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The Resources Agency
DEPARTMENT OF FISH AND GAME

2000-2001 ANNUAL REPORT
ESCAPEMENT AND LIFE HISTORY PATTERNS OF ADULT STEELHEAD IN FRESHWATER CREEK CALIFORNIA
PROJECT 1a1

Prepared By

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LIST OF FIGURES

ABSTRACT

Adult steelhead escapement into Freshwater Creek was estimated using a Petersen mark recapture experiment. Fifty-six steelhead were captured during their upstream migration. Thirty-five of these fish were PIT tagged. Ten of thirty recaptured downstream running kelts contained tags. The escapement of adult steelhead is estimated at 99" 23 (SE). Of the 44 scale samples collected, 35 displayed intact freshwater growth. The dominant scale pattern is the 2/2, having spent two years in freshwater, and two years in the ocean, spawning after the second ocean year at age 4. Adult steelhead spent an average of 50 " 4.5 (SE) days in Freshwater Creek before migrating back past the weir to the ocean.

INTRODUCTION

Many populations of salmonids in California are considered at risk of extinction and are listed or are proposed for listing under the Federal Endangered Species Act (ESA) (Nehlsen et al. 1991, Federal Register 1996, Huntington et al. 1996, Federal Register 2000). In June 2000 The National Marine Fisheries Service (NMFS) formally listed northern California ESU steelhead as Threatened Species under the ESA (Federal Register 2000). The listing is due in part to the lack of available information regarding the status and trends of populations (McEwan and Jackson 1996).

The NMFS identified four key parameters for assessing viable salmonid populations, including; population size, population growth rate, population spatial structure, and life history diversity (McElhany et al. 2000). Monitoring adult escapement is an appropriate measure of population size for a specific drainage, and over time can indicate the growth rate of that population. Analysis of scale patterns can lead to inferences on growth and associated life history strategies.

Objectives

This study is designed to; i) estimate adult steelhead escapement into Freshwater creek ii) analyze scale patters to gain insight on growth and life history patterns of successful returning adult steelhead.

Study Area Description

The Freshwater Creek basin is located in Humboldt County between Eureka to the south and Arcata to the north (Figure 1). Freshwater Creek is a fourth order stream that has a drainage area of approximately 9227 hectares (31 square miles) and drains into Humboldt Bay via the Eureka Slough. Elevations in the watershed range from 823 meters at the headwaters to sea level at the mouth. Main stem Freshwater Creek is approximately 23 km long, of which 14.5 km is anadromous fish habitat. Five main tributaries, Little Freshwater, Graham Gulch, Cloney Gulch, McCready Gulch and South Fork Freshwater each provide 2 to 4 km of anadromous fish habitat.

Annual rainfall amounts to approximately 150 cm in the headwaters and 100 cm near the mouth. The lower 6 km of Freshwater Creek is primarily cattle grazing land and is characterized by a low gradient, with limited riparian development. Levees confine the channel in this reach. Upstream of this section, the riparian community is much more highly developed, composed of willow (*Salix spp.)*, alder (*Alnus rubra*), black cottonwood (*Populus trichocarpa*), blackberry (*Rubus ursinus*), salmonberry (*Rubus spectasbilis*), and other herbaceous plants. Bordering the riparian areas are forests of redwood (*Sequoia sempervirens*), Douglas-fir (*Psuedotsuga menziesii*), white fir (*Abies concolor*) and Sitka spruce (*Picea sitchensis*).

The fishery resources of the basin include three species of salmon, chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), and steelhead (*O. mykiss*). Occasionally, chum salmon (*O. keta*) are observed. Other fish present in the basin include Pacific lamprey (*Entosphenus tridentatus*), brook lamprey (*Lampreta pacifica*), cutthroat trout (*O. clarki*), and prickly and coast range sculpin (*Cottus asper, Cottus aleuticus*).

Amphibians and reptiles present include pacific giant salamanders (*Dicamptodon ensatus*), red legged frogs (*Rana boylii*), tailed frogs (*Ascaphus truei*) and western pond turtles (*Clemmys marmorata*).

