ANNUAL PROGRESS REPORT

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OREGON

PROJECT TITLE: Life history variability, habitat use, and migratory behavior of coastal cutthroat trout in the Salmon River, Oregon

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INTRODUCTION

A previous study characterized a diversity of life history strategies of coastal cutthroat trout (*Oncorhynchus clarki clarki*) in Salmon River (Krentz 2007). In contrast to life history patterns in other Oregon estuaries (Giger 1972), cutthroat trout of all sizes resided for extended periods of time throughout the available channel habitats in Salmon River estuary. The estuarine resident population appeared to represent a significant portion of the migratory individuals, and included all age classes. Estuary growth was similar to that of their ocean migrant counterparts, and survival in the estuary was high. Because cutthroat were collected and marked primarily within the estuary (Krentz 2007), it is unclear what portion of the migrant population remained in the estuary relative to the ocean migrants, or whether the tagged group was representative of the anadromous populations. The current study was designed to track a representative sample of the downstream migrant population, and assess the relative success (survival) of the estuary and ocean migrants.

Similar studies in the Columbia River documented directed and rapid migration through the estuary (Zydlewski et al. 2008, Hering et al. 2009). With one exception, cutthroat trout were not observed to rear in the estuary. In addition, many fish disappeared before reaching the ocean and few of the ocean migrants returned to the site of release. In this study we replicated the study design used in the Columbia River studies to allow comparison of estuary migration and rearing strategies between the two estuaries.

The primary objective of our work in the Salmon River was to increase understanding of coastal cutthroat trout biology and the relationship between resident and migratory cutthroat. Study objectives were to:

1. Estimate the distribution and abundance of coastal cutthroat trout in the Salmon River watershed
2. Quantify the proportions of the cutthroat populations that are migratory, identify which individuals migrate and describe the timing of migration
3. Describe habitats used by anadromous migrants and characterize migration behavior within the Salmon River estuary
4. Estimate growth rate of estuary resident cutthroat
5. Estimate estuarine/marine survival of anadromous individuals and document return to estuary
6. Compare migratory patterns and survival with cutthroat in the Columbia River

In this report, we will discuss migration patterns, habitat use, and growth. The study will be continued in 2010 to meet objectives (1), (2), and (6), and provide more detail to objectives (3), (4), and (5).

METHODS

Study Site

The Salmon River watershed is located on the north-central Oregon coast near Lincoln City (Figure 1). The basin is 195 km^2 in size, with an 800 hectare estuary that extends to river kilometer (rkm) 6.5. The estuary has extensive wetlands, some of which were restored in 1978, 1987, and 1996. The basin has a diverse ownership and management: US Forest Service (USFS) Cascade Head Scenic Research Area in the estuary, USFS and private industrial forest in the uplands, Oregon State Parks in 3.2 km of stream corridor, and rural residential along the lower reaches of the mainstem Salmon River.

Study Approach

In 2004 and 2009 we placed a rotary screw trap in the lower Salmon River above the head of tide at rkm 7.9 near the Salmon River Fish Hatchery to capture cutthroat trout during their migration to the estuary and ocean (Figure 2). Downstream migrant cutthroat were enumerated at the screw trap from mid-March through June. We used both passive integrated transponder (PIT) tags and acoustic tracking techniques to monitor the movement of individuals through the estuary. All cutthroat had PIT tags implanted and selected cutthroat trout (>170mm) were implanted with an acoustic tag. Thirty-three cutthroat trout (22 in 2004 and 11 in 2009) were implanted with acoustic tags (Table 1) and their movements were tracked from the river to the ocean, and back. The movement of acoustic-tagged cutthroat was detected with a series of acoustic receivers strategically placed throughout lower Salmon River, in the estuary, near the mouth, and offshore. (Figure 3, Table 2).

Downstream Migrant Trapping

In 2004, we installed and operated a rotary screw trap from mid- March through late June on the Salmon River near the Salmon River hatchery solely for the purpose of collecting appropriately sized cutthroat to tag. No estimates of abundance were made, and only cutthroat with a fork length of >170mm were retained for acoustic tag implantation (n=22).

In 2008 and 2009, abundance, timing, and size distribution of downstream migrant cutthroat trout were monitored with a rotary screw trap in the same location as in 2004, located just downstream of the Salmon River hatchery at river kilometer 7.9 (Figure 2). The trap was operated from mid-March to late June each year. All cutthroat

captured in the screw trap were enumerated, measured (FL), and weighed. A subsample of captured fish were marked with a caudal fin clip and released upstream of the trap to estimate trapping efficiency. Total abundance of downstream migrants was estimated as the number captured in the trap, adjusted by recapture efficiency. Cutthroat were tagged with a PIT tag, and in 2009, all cutthroat >170mm in length also were implanted with an acoustic tag (n=11).

Estuarine use

We established sites in a diversity of mainstem river and marsh channel habitats in the estuary. The marsh sites were typically shallow and muddy, river channel sites were deeper with coarser substrate, and lower estuary sites were sandy and more saline. The sites were sampled with a 38m x 2.7m beach seine (1.9cm stretch mesh wings, reduced to 0.6cm stretch mesh in center panel) at least fortnightly from April through December 2008, and from January through December in 2009. We did not sample cutthroat in the estuary with a beach seine in 2004.

PIT Telemetry

Most coastal cutthroat trout >65mm that were captured at the Salmon River screw trap or by beach seining in the estuary were marked with full duplex Passive Integrated Transponders (PIT-tags). Fish <120mm were internally implanted with 12mm tags ((Destron-Fearing model TX1411SST, 0.10 g dry weight), while those >120mm were tagged with 23mm full duplex (Destron-Fearing model TX1420SST, 0.37g dry weight). In 2008 and 2009, a total of 383 cutthroat were tagged at the screw trap and 485 were tagged in the estuary. All cutthroat recaptured in 2008 and 2009 were measured and weighed.

Acoustic Telemetry

To evaluate estuarine habitat use, migration behavior, and survival of migrant coastal cutthroat trout, we tagged a sample of cutthroat captured at the migrant trap during 2004 and 2009 with individually coded hydroacoustic transmitters (Vemco, Ltd. Transmitters). Model V9 tags were used both years. The V9 tags are 29m long x 9mm diameter, weigh 4.9g, and have a battery life up to 374 days. Prior to tagging, cutthroat were anesthetized (MS-222, $\leq$50 mg$\cdot$L^{-1}), measured, and weighed. Tags were implanted in the peritoneum through a ventral incision using techniques similar to Zydlewski et al. (2008). Incisions were closed with two to four non-absorbable nylon monofiliament sutures. Tagged cutthroat were allowed to recover for at least four hours (2004) or overnight (2009) in an aerated 75L cooler or a perforated 190L barrel anchored in the stream and were released approximately 100 meters downstream of the trap site of capture. A total of 22 and 11 cutthroat were tagged in 2004 and 2009, respectively (Table 1).

