State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

PACIFIC STATES MARINE FISHERIES COMMISSION

JUVENILE SALMONID USE OF THE TIDAL PORTIONS OF SELECTED TRIBUTARIES to HUMBOLDT BAY, CALIFORNIA

By

Michael Wallace, Natural Stocks Assessment Project,
California Department of Fish and Game

Stan Allen, Pacific States Marine Fisheries Commission

Final Report for Contract
P0410504

June 2007

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. The State of California also enacted the Salmon, Steelhead and Anadromous Fisheries Program Act (SB 2261) in 1988 that directed California Department of Fish and Game (CDFG) to develop a statewide plan and program with the objective of doubling the State's natural anadromous fish production by the end of the 20th century.

Estuaries are important habitat for juvenile salmonids and other popular sport fish species. Numerous studies have documented extended estuarine residence by juvenile Chinook salmon (Reimers 1971; Healey 1982; Kjelson et al.1982; Healey 1991; Wallace 2000), coho salmon (Miller and Sadro 2003; Nielsen 1994; Tschaplinski 1982) and sea-run coastal cutthroat trout (Trotter 1997; Northcote 1997; CDFG 2000; CDFG 2001). Wallace (2006) reported that juvenile salmonids, especially young-of-the-year (yoy) coho salmon, rear in Freshwater Creek Slough for significant periods of time making this tidal area important rearing habitat for juvenile salmonids. Prior to this study virtually nothing was known about juvenile salmonid use of Humboldt Bay or the sloughs and tidal portion of its tributaries. 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. An ongoing study by CDFG's Anadromous Fisheries Resource Assessment and Monitoring Program (AFRAMP) made observations that suggest yoy coho salmon and age 1 steelhead may rear downstream of the head of the tide during the spring and summer, then migrate back into Freshwater Creek to over-winter before emigrating to the ocean the following year. Miller and Sadro (2003) documented that yoy coho migrate to the tidal portion of Winchester Creek (a tributary of South Slough, Coos Bay, Oregon) and adjacent tidal freshwater marshes and rear for up to 8 months. NSA sampled Freshwater Creek Slough in 2003 and 2004 and found that some yoy coho salmon reared throughout the summer and into the fall and that yoy Chinook salmon reared for up to 8 weeks in Freshwater Creek Slough in 2003

The majority of tidal wetlands around Humboldt Bay have been diked and converted to pasture land during the past 150 years (HBWAC 2005). Currently, historic pieces marshland habitat around Humboldt Bay are being acquired by various public agencies and numerous marsh restoration projects are being planned or implemented near Humboldt Bay tributaries such as Salmon Creek, Jacoby Creek, Rocky Gulch, McDaniel Slough, Gannon Slough, Wood Creek and Fay Slough (tributaries to Freshwater Creek Slough), and Martin Slough (tributary to Elk River Slough). Most if not all Humboldt Bay sloughs are now contained between levees and their adjacent marshes converted to pasture lands. Restoring these marshes will likely benefit coho salmon and steelhead trout as well as juvenile Chinook salmon, coastal cutthroat trout and other estuarine fishes.

During the duration of this contract period (2005-2007) the California Department of Fish & Game's (CDFG) Natural Stocks Assessment Project (NSA) continued to sample the tidal portion of Freshwater Creek Slough to document its use by juvenile salmonids. NSA also began sampling Elk River Slough and Salmon Creek estuary to determine if juvenile salmonids also rear in the tidal portions of these large Humboldt Bay tributaries. NSA also conducted some qualitative sampling of Martin Slough. Then beginning in 2007 NSA began sampling smaller Humboldt Bay tributaries such as 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 hopes 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

Study Area

Humboldt Bay is located 275 miles north of San Francisco, CA. and its watershed area is 223 square miles (HBWAC 2005). Its three largest tributaries are Freshwater Creek, Elk River, and Salmon Creek (Figure 1). Numerous smaller tributaries also drain into Humboldt Bay and numerous sloughs and tidal streams exist around the bay

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 (31 square miles). The lower 9 kilometers (km) of Freshwater Creek is primarily cattle grazing land and is characterized by a low gradient, with limited riparian development. Levees confine the channel in this reach. Elk River Slough enters the bay just south of Eureka near the mouth of Humboldt Bay. Elk River drains approximately 29 square miles (8632 hectares). The lower 10 kilometers (km) of Elk River is primarily cattle grazing land and is characterized by a low gradient, with limited riparian development. Levees confine the channel in this reach. Salmon Creek enters the bay at the extreme southern end of Humboldt Bay via Hookton Slough (Figure 1). Salmon Creek drains approximately 17 square miles (5060 hectares). The tidal portion of Salmon Creek is contained within the Humboldt Bay National Wildlife Refuge. A tidegate at the mouth of Salmon Creek where it enters Hookton Slough mutes tidal influence in Salmon Creek. Much of the above information comes from HBWAC (2005).

