
12-02-09	1	63	63	0	-	-	0	-	-
1-08-10	44	75	56-107	0	-	-	0	-	-
2-03-10	37	72	53-112	0	-	-	0	-	-
3-03-10	59	90	65-119	0	-	-	0	-	-
4-01-10	9	105	80-115	0	-	-	0	-	-
5-03-10	8	103	85-115	0	-	-	0	-	-
6-02-10	5	78	62-127	0	-	-	0	-	-

	Gannon Slough					Jacoby Creek				
Date	Effort		Coho	SH	Cutt	Effort	Coho	SH	Cutt	Yoy Trout
	MT	Seine				Seine				
7-28-09	4	6	0	2	2	2	0	0	0	0
8-24-09	4	6	0	0	0	2	4	2	0	0
9-23-09	4	6	0	1	0	2	0	0	0	0
10-21-09	5	6	0	0	0	2	0	0	0	0
11-24-09	5	6	2	0	0	2	0	0	0	0
12-17-09	5	4	0	0	0	2	9	0	0	0
1-21-10	5	0	0	0	0	0	-	-	-	-
2-23-10	5	6	2	0	0	2	0	0	0	0
3-23-10	6	4	0	0	0	2	0	0	0	0
4-21-10	5	6	0	0	0	0	-	-	-	-
5-24&26-10	5	6	3	0	1	2	19	3	0	0
6-16-10	6	4	2	0	0	2	9	1	0	0

This proves that some juvenile coho salmon residing upstream in Humboldt Bay tributaries redistribute themselves in the fall to the stream-estuary ecotone seeking low velocity over winter habitat. This relatively active movement in Martin Slough suggests that these coho have not set up territories and may be more nomadic in nature once they redistribute themselves downstream than the yoy coho residing here in the summer. The mean growth rate of the coho tagged and recaptured in Martin Slough was 0.32 mm/day (n=31; range -0.04 to 0.67 mm/day. Their weight increased on average 0.16 g/day (n=11; range -0.03 to 0.30 g/day), and we observed increases in their initial body weight ranging from -0.16 to 2.53% per day.

We also applied PIT tags to 24 yoy coho and recaptured 4 (16.7%) of them. The recaptured fish were at large 28 to 126 days. At time of tagging the recaptured fish ranged in size from 84 to 90 mm FL and 7.6 to 8.9 grams. Their growth rate ranged from 0.21 to 0.43 mm/day and 0.10 to 0.16 g/day. We applied PIT tags to 12 cutthroat trout and recaptured six (50%) of them. They were at large 63 to 184 days. At time of tagging the recaptured fish ranged in size from 138 to 245 mm FL. Their growth rate ranged from 0.19 to 0.41 mm/day. During 2009 we tagged only one juvenile steelhead and did not recapture it.

June 2010 was the last of our planned surveys for Martin Slough. We are ending this survey to devote more time and resources to evaluating the success of estuarine habitat restoration projects in Wood Creek and Salmon Creek. The information learned at Martin Slough, especially the heavy use of pond habitat by juvenile coho, is being incorporated into these and other estuarine restoration projects. We are still analyzing PIT tag information for 2010 and these results will be reported in our project's 2010/11 SFRA Annual Report.

Rocky Gulch

July-December 2009. We captured one juvenile coho salmon in Rocky Gulch during this time period and it was 84 mm FL (Table 5). Cutthroat trout were the most abundant salmonid we captured in Rocky Gulch during this time period (Table 5). Their FL's ranged from 84 to 157 mm.

January-June 2010. Juvenile coho salmon were the most abundant salmonid captured in Rocky Gulch during this time period (Table 5). The coho were captured from January to May and their peak catch occurred in March. Based on their size and appearance the coho captured were probably yearling fish, but we did not examine scales to confirm this. Their monthly mean FL increased from 74 mm in January to 119 mm in May and individual FL's ranged from 62-124 mm (Table 5). It appeared that all yearling coho salmon had emigrated from Rocky Gulch by late June. NSA captured seven cutthroat trout, most of them April through June (Table 5). Their FL's ranged from 117-160 mm. We also captured one juvenile steelhead in April. It was 138 mm FL and we applied a PIT tag to it.

