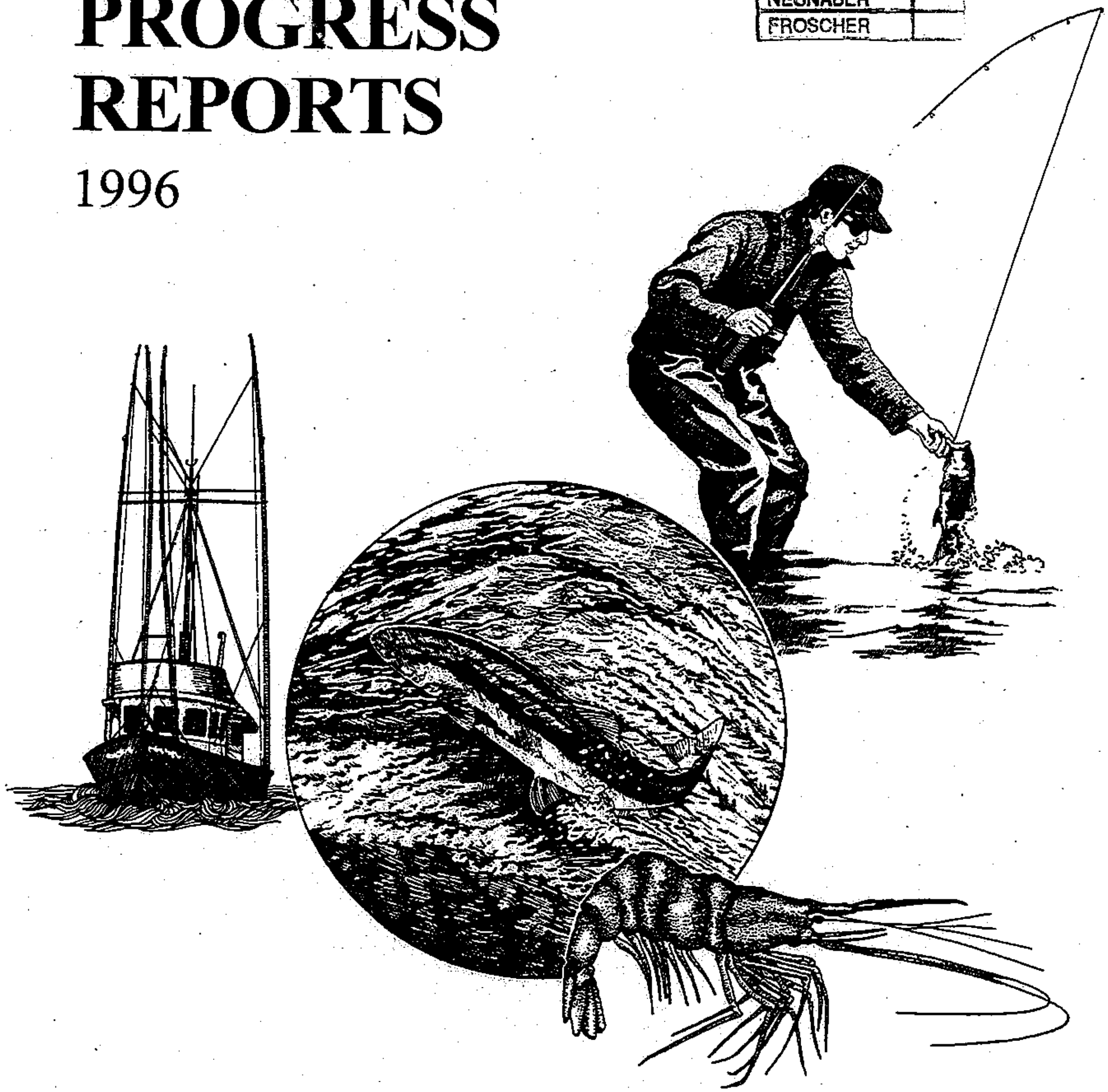
PROGRESS REPORTS

1996



FISH DIVISION

Oregon Department of Fish and Wildlife

Residual Hatchery Steelhead: Characteristics and Potential Interactions with Spring Chinook Salmon in Northeast Oregon

ANNUAL PROGRESS REPORT

FISH RESEARCH PROJECT

OREGON

PROJECT TITLE: Residual Hatchery Steelhead: Characteristics and Potential Interactions with Spring Chinook Salmon in Northeast Oregon

Contract Number: 14-48-0001-95560

Funding Period: 1 April 1995 to 31 March 1996

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This project was financed by the U.S. Fish and Wildlife Service under the Lower Snake River Compensation Plan.

PREFACE

This report documents activities conducted during the period from 1 June 1995 to 30 May 1996. This report focuses on 1994 brood summer steelhead juveniles that were released in the spring of 1995. Those individuals remaining in freshwater after 20 June 1995 were considered to be residual hatchery steelhead. Although fish which remained in the mainstem of the Snake or Columbia rivers (for example) would be defined as residual hatchery steelhead, this project focused only on those fish which residualized in the Imnaha or Grande Ronde river basins. We sampled in the Grande Ronde and Imnaha river basins during the summer (21 June - 20 September) of 1995, and sampled residual hatchery steelhead captured at steelhead broodstock collection facilities during the spring of 1996. This report focuses on four primary objectives. Data on the densities of naturally-produced steelhead that were collected during this project but were not associated with a specific objective are presented in Appendix A. Catch data for residual hatchery steelhead in Grande Ronde and Imnaha river steelhead fisheries that were collected during this project but were not associated with a specific objective are shown in Appendix B. This report documents activities from 1 April 1995 through 20 June 1996. The above period represents the fourth and final year of data collected for this study. In future years we plan to measure the summertime abundance of residual steelhead at index areas in the Grande Ronde and Imnaha river basins.

ACKNOWLEDGMENTS

We would like to thank D. Herrig and J. Krakker for working with us to develop the study design; D. Anderson, B. Cannon, M. Rost, S. Stennfeld, A. Wilson for their dedication and persistence in conducting the field work; M. Flesher, M. Keefe, P. Lofy, M. McLean, R. Messmer, and S. Parker for their cooperation and assistance. This project was funded by the U.S. Fish and Wildlife Service under the Lower Snake River Compensation Plan, contract number 14-48-0001-95560 as a cooperative agreement with the Oregon Department of Fish and Wildlife.

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SUMMARY

Objectives

1. Characterize the yearly variation in the relative abundance of residual hatchery steelhead at index areas.

2. Evaluate the potential for residual hatchery steelhead to prey on juvenile spring chinook salmon.

3. Characterize the steelhead which residualize.

4. Determine strategies to reduce the number of residual hatchery steelhead.

Accomplishments and Findings

1. Densities of residual hatchery steelhead were relatively high (30.5 fish/100m^2) in Little Sheep Creek (Imnaha River) and low (1.8 fish/100m^2) in Deer Creek (Grande Ronde River) at the release sites in summer 1995.

2. Highest densities of residual steelhead were generally found near the release sites in Little Sheep Creek and Deer Creek.

3. An estimated 7,200 hatchery steelhead (2.5% of the fish released in 1995) remained in Little Sheep Creek during summer 1995.

4. An estimated 67 hatchery steelhead (0.2% of the fish released in 1995) remained in Deer Creek during summer 1995.

5. The density of residual steelhead at a given site varies greatly between years. This variation was not clearly related to release number or stream flow.

6. The largest prey consumed during controlled predation trials was an 84 mm naturally-produced steelhead eaten by a 191 mm residual hatchery steelhead. The largest prey consumed relative to the predator's body size was 44% of the predator's body length.

7. Presence or absence of parr marks and black fin margins, the degree of silver coloration, condition factor and liver weight appear to be useful characteristics for discriminating between rainbow trout and steelhead smolts during the spring.

8. Between 75% and 90% of steelhead released from Wallowa Fish Hatchery appeared to leave the facility volitionally.

Management Recommendations

1. Continue releasing hatchery-reared steelhead at the current release sites in the upper Grande Ronde River, Catherine Creek, Deer Creek, Spring Creek, and Little Sheep Creek. Releases at these sites minimize the probability of residual hatchery steelhead interacting with naturally-produced chinook salmon juveniles.

2. Investigate volitional releases from steelhead acclimation ponds and culling the fish remaining in the ponds to reduce the number of residual steelhead.

3. To reduce the risk of interactions between wild chinook salmon and hatchery steelhead, avoid future releases of steelhead smolts in or near chinook spawning grounds.

4. To reduce the abundance of residual steelhead, attempt to exploit residual steelhead trout in rainbow trout fisheries to the maximum extent possible.

INTRODUCTION

Associated with the construction of the mainstem Snake and Columbia river dams, there has been a decline in the sizes of anadromous fish populations from basins which drain into the lower Snake River (U.S. Army Corps of Engineers 1975). These declines prompted Congress to authorize the Lower Snake River Fish and Wildlife Compensation Plan (LSRCP) in 1976. This plan is a federal mandate to compensate for fish and wildlife losses attributed to the construction of the dams in the lower Snake River. The original fisheries goals of this plan were to: (1) compensate for adult run sizes of salmon and steelhead and (2) restore sport and tribal fisheries. In addition, Oregon also has a goal to enhance the natural production of salmonids. In northeast Oregon, the LSRCP has been responsible for the development of the Wallowa and Irrigon fish hatcheries as well as the construction of the Wallowa, Big Canyon, and Little Sheep Creek acclimation facilities. In general, hatchery programs are designed to minimize the mortality which naturally-produced juveniles suffer in freshwater (Hoar 1988). In 1995, approximately 1,403,000 Wallowa stock and 339,000 Imnaha stock, 10-12 month old, hatchery-reared steelhead (*Oncorhynchus mykiss*) were released in northeast Oregon from LSRCP facilities.

