

Redwood

National Park

National Park Service
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2014 Redwood Creek Estuary Monitoring



Fish and Wildlife Branch
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Cover:(Summer/Fall 2014)

Top Left: Coho Smolt from Redwood Creek Estuary
 Top Right: Estuary Seining Crew
 Middle Left: Boat Access at Redwood Creek Estuary
 Middle Right: Pacific Herring
 Lower Right: Coastal Cutthroat Trout
 Lower Left: Coastal Cutthroat Trout Caudal Fin
 Bottom: Fish and Wildlife Branch Estuary Seining Crew

Back Cover

Top: Mouth of Redwood Creek Open to the Ocean, May 21, 2014
 Bottom: Redwood Creek Estuary – Pre-breach, Waves Propagating into Estuary, September 24, 2014

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Young-of-the-year (0+) coho salmon seined in the Redwood Cr Estuary, June 9, 2014.



Coastal Cutthroat Trout seined in the Redwood Creek Estuary, September 18, 2014

2014 Estuary Monitoring Summary

The Redwood Creek estuary was monitored in summer/fall/winter 2014. Four combined population and growth estimates were conducted the weeks of June 9, July 15, August 18, and September 15. Embayment water elevations were monitored from June 16 to November 6. A temperature logger recorded water temperature in the embayment every hour from June 12 through October 7. During the summer/fall of 2014 five salmonid species were seined in the Redwood Creek embayment; chinook, coho, and pink salmon, and steelhead and coastal cutthroat trout

- Estimated estuary juvenile chinook and steelhead populations were low at the beginning of June and decreased through the summer.
 - There was a 91% decrease in the chinook population between July and September, from 15,430 to 1,390.
 - Between June and September the steelhead population decreased 78%, from 12,430 to 2,750.
 - Coho were caught in June, an estimate of 970 smolts, and one only in July. None were captured the rest of the season.
 - A total of 44 cutthroat were caught during the 2014 season.
- Mean fork lengths and weights of chinook, steelhead, and cutthroat increased during the summer. Fish that remained in the estuary were larger than those that emigrated to the ocean prior to the July 8th closure.
 - Mean chinook fork length increased from 70 to 93 mm, an increase of 23 mm between the weeks of June 9 and September 15.
 - Mean coho fork length the week of June 9 was 112 mm and the one fish caught in July was 109 mm.
 - Mean steelhead fork length increased from 122 mm to 143 mm, an increase of 21 mm between the weeks of June 9 and September 15.
- Water temperatures in the embayment were warm. The maximum and minimum temperatures measured between June 9 and October 7 were 20.3°C and 12.3°C, respectively. The average water temperature for this period was 17.7°C.
 - July and August were the warmest months of the summer. Water temperature was equal to or greater than 18.0°C 76 percent of the time.
 - Diurnal water temperature differences were greater when the mouth was open accounting for the cooler ocean tidal influence and warmer upper river temperatures.
- The Redwood Creek estuary closed and breached twice. The estuary mouth first closed on June 28, breached on June 30, and closed again on July 8, breaching on September 24.
 - The estuary remained closed for a total of 79.8 days.
 - Average water elevation during the 78 day closure was 5.6 ft MSL.
 - The highest recorded water elevation in the estuary was 7.2 ft MSL, the lowest at a tidally influenced elevation of 1.2ft MSL.

2014 Redwood Creek Estuary Monitoring

Introduction

This report summarizes 2014 Redwood National Park Fish and Wildlife Branch biological and physical monitoring activities in the Redwood Creek estuary. Monitoring has occurred in the Redwood Creek estuary since 1980. The purpose of the estuary monitoring is to estimate fish population numbers and growth; record estuary water quality and water elevations; determine cross section changes; and document breaching incidents.

Location

Redwood Creek estuary is located 2.5 miles west of Orick, California at the confluence of Redwood Creek with the Pacific Ocean (Figure 1). Redwood Creek is 108 km long and the watershed is 720 km² in area. The U.S. Army Corps of Engineers completed construction of 3.4 miles of flood control levees in 1968 on lower Redwood Creek. The levees bisect and terminate in the estuary. The estuary consists of the north and south sloughs, and the embayment. The south slough was historically the last meander of Redwood Creek. It was cut off by the south levee. Gated culverts through the south levee now connect the slough and creek when the gates are open.

Methods

Fish Monitoring

Population Estimates - The Peterson mark and recapture method (Youngs and Robson 1978) was used to estimate numbers of juvenile salmonid fish in the Redwood Creek embayment. Fish were seined with a 150-foot long, 16-foot wide, quarter inch knotless mesh beach seine net deployed off the bow of a 16-foot boat powered by a 15 hp outboard motor. Seining occurred downstream of the south levee culverts in the embayment along the sand banks and berm and north and south levee rip rap. A blue mark was applied to the upper, middle, or lower caudal fin or anal fin of Alka-Seltzer Gold anesthetized fish using a Panjet needleless injector and Alcian Blue dye. Mark appearance ranged from a blue dot to a pigment streak along a fin ray. Fish were marked the first two days, allowed to mix the third day, and seined on the fourth day to determine the ratio of marked to unmarked fish. Population and 95 percent confidence interval (95% CI) estimates are rounded off to the nearest 10. Four population estimates were conducted, one each in June, July, August, and September during summer 2014.

Growth Estimates – Fish fork lengths were measured to the nearest 1 mm. Though not always possible, 200 fork lengths each of chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*O. mykiss*), and wet weight (g) from 30 juveniles of each species were measured. Two electronic balances were used, a 200 g $\pm$ 0.01g capacity balance for smaller fish, and a 5,000 g $\pm$ 2g capacity balance for larger fish. Fish weights were rounded off to the nearest 0.1g for the smaller capacity balance. Other salmonid species, coastal cutthroat trout (*O. clarki*) and coho salmon (*O. kisutch*), though not as numerous, were measured and weighed. Non-salmonids were also measured (total length). Four growth estimates were conducted in conjunction with the population estimates.



Figure 1. Redwood Creek Estuary, Humboldt County, California, including the embayment, north and south sloughs, levees, and south levee gated culverts (Google Earth June 6, 2013).

Condition Factor- Condition factor, a measure of fish ‘fatness’ was calculated for salmonid species measured and weighed. Because of the wide range of fish lengths, condition factor (K’) was calculated as: $K' = (100 \times \text{Weight}_{(g)}) / \text{Fork Length}_{(cm)}^b$ (Bagenal and Tesch 1978). Slope (b) was calculated as: $\log_{10} \text{Weight}_{(g)} = \log_{10} a + b \log_{10} \text{Fork Length}_{(cm)}$.

PIT Tagged Fish – Some fish trapped at the two California Department of Fish and Wildlife (CDFW) downstream migrant traps on mainstem Redwood Creek (River mile 4.2 and 33) and Humboldt State University USGS Cooperative Fish and Wildlife Unit (Fish Coop) coho studies in Prairie Creek and its tributaries are tagged with passive integrated transponders (PIT) tags. Each tag has an individual unique number and are implanted in the body cavity of the fish. During the processing of estuary seined fish, a PIT tag reader is used to scan every fish.

Physical Monitoring

Water Temperature - In summer/fall 2014, water temperature (°C) was measured hourly in the Redwood Creek embayment with an Onset TIDBIT temperature logger (S/N 10198976). It was located in the Redwood Creek channel beyond the ends of the north and south flood control levees (UTM 408773E 4571717N NAD83). The logger, anchored to a large cinder block, was suspended in the water column about one foot off the bottom.

Embayment Water Level Gaging – Estuaries are dynamic, with interactions between ocean, coastal, stream, and floodplain processes that influence estuary volume, the location of the creek mouth, opening and closing of the mouth, and flooding in the lower valley. Redwood Creek embayment water elevation, feet Mean Sea Level (ft MSL), was determined using a ventless U20 Onset water level data logger (SN 9673046) that recorded water depth every 15 minutes inside a perforated steel pipe driven into the channel thalweg near the end of the south levee (UTM 408795E 45711698 NAD83). The estuary data logger is a temporary gaging station installed when the creek mouth is open and retrieved after the estuary breaches and before large flow events can bury the pipe. A second water level data logger located 1.6 miles away at SOC, measured atmospheric barometric pressure for corrections to the water depth data. Conversion from water depth to water elevation feet MSL is done using surveyed water level elevations when the estuary cross sections are surveyed.

The embayment gage site at the end of the south levee measures lower embayment water elevations than in the south slough. The lowest water levels in the south slough are limited by the invert of the south slough culvert gates and sand deposited in the south slough outlet channel.

Tide, Ocean Waves, Stream Flow, and Precipitation – Tide at the mouth of Redwood Creek is determined using verified tide data downloaded from the Crescent City gage located in the harbor (<http://tidesandcurrents.noaa.gov/>) and corrected for the Redwood Creek ocean location (Hubbard, J.R., 1986). Hourly ocean wave height (ft) was determined using downloaded data from NOAA buoy 46027 located 8 nm NW of Crescent City (<http://www.wrh.noaa.gov/eka/marine/buoys.php>). Redwood Creek stream flow (cfs) for the calendar year was downloaded from the California Department of Water Resources (DWR) California Data Exchange Center (<http://cdec.water.ca.gov/queryTools.html>). The DWR/USGS operated Orick (ORK) station is located in lower Redwood Creek, 3.7 miles from the mouth of

Redwood Creek at the northern end of the town of Orick. A tipping bucket measures precipitation (inches) at the station.

Estuary Cross-sections - Five permanent cross-sections, E-1 through E-5, located in the estuary embayment perpendicular to the channel are surveyed during the summer. The five parallel cross-sections start between the ends of the levees with E-1 and end to the west with E-5 at the sea stack on the beach. Established in 1998, the cross-sections are shot with a Nikon Total Station and prism rod at a bearing of 170° from the north endpoints through the embayment to the back dunes to the south. The elevations are converted to feet MSL using a BLM reference monument located adjacent to the north levee at the park boundary.

2014 Results

Fish Monitoring

Sampling Dates – The Redwood Creek estuary embayment was sampled four weeks during the summer/fall of 2014 for population and growth estimates. Sample dates were; June 9, 10, and 12; July 15, 16, and 17; August 18, 19, and 21; and September 15, 16, and 18, 2014. For July, because of a work safety stand down on Monday July 14, the population estimate was completed in three consecutive days, instead of a Wednesday break, the normal procedure. A planned growth estimate for October was cancelled when the mouth breached in late September.

Seines and Fish Handled - The total number of estuary seine hauls in 2014 was 70. The numbers of salmonid fish processed during estuary monitoring were 2,838 juvenile chinook (9 incidental mortalities, 0.32%), 1,942 steelhead (1 incidental mortality, 0.05%), 137 coho smolts (0 mortality), one pink salmon (0 mortality), and 46 coastal cutthroat (0 mortality) for a total of 4,964 fish and 10 incidental mortalities (0.20%). Authorization for handling threatened fish was under Redwood National Park's 4(d) NOAA/CDFW permit #18504, CDFW Scientific Collecting Permit #SC-10028, and CDFW CESA MOU for coho salmon.

Fish Presence – During the summer/fall of 2014 five salmonid species were seined in the Redwood Creek embayment; chinook, coho, and pink salmon (*O. gorbuscha*), and steelhead and coastal cutthroat trout (Table 1). Juvenile chinook and steelhead were present on all sample dates between June 9 and September 18. Pink salmon, one, was captured on June 9. Cutthroat were captured on the July, August, September sample dates. Coho salmon were captured on all three days in June and one on July 16. The pink salmon juvenile was the first occurrence in the Redwood Creek estuary (Figure 2), though CDFW has caught them in the past at their downstream migrant traps and three were caught at the lower trap in 2014 (Sparkman, et al. 2015a).

In addition to the juvenile salmonids and adult cutthroat captured, seven additional fish species were captured; Staghorn Sculpin (*Leptocottus armatus*), Prickly Sculpin (*Cottus asper*), Threespine Stickleback (*Gasterosteus aculeatus*), Sacramento Sucker (*Catostomus occidentalis*), Starry Flounder (*Platichthys sellatus*), Surfsmelt (*Hypomesus pretiosus*), and Pacific Herring (*Clupea pallasii*). The latter two, marine species, was due to the mouth of the creek being open to the ocean and tidal action into the estuary.

Table 1. List of salmonid and non-salmonid fish seined, birds, amphibians, mammals, invertebrates, and algae observed at and adjacent to the Redwood Creek estuary, Redwood National Park, Humboldt County, California during the Summer/Fall 2014 fish sampling (shading denotes presence).