During this time period we also captured tidewater goby, unidentified juvenile goby, threespine stickleback, Pacific staghorn sculpin, starry flounder, larval smelt, Gambusia spp. (mosquitofish), red legged frog, and unidentified tadpoles in Rocky Gulch.

PIT Tag Results for 2009. We applied PIT tags to 28 yearling coho salmon and recaptured four (14.3%) of them. The yearling coho were at large 43-69 days and they grew 4-16 mm. Their growth rate ranged from 0.09 to 0.26 mm/day. All fish were recaptured at the same site where we originally marked them. We also applied PIT tags to 46 cutthroat trout and recaptured 12 (26.1%) of them. We also recaptured one cutthroat trout tagged by NSA in December 2008. Their mean residence time in Rocky Gulch was 133 days (n=13; range 69 to 264 days). Their mean growth rate was 0.19 mm/d and ranged from 0.04 to 0.46 mm/day. We captured three (23%) of the cutthroat at different sites than where we originally marked them.

Wood Creek

July-December 2009. Juvenile coho salmon and cutthroat trout were the only salmonids captured in Wood Creek, with coho being the most abundant (Table 5). Based on their size and appearance the coho were probably yoy fish but we did not examine scales to confirm this. We captured eight coho from August to December (Table 5). Their FL's ranged from 63-105 mm (Table 5). We also captured three cutthroat trout, all in August and October. They ranged in size from 125-139 mm FL (Table 5).

January-June 2010. Juvenile coho salmon were the only salmonids captured in Wood Creek during this time period. Their peak catches occurred January through March (Table 5). Based on their size and appearance they were probably yearling and older fish but we did not examine scales to confirm this. Our juvenile coho catches remained high throughout the winter and into spring indicating coho were using Wood Creek as primarily as over-winter habitat. Their monthly mean FL's increased from 75 mm in January to 105 mm in April. Their mean FL's decreased to 78 mm by June due to the arrival of yoy coho. Smaller sized coho appeared in Wood Creek in January through March after winter rains increased stream flows providing more evidence that juvenile coho salmon residing upstream redistribute themselves in the fall to the stream-estuary ecotone seeking low velocity over-winter habitat. However, this year due to the detection of numerous coho in Wood Creek PIT tagged in Freshwater Creek in the fall of 2009 we were able to verify that large numbers of juvenile coho redistribute downstream to the stream-estuary ecotone (see below). In 2009 recaptured PIT tagged coho grew 0.03-0.35 mm/day (see below).

PIT Tag Antenna 2010- NSA installed a PIT tag antenna array at the mouth of the newly constructed off channel pond on January 29, 2010 and at the mouth of Wood Creek in the tide gate structure on February 22, 2010. We installed two antennas at each site in an attempt to discern directional movement in and out of the pond. However, due to the voluminous amount of data recorded I will only present a general summary for this report. Also, since the fish were detected remotely by the antenna array we never actually handled and measured the fish. We tagged and released 93 coho salmon in the newly constructed pond in 2010 and eventually detected 80 (86%) of these coho at either or both of the antennas (74 at pond; 34 at tide gate; 28 at both). We tagged and released 102 coho salmon into the mainstem Wood Creek and eventually detected 60 (59%) of these coho at either or both of the antennas (27 at pond; 49 at tide gate; 16 at both). The pond antenna eventually detected 80% of the pond tagged coho and 26% of the creek tagged coho. The tide gate antenna eventually detected 37% of the tagged pond fish and 48% of the tagged creek fish. Detection rates were almost certainly lower at the tide gate antenna than the pond antenna due to the larger area of the tide gate antennas and the more frequent occurrence of brackish water at the tide gate. NSA tests showed that water salinity as low as 3 to 5 ppt drastically reduced the read range of our PIT tag antennas.