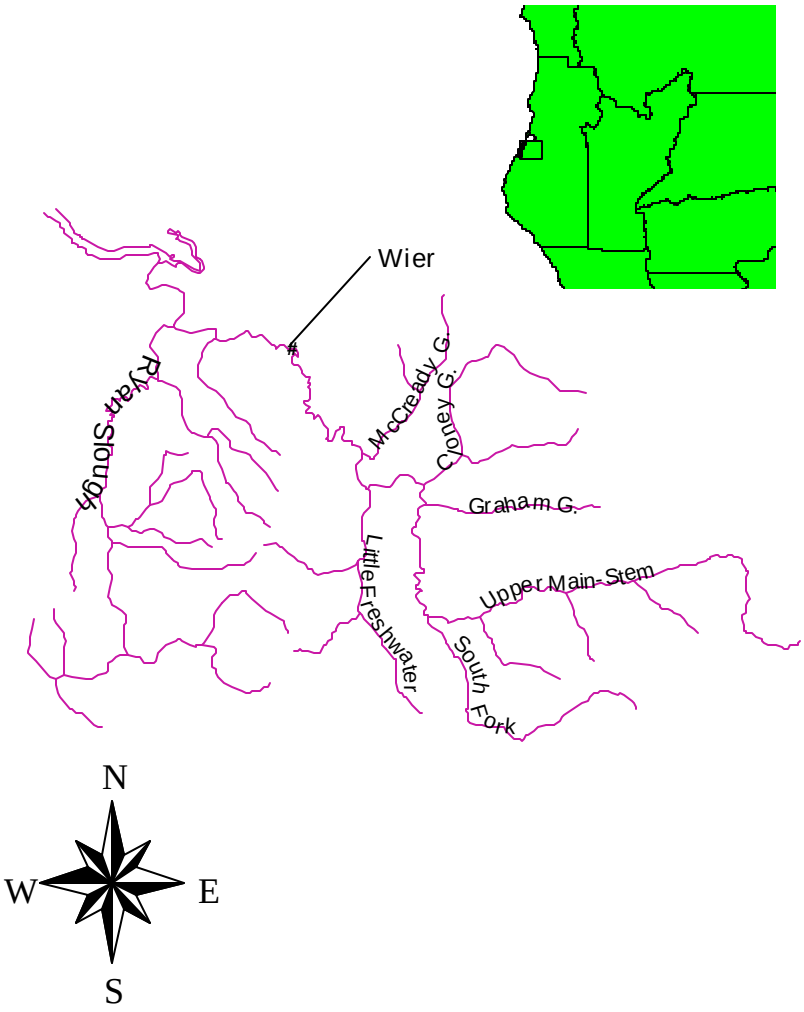

Figure 1. Freshwater Creek basin, depicting relative location in Humboldt County, and the location of the weir.

METHODS

Adult Steelhead Escapement

Theoretically, estimation of adult steelhead escapement would be unnecessary when a continual trapping schedule is employed, a direct count of fish would be sufficient. However, stream flow in Freshwater Creek is highly variable dependant on several factors including the periodicity and intensity of storm events, ground saturation and base flows. Past records indicate that anywhere from 5 to 20 days in a normal trapping season may be "unfishable" due to high flows. Therefore, a Peterson type (change in ratio) estimator was used to calculate steelhead escapement (Ricker 1975).

The first phase of obtaining the marked sample was accomplished at the permanent weir site located near "three corners" approximately 5 river kilometers (rk) upstream the mouth of Freshwater Creek where it enters Humboldt Bay. The weir is constructed of a series of metal panels, which are attached to a concrete base on the creek bed and concrete abutments on either bank. Each panel can be raised and lowered independently for cleaning purposes or when flows preclude trapping. The trap is located on the northern side of the weir structure and consists of two concrete walls on each side and metal panels on the up- and downstream ends. Fish volitionally enter the trap through two fyke panels attached to the downstream side of the trap. Captured steelhead were netted and placed in a tagging cradle for biological sampling. Each steelhead was measured for total length, examined for fin-clips, punches, tags, predator marks and other wounds, and sexed. Scale samples were collected from the appropriate location, posterior to the dorsal fin between the lateral line and the dorsal. Prior to release, each steelhead received an individual identifying mark (PIT tag) for recognition purposes. All steelhead were then released immediately upstream of the trapping facility.

