1996 OUTMIGRANT TRAPPING PROGRAM
REDWOOD CREEK, MARIN COUNTY

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SUMMARY

An outmigrant trapping program on Redwood Creek, Marin Co. was operated from March 6 through June 28, 1996 by dedicated volunteers and Park personnel. Results indicate a smolt outmigration pattern for coho and steelhead that appears independent of peak flow events for spring-summer 1996. Conversely, young-of-the-year steelhead and coho moved in accordance to peak flow events. This trend is similar to that reported by other investigators. We captured 569 coho smolts and parr-smolts and 14 steelhead smolts and parr-smolts. The production rate of coho smolts and parr-smolts for the 1994-1995 spawning season cohort is estimated at 60.5 fish per km. The production rate of steelhead smolts and parr-smolts for the 1994-1995 spawning season cohort is estimated at 1.3 fish per km. This calculation may be a slight underestimate because trap efficiency was never assessed and high flow events at the tails of the major coho outmigration period were not entirely captured by the trap.

INTRODUCTION

The Redwood Creek watershed is a coastal drainage in southern Marin County, California. It covers 7.5 square miles (PWA *et al*. 1994). The Redwood Creek watershed supports self-sustaining runs of anadromous coho salmon *(Oncorhynchus kisutch*) and steelhead trout (*Oncorhynchus mykiss*). At this time, coho salmon in the Central California Coast Evolutionary Significant Unit are listed as threatened and steelhead are proposed as endangered by the National Marine Fisheries Service.

The range of steelhead and coho salmon within the drainage is variable, depending upon flow conditions that allow adults access into headwater areas of the drainage. During the winter of 1994-1995, adult coho salmon have been observed as far upstream as Bridge 4 in Muir Woods and to the falls in Fern Creek (approx. 1 km from confluence with Redwood Creek). In addition, juvenile coho salmon during the summer of 1995 were found in Kent Canyon just below the falls (approx. 0.6 km from confluence with Redwood Creek) (M. Khosla, pers. comm. 1995). The range of steelhead within the Redwood Creek drainage is slightly larger. They have been reported by Hofstra and Anderson (1989) to extend to the confluence with Rattlesnake Creek, a distance of 1.1 km above Bridge 4 in Muir Woods. The estimated stream distance used by coho salmon and steelhead are 9.4 km and 10.5 km respectively, based on measurements from stream habitat inventory and USGS topographic maps (Pt. Bonita and San Rafael 7.5 minute quads).

Past efforts to improve habitat quality and quantity for aquatic animals within the Redwood Creek watershed have resulted in reduced water diversions, elimination of Park Service septic systems, improved land management through the reduction of grazing and cessation of logging, and cessation of instream removal of woody materials.

In addition, future actions are underway to further improve freshwater habitat conditions for aquatic species within Redwood Creek. A major restoration project is planned for Big Lagoon at the mouth of Redwood Creek, in part to benefit anadromous fisheries (PWA *et al*. 1994). Implementation of the preferred restoration alternative would enlarge and deepen Big Lagoon to its approximate historic configuration. In addition, a 5-year project is now underway to assess population status and conditions for salmonids in 4 major stream systems within Point Reyes National Seashore and Golden Gate National Recreation Area. Implementation of restoration and preservation actions will be a key component of this project.

In order to assess the benefits of the restoration project (and other watershed improvement actions) to special status species such as steelhead and coho, baseline estimates (pre-project data) of fish are needed. Use of counts from outmigrant traps is one means of obtaining this data.

In addition, several monitoring activities for different life stages of coho and steelhead are underway. Winter counts are being conducted by the Golden Gate National Recreation Area (GGNRA) to develop an index of returning adult coho. Dr. Jerry Smith (San Jose State Univ.) has been conducting electrofishing surveys to determine the densities of juvenile coho and steelhead during the late summer. Information from an outmigrant trapping program will supplement these ongoing efforts and help determine the numbers of fish that survive winter conditions and leave the freshwater environment as smolts. It will also provide life history information that could be used in interpretive programs for GGNRA.

National Park Service Policy

It is a policy of the National Park Service (NPS) that the primary management objective in natural zones will be the protection of natural resources and values for appropriate types of enjoyment while ensuring their availability to future generations. Furthermore, the NPS will identify and promote the conservation of all federally listed threatened, endangered, or candidate species.

The Natural Resources Section of the Resources Management Plan for GGNRA (Coho salmon and steelhead preservation/restoration: GOGA-N-81) has recommended three years of surveys in Redwood Creek to assess returning adults, rearing juveniles, and smolt escapement.

Objectives

The project objectives were as follows:

1. Estimate the number of outmigrating steelhead and coho smolts in the Redwood Creek watershed for the winter 1994-1995 year class

2. Determine characteristics of the outmigration, including period of peak outmigration and associated hydrologic characteristics including rainfall, water temperature, and discharge.

METHODS

Outmigrant Trap

In Waddell and Scott Creeks (Santa Cruz County), outmigration of coho smolts occurred in mid-March and peaked in mid-May (Shapovalov and Taft 1954). In Lagunitas Creek (Marin Co.), results from smolt trapping from 1983-1985 indicated that coho emigration began in early April and ended in late June (Bratovich and Kelley 1988). Steelhead emigration generally begins in early-March and ends by June (Bratovich and Kelley 1988). Based on this information, we deployed the outmigrant trap from March through the end of June 1996. The trap was removed intentionally on two occasions: March 16-17 and April 2-16, 1996 (high flow events). The trap was dismantled by unknown individual(s) on April 22-23rd.

The trap site was located 600 meters above the mouth of the creek (Figure 1). We placed the trap at the head of a pool with a backwater area associated with it. We situated the trap mouth near the thalweg so that most of the flows went directly into the trap rather than into the fence.