Species		2014 Date			
Common Name	Scientific Name	June 9 ^a	July 15 ^a	August 18 ^a	September 15 ^a
Salmonid Fish					
Chinook Salmon *	<i>Oncorhynchus tshawytscha</i>				
Coastal Cutthroat Trout	<i>Oncorhynchus clarki</i>				
Coho Salmon *	<i>Oncorhynchus kisutch</i>				
Steelhead Trout *	<i>Oncorhynchus mykiss</i>				
Pink Salmon	<i>Oncorhynchus gorbuscha</i>				
Other Fish					
Pacific Herring	<i>Clupea pallasii</i>				
Prickly Sculpin	<i>Cottus asper</i>				
Sacramento Sucker	<i>Catostomus occidentalis</i>				
Staghorn Sculpin	<i>Leptocottus armatus</i>				
Starry Flounder	<i>Platichthys stellatus</i>				
Surf Smelt	<i>Hypomesus pretiosus</i>				
Three Spine Stickleback	<i>Gasterosteus aculeatus</i>				
Amphibians					
Red-legged Frog	<i>Rana aurora</i>				
Birds					
American Crow	<i>Corvus brachyrhynchos</i>				
American Goldfinch	<i>Carduelis tristis</i>				
American Kestrel	<i>Falco sparverius</i>				
American Pipit	<i>Anthus rubescens</i>				
Anna's Hummingbird	<i>Calypte anna</i>				
Bald Eagle	<i>Haliaeetus leucocephalus</i>				
Band-tailed Pigeon	<i>Patagioenas fasciata</i>				
Barn Swallow	<i>Hirundo rustica</i>				
Belted Kingfisher	<i>Ceryle alcyon</i>				
Black Oystercatcher	<i>Haematopus bachmani</i>				
Black Phoebe	<i>Sayornis nigricans</i>				
Black Turnstone	<i>Arenaria melanocephala</i>				
Black-capped Chickadee	<i>Poecile atricapillus</i>				
Brown Pelican	<i>Pelecanus occidentalis</i>				
Brown-headed Cowbird	<i>Molothrus ater</i>				
California Gull	<i>Larus californicus</i>				
Canada Goose	<i>Branta canadensis</i>				
Caspian Tern	<i>Sterna caspia</i>				
Cedar Waxwing	<i>Bombicilla cedrorum</i>				
Chestnut-backed Chickadee	<i>Poecile rufescens</i>				
Cliff Swallow	<i>Petrochelidon pyrrhonota</i>				
Common Merganser	<i>Mergus merganser</i>				
Common Raven	<i>Corvus corax</i>				
Common Yellowthroat	<i>Geothlypis trichas</i>				
Cooper's Hawk	<i>Accipiter cooperii</i>				

Species		2014 Date			
Common Name	Scientific Name	June 9 ^a	July 15 ^a	August 18 ^a	September 15 ^a
Double-crested Cormorant	<i>Phalacrocorax auritus</i>				
Elegant Tern	<i>Sterna elegans</i>				
European Starling	<i>Sturnus vulgaris</i>				
Golden-crowned Kinglet	<i>Regulus satrapa</i>				
Great Blue Heron	<i>Ardea herodias</i>				
Great Egret	<i>Ardea alba</i>				
Greater Yellowlegs	<i>Tringa melanoleuca</i>				
Heermann's Gull	<i>Larus heermanni</i>				
Killdeer	<i>Charadrius vociferus</i>				
Least Sandpiper	<i>Calidris minutilla</i>				
Long-billed Curlew	<i>Numenius americanus</i>				
Northern Flicker	<i>Colaptes auratus</i>				
Northern Harrier	<i>Circus cyaneus</i>				
Northern Pintail	<i>Anas acuta</i>				
Northern Rough-winged Swallow	<i>Stelgidopteryx serripennis</i>				
Orange-crowned Warbler	<i>Vermivora celata</i>				
Osprey	<i>Pandion haliaetus</i>				
Pelagic Cormorant	<i>Phalacrocorax pelagicus</i>				
Peregrine Falcon	<i>Falco peregrinus</i>				
Purple Finch	<i>Carpodacus purpureus</i>				
Red Crossbill	<i>Loxia curvirostra</i>				
Red-shouldered Hawk	<i>Buteo lineatus</i>				
Red-tailed Hawk	<i>Buteo jamaicensis</i>				
Red-throated Loon	<i>Gavia stellata</i>				
Red-winged Blackbird	<i>Agelaius phoeniceus</i>				
Song Sparrow	<i>Melospiza melodia</i>				
Steller's Jay	<i>Cyanocitta stelleri</i>				
Swainson's Thrush	<i>Catharus ustulatus</i>				
Tree Swallow	<i>Tachycineta bicolor</i>				
Turkey Vulture	<i>Cathartes aura</i>				
Unidentified Duck	Anatinae sp.				
Unidentified Gull	<i>Larus sp</i>				
Unident. Hummingbird	<i>Trochilidae sp.</i>				
Unidentified Loon	<i>Gavia sp.</i>				
Unidentified Sandpiper	Scolopacidae				
Unidentified Sparrow	Passeridae				
Unidentified Swallow	<i>Hirundidae sp</i>				
Unidentified Yellowleg	Scolopacidae				
Vaux's Swift	<i>Chaetura vauxi</i>				
Violet-green Swallow	<i>Tachycineta thalassina</i>				
Western Gull	<i>Larus occidentalis</i>				
Western Sandpiper	<i>Calidris mauri</i>				
Western Tanager	<i>Piranga ludoviciana</i>				
Whimbrel	<i>Numenius phaeopus</i>				
White-crowned Sparrow	<i>Zonotrichia leucophrys</i>				

Species		2014 Date			
Common Name	Scientific Name	June 9 ^a	July 15 ^a	August 18 ^a	September 15 ^a
Wilson's Warbler	<i>Wilsonia pusilla</i>				
Wrentit	<i>Chamaea fasciata</i>				
Mammals					
River Otter	<i>Lontra canadensis</i>				
Invertebrates					
Amphipod	<i>Corophium sp.</i>				
Scud	<i>Gammarus</i>				
Caddisfly (larvae)	<i>Limnephilidae</i>				
Isopod	<i>Gnorimosphaeroma sp.</i>				
Damselfly (nymph)	<i>Zygoptera</i>				
Mysid Shrimp	<i>Neomysis mercedes</i>				
New Zealand Mud Snail	<i>Potamopyrgus antipodarum</i>				
Water Boatman	<i>Corixidae</i>				
Algae					
Sea Lettuce	<i>Ulva sp.</i>				
Green Algae	<i>Unidentified filamentous species</i>				
^a = the week of * = Federally listed as Threatened					



Figure 2. Pink Salmon juvenile seined in Redwood Creek Estuary on June 9, 2014. Blue mark on top caudal fin is a PanJet applied fin mark (RNP).

Of the fish captured, chinook (California Coastal Chinook Salmon ESU), coho (Southern Oregon/Northern California Coast Coho ESU), and steelhead (Northern California Steelhead DPS) are federally listed as threatened. No endangered tidewater gobies (*Eucyclogobius newberryi*) were captured during estuary seining in 2014. They are no longer present.

Other Species - Other non-fish species were caught: *Corophium*, *Gnorimosphaeroma*, Gammarus amphipods, Mysid shrimp, invasive New Zealand Mud Snails (*Potamopyrgus antipodarum*), Damselfly nymphs, Corixidae water boatman, Limniphilid stonecase caddisfly nymphs, and Red-legged frogs.

In addition, 64 bird species were identified in and adjacent to the Redwood Creek estuary. Several of those are fish predators including Bald Eagle, Belted Kingfisher, Brown Pelican, Caspian Tern, Common Merganser, Double-crested Cormorant, Elegant Tern, Great Blue Heron, Great Egret, Osprey, and Pelagic Cormorant. Groups of mergansers were commonly seen working together to catch fish. River otters were also observed.

Population Estimates - Low numbers of salmonids were estimated in the estuary for 2014. Four population estimates were conducted during the weeks of June 9, July 19, August 18, and September 15 (Table 2). The mouth was open during the first June population estimate and closed during the July, August, and September estimates. The number of fish marked, marked recaptures, total individuals captured in the 'second sample', number of seines, and fins marked are presented in Appendix I.

Chinook Salmon - The first juvenile chinook salmon estimate, the week of June 9 was 15,110 (95% Confidence Interval [CI] 10,030 to 20,180). The estimate for the week of July 15 was 15,430 (95% CI 8,360 to 22,510). For the week of August 18, the estimate was much lower, 850 (95% CI 189 to 1,530). The week of September 15 population estimate was 1,390 (95% CI 350 to 2,430). There was a 91% decrease in population between July and September.

Coho Salmon - The week of June 9 population estimate was 970 (95% CI 132 [actually caught] to 1,860). No estimate for the week of July 15 was possible as only one coho salmon was seined. None were captured the rest of the season.

Pink Salmon - Only one pink salmon was caught, on June 9.

Steelhead Trout - The first estimate, the week of June 9 was 12,430 (95% CI 341 [actually caught] to 29,420). The estimate for the week of July 15 decreased to 6,800 (95% CI 3,520 to 10,080). For the week of August 18, the estimate was even lower, 2,740 (95% CI 1,940 to 3,550). The week of September 15 population estimate was 2,750 (95% CI 1,060 to 4,430). Between June and September the population decreased 78%.

Coastal Cutthroat Trout - No coastal cutthroat trout were captured during the week of June 9. In each of the following three estimates, no marked fish were recaptured. Sixteen, 11, and 17 cutthroat were seined in July, August, and September, respectively. A total of 44 cutthroat were caught during the 2014 season.

Table 2. Population estimates and 95 percent confidence intervals for juvenile chinook, coho, and pink salmon, juvenile steelhead trout, and coastal cutthroat trout seined in the Redwood Creek estuary embayment, Humboldt County, California, Summer/Fall 2014. Mouth of creek denotes if Redwood Creek mouth was open or closed to the Pacific Ocean during the estimate.

2014 DATE	Mouth of Creek (Open or Closed)	Chinook Salmon		Coho Salmon	
		Population Estimate	95% Confidence Interval	Population Estimate	95% Confidence Interval
6/ 9, 10, 12	OPEN	15, 110	$\pm 5,080$ (10,030 – 20,180)	970	± 890 (132 ^b – 1,860)
7/15, 16, 17	CLOSED	15,430	$\pm 7,080$ (8,360 – 22,510)	1 ^a	---
8/ 18, 19, 21	CLOSED	850	± 670 (180 – 1,530)	None caught	---
9/15, 16, 18	CLOSED	1,390	$\pm 1,040$ (350 – 2,430)	None caught	---
		Steelhead Trout		Cutthroat Trout	
6/ 9, 10, 12	OPEN	12,430	$\pm 16,990$ (341 ^b – 29,420)	None caught	---
7/15, 16, 17	CLOSED	6,800	$\pm 3,280$ (3,520 – 10,080)	16 ^a	---
8/ 18, 19, 21	CLOSED	2,740	± 810 (1,940 – 3,550)	11 ^a	---
9/15, 16, 18	CLOSED	2,750	$\pm 1,690$ (1,060 – 4,430)	17 ^a	---
		Pink Salmon			
06/ 9, 10, 12	OPEN	1 ^a	---		
a. No marked fish were recaptured. Actual number of fish captured in seine net hauls b. Actual minimum count, calculated 95% lower confidence interval was below what was actually caught					

Growth Estimates – Four growth estimates were conducted in conjunction with the four population estimates during the weeks of June 9, July 15, August 18 and September 15 (Table 3). The absence of fish made it difficult to attain the 200 length measurements for chinook in August and September.

Chinook Salmon – A total of 776 juvenile chinook salmon were measured. Mean fork length increased from 70 to 93 mm, a 23 mm increase between the weeks of June 9 and September 15 (Table 3 and Figure 3). The smallest fish were measured in June at 50 mm. The largest fish measured was 110 mm in September. The minimum and maximum fork lengths measured the week of June 9 were 50 and 94 mm, respectively; 61 and 100 mm for the week of July 15; 66 and 99 mm for the week of August 18; and 73 and 110 mm for the week of September 15.

Of a total of 129 chinook weighed, mean weight increased from 4.1 g to 8.5 g between the weeks of June 9 and September 15, an increase of 4.4 g. During the sample period the minimum and maximum chinook weights were 1.4 g and 13.0 g, respectively.

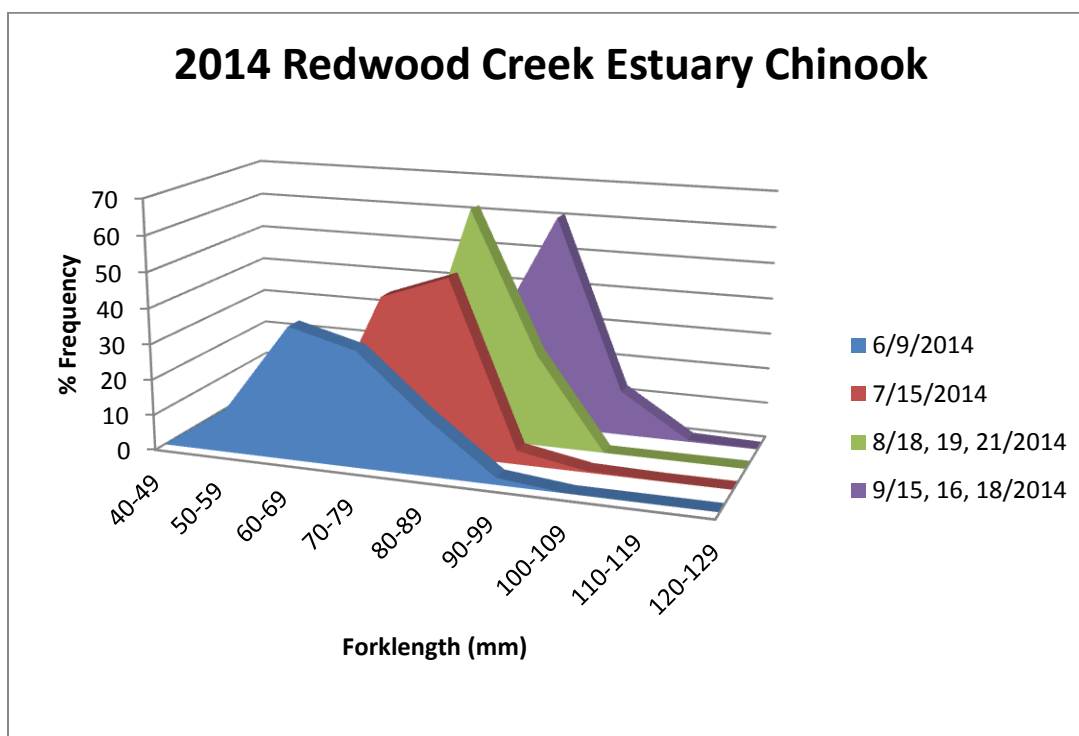


Figure 3. Fork length (mm) versus frequency (%) histogram of Redwood Creek estuary juvenile chinook sampled June 6 through September 18, 2014. The fork length intervals were 10-mm increments.

Coho Salmon - Of the 133 juvenile coho measured, fork lengths ranged from 50 to 153 mm. This shows at least two age classes were present, 0+ and 1+ (Figure 4). The 0+ fish comprised only 2.3 % of coho captured in the estuary. Mean fork length the week of June 9 was 112 mm and the one fish caught on July 16 was 109 mm. Mean weight in June was 16.2 g and the one fish caught in July was 13.8 g. Coho weight ranged from 1.3 g to 38.0 g.

Table 3. Mean fork length (mm), mean weight (g), standard deviation, range, dates, and numbers sampled of juvenile chinook, coho, and pink salmon, and steelhead and coastal cutthroat trout seined in the Redwood Creek estuary embayment, Humboldt County, California, during Summer/Fall of 2014 from June 9 to September 18. Mouth denotes if Redwood Creek mouth was open or closed to the ocean.

