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JUVENILE SALMONID USE OF FRESHWATER SLOUGH AND TIDAL PORTION OF FRESHWATER CREEK, HUMBOLDT BAY, CALIFORNIA 2003 ANNUAL REPORT

By

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Northern California North Coast Region

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ABSTRACT

The California Department of Fish and Game's (CDFG) Natural Stocks Assessment Project (NSA) sampled juvenile salmonids in Freshwater Creek Slough, Humboldt Bay from March through October 2003 to determine their migration timing and use of estuarine habitat. This report covers the first year of a planned multi-year field study. NSA staff used seine nets to capture fish in the main channel of the slough and fyke traps to sample tidal meanders and a restored marsh adjacent to the slough. In the upper slough, NSA personnel captured yearling coho salmon, *Oncorhynchus kisutch*, in mid March and from mid May until late June. Their peak catch occurred in mid March with a smaller peak in late May. NSA staff captured young-of-the-year (yoy) coho salmon from mid May until late October; peak catches occurred in early July. Field crews captured yoy Chinook salmon, *O. tshawytscha*, from mid May until early August; peak catches occurred in early June. In the lower slough, yearling coho were captured from early April until early July, with peak catches occurring mid to late May. NSA crews captured yoy coho salmon mostly in early April and then in low numbers until mid June. NSA staff captured yoy Chinook salmon from early April until mid July, with peak catches occurring in mid June. Yearling coho were longer in size in the lower slough than in the upper slough. The mean fork length (FL) of yoy coho salmon residing in the upper slough was longer than those in Freshwater Creek upstream of the estuary. The average length of estuarine residence for mark/recaptured fish was 1 week (range 1-3 weeks) for yearling coho salmon and 4 weeks (range 1-8 weeks) for yoy Chinook salmon. Yoy Chinook salmon recaptured in the lower slough had a longer average estuarine rearing time than those recaptured in the upper slough. Mark/recaptured yoy coho salmon reared in the upper slough for up to 11 weeks after marking.

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[1] Fisheries Program Branch Administrative Report No. 2006- . Edited by K. Hashagen (retired), California Department of Fish and Game. Submitted December 2005. This report was prepared as part of the Federal Aid in Sport Fish Restoration Act Program (California Project F-51-R). Additional funding was also received from the Fisheries Restoration Grants Program.

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Saltwater intrusion and water temperature showed a high degree of seasonal variation. Water temperatures routinely exceeded 20°C and ranged up to 25°C in the mid portion of the lower slough during June and August but never exceeded 19°C near the mouth of Freshwater Slough or 18°C in the upper slough of Freshwater Creek.

INTRODUCTION

California salmonid populations have declined considerably from historic levels (Brown et al. 1994, Weitkamp et al.[3] 1995; Busby et al.[4] 1996; Myers et al.[5] 1998; CDFG[6] 2002). Humboldt Bay tributary populations of coho salmon, Chinook salmon, 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 fish species. Numerous studies have documented extended estuarine residence by juvenile Chinook salmon (Reimers[7] 1971; Healey 1982; Kjelson et al.1982; Healey 1991; Wallace[8] 2000), coho salmon (Tschaplinski[9] 1982; Miller and Sadro 2003) and

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[3] Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. NOAA Tech. Memo. NMFS-NWFSC-24, 258 pp.

[4] Busby, P.J., T.C. Wainwright, 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.

[5] Myers, J.M., R.G. Cope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neeley, 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.

[6] California Department of Fish and Game. 2002. Status review of California coho salmon north of San Francisco. Report to the California Fish and Game Commission. 232 pp. plus appendices.

[7] 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.

[8] 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 Number F-51-R; Project No. 17; Job No. 5. 21 pp.

[9] 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

cutthroat trout, *O. clarkii clarkii*, (Northcote 1997; Trotter 1997; CDFG[10] 2000; CDFG[11] 2001). However, virtually nothing is known about juvenile salmonid use of Humboldt Bay or the sloughs and tidal portion of its tributaries (HBWAC[12] 2005). Chamberlain[13] (1988) captured small numbers of juvenile coho salmon in a newly restored marsh adjacent to Freshwater Slough between November 1981 and April 1982 but did not capture any other salmonid species. Shapiro[14] (1980) stated that juvenile salmonids probably use portions of Freshwater Slough for rearing but the extent of this rearing was unknown. Some of the most viable stocks of wild coho salmon remaining in California occur in Humboldt Bay tributaries such as Freshwater Creek and Elk River (Brown et al. 1994). These streams also support Chinook salmon, steelhead trout, and coastal cutthroat trout and the sloughs and tidal portion of these streams may be important rearing habitat for these fish species.

An ongoing study by the CDFG's Anadromous Fisheries Resource Assessment and Monitoring Program (AFRAMP) is studying the life histories of salmonids in Freshwater Creek. AFRAMP has collected data and made observations that suggest some young-of-the-year (yoy) coho salmon and age 1+ steelhead rear downstream of the head of the tide during the spring and summer (HBWAC[12] 2005), then migrate upstream into Freshwater Creek to over-winter before emigrating to the ocean the following year (Seth Ricker CDFG, pers. comm.). This life history pattern has been documented in a tributary of Coos Bay Oregon for yoy coho salmon (Miller and Sadro 2003).

Workshop: a ten year review. Malaspina College, Nanaimo, British Columbia.

[10] 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 and 2.

[11] 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 and 2.

[12] Humboldt Bay Watershed Advisory Committee. 2005. Humboldt Bay Watershed and 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. 232 pp.

[13] Chamberlain, R.H. 1988. Fish use of a mitigation salt marsh. M.S. Thesis. Dept. of Fisheries, Humboldt State University, Arcata, CA. 122 pp.

[14] Shapiro and Associates, Inc. 1980. Humboldt Bay wetlands review and baylands analysis, final report. United States Army Corps of Engineers, San Francisco, CA. 668 pp.

About 85-90% of the historical marsh habitat around Humboldt Bay has been lost due to the construction of dikes and levees to reclaim marshes for pasture land and other types of land uses (HBWAC[12] 2005). Recently, parcels of historic marsh land contained behind levees around Humboldt Bay have been or are planned to be acquired, and restored back to marsh habitat. However, very little information exists about how and when marsh habitat is used by juvenile salmonids or what type of marsh habitat is most beneficial to them.

The primary purposes of CDFG's Natural Stocks Assessment Project (NSA) study are 1) compliment the AFRAMP studies by supplying life history information about the estuarine life stage of juvenile salmonids leaving the Freshwater Creek basin; 2) document the degree of importance of marsh and slough habitat to juvenile salmonids in Freshwater Slough and, 3) determine the types of estuarine habitat important to juvenile salmonids. Hopefully, this project will provide information to CDFG and the habitat restoration community to help design effective marsh restoration projects to benefit juvenile salmonids.

Study Area

The Freshwater Creek basin is located in Humboldt County between Eureka to the south and Arcata to the north (Figure 1). Freshwater Creek is a fourth order stream with a drainage area of approximately 9227 hectares (31 square miles) and drains into Humboldt Bay via Eureka Slough (Ricker[15] 2002). The lower 6 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.

I defined the estuary 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 Slough (see Water Quality section below) and about 1 km above the county road at Freshwater Corners (Figure 1). However, HBWAC[12] (2005) reported that tidal influence was documented as far upstream as Howard Heights Road (about 13 km upstream of the mouth). The slough upstream of the Highway 101 Bridge is contained between levees. The lowermost portion of the slough is characterized by extensive mudflats, modest to moderate amounts of eelgrass beds, and some areas of salt marsh (Figure 2). Upstream of Fay Slough the channel is tightly constricted between levees (Figure 1). Riparian vegetation, primarily in the form of willow (*Salix spp*) begins to form just downstream of the county road bridge at Freshwater Corners, and becomes quite dense upstream of the county road bridge (Figure 2).

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[15] Ricker, S.J. 2002. Results of juvenile downstream migrant trapping conducted on Freshwater Creek, 2002. 2001-2002 Annual Report Project 2a6. California Department of Fish and Game Steelhead Research and Monitoring Program. Arcata, CA. 17 pp.

Physical conditions in Freshwater Creek Slough such as saltwater intrusion show a high degree of annual, seasonal, and daily variation due to changes in river flow and tidal action (see Water Quality section below). The lower slough 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. Brackish water usually extended upstream to about 6.5 km at high tide, but reached as far as the Humboldt Fish Action Council (HFAC) weir site (about 8.5 km) during the highest tides in late summer. The water column was generally well mixed. Some stratification between fresh and saltwater occurred in the spring during high stream flows, but little to no stratification occurred throughout most of the summer during low stream flow conditions upstream of River Kilometer (RK) 1.

