Issue Paper:

LENGTH OF HATCHERY STEELHEAD SMOLTS RELEASED IN IDAHO WITH IMPLICATIONS TO RESIDUALISM

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INTRODUCTION

The National Marine Fisheries Service (NMFS) recommended that by January 1996, only juvenile steelhead between 170 - 220 mm total length (tl), approximately 163 - 212 mm fork length (fl), be released as smolts to reduce adverse effects on chinook salmon (NMFS 1995). This size criterion was largely based on the work of two researchers, Cannamela (1992, 1993) and Partridge (1985, 1986). Partridge examined the effect of steelhead trout smolt size on the rate of residualism in the Salmon River by releasing two marked groups of hatchery steelhead of different sizes: "large" ≈ 261 mm fl; and "normal" ≈ 204 mm fl. He concluded that the large size group residualized at a higher rate (13%) as compared to the normal size group (1%). Cannamela used Partridge's residualism estimates to predict potential impacts of hatchery steelhead smolts on juvenile chinook salmon (1992) and to estimate a predation rate for hatchery steelhead smolts on juvenile chinook (1993).

Partridge's results are questionable since inherent biases associated with sampling methods were not adequately addressed. Partridge's residualism estimates relied primarily on creel harvest data which may be biased toward larger sized fish due to angler preference and/or gear type. Moreover, downstream tributaries were not sampled (electrofished) until the middle of summer and recent research suggests that residuals were less likely to be observed at this time. ODFW (Jonasson et al. 1995) reported that the densities of residual steelhead declined during the summer in Oregon streams and the United States Fish and Wildlife Service (USFWS) (Bigelow 1995a) reported that the number of strays captured in tributaries of the Clearwater River, Idaho, declined as the season progressed.

Although Partridge's sampling methods may have introduced bias where small fish were not adequately sampled, large fish were found to residualize. However, new data (Whitesel et al. 1993, Jonasson et al. 1994, Jonasson et al. 1995) reveals that fish less than 200 mm, fl, are also prone to residualize. Partridge and Cannamela did not adequately address residualism rates for fish slightly larger, or slightly smaller, than the "normal" size group.

In this document we: 1) provide descriptive length statistics for steelhead (*Oncorhynchus mykiss*) produced in Idaho fish hatcheries in 1995 and 1996; 2) describe characteristics of steelhead smolts known to migrate; 3) describe characteristics of steelhead residuals (non-migrants); and 4) discuss the National Marine Fisheries Service size at release recommendation for hatchery steelhead. Cooperators in the Lower Snake River Compensation Plan (LSRCP) are charged with monitoring and evaluating the hatchery mitigation programs. The cooperators, specifically the Idaho Department of Fish and Game (IDFG), the Oregon Department of Fish and Wildlife (ODFW), and the Washington Department of Fish and Wildlife (WDFW) have collected and analyzed data pertaining to the hatchery steelhead trout programs in their respective states. These data suggest that restricting the size at release of steelhead smolts to between 170 and 220 mm total length may not achieve the desired goal of reducing the proportion of the release group that residualizes.

STEELHEAD AT IDFG HATCHERIES

Steelhead hatcheries operated by the IDFG include Clearwater Fish Hatchery, Magic Valley Fish Hatchery, and Niagara Springs Fish Hatchery. Steelhead are reared on a ten-month rearing program. Table 1 contains length statistics of steelhead released from Magic Valley and Niagara Springs fish hatcheries in 1995 and 1996. Data used for this analysis were collected in late March or early April, approximately two weeks prior to when the fish were released. Brood year 1994 steelhead were released in 1995; brood year 1995 steelhead were released in 1996. All length statistics reported in this document pertain to fork length, not total length.

Brood year 1994 steelhead were programmed to average 210 mm, fork length (fl) (4.5 fish per pound) at the time of release. Steelhead released in 1995 from Niagara Springs Fish Hatchery averaged 198 mm in length (fl) (weighted average); steelhead released from Magic Valley Fish Hatchery averaged 198 mm in length (fl) (weighted average) (Table 1).

Brood year 1995 steelhead were programmed to average 201 mm, fl, (5.0 fish per pound) at release to comply with the NMFS size at release recommendation specified in the *Proposed Recovery Plan for Snake River Salmon* (NMFS 1995). The average length for steelhead released from Niagara Springs Fish Hatchery in 1996 was 197 mm, fl (weighted average) (Table 1). Steelhead released from Magic Valley Fish Hatchery in 1996 averaged 212 mm in length (fl) (weighted average) and exceeded the programmed size. The size difference was attributed to an experimental feeding regime implemented to reduce size variation while controlling growth.