Growth - Redwood Creek Estuary – Summer/Fall 2014									
2014 DATE	MOUTH	FORK LENGTH (mm)				WEIGHT (g)			
		No. Measured	Mean	Std. Dev	Range	No. Weighed	Mean	Std. Dev.	Range
JUVENILE CHINOOK SALMON									
6/ 09	OPEN	204	70	9.4	50 - 94	38	4.1	1.5	1.4 – 7.1
7/15	CLOSED	235	80	6.0	61 – 100	31	5.5	1.4	3.7 – 9.9
8/18, 19, 21	CLOSED	155	86	5.4	66 – 99	30	6.1	1.0	3.1 – 8.1
9/15, 16, 18	CLOSED	182	93	6.2	73 – 110	30	8.5	1.6	5.7 – 13.0
JUVENILE COHO SALMON									
6/09, 10, 12	OPEN	132	112	13.5	50 - 153	132	16.2	5.1	1.3 – 38.0
7/16	CLOSED	1	109	---	---	1	13.8	---	---
8/18, 19, 21	CLOSED	None caught	---	----	----	----	----	----	---
9/15, 16, 18	CLOSED	None caught	---	----	----	----	----	----	---
JUVENILE PINK SALMON									
6/09	OPEN	1	64	---	---	---	---	---	---
JUVENILE STEELHEAD TROUT									
6/09, 10, 12	OPEN	213	122	17.4	55 – 174	33	19.1	8.8	1.2 – 47.0
7/15, 16, 17	CLOSED	212	124	32.2	52 – 250	36	24.6	12.9	2.5 – 51.8
8/18, 19, 21	CLOSED	208	140	26.4	60 – 198	33	32.0	21.2	2.7 – 74.2
9/15, 16	CLOSED	206	143	29.8	57 – 216	29	32.6	18.4	4.6 – 76.3
CUTTHROAT TROUT									
6/09, 10, 12	OPEN	None caught	---	----	----	----	----	----	---
7/15, 16, 17	CLOSED	16	283	46.3	196 – 349	13	256.2	124.8	78.5 - 510
8/18, 19, 21	CLOSED	11	258	44.1	220 - 354	11	195.4	130.7	88.3 - 498
9/15, 16, 18	CLOSED	17	289	61.1	139 - 380	17	321.5	181.7	126 - 672

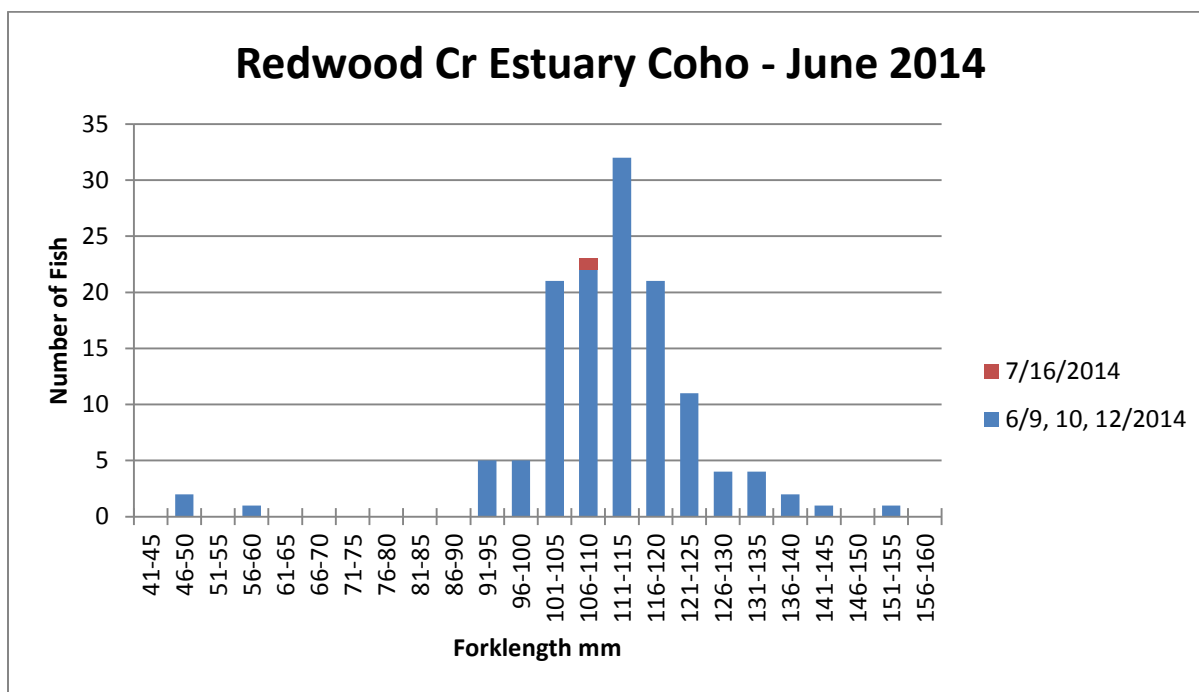


Figure 4. Fork length (mm) histogram of Redwood Creek estuary juvenile coho salmon sampled June 9, 10, 12, 2014 and July 16, 2014. The fork length intervals were 5-mm increments.

Pink Salmon – The one pink salmon caught on June 9 was 64 mm long.

Steelhead Trout - A total of 839 juvenile steelhead were measured. Mean fork length increased from 122 mm to 143 mm, a 21 mm increase between the weeks of June 9 and September 15 (Table 3). For the season, the smallest fish measured was 52 mm, the largest 250 mm. Several age classes were present but few young-of-the-year fish were captured (Figure 5). Mean juvenile weight increased from 19.1 g to 32.6 g, a 13.5 g increase between the weeks of June 9 and September 15. The minimum and maximum weight measured during the sample season was 1.2 g and 76.3 g, respectively.

Cutthroat Trout - A total of 44 coastal cutthroat trout were captured. Mean fork length was similar from July to September, ranging from 258 mm to 289 mm. The smallest cutthroat measured was 139 mm, the largest 380 mm. Several age classes were present (Figure 6). Mean weight was 256.2 g in July, 195.4g in August, and 181.7 g in September. Weight ranged between 78.5 and 672 g (1.5 lb.).

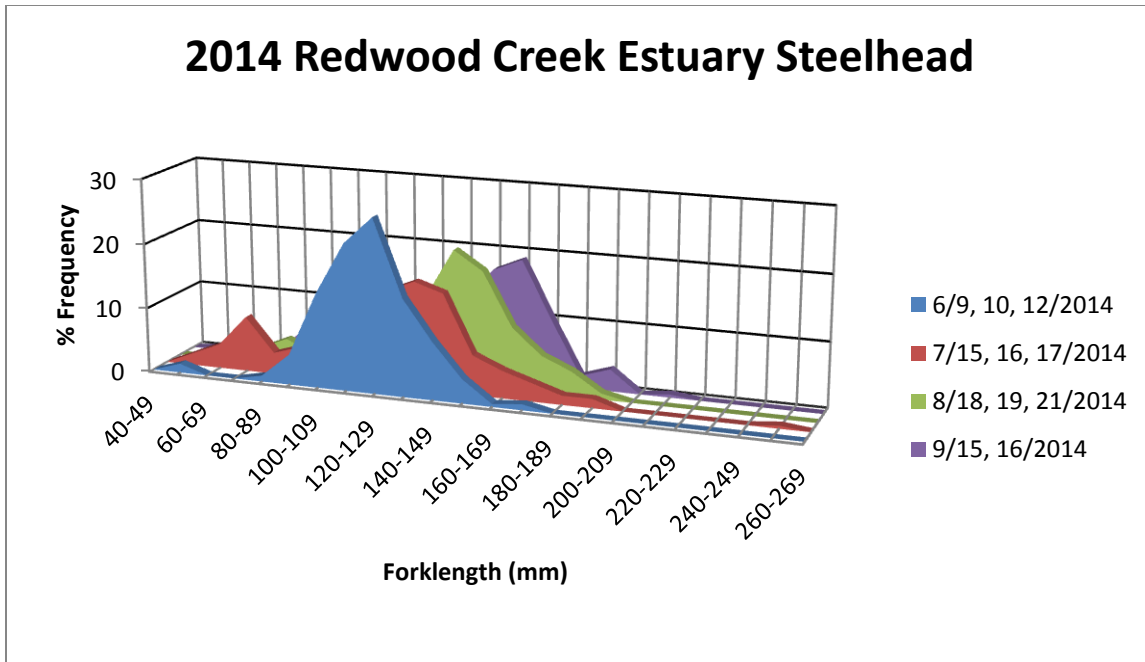


Figure 5. Fork length (mm) versus frequency (%) histogram of Redwood Creek estuary juvenile steelhead trout sampled June 9 through September 16, 2014. The fork length intervals were 10-mm increments. Several age classes are present.

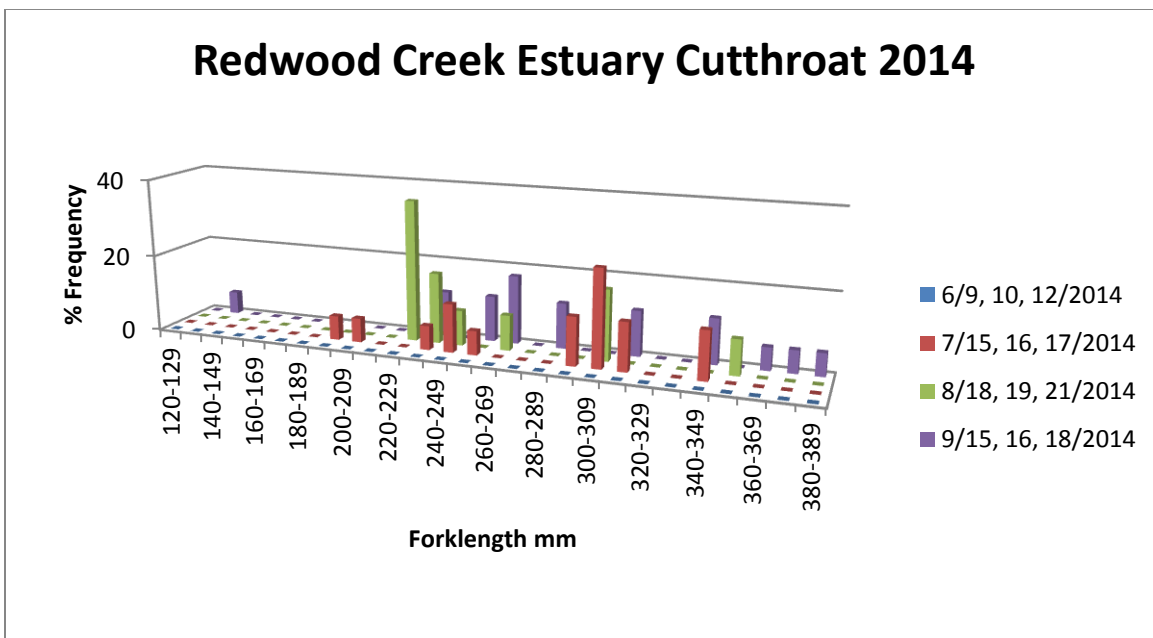


Figure 6. Fork length (mm) versus frequency (%) histogram of Redwood Creek estuary coastal cutthroat trout sampled June 9 through September 18, 2014. The fork length intervals were 10-mm increments.

Condition Factor (K') – Fish condition factors are presented in Table 4. Species mean condition factors of each date remained approximately the same throughout the season. Mean chinook K' for the four sample dates ranged from 0.8668 to 0.8939, but individual K' ranged between 0.5012 and 1.0733. The seasonal mean for all chinook was 0.8847. The seasonal mean for all 130 coho was 1.4985. Mean steelhead K' for sample dates ranged from 1.1173 to 1.2723, but individual K' ranged between 0.6204 and 4.2098. The seasonal mean for all steelhead was 1.1790. Mean cutthroat K' for the sample dates ranged from 3.8256 to 5.3333, but individual K' ranged between 2.6473 and 17.5583. The seasonal mean for all cutthroat was 4.6498.

PIT Tagged Fish – In 2014, 11 CDFW PIT tagged fish, one chinook, 8 steelhead, and two cutthroat were detected among the 4,964 estuary fish processed (Table 5). Nine fish had been tagged at the upper Redwood Creek trap (rm 33) and one at the Prairie Creek trap in 2014, and one cutthroat tagged at the lower Redwood Creek trap in July of 2013. Of the 11, five fish, one cutthroat and four steelhead were recaptured again in the estuary.

Comparing steelhead daily growth rates for riverine+estuary growth (first estuary capture) versus estuary growth only (second estuary capture), mean mm/day was larger for estuary growth only, 0.56 versus 0.47 mm/day. The same was true for weight, mean estuary growth/day at 0.44 g/day versus 0.26 g/day for riverine+estuarine growth.

Table 4. Mean condition factor (K'), sample size, standard deviation, minimum and maximum values of captured salmonids measured (fork length cm) and weighed (g) from the Redwood Creek embayment, Humboldt County, California, during the Summer and Fall of 2014. Condition factor is calculated as: $K' = 100W_{(g)} / FKL_{(cm)}^b$. Slope (b) was calculated as: $\log_{10} \text{Weight}_{(g)} = \log_{10} a + b \log_{10} \text{Fork Length}_{(cm)}$.