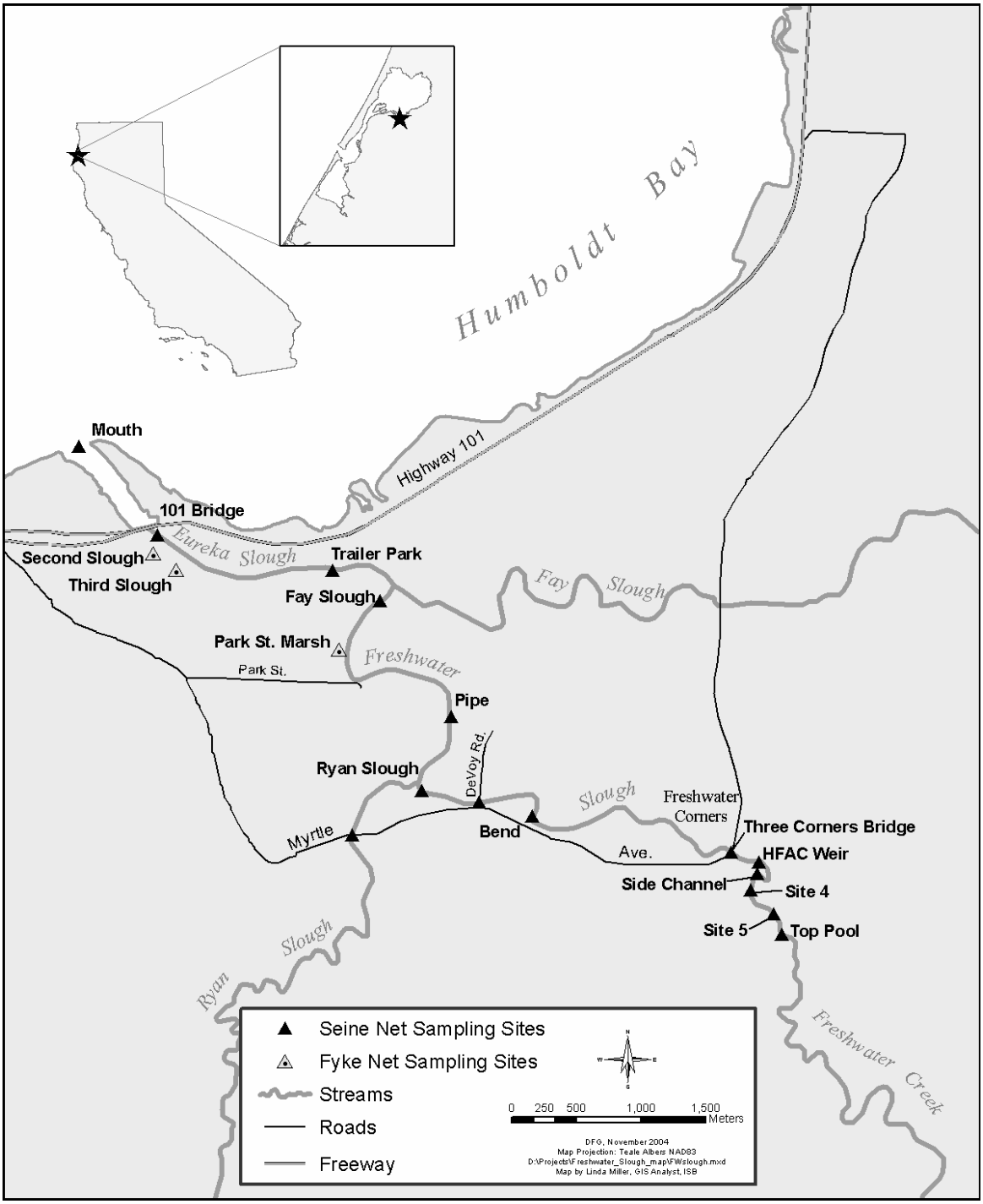

Figure 1. Map of Freshwater Creek Slough showing fish sampling sites in the upper and lower slough. Boundary between upper and lower slough is at Three Corners Bridge.

Figure 2. Representative sections of the lower slough showing mud flat and eel grass habitat and the upper the slough showing extensive riparian cover.

METHODS

Fish Capture

I stratified Freshwater Creek Slough into two sampling areas, divided by the Three Corners Bridge at Freshwater Corners (Figure 1). NSA field crews attempted to sample each area on a weekly basis. The stratification was necessary due to the presence of heavy riparian vegetation in the upper slough, requiring field crews to use a smaller seine net than they used to sample the larger water area in the lower slough. 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.

The upper slough sampling area was approximately 8.4 to 9.7 RK above the mouth of the slough (Figure 1). Field crews began sampling the upper slough in mid-March but were forced to discontinue until mid-May due to high stream flows. We sampled weekly from mid-May through August and then intermittently through October. I subjectively chose sampling sites throughout the entire upper slough segment where thick vegetation and instream woody debris did not interfere with seine hauls. I selected six standard sampling sites and field crews performed two seine hauls at each site using a 9.1 mX1.8m X6.4 millimeter (mm) mesh beach seine. The two downstream most sites in this area experience the greatest tidal height variation and were seined near low tide to ensure there was exposed beach/bar areas on which to land the net. The upstream most site in the upper slough was situated just upstream of the observed tidal portion of the stream in order to compare differences in fish use between tidally influenced and non-influenced sites.

The lower slough sampling area extended from the mouth of the slough to approximately 5.7 km upstream (Figure 1). Field crews sampled the lower slough every week from early April until the end of August. I subjectively chose sampling sites to sample areas throughout the entire lower slough segment where there were exposed beaches or bars on which to land the net. I selected seven standard sampling sites and field crews performed one seine haul at each site using a beach seine 30.5 mX2.4 m deployed by hand or boat. The mesh size of the wings was 19.1 mm and the bag was 1.5 m deep with 6.4 mm mesh. All sites in this area experience tidal variation and were seined near low tide to ensure crews had exposed beach/bar areas on which to land the net.

NSA also sampled two tidal meanders and a restored marsh site in the lower slough (Figure 1). Field crews sampled these areas about once a month from May to August using 1.2 mX1.2 m fyke traps fished on an outgoing tide. Only presence/absence information was gathered and I made no effort to quantify or even standardize the catches.

Fish Marking

NSA field crews anaesthetized juvenile salmonids with alka seltzer, counted, and examined them for marks and tags. At each sampling site the first 30 fish of each species and life stage (i.e., yoy, yearling plus, adult) were measured for fork length (FL), and weighed to the nearest 0.1 gram (g). Field crews collected scales from the first 10 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 recorded. Once processed, the fish were allowed to recover and released back into the sampling site.

Personnel from AFRAMP applied either passive integrated transponder (PIT) tags or week and site specific Visual Implant Elastomer (VIE) marks to juvenile salmonids throughout the Freshwater Creek basin. See Ricker[15] (2002) for a description of marking techniques. I calculated length of estuarine residence for VIE marked fish as the number of weeks between the week of marking at AFRAMP's lower most trapping site (approximately 1 km upstream of our most upstream site) and the week of recapture in the slough. Since PIT tags are individual marks, length of estuarine residence of PIT tagged fish was simply the number of days between date of marking and date of recapture. NSA field crews also applied PIT tags or VIE marks to juvenile salmonids in the upper and lower sloughs. NSA applied PIT tags to yearling and older coho salmon, steelhead, and cutthroat trout by making a small incision and inserting the tag into the body cavity. In mid July, NSA marked yoy coho salmon by using a syringe to inject a small line of colored VIE into their snout. Each sampling site was designated with a specific colored VIE mark so that NSA could check for fish movement between sampling sites.

Water Quality

NSA staff collected water quality data in lower Freshwater Creek Slough near high slack tide on a monthly basis from April through August 2003. We attempted to sample the highest tide of the month (during daylight hours) to identify the upstream location of the saltwedge in the lower slough. We collected water temperature, dissolved oxygen, and salinity information using a YSI model 85 Oxygen/Conductivity/Salinity/Temperature meter. We sampled all seven fish sampling locations in the lower slough. We also collected water quality information at the HFAC weir site in the upper slough in April, July, and late August. We collected samples near the channel thalweg at surface, mid-water, and bottom elevations. We also routinely sampled surface water temperatures with a hand held thermometer during fish sampling.

RESULTS

Emigration Timing

Upper Slough- NSA field crews captured juvenile salmonids throughout the sampling season. NSA captured yearling coho salmon in mid March and from mid May until late June. Their peak catch-per-unit-effort (CPUE) occurred in mid March, with a smaller peak in late May (Table 1). In mid March, field crews classified 69% of the yearling coho salmon catch as smolts and the remaining 31% as presmolts (Table 2). When NSA resumed sampling in mid May, field crews classified only 8% of the May catch and 21% of the June catch as smolts.