Between late January and the end of June we detected 152 coho salmon, one steelhead, and two cutthroat trout at the Pond antenna. Individual coho were first detected on 1/29/10 and last detected on 6/15/10, though most had left the pond by the end of April. Most fish were last detected in March suggesting that was the time of peak emigration of coho out of the pond. Of the 152 coho detected in the pond, 74 were tagged and released into the pond, 27 from Wood Creek, 46 tagged upstream in Freshwater Creek basin during the fall of 2009, and five from Freshwater Creek Slough tagged by NSA in the summer and fall of 2009. One hundred twenty two of the fish were detected in the pond on more than one day. These 122 fish had an average time between first and last detection (a surrogate for residence time) of 23 days (range 1-87 days).

The one steelhead detected in the pond occurred on May 16, 2010. This fish was tagged by AFRAMP and NSA at the HFAC weir site on May 9, 2010. The two cutthroat trout detected in the pond were also both marked at the HFAC weir. One fish was tagged on April 18 and then

detected at the tide gate on April 18 and in the pond on April 19. The other fish was tagged on March 29 and then detected at the tide gate on April 1 and in the pond on April 6.

On February 22, 2010 we installed a PIT tag antenna array at the mouth of Wood Creek in the tide gate structure. Between late February and the end of July we detected 309 coho salmon, 31 juvenile steelhead, and 58 cutthroat trout at the tide gate antenna. Individual coho were first detected on 2/22/10 and last detected on 7/6/10, though most (>80%) were detected by the end of May. Most fish were last detected in May suggesting that was the time of peak emigration of coho out of Freshwater Creek. Of the 309 coho detected at the tide gate, 34 were tagged by NSA and released into the newly constructed off channel pond and 48 were tagged by NSA and released into Wood Creek in 2010. The remaining coho were comprised of one fish tagged by NSA and released into Wood Creek in 2009, 162 fish tagged by AFRAMP and NSA at the HFAC weir site in 2010, one fish tagged by AFRAMP and NSA at the HFAC weir site in 2009, 52 tagged by AFRAMP upstream in Freshwater Creek basin during the fall of 2009, four fish tagged by NSA in Ryan Slough in the winter of 2010, and nine fish tagged by NSA in Freshwater Creek Slough the summer and fall of 2009. One hundred eight of the 309 coho were detected at the tide gate on more than one day. These 108 fish had an average time between first and last detection (a surrogate for residence time) of 11 days (range 1-67 days). The average residence time in Wood Creek for coho tagged in the winter of 2009 through the spring of 2010 (from day of tagging and final detection at either antenna) was 40 days (n=137; range 0 to 137 days). We also captured one coho salmon marked in Wood Creek by NSA in the summer of 2009 that was at large 373 days.

NSA detected 162 coho salmon at the tide gate antenna originally tagged at the HFAC weir in 2010. These fish had a mean travel time of 12 days (range 0 to 64 days) between the HFAC weir and Wood Creek. Travel time was calculated as the number of days between day of tagging and the last day of detection at Wood Creek. Fifty (31%) of these fish were at large at least 14 days and 32 (20%) were at large at least 21 days. This shows that a significant portion of emigrating coho were rearing in the stream-estuary ecotone of Freshwater Creek Slough between HFAC weir and the mouth of Wood Creek, even though most of this section of Freshwater Creek Slough is contained between levees and the habitat heavily degraded.

The 31 steelhead detected at the tide gate antenna were first detected on March 2, 2010 and last detected on July 28, 2010. March and July were the months with the highest number of steelhead detections. Of the 31 steelhead detected at the tide gate all but one was tagged at the HFAC weir site. Seven of the steelhead tagged at the HFAC weir were tagged in 2009 and 23 tagged their in 2010. The mean residence time for 2010 tagged steelhead between tagging and final detection at the tide gate was 44 days (n=23; range 1-95 days). The residence times of the seven steelhead tagged in 2009 ranged from 323 to 378 days. The remaining steelhead was tagged in the lower mainstem of Freshwater Creek by AFRAMP in 2008. Its residence time between tagging and final detection was 682 days.