Condition Factor (K') - Redwood Creek Estuary 2014					
Date (week of)	6/9/2014	7/15/2014	8/18,19/2014	9/15,16/2014	Summer/ Fall 2014
Chinook Salmon (b = 3.0870)					
Mean	0.8848	0.8668	0.8938	0.8939	0.8847
Standard Deviation	0.0860	0.0531	0.0691	0.0425	0.0664
Minimum	0.5012	0.7710	0.7408	0.7505	0.5012
Maximum	1.0563	1.0153	1.0722	0.9851	1.0722
Count	38	31	30	30	129
Coho Salmon (b = 2.8797)					
Mean	1.4991	1.4204			1.4985
Standard Deviation	0.1234	---			0.1231
Minimum	1.2085	1.4204			1.2085
Maximum	2.1256	1.4204			2.1256
Count	129	1	0	0	130
Steelhead Trout (b = 2.9864)					
Mean	1.1675	1.1537	1.2723	1.1173	1.1790
Standard Deviation	0.1140	0.0868	0.5513	0.1179	0.2938
Minimum	0.7382	1.0193	1.0410	0.6204	0.6204
Maximum	1.3908	1.3378	4.2098	1.2627	4.2098
Count	33	36	33	29	131
Cutthroat Trout (b = 2.5893)					
Mean		4.4532	3.8256	5.3333	4.6498
Standard Deviation		0.5169	0.7451	3.2133	2.1787
Minimum		3.5383	2.6473	3.7533	2.6473
Maximum		5.3169	4.8569	17.5583	17.5583
Count	0	13	11	17	41

Table 5. CDFW PIT tagged fish captured in the Redwood Creek estuary during Summer 2014.

2014 REDWOOD CREEK ESTUARY RECOVERED PIT TAG FISH																			
FISH ID	PIT TAG#	Estuary Date Recaptured	FKL (mm)	WT (g)	Recaptured in Estuary	CDFW Date tagged/released	Where Tagged	FKL (mm) Initial	Wt (g) Initial	No. of days	Increase FKL (mm)	River + Estuary FKL mm/day	Increase Wt (g)	River + Estuary g/day	Estuary no. of days	Increase FKL (mm)	Estuary FKL mm/day	Increase Wt (g)	Estuary Wt g/day
CUT	5225783	7/17/2014	307	NA	NO	4/20/2014	Prairie Cr trap	272	192.1	88	35	0.40	na	na					
CUT	53385052	8/21/2014	244	170.0		7/8/2013	lower trap rm 4	139	31.9	409	105	0.26	138.10	0.34	25	15.0	0.60	16.00	0.64
CUT	53385052	9/15/2014	259	186.0	YES														
KS	5719370	7/15/2014	79	4.9	NO	6/9/2014	upper trap rm 33	67	3.0	36	12	0.33	1.90	0.05					
SHD	5909192	6/9/2014	114	17.2		5/6/2014	upper trap rm 33	93	8.5	34	21	0.62	8.70	0.26	37	16.0	0.43	9.80	0.26
SHD	5909192	7/16/2014	130	27.0	YES														
SHD	5737938	6/10/2014	113	15.8	NO	5/20/2014	upper trap rm 33	110	13.5	21	3	0.14	2.30	0.11					
SHD	5747423	6/12/2014	136	30.4		5/11/2014	upper trap rm 33	114	16.2	32	22	0.69	14.20	0.44	34	25.0	0.74	21.40	0.63
SHD	5747423	7/16/2014	161	51.8	YES														
SHD	5259718	7/16/2014	134	29.0		4/27/2014	upper trap rm 33	90	9.1	80	44	0.55	19.90	0.25	1	-1.0	-1.00	0.60	0.60
SHD	5259718	7/17/2014	133	29.6	YES														
SHD	5288565	7/16/2014	161	45.5	NO	5/1/2014	upper trap rm 33	117	15.5	76	44	0.58	30.00	0.39					
SHD	5749683	7/16/2014	118	17.7		5/27/2014	upper trap rm 33	103	11.9	50	15	0.30	5.80	0.12	34	17.0	0.50	9.50	0.28
SHD	5749683	8/19/2014	135	27.2	YES														
SHD	5243973	8/21/2014	159	44.7	NO	4/24/2014	upper trap rm 33	103	10.9	119	56	0.47	33.80	0.28					
SHD	5268053	8/21/2014	137	30.5	NO	4/11/2014	upper trap rm 33	79	5.2	132	58	0.44	25.30	0.19					

KS= Chinook Salmon, SHD = Steelhead Trout, and CUT = Coastal Cutthroat Trout

Physical Monitoring

Water Temperature - In summer/fall 2014, water temperature (°C) was measured hourly in the Redwood Creek embayment from June 12 through October 7, 2014 (Figure 7). Similar to other years, placement of the probe was delayed from the recommended June 1st date because the Redwood Creek mouth was open. It was feared the probe would be stolen when visible at low water levels. The maximum and minimum temperatures measured between June 9 and October 7 were 20.3°C (8/31 at 17:00) and 12.3°C (6/13 at 2:00), respectively. The average water temperature for this period was 17.7°C.

The maximum and minimum water temperatures from July 1 to August 31, the warmest period of the summer, were 20.3 °C and 15.7°C, respectively. The average water temperature for that period was 18.4°C. Maximum weekly average temperature (MWAT) was 18.9°C, and maximum weekly maximum temperature (MWMT) was 19.5°C.

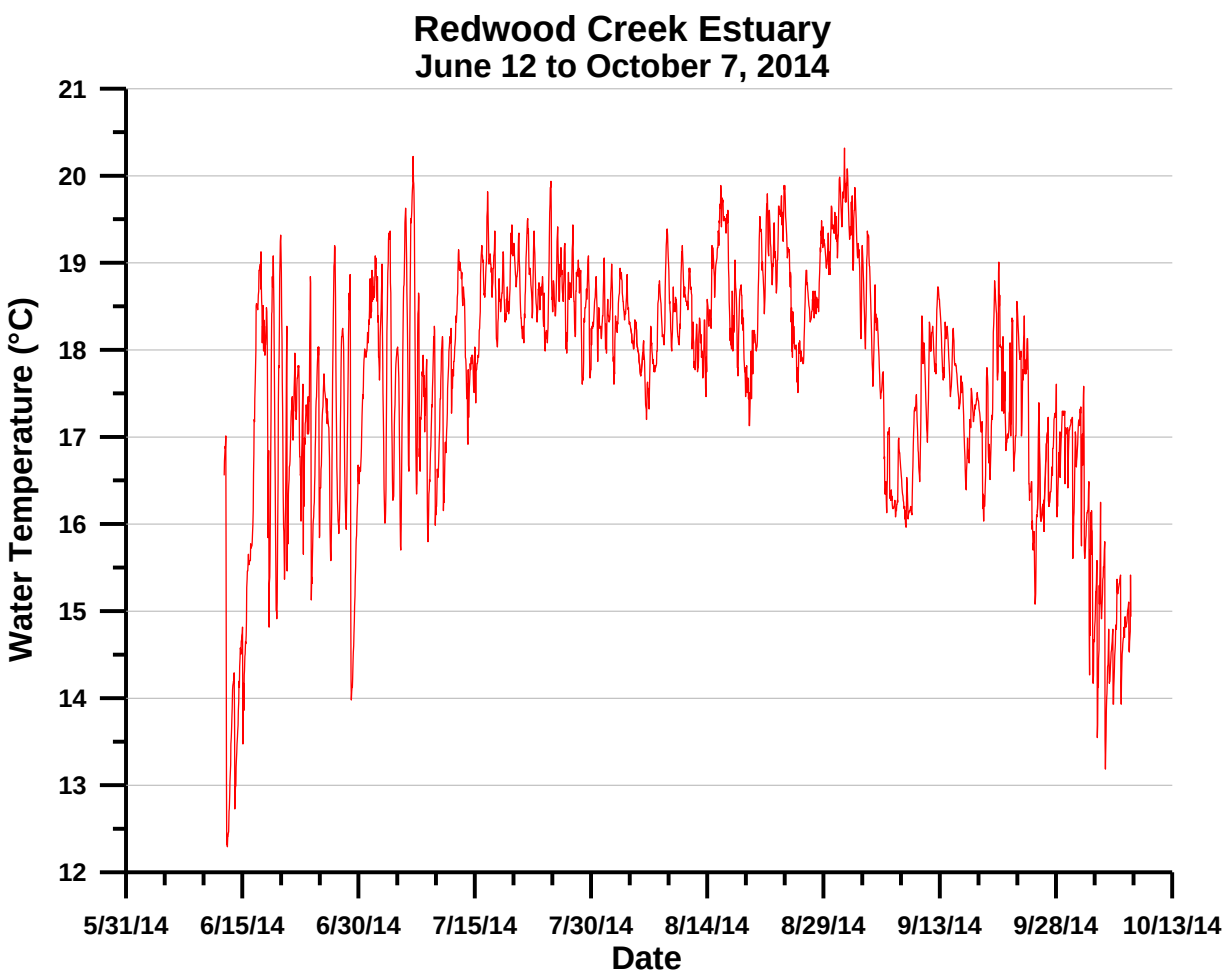


Figure 7. Redwood Creek estuary water temperatures (°C) measured by an Onset Tidbit temperature logger located in the embayment beyond the ends of the north and south levees. The temperature logger, located one foot from the bottom, recorded water temperature every 1-hour from June 12 to October 7, 2014.

Water temperature was equal to or greater than 18.0°C 76 percent of time during July and August. For June 12 to the 30th, the average water temperature was 16.6°C; for July, 18.3°C; for August, 18.6°C; for September, 17.4°C; and for October 1 to 7, 15.1°C.

The large daily temperature ranges in the embayment when the mouth was open are the result of tidal action; the minimums influenced by the cooler ocean water entering the estuary at high tide, and the maximums influenced by the warmer water from upstream at low tide. After the closure of the mouth the diurnal ranges were less.

Tides at the Mouth of Redwood Creek - The maximum and minimum tide at the mouth of Redwood Creek (based on verified tides at Crescent City, California) was 5.0ft MSL and -5.8 ft MSL, respectively, a range of 10.8 feet. Tidal data is included in presented in Appendix II and included in Figure 11.

Stream Flow - Calendar year 2014 stream flow data, January 1 through December 31, is presented in Figure 8. 2014 was a drought year. The maximum flow was 13,400 cfs on December 21. The gage measured a minimum flow of 6 cfs between September 12 and 17. The first flow event of the fall occurred on September 24, when after 2.52 inches of rain that day, flow increased from 8 cfs to a peak of 290 cfs. (The flow data is provisional and subject to revision by the California Department of Water Resources.)

Embayment Water Level Gaging

Redwood Creek embayment water elevation (feet MSL) was recorded every 15 minutes with a ventless U20 Onset water level data logger. The temporary embayment gage was installed near the end of the south levee on June 16 and removed on November 6, 2014.

The embayment gage site at the end of the south levee measures lower embayment water elevations than in the south slough. The lowest water levels in the south slough are limited by the invert of the south slough culvert gates and sand deposited in the south slough outlet channel.

Closure, Breaching and Estuary Response - Based on observations and the embayment recording water level gage data, the Redwood Creek estuary closed and breached twice (Figure 9). The estuary mouth first closed on June 28 and breached on June 30, and closed again on July 8, breaching on September 24. It remained closed for a total of 79.8 days.

June 28 Closure and June 30 Breach - The mouth of the Redwood Creek closed on June 28th at an estuary water elevation of 4.1ft MSL (Figure 9). Redwood Creek flow at the time was 115cfs, having peaked on June 26 at 128cfs, the result of 0.52 inches of rain on June 25-26, and 0.08 inches on June 27 (measured at the Orick stream flow gage). Wave height at closing was 3.0 ft but increasing in height (Figure 10). The water elevation rose to 7.1ft before the mouth breached on June 30, Redwood Creek flow at 84cfs. Wave height was 10.9 ft. The estuary was closed for 1.8 days.

July 8 Closure to September 24 - The mouth of Redwood Creek closed again on July 8 at an estuary water elevation of 3.7ft. Redwood Creek flow was 61cfs and ocean wave height 6.4 ft, the high tides increasing in height (Figure 10). The mouth closed, estuary water elevation

peaked at 7.2ft on July 16, and slowly decreased to a low of 4.5ft on September 16 (Figure 9). The estuary remained closed for 78 days until September 24 at around 7:15pm when the sand spit was breached. The average water elevation during the 78 day closure was 5.6 ft MSL.

September 24 Breach - A combination of wave overwash and stream flow caused the estuary to fill in a short amount of time and cause the spit to breach. On September 24, the first storm of the season dropped 2.52 inches of rain between 1am and 6pm, causing Redwood Creek flow to increase from 9cfs at 8am to a peak of 290cfs by 6pm (Figure 8). At the same time, large ocean waves were observed at 4:30pm breaking offshore and at times immersing the entire sand spit with wave overwash, waves propagating into the estuary. Ocean buoy data recorded a peak height of 15.5 ft waves at 6pm, but was 14.5ft at the time of the breach.

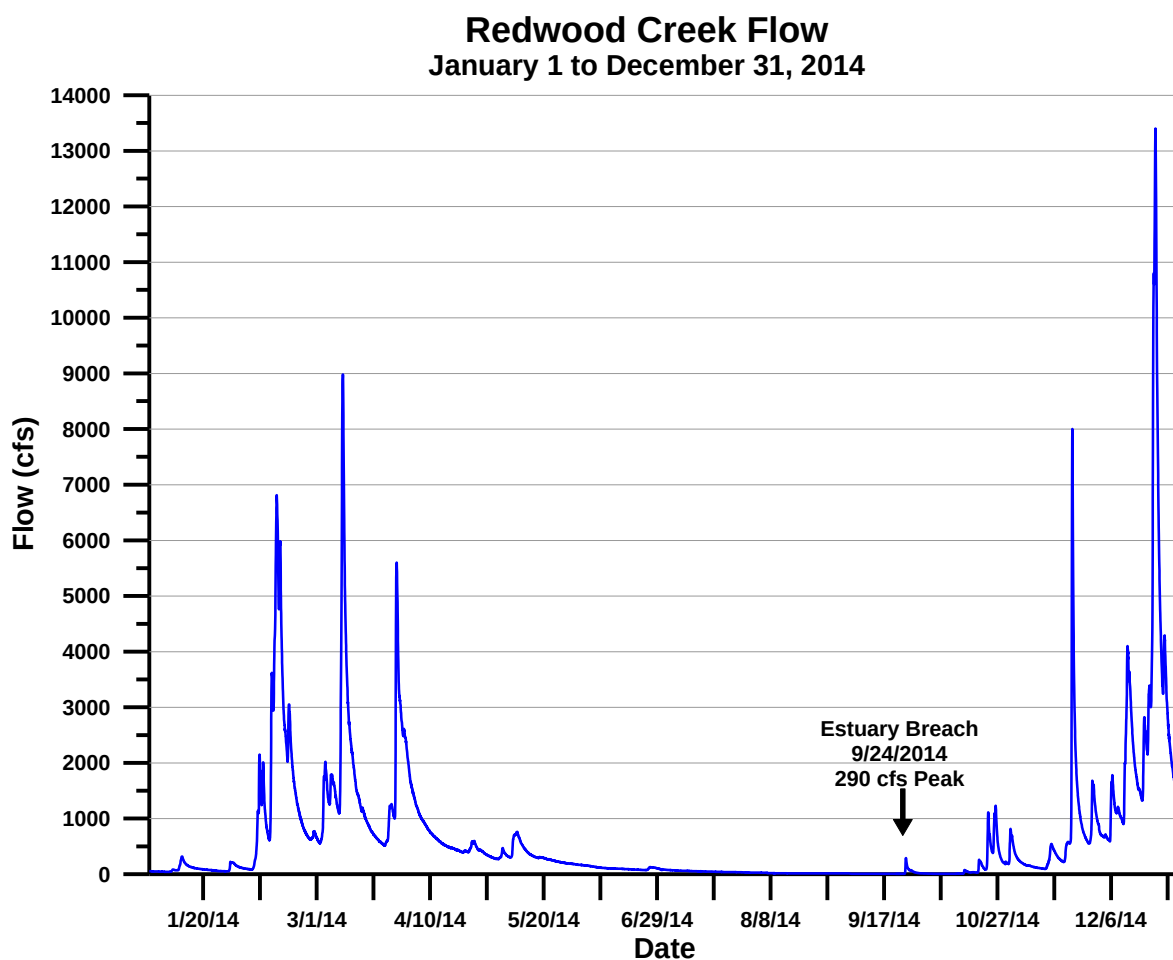


Figure 8. Redwood Creek flow (cfs) at Orick for calendar year 2014.