NSA crews captured yoy coho salmon from mid May until late October. Their peak CPUE occurred in early July (Table 1).

NSA captured wild yoy Chinook salmon from mid May until early August. Their peak CPUE occurred in early June (Table 1). HFAC released 28,123 yoy Chinook salmon into Freshwater Creek in late June (Doug Kelly, HFAC, personal communication). Field crews captured these fish from early to late July with their peak CPUE occurring the first week of capture (Table 1).

NSA captured small numbers of juvenile steelhead throughout the sampling season with no obvious peak CPUE. The highest CPUE occurred in mid March and mid September (Table 1). In March, field crews classified 2 of the 3 (67%) captured steelhead as smolts. No other steelhead smolts were captured the rest of the season. The remaining steelhead captured from May through September were classified as presmolts (65%, n=40) and parr (32%, n=20) (Table 2).

Cutthroat trout were captured from mid May until mid September, with no obvious peak CPUE (Table 1). The highest CPUE occurred in mid September. Field crews classified 6% (n=2) of the captured cutthroat trout as smolts and both were

captured in June. The remaining cutthroat trout were classified as adults (45%, n=15), presmolts (45%, n=15), and parr (3%, n=1) (Table 2).

Lower Slough- In contrast to the upper slough, NSA field crews captured juvenile salmonids from early April until only early August in the lower slough (Table 1). Yearling coho salmon were captured from early April until early July and their peak CPUE occurred mid to late May. Field crews classified the majority of captured yearling coho salmon as smolts in April (55%), May (64%), and June (65%) (Table 2). The remaining yearling coho salmon were classified as presmolts.

NSA staff captured yoy coho salmon mostly in early April and then in low numbers until mid June (Table 1).

NSA crews captured wild yoy Chinook salmon from early April until mid July. Their peak CPUE occurred in mid June (Table 1). HFAC released 28,123 yoy Chinook salmon with a right maxillary clip into Freshwater Creek in late June. Field crews captured a few of these fish from early to mid July (Table 1).

NSA captured only two juvenile steelhead during the sampling season. Both were smolts and both were captured in late August.

NSA captured cutthroat trout in low numbers from mid May until early August, with the highest catch occurring in early June (Table 1). Field crews classified 29% (n=5) of the captured cutthroat trout as smolts, with four of the five being captured in June and July. Presmolts made up 47% (n=8) of the catch, with most being captured in June (Table 2). The remaining cutthroat trout were classified as adults (18%, n=3) and parr (6%, n=1).

Fyke Net Catches- NSA captured small numbers of juvenile salmonids in two tidal meanders (Second Slough and Third Slough) and the Park Street mitigation marsh (Table 3). Most of the juvenile salmonids were captured in May; by August no salmonids were captured. In the tidal meanders, yearling coho salmon were the most common salmonid captured. Yoy coho salmon was the most common salmonid captured in the mitigation marsh but none were captured farther downstream in the tidal meanders. Yoy Chinook salmon and cutthroat trout were also captured at both sites.

Size

Yearling coho salmon monthly mean fork length (FL) in the upper slough rose from 94$\pm$12.9 mm in March to 102$\pm$10.2 mm in May and then decreased to 97$\pm$10.2 mm in June (Table 4). In the lower slough, the same size pattern held true, with the mean FL increasing from 95$\pm$15.7 mm in April to 114$\pm$12.0 mm in May, and then declining to 104$\pm$8.0 mm in June (Table 4). Monthly mean FL's were longer in the lower slough than the upper slough. Monthly mean FL's of

yearling coho salmon classified as smolts were longer than those classified as presmolts for every month in both the upper and lower slough (Table 2).

Young-of-the-year coho salmon monthly mean FL's in the upper slough increased steadily each month from 48±5.1 mm in May to 70±6.6 mm in August (Table 4). In the lower slough, the mean FL of yoy coho salmon was 39±2.4 mm in April. Very few yoy coho salmon were captured after April in the lower slough. The mean FL of yoy coho salmon were larger than those observed upstream of the estuary in Freshwater Creek.

Yoy Chinook salmon monthly mean FL's in the upper slough increased steadily each month from 51±5.6 mm in May to 75±4.8 mm in July (Table 4). In the lower slough, the mean FL of yoy Chinook salmon increased from 42±2.7 mm in April to 75±7.1 in July (Table 4).

The monthly mean FL of juvenile steelhead in the upper slough ranged from 107 to 120 mm between April and August (Table 4). Monthly mean FL's of steelhead classified as smolts were longer than those classified as presmolts, and fish classified as presmolts were longer than those classified as parr for every month in the upper slough (Table 2).

The monthly mean FL of cutthroat trout in the upper slough ranged from 188 to 224 mm between May and August (Table 4), but there was no discernable trend in growth. Monthly mean FL's of yearling plus cutthroat trout classified as smolts were longer than those classified as presmolts, and fish classified as presmolts were longer than those classified as parr (Table 2). In the lower slough, yearling plus cutthroat trout were on average smaller than those observed in the upper slough (Table 4). However, this is likely due to the relatively high composition of what were likely adult cutthroat trout in our upper slough catch during July and August (Table 2).

Table 1. Number captured and catch-per-unit-effort (number of fish captured/seine haul) of juvenile salmonids captured in upper and lower Freshwater Creek Slough in 2003.

	Upper Slough											
Date	# Wild Chinook	CPUE Wild Chinook	No. Hatchery Chinook	CPUE Hatchery Chinook	No. YOY Coho	CPUE YOY Coho	No. 1+ Coho	CPUE 1+ Coho	No. 1+ SH	CPUE 1+ SH	No. 1+ Cutt	CPUE 1+ Cutt
3/12	0	0	0	0	0	0	38	7.60	3	0.60	0	0
March Total	**0**	**0**	**0**	**0**	**0**	**0**	**38**	**7.60**	**3**	**0.60**	**0**	**0**
5/14	15	1.25	0	0	30	2.50	36	3.00	3	0.25	3	0.25
5/21	16	1.33	0	0	93	7.75	44	3.67	0	0	1	0.08
5/28	20	1.67	0	0	105	8.75	44	3.67	5	0.42	2	0.17
May Total	**51**	**1.42**	**0**	**0**	**228**	**6.33**	**124**	**3.44**	**8**	**0.22**	**6**	**0.17**
6/02	36	3.00	0	0	117	9.75	10	0.83	3	0.25	1	0.08
6/09	12	1.00	0	0	109	9.08	5	0.42	0	0	1	0.08
6/16	19	1.58	0	0	129	10.75	2	0.17	3	0.25	1	0.08
6/23	17	1.42	0	0	123	10.25	2	0.17	6	0.50	0	0
June Total	**84**	**1.75**	**0**	**0**	**478**	**9.96**	**19**	**0.40**	**12**	**0.25**	**3**	**0.06**
7/03	13	1.08	33	2.75	142	11.83	0	0	4	0.33	4	0.33
7/10	3	0.25	10	0.83	80	6.67	0	0	4	0.33	3	0.25
7/15	0	0	16	1.33	67	5.58	0	0	5	0.42	5	0.42
7/24	4	0.33	4	0.33	100	8.33	0	0	0	0	3	0.25
7/28	1	0.08	2	0.17	55	4.58	0	0	5	0.42	1	0.08
July Total	**21**	**0.35**	**65**	**1.08**	**444**	**7.40**	**0**	**0**	**18**	**0.30**	**16**	**0.27**
8/07	1	0.08	0	0	54	4.50	0	0	1	0.08	2	0.17
8/15	0	0	0	0	43	3.58	0	0	0	0	1	0.08
8/21	0	0	0	0	48	4.00	0	0	5	0.42	0	0
8/26	0	0	0	0	32	2.67	0	0	4	0.33	4	0.33
August Total	**1**	**0.02**	**0**	**0**	**177**	**3.69**	**0**	**0**	**10**	**0.21**	**7**	**0.15**
9/12	0	0	0	0	60	5.00	0	0	8	0.67	6	0.50
9/26	0	0	0	0	27	2.25	0	0	3	0.25	4	0.33
Sept Total	**0**	**0**	**0**	**0**	**87**	**3.63**	**0**	**0**	**11**	**0.46**	**10**	**0.42**
10/24	0	0	0	0	24	2.00	0	0	1	0.08	1	0.08
Mar-Aug TOTAL	**157**	**0.80**	**65**	**0.33**	**1,327**	**6.74**	**181**	**0.92**	**51**	**0.26**	**32**	**0.16**