Acoustically-tagged fish were detected with a network of stationary receivers (hydrophones) anchored above tide water, in the Salmon River estuary and, in 2009, at

five locations in the ocean near Three Rocks (Figure 3). Receivers recorded the unique identification code of detected transmitters and the date and time of detections. Open water receivers were moored as described in Clements et al. (2005), and additional receivers were attached to stationary objects on the channel margins. Receivers were downloaded approximately monthly. In 2004, twelve receivers were deployed at locations between and including the Hatchery Hole and Crowley Creek. In 2009 thirteen receivers were deployed. Several of the 2004 receiver locations were duplicated in 2009 and we added a receiver directly upstream and downstream of the release site (smolt trap). We also had success maintaining receivers offshore.

RESULTS

Size, timing, migration in Salmon River

In 2008, we operated our smolt trap on the Salmon River from March 18 until June 20. Coastal cutthroat trout (n=135) were captured with 60% of the catch occurring between mid-April and mid-May. Fish ranged in size from 57mm to 265mm, with a median length of 131mm. Smolt trap efficiency for cutthroat was low, averaging 1.5% for the 2008 sampling period.

In 2009, 268 cutthroat trout were captured in the Salmon River smolt trap from March 13, 2009 until the trap was removed on July 2, 2009. Migrants ranged in size from 71mm fork length to 365mm, with a median length of 136mm. Ninety five percent of cutthroat captured in the smolt trap were <200mm, and 79% were between 100mm and 170mm (Figure 4). Downstream migration in 2009 peaked in late April/early May (Figure 5). The screw trap efficiency averaged 6.4% for cutthroat in 2009. Approximately 4,000 cutthroat were estimated to migrate to the lower river in 2009. However, the trapping efficiency for larger cutthroat is probably lower than that estimated.

Estuarine habitat use, temporal distribution, size, and growth

Studies have shown that Cutthroat reside in the estuary all months of the year (Krentz 2007). In 2009, we caught cutthroat in the estuary in all months except February (Figure CPUE). In the mid estuary seining sites, we saw an early peak of cutthroat numbers in April and again in late summer (Figure 6).

Ninety percent of cutthroat trout were caught in river channel sites with deeper pools, while 8 % of the total catch was in marsh channels and 2% in the lower estuary sites. The section of the estuary around Crowley Creek (rkm 1.5) had consistently the highest CPUE in our seine hauls, while the 96 marsh had the highest number of cutthroat of the three marshes (Figure 7).

Cutthroat trout caught in the estuary ranged from 58 to 427 mm fork length. Those caught in marsh channels were typically smaller than those caught in the main

estuary river channel, with an average fork length of 155mm compared to 243mm (Figure 8). The cutthroat observed in the estuary included larger, and presumably older, segment of the population than that observed in the freshwater streams in August and September or at the screw trap in the spring (Figure 9).

In 2009 we recaptured 69 of the 286 cutthroat (24%) that we tagged in the estuary; 19 of the 69 (29%) were recaptured more than once. We also recaptured 5 of the 228 that were tagged at the screw trap, and 2 of the 333 that were tagged upriver during a 2008 juvenile coho population estimate. Of the 110 recapture events in 2009 estuary seining, 87 (79%) of those were at the same location that the fish was previously caught (tagged or recaptured).

The average growth rate of all individuals sampled in the estuary was 0.40mm/day, or an average increase of 0.17% of body length per day. Cutthroat growth rates during calendar seasons may show a slight increase in growth during the spring but are somewhat similar (Figure 10). Mean seasonal growth rates were 0.24% for spring, 0.18% for summer, 0.15% for fall, and 0.11% for winter.

Estuary-ocean migration and survival

In 2004 twelve acoustic receivers were deployed in the lower Salmon River and the estuary. Three receivers were placed upstream of tidal influence and the other nine were strategically placed along the channel margins of the estuary. From the 2004 acoustic tagged trout, there were a total of 149,993 observations recorded between the twelve acoustic receivers, and summarized in Table 3. Three tags were never detected on any receiver once the fish were released from the holding tank. Five of the acoustic tagged fish were exclusively observed at the Hatchery Hole and had no detected movement further downstream. This could indicate either the tags were not securely inserted in the fish, the fish died, or the fish moved upstream. One fish displayed movement within the upper estuary and was last observed by the screw trap acoustic receiver. One of the acoustic transmitters was detected 52,786 times below the 101 bridge receiver suggesting it had settled in the nearby substrate. Twelve of the 22 acoustic tagged cutthroat were last detected on the Crowley Creek receiver at rkm 1.5, 2-28 days after tagging. The median time from the screw trap to rkm 1.5 was 12.8 days. We are assuming these fish entered the ocean. Two of these12 fish returned to the estuary after approximately 8 weeks of absence (Table 5). The detections of individual fish are summarized in Tables 6 and 7.

Three additional acoustic tags from 2003 were detected by the receivers. One tag had all 86592 observations recorded at the Booth Hole receiver suggesting the tag had settled in the substrate. The second transmitter was detected exclusively at the Salmon Creek receiver 6821 times. The third transmitter was detected throughout the estuary until April 8, 2004 when all detections thereafter were recorded at the Booth Hole receiver.

A total of thirteen acoustic receivers were placed in the Lower Salmon River, estuary and ocean in 2009. Of those thirteen, five were anchored offshore in a semi-circle around the rock formation of Three Rocks. One receiver was placed upstream of the screw trap above the hatchery weir and one receiver was approximately 200 meters downstream from the screw trap. A total of 59,633 observations were recorded between the 13 acoustic receivers, and summarized in Table 3. Five of the 11 fish were detected near the screw trap area and were not observed further downstream. One fish was detected exclusively on the upstream receiver above the weir. We can assume this fish is a resident trout. Two were last detected near the mouth and at the Crowley Creek site, suggesting they left the estuary and entered the ocean. Three were last detected at the offshore receivers. The 5 fish spent 8-44 days before entering the ocean, with a median travel time of 29.2 days (Table 4). None of the five fish were detected returning to the estuary. The five offshore receivers and two mouth receivers were removed in late September 2009, although four receivers remained deployed in the estuary and river through the winter. The last recorded tag detections of the 2009 were in the Salmon River on July 15 just downstream of the hatchery, June 14 in the estuary, and August 12 on the offshore receivers. Observations of individual fish are presented in Tables 6 and 7.