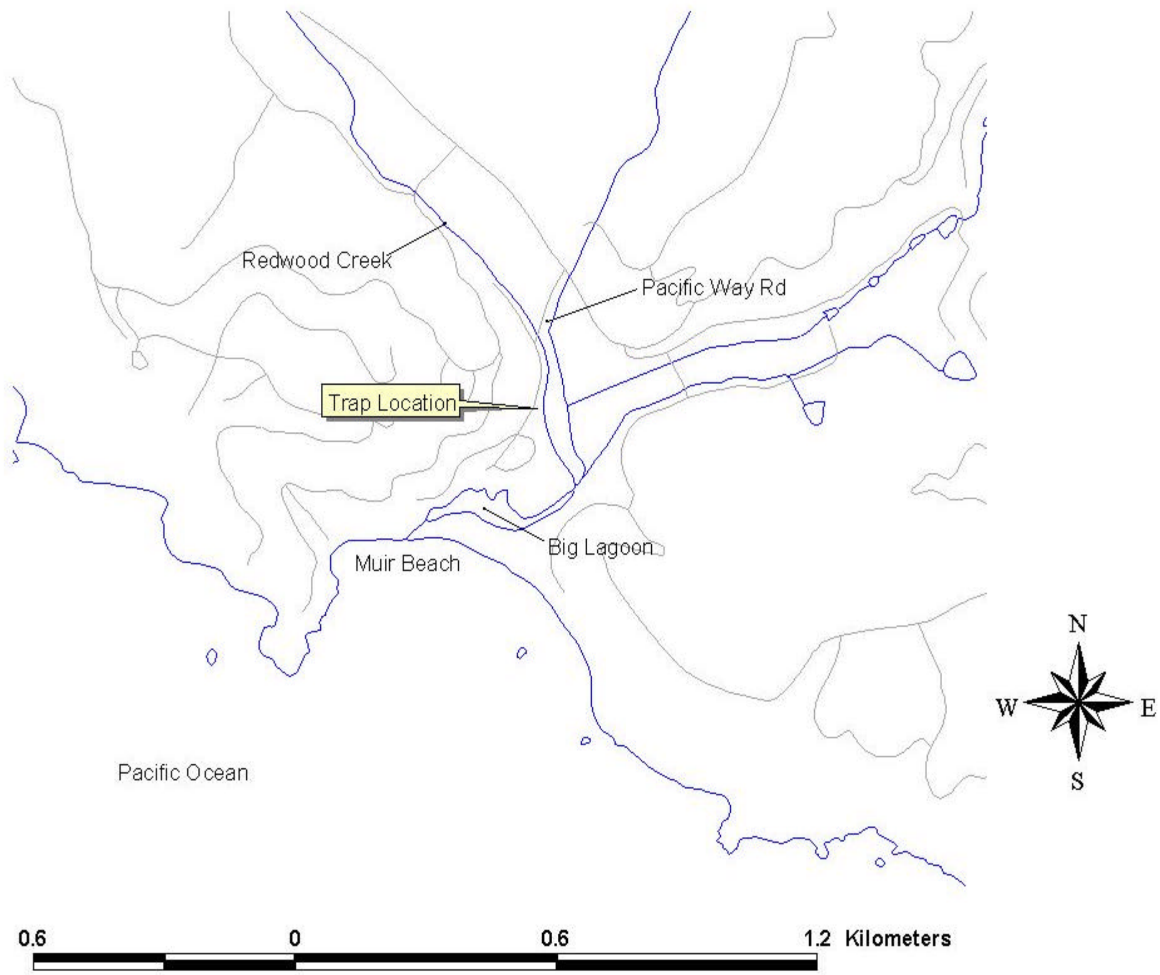


Figure 1: Location of Outmigrant Trap, Lower Redwood Creek, Marin Co., Spring 1996

Bill Cox, Wendy Jones and Jennifer Nelson (California Department of Fish and Game), Gary Stern (National Marine Fisheries Service) and Paul Bratovich provided information regarding operation, location, and design of traps. We used a live box made of 1/8 inch mesh and supported by a frame made of PVC pipe attached to a fyke net (approximately 5 m in length) (Figure 2). Baffles were placed within the live box to reduce water velocities. We installed a fence comprised of ¼ inch and ½inch mesh hardware cloth to direct fish and other organisms into the attached fyke net and live box. During the month of March, a small portion of flows were allowed to bypass the trap along the inside point bar. This arrangement allowed any adult steelhead to move relatively unimpeded to upstream spawning sites. A picture of the trap set-up is illustrated in Figure 3.

Figure 2: Live car box for outmigrant trap

Figure 3: Redwood Creek smolt trap layout

Under normal flow conditions, the trap was checked once in the early morning. This frequency was selected to balance excessive labor efforts with the need to prevent injury because of prolonged trap residence. Most seaward movement of juvenile salmonids occurs at night. Similarly, twice-daily trap visits on Lagunitas Creek were abandoned because few or no few fish were captured between the morning and afternoon (Bratovich and Kelley 1988). Also, trap checks that occurred during the day for this project produced few or no juvenile salmonids. Under high flow events, the trap was checked frequently during the day to remove accumulated debris within the trap and along the wing walls.

Volunteers, park maintenance and interpretive staff all assisted in the operation of the outmigrant trap. Prior to field activities, the Park aquatic ecologist provided a training session to review data collection, species identification, and handling of organisms. The Park aquatic ecologist also assisted each team throughout the trapping season.

Collected Species Data

All collected species were identified and counted. For young-of-the-year steelhead and coho, up to 50 randomly selected fish were measured for length and weights. We recorded the lengths and weights of all smolts and parr-smolts. To minimize handling stress of fish, a handful of fish were placed in a partially filled 5-gallon bucket of water containing 1-2 Alcaseltzer tablets. Fish were removed and measured after their equilibrium appeared impaired. Following measurements, fish were placed in a dark, aerated bucket to recover. Collected information included species identification, morphological categories, numbers of fish, fish length (fork length for salmonids, total length for other fish), and wet weight (gm). We used an Ohaus scale to record wet weights to the nearest gram. Steelhead and coho were separated into the following morphological categories: smolt (near absence of parr marks, silver body, deciduous scales), parr (small size, parr marks), partial smolt (intermediate characteristics), and adults (Figures 4-5) (Bratovich and Kelley, 1988; Nelson 1994). Any mortality or injury were recorded as well as the probable cause.

Figure 4: Coho morphological condition, Redwood Creek

Figure 5: Steelhead morphological condition, Redwood Creek

Following acclimation, the measured fish were released at various locations downstream of the trap in order to reduce predation risk. Several large 1-2+ steelhead were observed in pool where the trap was located.

Trap Efficiency

We did not evaluate trap efficiency. Standard methods of marking fish (e.g. mutilation or fin clips) were rejected because of potential impairment to individual fitness. Furthermore, adipose fin clips with the least likelihood of impairing fitness were not recommended because hatchery fish typically have their adipose fins removed. Near the end of the trapping season, 4 coho smolts were tattooed with Alcian Blue stain using a needleless injector (Panjet). Tattooed smolts were released in a main channel pool several meters upstream of trap. No smolts were reported as recaptured; however, 4 similarly sized fish were reported in subsequent days lacking marks. It is possible that marks were misapplied or may have faded.