Hatchery-reared steelhead which are outplanted as juveniles may remain in freshwater rather than migrate to the ocean as smolts (see Partridge 1985). For the purpose of this investigation residual hatchery steelhead (residuals) are defined as hatchery-reared fish which do not migrate to the ocean during the initial smolt migration season after release and remain in freshwater after 20 June. The rate of residualism is variable, but may reach as high as 33% (Viola and Schuck 1991). The residualism of hatchery-reared steelhead represents a loss of anadromous fish production from hatcheries and, from the stand point of supplementation and compensation, residuals are currently viewed as undesirable. In addition, residuals may interact with, and reduce the production of, naturally-produced juvenile salmonids. The National Marine Fisheries Service specifically addressed the concern over residuals in their Proposed recovery Plan for Snake River Salmon (Schmitten et al. 1995).

The potential impacts of residuals on the ecosystem, specifically interactions with naturally-produced juvenile spring chinook salmon (*O. tshawytscha*) in lower Snake River subbasins, has been recognized by fisheries biologists from Oregon (Whitesel et al. 1993), Washington (Martin et al. 1993) and Idaho (Cannamela 1993). The magnitude of the impacts of residuals on the ecosystem are dependent, in part, on the number of steelhead that residualize. The magnitude of the variability in the number of residuals from year to year and the factors responsible for this variability, however, are not known. Thus, our first objective was to characterize the yearly variation in the relative abundance of residuals at index areas in the Grande Ronde and Imnaha river basins.

Current mitigation strategies for lower Snake River drainages call for the release of large numbers of hatchery-reared steelhead, in specific locations, at relatively high concentrations. In Oregon, hatchery-reared steelhead are generally not released in areas where chinook salmon spawn. However, steelhead may migrate through or emigrate to areas where juvenile chinook salmon rear. In particular, this may occur near the time when chinook salmon fry have just emerged from the gravel. Therefore, steelhead migrating as smolts as well as those that residualize may have the opportunity to prey on juvenile chinook salmon. Preliminary observations suggest that less than 1% of the residuals prey on juvenile chinook salmon (Cannamela 1993; Martin et al. 1993; Whitesel et al. 1993; Jonasson et al. 1994, 1995). However, our modelling efforts have suggested that if 10% of the hatchery-reared steelhead become residuals, predation rates as low as 0.001 juvenile chinook salmon eaten/residuals per day could result in the loss of approximately 50 adult-equivalent chinook salmon (Whitesel et al. 1993). Thus, our second objective was to evaluate the potential for residuals to prey on juvenile chinook salmon.

Hatchery production strategies may predispose juvenile steelhead to residualize in freshwater rather than migrate to the ocean as smolts. Hatchery steelhead production in northeast Oregon results in fish that are released near 10 months of age with a fork length near 200 mm (Messmer et al. 1989). In contrast, naturally-produced steelhead smolts generally migrate when they are 22 months old at a fork length of approximately 145 mm (Gaumer 1968). In theory, residuals may mature sexually or defer smoltification for an additional year. However, studies that experimentally compare these strategies are not abundant. Thus, our third objective was to characterize the life history strategies adopted by residuals.

Hatchery-reared steelhead that residualize in freshwater are considered undesirable. Residual hatchery steelhead may adversely impact the ecosystem and present a net loss to anadromous production. Fisheries managers are currently seeking strategies to reduce the number of steelhead that residualize. The majority of residuals in northeast Oregon are male and some of the smallest fish from the release groups (Whitesel et al. 1993; Jonasson et al. 1994, 1995). Furthermore, Viola and Schuck (1995) have experimented with volitional releases of hatchery-reared steelhead and found that most of the fish which did not migrate volitionally were small males. Thus, it may be possible to cull steelhead that will residualize from a release group by using volitional releases. Thus, our fourth objective was to evaluate strategies that may result in a lower rate of hatchery steelhead residualism in northeast Oregon.

STUDY AREA AND POPULATIONS

This study was conducted in the Grande Ronde and Imnaha river basins in the northeast corner of Oregon (Figure 1). Hatchery-reared steelhead were released by Oregon Department of Fish and Wildlife (ODFW) into the Grande Ronde and Imnaha basins and by Washington Department of Fish and Wildlife (WDFW) in the Grande Ronde Basin in 1995 (Table 1, Figure 1). Wallowa stock steelhead were released at each of the Grande Ronde River basin sites whereas Imnaha stock steelhead were released at each of the Imnaha River basin sites. All release groups were from the 1994 brood year.

Hatchery-reared fish from the 1994 brood which remained in freshwater after 20 June 1995 were considered to have residualized.

Table 1. Release information for hatchery-reared steelhead released into the Grande Ronde and Imnaha river basins, 1995. All releases were made by Oregon Department of Fish and Wildlife, unless otherwise noted.

Basin, stream	Approximate Rkm of release	Release type	Date	Number
Grande Ronde				
Catherine Creek	27	direct	04/12	27,503
Catherine Creek	29	direct	04/12	35,010
Deer Creek	0	acclimated	04/21	224,956
Deer Creek	0	acclimated	05/08	154,196
Deer Creek	0	direct	04/21	53,822
Grande Ronde River[a]	87	direct	04/24	50,051
Grande Ronde River	251	direct	04/11	100,029
Grande Ronde River	256	direct	04/10-11	99,994
Spring Creek	3	acclimated	04/16	495,137
Spring Creek	3	acclimated	05/02	162,296
Imnaha				
Imnaha River	27	direct	04/28	50,676
Little Sheep Creek	8	acclimated	05/01	230,882
Little Sheep Creek	8	direct	05/01	57,012

[a] *Released by Washington Department of Fish and Wildlife.*

RELATIVE ABUNDANCE OF RESIDUAL HATCHERY STEELHEAD

Methods

In 1995 we focused sampling efforts near release sites in Deer and Little Sheep creeks to characterize more precisely residual hatchery steelhead populations where abundance is greatest. Sampling during summers of 1992 and 1993 indicated that residual hatchery steelhead abundance was highest near release sites in Deer and Little Sheep creeks. We identified index areas to sample each summer for abundance of residuals at the release sites in Deer and Little Sheep creeks. The index areas have been sampled each summer since 1992 when this project began. In addition, we selected seven locations in

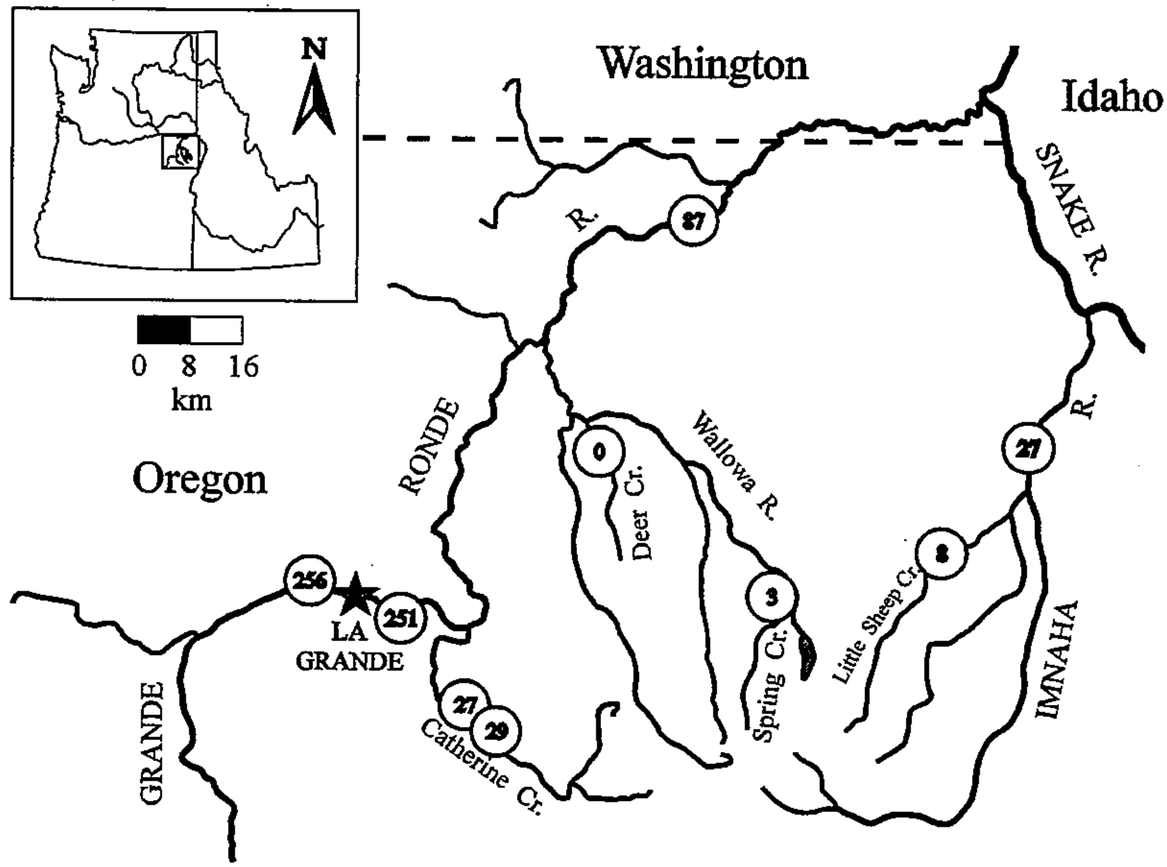

Figure 1. Major river basins in northeast Oregon and the locations where ODFW and WDFW released hatchery-reared summer steelhead in spring 1995. River kilometers are shown in circles to cross reference to Table 1 for specific release information.

Deer Creek (including one in Sage Creek, a tributary to Deer Creek) and nine locations in Little Sheep Creek (including one in Bear Gulch, a tributary to Little Sheep Creek). We also sampled near release sites in the Grande Ronde River near La Grande and in the Imnaha River. We selected sample locations based on release locations of hatchery-reared steelhead, the distribution and abundance patterns of residuals in the summers of 1992-94 (Whitesel et al. 1993, Jonasson et al. 1994, 1995) and stream accessibility.

Whenever possible, all sample locations were sampled for the relative abundance of residuals. If not possible, then the locations were sampled for the presence/absence (distribution) of residuals. Two sites were sampled at each location. We attempted to sample a riffle-pool combination at each site. If riffle-pool combinations were not available near the location, a section of stream approximately 25 m in length was chosen for each site.