The second phase of obtaining the recovery sample was performed by capturing downstream migrating kelts with a modified adult pipe trap at the permanent weir facility and at juvenile down stream migrant traps. Numbers of unmarked and marked steelhead were recorded at the downstream traps. Unmarked kelts captured at the juvenile traps received a hole punch in the anal fin to identify them as "counted" if they were captured again at any of the other traps. All kelts were then released to return to the ocean.

Statistical analysis

Steelhead escapement in Freshwater Creek was estimated using a modified version of the Petersen mark-recapture method in which the recapture sample is drawn with replacement. The formula is represented by:

$$\hat{N} = \frac{M(C + 1)}{(R + 1)}$$

Where $\hat{N}$ = Estimated population size

M = The number of marked fish

C = The number of fish in the recapture sample

R = The number of fish in the recapture sample that are marked

The estimated variance of this estimate is expressed as:

$$\hat{V}(\hat{N}) \approx \frac{M^2(C+1)(C-R)}{(R+1)^2(R+2)}$$

Scale Analysis

Scale samples were dry mounted between two microscope slides. Juvenile and adult age classification was determined by viewing the individual scale samples twice. The two reading sessions were separated by 3 months. The results of the first reading were not available during the second reading. Any discrepancy between the first and second readings were noted and deliberated upon. If a distinction could not be made, the sample was deleted from the analysis.

The number of freshwater annuli is designated as a numeric character to the left of a slash; the saltwater annuli is designated as a numeric character to the right of the slash (Davis and Light 1985). If a spawning check was observed, it is designated with a capital “S”.

The time adult spawners spent in Freshwater Creek was determined from the individually PIT tagged fish captured and released upstream of the weir, and recaptured at the weir during the downstream migration back to the ocean.

RESULTS

Fifty-six adult steelhead were captured during the upstream migration. Fork lengths of captured steelhead ranged from 35 to 80 cm (Figure 2). Thirty-five (M) adult steelhead were PIT tagged. Ten (R) of the 30 (C) recaptured kelts were identified as having been tagged. The adult steelhead escapement to Freshwater Creek is estimated to be 99 " 23 (SE).

Riverine residence time of adult steelhead ranged between 33 to 75 days. The average number of days spent in the river was 50 " 4.5 (SE) (Figure 3).

Thirty-five adult scales displayed intact freshwater and ocean growth. The dominant life history pattern of all scales interpreted is the 2/2, four-year-old fish

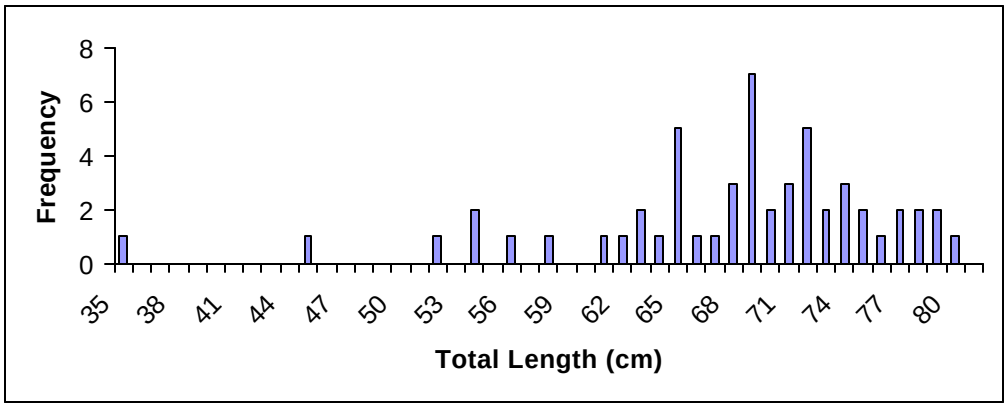

Figure 2. Length-frequency of adult steelhead captured at the permanent weir on Freshwater Creek, 2000-2001.

having spent 2 freshwater years, and 2 ocean years, spawning after the second ocean year (Figures 4 and 5).