The estuary was defined as the portion of the stream under tidal influence during low stream flow in the summer. NSA observed tidal influence approximately 9 km upstream of the mouth of Freshwater Creek Slough and about 6 km upstream of the mouth of Elk River. The lower portion of Freshwater Creek Slough is characterized by extensive mudflats, modest to moderate amounts of eelgrass beds, and some areas of salt marsh. The lower portion of Elk River Slough lacks the mudflats and instead flows through large areas of sand. Hookton Slough also has large areas of mudflats while Salmon Creek upstream of the tidegate is confined to a narrow channel. The tidal freshwater portions of all three tributaries have dense stands of riparian vegetation, primarily in the form of willow and alder trees. Physical conditions in Humboldt Bay tributaries such as saltwater intrusion show a high degree of annual, seasonal, and daily variation due to changes in river flow and tidal action. The lower sloughs experienced fluctuations in tidal height up to 3 meters (m) and brackish water 25-30 parts per thousand (ppt) is usually present from late spring through summer. Water temperatures of 20-25 C were present during the summer in the lower portion of Freshwater and Hookton Sloughs due to water heating up on the mudflats (Wallace 2006).

Methods

In Freshwater Creek Slough, Elk River Slough, and Salmon Creek/Hookton Slough stratified sampling was used between the upper and lower sloughs due to differences in water salinity and the need to use different gear types in the two sections of the sloughs. The stratification was necessary due to the presence of heavy riparian vegetation in the upper sloughs requiring field crews to use a smaller seine net than they used to sample the larger water area in the lower sloughs. This is also the general area where riparian vegetation started to appear and intuitively seemed to represent the boundary between primarily estuarine and tidal freshwater habitat. In Salmon Creek/Hookton Slough the tide gate at the mouth of Salmon Creek was the boundary between the lower and upper sloughs.

In Freshwater Creek Slough field crews conducted sampling for juvenile salmonids in both the lower slough and upper sloughs from January-December 2005. In 2006 crews sampled the lower slough from early January to late November and the upper slough from mid February to early December. In Elk River Slough crews sampled the lower slough from late January to mid December 2005 and early January to late November 2006. Field crews sampled upper Elk River Slough from early February to mid December 2005 and mid February to early December 2006. Crews sampled Salmon Creek/Hookton Slough from early February to mid December 2005 and late January to late November 2006. We sampled the sloughs on a weekly basis (except during high stream flows), with the exception of Salmon Creek/Hookton Slough which we sampled biweekly in 2006. Multiple sampling sites within each tributary were sampled to make sure we sampled the entire range of habitats found within the area of tidal influence.

In the upper sloughs crews made two hauls at each site using a 9.1mX1.8mX6.4millimeter (mm) mesh beach seine. In the lower sloughs crews made one seine haul at each site using a 30.5mX2.4m beach seine deployed by hand or boat. The mesh size of the wings was 19.1mm and the bag was 1.5m deep with 6.4 mm mesh.

Field crews anaesthetized juvenile salmonids with alka seltzer, counted, and examined them for marks and tags. At each sampling site the first thirty fish of each species and life stage (i.e. yoy, parr, pre-smolt, smolt, adult) were measured for fork length (FL), and weighed to the nearest 0.1gram (g). Field crews collected scales from the first ten fish of each species captured each week in the upper and lower sloughs. All salmonids containing tags or marks were measured for FL, weighed, scale sampled, and their mark or tag number was recorded. Once processed, the fish were allowed to recover and released back into the sampling site. NSA applied PIT tags to all juvenile salmonids by making a small incision and inserting the tag into the body cavity. All coho and Chinook salmon $\geq$ 70 mm FL received an 11.5 mm tag. Juvenile steelhead and cutthroat trout $\geq$70 mm but < 100 mm FL received a 11.5 mm tag and trout $\geq$ 100 mm FL received a 23 mm tag. Length of estuarine residence for PIT tagged fish was calculated as the number of days between date of marking and date of last recapture.

Results and Discussion

Freshwater Creek Slough 2005- Yoy coho salmon were by far the most common salmonid captured and were found primarily in the upper slough. In the upper slough we captured yoy coho salmon from late April to late November but their peak catches occurred in early May and they remained abundant through August. Their weekly mean FL increased from 40 mm in late April to 86 mm in mid November. We captured relatively few yoy coho in the lower slough. Their abundance peaked in late May but we captured them from early April to late June followed by small pulses in late August and November and December. We applied PIT tags to 314 yoy coho in 2005 and recaptured 112 (35.7%) of them. The PIT tagged yoy coho salmon resided in the tidal freshwater portion of Freshwater Creek Slough throughout the summer. Their mean length of residence was 32 days and ranged from 4 to 128 days. One hundred and nine out of 112 (97.3%) project marked 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. The mean growth rate of the 79 recaptured yoy coho at large for at least two weeks was 0.17 mm/day and ranged from 0 to 0.43 mm/day.