Thirty six percent (2004) and 55% (2009) of acoustically tagged cutthroat were not detected entering the estuary, presumably because these fish shed their tags, died, or did not continue downstream after tagging. Of those fish that did enter the estuary, 55% from 2004 and 45% from 2009 were detected entering the ocean (if we assume fish detected at the Crowley Creek receiver site entered the ocean).

The rate of return of acoustic tagged cutthroat trout from the ocean back to Salmon River estuary was low (Table 5). In 2004, 2 out of the 12 (16%) acoustically tagged fish that emigrated to the ocean in late May returned to the estuary in mid July. In 2009 zero of the 5 acoustically tagged fish that emigrated to the ocean were detected returning to the estuary, although one was detected by an offshore receiver on August 12, 2009. It should be noted that the two fish returning from the ocean were the two largest cutthroat trout tagged in 2004. They were absent an average of 53 days (388m, 50 days; 352mm, 56 days).

DISCUSSION

Approximately half of the fish tagged at the screw trap in 2004 and 2009 did not migrate to the estuary even though the trap is less than a kilometer above the head of tide. Of the fish that migrated to the estuary, all migrated to the ocean. Time of tagging, March through June, did not appear to influence tendency to migrate to the estuary. With the exception of the two largest cutthroat, size at tagging was not related to migration behavior. These results are in sharp contrast to the migration behavior observed by Krentz (2007). Krentz tagged cutthroat in the estuary, and a significant portion of those fish entered the ocean while many remained throughout the summer in the estuary. We also observed, through beach seine sampling, a large number of cutthroat that resided in

the estuary during the summer and fall of 2008-09. It is clear that cutthroat were using the estuary and ocean environment for summer rearing (Krentz 2007, and results of beach seine), but the results of the acoustic tagging studies would suggest otherwise.

Forty two percent of the acoustically tagged cutthroat trout were observed exclusively above tide water and there is no indication they entered the Salmon River estuary. This may be due to tag loss, post-tagging mortality, natural mortality, or rearing in freshwater or upper tidal areas. One fish was detected upstream from the trap indicting it likely is a resident trout. It is also possible that some of these other fish were resident individuals that simply remained in the stream or the upper estuary following release. Because there was no receiver deployed upstream from the rotary screw trap in 2004, potential transmitter recordings of upstream migration was not possible.

Field research and additional analyses in 2010 are designed to clarify the discrepancy between the studies. We are tagging another 13 cutthroat at the screw trap in 2010, and operating a PIT antenna in the upper estuary to gather additional migratory information. The lack of correspondence between behavior of fish tagged at the screw trap and those tagged in the estuary is perplexing. The use of a PIT antenna will permit detection of the much larger population of PIT tagged fish.

ACKNOWLEDGEMENTS

We thank Lisa McLaughlin for designing and implementing the study in 2004, Jim Powers (USEPA) and Jeremy Romer (OSU Fisheries and Wildlife) for the loan of acoustic receivers, Ben Soeby and Nancy Welch for operating the screw trap and tagging fish, and David Welch (Salmon River Hatchery), Jack Booth, and Cascade Head Ranch for support and allowing access to the study sites.

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Table 1. Size and date of cutthroat trout implanted with acoustic tags in 2004 and 2009

Year	Tag Type	Sample Size	Length (mm)	Median (mm)	Dates
2004	V9-2L-R04K	22	173-388	216	4/13 - 6/04
2009	V9-2L-R04K	11	175-246	201	4/14 – 6/15

Table 2. Number and location of acoustic receivers in 2004 and 2009 placed above tide water, in the estuary, near the mouth and offshore

Year	N	Fresh water	Estuary	Mouth	Offshore
2004	12	2	10	0	0
2009	13	2	4	2	5

Table 3. The number and percent of acoustically tagged cutthroat that were detected at several points during downstream migration.

Year	N	Above Tidewater (rkm 7.8)	Booth hole (rkm 3.7)	Lighthouse / Crowley (rkm 1.5)	Ocean (rkm 0.0)
2004	22	5 (20.8%)	12 (55%)	12 (55%)	N/A
2009	11	11 (100%)	5 (45%)	5 (45%)	4 (36%)

Table 4. Migration Rates and number of acoustic tagged fish that were detected at the ocean entrance.

Year	N	Elapse Time (days)	Median Elapse Time (days)
2004	12	2-28	12.8
2009	5	8-44	29.2

Table 5. Length, travel time, and return time of acoustically tagged cutthroat that left estuary and were detected returning from the ocean in 2004.

Length	Release date	To Sea Date	Days traveled	Return Date	Days undetected
388mm	5/3/2004	5/31/2004	28	7/20/2004	50
352mm	5/21/2004	5/23/2004	2	7/18/2004	56

Table 6. Cutthroat trout tagged at the rotary screw trap in 2004 and 2009. The bold data indicates fish that entered the ocean. Tag number, length of fish at tagging, release date from holding pen, location and last date the fish was detected on receiver, and the total number of days fish was recorded on a receiver

2004

Tag No.	Length (mm)	Released Date	Last Date Detected	Location	Total Days Observed
171	176	4/13/2004	8/23/2004	Below 101	
172	**222**	**4/30/2004**	**5/8/2004**	**Crowley Creek**	**8**
173	**195**	**4/26/2004**	**5/15/2004**	**Crowley Creek**	**19**
174	**209**	**4/27/2004**	**5/22/2004**	**Crowley Creek**	**25**
175	177	4/28/2004	6/22/2004	Hatchery Hole	55
176	178	4/28/2004	7/13/2004	Hatchery Hole	76
177	190	4/30/2004	6/19/2004	Hatchery Hole	50
179	**239**	**4/30/2004**	**5/14/2004**	**Crowley Creek**	**14**
180	**388**	**5/3/2004**	**7/21/2004**	**Deer Creek**	**79**
181	228	5/8/2004	0	0	0
182	**241**	**5/19/2004**	**5/23/2004**	**Crowley Creek**	**4**
183	**188**	**5/19/2004**	**5/23/2004**	**Crowley Creek**	**4**
184	176	5/19/2004	0	0	0
185	**199**	**5/21/2004**	**5/31/2004**	**Crowley Creek**	**10**
186	**214**	**5/21/2004**	**6/2/2004**	**Crowley Creek**	**12**
188	**352**	**5/21/2004**	**7/25/2004**	**Deer Creek**	**65**
196	**192**	**5/23/2004**	**6/14/2004**	**Crowley Creek**	**22**
197	175	5/23/2004	0	0	0
190	173	5/25/2004	6/27/2004	Hatchery Hole	33
191	220	5/25/2004	6/2/2004	Hatchery Hole	8
192	222	5/25/2004	7/1/2004	Hatchery Hole	37
193	**198**	**6/4/2004**	**6/8/2004**	**Crowley Creek**	**4**