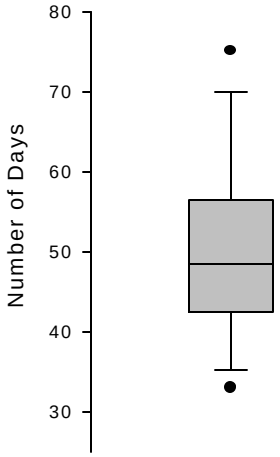

Figure 3. Box plot of the number of days adult steelhead spent in Freshwater Creek. Box depicts 25th , median, and 75th percentiles, wiskers represent 10th and 90th percentiles, and points depict outliers (n=8).

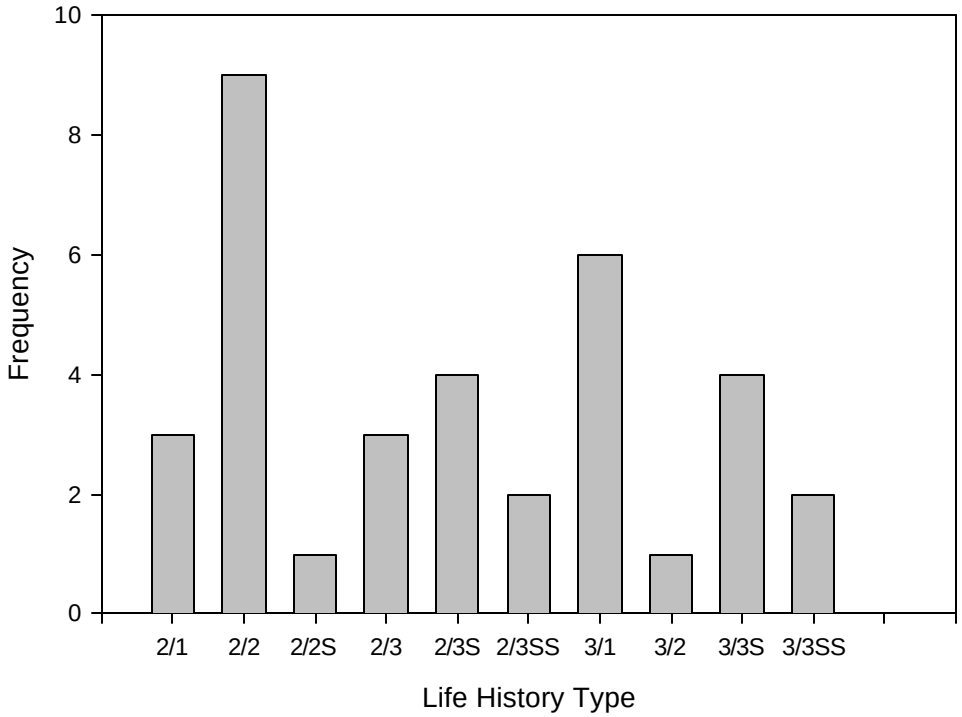

Figure 4. Frequency of life history types interpreted from scale samples of returning adult steelhead.