Electrofishing techniques were used whenever possible. Blocking nets (6 mm mesh) were placed across the stream at the top and bottom of the sample site to prevent fish from moving into or out of the area during sampling. A three person sampling crew made two or three passes through the site with an electrofisher to collect and remove salmonids. Fish captured during each pass were netted, held in separate containers and later anesthetized, identified to species, classified by age (salmonids only) and enumerated. A multiple pass removal method (Zippen 1958) was used to estimate the abundance of fish within the sampling site. Surface area of each sampling site was calculated from measurements of total length and average width.

We snorkeled at sampling sites when water conditions would not permit the use of electrofishing techniques. Visual observations were made of the species present and the number of individuals in each salmonid species. Generally, three snorkelers, swimming simultaneously and parallel, observed and counted salmonids. At abundance sites which were snorkeled, two passes were made and the highest count for each species was used as our estimate of the number present in the site.

We calculated densities of residuals at locations sampled for abundance using the surface area and the estimated number of residuals of both sites. Data from only one site was used when we were unable to make two abundance estimates at a location. We used linear regression analysis to examine relationships between residual hatchery steelhead densities during the summers of 1992 through 1995 at the Deer Creek and Little Sheep Creek release sites and the total number of hatchery steelhead released at each of these sites (Table 2) and spring stream discharge (Table 3). To estimate the rate at which hatchery-reared steelhead residualize within Deer and Little Sheep creeks, we also estimated the total abundance of residuals in Deer and Little Sheep creeks. This was done using the estimated relative densities of residuals at each sampling location, the estimated stream surface area between each location, and interpolating densities between index areas. We were not able to calculate confidence intervals for our estimates of total abundance of residuals in Deer and Little Sheep creeks. We estimated the rates of

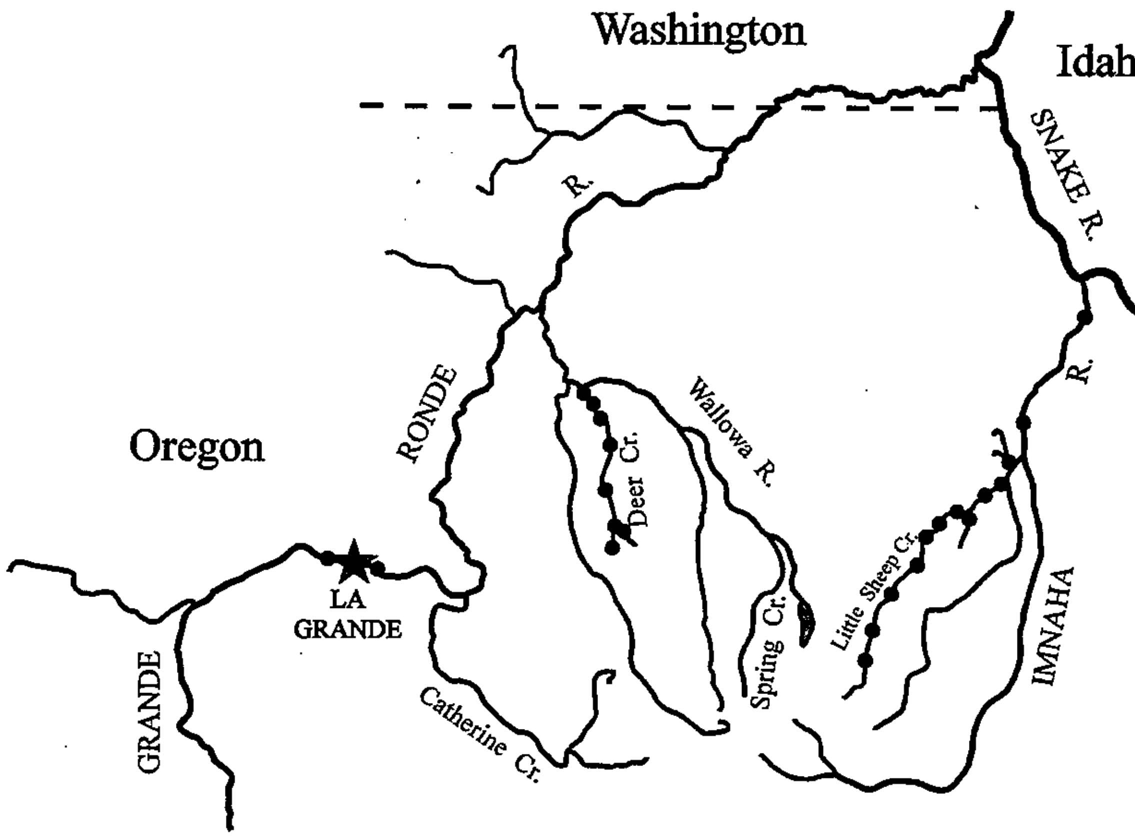

Figure 2. Locations sampled during summer 1995 in the Grande Ronde and Imnaha river basins. Information was also obtained from angler surveys that focused on Imnaha River rkm 0-18, Grande River rkm 63-132, and Wallowa River rkm 0-29.

Table 2. Number of hatchery-reared steelhead released at Deer Creek and Little Sheep Creek release sites, 1992 to 1995.

Stream	Number released 1992	1993	1994	1995
Deer Creek	476,489	432,977	155,751	432,974
Little Sheep Creek	248,787	286,694	300,744	287,894

Table 3. River discharge from 16 April to 31 May for 1992 to 1995 in the Grande Ronde and Imnaha river basins. Discharge records were obtained from USGS gaging stations.

Stream	Location	Mean discharge (m^3/s) 1992	1993	1994	1995
Grande Ronde River	Troy	83.3	269.4	150.0	246.7
Catherine Creek	Union	5.0	15.1	8.1	10.5
Minam River	Minam	24.1	39.1	30.4	30.6
Imnaha River	Imnaha	15.3	49.8	29.1	52.4

residualism in Deer and Little Sheep creeks by dividing the estimated number of residuals in each stream by the number of hatchery steelhead released in the respective streams.

When we were not able to estimate the density of residuals at a site due to environmental conditions (high flow or poor visibility) we made a maximum of one snorkeling or two electrofishing passes to determine the presence or absence of residuals. If at least one residual was observed, sampling was terminated at that site. If one residual was not observed after completing these passes they were considered absent from that site. This was done in an attempt to use a constant effort when determining the presence or absence at each site.

Results

Densities of residuals in Deer and Little Sheep creeks were highest at the release sites and decreased as distance from the release site increased (Figures 3 and 4; Table 4). Residual hatchery steelhead were not found upstream of the release site in Little Sheep Creek, and few were found upstream of the release site in Deer Creek.

Relative density of residuals was lower at the Little Sheep Creek release site during summer 1995 than the previous year, whereas the density of residuals in Deer Creek was similar at the Deer Creek release site during summers 1994 and 1995 (Figure 5). The number of hatchery steelhead smolts released was lower in Little Sheep Creek and higher in Deer Creek in 1995 than in 1994.

We did not find a significant relationship between residual density during summers 1992-95 at the Little Sheep Creek release site and the number of hatchery fish released at this site ($r^2 = 0.176$, $P = 0.581$), or between summer densities at this release site and Imnaha River discharge in the spring ($r^2 = 0.175$, $P = 0.582$). We also did not find a significant relationship between residual density during summers 1992-95 at the Deer Creek release site and the number of hatchery fish released there ($r^2 = 0.336$, $P = 0.420$), or between summer densities at this release site and Minam River discharge in the spring ($r^2 = 0.238$, $P = 0.513$).

We estimated there were 7,200 residuals in Little Sheep Creek during summer 1995. These residuals represent 2.5% of the hatchery steelhead released as smolts into Little Sheep Creek in April 1995. We estimated there were only 67 residuals in Deer Creek during summer 1995, representing 0.02% of the hatchery steelhead released as smolts into Deer Creek.

Discussion and Management Implications

The number of residuals in northeast Oregon is variable from year to year, based on our sampling of index areas. We did not find a statistically significant relationship between number of smolts released and residual densities during summer at the release sites. River discharge during spring, which appeared to be related to residual densities during the first two years, now does not appear to be related to the summer densities of residuals at the release sites. However, the data from Deer Creek should be viewed cautiously. Although few fish appeared to have residualized from the releases at Deer Creek, the release site in Deer Creek is at rkm 0 and the majority of the residuals may have moved into the Wallowa River. In general, we are still unclear about what factors are responsible for the variability of the numbers of residuals between years.

Our estimate of the number of steelhead which residualized in Little Sheep Creek during summer 1995 was about 50% of the number we estimated during summer 1994, and the estimated density in the index area was 56% of the estimated density in 1994. An estimate of the density of residuals at the index area on Little Sheep Creek appears to be a good measure of the abundance of residuals remaining in Little Sheep Creek during summer.

Table 4. Observed densities (fish/100 m^2) of residual hatchery steelhead at index areas in Deer Creek and its tributary Sage Creek, and Little Sheep Creek and its tributary Bear Gulch, summer 1995.