2009

Tag	Length (mm)	Released Date	Last Date Detected	Location	Total Days Observed
57190	175	4/15/2009	4/16/2009	Guard Rail	1
57191	**218**	**4/16/2009**	**8/12/2009**	**Offshore**	**118**
57192	246	4/21/2009	5/27/2009	Guard Rail	36
57193	**208**	**4/23/2009**	**6/1/2009**	**Offshore**	**39**
57194	185	4/25/2009	4/30/2009	Above Weir	5
57195	**178**	**5/1/2009**	**6/14/2009**	**Crowley Creek**	**44**
57196	**204**	**5/7/2009**	**5/20/2009**	**Mouth**	**13**
57197	179	5/7/2009	5/7/2009	Guard Rail	0
57198	204	5/22/2009	5/24/2009	Guard Rail	2
57199	**220**	**5/24/2009**	**6/1/2009**	**Offshore**	**8**
57201	192	6/16/2009	8/25/2009	Guard Rail	70

Table 7. 2004 and 2009 acoustically tagged trout that entered the ocean. Tag number, length of fish, release date from holding pen, last day the fish was detected on receiver and the total number of days for migration from smolt trap to estuary or ocean.

2004

Tag	Length (mm)	Released Date	Last detection	Last Detected Location	Days of Travel
172	222	4/30/2004	5/8/2004	Crowley Creek	8
173	195	4/26/2004	5/15/2004	Crowley Creek	19
174	209	4/27/2004	5/22/2004	Crowley Creek	25
179	239	4/30/2004	5/14/2004	Crowley Creek	14
180	388	5/3/2004	5/31/2004	Crowley Creek	28
182	241	5/19/2004	5/23/2004	Crowley Creek	4
183	188	5/19/2004	5/23/2004	Crowley Creek	4
188	352	5/21/2004	5/23/2004	Crowley Creek	2
185	199	5/21/2004	5/31/2004	Crowley Creek	10
186	214	5/21/2004	6/2/2004	Crowley Creek	12
196	192	5/23/2004	6/14/2004	Crowley Creek	22
193	198	6/4/2004	6/8/2004	Crowley Creek	4

2009

Tag	Length (mm)	Released Date	Last detection	Last Detected Location	Days of Travel
57191	218	4/16/2009	8/12/2009	Offshore	118
57193	208	4/23/2009	6/1/2009	Offshore	39
57195	178	5/1/2009	6/14/2009	Crowley Creek	44
57196	204	5/7/2009	5/20/2009	Mouth	13
57199	220	5/24/2009	6/1/2009	Offshore	8

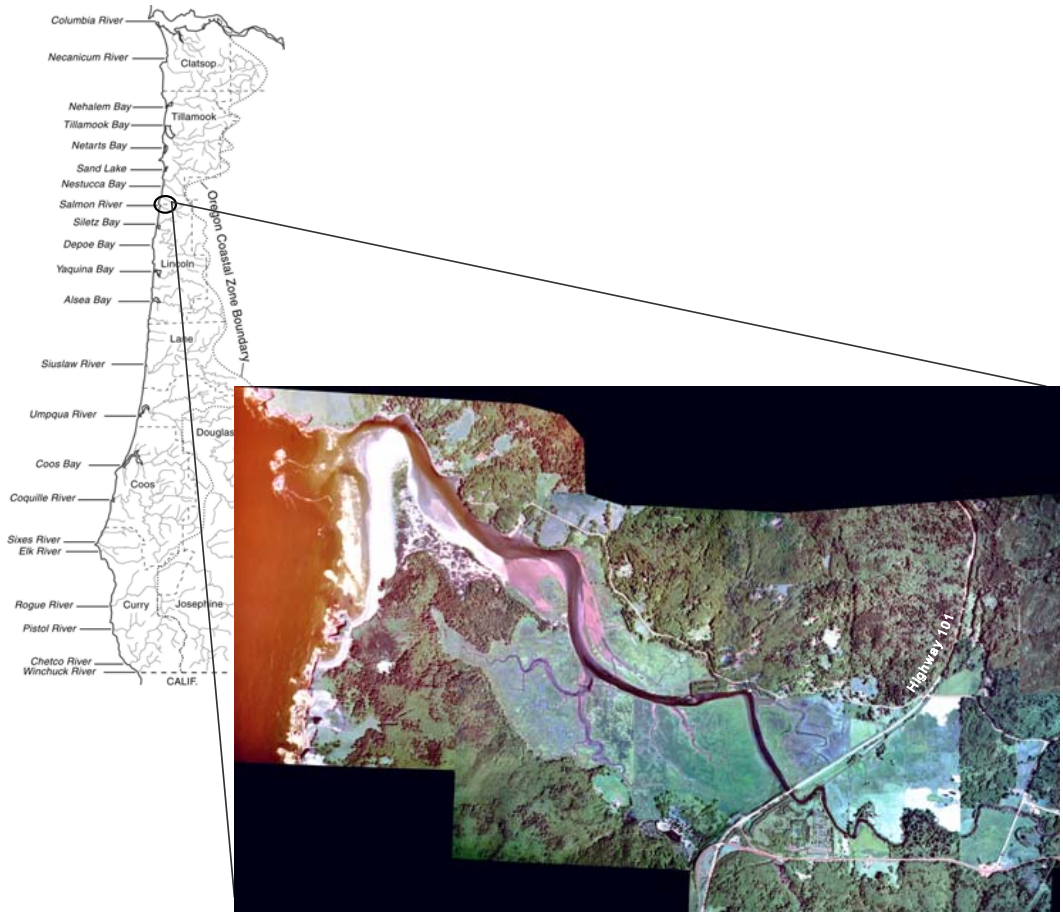

Figure 1. Oregon coast and aerial photograph of Salmon River estuary (graphic courtesy of Jim Good)