We assumed that very few smolts bypassed the trap under normal flow conditions. Most smolts appeared during mid-April through May, when all flows were captured by the trap. On 3 occasions in March when flows exceeded 40 cfs, a side channel upstream of the trap likely diverted up to 15% of total creek flows. In addition, we left a narrow gap at the end of our trap fence near the point bar to allow passage of any upstream migrating steelhead through the end of March. On the night of May 15th, high flows resulted in up to 50% of flows being diverted around trap and in the upstream secondary channel. During this period, 41 coho smolt and parr-smolts were captured. Perhaps another 40 or so coho smolts and parr-smolts would have been caught if all flows were captured by the trap.

Physical/Hydrologic Data

Outmigration is influenced by several environmental factors. The timing and numbers of emigration are influenced by water temperatures, photoperiod, size of fish, flow conditions, dissolved oxygen levels, and food availability (Sandercock 1991). Downstream movement ceases when water temperatures approach 18^{o}C (Kelley 1992). In years with low flow and higher temperatures, outmigration is often earlier than usual (Sandercock 1991).

While it is not possible to measure all factors that influence outmigration, at least temperature, daily rainfall, and discharge information were recorded. A remote temperature data logger (Onset Instrument-Stowaway WTS6-2K) was placed in a backwater pool in Redwood Creek upstream of trap and at the pedestrian bridge at Big Lagoon. Only the data logger at the Big Lagoon site operated properly throughout the entire sampling period. The weather station in Muir Woods National Monument provided daily rainfall totals. A staff gage, located on the Pacific Way Bridge, just a couple hundred meters upstream of the trap, was read daily to estimate discharge. Periodic measurements of discharge using a pygmy gurley meter were conducted under a range of flow conditions to establish a stage-discharge relationship.

We measured water velocities during March and April in front of the trap and within the live box. Information was used to add and adjust baffles to reduce water velocities that would result in mortality or undue stress.

Throughout the entire trapping season, we periodically checked the lagoon to see if there was a connection to the Pacific Ocean. Because of late season rains in April, the lagoon was open to the ocean throughout the entire trapping season.

Data Analyses

All hydrologic and fish data were entered into Microsoft Excel 5.0 spreadsheets. Data analyses were conducted in Microsoft Access and Excel. For coho and steelhead parr, parr-smolts, and smolts, we computed a Fulton condition factor (K).

$K = \text{Weight} \times 100{,}000 / \text{Length}^3$, where weight= grams and length= fork length (mm).

Permits Required

The U.S. Corps of Engineers (Regulatory Branch-San Francisco) was contacted to determine if installation of fence posts and trap would be regulated under their authorities. Because no discharge of fill was involved, no permit was be needed. Also, Nationwide Permit 4 (Fish and Wildlife Harvesting, Enhancement, and Attraction Devices) would cover proposed activities. The project also went through GGNRA's project review. Sampling activities were also covered by the park's scientific collection permit (GOGA-96-001).

RESULTS AND DISCUSSION

Injury and Mortality

Throughout the entire outmigrant trapping period, observers paid careful attention to the injury and mortality of all trapped organisms. To the extent practicable, the trap was also modified to reduce stress and prevent capture of sensitive life stages of fish and other animals. Solid and preforated baffles were placed within the trap to deflect the brunt of flows and create backwater like conditions in the trap. Midway through the trapping period, we placed a pre-screen in front of the trap to shunt ducklings and other floating life away from the trap. The wing walls were also changed from ¼inch wire mesh to ½inch wire mesh to reduce the number of young-of-the-year salmonids captured in the trap as well as to reduce the volume of flow directed into the trap. During high flow events, the trap was often checked twice to release captured fish and to clear debris from the trap. On two occasions, the trap was pulled from the creek because of extremely high creek flows and trap mortalities.

Most mortalities were associated with extremely high flows that likely caused injury and death within the trap due to impingement and/or fatigue. Incidental mortalities were observed to the following species: mallard duck (ducklings), coho (smolt and young-of-the-year), steelhead (young-of-the-year), and three-spine stickleback. An unknown number of young-of-the-year salmonids also fell prey to older steelhead and sculpin. Many of the captured larger fish had distended stomachs (Figure 5). The summary of injury and mortalities are provided in the following table:

Table 1: Accidental outmigrant trap mortalities, Redwood Creek, Marin Co., March 6-June 28, 1996.

Species	***Life Stage***	***No. of Injuries/Mortalities***	***Percent of Total Captured***
coho salmon	young-of-the-year*	210 (m)	5.3
	parr-smolt	1 (m)	2.7
	Smolt	4 (m)	0.8
steelhead trout	young-of-the-year*	13 (m)	3.7
three-spine stickleback	N.A.	3 (m)	6
California giant salamander	adult**	1 (i)	100
mallard	Duckling	6 (m)	

Notes: *Because of their small size, a few mortalities may have been misidentified as young-of-the-year steelhead.
**The only adult California giant salamander had a mangled upper jaw that might be a trap-induced injury.

Species Composition

A total of 11 species were captured in the outmigrant trap (APPENDIX 1). Fish taxa included coho salmon (yoy, parr, parr-smolt, smolts), steelhead trout (yoy, parr, parr-smolt, smolts, adult), threespine stickleback, prickly sculpin, and unidentified sculpins. Not all of the captured organisms were fish. Non-fish species captured included mallards (adult and duckling), California giant salamanders (adult and juvenile), California newt, rough-skinned newt, Pacific treefrog, and signal crayfish (adult and larval). All of these species have been previously reported to have been within the Redwood Creek watershed.

A total of 5102 individuals were captured by trapping activities between March 6 and June 28, 1996. Young-of-the-year steelhead and coho comprised the bulk of these individuals. A total of 4427 coho and steelhead young-of-the-year constituted 87% of all individuals trapped.

Young-of-the-year coho and steelhead

Large numbers steelhead and coho YOY (>50 inviduals/trap day) were consistently captured over a two-week period (March 7-21, 1996). In general, sharp increases in discharge corresponded with large numbers of steelhead and coho YOY being captured in the trap (Figure 6). The sharp increases in discharge were associated with rainfall events (Figure 7). These results are consistent with the findings of Hartman et al. (1982) which found that seaward movement of coho fry in a British Columbia stream was triggered by rain or initial rises in water level. Later work on this same British Columbia stream (Carnation Creek) found a strong temperature dependent relationship between the median date of coho fry emigration and accumulated temperatures (Holtby et al. 1989)

Some of the salmonid YOY during March were hard to differentiate because of their small size (less than 30 mm FL), absence of dorsal spotting, and similar parr marks. Based on examination of anal fins from preserved mortalities, we suspect that most of these March YOY were coho. Nevertheless, we lumped these two together in the March totals. The peak downstream movements of YOY did not correspond with coho smolts and parr-smolts. The March 7-21st period had very few smolts and parr-smolts moving downstream.