Stream	Rkm	Density
Deer Creek	0	1.846
	2	0.000
	3	0.000
	6	0.000
	11	0.740
	16	0.000
	19	0.000
Sage Creek	0	0.000
Little Sheep Creek	0	3.215
	3	9.324
	6	25.177
	8	30.459
	10	0.000
	13	0.000
	20	0.000
	29	0.000
	39	0.000
Bear Gulch	0	24.704

POTENTIAL FOR PREDATION BY HATCHERY-REARED STEELHEAD ON JUVENILE SPRING CHINOOK SALMON

Methods

We conducted controlled feeding trials to relate the size of predators (residuals) to the size of prey (naturally-produced steelhead). We used naturally-produced steelhead as prey in these studies because they were available at sizes of naturally-produced spring chinook salmon juveniles, were collected easily from Deer Creek, and similar trials from 1994 (Jonasson et al. 1995) indicated that residuals would prey on juvenile steelhead while in confinement. Naturally-produced, juvenile spring chinook were not available as they are listed under the Endangered Species Act and hatchery-reared juvenile spring chinook were unnaturally large. We held individual residuals in separate net pens (0.9 x 0.6 x 0.6 m, 6 mm mesh) in ponds at our Big Canyon Facility. We collected the residuals from Deer Creek and placed them in net pens, and then starved them for 48 h before introducing three naturally-produced juvenile steelhead. We recorded fork length and weight of each predator and prey before placing them in the net pens. We examined the pens three times per week to note the number of prey remaining in the pen with the

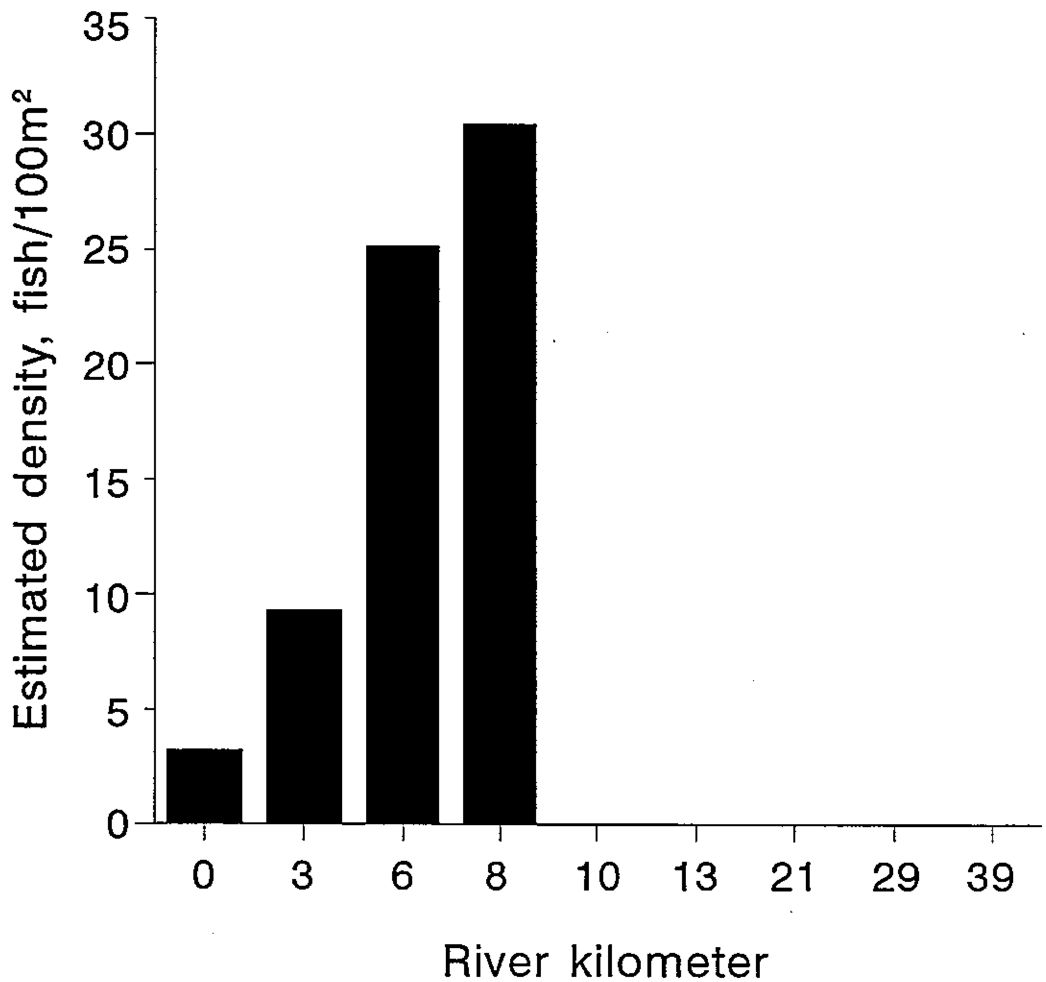

Figure 3. Density of residual hatchery steelhead in index areas of Little Sheep Creek during summer 1995. Hatchery steelhead were released at rkm 8.

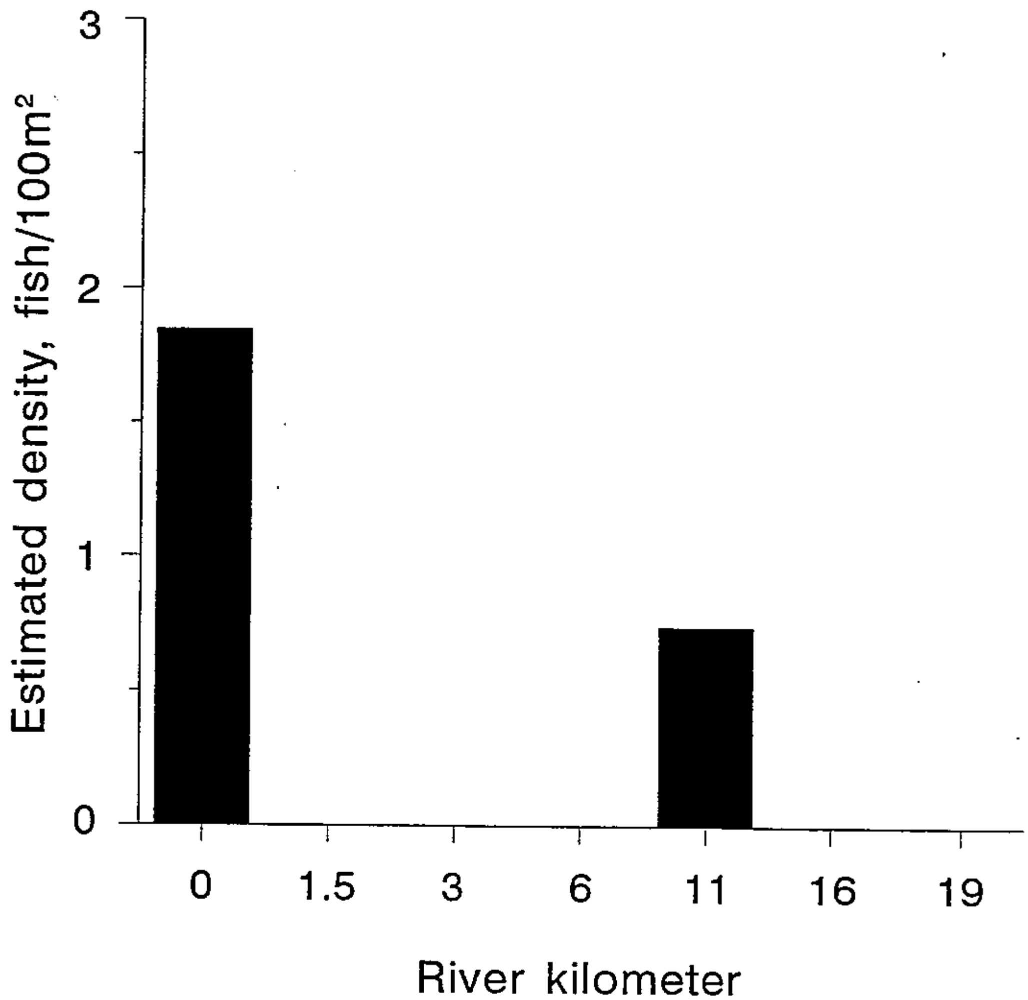

Figure 4. Density of residual hatchery steelhead in index areas of Deer Creek during summer 1995. Hatchery steelhead were released near rkm 0.