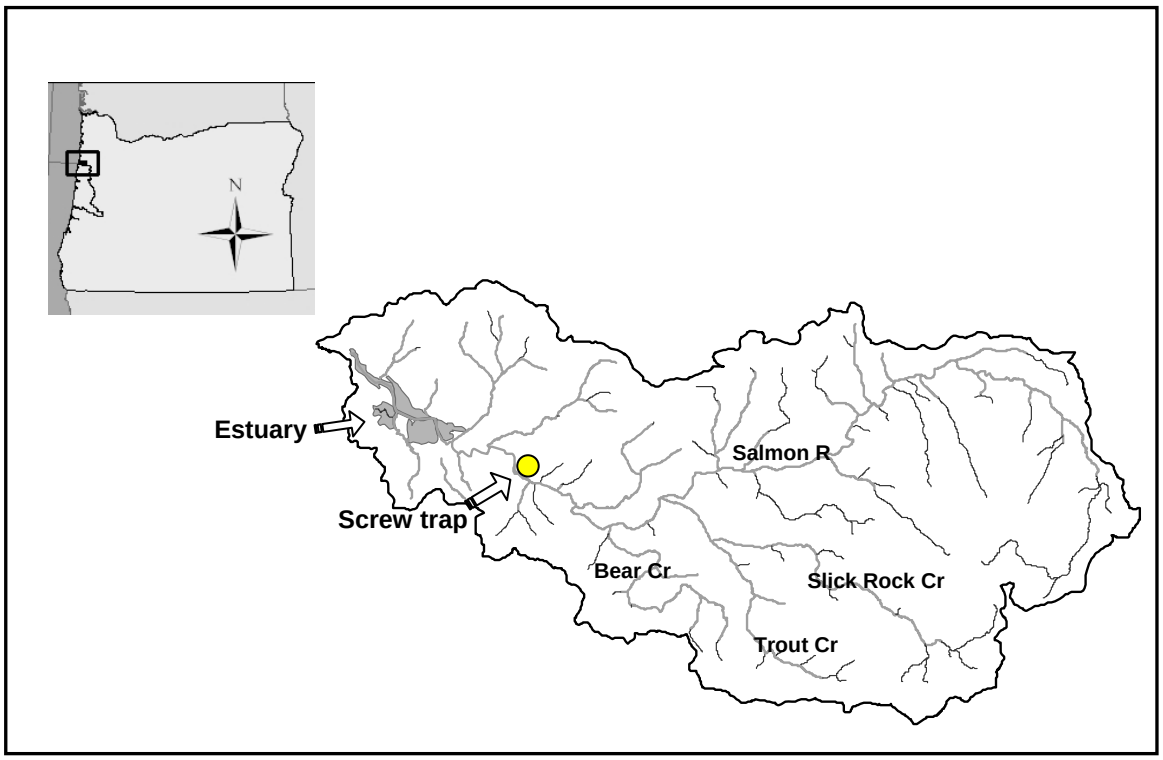

Figure 2. Cutthroat were captured in 2004 and 2009 by a 5-m diameter rotary screw trap operated from March to June each year at rkm 7.9 at the head of tidal influence.

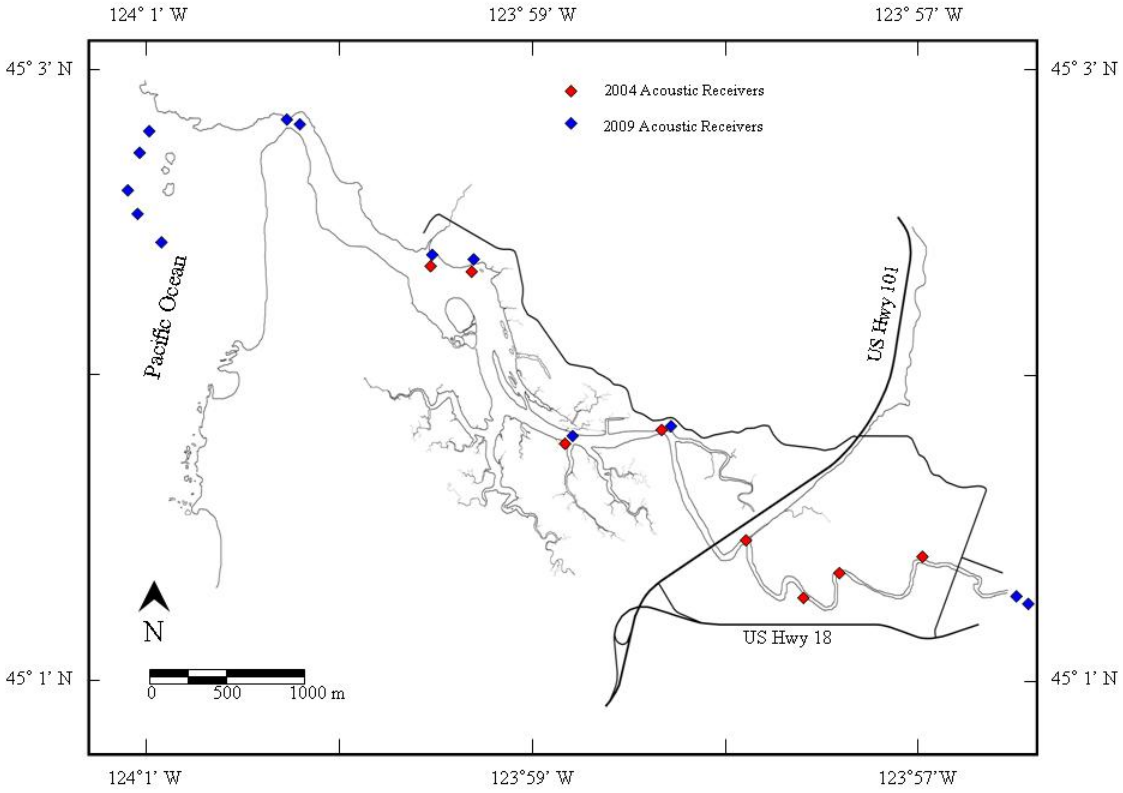

Figure 3. Acoustic receiver locations in 2004 and 2009 in the Salmon River Estuary, near the mouth and offshore.