Coho smolts and parr smolts

We generated a minimum production estimate for the Winter 1994-1995 coho year class. Spawning activities occurred from above the Pacific Way bridge through MUWO and into State Parks. In addition, spawning activities occurred within Kent Canyon and Fern Creeks. A rough estimate of total distance is 9.4 km. The total number of captured parr-smolts and smolts was 569. The estimated production of coho is 60.5/km. For comparison, the computed production estimates for Waddell Creek range from 34-1,120 coho/km of usable stream (Shapovalov and Taft 1954).

Our production estimate for Redwood Creek's Winter 1994-1995 year class falls close to the low end of production for Waddell Creek.

It is possible that early smolting individuals may have left the Redwood Creek system prior to trap installation in March. However, it is unlikely that they represent a significant proportion of the year class production of smolts. During their 6-year operation of a downstream trap on Waddell Creek, only 4 percent of a year class's production left for the ocean between July and March (Shapovalov and Taft 1954).

Coho parr-smolts and smolts were captured throughout the trapping season. However, peak numbers occurred during 3.5 weeks in late April - early May after a major high flow in late March (Figure 8). During this period, we captured 91% of the coho smolts and parr-smolts for the season. This pattern is similar to another stream. In Carnation Creek, British Columbia, Holtby et al (1989) found that 50% of emigrating coho fry and smolts emigrated over a 2-3 week period. The outmigration peak occurred earlier that reported by Shapovalov and Taft (1954), which consistently found peak numbers occurring in early to mid-May.

Although scale samples were not obtained from smolts and parr-smolts, most are probably 1+ fish. The length-frequency distribution shows a unimodal distribution that suggests a single year class (Figure 9). Similarly, Shapovalov and Taft (1954) note that scale analyses from returning adults show all adults migrating to the ocean at age 1.

Length and Condition. We broke the trapping period into 3 separate time periods to determine if there were any obvious patterns in fork length or condition with outmigrating smolts. There were no obvious patterns in mean fork lengths during the three time periods for parr-smolts (ANOVA, df= 36, p=0.52). However, outmigrating smolts during the April 15-May 14 period were on average, significantly larger than smolts leaving later (Table 2) (Student t-test, df=530, p=0.05).

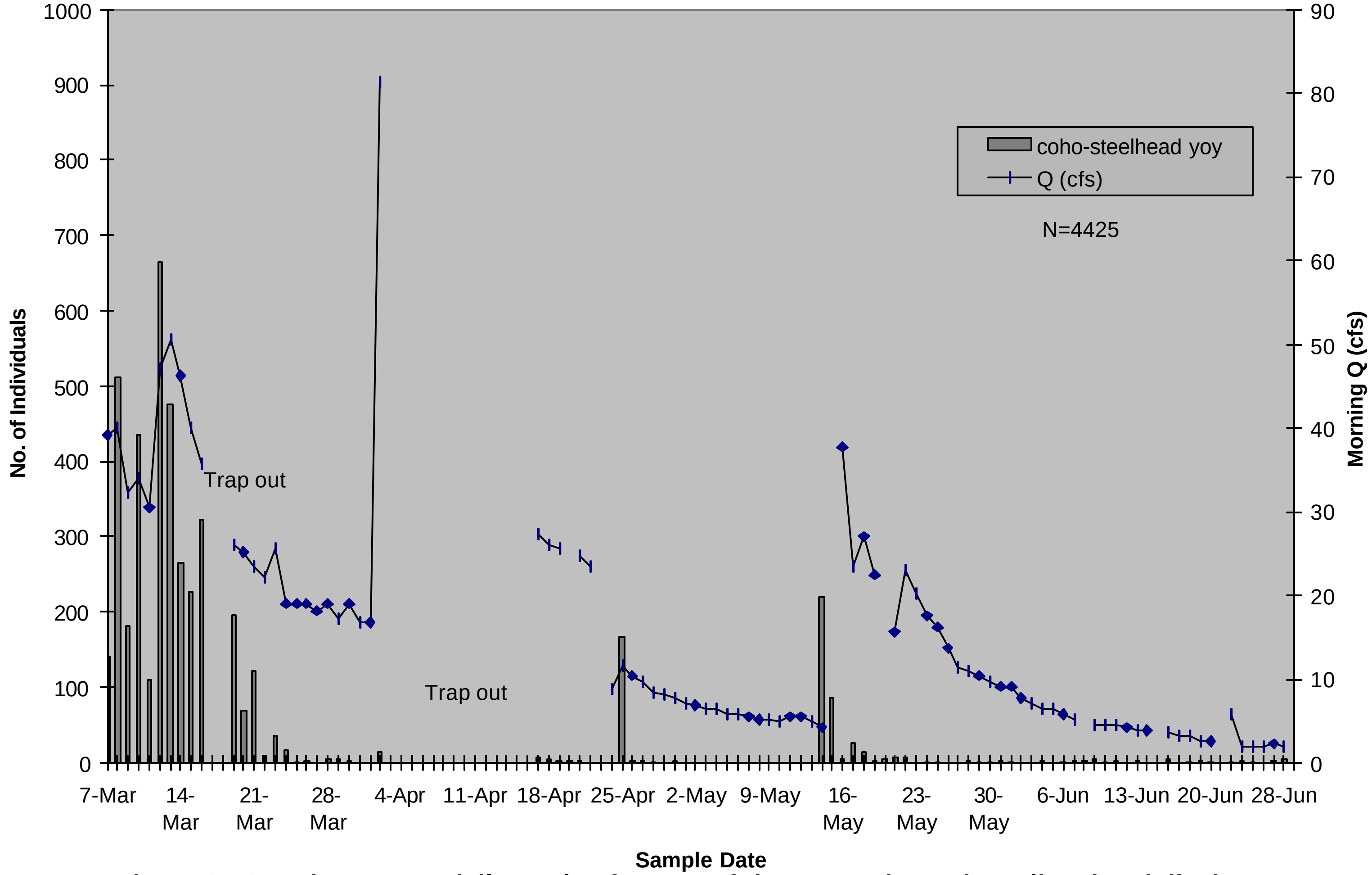


Figure 6: Outmigrant trap daily totals of young-of-the-year coho and steelhead and discharge in Redwood Creek, Marin Co., March-July 1996