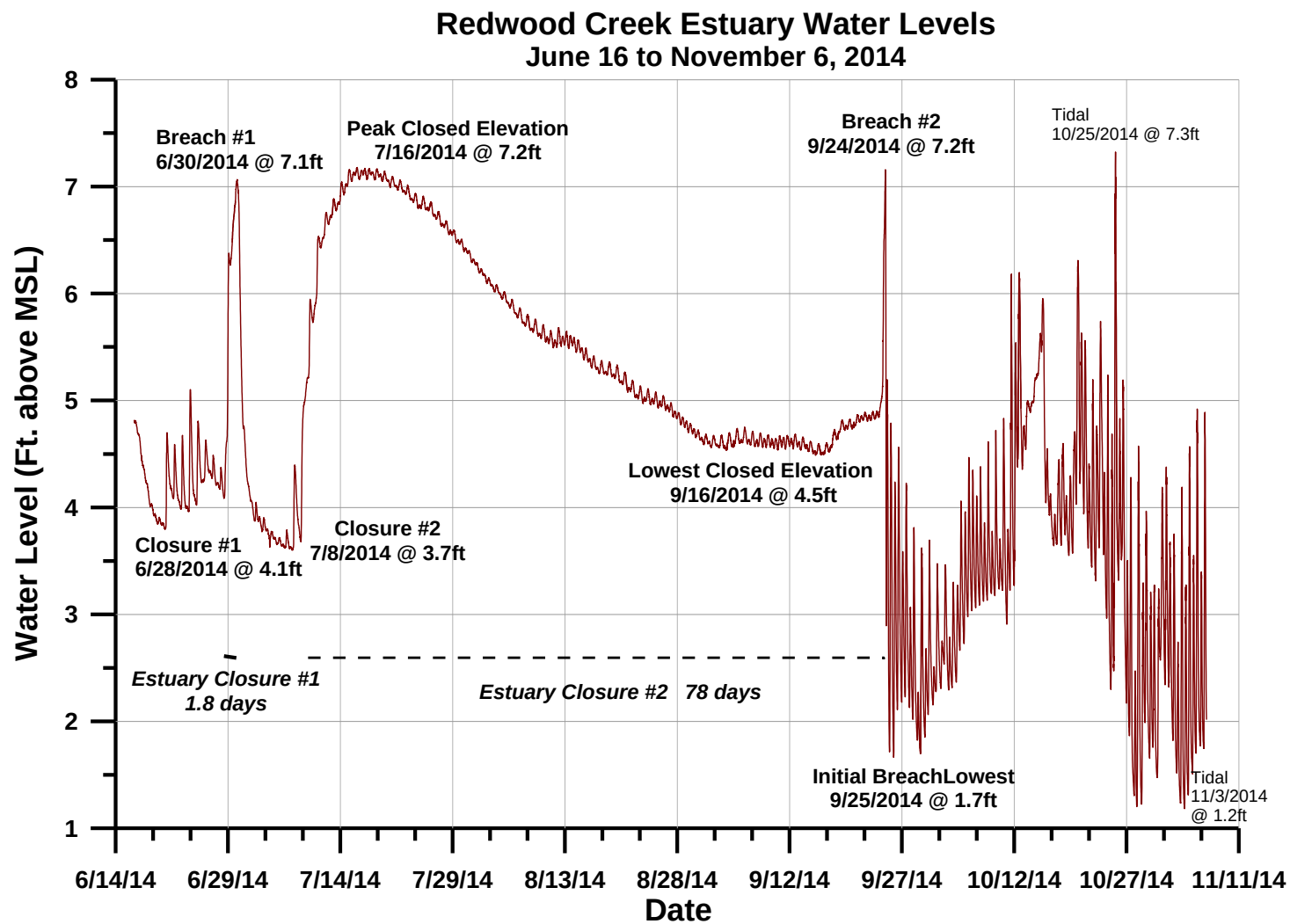


Figure 9. Water level elevations (ft. Mean Sea Level [MSL]) recorded in the Redwood Creek estuary, Humboldt County, California for June 16 through November 6, 2014.

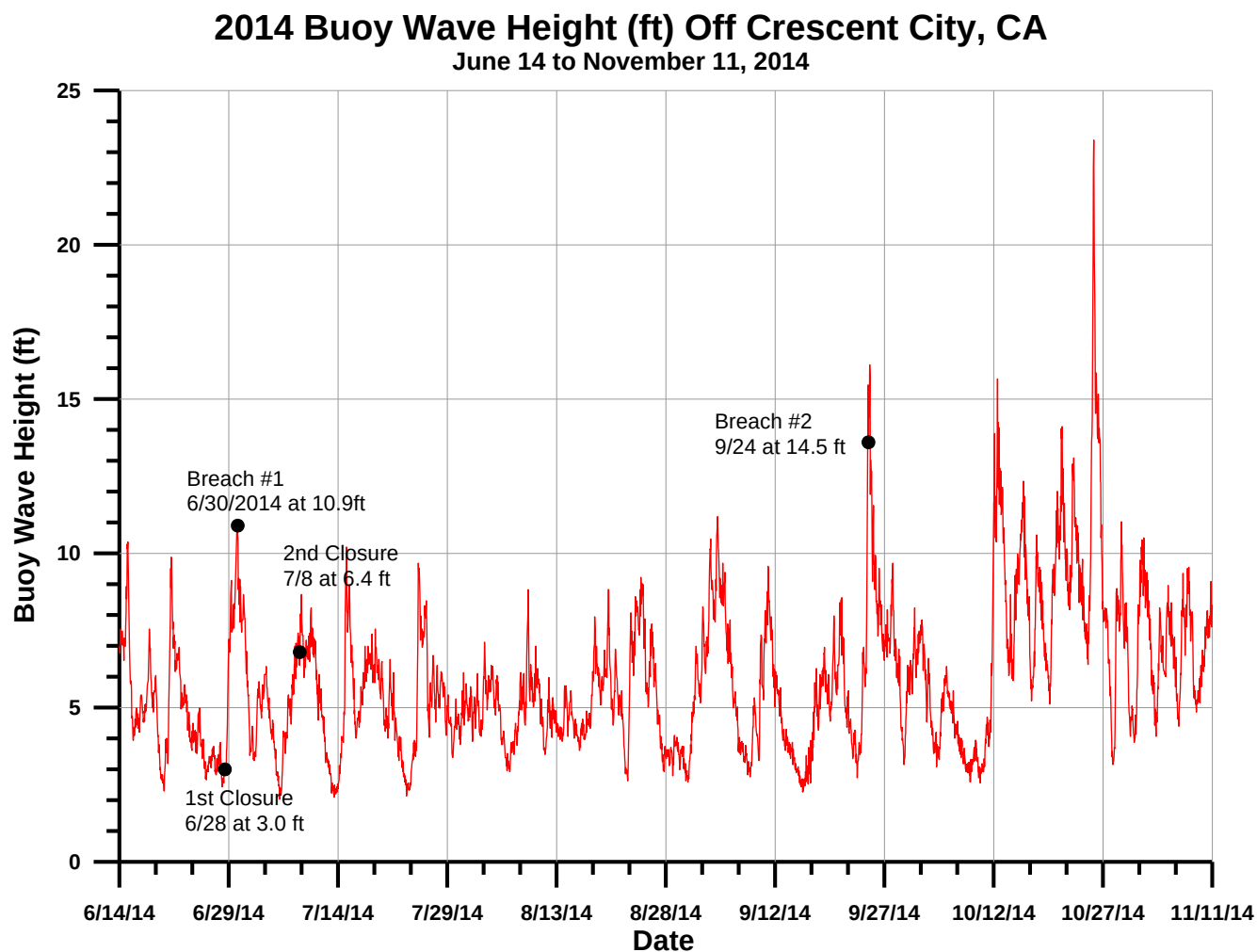


Figure 10. Ocean wave heights (ft) measured hourly by Buoy 4627 located 8nm NW of Crescent City, California, and the wave heights at Redwood Creek closure and breaching incidents.

Redwood Creek Estuary Water Levels and Tides at Mouth of Redwood Creek June 16 to November 6, 2014

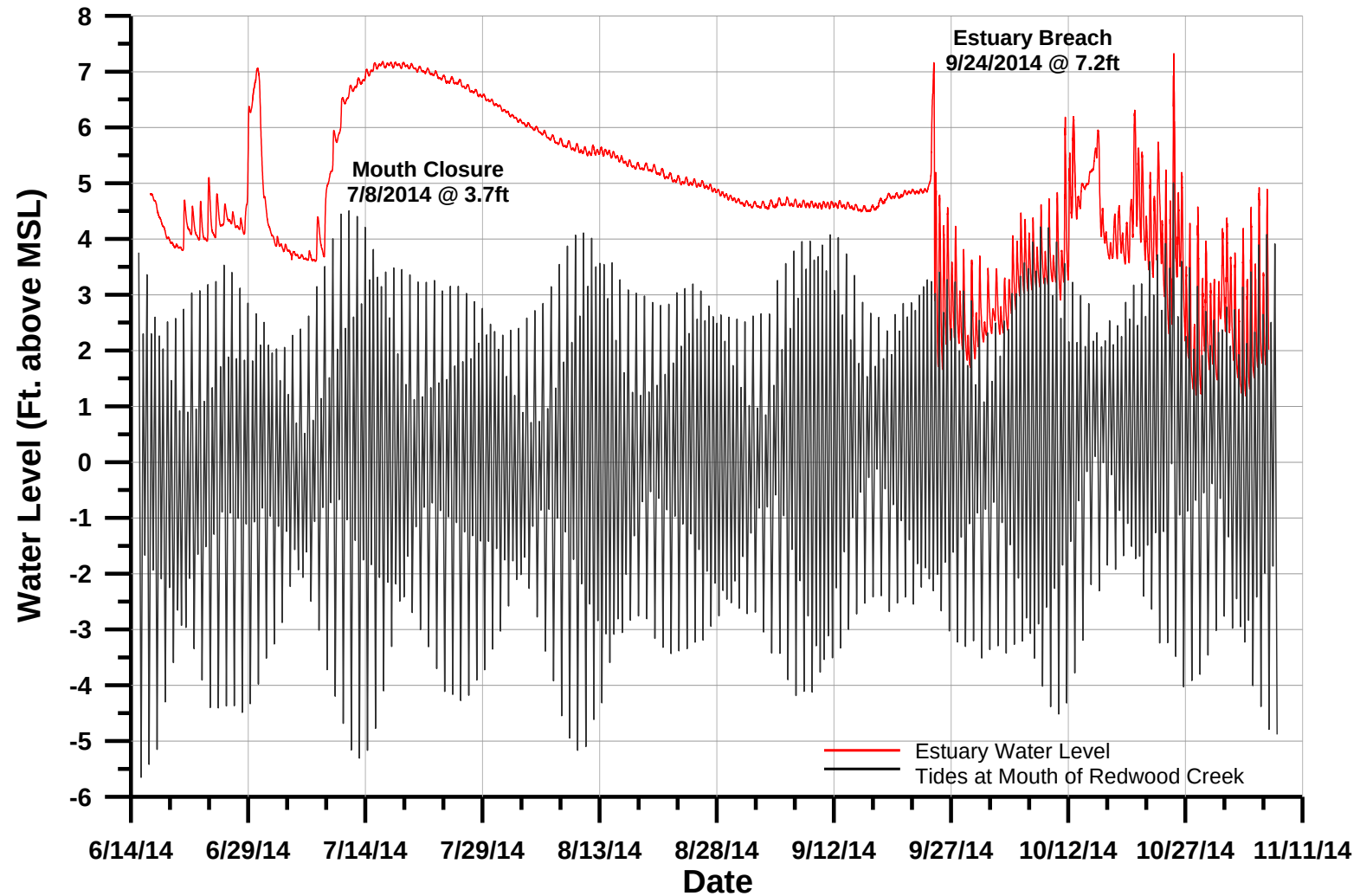


Figure 11. Redwood Creek estuary water levels and tides at the mouth of Redwood Creek June 16 to November 6, 2014.

The water elevation, 4.8 ft, began to rise on September 23 at 10:15pm and increased to 7.2ft on September 24 at 7:15 pm when the berm breached. The water level fell to 2.9ft MSL by 10pm that night, an initial drop of 4.3ft, before the tidal influence increased the water level. However, on September 25 at 9:45pm, the water elevation decreased to 1.7ft MSL. Two people who witnessed the breach reported the estuary berm crested about “45 minutes before sunset” and they could see flow over the berm, the berm just starting to erode. They described it as a slow process. After the breach, estuary water elevations remained tidal, with a high of 7.3ft on October 25 and a low of 1.2ft of November 3.