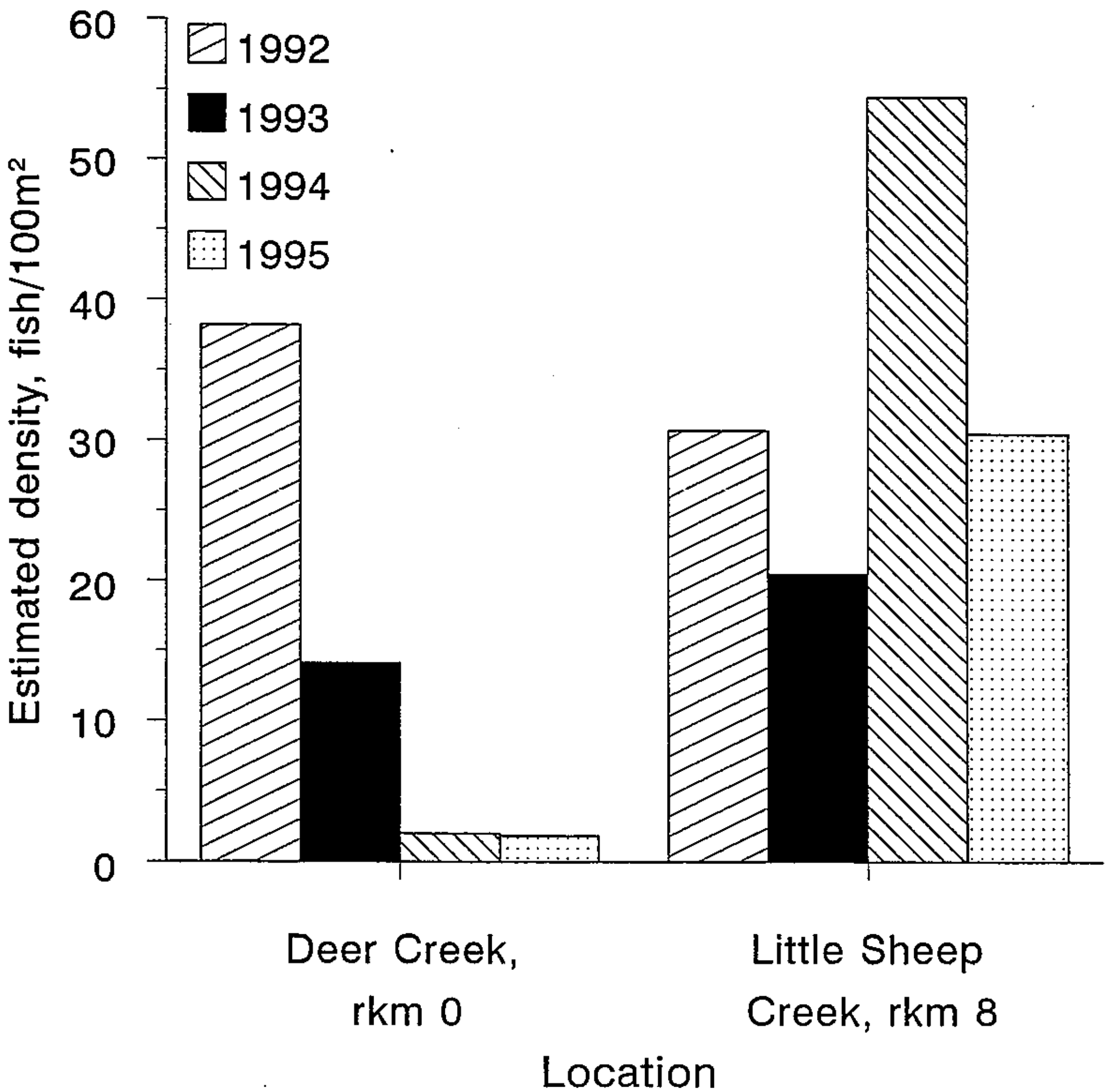

Figure 5. Densities of residual hatchery steelhead at release sites during summers 1992 to 1995.

predator. If a prey item was missing, the remaining prey items were measured to determine the size of the missing prey. We conducted three trials lasting 21 days with nine or 10 predators. During each trial we had at least one pen containing only prey items to serve as a control. At the conclusion of the second and third trials we added previously frozen steelhead eggs to the pens as positive controls to ascertain that the predators would eat while in the net pens.

To refine our assessment of the likelihood that residual steelhead prey on juvenile chinook salmon, we examined the size of naturally-produced, juvenile chinook salmon. We sampled juvenile chinook salmon found in the upper and lower reaches of the Grande Ronde River. We also sampled juvenile chinook salmon found in these reaches during June and August. The size characteristics of naturally-produced, juvenile chinook salmon were compared to the size characteristics of fish prey that were consumed by residual steelhead in the feeding trials.

Results

Eight (29.6%) of the residuals consumed juvenile steelhead, whereas nineteen (70.3%) of the residuals consumed either juvenile steelhead, trout eggs, or both. Seven of the eight (87.5%) residual steelhead that consumed fish ate the smallest prey available, three of these eight (37.5%) consumed the second largest prey available, and only two of these eight (25.0%) consumed the largest prey available. The predators tended to be the largest of the residual steelhead (Figure 6). The smallest residual steelhead predator was 189 mm in fork length. Based on fork length, the largest prey:predator ratio was 0.44. The majority of of the prey that were consumed tended to be from the smallest prey:predator size ratios (Figure 7). The lower the prey:predator size ratio the higher the percentage of prey fish that were consumed (Figure 8). The largest prey consumed during the controlled predation trials was 84 mm FL (Table 5).

In the Grande Ronde River during June, the size of juvenile chinook salmon ranged from 31-100 mm in fork length (Figure 9). The distribution of fork lengths for these salmon had a peak near 36-40 mm, characteristic of fish from the upper reaches of the river, and another peak near 81-85 mm, characteristic of fish from the lower reaches of the river. From the upper reaches of the river, more than 95% of the salmon were in the size range of fish prey consumed by residual steelhead in the feeding trials. From the lower reaches of the river, more than 70% of the salmon were in the size range of fish prey consumed by residual steelhead in the feeding trials.

In the Grande Ronde River during August, the size of juvenile chinook salmon ranged from 41-185 mm in fork length (Figure 10). The distribution of fork lengths for these salmon had a peak near 46-50 mm, characteristic of fish from the upper reaches of the river, and another peak near 86-90 mm, characteristic of fish from the lower reaches of the river. From the upper reaches of the river, more than 80% of the salmon were in the size range of fish prey consumed by residual steelhead in the feeding trials. From the

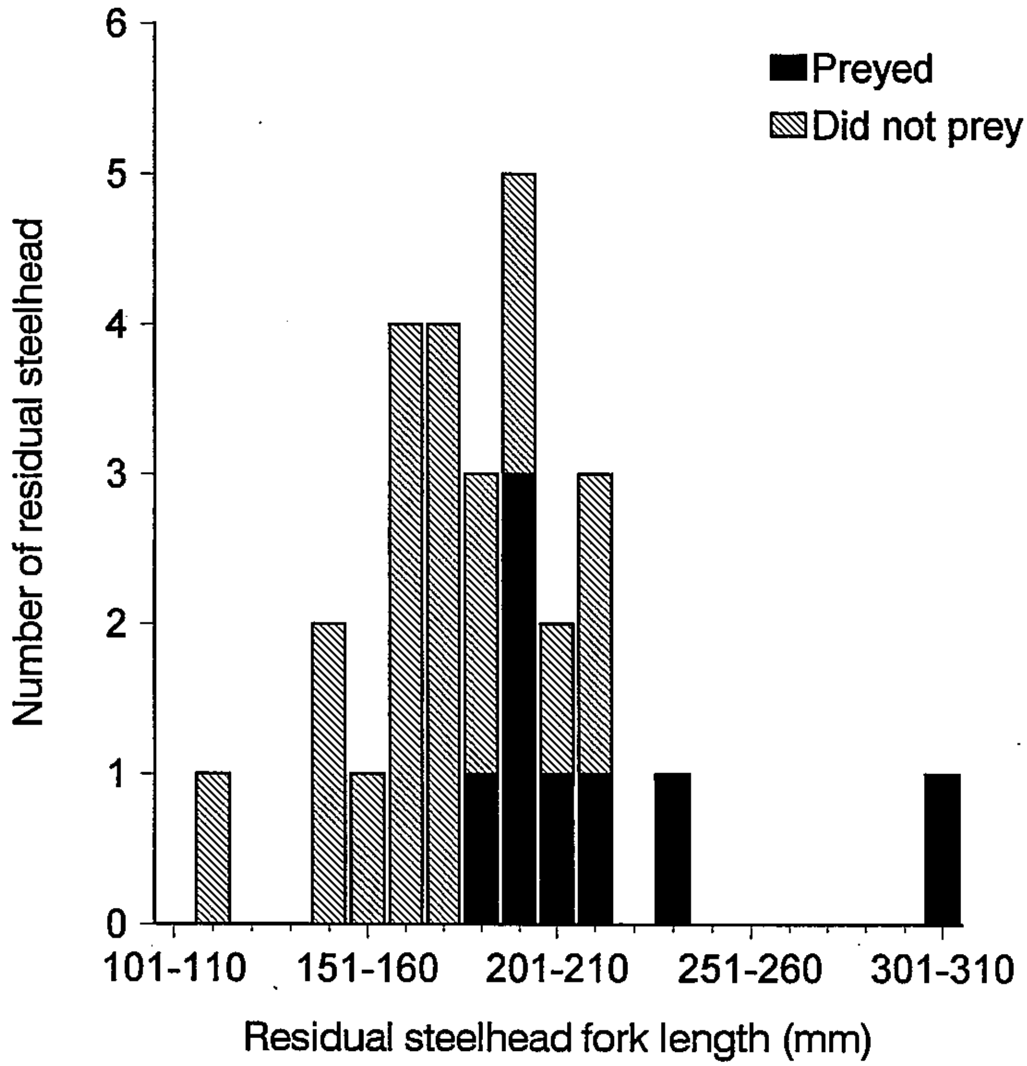

Figure 6. The relationship between the length of residual steelhead used and the number of prey eaten in the controlled feeding trials.

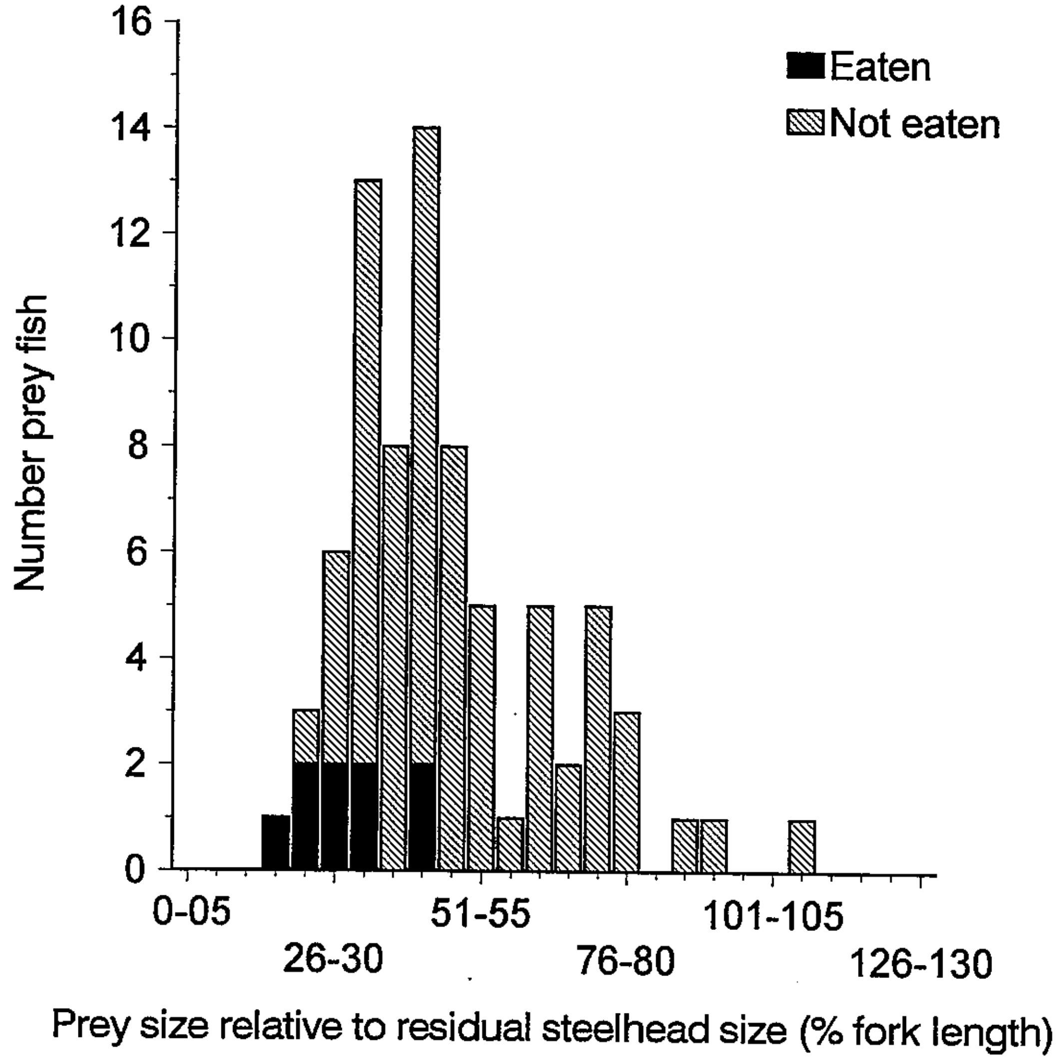

Figure 7. The relationship between the prey:predator size ratio and the number of prey eaten in the controlled feeding trials.