Yearling coho salmon were present in our upper estuary catches from late January to early July and their peak catch occurred from late April to late May. Their weekly mean FL increased from 77 mm in late January to 110 mm in early June. In the lower slough we captured yearling coho salmon from early March to late June and their peak catch occurred early to mid May. Their weekly mean FL increased from 79 mm in early March to 119 mm in early May and then ranged from 96 to 109 mm in June. We applied PIT tags to 224 yearling coho in 2005 and recaptured

12 (5.4%) of them. Their mean length of estuarine residence was 31 days and ranged from 5 to 100 days. All project marked yearling coho were recaptured at the same site where they were marked indicating that they moved very little while residing in the slough. We also captured another 20 yearling coho that were tagged by other projects in the Freshwater Creek basin. The mean growth rate of the eight recaptured yearling coho at large for at least two weeks was 0.39 mm/day and ranged from 0.21 to 0.56 mm/day.

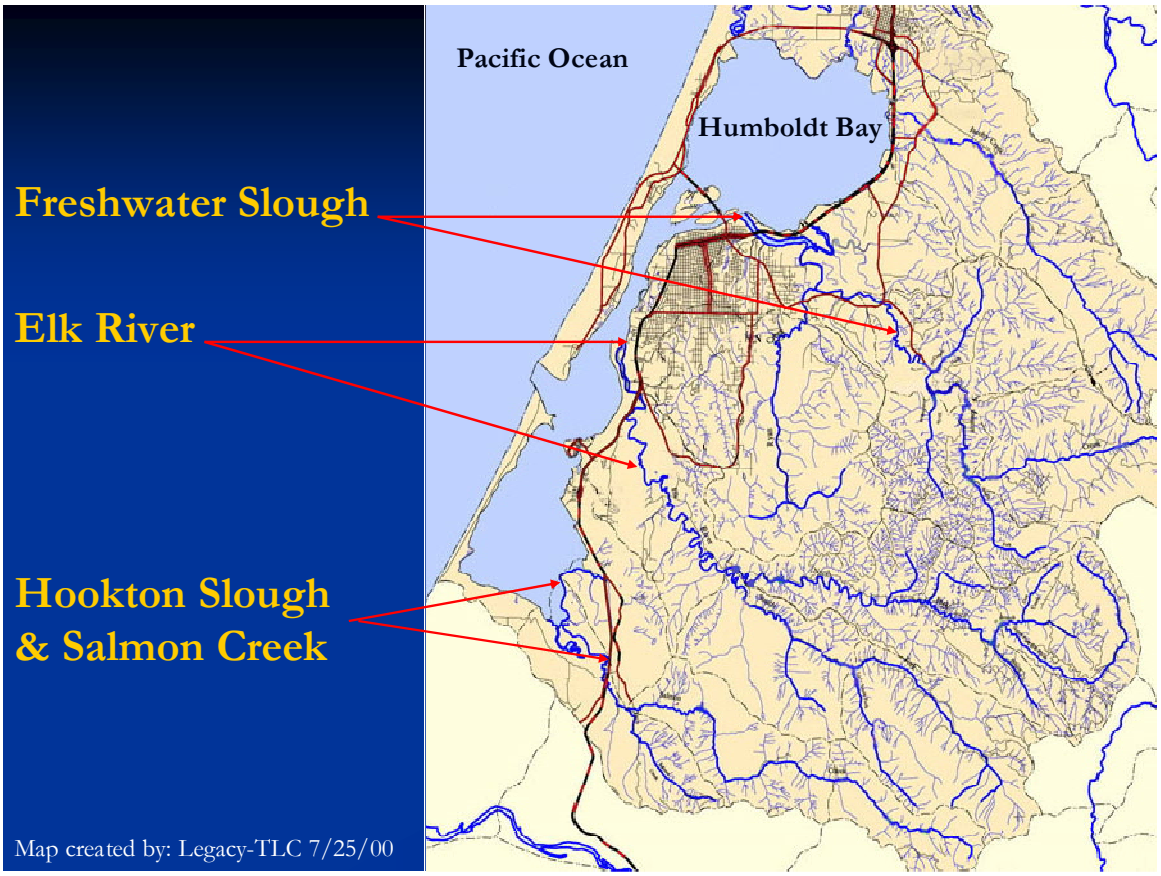

Figure 1. Locations of the tidal portion of major Humboldt Bay tributaries.