In 1995 (brood year 1994), 27% (weighted average) of the steelhead released from Magic Valley and Niagara Springs fish hatcheries were greater than 212 mm, fl, and 10% (weighted average) were less than 163 mm, fl, (Table 1). In 1996 (brood year 1995), 40% (weighted average) of the fish released from the two hatcheries were greater than 212 mm, fl, and 5% (weighted average) were less than 163 mm, fl. Steelhead were larger in 1996 because of the experimental feeding regime discussed previously.

Length frequency distributions for steelhead released in 1995 (brood year 1994) are shown, by hatchery and by stock, in Appendices A - C. For Magic Valley Fish Hatchery, length data were not significantly different ($P \leq 0.05$) among stocks, so data were pooled (Appendix A). Length frequency distributions for steelhead released in 1996 (brood year 1995) are shown, by hatchery and by stock, in Appendices D - H. Appendices A - H also show descriptive statistics for the fish sampled and the corresponding length ranges (boundaries) that contain 70%, 80%, and 90% of the distribution (e.g., 70% of the population would be between 192 mm and 238 mm).

SIZE AT RELEASE AND RESIDUALISM

The ODFW (Messmer et al. 1989) hatchery steelhead program produces steelhead smolts that average 200 mm, fl, which are similar to Partridge's "normal" size group. ODFW (Jonasson

Table 1. Fork length statistics for steelhead released in Idaho in 1995 and 1996. Brood year 1994 steelhead were released in 1995 and brood year 1995 steelhead were released in 1996. The columns on the right document the percentage of fish in the sample that were greater than 212 mm and less than 163 mm.

BROOD YEAR	HATCHERY	STOCK	N	MEAN (mm)	STD (mm)	MIN (mm)	MAX (mm)	Percent < 163 (mm)	Percent > 212 (mm)
1995	Magic	Dworshak B	503	214.92	22.24	120.00	280.00	0.80	52.29
1995	Magic	East Fork B	94	217.67	25.40	162.00	286.00	1.06	62.77
1995	Magic	Pahsimeroi A	400	208.39	21.30	118.00	256.00	2.25	40.75
		TOTAL	997						
		WEIGHTED	VALUES	212.56	SE=	2.75		1.40	48.65
1995	Niagara	Oxbow A	600	206.41	24.37	99.18	282.00	4.17	41.67
1995	Niagara	Pahsimeroi A	354	183.46	28.34	97.00	285.00	18.36	11.30
		TOTAL	954						
		WEIGHTED	VALUES	197.89	SE=	11.48		9.43	30.40
1994	Magic	Dworshak B	354	198.66	26.61	94.29	270.34	12.43	27.12
1994	Magic	East Fork B	122	196.86	23.15	113.85	250.78	12.30	20.49
1994	Magic	Pahsimeroi A	545	199.17	28.56	90.38	280.12	10.28	27.89
		TOTAL	1021						
		WEIGHTED	VALUES	198.72	SE=	0.70		11.26	26.74
1994	Niagara	Oxbow A	186	208.47	22.70	125.59	273.27	1.08	43.01
1994	Niagara	Pahsimeroi A	252	190.64	23.50	81.57	247.84	10.71	14.29
		TOTAL	438						
		WEIGHTED	VALUES	198.21	SE=	8.92		6.62	26.48

et al. 1995) reported that 5% of the hatchery steelhead released as smolts into Little Sheep Creek, Oregon, residualized. Unlike Partridge's findings, ODFW found that in 1992 (Whitesel et al. 1993), 1993 (Jonasson et al. 1994), and 1994 (Jonasson et al. 1995) the residuals were significantly ($P < 0.05$) smaller than the fish which were released (Figure 1). ODFW (Jonasson et al. 1995) characterized residuals as smaller than average and being predominantly male.

Bigelow (1995a) conducted a study at Dworshak National Fish Hatchery, Idaho, to examine the characteristics and movement of juvenile fish that stray into downstream tributaries for three different sizes classes of hatchery steelhead: "small" ≤ 180 mm fl; "medium" > 180 mm to ≤ 200 mm fl; and "large" > 200 mm fl. Bigelow also reported that the steelhead that strayed into tributaries of the Clearwater River, Idaho, were primarily from the small size class and that these strays were significantly ($P < 0.001$) smaller than the fish released from Dworshak National Fish Hatchery.