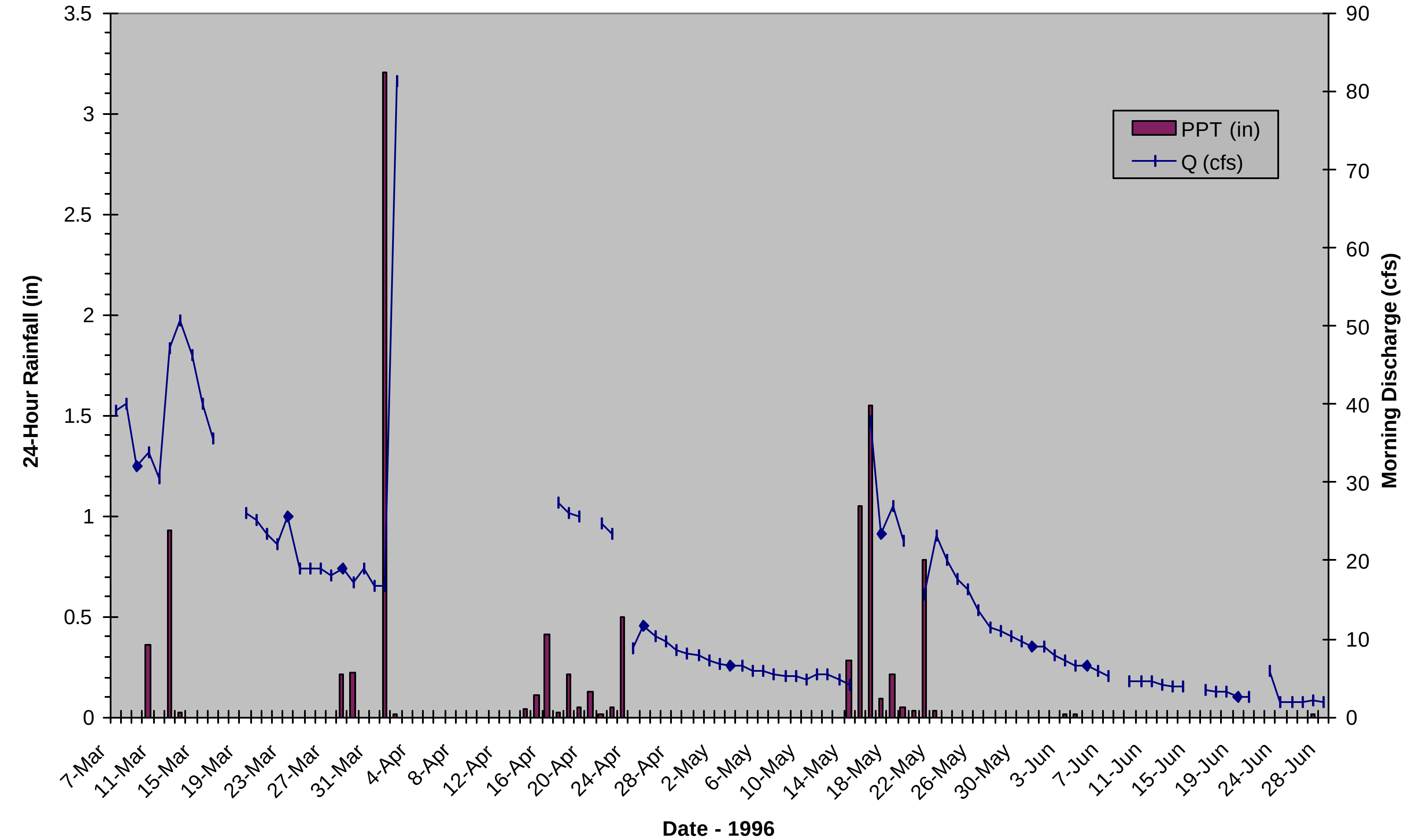


Figure 7: Daily rainfall and discharge at Redwood Creek, Marin Co., March-July 1996.

Figure 8: Outmigrant trap daily totals of coho smolts and parr-smolts and discharge in Redwood Creek, Marin Co., March-July 1996