Yoy Chinook salmon were present in our upper estuary catches from early May to early August and their peak catch occurred in early June. Their weekly mean FL increased from 47 mm in early May to 72 mm in early August. In the lower slough we captured yoy Chinook salmon from late May to early July and their peak catch occurred in late June. Their weekly mean FL increased from 65 mm in late May to 70 mm in early July. The yoy Chinook were too small for PIT tags so we have no information on the estuarine residency or growth rate.

Juvenile steelhead were present in upper estuary catch from early February to late November and their peak catch occurred in early August. Their weekly mean FL ranged from 80-155 mm with no apparent size pattern during the year. In the lower slough we captured relatively few steelhead (n=19) and all were captured from mid March to early July. Their peak catch occurred in mid June. We applied PIT tags to 85 juvenile steelhead in 2005 and recaptured 10 (11.8%) of them. Their mean length of estuarine residence was 27 days and ranged from 4 to 69 days. All project marked yearling coho were recaptured at the same site where they were marked indicating that they moved very little while residing in the slough. We also captured another 10 juvenile steelhead that were tagged by other projects in the Freshwater Creek basin.

The mean growth rate of the eight recaptured juvenile steelhead at large for at least two weeks was 0.26 mm/day and ranged from 0.07 to 0.59 mm/day.

Coastal cutthroat trout were present in our upper estuary catch from early March to mid November and their peak catch occurred in early October. Their weekly mean FL ranged from 80-256 mm with no apparent size pattern during the year. In the lower slough we captured relatively few cutthroat trout (n=8) and all were captured from mid May to early August. We applied PIT tags to 41 cutthroat trout in 2005 and recaptured eight (19.5%) of them. Their mean length of estuarine residence was 48 days and ranged from 8 to 102 days. All project marked cutthroat trout were recaptured at the same site where they were marked indicating that they moved very little while residing in the slough. We also captured another five cutthroat trout that were tagged by other projects in the Freshwater Creek basin. The mean growth rate of the seven recaptured cutthroat trout at large for at least two weeks was 0.25 mm/day and ranged from 0 to 1.03 mm/day. It is likely that some of the cutthroat trout captured by our project were resident adult fish.

Freshwater Creek Slough 2006- Yoy coho salmon were by far the most common salmonid captured and were found primarily in the upper slough. In the upper slough we captured yoy coho salmon from early May to early December but their peak catches occurred in late June and they remained abundant through August. Their relative abundance was much greater in 2005 than in 2006. The CPUE of yoy coho from the weeks of 4/29-8/31, 2005 was 6.49 fish/set compared to 1.98 fish/set for the weeks of 4/30-8/27, 2006. Their weekly mean FL increased from 41 mm in early May to 100 mm in mid November. We applied PIT tags to 237 yoy coho in 2006 and recaptured 57 (24.1%) of them. The PIT tagged yoy coho salmon resided in the tidal freshwater portion of Freshwater Creek Slough throughout the summer. Their mean length of residence was 33 days and ranged from 5 to 106 days. Fifty four out of 57 (94.7%) project marked 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. The mean growth rate of the 46 recaptured yoy coho at large for at least two weeks was 0.15 mm/day and ranged from 0 to 0.29 mm/day.

Yearling coho salmon were present in our upper estuary catches from mid February to mid June and their peak catch occurred from early to late May. Their weekly mean FL decreased from 112 mm in early May to 97 mm in mid June. In the lower slough we captured yearling coho salmon from early March to early August. There was no real peak catch but we had small but consistent catches from mid April to early June. Their weekly mean FL increased from 84-102 mm in early March to 115-147 mm in May to early June. We applied PIT tags to 81 yearling coho in 2006 and recaptured four (4.9%) of them. Their mean length of estuarine residence was 7 days and ranged from 5 to 11 days. All project marked yearling coho were recaptured at the same site where they were marked indicating that they moved very little while residing in the slough. We also captured another 30 yearling coho that were tagged by other projects in the Freshwater Creek basin. No PIT tagged yearling coho were at large for at least two weeks; however, the fish at large 11 days grew 0.64 mm/day.

Yoy Chinook salmon were present in our upper estuary catches from late May to late June and their peak catch occurred in early June. Their weekly mean FL increased from 60 mm in late May to 69 mm in mid June. In the lower slough we captured only four yoy Chinook salmon. We captured them from mid May to early July. Their FL's increased from 47 mm in mid May to 86 mm in early July.

Juvenile steelhead were present in our upper estuary catch from mid February to early December and their peak catch occurred in late June. Their weekly mean FL ranged from 70-186 mm with no apparent size pattern during the year. In the lower slough we captured only

one steelhead. It was 167 mm FL and was captured in mid May. We applied PIT tags to 73 juvenile steelhead in 2006 and recaptured eight (11.0%) of them. They were at large for 4 to 339 days. All fish were recaptured at the same site where they were marked. We also captured another 7 juvenile steelhead that were tagged by other projects in the Freshwater Creek basin. The growth rates of the four recaptured juvenile steelhead at large for at least two weeks ranged from 0.09 to 0.39 mm/day. The fish at large for 339 days (3/8/05-2/10/06) was marked at 81 mm FL and grew to 213 mm FL.