Table 1. Continued

Lower Slough												
Date	# Wild Chinook	CPUE Wild Chinook	No. Hatchery Chinook	CPUE Hatchery Chinook	No. YOY Coho	CPUE YOY Coho	No. 1+ Coho	CPUE 1+ Coho	No. 1+ SH	CPUE 1+ SH	No. 1+ Cutt	CPUE 1+ Cutt
4/03	3	0.43	0	0	25	3.57	1	0.14	0	0	0	0
4/08	3	0.43	0	0	1	0.14	4	0.57	0	0	0	0
4/17	1	0.14	0	0	6	0.86	1	0.14	0	0	0	0
4/22	4	0.57	0	0	3	0.43	4	0.57	0	0	0	0
4/30	2	0.33	0	0	2	0.33	4	0.67	0	0	0	0
April Total	**13**	**0.36**	**0**	**0**	**37**	**1.03**	**15**	**0.42**	**0**	**0**	**0**	**0**
5/05	0	0	0	0	0	0	4	0.57	0	0	0	0
5/15	3	0.43	0	0	1	0.14	35	5.00	1	0	1	0.14
5/20	15	2.14	0	0	1	0.14	39	5.57	0	0	0	0
5/29	4	0.57	0	0	0	0	16	2.29	0	0	1	0.14
May Total	**22**	**0.79**	**0**	**0**	**2**	**0.07**	**94**	**3.36**	**0**	**0**	**2**	**0.07**
6/02	12	1.71	0	0	0	0	5	0.71	0	0	7	1.00
6/12	17	2.43	0	0	2	0.29	7	1.00	0	0	2	0.29
6/19	2	0.29	0	0	0	0	5	0.71	0	0	0	0
6/26	4	0.57	0	0	0	0	1	0.14	0	0	0	0
June Total	**35**	**1.25**	**0**	**0**	**2**	**0.07**	**18**	**0.64**	**0**	**0**	**9**	**0.32**
7/03	3	0.43	1	0.14	0	0	1	0.14	0	0	1	0.14
7/09	3	0.43	2	0.29	0	0	0	0	0	0	0	0
7/15	1	0.14	2	0.29	0	0	0	0	0	0	1	0.14
7/22	0	0	0	0	0	0	0	0	0	0	0	0
7/29	0	0	0	0	0	0	0	0	0	0	0	0
July Total	**7**	**0.20**	**5**	**0.14**	**0**	**0**	**1**	**0.03**	**0**	**0**	**2**	**0.06**
8/05	0	0	0	0	0	0	0	0	0	0	1	0.14
8/14	0	0	0	0	0	0	0	0	0	0	0	0
8/19	0	0	0	0	0	0	0	0	0	0	0	0
8/26	0	0	0	0	0	0	0	0	2	0.29	0	0
August Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0.07**	**1**	**0.04**
Apr-Aug **TOTAL**	**77**	**0.50**	**5**	**0.03**	**41**	**0.26**	**128**	**0.83**	**2**	**0.01**	**14**	**0.09**

Table 2. Monthly catch composition of salmonids by life stage designation and their corresponding mean fork length (mm) in upper and lower Freshwater Creek Slough, 2003.

LOWER SLOUGH

		smolts			presmolts			parr			adults		
	n	#	%	$\bar{X}$FL	#	%	$\bar{X}$FL	#	%	$\bar{X}$FL	#	%	$\bar{X}$FL
1+ Coho													
April	11	6	55	103	5	45	80	0	0	-	0	0	-
May	103	66	64	119	37	36	108	0	0	-	0	0	-
June	23	15	65	110	8	35	99	0	0	-	0	0	-
1+ Cutthroat													
May	2	1	50	157	1	50	150	0	0	-	0	0	-
June	10	2	20	181	7	70	178	0	0	-	1	10	290
July	4	2	50	189	0	0	-	1	25	150	1	25	213
August	1	0	0	-	0	0	-	0	0	-	1	100	248

UPPER SLOUGH

	n	#	%	$\bar{X}$FL	#	%	$\bar{X}$FL	#	%	$\bar{X}$FL	#	%	$\bar{X}$FL
1+ Coho													
March	38	25	69	98	13	31	87	0	0	-	0	0	-
May	124	10	8	113	114	92	101	0	0	-	0	0	-
June	19	4	21	104	15	79	96	0	0	-	0	0	-
1+ Steelhead													
March	3	2	67	225	0	0	-	1	33	87	0	0	-
May	9	0	0	-	8	89	108	1	11	97	0	0	-
June	16	0	0	-	4	25	110	12	75	108	0	0	-
July	16	0	0	-	12	75	119	4	25	107	0	0	-
August	8	0	0	-	7	88	126	1	12	80	0	0	-
Sept	9	0	0	-	9	100	132	0	0	-	0	0	-
1+ Cutthroat													
May	6	0	0	-	6	100	190	0	0	-	0	0	-
June	4	2	50	218	1	25	166	1	25	149	0	0	-
July	16	0	0	-	7	44	190	0	0	-	9	56	225
August	7	0	0	-	1	14	153	0	0	-	6	86	236

Table 3. The monthly number of juvenile salmonids captured by fyke nets in Second and Third Sloughs and the Park Street mitigation marsh May-August, 2003.

Second and Third Sloughs	May	June	July	August
Yearling Coho Salmon	6	3	-	-
Yoy Chinook Salmon	-	-	1	-
Cutthroat Trout	-	-	1	-
Mitigation Marsh				
Yearling Coho Salmon	-	1	-	-
Yoy Coho Salmon	6	-	-	-
Yoy Chinook Salmon	1	-	1	-
Cutthroat Trout	-	-	1	-

Young-of-the-year Coho Salmon Movement

During July 9-11, NSA staff marked a total of 229 yoy coho salmon in the upper slough at six different sites (Table 5). Most marked fish were recaptured at the same sampling site where they were marked. NSA crews recaptured 308 marked fish (some fish must have been recaptured multiple times), of which 295 (95.8%) were captured at their original marking site. Of the 13 fish recaptured at different sampling sites, 9 (69.2%) were recaptured at an adjacent site, 3 (23.1%) were captured two sampling sites away, and 1 (7.7%) was captured three sites away. Of the 13 fish that were recaptured at different sampling sites, 10 moved upstream and 3 moved downstream.

Estuary Residence Times

The mean length of estuarine residence for elastomer-marked yearling coho salmon was 1.4 weeks and ranged from 1 to 3 weeks for fish marked at AFRAMP's lower mainstem weir site (near Howard Heights Road) just upstream of the tidal portion of Freshwater Creek (Table 6). The longest "at-large" estimate for a yearling coho salmon was 4 weeks. This fish was marked in Little Freshwater Creek and, therefore, spent some amount of time upstream of the estuary above AFRAMP's mainstem weir.

Young-of-the-year coho salmon had the longest estuarine residence times of the salmonid species captured by NSA. Project elastomer-marked yoy coho salmon reared in the upper slough for up to 11 weeks after marking in July (Table 5). However, it is likely that yoy coho salmon reared much longer in the estuary since they were present in our catches in April and May but were not large enough to mark until July.

The mean length of estuarine residence for elastomer marked and recaptured yoy Chinook salmon was 4 weeks and ranged from 1 to 8 weeks (Table 7).

Chinook salmon recaptured in the lower slough had a longer rearing time, on average, than those recaptured in the upper slough.

We captured too few elastomer-marked juvenile steelhead and cutthroat trout to estimate their estuarine residence times. However, we did capture six steelhead containing PIT tags. Two were PIT tagged in the upper slough in 2002 by AFRAMP. One was at large 359 days and had grown 56 mm and the other was at large 360 days and grew 63 mm. Two of the steelhead were PIT tagged by NSA in the upper slough during 2003. One was at large 24 days and had grown 8 mm and the other was at large 85 days and had grown 23 mm. The final two steelhead were PIT tagged by AFRAMP in 2003 upstream of the estuary. One fish was at large 114 days and grew 22 mm and the other was at large 48 days and grew 17 mm. NSA also captured two cutthroat trout containing PIT tags. Both were marked in the upper slough in 2002 by AFRAMP. One was at large 325 days and had grown 71 mm and the other was at large 423 days and grew 93 mm.

Water Quality

Physical conditions in Freshwater Creek Slough such as saltwater intrusion and water temperature showed a high degree of seasonal variation due to changes in river flow and tidal action (Table 8). NSA detected brackish water at the Highway 101 bridge in April and then detected brackish water farther upstream May through August (Table 8). Field crews also detected salinities up to 7.6 ppt at the HFAC weir in late August (CDFG unpublished data). Water temperatures increased at all sites from April to August, especially at Pipe and Bend (Table 8). Water temperatures exceeded 20 ^{o}C at Pipe and Bend in June and August during monthly water quality sampling and up to 25 ^{o}C during fish sampling. Water temperatures never exceeded 19 ^{o}C at the Highway 101 bridge or 18 ^{o}C upstream of the HFAC weir in Freshwater Creek. Dissolved oxygen levels dropped below 7 mg/l at Pipe and Bend during the summer but remained above 6 mg/l (Table 8).