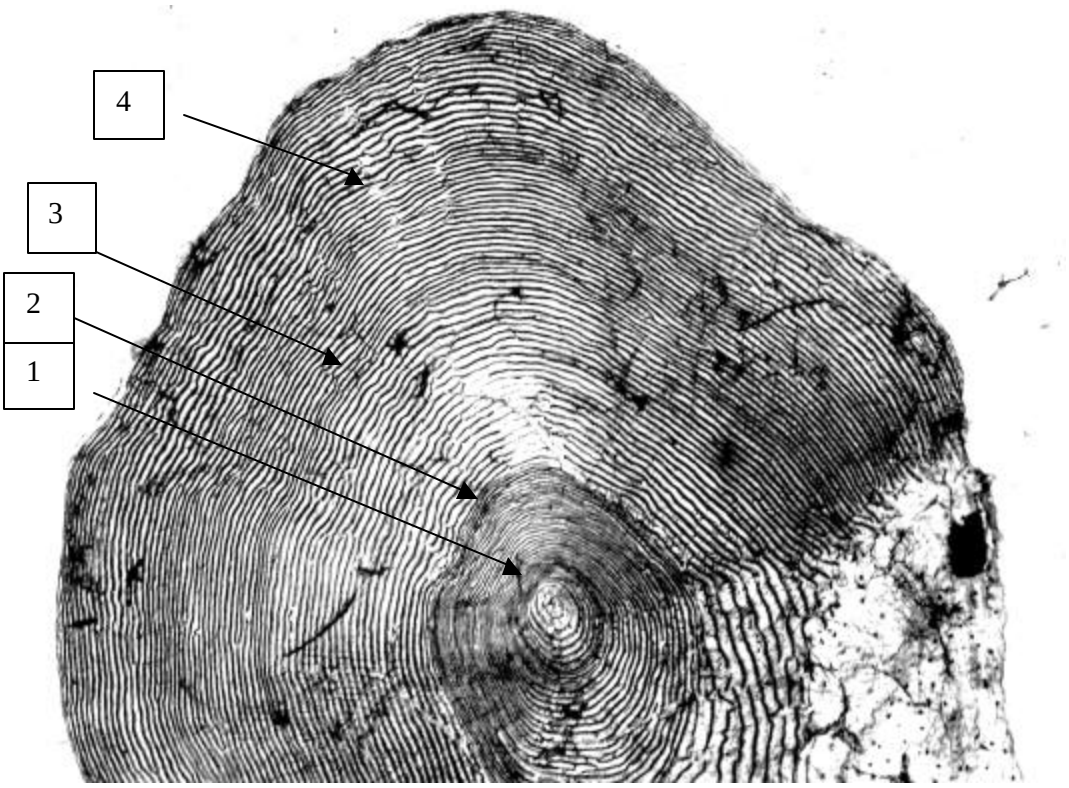

Figure 5. Adult steelhead scale depicting a 2/2 life history. (1) first freshwater annulus (2) Ocean entry + second annulus, (3) ocean growth check, (4) ocean annulus.

All of the scales displayed at least two years freshwater residency before the ocean entry check. Of the 44 scale samples that ocean life history was intact, 64% (28) were spawning for the first time, 25% (11) for the second, and 11% (5) the third. Figure 6 depicts a adult fish scale having spent 3 years prior to ocean entry, 2 spawning checks and was captured during it's third upstream spawning attempt.