Coastal cutthroat trout were present in our upper estuary catch from late March to early December and their peak catch occurred in late September. Their weekly mean FL ranged from 156-279 mm with no apparent size pattern during the year. In the lower slough we captured relatively few cutthroat trout (n=4) and all were captured in June. We applied PIT tags to 26 cutthroat trout in 2006 and recaptured two (7.7%) of them. One was at large for 62 days and the other for 385 days. Both fish were recaptured at the same site where they were marked. We also captured another 5 cutthroat trout that were tagged by other projects in the Freshwater Creek basin. The growth rates of the recaptured cutthroat trout was 0.16 mm/day for the fish at large for 62 days (5/18-7/19) and 0.15 mm/day for the fish at large 385 days (7/18/05-8/7/06). It is likely that some of the cutthroat trout captured by our project were resident adult fish.

Elk River Slough 2005- Yoy coho salmon were by far the most common salmonid captured and were found primarily in the upper slough (n=1,263). In the upper slough we captured yoy coho salmon from mid April to mid November. Their peak catches occurred in early August but they were abundant from early May through early November. Their weekly mean FL increased from 39 mm in mid April to 82 mm in early November. We captured relatively few yoy coho in the lower slough (n=28). Their abundance peaked in late May but we captured them from late March to late June. We applied PIT tags to 344 yoy coho in 2005 and recaptured 121 (35.2%) of them. The PIT tagged yoy coho salmon resided in the tidal freshwater portion of Elk River Slough throughout the summer. Their mean length of residence was 34 days and ranged from 4 to 110 days. One hundred twenty out of 121 (99.2%) project marked 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. The mean growth rate of the 85 recaptured yoy coho at large for at least two weeks was 0.13 mm/day and ranged from 0 to 0.38 mm/day.

Yearling and older coho salmon were present in our upper estuary catches from early February to late June and their peak catch occurred in early February. Their weekly mean FL increased from 76 mm in early February to 114 mm in early and late May, then their mean FL dropped to 104 mm in late June. In the lower slough we captured yearling coho salmon from late January to early July and their peak catch occurred in late April and late May. Their weekly mean FL increased from 64 mm in early January to 129 mm in early July. We applied PIT tags to 138 yearling coho in 2005 and recaptured three (2.2%) of them. They were at large for 9 to 94 days. Two of the fish were recaptured at the same site where they were marked and the other moved one site upstream from where it was originally marked. The growth rates of the recaptured yearling coho ranged from 0.11 to 0.33 mm/day.

We captured only four yoy Chinook salmon in the upper estuary. We captured them from early June to mid July. Their FL increased from 62 mm in early June to 85 mm in late June. In the lower slough we captured 35 yoy Chinook salmon. We captured them from late May to early September and the peak catch occurred in late June. Their FL's increased from 69 mm in late May to 112 mm in early September.

Juvenile steelhead were present in our upper estuary catch from late June to early November and their peak catches occurred late June to late July and early September to early November. Their FL's ranged from 80-185 mm with no apparent size pattern during the year. In the lower

slough we captured only five steelhead from late February to mid October. They ranged from 135 to 281 mm FL. We applied PIT tags to 22 juvenile steelhead in 2005 and recaptured one (4.5%) of them. It was at large for 118 days, had a growth rate of 0.19 mm/day, and was recaptured at the same site where it was originally marked.

We captured only four coastal cutthroat trout in the upper estuary from late June to mid November. Their FL's ranged from 138-254 mm. In the lower slough we captured only four cutthroat trout from late April to early November. We applied PIT tags to seven cutthroat trout in 2005 and did not recapture any of them. It is likely that some of the cutthroat trout captured by our project were resident adult fish.

Elk River Slough 2006- Yoy coho salmon were by far the most common salmonid captured and were found primarily in the upper slough (n=240). In the upper slough we captured yoy coho salmon from late April to early December. Their peak catches occurred in early August and they were abundant from late June to mid September. Their relative abundance was much greater in 2005 than in 2006. The CPUE of yoy coho from May to September 2005 was 6.42 fish/set compared to 1.26 fish/set for May to September 2006. Their weekly mean FL increased from 38 mm in late April to 103 mm in mid November. We captured relatively few yoy coho in the lower slough (n=24). We captured 23 of the 24 yoy coho in late November. We applied PIT tags to 107 yoy coho in 2006 and recaptured 41 (38.3%) of them. The PIT tagged yoy coho salmon resided in the tidal freshwater portion of Elk River Slough throughout the summer. Their mean length of residence was 39 days (n=41) and ranged from 6 to 128 days. All project marked 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. The mean growth rate of the 30 recaptured yoy coho at large for at least two weeks was 0.19 mm/day and ranged from 0.07 to 0.39 mm/day.