Table 4. Number measured (n),mean fork length (FL), and standard deviation (SD) of juvenile salmonids captured in upper and lower Freshwater Creek Slough in 2003.

	Upper Slough																	
	YOY Coho			1+ Coho			YOY Chinook			1+ Steelhead			1+ Cutthroat			YOY Trout		
Date	**n**	**FL**	**SD**	**n**	**FL**	**SD**	**n**	**FL**	**SD**	**n**	**FL**	**SD**	**n**	**FL**	**SD**	**n**	**FL**	**SD**
3/12	0	-	-	38	94	12.9	0	-	-	3	179	80.1	0	-	-	0	-	-
March	**0**	**-**	**-**	**38**	**94**	**12.9**	**0**	**-**	**-**	**3**	**179**	**80.1**	**0**	**-**	**-**	**0**	**-**	**-**
5/14	30	44	4.0	36	105	10.0	15	47	3.5	4	107	12.5	3	214	19.1	3	30	1.5
5/21	61	47	4.7	44	102	8.7	16	50	3.7	0	-	-	1	186	-	4	35	1.7
5/28	73	50	4.8	44	100	11.4	20	55	6.2	5	107	12.9	2	157	3.5	1	37	-
May	**164**	**48**	**5.1**	**124**	**102**	**10.2**	**51**	**51**	**5.6**	**9**	**107**	**11.9**	**6**	**190**	**30.8**	**8**	**34**	**3.1**
6/02	97	51	5.1	10	97	10.7	36	57	5.7	3	100	9.5	1	166	-	3	44	5.0
6/09	68	53	4.7	5	100	10.0	12	59	5.4	0	-	-	2	218	8.5	1	47	-
6/16	106	57	6.0	2	88	2.1	19	60	6.2	3	121	17.7	1	149	-	6	49	7.6
6/23	118	59	5.3	2	106	9.2	17	64	6.3	6	107	25.9	0	-	-	8	55	10.0
June	**389**	**56**	**6.3**	**19**	**97**	**10.2**	**84**	**59**	**6.5**	**12**	**108**	**21.0**	**4**	**188**	**36.0**	**18**	**51**	**8.8**
7/03	93	62	5.5	0	-	-	33	75	4.4	3	105	12.8	4	215	12.0	1	58	-
7/10	72	64	5.8	0	-	-	10	75	4.4	8	122	35.6	3	242	21.5	4	58	2.2
7/15	67	65	5.0	0	-	-	16	76	5.5	5	104	11.3	5	215	17.5	6	61	7.3
7/24	68	67	5.7	0	-	-	4	76	8.1	0	-	-	3	192	64.3	4	64	3.8
7/28	52	67	4.9	0	-	-	2	77	1.4	4	129	40.6	1	122	-	1	61	-
July	**352**	**65**	**5.8**	**0**	**-**	**-**	**65**	**75**	**4.8**	**20**	**116**	**29.6**	**16**	**210**	**39.1**	**16**	**61**	**5.2**
8/07	47	68	5.3	0	-	-	1	64	-	1	80	-	2	206	43.8	1	69	-
8/15	39	71	7.8	0	-	-	0	-	-	0	-	-	1	238	-	0	-	-
8/21	42	71	5.9	0	-	-	0	-	-	4	122	26.9	0	-	-	1	73	-
8/26	32	71	7.3	0	-	-	0	-	-	3	131	28.0	4	229	54.4	0	-	-
August	**160**	**70**	**6.6**	**0**	**-**	**-**	**1**	**64**	**-**	**8**	**120**	**28.6**	**7**	**224**	**44.3**	**2**	**71**	**2.8**
MAR-AUG TOTAL	**1065**	**60**	**9.5**	**181**	**100**	**11.3**	**157**	**58**	**8.8**	**52**	**117**	**32.7**	**33**	**207**	**39.0**	**44**	**52**	**12.3**

Table 4. Continued

							Lower Slough											
	YOY Coho			1+ Coho			YOY Chinook			1+ Steelhead			1+ Cutthroat			YOY Trout		
Date	**n**	**FL**	**SD**	**n**	**FL**	**SD**	**n**	**FL**	**SD**	**n**	**FL**	**SD**	**n**	**FL**	**SD**	**n**	**FL**	**SD**
4/03	25	38	1.4	1	96	-	3	39	1.2	0	-	-	0	-	-	0	-	-
4/08	1	37	-	4	81	5.9	3	42	1.5	0	-	-	0	-	-	0	-	-
4/17	6	40	1.4	1	81	-	1	40	-	0	-	-	0	-	-	0	-	-
4/22	3	43	5.7	4	99	11.5	4	42	2.5	0	-	-	0	-	-	0	-	-
4/30	2	41	0.7	3	112	16.0	2	46	3.5	0	-	-	0	-	-	0	-	-
April	**37**	**39**	**2.4**	**13**	**95**	**15.7**	**13**	**42**	**2.7**	**0**	**-**	**-**	**0**	**-**	**-**	**0**	**-**	**-**
5/05	0	-	-	4	121	19.5	0	-	-	0	-	-	0	-	-	0	-	-
5/15	1	41	-	35	112	10.1	3	54	4.0	0	-	-	1	150	-	0	-	-
5/20	1	53	-	39	116	11.3	15	56	4.7	0	-	-	0	-	-	0	-	-
5/29	0	-	-	16	110	14.7	4	59	3.8	0	-	-	1	157	-	0	-	-
May	**2**	**47**	**8.5**	**94**	**114**	**12.0**	**22**	**56**	**4.5**	**0**	**-**	**-**	**2**	**154**	**5.0**	**0**	**-**	**-**
6/02	0	-	-	5	103	6.5	12	61	4.5	0	-	-	7	186	18.0	0	-	-
6/12	2	60	0.7	7	109	7.8	17	65	5.4	0	-	-	3	198	80.2	0	-	-
6/19	0	-	-	5	98	6.8	2	80	3.5	0	-	-	0	-	-	0	-	-
6/26	0	-	-	1	109	-	4	80	5.2	0	-	-	0	-	-	0	-	-
June	**2**	**60**	**0.7**	**18**	**104**	**8.0**	**35**	**66**	**8.1**	**0**	**-**	**-**	**10**	**190**	**41.0**	**0**	**-**	**-**
7/03	0	-	-	1	109	-	3	76	8.5	0	-	-	1	150	-	0	-	-
7/09	0	-	-	0	-	-	3	73	7.0	0	-	-	0	-	-	0	-	-
7/15	0	-	-	0	-	-	1	82	-	0	-	-	1	187	-	0	-	-
7/22	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
7/29	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
July	**0**	**-**	**-**	**1**	**109**	**-**	**7**	**75**	**7.1**	**0**	**-**	**-**	**2**	**169**	**26.2**	**0**	**-**	**-**
8/05	0	-	-	0	-	-	0	-	-	0	-	-	1	248	-	0	-	-
8/14	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
8/19	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
8/26	0	-	-	0	-	-	0	-	-	2	151	4.2	0	-	-	0	-	-
August	**0**	**-**	**-**	**0**	**-**	**-**	**0**	**-**	**-**	**2**	**151**	**4.2**	**1**	**248**	**-**	**0**	**-**	**-**
APR-AUG TOTAL	**41**	**40**	**5.4**	**127**	**111**	**13.3**	**77**	**60**	**12.0**	**2**	**151**	**4.2**	**15**	**186**	**40.1**	**0**	**-**	**-**

Table 5. The number of young-of-the-year coho salmon marked by this project at each upper slough sampling site during the week of July 6 and the number recaptured and their percent composition (comp) of subsequent catches at each site in upper Freshwater Creek Slough July-September, 2003.