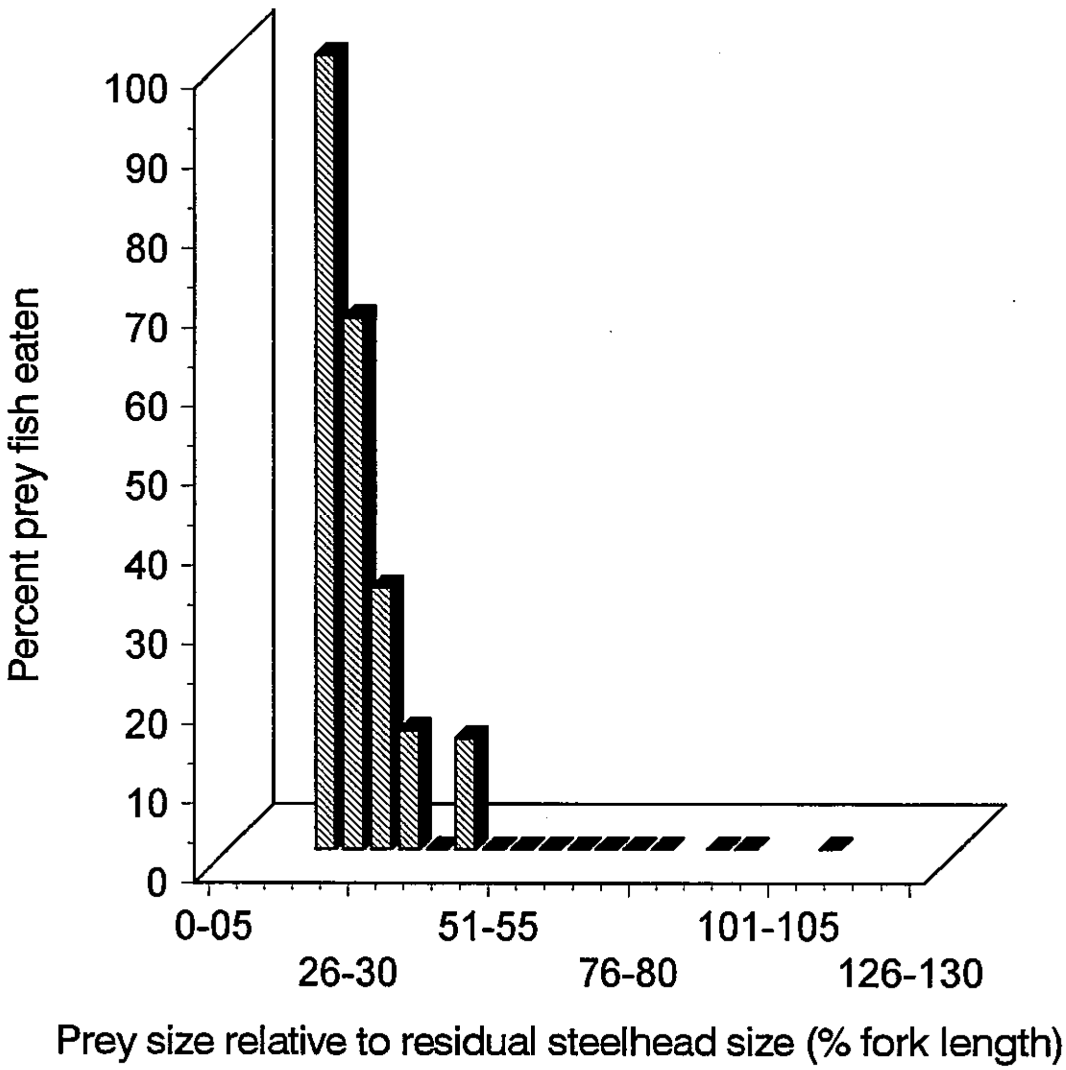

Figure 8. The relationship between the prey:predator size ratio and the percent of prey fish eaten in the controlled feeding trials.

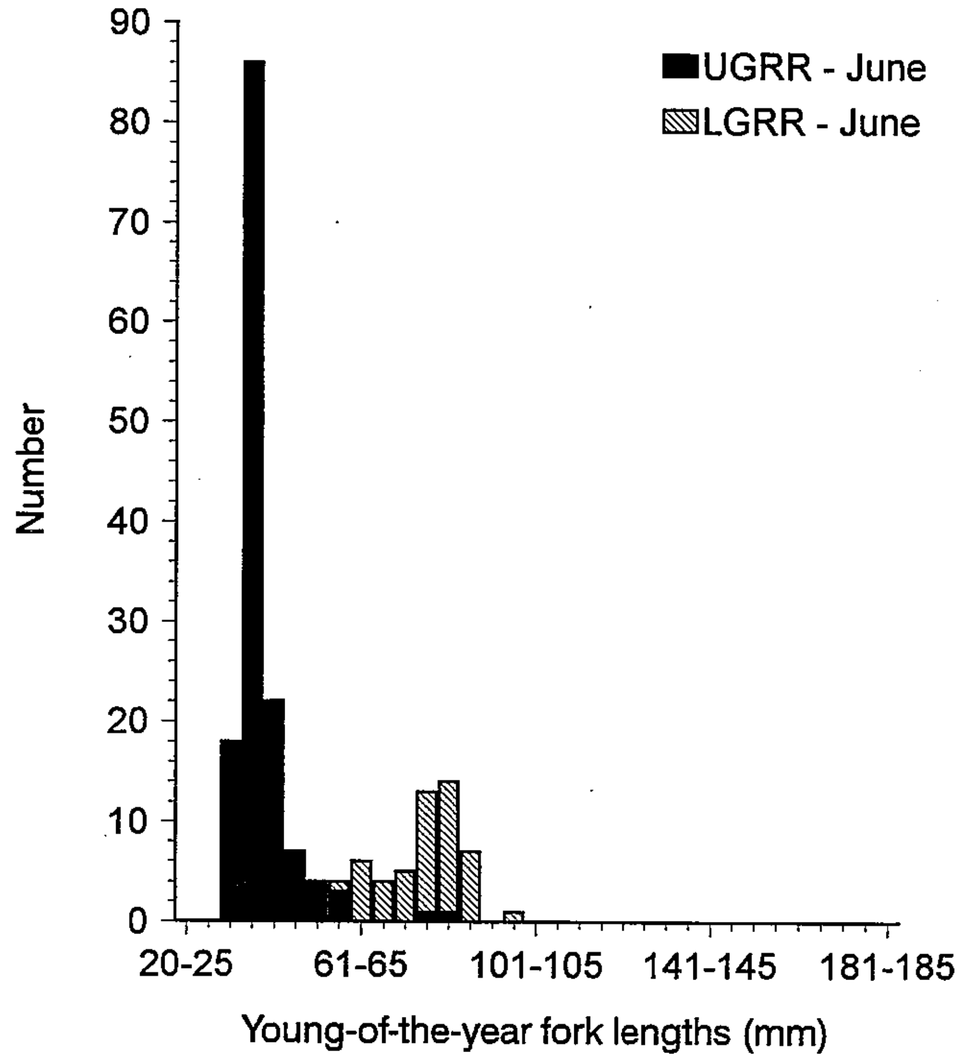

Figure 9. Length of naturally-produced, spring chinook salmon in the Grande Ronde River during June, 1994.