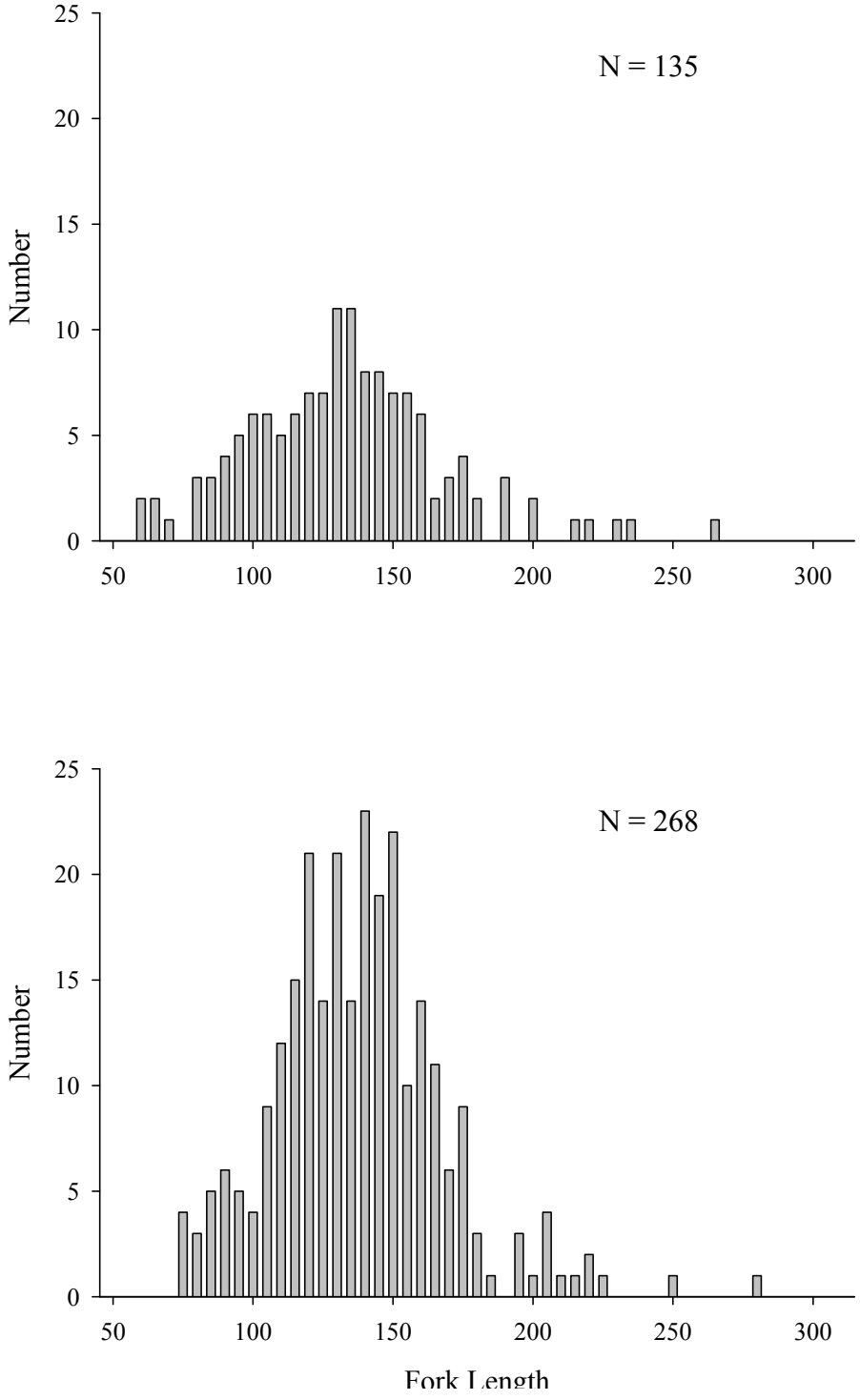

Figure 4. Fork lengths of downstream migrating cutthroat in Salmon River in 2008 (top) and 2009 (bottom).

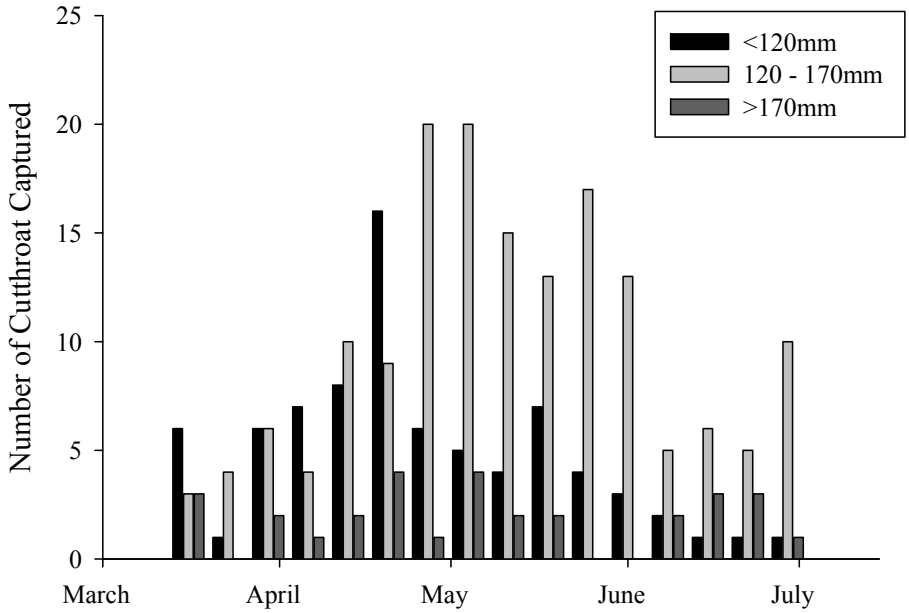

Figure 5. Weekly downstream migration timing of cutthroat trout in the Salmon River smolt trap 2009.