	Jul 6	Jul 13		Jul 20		Jul 27		Aug 3		Aug 10		Aug 17		Aug 24		Sep 7		Sep 21	
	#		%		%		%		%		%		%		%		%		%
Site	mark	#	comp	#	comp	#	comp	#	comp	#	comp	#	comp	#	comp	#	comp	#	comp
1	2	0	0	0	0	1	50	1	33	0	-	0	-	0	-	0	-	0	-
2	33	1	50	1	33	0	0	1	100	0	-	2	67	1	11	0	0	0	-
3	40	12*	52	8*	53	2	29	4**	80	3***	60	0	0	3**	60	1	25	0	0
4	46	7~	50	5	36	2	29	2	25	0	0	1	17	0	-	0	0	0	-
5	10	3	60	2	33	0	0	0	-	0	0	0	0	0	0	0	0	2	67
6	98	17	74	33***	53	19***	59	21~~	62	19	56	21	58	9	56	20	44	8	36
Tot	229	40	60	49	49	24	44	29	54	22	51	24	50	13	41	21	35	10***	37

* Includes one recaptured fish from sites 2 and 4
** Includes one recaptured fish from site 2
*** Includes one recaptured fish from site 4
~ Includes two fish recaptured from site 3
~~ Includes one fish recaptured from site 3

Table 6. Length of residence information for recaptured yearling coho salmon captured in upper and lower Freshwater Creek Slough, 2003. All coho salmon were originally marked throughout the Freshwater Creek basin by AFRAMP personnel.

Area recaptured	Mark week	Mark location	Recapture week	Weeks at liberty
Upper	5/12	South Fork	5/19	1
Upper	5/12	South Fork	5/19	1
Upper	5/19	Lower Mainstem	5/26	1
Upper	5/19	Lower Mainstem	5/26	1
Upper	5/19	Lower Mainstem	5/26	1
Upper	5/19	Lower Mainstem	5/26	1
Upper	5/26	Upper Mainstem	5/26	0
Upper	5/19	Lower Mainstem	6/02	2
Upper	6/02	Little Freshwater	6/09	1
Upper	5/19	Lower Mainstem	6/09	3
Upper	5/19	Little Freshwater	6/16	4
Lower	5/12	Lower Mainstem	5/19	1
Lower	5/12	Lower Mainstem	5/19	1

Lower Mainstem marked	n= 8	Mean weeks at liberty= 1	range= 1-3 weeks
Upper Total	n=11	Mean weeks at liberty= 1	range= 0-4 weeks
Lower Total	n= 2	Mean weeks at liberty= 1	range= 1-1 weeks
Combined	n=13	Mean weeks at liberty= 1	range= 0-4 weeks

Table 7. Length of residence information for recaptured young-of-the-year Chinook salmon captured in upper and lower Freshwater Creek Slough, 2003. All Chinook salmon were originally marked at the lower mainstem Freshwater Creek trapping site approximately 1 km upstream of our uppermost sampling site by AFRAMP personnel.

Area recaptured	Mark week	Recapture week	Weeks at liberty
Upper	5/26	6/02	1
Upper	5/26	6/02	1
Upper	5/19	6/02	2
Upper	6/02	6/09	1
Upper	5/26	6/16	3
Upper	5/19	6/16	4
Lower	5/19	6/09	3
Lower	5/19	6/09	3
Lower	6/02	6/09	1
Lower	5/12	7/07	8
Lower	6/02	7/14	6

Upper Total	n= 6	Mean weeks at liberty= 2	range= 1-4 weeks
Lower Total	n= 5	Mean weeks at liberty= 4	range= 1-8 weeks
Combined	n=11	Mean weeks at liberty= 3	range= 1-8 weeks

Table 8. Salinity (ppt), water temperature (^{o}C), and dissolved oxygen measurements (mg/l) taken near high tide at surface (Top) and bottom (Bot) elevations at selected lower Freshwater Creek Slough fish sampling sites, April through August 2003.

Salinity	April 16		May 15		June 19		July 7		Aug 19	
Location	Top	Bot	Top	Bot	Top	Bot	Top	Bot	Top	Bot
Hwy 101 Bridge	18.6	20.7	26.5	26.7	30.1	30.1	30.6	30.6	30.5	30.4
Pipe	0.2	0.2	11.6	12.8	25.0	26.7	27.2	27.8	27.9	28.5
Bend	0.1	0.1	0.6	0.6	17.4	19.6	21.0	21.7	21.4	23.3

Temperature	April 16		May 15		June 19		July 7		Aug 19	
Location	Top	Bot	Top	Bot	Top	Bot	Top	Bot	Top	Bot
Hwy 101 Bridge	12.4	12.5	14.3	14.0	15.8	15.5	15.5	15.4	18.8	18.7
Pipe	10.0	9.9	15.5	15.3	19.7	19.1	18.2	18.2	21.9	22.0
Bend	10.1	9.9	13.0	13.0	20.5	20.4	19.1	19.1	21.8	22.7

Dissolved Oxygen	April 16		May 15		June 19		July 7		Aug 19	
Location	Top	Bot	Top	Bot	Top	Bot	Top	Bot	Top	Bot
Hwy 101 Bridge	8.1	8.1	7.3	7.5	7.2	7.0	7.4	7.4	7.4	7.1
Pipe	9.6	9.7	8.2	8.0	6.6	6.4	6.9	7.1	7.1	6.4
Bend	9.4	9.7	8.4	8.8	6.8	6.3	6.0	6.4	7.8	6.2

DISCUSSION

During the 2003 field season, NSA captured yearling and yoy coho salmon, yoy Chinook salmon, and, to a lesser extent, juvenile steelhead and cutthroat trout. NSA also captured numerous other fish species (Appendix 8). Based on visual estimates of our catch species such as surfsmelt, *Hypomesus pretiosus*, topsmelt, *Atherinops affinis*, threespine stickleback, *Gasterosteus aculeatus*, and shiner surfperch, *Cymatogaster aggregate*, were much more numerous than salmonids in the lower slough, but in the upper slough salmonids and three spine stickleback were the most numerous fishes captured.

The pattern of juvenile salmonid use of Freshwater Creek Slough appears to be similar to patterns reported for other Pacific coast estuaries in that yoy Chinook salmon rear in estuarine habitat for extended times while yearling coho salmon move through the estuary relatively quickly (Healey 1991; Sandercock 1991; Thorpe 1994; Quinn 2005). However, the extended residence of yoy coho salmon in the tidal freshwater portion of the estuary is less typical. This life history trait has been reported in relatively few estuaries such as South Slough, Coos Bay, Oregon (Miller and Sadro 2003) and Carnation Creek British Columbia (Tschapliski[9] 1982). Nielsen (1994) observed subyearling coho salmon rearing in shifting freshwater habitat above the tidal prism of the estuaries of 10 Mendocino County streams in northern California. A few (usually <10) yoy coho have been observed in the Klamath River estuary (M. Wallace, CDFG, unpublished data), Redwood Creek estuary (David Anderson, National Park Service,

pers. comm.), and the Navarro River estuary (Steve Cannata, CDFG, pers. comm.). Small numbers of yoy coho salmon were observed during snorkel surveys throughout the summer in the Albion River estuary in 1996 (Maahs and Cannata[16] 1998).

NSA field crews were successful at capturing yearling and yoy coho salmon, yoy Chinook salmon, and, to a lesser extent juvenile steelhead and cutthroat trout. NSA crews captured wild yoy Chinook salmon from mid May until early August and their peak CPUE occurred in early June. Yoy Chinook salmon released by HFAC just upstream of the upper slough were present in our catches for about 3 weeks. Their peak catch occurred the first week after their release suggesting that most of these fish emigrated quickly through the estuary. Based on mark recapture data, yoy Chinook reared in the estuary for an average of 3 weeks, but individual fish reared for up to 8 weeks. Their residence time in the estuary may have been limited by the eventual warming of the water in the lower slough, which reached near lethal levels by late June and remained there throughout the summer forcing yoy Chinook salmon out of the slough and into Humboldt Bay during the mid to late summer. The size of the Chinook salmon captured by NSA staff in Freshwater Slough was somewhat smaller than reported from other estuaries (Healy 1991). There is no information on their use of Humboldt Bay and a study to determine if they rear and grow there before entering the ocean would be very useful. Starting in 2004 NSA plans to PIT tag yoy Chinook salmon $\geq$ 70 mm FL to determine their growth rate and movement in Freshwater Slough.

It appeared that yearling coho salmon passed relatively quickly (about 1 week) through the tidal portion of Freshwater Creek. This is similar to study results in other Pacific coast estuaries (Myers and Horton 1982; Healey 1991; Sandercock 1991). However, yearling coho salmon may have resided in the upper slough during the winter and early spring. Though field crews were not able to sample the upper slough from late March to mid May 2003 due to high stream flows, in 2005 NSA staff marked and recaptured a few coho that resided 2-3 months and grew 20-33 mm in the upper slough between January and May (CDFG unpublished data). The size of yearling coho salmon captured by NSA crews in Freshwater Slough was somewhat smaller than reported for natural yearling coho from the Klamath River estuary (Wallace[17] 2003) and other estuaries (Healy 1991). There is no information on their use of Humboldt Bay and a study to determine if they rear and grow there before entering the ocean would be very useful.