Estuary Cross Sections

All five estuary embayment cross sections, E-1 through E-5, were surveyed on June 17, 2014 and are presented in Appendix IV. The mouth of Redwood Creek was open to the ocean at the time of the survey. It was the 13th time the cross sections had been surveyed since 1998. Generally, the channel thalweg and form is more variable with distance from the static levees, E-5 the cross-section closest to the Redwood Creek mouth having the most year-to-year change.

Estuary Volume - Also calculated for the embayment (excluding the north and south sloughs and the area of the embayment/channel upstream of the ends of the levees) was embayment volume (ft³) for varying water elevations (Appendix V). Calculated embayment volume ranged from 1,009 ft³ at -3ft MSL to 1,652,419 ft³ at 7ft MSL. At 0ft MSL the volume was 161,911 ft³.

South Slough Culvert Gates

The culvert gates are opened to increase circulation between the south slough and the embayment after the last storms of spring and closed before the first storms of the fall/winter season. However, in 2014 the gates were not manipulated due to a question that their operation may require Section 7 consultation. The broken head valve of culvert #3 was replaced in 2014.

CDFG Redwood Creek Downstream Migrant Trapping

Population Abundance - At the lower Redwood Creek downstream rotary screw trap (river mile 4), Sparkman et al. (2015a) estimated 209,005 0+ and 1,268 1+ chinook; 3,955 0+ and 564 1+ coho salmon; 37,376 1+ steelhead and 14,104 2+ steelhead; and 442 coast cutthroat trout passed by the trap in 2014 (Table 6). The trap, first a rotary trap and later a fyke net trap fished from April 8 to August 26, 2014.

June accounted for 40% of the 0+ chinook total, April and June combined accounting for 67% of the total, the peak week April 23 to 29. For 0+ coho, April accounted for 47% of the total, April and May combined accounting for 67% of the total, the peak week April 16 to 22. For 1+ coho, May accounted for 67% of the total, April and May combined accounting for 88% of the total, the peak week May 21-27. For 1+ steelhead, June accounted for 40% of the total, April and June combined accounting for 68% of the total, and the peak week April 9 to 15. For 2+ steelhead, June accounted for 60% of the total, June and July combined accounting for 79% of the total, and peak week June 18 to 24.

At the trap at the mouth of Prairie Creek, Sparkman et al. (2015b) estimated 15,179 0+ chinook; 14,126 0+ and 19,046 1+ coho; 7,381 1+ and 1,875 2+ steelhead; and 4,581 cutthroat immigrated

Table 6. Estimated population abundance and peak monthly migration of juvenile salmon and steelhead, and cutthroat trout from CDFW downstream migrant rotary screw trapping on lower Redwood Creek and the mouth of Prairie Creek, 2014.

2014 CDFW Redwood Creek Downstream Migrant Rotary Screw Trapping							
Downstream Migrant Trap	0+ Chinook	1+ Chinook	0+ Coho	1+ Coho	1+ Steelhead	2+ Steelhead	Cutthroat
Lower Redwood	209,005	1,268	3,955	564	37,376	14,104	442
	June (40%) April & June (67%)	April & May (100%)	April (47%) April & May (67%)	May (67%) April & May (88%)	June (40%) April & June (68%)	June (60%) June & July (79%)	June (59%) June & July (80%)
Prairie Creek	15,179	---	14,126	19,046	7,381	1,875	4,581
	May (65%) April & May (81%)	---	May (70%) April & May (94%)	May (51%) April & May (86%)	April (41%) April & May (81%)	April (38%) April & May (67%)	April (51%) April & May (86%)
Total	224,184	1,268	18,081	19,610	44,757	15,979	5,023
From Sparkman, et al. 2015a and 2015b							

out of the Prairie Creek watershed into Redwood Creek. The trap, first a rotary trap and later a fyke net/pipe trap fished March 21 through August 12, 2014.

April and May were the peak months for 0+ chinook, 0+ and 1+ coho, 1+ and 2+ steelhead, and cutthroat trout. For 0+ chinook, May accounted for 65% of the total, May and April combined accounting for 81% of the total, and peak week April 30 to May 6. For 0+ coho, May accounted for 70% of the total, April and May combined accounting for 94% of the total, the peak week April 30 to May 6. For 1+ coho, May accounted for 51% of the total, April and May combined accounting for 86% of the total, the peak week April 30 to May 6. For 1+ steelhead, April accounted for 41% of the total, April and May combined accounting for 81% of the total, the peak week May 21 to 27. For 2+ steelhead, April accounted for 38% of the total, April and May combined accounting for 86% of the total, and peak week April 30 to May 6.

Potentially, 328,902 salmonids migrated to the lower river and estuary in 2014 and most of them before RNP estuary monitoring began the second week of June. It is probable that a large number of them migrated into the ocean before June.

Growth – Mean 0+ chinook fork length comparison between the estuary and lower Redwood Creek trap shows they are essentially the same during the first week of June, 70 and 71 respectively which probably reflects the June peak migration of 83,356 0+ chinook into the lower river and estuary (Figure 12). Later, estuary fish are longer than fish trapped at the same time on the lower river. In July (July 15 estuary versus July 14 -16 lower river), mean estuary fork length was 80 mm versus 76 mm for the lower trap. In August (August 18 – 21 estuary versus August 18 – 21 lower river), mean estuary fork length was 86 mm versus 80 mm in the lower river. The same is true for 0+ chinook weight (Table 7).

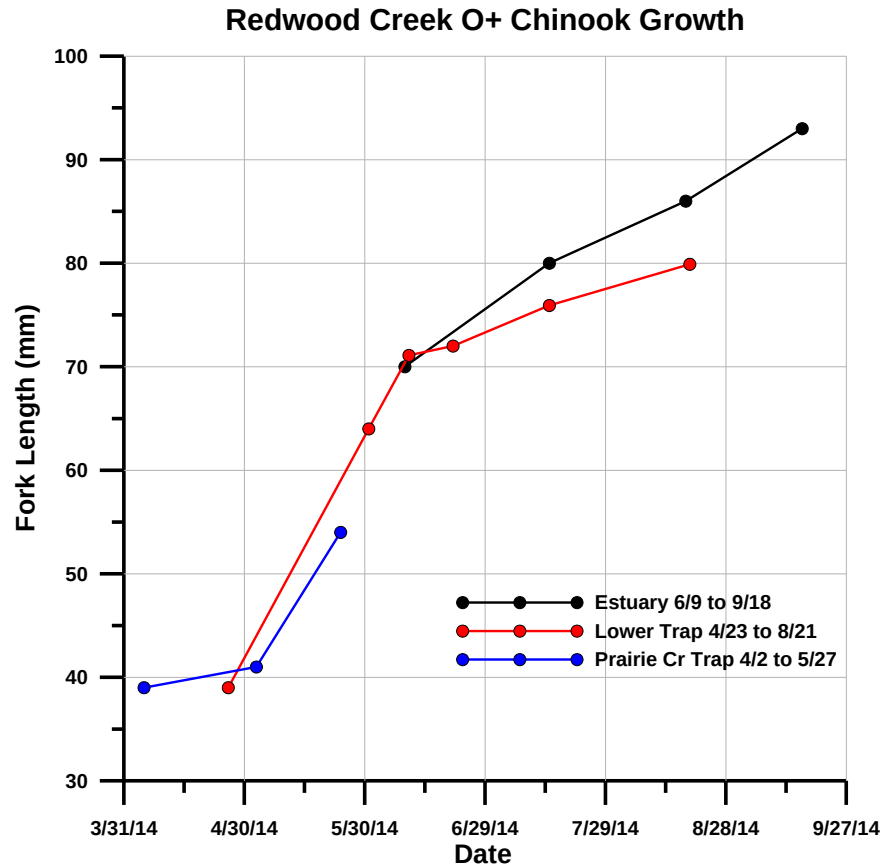


Figure 12. 0+ Chinook fork length (mm) for fish measured in the Redwood Creek Estuary and at the CDGW downstream migrant traps in Lower Redwood Creek and Prairie Creek mouth in 2014. (Trap data adapted from Sparkman et al. 2015a and 2015b).

Table 7. Mean 0+ chinook weight (g) and range comparison between the Redwood Creek estuary and lower Redwood Creek CDFW trap in 2014.

Location	2014 Date	No. Sampled	Mean Weight (g)	Range
Estuary	6/ 9	30	4.1	1.4 -7.1
Lower Trap	6/9, 10, 11, 13	60	4.02	1.0 – 7.6
Estuary	7/15	30	5.5	3.7 – 9.9
Lower Trap	7/14 -16	60	4.67	2.6 – 7.8
Estuary	8/18, 19, 21	30	6.1	3.1 – 8.1
Lower Trap	8/18 – 21	7	5.63	4.1 – 6.8
CDFW Data – M. Sparkman personal communication				

Mean fork length and weight for 0+ and 1+ coho at the Prairie Creek trap was 40.6 mm and 0.85 g and 104.9 mm and 12.5g respectively. At the lower trap, it was 50.7 mm and 1.79g and 110.5 mm and 14.58 g for 0+ and 1+ coho respectively (Sparkman et al. 2015a). Estuary mean fork length and weight for 0+ coho was 52.7 mm and 2.5 g, respectively. For estuary 1+ coho, mean fork length was 113 mm and mean weight was 16.5 g. Both estuary ages classes are larger,

probably reflecting additional time to grow before migrating out of the estuary into the ocean and the fact we caught the last of the coho migration in June and July.

Lower Redwood Creek trap 0+, 1+, and 2+ steelhead mean fork length was 53 mm, 103 mm, and 145.5 mm, respectively. Though we did not differentiate between age classes, estuary steelhead mean fork length was 122 mm in June and 143 mm in September. Mean fork length for cutthroat trout was 164.4 mm at the lower trap and 149.5 mm at the Prairie Creek trap. Mean fork length in the estuary ranged between 258 and 289 mm during the sampling period. The disparities was the same for cutthroat weight, mean weight was 52.7 g at the lower trap, 38.9 g at the Prairie Creek trap, and ranged between 124.8 g and 181.7 g in the estuary.

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Personal Communication

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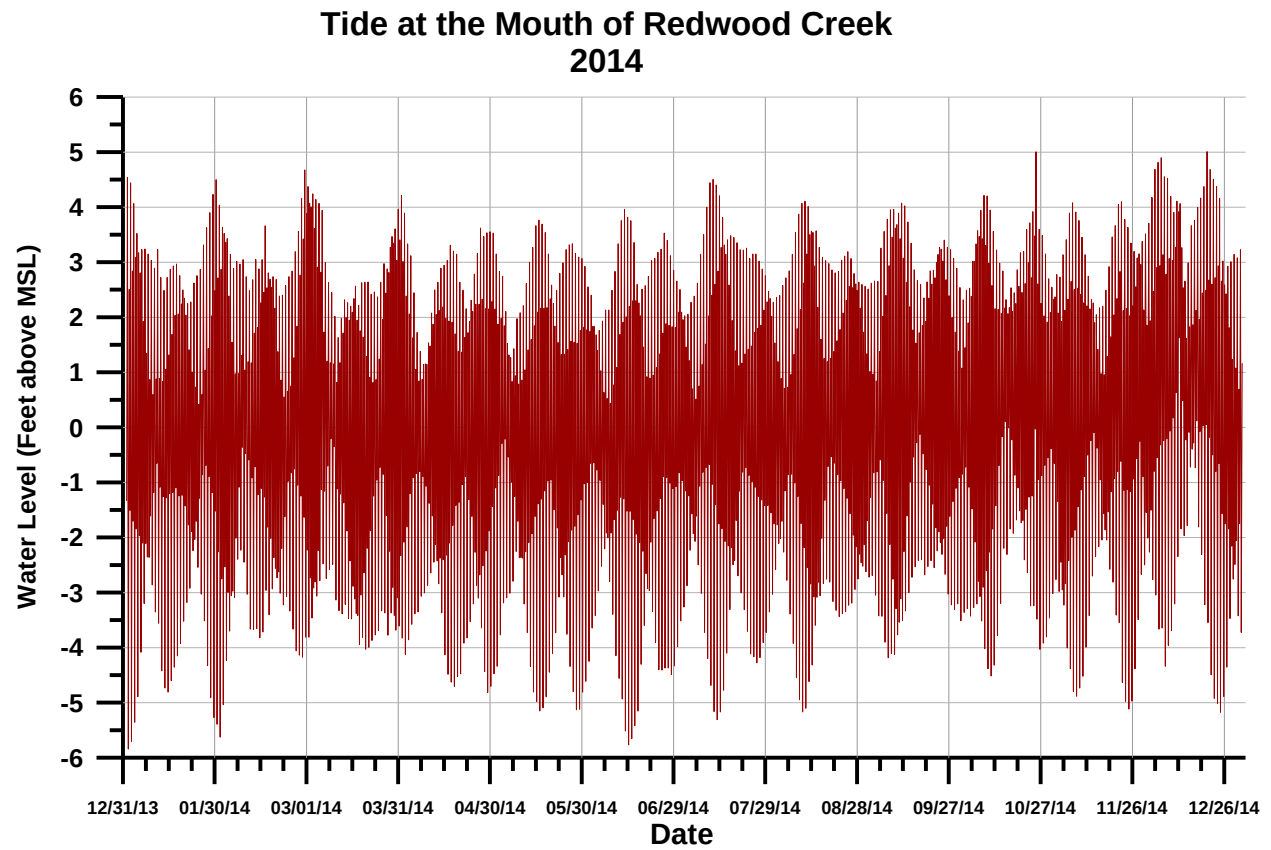
Appendix I. Number of salmonid fish marked, marked recaptures, total individuals captured in the second sample, and total number of seines from the RNSP Redwood Creek estuary mark and recapture population estimates during the summer/fall of 2014. Fish fins; top, middle, and bottom caudal, and anal fins were marked with a Panjet needleless injector using Alcian Blue dye. Formulas used to calculate population estimate and its 95% confidence interval.