Yearling coho salmon were present in our upper estuary catches from mid February to mid July and their peak catch occurred in mid May. Their weekly mean FL increased from 94 mm in mid February to 127 mm in early May, then their mean FL dropped to 100-110 mm in early July. In the lower slough we captured yearling coho salmon from early March to mid July and their peak catch occurred in May. Their weekly mean FL increased from 115 mm in early March to 133 mm in early May, and then their mean FL ranged from 108 to 124 mm until mid July. We applied PIT tags to 150 yearling coho in 2006 and recaptured seven (4.7%) of them. They were at large for 6 to 106 days. Five of the fish were recaptured at the same site where they were marked. The other fish was marked on February 14 and was recaptured on May 31 and moved from tidal freshwater habitat in the upper slough to brackish water habitat in the lower slough.

We did not capture any yoy Chinook salmon in the upper slough. In the lower slough we captured 12 yoy Chinook salmon. We captured them from late June to late August and the peak catch occurred in July. Their FL's increased from 80 mm in late June to 105 mm in late August. We applied PIT tags to 9 yoy Chinook in 2006 and recaptured two (22.2%) of them. They were at large for 6 to 13 days and were both recaptured at the same site where they were marked. The fish at large for 13 days had a growth rate of 0.85 mm/day.

Juvenile steelhead were present in our upper estuary catch (n=44) from early May to early December and their peak catch occurred in early July. Their FL's ranged from 85-186 mm with no apparent size pattern during the year. In the lower slough we captured only eight steelhead from early January to early May. They ranged from 67 to 240 mm FL. We applied PIT tags to 50 juvenile steelhead in 2006 and recaptured five (10.0%) of them. They were at large for 13-112 days and had growth rates of 0.21-0.31 mm/day. They were all recaptured at the same site where they were originally marked.

We captured coastal cutthroat trout in the upper estuary (n=49) from early May to early December. Their FL's ranged from 138-258 mm. In the lower slough we captured only eight cutthroat trout from late May to early September. We applied PIT tags to 39 cutthroat trout in 2006 and recaptured eight (20.5%) of them. They were at large for 13-150 days and had growth rates of 0.05-0.29 mm/day. They were all recaptured at the same site where they were originally marked. It is likely that some of the cutthroat trout captured by our project were resident adult fish.

Salmon Creek/Hookton Slough 2005- We captured markedly fewer juvenile salmonids in Salmon Creek/Hookton Slough than in Freshwater Creek and Elk River Sloughs. Juvenile steelhead were by far the most common salmonid captured (n=73) and over 90% of them were found upstream of the tidegate in Salmon Creek. We captured juvenile steelhead from early February to early December but their peak catches occurred in late March. Their weekly mean FL ranged from 71 to 161 mm. We applied PIT tags to 53 juvenile steelhead in 2005 and recaptured 10 (18.9%) of them in 2005 and one (1.9%) in 2006. The PIT tagged juvenile steelhead resided just upstream of the tidal freshwater portion of Salmon Creek estuary throughout the summer and into the following winter. Their mean length of residence was 131 days (n=11) and ranged from 9 to 297 days. The longer estuary residence time of steelhead in Salmon Creek estuary compared to Freshwater and Elk estuaries is most likely because we marked a higher percentage of yoy and Age 1 steelhead in Salmon Creek than in Freshwater Creek and Elk River Sloughs. Therefore, the PIT tagged Salmon Creek steelhead were younger less likely to migrate to sea than the PIT tagged steelhead from the other sloughs. All project marked steelhead were recaptured at the same site where they were originally marked indicating that they moved very little while residing in the slough. The mean growth rate of the 10 recaptured yoy coho at large for at least two weeks was 0.15 mm/day and ranged from 0.10 to 0.25 mm/day.

We captured 15 yoy coho salmon, all upstream of the tidegate. We captured 13 yoy coho from mid April to late June and the remaining two in early December. Their weekly mean FL increased from 32 mm in mid April, to 72 mm in late June, and to 83 mm in early December. We did not capture any other juvenile salmonid species.

Salmon Creek/Hookton Slough 2006- Field crews captured markedly fewer juvenile salmonids in Salmon Creek/Hookton Slough in 2006 compared to 2005. We captured 15 juvenile steelhead in 2006. We captured them in mid February and again in mid to late November. Their weekly mean FL was 123 mm in February and 59 to 68 mm in November. We applied PIT tags to 8 juvenile steelhead in 2006 and did not recapture any of them during the year.