The 58 cutthroat trout detected at the tide gate antenna were first detected on February 26, 2010 and last detected on July 29, 2010. May was the month with the highest number (23) of cutthroat trout detections. Of the 58 cutthroat detected at the tide gate 40 were tagged at the HFAC weir site in 2010, 13 at the HFAC weir site in 2009, three in Ryan Creek Slough by NSA (two in 2009 and one in 2010), one by NSA in Wood Creek in 2009, and one in the lower mainstem Freshwater Creek by AFRAMP in 2007. The mean residence time for 2010 tagged cutthroat trout between tagging and final detection at the tide gate was 28 days (n=40; range 1-100 days). The mean residence time of the 13 cutthroat trout tagged in 2009 was 385 days and ranged from 336 to 448 days. The cutthroat trout originally tagged in Ryan Creek Slough in 2009 were at large 245 to 249 days, and the one tagged in 2010 was at large 45 days. The cutthroat trout tagged in Wood Creek in 2009 was at large 348 days and the cutthroat trout tagged in the lower mainstem Freshwater Creek was at large 1,027 days.

During the entire year we also captured threespine stickleback, prickly sculpin, and Pacific staghorn sculpin.

PIT Tag Results for 2009. This section describes NSA's tagging and physical recapture of PIT tagged salmonids in 2009. We applied PIT tags to 55 yearling coho and recaptured three (5.5%) of them in 2009. We also captured two yearling coho tagged by our project in December 2008 in Wood Creek. The five coho were at large 23 to 91 days and grew 1 to 13 mm (n=5; range 0.03 to 0.35 mm/day). Two of the five fish were recaptured at different sites from where we originally tagged them. Additionally, we recaptured two yearling coho that were marked by CDFG's AFRAMP project in Freshwater Creek in October 2008. One fish was marked in the upper mainstem of Freshwater Creek and the other in the middle mainstem of Freshwater Creek. We recaptured one in March and the other in October 2009 (DAL=125 to 352 days). They grew 24 and 46 mm (0.13 to 0.19 mm/day) while at large.

We PIT tagged six yoy coho salmon and recaptured one (17%) of them. It was at large for 58 days and grew 10 mm (0.17 mm/day) during this time. We also applied PIT tags to six cutthroat trout and recaptured one (17%) of them. The cutthroat trout was at large for 25 days and it grew 8 mm (0.32 mm/day) during this time. We also recaptured two cutthroat trout originally tagged at the HFAC weir site on Freshwater Creek Slough. Both fish were tagged on March 21 and were recaptured on April 9 (19 days) October 7 (200 days) at the upstream end of our Wood Creek sampling area. The fish at large 19 days grew 1 mm (0.05 mm/day) and the one at large for 200 days grew 39 mm (0.20 mm/day).

Gannon Slough/Jacoby Creek

July-December 2009. In Gannon Slough we captured two coho salmon in November, three juvenile steelhead in July and September, and two cutthroat trout in July (Table 5). Based on their size and appearance the coho were probably yoy fish but we did not examine scales to confirm this. Their mean FL was 66 mm and ranged from 57 to 75 mm. The mean FL of the steelhead was 149 mm and ranged from 128-161 mm. The mean FL of the cutthroat was 183 mm and ranged from 182-184 mm. In Jacoby Creek we captured 13 juvenile coho salmon in August and December and two juvenile steelhead in August (Table 5). Based on their size and appearance the coho were probably yoy fish but we did not examine scales to confirm this. Their mean FL was 69 mm and ranged from 63 to 77 mm. The mean FL of the steelhead was 115 mm and ranged from 103-127 mm.

January-June 2010. NSA captured seven juvenile coho in February, May and June. Based on their size and appearance the coho were probably yearling fish, but we did not examine scales to confirm this. Their mean FL was 106 mm and ranged from 98 to 130 mm. We also captured one cutthroat trout in May and it was 137 mm FL. In Jacoby Creek we captured 28 juvenile coho salmon in May and June (Table 5). Based on their size and appearance 19 of the coho were yearling fish and nine were yoy coho, but we did not examine scales to confirm this. The mean FL of the yearling coho was 102 mm and ranged from 91-123 mm. The mean FL of the yoy coho was 48 mm and ranged from 28-59 mm. We also captured four juvenile steelhead in May and June (Table 5). Their FL's ranged from 86-120 mm.