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[16] Maahs, M. and S. Cannata. 1998. The Albion River Estuary: Its history, water quality and use by salmonids, other fish and wildlife species. Prepared for the Humboldt County Resource Conservation District and the Coastal Land Trust. March 1998.

[17] Wallace, M. 2003. 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. Final Performance Report. Federal Aid in Sport Fish Restoration Act. Project Number F-51-R; Project No. 17; Jobs No. 1 and 2. 51 pp.

Young-of-the-year coho salmon used the tidal freshwater habitat in Freshwater Creek Slough extensively. They were present from April through September, primarily in the upper slough. They were also present in the lower slough during and shortly after spring freshets but were no longer captured when saltwater intruded upstream in the late spring and summer. Yoy coho salmon residing in the upper slough were larger than their cohorts residing upstream in Freshwater Creek. During the week of August 8, the average FL of yoy coho salmon captured by NSA crews in the upper slough was 68 mm FL and those captured by DFG's AFRAMP project upstream in Freshwater Creek was 56 mm. During the week of August 15, the average FL of coho salmon was 71 mm in the upper slough and 63 mm upstream in Freshwater Creek (Seth Ricker, DFG pers. comm.).

This project was not able to ascertain the fate of the yoy coho salmon rearing in the estuary. The abundance of project marked and unmarked yoy coho in the upper slough decreased towards late summer and early fall, but we could not determine whether this was due to mortality, emigration, or both. Data from elastomer-marked fish showed that, after mid July, yoy coho salmon moved very little while rearing in the upper slough, but NSA did not capture any elastomer marked fish the following spring. Estuary reared yoy coho salmon have been shown to both emigrate to the sea at the end of the summer (Tschaplinski et al. [9] 1982) or migrate upstream and over-winter before emigrating to the ocean the following spring (Miller and Sadro 2003). NSA and AFRAMP field crews did not capture any project marked coho salmon the following spring in either Freshwater Creek or the estuary (CDFG unpublished data), so I was unable to ascertain which life history strategy Freshwater Creek Slough yoy coho salmon utilized. However, in the late summer of 2003 (and subsequent years of sampling) NSA staff captured yoy coho salmon residing downstream of the HFAC weir site in areas of 15-30 ppt saltwater that were large (85-95 mm FL) and silvery like smolts and could conceivably be physiologically ready for the ocean. It may be that at the end of summer in Freshwater Creek Slough some yoy coho salmon migrate back upstream to over winter while those that are physiologically ready continue their seaward migration.

AFRAMP staff marked and released juvenile steelhead near the upper slough in the spring and early summer and subsequently recaptured a few of them the following winter and spring well upstream of where they were marked (Seth Ricker, CDFG pers. comm.). This data suggests that these fish did migrate back upstream to over-winter.

NSA's findings on yoy coho salmon in Freshwater Creek Slough are similar to those described by Miller and Sadro (2003) in South Slough, Coos Bay, Oregon. They observed that a portion of subyearling Age 0 coho entered the estuary in the spring and reared there over summer for up to 8 months. Another portion of subyearling coho salmon entered the estuary in winter and reared there about 2 months. The final group of coho salmon entered the following spring as Age 1 smolts and migrated through the estuary fairly quickly (about 2 weeks). They also noted that yoy coho that reared in the estuary were larger than those that did not. NSA plans to extend sampling to a year-

round basis to try and describe the appearance and use of the estuary during the winter by yoy coho salmon.

NSA crews captured yearling coho in various habitats throughout the slough. Most of the sampling effort (and coho catches) came from the main channel of the slough. However, NSA crews captured yearling coho salmon during qualitative sampling in tidal meanders and restored marshes adjacent to the main channel in the lower slough. This suggests that yearling coho do linger in the estuary and will use natural and restored marsh habitat when and if it is available to them. Also, field crews captured yoy coho salmon in the mitigation marsh in April when freshwater stream flows were relatively high, showing that they too will leave the mainstem slough when appropriate off channel habitat is available. The fact that they were not captured in the mitigation marsh after April or farther downstream in the tidal meanders strongly suggests that they require primarily freshwater habitat. The establishment of cool freshwater habitat at the mouths of small streams entering Freshwater Creek Slough (presently behind tide gates) could potentially increase the rearing area for yoy coho salmon in the estuary.

It appears that a significant portion of subyearling coho salmon in Freshwater Creek rear in the estuary for an extended period of time and those that rear there are larger than their cohorts rearing in the tributaries upstream. Larger size at ocean entry has been shown to increase marine survival of juvenile salmonids (Healey 1991: Sandercock 1991). Therefore, estuary rearing may infer an advantage to the coho salmon rearing there and they may survive and return to Freshwater Creek as adults at a higher rate than those that don't. NSA and AFRAMP will continue to mark juvenile coho salmon with PIT tags both upstream and in the estuary and to recover the tags from returning adults to confirm this hypothesis.

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.

Juvenile salmonid monitoring should be expanded to the tidal portions of other Humboldt Bay tributaries such as Elk River, Salmon Creek, and Jacoby Creek to determine if their salmonid populations show similar patterns of estuarine use.

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

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) potentially could increase the rearing area for yoy coho salmon in the estuary.

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 Slough 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 Freshwater Slough and exacerbated by the lack of tidal circulation within the levied slough. Therefore, management efforts to reduce water temperatures in Freshwater Slough and Freshwater Creek 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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Appendix 1. Catch-per-unit effort (fish/seine haul) of age 1+ coho salmon captured by sampling location in upper Freshwater Slough in 2003. Except where noted two seine hauls were conducted at each site.

Date	Bridge	Weir	Sidechannel	Bar 4	Bar 5	Top	Total	
							No.	CPUE
3/12	-	8.5	13.0*	4.0	-	-	38	7.60
5/14	1.5	3.0	2.5	4.0	3.5	3.5	36	3.00
5/21	0	0.5	1.5	3.5	8.5	8.0	44	3.67
5/28	1.0	3.5	4.0	1.5	4.0	8.0	44	3.67
6/02	0	1.0	1.0	1.5	0.5	1.5	10	0.83
6/09	0	0	0	0	1.5	1.0	5	0.42
6/16	0	0	0	0	0	0.5	2	0.17
6/23	0	1.0	0	0	0	0	2	0.17
7/03	0	0	0	0	0	0	0	0
7/10	0	0	0	0	0	0	0	0
7/15	0	0	0	0	0	0	0	0
7/24	0	0	0	0	0	0	0	0
7/28	0	0	0	0	0	0	0	0
8/07	0	0	0	0	0	0	0	0
8/15	0	0	0	0	0	0	0	0
8/21	0	0	0	0	0	0	0	0
8/26	0	0	0	0	0	0	0	0
Total	0.16	1.03	0.91	0.88	1.13	1.41	181	0.92

* one seine haul

Appendix 2. Catch-per-unit effort (fish/seine haul) of age 1+ coho salmon captured at each sampling site in lower Freshwater Slough in 2003. Except where noted one seine haul was conducted at each site.

		Hwy 101	**Trailer**	**Fay**		**Ryan**		**Total**	
Date	Mouth	Bridge	Park	Slough	Pipe	Slough	Bend	No.	CPUE
3/20	-	1	-	-	0	-	-	1	0.50
4/03	0	0	0	0	0	1	0	1	0.14
4/08	0	0	0	0	0	1	3	4	0.57
4/17	0	0	0	0	0	1	0	1	0.14
4/22	0	1	0	0	3	0	0	4	0.57
4/30	0	2	0	0	1*	-	-	4	0.67
5/05	0	0	1	0	3	0	0	4	0.57
5/15	0	0	0	8	10	0	17	35	5.00
5/20	3	24	6	1	3	2	0	39	5.57
5/29	0	2	1	0	2	8	3	16	2.29
6/03	1	2	0	2	0	0	0	5	0.71
6/12	0	0	0	0	7	0	0	7	1.00
6/19	1	0	0	0	2	0	2	5	0.71
6/26	0	0	1	0	0	0	0	1	0.14
7/03	0	1	0	0	0	0	0	1	0.14
7/09	0	0	0	0	0	0	0	0	0
7/15	0	0	0	0	0	0	0	0	0
7/22	0	0	0	0	0	0	0	0	0
7/29	0	0	0	0	0	0	0	0	0
8/05	0	0	0	0	0	0	0	0	0
8/14	0	0	0	0	0	0	0	0	0
8/19	0	0	0	0	0	0	0	0	0
8/26	0	0	0	0	0	0	0	0	0
Total	0.23	1.43	0.41	0.50	1.29	0.62	1.19	127	0.82

* 2 seine hauls

Appendix 3. Catch-per-unit effort (fish/seine haul) of young-of-the-year coho salmon captured by sampling site in upper Freshwater Slough in 2003. Two seine hauls were conducted at each site.