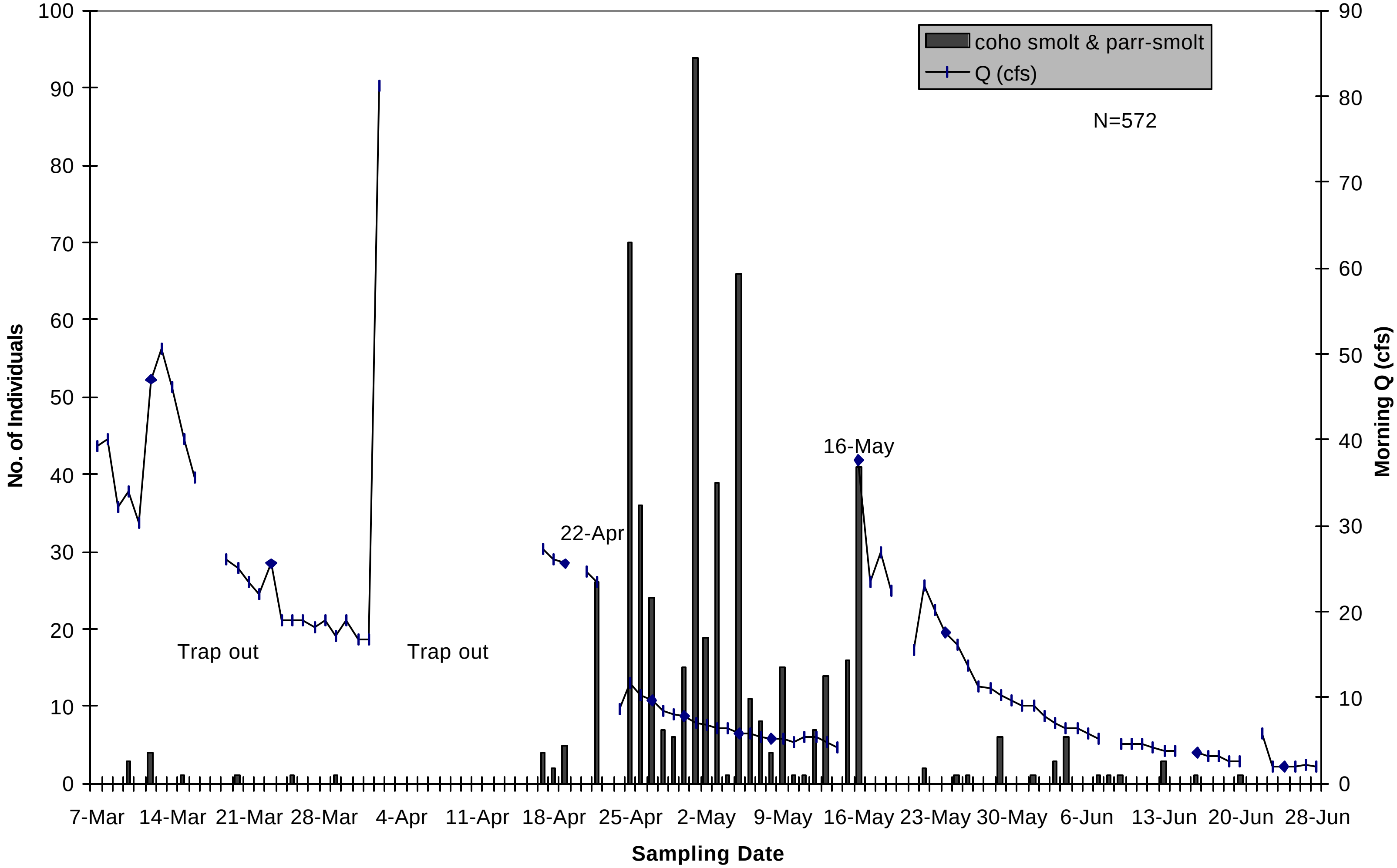
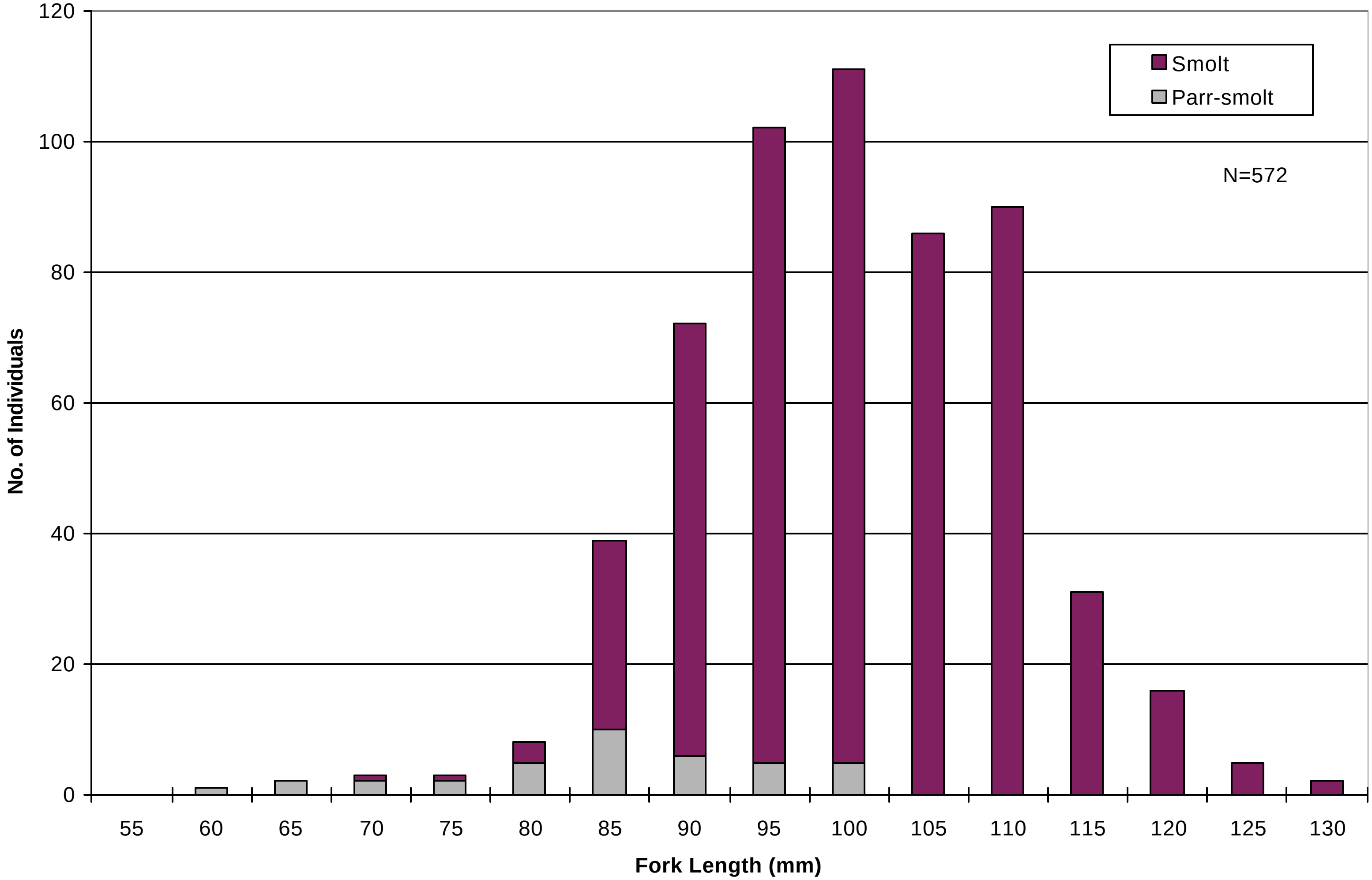


Figure 9: Length-frequency distribution for coho parr-smolt and smolts captured from March 7-June 28, 1996 in Redwood Creek, Marin Co.