During the entire year in Jacoby Creek we also captured tidewater goby, starry flounder, bay pipefish, Pacific staghorn sculpin, prickly sculpin, unidentified juvenile sculpin, threespine stickleback, and larval smelt. In Gannon Slough we also captured tidewater goby, starry flounder, Pacific staghorn sculpin, prickly sculpin, unidentified juvenile sculpin, threespine stickleback, surfsmelt, topsmelt, unidentified larval smelt, saddleback gunnel, shiner surfperch, bay pipefish, Gambusia spp., juvenile Dungeness crab, red legged frog, and rough skin newt.

Table 6. Monthly catch-per-unit-effort (CPUE) and fork length (FL) in millimeters of young-of-the-year (yoy) Chinook salmon, yoy coho salmon, yearling and older coho salmon, juvenile steelhead trout, and cutthroat trout in Salmon Creek estuary, July 2009-June 2010. CPUE is number of fish per seine haul.

Seining

		Trout			YOY Coho			Yearling Coho			Steelhead			Cutthroat		
	No.		Mean			Mean			Mean			Mean			Mean	
Month	Sets	CPUE	FL	Range	CPUE	FL	Range	CPUE	FL	Range	CPUE	FL	Range	CPUE	FL	Range
July	12	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
Aug	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sept	6	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
Oct	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nov	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dec	4	0	-	-	0	-	-	0	-	-	0.25	72	72	-	-	-
Jan	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Feb	2	0	-	-	0	-	-	0	-	-	0.50	65	65	0	-	-
Mar	2	-	-	-	0	-	-	0	-	-	0	-	-	0	-	-
Apr	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	2	0	-	-	0	-	-	0	-	-	1.00	97	82-116	0	-	-
June	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Minnow Traps

		Trout			YOY Coho			Yearling Coho			Steelhead			Cutthroat		
	No.	No.	Mean		No.	Mean		No.	Mean		No.	Mean		No.	Mean	
Month	Traps	Caught	FL	Range	Caught	FL	Range	Caught	FL	Range	Caught	FL	Range	Caught	FL	Range
July	4	0	-	-	0	-	-	0	-	-	17	103	92-126	0	-	-
Aug	3	0	-	-	0	-	-	0	-	-	2	105	98-111	0	-	-
Sept	5	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
Oct	6	0	-	-	0	-	-	0	-	-	5	108	95-120	0	-	-
Nov	5	0	-	-	0	-	-	0	-	-	5	98	89-106	0	-	-
Dec	4	0	-	-	0	-	-	0	-	-	3	59	50-67	0	-	-
Jan	2	0	-	-	0	-	-	0	-	-	1	75	75	0	-	-
Feb	3	0	-	-	0	-	-	0	-	-	5	80	60-116	0	-	-
Mar	4	0	-	-	0	-	-	0	-	-	6	94	77-136	0	-	-
Apr	3	0	-	-	0	-	-	0	-	-	1	78	78	0	-	-
May	4	0	-	-	0	-	-	1	89	89	2	106	105-107	0	-	-
June	4	0	-	-	0	-	-	1	107	107	3	108	98-117	0	-	-

Hookton Slough/Salmon Creek

July-December 2009. While seining during this time period, NSA captured one juvenile steelhead in Salmon Creek. We captured it in December and it was 72 mm FL (Table 6). We continued qualitative sampling using minnow traps baited with frozen salmon roe again in 2009 and 2010. We fished these traps in deeper water or more heavily vegetated habitat near our normal seining sites. We captured 32 juvenile steelhead ranging in size from 50-126 mm FL (Table 6). The peak catches for steelhead occurred in July.

January-June 2010. While seining in Salmon Creek during this time period NSA captured three juvenile steelhead (Table 6). Their FL's ranged from 65-116 mm. We continued qualitative sampling using minnow traps baited with frozen salmon roe again in 2009 and 2010. We captured two yearling coho salmon and 18 juvenile steelhead (Table 6). The coho were caught in May and June and ranged from 89-107 mm FL. The peak catches for steelhead occurred in February and March and individual FL's ranged from 60-136 mm (Table 6).