We captured four yearling coho salmon, three upstream of the tidegate and one downstream of the tidegate in Hookton Slough. We captured them from late March to early June. Their weekly mean FL ranged from 106 to 127 mm. We applied PIT tags to the four coho but did not recapture any of them. We also captured one unidentified yoy trout in early June.

Martin Slough 2005 & 2006- We conducted some periodic qualitative sampling in Martin Slough on Eureka Municipal Golf Course property with seine nets and minnow traps baited with frozen salmon roe. A habitat restoration plan is being prepared to improve salmonid habitat in the tidal portion of Martin Slough and NSA is providing baseline data to this project.

On July 7, 2005 we fished two minnow traps in Martin Slough upstream of the 17th hole pond and captured four yoy coho salmon with a mean FL of 78 mm. On July 14 we made one seine haul with a 100 foot seine net in the pond adjacent to the 17th hole and captured 147 juvenile coho salmon with a mean FL of 81 mm (n=30, range 64-107 mm) and one cutthroat trout that was 160 mm FL. We also fished two minnow traps in a small tributary to Martin Slough

downstream of the 17th hole pond and captured one yoy coho salmon that was 62 mm FL. Finally, we made one seine haul with a 30 foot seine net in Martin Creek approximately ¼ mile upstream of the 17th hole pond. We captured one yoy coho salmon and it was 62 mm FL.

On February 9, 2006 we made one seine haul with a 100 foot seine net in the pond adjacent to the 17th hole and captured eight yearling coho salmon with a mean FL of 101 mm (n=7, range 88-108 mm). We then made two seine hauls with a 30 foot net in Martin Slough just downstream of the 17th hole pond and captured one yearling coho salmon and it was 98 mm FL. We then made two seine hauls with a 30 foot net in Martin Slough about 100 yards downstream of the 17th hole pond and captured five yearling coho salmon with a mean FL of 100 mm (n=5, range 87-114 mm). Finally, we then made one seine haul with a 30 foot net in a small tributary to Martin Slough downstream of the 17th hole pond and captured four yearling coho with a mean FL of 99 mm (n=4, range 93-107 mm).

On May 25, 2006 we made one seine haul with a 100 foot seine net in the pond adjacent to the 17th hole and captured 14 yearling coho salmon with a mean FL of 126 mm (n=14, range 115-143 mm). We then made two seine hauls with a 30 foot net in Martin Slough just downstream of the 17th hole pond and captured two yearling coho salmon with a mean FL of 116 mm.

Humboldt Bay Tributary Sampling 2007- In 2007 we are continuing to sample juvenile salmonids in Freshwater Creek, Elk River, and Salmon Creek/Hookton Sloughs. We are in the midst of field sampling and are still entering the 2007 data. We plan to edit and analyze the 2007 data after the end of the calendar year and produce a report of our findings shortly thereafter.

Beginning in 2007 we also began monthly sampling of several smaller tributaries to Humboldt Bay and one slough in the Eel River estuary where marsh restoration projects designed to benefit juvenile salmonids are either being planned or have already begun. In addition to Martin Slough which we periodically sampled in 2005 and 2006 the new sites are the tidal portions of Wood Creek, Fay Slough (both tributaries to Freshwater Creek Slough), Rocky Gulch (tributary to Humboldt Bay), and McNulty Slough (tributary to Eel River estuary). We are sampling juvenile salmonids with seine nets and minnow traps baited with frozen salmon roe. The minnow traps have proved effective in capturing juvenile salmonids in areas where we are unable to use seine nets. We will include the results of these surveys in the above report.

Water Quality- NSA deployed HOBO temperature data loggers in Freshwater Creek, Elk River, and Salmon Creek/Hookton Sloughs to continuously measure spring to fall water temperatures in estuarine habitat. The HOBO meters documented that water temperatures in the freshwater portions of the sloughs did not exceed 17-18 ^{o}C and that water temperatures at the mouths of the sloughs where they entered Humboldt Bay was normally 14-16 ^{o}C. However, in Hookton Slough and about a 5 km portion of lower Freshwater Creek Slough NSA recorded water temperatures routinely greater than 20°C and up to 26°C. They almost always remained above 20°C from mid June through mid August regardless of tide stage or time of day. A portion of lower Elk River Slough also had elevated water temperatures but was about 3-5 ^{o}C lower than Freshwater Creek and Hookton Sloughs. The elevated temperatures in Freshwater Creek and Hookton Sloughs are probably due to the extensive mudflats that surround these two sloughs. The mud flats are heated by the sun at low tides and warms the slough water as it rises over the flats. The lack of water circulation within the leveed sloughs traps the warmed water within sections of the lower sloughs. Elk River Slough is not adjacent to extensive mud flats so it does not heat up as much as Freshwater Creek and Hookton Sloughs.