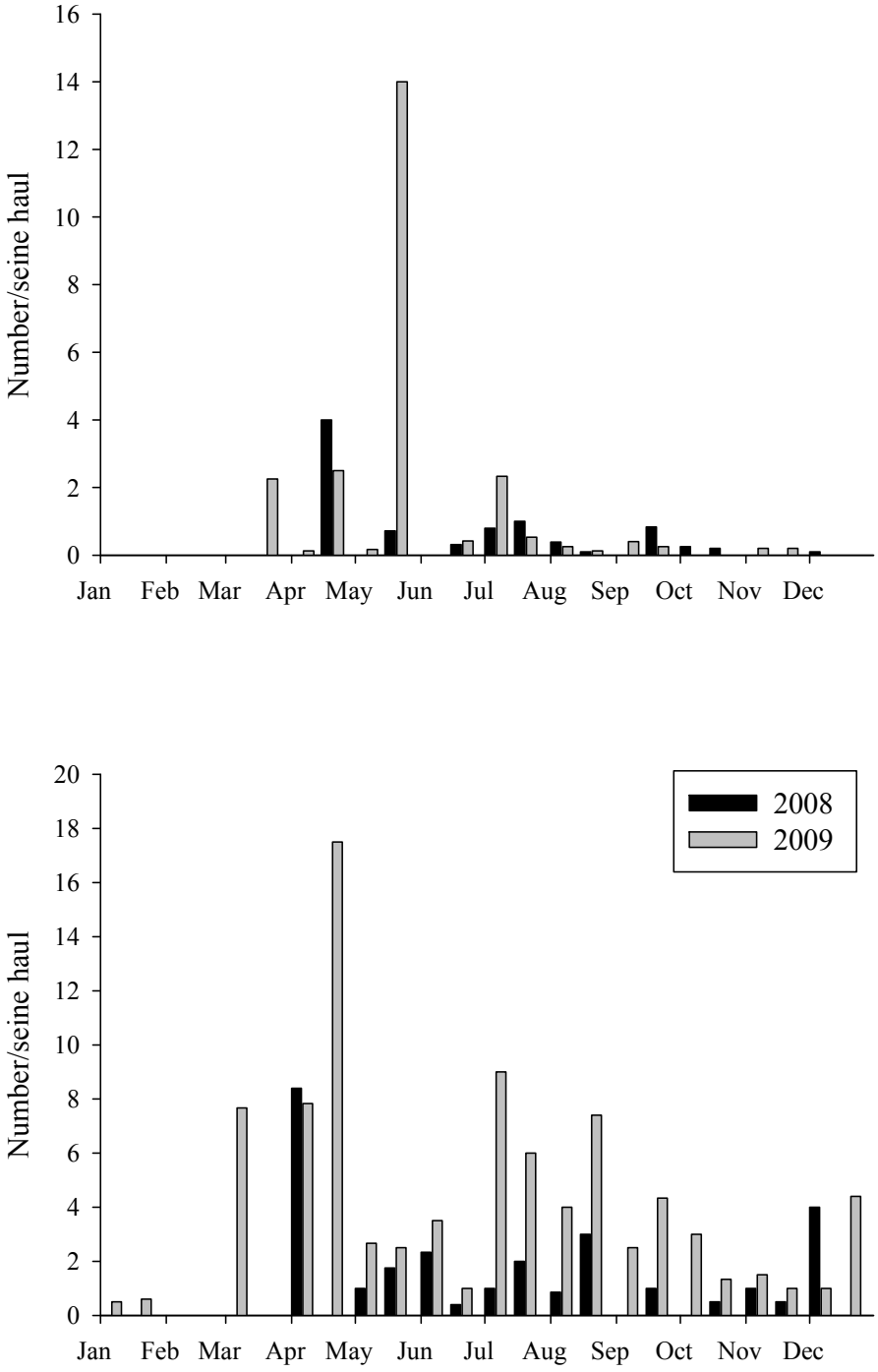

Figure 6. Catch per unit effort of cutthroat trout with a 125' beach seine in the upper estuary (above rkm 2.5) (top) and mid estuary (rkm 1.3 - 2.4) (bottom).

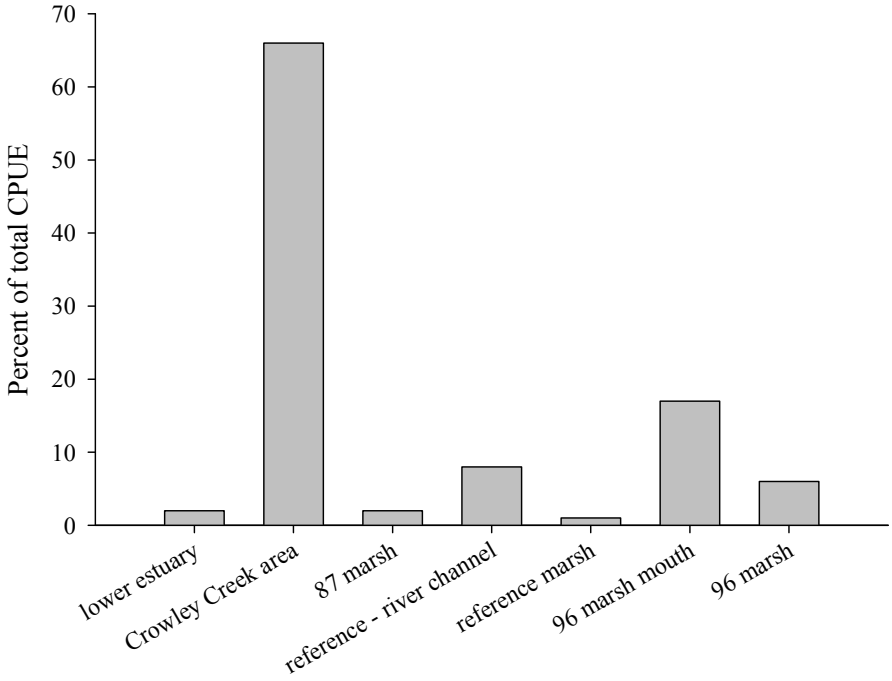

Figure 7. Distribution of cutthroat trout in the Salmon River estuary.

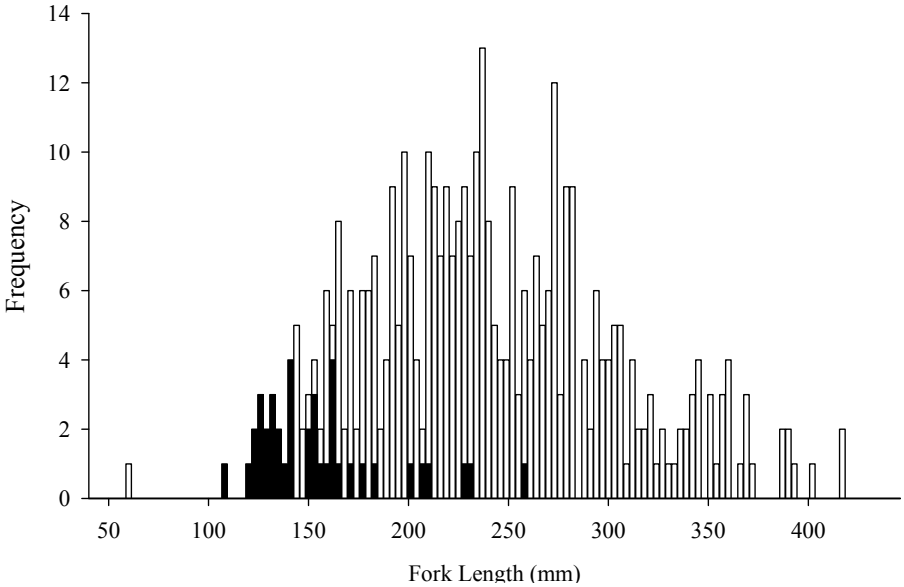

Figure 8. Size frequency histogram comparing fork lengths of cutthroat found in the estuarine marsh channels (black fill) compared to those found in the estuarine river channel.