In December 2009 we began minnow trapping Cattail Creek and Long Pond just north of Salmon Creek. This was done to determine if juvenile salmonids moved into these areas during high stream flows when Salmon Creek leaves its banks and floods the entire flat land between Salmon and Cattail Creeks. We used minnow traps baited with frozen salmon roe and sampled four locations in Cattail Creek and two locations in Long Pond (Figure 2). We did not capture any juvenile salmonids during our sampling effort. We did capture threespine stickleback in Cattail Creek and Long Pond.

PIT Tag Results for 2009. We applied PIT tags to 46 juvenile steelhead and recaptured 10 (21.7%) of them. This includes fish collected by seining and in minnow traps. The steelhead were at large for an average of 96 days (n=10; range 29-189 days). The recaptured tagged steelhead grew 1 to 41 mm while at large for an average growth rate of 0.15 mm/day (n=10; range 0.03-0.27 mm/day). All the steelhead were marked and recaptured in the site where we originally tagged them. We applied PIT tags to two coho salmon and one Chinook salmon (in Hookton Slough) but did not recapture any of these fish.

Summary of Project Results:

Project objectives were met.

Project documented that yoy coho salmon rear in the tidal freshwater portion of Humboldt Bay tributaries throughout the summer. Some coho continue to rear in the stream-estuary ecotone over the winter bringing their total rearing time to over a year. Until recently, this life history trait had been rarely documented in California for coho salmon (Nielsen 1994). However, recent information collected by Yurok Tribal biologists found that coho salmon from the middle Klamath River tributaries move into lower Klamath tributaries such as Waukell Creek to over-winter in low gradient habitat.

Project also captured individual juvenile steelhead and cutthroat trout that reared for a year or more in the freshwater-estuary ecotone.

Project documented that juvenile coho moved to low velocity or off channel habitat such as Martin Slough pond and Wood Creek during winter presumably to escape high velocity flows in the main channel.