Summary of Project Results:
Project documented that yoy coho salmon rear in the tidal freshwater portion of Humboldt Bay

tributaries for at least 3 months. This is a life history trait has only been rarely documented in California for coho salmon (Nielsen 1994).

Project documented that yoy 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, 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 this type of habitat to increase rearing habitat for yoy coho salmon.

Project results show that yoy coho salmon that rear in the estuary grow larger than their cohort rearing in stream habitat farther upstream in the basin. Based on other studies larger size at ocean entry usually results in higher ocean survival.

Project documented that yearling coho salmon over-winter in the tidal freshwater portion of Humboldt Bay tributaries. They probably do this to take advantage of the low gradient habitat during high winter stream flows.

Project documented that the other juvenile salmonid species rear in the tidal portions of Humboldt Bay tributaries for significant periods of time strongly suggesting that they are important to their survival.

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?

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 showed that after rearing in the estuary for the summer yoy coho salmon migrate back upstream to over-winter. Another study in British Columbia showed that after rearing in the estuary for the summer yoy coho salmon migrated to the ocean. This project made observations suggesting that both of the above scenarios may be occurring in Humboldt Bay tributaries. What is the dominate life history strategy of yoy coho salmon in Humboldt Bay tributaries?

Preliminary data suggests that a significant portion of coho smolts over-winter in the low gradient section of Freshwater Creek in the freshwater/estuary ecotone as compared to the rest of the Freshwater Creek basin. What portion of coho salmon smolts originate from the freshwater/estuary ecotone?

Will creation of low water velocity habitat i.e. side channels, freshwater or saltwater marshes, ponds increase over-wintering and spring/summer rearing habitat?

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.

Downstream migrant traps should be established at the upstream and downstream borders of the freshwater/estuary ecotone to conduct a mark-recapture study on coho salmon smolts. This study will determine the number of coho salmon smolts originating from the freshwater/estuary ecotone and the number from the rest of the Freshwater Creek basin upstream.

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 rearing habitat for yoy 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 yearling coho in the winter.

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

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.

Acknowledgements

Thank you to Eric Ojerholm for being a great field crew leader and to N. Burks, C. Hannon, A. Jeffrey, V. Jimenez, D. Kyle, M. Lomeli, C. Merredith, J. Sartori, and A. Shows for their expert fieldwork. This project was funded by Aid in Sport Fish Restoration Project # F-51-R-67 and the California Department of Fish and Game's Fishery Restoration Grants Program. Fisheries Technicians and administrative support was provided by the Pacific States Marine Fisheries Commission under contracts P0310534 and P0410504. Finally, thank you to the Eureka Municipal Golf Course and the other private landowners for allowing us to access their property.

Literature Cited

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1994. Historical decline and current status of coho salmon in California. North American Journal of Fisheries Management 14: 237-261.

Busby, P.J., T.C. Wainwhright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-27, 261 pp.

California Department of Fish & Game. 2002. Status review of California coho salmon north of

San Francisco. Report to the California Fish and Game Commission. 232 pp. plus appendices.

California Department of Fish and Game. 2001. Natural vs. hatchery proportions of juvenile salmonids migrating through the Klamath River estuary *and* Monitor natural and hatchery juvenile salmonid emigration from the Klamath River basin. Annual Performance Report. Federal Aid in Sport Fish Restoration Act. Project Number F-51-R-6. Project No. 32. Jobs No. 1 & 2.

California Department of Fish and Game. 2000. Natural vs. hatchery proportions of juvenile salmonids migrating through the Klamath River estuary *and* Monitor natural and hatchery juvenile salmonid emigration from the Klamath River basin. Annual Performance Report. Federal Aid in Sport Fish Restoration Act. Project Number F-51-R-6. Project No. 32. Jobs No. 1 & 2.

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. 232pp.

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.

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.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35, 443 pp.

Nielsen, J.L. 1994. Invasive cohorts: Impacts of hatchery-reared coho salmon on the trophic, developmental, and genetic ecology of wild stocks. Pages 361-378 *in* D.J. Stouder, K.L. Fresh, and R.J. Feller, (editors). Theory and application in fish feeding ecology. The Belle W. Baruch library in marine science number 18. University of South Carolina Press.

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.

Reimers, P.E. 1971. The length of residence of juvenile fall Chinook salmon in Sixes River, Oregon. Ph. D., Oregon State University, Corvallis. 99 pp.

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.

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. 2000. Length of residency of juvenile Chinook salmon in the Klamath River estuary. Final Performance Report. Federal Aid in Sport Fish Restoration Act. Project No. F-51-R; Project No. 17; Job No. 5. 21pp.

Wallace, M. 2006. Juvenile salmonid use of Freshwater Slough and tidal portion of Freshwater Creek, Humboldt Bay, California. 2003 Annual Report. Final Report for contract P0210710. March 2006. 32pp.

Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-24, 258 pp.