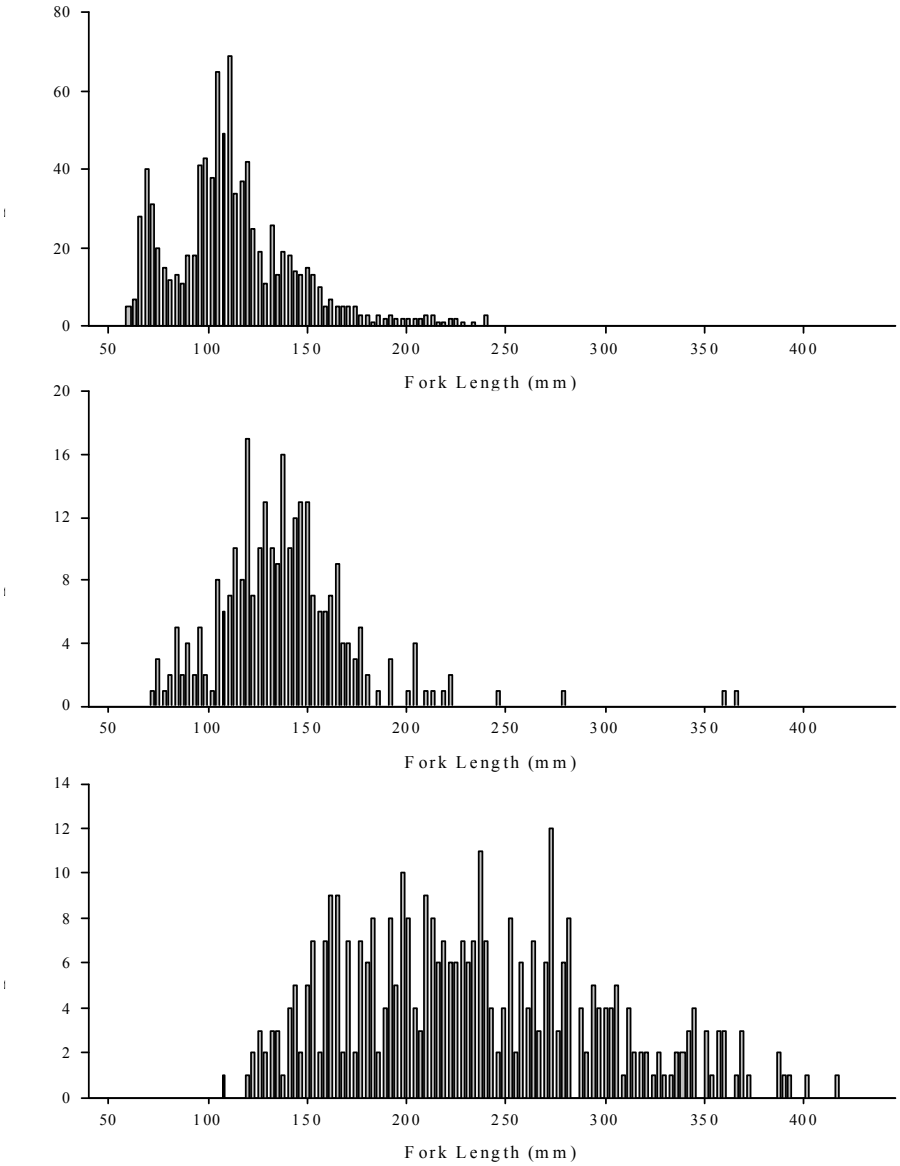

Figure 9. Size frequency histograms for cutthroat trout found in the upper basin in August and September, 2009 (upper graph), caught in the screw trap near the head of tide in March – June, 2009 (middle graph), and caught in the estuary January – December 2009.

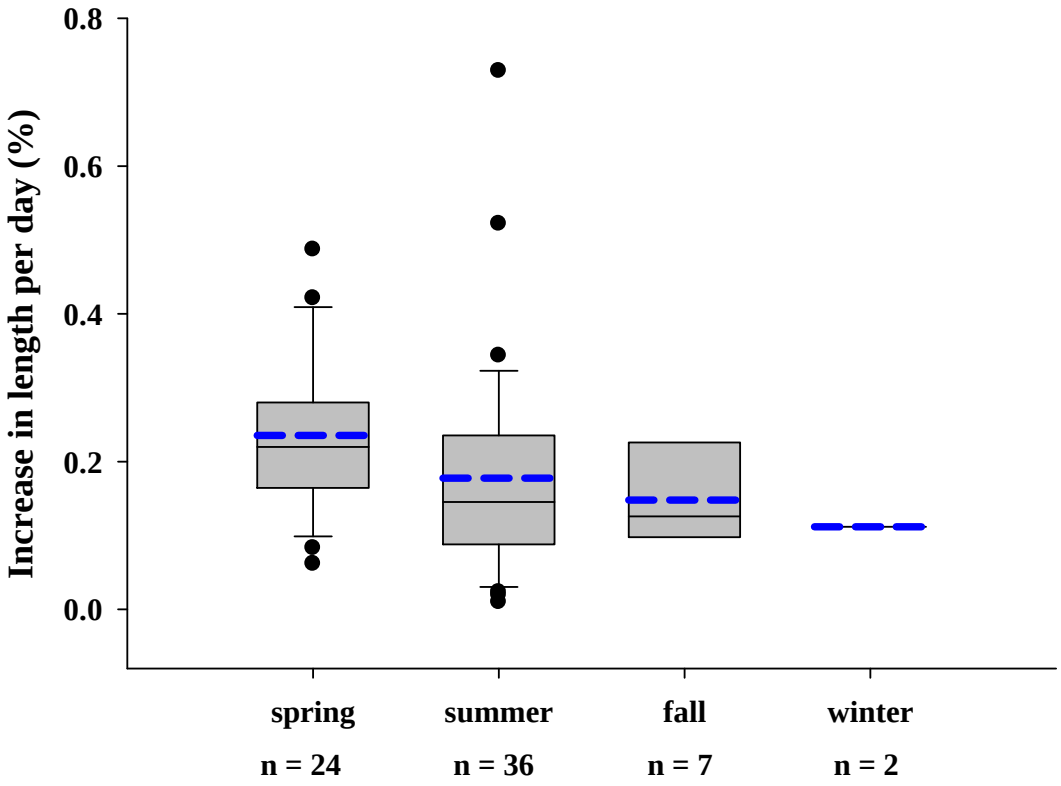

Figure 10. Seasonal growth of cutthroat trout in the estuary based on multiple recaptures of individual fish within distinct seasons. Dashed line indicates the mean growth per season.