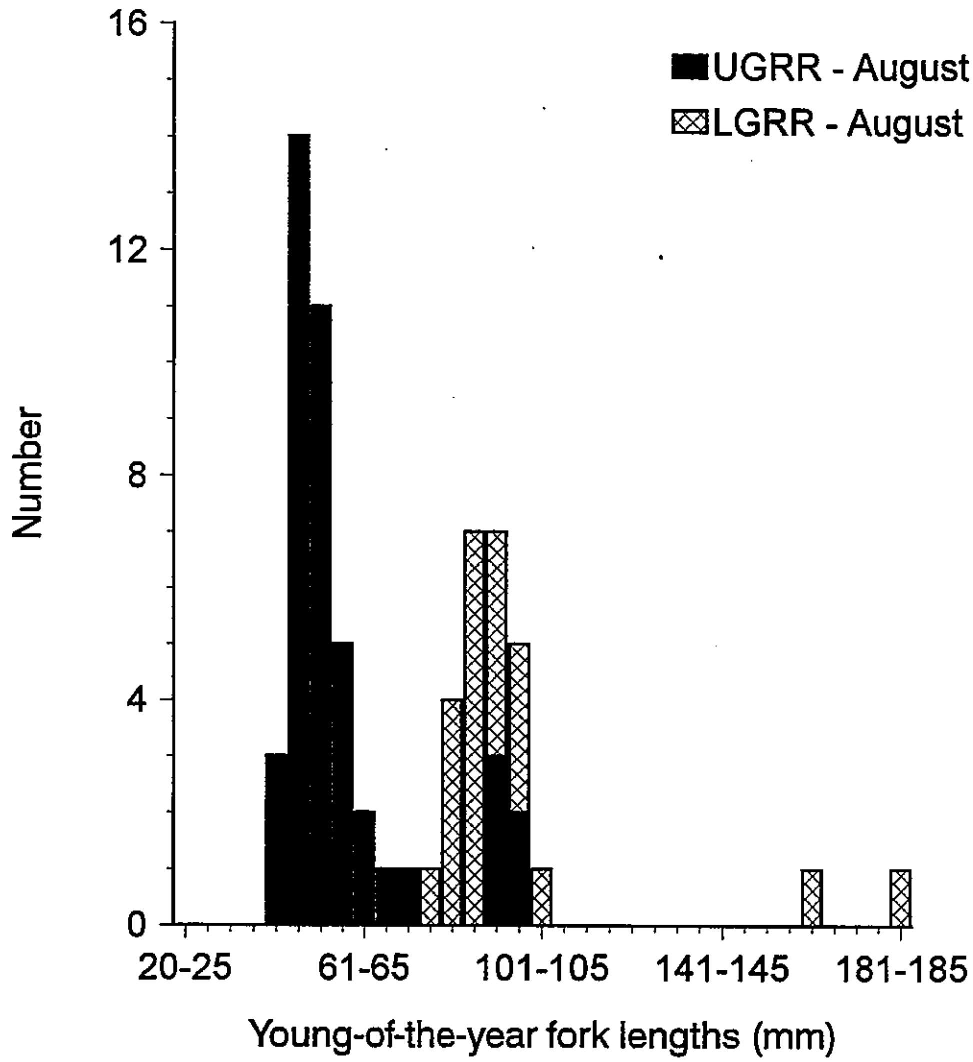

Figure 10. Length of naturally-produced, spring chinook salmon in the Grande Ronde River during August, 1994.

lower reaches of the river, less than 10% of the salmon were in the size range of fish prey consumed by residual steelhead in the feeding trials.

Table 5. Fork lengths (mm) of predators (residual hatchery steelhead), prey (naturally-produced steelhead) consumed and prey available for controlled predation trials. Prey fork length, expressed as percentage of predator fork length, is in parentheses.

	Largest prey	
Predator	consumed	available
189	66 (35%)	79 (42%)
191	84 (44%)	148 (77%)
197	42 (21%)	88 (45%)
200	81 (41%)	81 (41%)
201	77 (38%)	77 (38%)
219	59 (27%)	79 (36%)
235	52 (22%)	119 (51%)
310	58 (19%)	84 (27%)
mean length:	70.5 (33.8%)	91.0 (43.3%)

Discussion and Management Implications

During the four years of this study, we found that residuals will consume juvenile salmonids in the size range of naturally-produced chinook salmon typically found in the Grande Ronde and Imnaha basins during summer. Although our previous studies (Whitesel et al. 1993; Jonasson et al. 1994) indicate that some residuals eat juvenile chinook salmon, this study supports the notion that residuals tend not to be very piscivorous. Although most residuals in the present study would eat during the controlled predation trials, most residuals would not eat juvenile salmonids. This confirms the results of our initial study (Jonasson et al. 1995) when only 21% of the residuals preyed on fish. This lack of piscivory, especially at sizes under 200-250 mm in fork length, is consistent with numerous reports in the literature (see Idyll 1942; Loar et al. 1985; Anagradi and Griffith 1990; Hubert et al. 1994). Residuals that were piscivorous tended to be the largest fish and they tended to eat the smallest prey. We found that residuals did not eat juvenile salmonids larger than 44% of their own fork length and the majority of fish they preyed on were smaller than one-third of their fork length. A similar relationship has been reported in the literature for natural *O. mykiss* (see Larkin and Smith 1954; Ginetz and Larkin 1976; East and Magnan 1991; Blinn et al. 1993).

Predation by stream-rearing hatchery steelhead on salmonids has been found to be rare (Cannamela 1993, Martin et al. 1993, Whitesel et al. 1993, Jonasson et al. 1994, 1995) or absent (Partridge 1985) in the Snake River basin. Our analysis suggests that juvenile chinook salmon in upper tributaries and the lower mainstem areas of the rivers in northeast Oregon are small enough to be susceptible to predation by residuals around the time of emergence and the early parr life stage. However, it appears that by August, chinook salmon in the lower mainstem areas of these rivers have grown large enough so that they may not be susceptible to predation by residuals. Our understanding of the distributions of residuals and juvenile chinook salmon in the Grande Ronde and Imnaha river basins (Whitesel et al. 1993, Jonasson et al. 1994, 1995) lead us to believe that, with the exception of the lower Grande Ronde and Imnaha rivers, interactions between residual steelhead and juvenile chinook salmon are minimal through most of their summer rearing areas. An integrated view of our study and reports in the literature indicate that the majority of juvenile chinook salmon in the lower river areas may outgrow the threat of predation by residuals relatively quickly. Given the distributions we've observed and our results of stomach sampling of free-living residuals during the first three years of this study, in conjunction with the present study's information on piscivory, we believe that predation by residuals on juvenile chinook salmon is not likely to be a significant problem in northeast Oregon.

CHARACTERISTICS OF RESIDUAL HATCHERY STEELHEAD

Methods

We examined characteristics of naturally-produced rainbow trout and steelhead captured during spring and quantified the percentages of residuals that adopt a nonanadromous life history strategy (i.e., rainbow trout) or maintain an anadromous life history (i.e., steelhead). Our intent was to gather information which would allow us to characterize residuals captured during spring one year after release. We collected naturally-produced rainbow trout from the Powder River basin, and naturally-produced steelhead smolts from a rotary screw fish trap at rkm 164 of the Grande Ronde River in May 1995. We determined the sex and measured the body weight, fork length, maturity, gonad weight, liver weight, presence or absence of parr marks and blackened fin margins, and the degree of silver coloration (1 = no silver to 5 = very silvery) of each of these fish. We classified the maturity of males using the following criteria: immature males had translucent, threadlike testes; maturing males had enlarged, opaque testes; and mature males had large, white testes from which milt could be expressed. Classification of the maturity of females was based on the following criteria: immature females had translucent ovaries; maturing females had enlarged, opaque ovaries; and mature females had large, pigmented eggs that appeared to be fully developed. We also calculated the condition factor and hepatosomatic index (liver weight expressed as percentage of the body weight) for each fish. We attempted to evaluate these characteristics to determine which might help us discriminate between rainbow trout and steelhead.

Results

We collected 19 naturally-produced steelhead smolts, and 24 rainbow trout during spring. All naturally-produced steelhead smolts collected were immature, while only 33% of the rainbow trout were immature. Means of the attributes we measured are shown in Table 6.

Discussion and Management Implications

Parr marks, black fin margins, and degree of silver coloration appear to be useful characteristics to discriminate between rainbow trout and steelhead. All rainbow trout had visible parr marks, no black fin margins, and a low degree of silver coloration, whereas steelhead smolts had no visible parr marks, black fin margins, and a high degree of silver coloration.

Table 6. Means and standard errors (se) of attributes of 19 naturally-produced steelhead smolts and 24 rainbow trout measured during spring 1996. NS = not significant; S = significant.

	Steelhead		Rainbow trout		
Attribute	mean	se	mean	se	Difference
Fork length, mm	178.1	4.59	180.1	3.06	NS
Weight, g	56.31	4.218	65.57	3.442	NS
Condition factor	0.975	0.0195	1.103	0.0202	S
Gonad weight, g	0.17	0.025	2.18	0.644	S
Liver weight, g	0.61	0.055	0.94	0.078	S
Liver wt/body wt	0.011	0.0007	0.014	0.007	NS
parr marks[a]	0.0	0.00	1.0	0.0	S
silvering[b]	4.6	0.19	1.3	0.10	S
black fin margins[c]	1.0	0.00	0.0	0.00	S

[a] *0 = parr marks not visible; 1 = parr marks visible.*
[b] *1 = no silver to 5 = very silver.*
[c] *0 = no black fin margins; 1 = black fin margins.*

STRATEGIES TO REDUCE THE NUMBER OF RESIDUAL HATCHERY STEELHEAD

Methods

We initiated trials to determine methods to conduct volitional releases of summer steelhead at Wallowa Fish Hatchery. The lower acclimation pond was set-up on 16 April. To allow steelhead juveniles to leave the pond volitionally, screens were pulled and the pond lowered to one-third of its original depth. The volitional release period lasted only two days. The briefness of this period was because a) of the desire to have fish acclimated for a minimum number of days and b) a second group of acclimated fish (the backfill group) was scheduled to be put in this pond on 19 April. A second trial, similar to the first, was conducted with the backfill group of steelhead during May.

Results

Hatchery personel estimated that up to 75% of the steelhead in the lower acclimation pond left during the first, two day volitional release period. Hatchery personnel estimated that up to 90% of the steelhead in the lower acclimation pond left during the second, two day release period.

Discussion and Management Implications

We found that the acclimation ponds at Wallowa Fish Hatchery could be modified to allow juvenile steelhead to leave volitionally. We found that fish would leave volitionally over a reasonably short period of time, but that we need a longer time of release for adequate evaluation. We believe that these types of modifications can also be made at the Big Canyon Facility. Given the results of these trials, we plan to initiate a longer-term study at these two facilities beginning with releases in 1996. We do not believe that volitional releases can be accomplished into Little Sheep Creek without major modifications to the facility.

FUTURE DIRECTIONS

1. Continue to monitor index areas for long term trends in the extent of residualism.

2. Develop and evaluate hatchery release strategies for steelhead, specifically volitional realeases, that may minimize the rate of residualism.