Date	Bridge	Weir	Sidechannel	Bar 4	Bar 5	Top	Total	
							No.	CPUE
3/12	-	0	0*	0	-	-	0	0
5/14	0.5	1.0	1.5	1.0	3.0	8.0	30	2.50
5/21	1.0	0	7.0	0.5	7.0	31.0	93	7.75
5/28	2.5	5.0	9.0	0	5.0	31.0	105	8.75
6/02	3.5	14.0	13.5	1.5	1.0	25.0	117	9.75
6/09	1.5	9.0	6.5	1.0	1.0	35.5	109	9.08
6/16	5.0	11.5	22.5	5.5	1.0	19.0	129	10.75
6/23	0.5	14.5	16.0	13.5	0.5	16.5	123	10.25
7/03	1.5	10.5	9.0	8.0	2.5	39.5	142	11.83
7/10	1.5	0	8.0	9.0	2.5	19.0	80	6.67
7/15	0	1.0	11.5	7.0	2.5	11.5	67	5.58
7/24	0	1.5	7.5	7.0	3.0	31.0	100	8.33
7/28	1.0	2.0	3.5	3.5	0.5	17.0	55	4.58
8/07	1.5	0.5	2.5	4.0	0	18.5	54	4.50
8/15	0	0	2.5	0.5	1.5	17.0	43	3.58
8/21	0	1.5	0.5	3.0	1.0	18.0	48	4.00
8/26	0	4.5	2.5	0	1.0	8.0	32	2.67
Total	1.25	4.50	7.48	3.82	2.06	21.59	1327	6.74

***** one seine haul

Appendix 4. Catch-per-unit effort (fish/seine haul) of wild young-of-the-year Chinook salmon captured by sampling location in upper Freshwater Slough in 2003. Two seine hauls were conducted at each site.

Date	Bridge	Weir	Sidechannel	Bar 4	Bar 5	Top	Total	
							No.	CPUE
3/12	-	0	0*	0	-	-	0	0
5/14	0.5	0.5	0	3.0	0.5	3.0	15	1.25
5/21	2.0	1.0	0	3.5	1.0	1.0	16	1.33
5/28	3.5	5.5	0.5	0.5	0	0	20	1.67
6/02	2.0	12.0	1.5	2.5	0	0	36	3.00
6/09	0	5.5	0.5	0	0	0	12	1.00
6/16	0	7.0	0	2.5	0	0	19	1.58
6/23	0	4.0	0	4.5	0	0	17	1.42
7/03	0	4.5	0.5	1.0	0	0.5	13	1.08
7/10	0	0.5	0.5	0	0	0.5	3	0.25
7/15	0	0	0	0	0	0	0	0
7/24	0	0.5	0	0.5	0	1.0	4	0.33
7/28	0	0	0	0	0	0.5	1	0.08
8/07	0	0.5	0	0	0	0	1	0.08
8/15	0	0	0	0	0	0	0	0
8/21	0	0	0	0	0	0	0	0
8/26	0	0	0	0	0	0	0	0
Total	0.50	2.44	0.21	1.06	0.09	0.35	157	0.80

***** one seine haul

Appendix 5. Catch-per-unit effort (fish/seine haul) of wild young-of-the-year Chinook salmon captured at each sampling location in lower Freshwater Slough in 2003. One seine haul was conducted at each site.

		Hwy 101	**Trailer**	**Fay**		**Ryan**		**Total**	
Date	Mouth	Bridge	Park	Slough	Pipe	Slough	Bend	No.	CPUE
3/20	-	0	-	-	0	-	-	0	0
4/03	0	0	0	0	0	2	1	3	0.43
4/08	0	0	0	0	0	0	3	3	0.43
4/17	0	0	0	0	1	0	0	1	0.14
4/22	0	0	0	0	2	2	0	4	0.57
4/30	0	2	0	0	1*	-	-	2	0.33
5/05	0	0	0	0	0	0	0	0	0
5/15	0	0	0	0	1	0	2	3	0.43
5/20	0	0	0	0	0	0	15	15	2.14
5/29	0	0	0	0	1	0	3	4	0.57
6/03	0	0	0	0	2	9	1	12	1.71
6/12	1	0	1	1	11	2	1	17	2.43
6/19	0	2	0	0	0	0	0	2	0.29
6/26	1	0	0	0	1	1	1	4	0.57
7/03	0	1	0	0	1	0	1	3	0.43
7/09	0	0	1	1	1	0	0	3	0.43
7/15	0	1	0	0	0	0	0	1	0.14
7/22	0	0	0	0	0	0	0	0	0
7/29	0	0	0	0	0	0	0	0	0
8/05	0	0	0	0	0	0	0	0	0
8/14	0	0	0	0	0	0	0	0	0
8/19	0	0	0	0	0	0	0	0	0
8/26	0	0	0	0	0	0	0	0	0
Total	0.09	0.17	0.09	0.09	0.96	0.73	1.33	77	0.50

* 2 seine hauls

Appendix 6. Catch-per-unit effort (fish/seine haul) of age 1+ steelhead and cutthroat trout captured by sampling location in upper Freshwater Slough in 2003. Field crews identified about 60% of the fish as steelhead trout but, due to the high potential of hybridization between the two species, I have presented their combined catch. Two seine hauls were conducted at each site.

Date	Bridge	Weir	Sidechannel	Bar 4	Bar 5	Top	Total	
							No.	CPUE
3/12	-	1.0	1.0*	0	-	-	3	0.60
5/14	0.5	0	1.5	1.5	0	0	7	0.58
5/21	0	0	0	0	0.5	0	1	0.08
5/28	0.5	0	2.0	0	0.5	0.5	7	0.58
6/02	0.5	0.5	0.5	0.5	0	0	4	0.33
6/09	0	0	0	0	0.5	0.5	2	0.17
6/16	0	0	1.5	0	0.5	0	4	0.33
6/23	0.5	0	1.5	0	1.0	0	6	0.50
7/03	0	0	0	1.0	2.5	0.5	8	0.67
7/10	0	0.5	0.5	1.0	1.5	0	7	0.58
7/15	0	2.5	0.5	0.5	1.0	0.5	10	0.83
7/24	0	0	0	0	1.5	0	3	0.25
7/28	0.5	0.5	0.5	1.0	0.5	0.5	7	0.58
8/07	0	0	0	0	1.5	0	3	0.25
8/15	0	0	0	0	0.5	0	1	0.08
8/21	0	0.5	0	0.5	1.5	0	5	0.42
8/26	0	2.0	0	0.5	1.5	0	8	0.67
Total	0.16	0.44	0.55	0.38	0.88	0.16	86	0.44

***** one seine haul

Appendix 7. Family, specific, and common names for all fish species collected in Freshwater Creek Slough from May-August, 2003.

Family	Species	Common name
Cottidae	*Leptocottus armatus*	Staghorn sculpin
	Cottus asper	Prickly sculpin
	Cottidae spp.	Unidentified sculpin
Atherinidae	*Atherinops affinis*	Topsmelt
Embiotocidae	*Damalichthys vacca*	Pile surfperch
	Cymatogaster aggregate	Shiner surfperch
	Embiotoca lateralis	Striped surfperch
	Hyperprosopon argenteun	Walleye surfperch
	Amphistichus koelzi	Calico surfperch
Osmeridae	*Hypomesus pretiosus*	Surfsmelt
	Spirinchus thaleichthys	Longfin smelt
Syngnathidae	*Sygnathus leptorhynchus*	Bay pipefish
Gasterosteidae	*Gasterosteus aculeatus*	Threespine stickleback
Clupiedae	*Clupea harengus*	Pacific herring
	Alosa sapidissima	American shad
Engraulididae	*Engraulis mordax*	Northern anchovy
Petromyzonidae	*Lampetra tridentate*	Pacific lamprey
	Lampetra richardsoni	Western brook lamprey
	Lampetra spp.	Unidentified ammocoete
Pholididae	*Pholis ornate*	Saddleback gunnel
Gobiidae	*Clevelandia ios*	Arrow goby
	Gillichthys mirabilis	Longjaw mudsucker
Pleuronectidae	*Platichthys stellatus*	Starry flounder
	Parophrys vetulus	English sole
Bothidae	*Citharichthys stigmaeus*	Speckled sanddab
Batrachoididae	*Porichthys notatus*	Plainfin midshipman

Family	Species	Common name
Gadidae	*Microgadus proximus*	Pacific tomcod
Poeciliidae	*Gambusia affinis*	Mosquitofish
Myliobatididae	*Myliobatis californica*	Bat ray
Carcharhinidae	*Triakis semifasciata*	Leopard shark