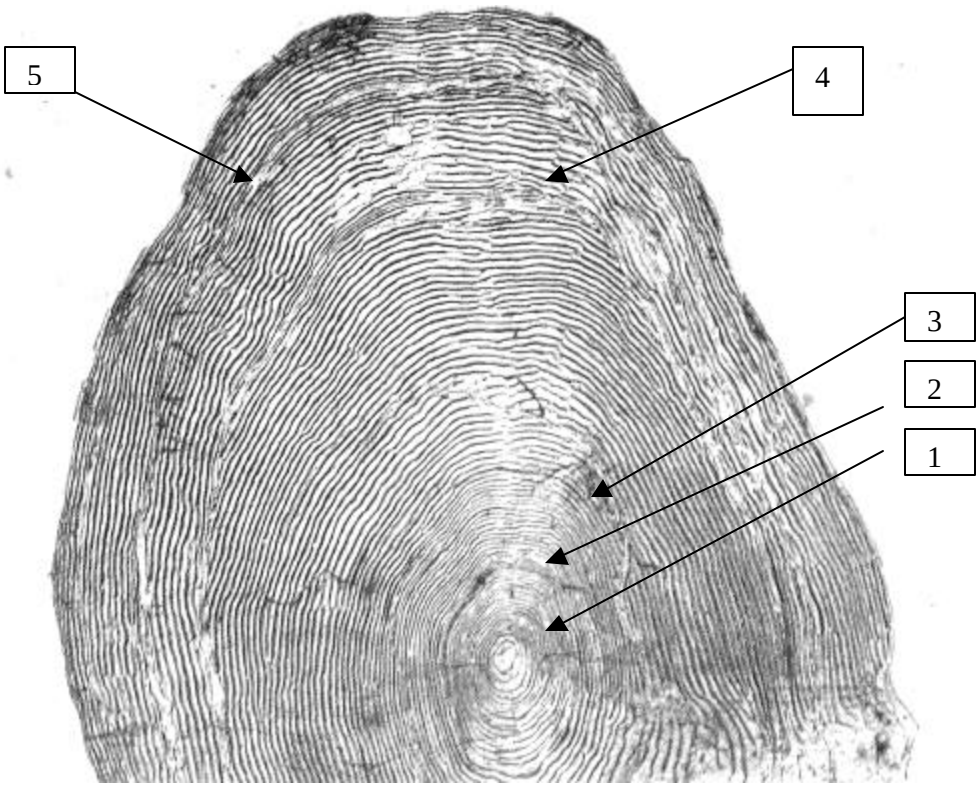

Figure 6. Adult steelhead scale depicting a 3/3SS life history. (1) first freshwater annulus (2) second freshwater annulus, (3) third freshwater annulus, (4) first spawning check, (5) second spawning check.

DISCUSSION

Steelhead exhibit the most variable life history strategy of all the Pacific salmonids. All of successful returning adult scales examined spent at least two years in the freshwater environment as juveniles. This contrasts sharply with juvenile emigrants captured in the spring of 2001 (see study 2a6), of which 90% were age 1+. This leads to the possibilities that either; 1) few or zero age 1+ steelhead smoltified and entered the ocean for the cohorts that made up the returning 2000-2001 adult run, 2) age 1+ steelhead that enter the ocean suffer zero or very low survival to adult, or 3) this age class of fish is migrating to the lower river/estuary and either residing there for a second year or migrating back upstream to rear until age 2+.

The relatively high incidence of adult steelhead returning for a second or third spawning attempt highlights the importance of return spawners to the escapement of Freshwater Creek.

Recommendations

To improve the adult escapement estimate, all upstream migrating steelhead should be marked. All downstream migrating kelts should all be examined for marks. A remote PIT reading antenna will be used to record downstream migrating kelts and will be coupled with video camera system to count unmarked fish. It is hoped this

system will allow the recapture data to be collected during most spring flows without an additional handling of fish, or a delay in their downstream migration.

Freshwater Creek steelhead scales are difficult to interpret. The coastal climate coupled with mild winters may cause freshwater annuli to be difficult to detect. Scale interpretation can be vastly improved with validating using otoliths. All steelhead mortalities encountered during the juvenile trapping and any weir mortality or carcass recoveries should have both scales and otoliths taken. As the study progresses over time, this type of scale -growth validation will allow a reference collection to be archived, and further the precision of scale pattern interpretation.

Investigation into the estuarine residence and utilization by age 1+ juvenile steelhead should be conducted to further understand the life history strategies of Freshwater Creek steelhead.

REFERENCES

Davis, N. D. and J. T. Light. 1985. Steelhead age determination techniques. (document submitted to annual meeting of the INPFC, 1985) Fisheries Research Institute, FRI-UW-3506. University of Washington, Seattle, Washington, 41p.

Federal Register. 2000. Endangered and Threatened Species: Threatened Status for one Steelhead Evolutionarily Significant Unit (ESU) in California. Federal Register, Washington D.C. 65: 36704-36094.

Federal Register. 1996. Proposed Listing Determination for 15 Evolutionarily Significant Units (ESU) of steelhead in Washington, Oregon, Idaho, and California. Federal Register, Washington D.C. 61:41514-41612.

Huntington, C., W. Nehlsen, and J. Bowers. 1996. A survey of Healthy Native Stocks of Anadromous Salmonids in the Pacific Northwest and California. Fisheries 21:6-14

McElhany, P., M. Ruckelshaus, M. Ford, T. Wainwright, and E. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42, 158p.

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho and Washington. Fisheries (AFS) 16:4-21

Ricker, W. E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Bulletin of the Fisheries Research Board of Canada. Bull 191. 382 p.