2014 Date		Number of Fish Marked ^a Marked Fish Recaptured ^b Total No. of Fish Captured in Second Sample ^c				Total No. of Seines	Panjet Fin Mark
		Chinook	Coho	Steelhead	Cutthroat		
June 9 & 10	a	700	41	104	0	15	Top Caudal
June 12	b	31	4	2	0		
	c	669	95	239	0		
July 15 & 16	a	739	1	311	1	16	Bottom Caudal blue
July 17	b	17	0	15	0		
	c	355	0	328	5		
Aug 18 & 19	a	33	0	330	6	21	Anal
August 21	b	5	0	35	0		
	c	129	0	291	5		
Sept 15 & 16	a	74	0	206	11	18	Middle Caudal
September 18	b	6	0	9	0		
	c	113	0	120	6		

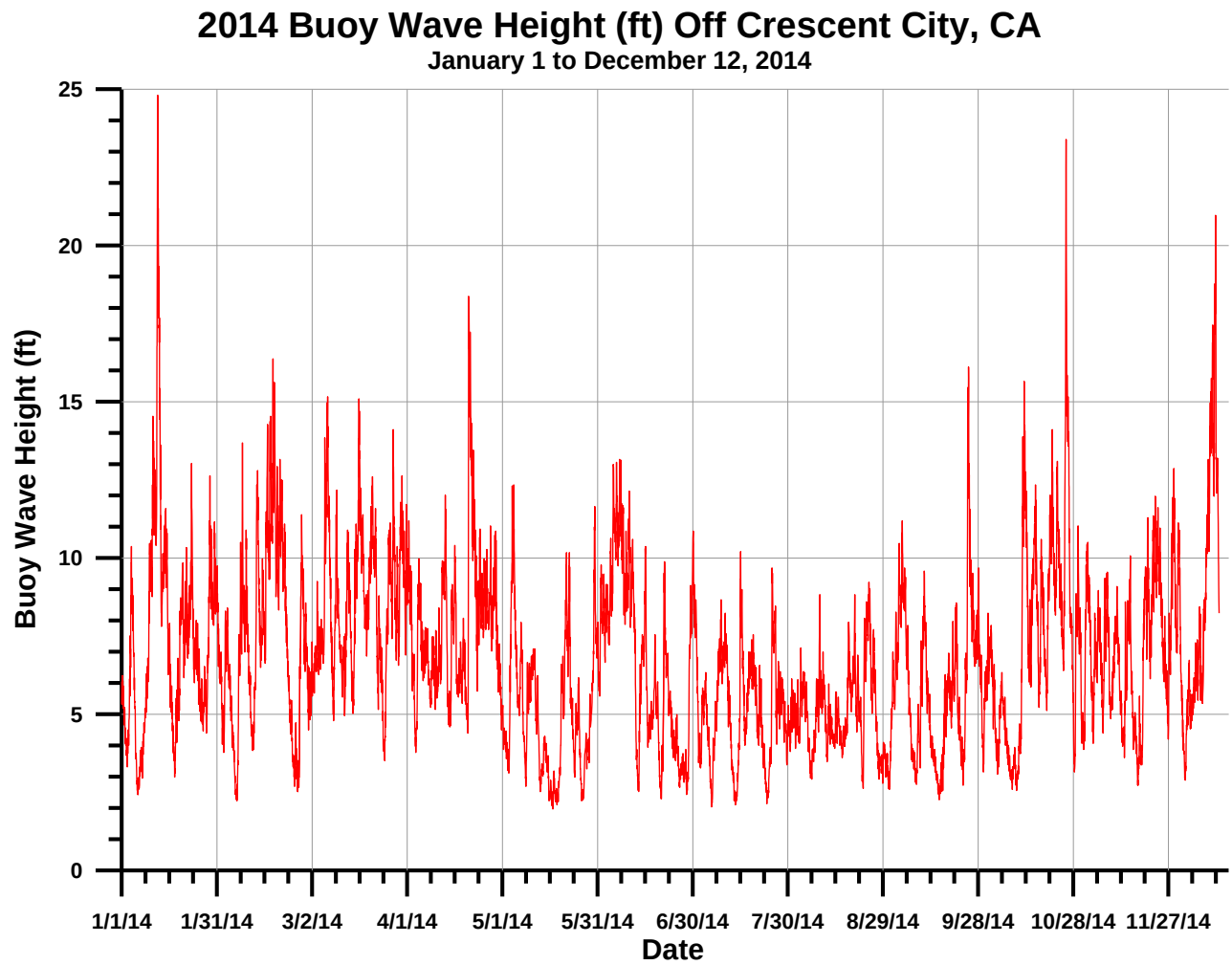
$$\text{Population Estimate (N)} = \frac{(\text{No. of fish marked}) \times (\text{total no. captured in second sample})}{(\text{No. of marked fish recaptured in second sample})}$$

$$95\% \text{ CI} = \pm 1.96 \times \sqrt{\frac{(N^2) \times (N - \text{no. marked}) \times (N - \text{no. in second sample})}{(N - 1) (\text{No. marked}) \times (\text{no. in second sample})}}$$

Appendix II. Tides (ft. MSL) calculated at the mouth of Redwood Creek for calendar year 2014.



Appendix III. Ocean wave heights (ft.) measured hourly by NOAA Buoy 46027 located 8 nm NW of Crescent City, California for January 1 to December 12, 2014.

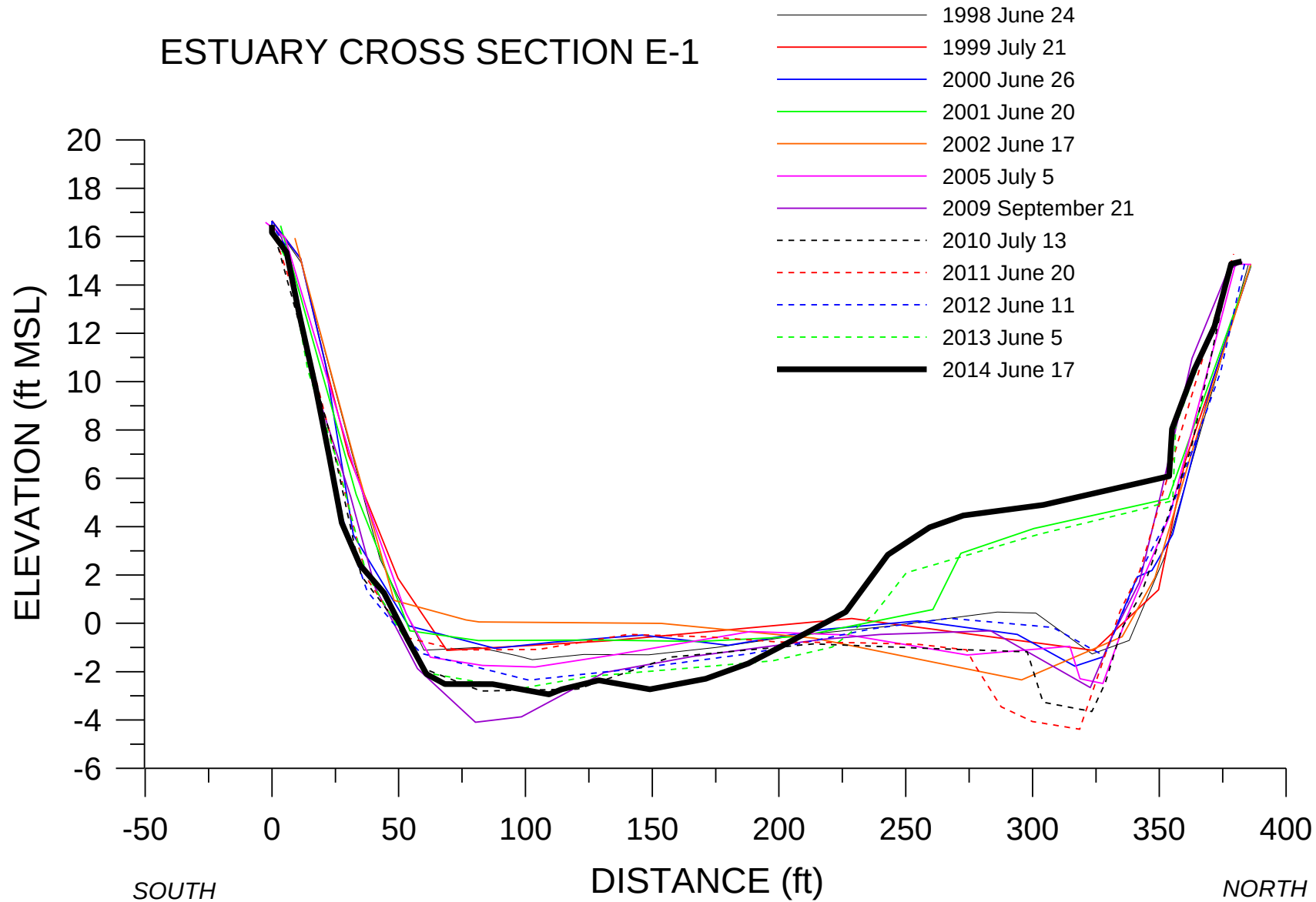


Appendix IV. Five permanent cross-sections (E-1 through E-5) surveyed June 17, 2014 in the Redwood Creek estuary embayment perpendicular to the channel. Established in 1998, each cross-section was shot at a bearing of 170° from the north endpoints through the embayment to the sand dunes on the south. The five parallel cross-sections start between the ends of the levees with E-1 and end at the west with E-5 at the sea stack adjacent to the beach.