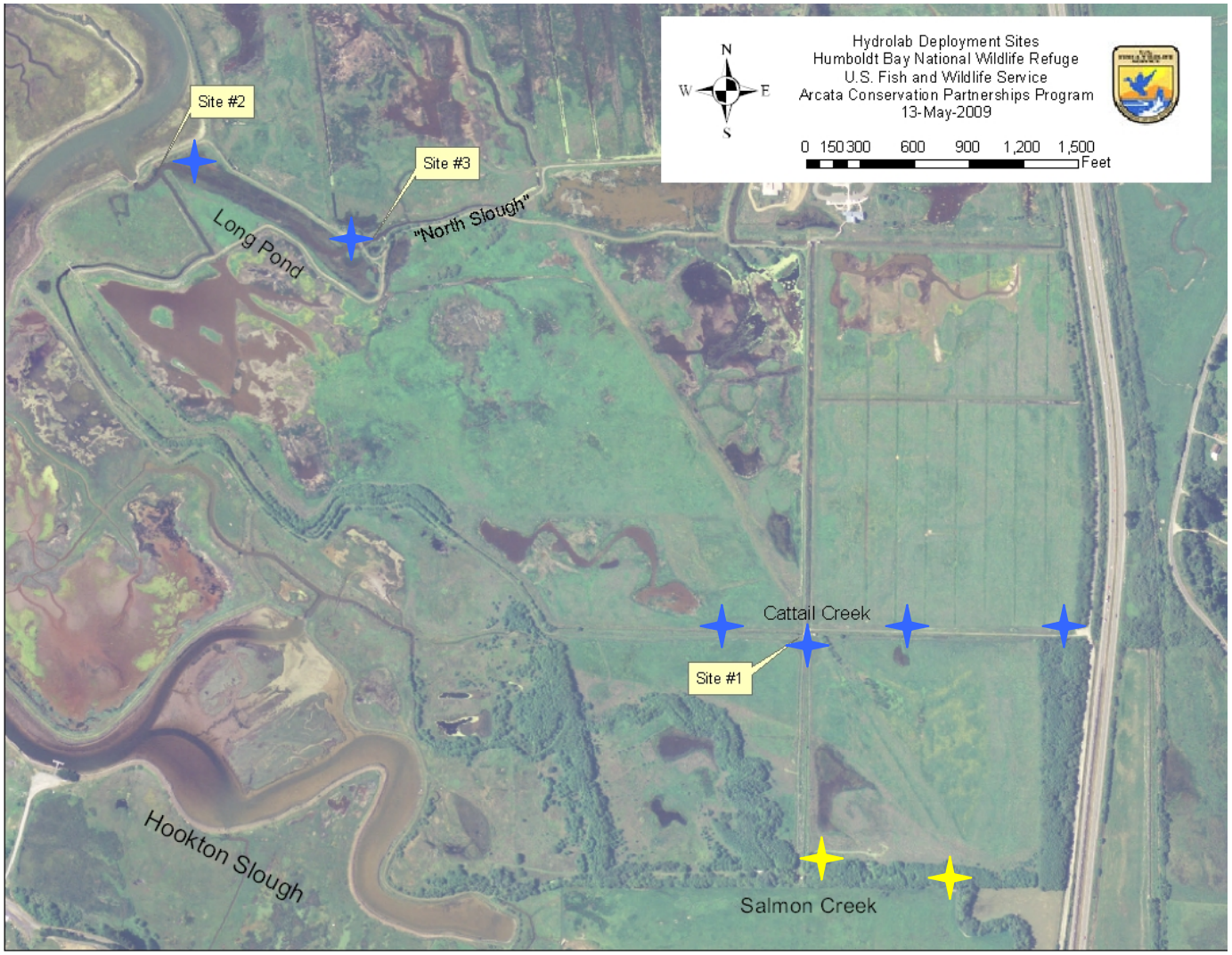

Figure 2. Approximate fish and water quality sampling locations in Salmon Creek (yellow stars), Cattail Creek, and Long Pond (blue stars) on the USFWS Humboldt Bay National Wildlife Refuge.

Project documented that juvenile coho salmon will utilize appropriate habitat adjacent to mainstem channels and collected basic habitat information about these areas. This includes tidal meanders, dead end sloughs, salt marshes, non-natal streams, and even pond habitat on an active golf course. Therefore this Project can provide information to the marsh restoration community to help design projects to create these types of habitat to increase rearing habitat for juvenile coho salmon.

Project results show that yoy and yearling coho salmon that rear in the estuary grow larger than their cohorts rearing in stream habitat farther upstream in the basin. Based on other studies larger size at ocean entry usually results in higher ocean survival. In conjunction with AFRAMP, Project documented that the stream-estuary ecotone located between the estuary and canyon stream habitat is extremely important to coho and especially steelhead smolt

production. Roughly 40% of the coho salmon smolts and about 80-90% of the steelhead smolts originated from the stream-estuary ecotone of Freshwater Creek in 2007 and 2008.

Project cooperated with USFWS which found that the mean length of residence of coho salmon smolts in lower Freshwater Creek Slough was about two weeks and as long as four weeks. They also found that coho smolts residence time in Humboldt Bay was about two weeks and ranged to about four weeks.

Project documented that some coho salmon smolts from Freshwater Creek basin would move into lower Elk River Slough while rearing in Humboldt Bay.

Project documented that a newly constructed off channel pond in Wood Creek was heavily utilized by juvenile coho salmon as soon as the pond converted to fresh water after winter rains. Project documented that large numbers of juvenile coho reared for weeks to months in the pond during the winter and spring.

With the installation of PIT tag antennas in Wood Creek, the Project (in conjunction with AFRAMP) documented the large scale movement of juvenile coho from the Freshwater Creek basin downstream to the stream-estuary ecotone of Freshwater Slough. This confirmed our hypothesis that the "fall redistribution" of coho to low velocity habitat ringing Humboldt Bay is an important life history strategy for them and not just an occasional or random movement.

Project documented the movement of juvenile coho and cutthroat trout throughout the stream-estuary ecotone (i.e. movement between Freshwater Creek Slough, Wood Creek, and Ryan Creek/Slough) suggesting that juvenile salmonids likely use the entire stream-estuary ecotone during their residence there.