3. Explore the possibility that a resident life history is a normal strategy for hatchery steelhead.

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APPENDIX A

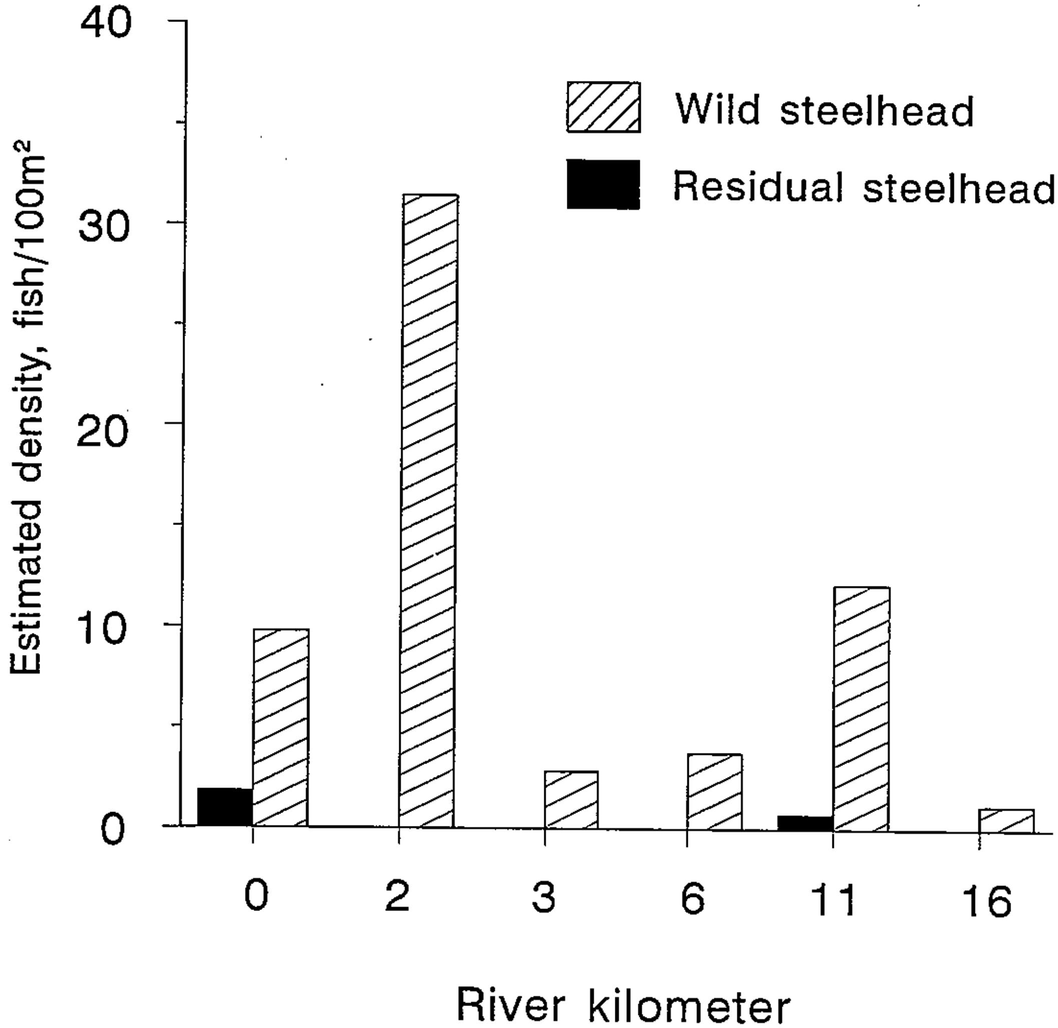
The Relative Densities of Naturally-produced Juvenile Steelhead in Deer and Little Sheep Creeks

We examined the relative densities of juvenile steelhead age-1 and older in Deer and Little Sheep creeks during summers 1993 to 1995 to see if there was any indication that residuals were displacing naturally-produced juvenile steelhead. Young-of-the-year steelhead were distinguished from age-1 and older steelhead based on length. The relative densities of naturally-produced and residual steelhead in Deer and Little Sheep creeks during summer 1993 and 1994 were reported in Jonasson et al. (1994), and Jonasson et al. (1995), respectively.

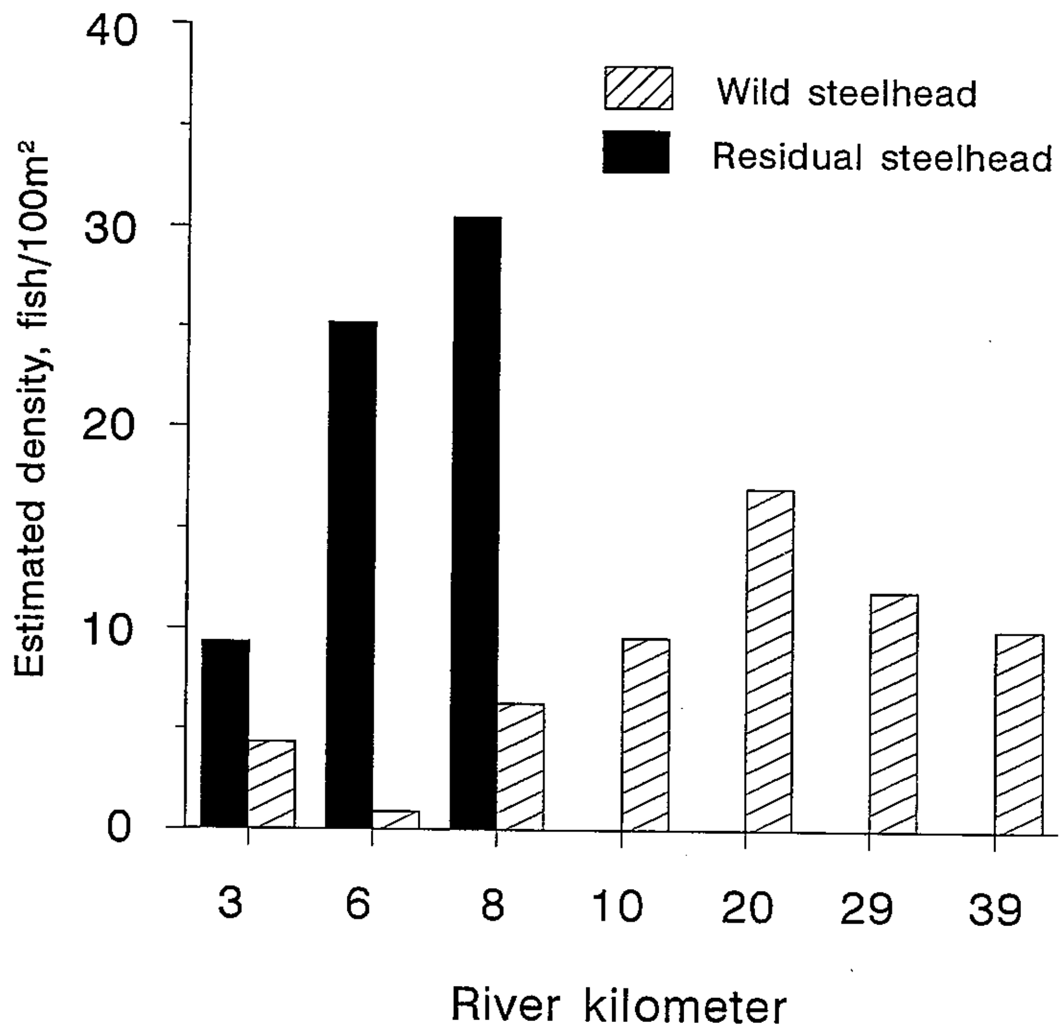
The relative densities of naturally-produced and residual steelhead in Deer Creek during summer 1995 are shown in **Appendix Figure A-1**. Displacement of naturally-produced steelhead by residuals was not apparent in Deer Creek at the low densities of residuals observed during summer 1995.

The relative densities of naturally-produced and residual steelhead in Little Sheep Creek during summer 1995 are shown in **Appendix Figure A-2**. After three years of sampling, it is still unclear whether residuals displace naturally-produced steelhead in Little Sheep Creek.

This is anecdotal information collected during this project, and the sampling was not designed to determine whether residuals were displacing naturally-produced juvenile steelhead.



Appendix Figure A-1. The relative densities of residual hatchery steelhead and naturally-produced steelhead (age 1 and older) in Deer Creek during summer 1995. Hatchery steelhead were released at rkm 0.



Appendix Figure A-2. The relative densities of residual hatchery steelhead and naturally-produced steelhead (age 1 and older) in Little Sheep Creek during summer 1995. Hatchery steelhead were released at rkm 8.

APPENDIX B

Catch of Residual Hatchery Steelhead in Summer Steelhead Fisheries in Northeast Oregon

We collected catch information for residuals during summer steelhead creel surveys in the fall on the Grande Ronde and Imnaha rivers, and in the spring on the Grande Ronde, Wallowa, and Imnaha rivers. Anglers interviewed during steelhead creel surveys reported catching residuals in the fall and spring in the Grande Ronde River basin and in the Imnaha River **(Appendix Table B-1)**, indicating that residuals do contribute to fisheries in northeast Oregon. The majority of the catch of residuals in the lower Grande Ronde River survey area and in the Imnaha River occurred during the fall. Some of the "residuals" may actually have been hatchery rainbow trout planted in the Grande Ronde River for trout fisheries. These fish were fin-marked, but no attempt was made to differentiate residuals from hatchery rainbow trout during these creel surveys.

Appendix Table B-1. Number of residual hatchery steelhead, wild rainbow trout and adult steelhead reported caught during steelhead creel surveys in the Imnaha and Grande Ronde river basins, fall 1995 to spring 1996.

Survey area	Season	Anglers interviewed	Residual steelhead	Wild trout	Adult steelhead
Imnaha River	fall	79	101	65	29
	spring	192	42	92	115
Lower Grande Ronde River	fall	586	600	285	154
	spring	119	21	12	51
Upper Grande Ronde River	spring	228	4	2	41
Wallowa River	spring	750	94	15	152

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