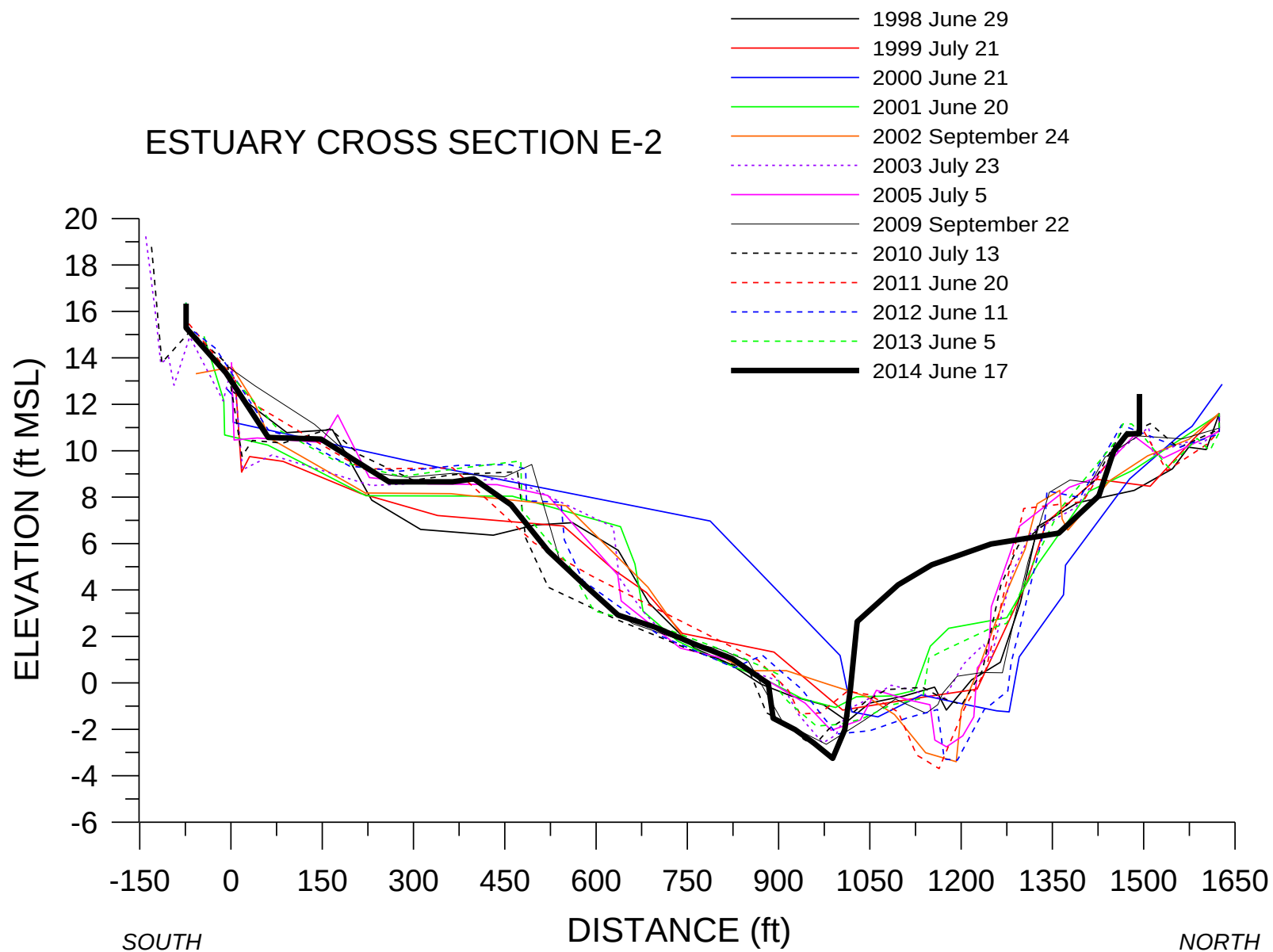


Redwood Creek Estuary Cross Section End Points and Reference Monuments

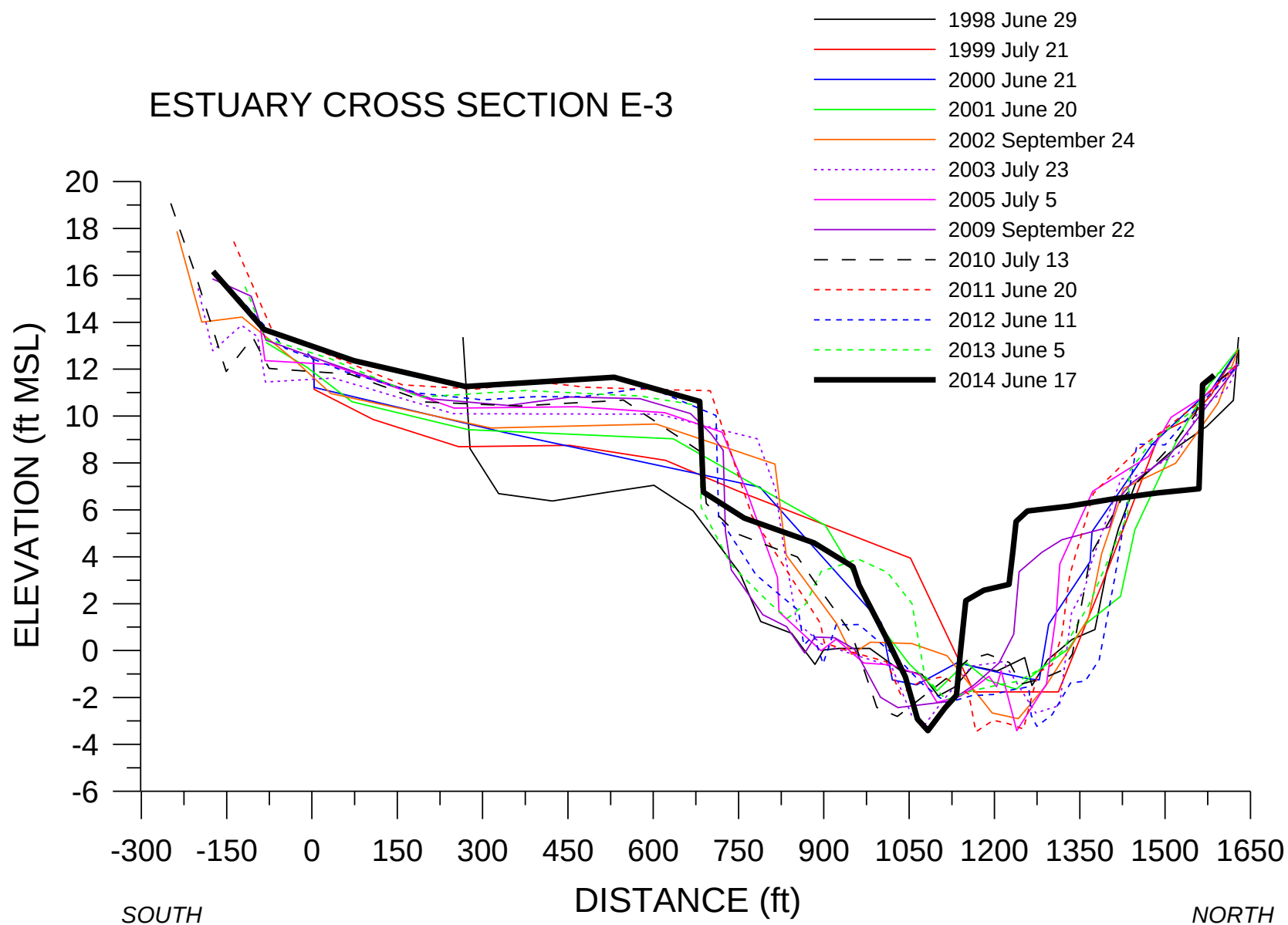
ESTUARY CROSS SECTION E-1



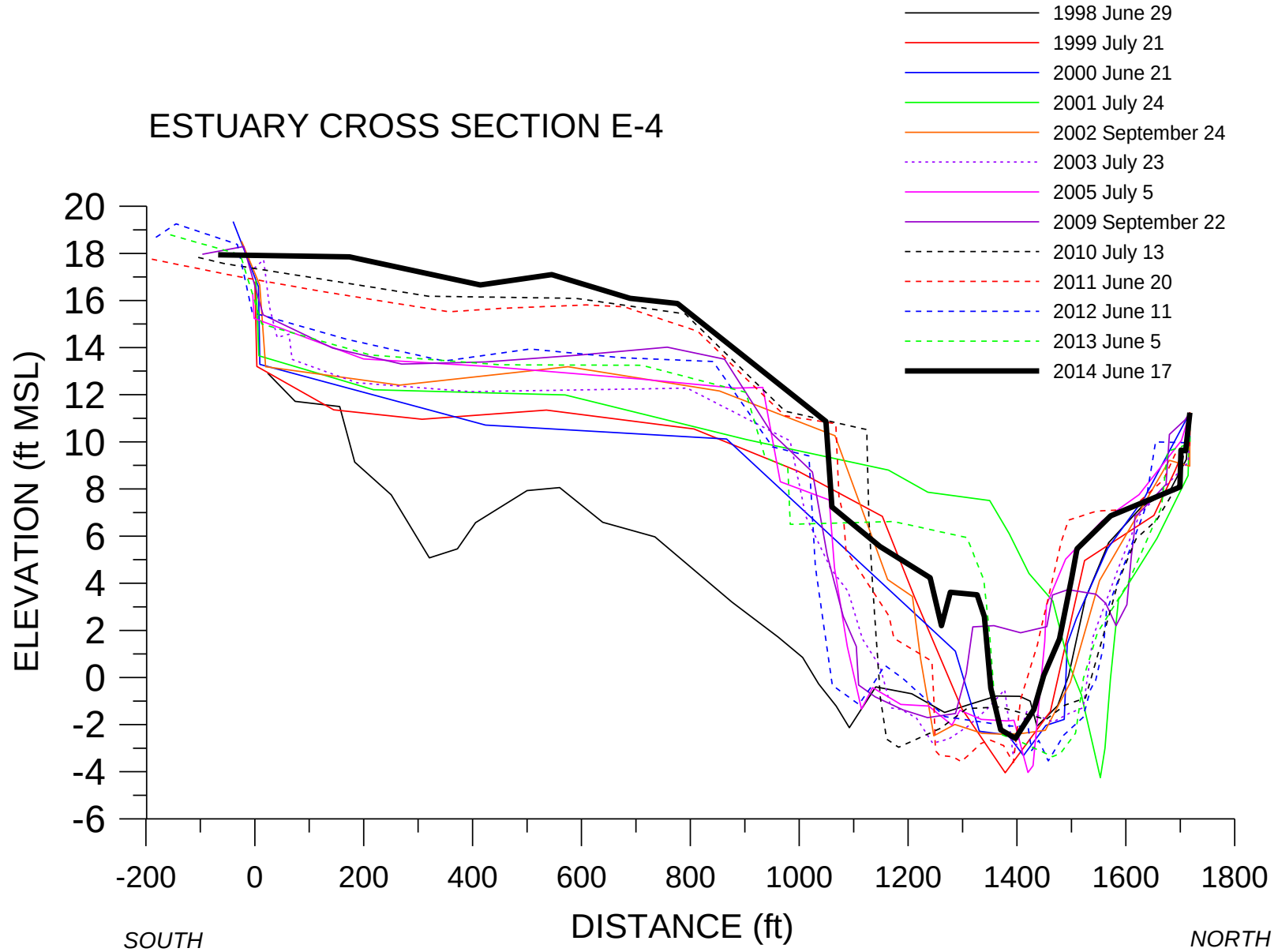
ESTUARY CROSS SECTION E-2



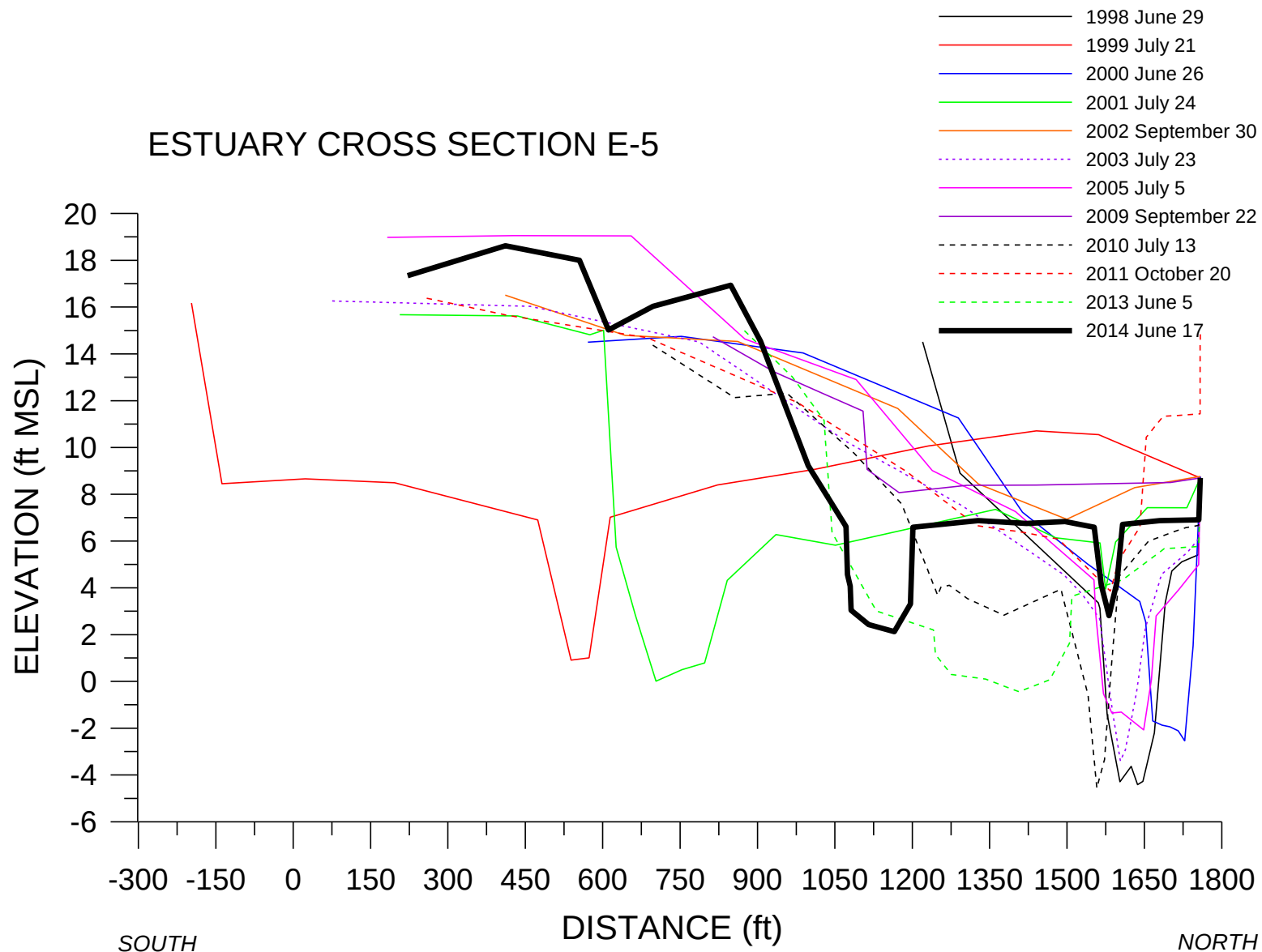
ESTUARY CROSS SECTION E-3



ESTUARY CROSS SECTION E-4

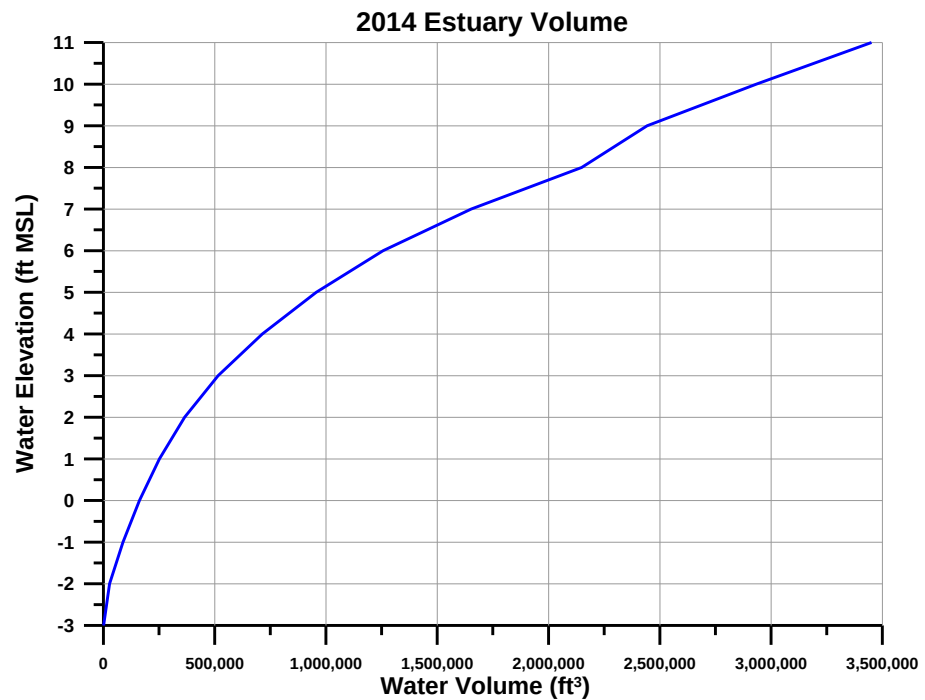


ESTUARY CROSS SECTION E-5



Appendix V. Calculated volume (ft³) of the Redwood Creek embayment at water elevations of -3 to 11 ft MSL based on the five cross sections E-1 through E-5 surveyed on June 17, 2014 (left). Volume of embayment is defined as the area west of the ends of the north and south levee and not including the north or south outlet channels or sloughs. Embayment water elevation versus volume (right).

Water Elev. (MSL ft)	Estuary Volume (ft ³)
11	3,451,526
10	2,933,590
9	2,443,016
8	2,148,811
7	1,652,419
6	1,256,683
5	956,364
4	714,213
3	515,464
2	364,878
1	251,758
0	161,911
-1	87,960
-2	27,535
-3	1,009



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Fish and Wildlife Branch: David Anderson and Kyle Max

Water Temperature Monitoring

Fish and Wildlife Branch: David Anderson and Kyle Max (placement and retrieval)

Geology Branch: Carrie Jones (data download, calibration of probes)

Embayment Cross-Sections

Fish and Wildlife Branch: David Anderson (rod)

Geology Branch: Carrie Jones (instrument and graphing) and Vicki Ozaki (rod)