Questions generated by Project:

The average size of yearling coho smolts leaving Freshwater Slough is smaller than reported from other Pacific coast estuaries. So do these smaller smolts rear in Humboldt Bay for significant periods of time before entering the ocean? (See answer from USFWS above)

The project has captured juvenile salmonids in areas containing eel grass beds. What role does eel grass play in life history of salmonids?

One study in Oregon (Miller and Sadro 2003), showed that after rearing in the estuary for the summer yoy coho salmon migrate back upstream to over-winter. Another study in British Columbia (Tschaplinski 1982), showed that after rearing in the estuary for the summer yoy coho salmon migrated to the ocean. This project made some observations showing that some yoy coho move downstream into the tidal portions of non-natal streams to over-winter. What is the dominate life history strategy of yoy coho salmon in Humboldt Bay tributaries? (So far our data points to the latter strategy of moving downstream to over winter in the stream-estuary ecotone. But juvenile coho will move upstream into small tributaries such as Wood Creek and Ryan Creek to over winter. To date, we have not observed any juvenile coho moving upstream in the mainstem Freshwater Creek to find over winter habitat.

Will creation of low water velocity habitat i.e. side channels, freshwater or saltwater marshes, ponds increase over-wintering and spring/summer rearing habitat? (See initial results for the construction of Wood Creek pond above)

Management Recommendations:
Juvenile salmonids in Freshwater Creek Slough should continue to be monitored on a year-round basis to determine seasonal and annual variation in their use of estuarine habitat.

Surveys in Humboldt Bay should be conducted to determine if juvenile salmonids use the bay for rearing, and if so, determine how long do they stay and what habitats (e.g. eel grass beds) do they utilize.

PIT tag antenna arrays should be installed in the freshwater-estuary ecotone to conduct a mark-recapture study on coho salmon smolts. This study could determine the proportion of coho salmon smolts originating from the freshwater-estuary ecotone compared to the number from the rest of the Freshwater Creek basin upstream and their relative survival rates.

An inventory of small streams entering the tidal portion of the major Humboldt Bay tributaries should be made to determine if they could provide suitable summer or over winter rearing habitat for juvenile coho salmon and other estuarine organisms. The establishment of cool freshwater habitat at the mouths of small streams entering Freshwater Creek Slough (presently behind tidegates) could potentially increase the rearing area for yoy coho salmon during the summer. These same areas could also provide a refuge from high velocity flows for yearling coho in the winter and early spring.

Increasing the access to and connectivity between tributaries entering Humboldt Bay should be a high priority. Our project documented that juvenile coho readily move into non natal small streams in search for suitable rearing habitat. For example, NSA captured two coho salmon in Rocky Gulch we originally tagged in Jacoby Creek. Enhancing the connections between adjacent watersheds will increase ease of access to over winter habitat by allowing fish to move between adjacent watersheds without having to enter Humboldt Bay.

Tidal lands adjacent to Humboldt Bay tributaries should be restored as the opportunity arises since juvenile salmonids will use tide channel habitat adjacent to the mainstem slough if it is available.

Habitat restoration projects to improve stream-estuary ecotone habitat should be monitored to assess their effectiveness and provide feedback to the restoration community to improve future restoration projects.

Water temperatures in lower Freshwater Creek and Hookton Sloughs become too high to support salmonids by mid summer. This is probably due to the heating of mud flats and shallow water in and adjacent to the sloughs and exasperated by the lack of tidal circulation within the levied sloughs. Therefore, management efforts to reduce water temperatures by conducting riparian planting, increasing tidal circulation, and reducing warm water runoff from adjacent agricultural lands should be pursued whenever possible and appropriate.

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7. Discuss differences:

The PIT tag antenna at the mouth of Wood Creek was inoperable during part of the survey season due to the presence of saltwater at its location. The read range of the

antenna is drastically reduced in salt water. Project personnel are researching other designs to see if we can increase the read range in salt water.

8. List any publications or in-house reports resulting from this work:

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