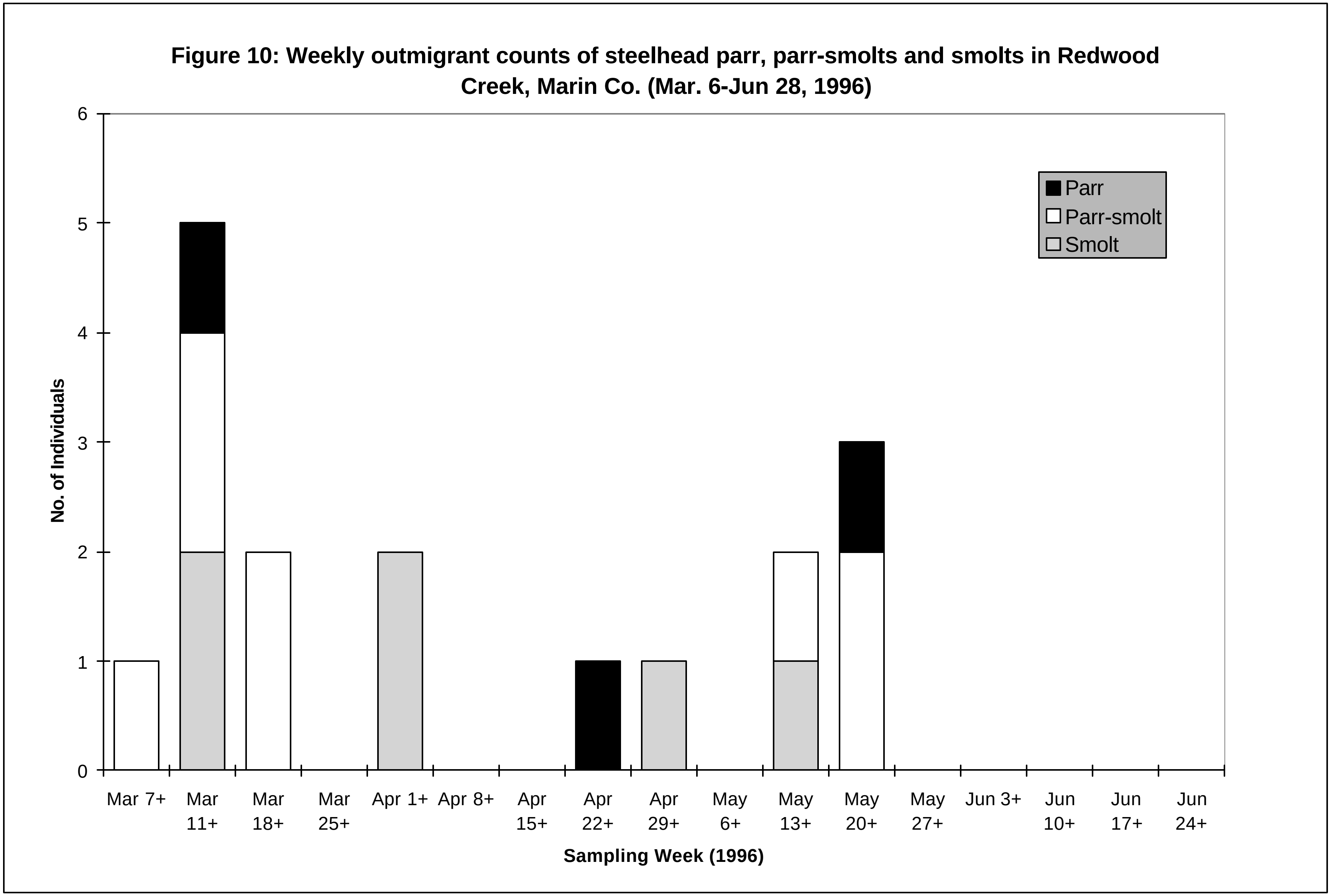


Figure 10: Weekly outmigrant counts of steelhead parr, parr-smolts and smolts in Redwood Creek, Marin Co. (Mar. 6-Jun 28, 1996)
No. of Individuals
0
1
2
3
4
5
6
Parr
Parr-smolt
Smolt
Mar 7+
Mar 11+
Mar 18+
Mar 25+
Apr 1+
Apr 8+
Apr 15+
Apr 22+
Apr 29+
May 6+
May 13+
May 20+
May 27+
Jun 3+
Jun 10+
Jun 17+
Jun 24+
Sampling Week (1996)

Figure 11: Water Temperature at Lower Redwood Creek at Big Lagoon Ped. Bridge (Feb. 1996-July 1996)

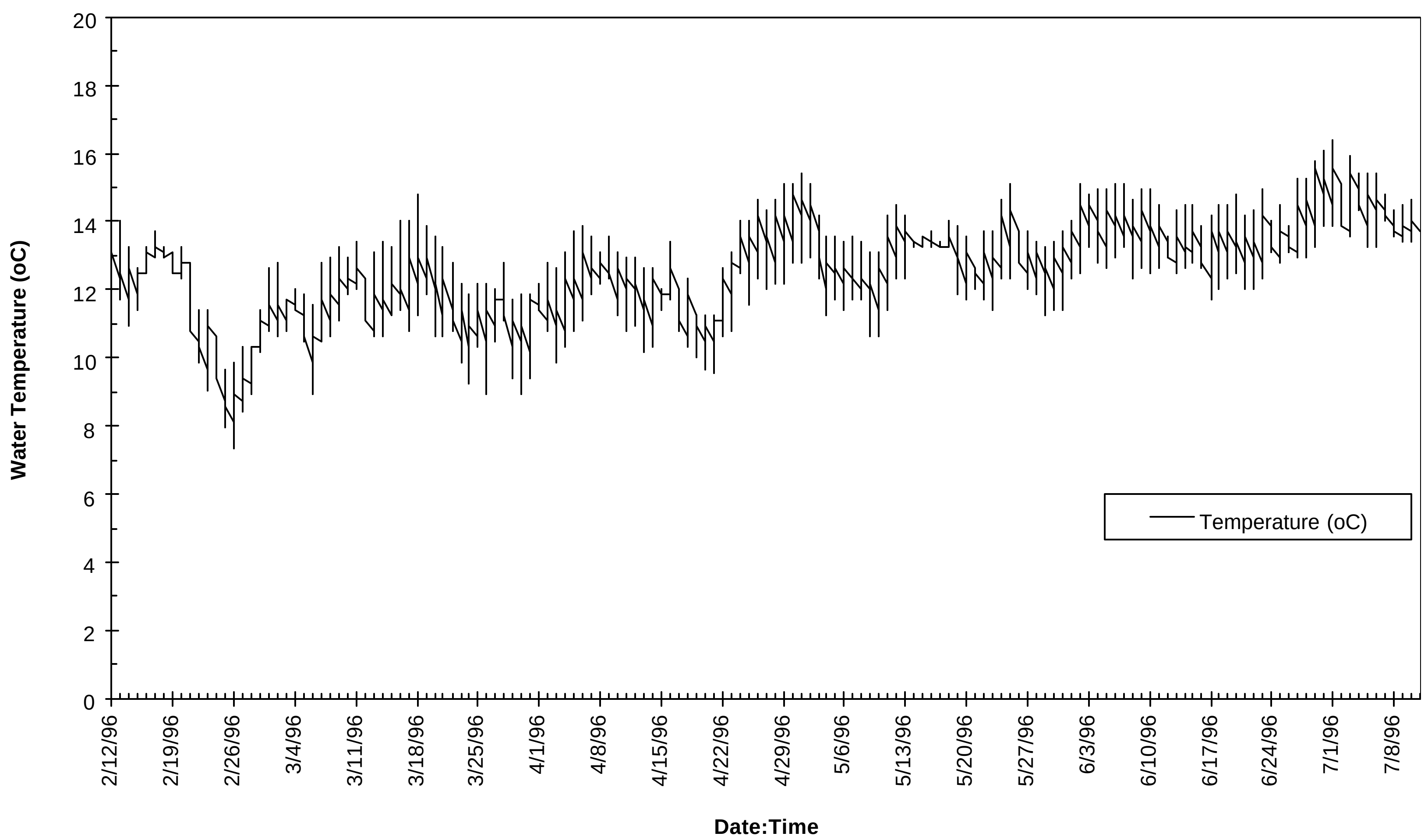


Table 2: Mean fork length of coho parr-smolt and smolts by sampling period, Redwood Creek, Marin Co., March 6-June 28, 1996.

Period	Coho Parr-Smolt			Coho Smolt		
	n	Mean (mm)	S.D.	n	Mean (mm)	S.D.
Mar 6-Apr 14	9	89.1	11.9	1	75.0	N.A.
Apr 15-May 14	18	88.2	6.9	457	103.3	9.3
May 15-June 28	10	92.0	6.9	75	101.0	8.5
Total	**36**	**89.3**	**8.3**	**533**	**102.9**	**9.3**

It appears that the Fulton condition factor for coho smolts during April 15-May14 was higher than the last time period, indicating that the early leaving fish were "plumper" than fish leaving during later periods (Table 3, Student t-test, df=503, p<0.01). Coho parr-smolts caught in the March 6-April 14 period were "plumper" than fish caught during the later periods (Table 3; ANOVA, df=33, p<0.01; Newman-Keuls Multiple Comparisons, 0.05 significance level).

Table 3: Mean Fulton condition of coho parr-smolt and smolts by sampling period, Redwood Creek, Marin Co., March 6-June 28, 1996.

Period	Coho Parr-Smolt			Coho Smolt		
	n	Mean	S.D.	n	Mean	S.D.
Mar 6-Apr 14	8	1.31	0.17	NA	NA	NA
Apr 15-May 14	18	1.12	0.18	457	1.06	0.13
May 15-June 28	8	1.02	0.10	73	1.01	0.17
Total	**34**	**1.14**	**0.19**	**530**	**1.05**	**0.14**

Steelhead smolts

We captured very few steelhead smolts and parr-smolts. A total of 14 smolt and parr-smolts were captured (Figure 10). Steelhead in this area can spend 1-4 years in the streams before leaving for the ocean (Shapovalov and Taft 1954). Two smolts had fork lengths of 243 and 250 mm respectively. Assuming similar growth rates to steelhead captured by Shapovalov and Taft (1954), these sizes indicate that they are likely 3-4 year olds. Excluding yoy steelhead, the predominant age classes leaving for the ocean are 1-2 year olds (Shapovalov and Taft 1954). The extreme low numbers of steelhead smolts suggests low production of winter 1994-1995 (1 year olds) and winter 1993-1994 (2 year olds). Dr. Jerry Smith found extremely low densities of juvenile steelhead in summer electrofishing sampling. However, this speculation cannot be confirmed since no outmigrant data are available for Spring/Summer 1995 or 1997.

Unlike coho, steelhead smolts and parr-smolts did not exhibit any pronounced peak in outmigration. This result is quite similar to that reported by Nelson (1994) for wild steelhead smolts trapped between March and May 1993 in Scott Creek, Santa Cruz County.

One run-back adult steelhead was captured on April 1.

Temperature

Water temperature data was only available from the Big Lagoon pedestrian bridge site. The temperature data logger at an upstream site in Redwood Creek experienced a short because of water infiltration into the battery casing. With the exception of Big Lagoon itself, temperatures at the exposed pedestrian bridge location represent the warmest waters within Redwood Creek. Even so, water temperatures from the Big Lagoon pedestrian bridge did not exceed 18^{o} C (Figure 11), which is the temperature that results in cessation of downstream smolt movement (Kelley 1992).

Other Streams

Temporal trends in outmigration are remarkably similar to those observed in local streams. Consultants for MMWD operated on outmigration trap on Lagunitas Creek from March through June 1983-1985, and 1983 on two tributaries. Steelhead smolts on Lagunitas Creek were captured sporadically between March through the end of May (D.W. Kelley and Assoc. 1988). Coho smolts were captured typically between April and June (D.W. Kelley and Assoc. 1988).

The Shapovalov and Taft data represents the only year-round outmigrant trapping on a central California coast stream. Their data are invaluable for viewing seasonal patterns of outmigration. Approximately 70% of all age 1-4 steelhead they captured occurred during the outmigrant trapping period we selected (March through June). For steelhead, age 1 represented the dominant class (67%) with the older age classes being progressively less important numerically {age 2 (31%), age 3 (2%), and age 4 (<1%)}.

Management Implications/Recommendations

1. *Maintain natural flows to minimize unnatural, early closure of lagoon mouth*

A small lagoon is present at the terminal end of Redwood Creek before it reaches the ocean. This lagoon is open for several months between the onset of winter rains until the summer when freshwater outflows decrease and can no longer maintain an open lagoon. Existing water quality within Big Lagoon is extremely poor for juvenile salmonids. Low dissolved oxygen levels and warm water temperatures are prevalent during the summer and fall. In addition, the lack of cover has resulted in predation of summer rearing steelhead by gulls, and possibly other birds (Fong, pers. obs., 1996).

Existing and future activities within the watershed can cumulatively contribute to early mouth closure. For instance, the Muir Beach Community Services District pumps approximately 0.25 cfs from Redwood Creek. Loss of this flow, particularly during drought years, would result in unnaturally, early mouth closure. If this occurred during May or June, a substantial proportion of the outmigrating coho and steelhead would be trapped in the lagoon and would not survive until the lagoon breaches in the winter.

Should water continue to be appropriated from Redwood Creek, it may be necessary during critically dry years to maintain the mouth of the Lagoon open through the month of June via hand labor.

2. *Increase education of regular park visitors to stop installation of rock crossings across the lagoon.*

When the mouth of the lagoon is open, regular park visitors install rock crossings at the mouth to access a sunbathing beach on the north side of Muir Beach. The crossings enable visitors to stay dry. Under most conditions, the crossings have sufficient spaces to allow outmigrating fish to squeeze by. However, there have been occasions were some of the crossings have been tightly packed. Signs to restrict installation of crossings or the preemptive placement of large flagstones set widely apart should reduce barriers to movement.

3. *Consider the use of an outmigrant trap during the spring to obtain young-of-the-year coho for use in restocking of extirpated runs.*

Restocking of coho at local, extirpated sites (e.g., Pine Gulch) can be accomplished using YOY captured from a outmigrant trapping program. Over 4,000 coho YOY were captured, with the bulk occurring during peak rain events in March. It is likely that many are washed into the ocean, where survival is unlikely. Sandercock (1991) notes that coho fry entering the sea during the first spring or summer of life do not generally survive to adult stage. Those that are not washed to sea and reside in Big Lagoon are also unlikely to survive. Fall snorkel surveys conducted in 1995 and 1996 did not find a single coho juvenile.

Acknowledgements

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APPENDIX I