Schuck et al. (1995) studied residualism of hatchery steelhead in the Tucannon River, Washington, between 1991 and 1994. In 1993 and 1994 WDFW (Schuck et al. 1995; Viola and Schuck 1995) tested a volitional release strategy designed to reduce the number of steelhead residuals in the Tucannon River. Steelhead that volitionally emigrated from the acclimation pond were classified as migrants; fish that did not volitionally leave the pond were classified as non-migrants. WDFW (Schuck et al. 1995) characterized non-migrants to be transitionally-developed males, with condition factors (K) greater than 1.05. Steelhead were also classified as "smolt", "transitional", and "parr" based on the presence or absence of parr marks and skin coloration. In 1994, the mean length of volitional migrants classified as smolts was 234.6 mm, fl, ($n = 211$); the mean length of non-migrants classified as smolts was 222.9 mm, fl ($n = 18$). The mean length of volitional migrant, transitional steelhead was 219.9 mm, fl, ($n = 110$); the mean length of non-migrant, transitional steelhead was 212.4 mm, fl ($n = 289$). No volitional migrants were classified as parr; the mean length of non-migrant parr was 141.2 mm, fl ($n = 4$).

IDFG's (unpublished) recent findings concur with ODFW's (Jonasson et al. 1995) characterization of residual steelhead (smaller than average and predominantly male). IDFG released steelhead juveniles at Pahsimeroi Fish Hatchery from April 9 to April 25, 1996. Between May 13 and May 28, 1996, 357 residuals were collected from the release site using dip nets. Residuals were significantly ($P < 0.0001$) shorter, lighter, and had lower condition factors than the released population (Figure 2). In addition, 82% (291) of the residuals collected were male and 73% (212) of the males were classified as mature (testes were enlarged).

SIZE AND MIGRATION

Several researchers have reported that the average length of migrating steelhead smolts was greater than the average length of the population that was released; they did not attribute the size difference to growth (Chrisp and Bjornn 1978; Bigelow 1995a; Bigelow 1995b; Schuck et al. 1995). This suggests that the smaller fish were not migrating and/or were not being collected or

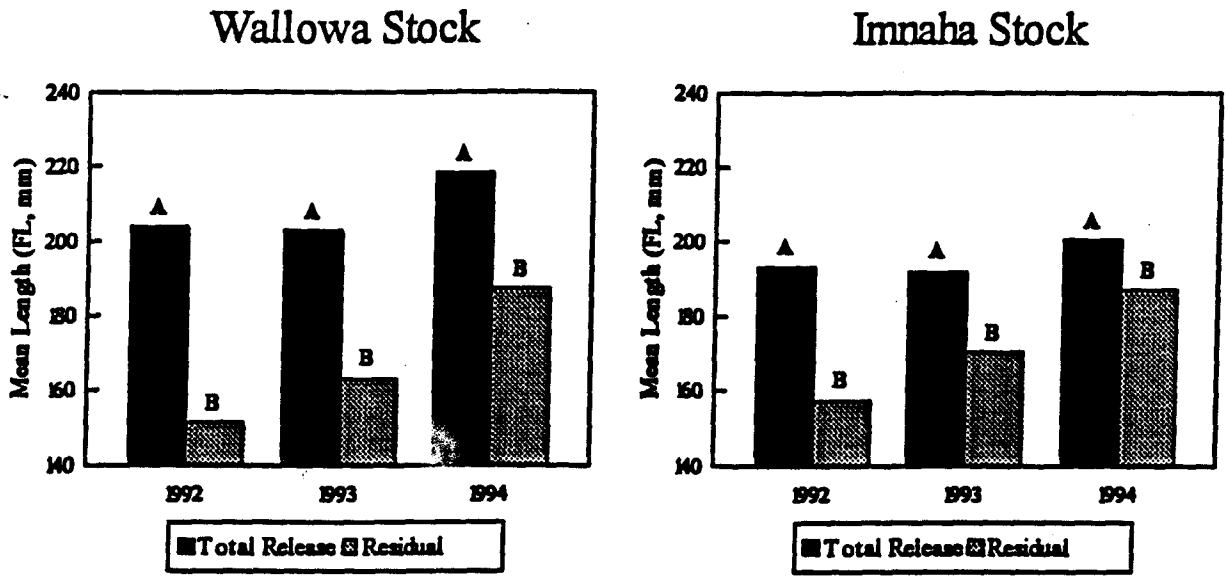


Figure 1. Mean fork length (mm) of hatchery-reared steelhead, by stock. Means not followed by the same letter are significantly ($P < 0.05$) different. Data taken from Whitesel et al. (1993), Jonasson et al. (1994), and Jonasson et al. (1995).

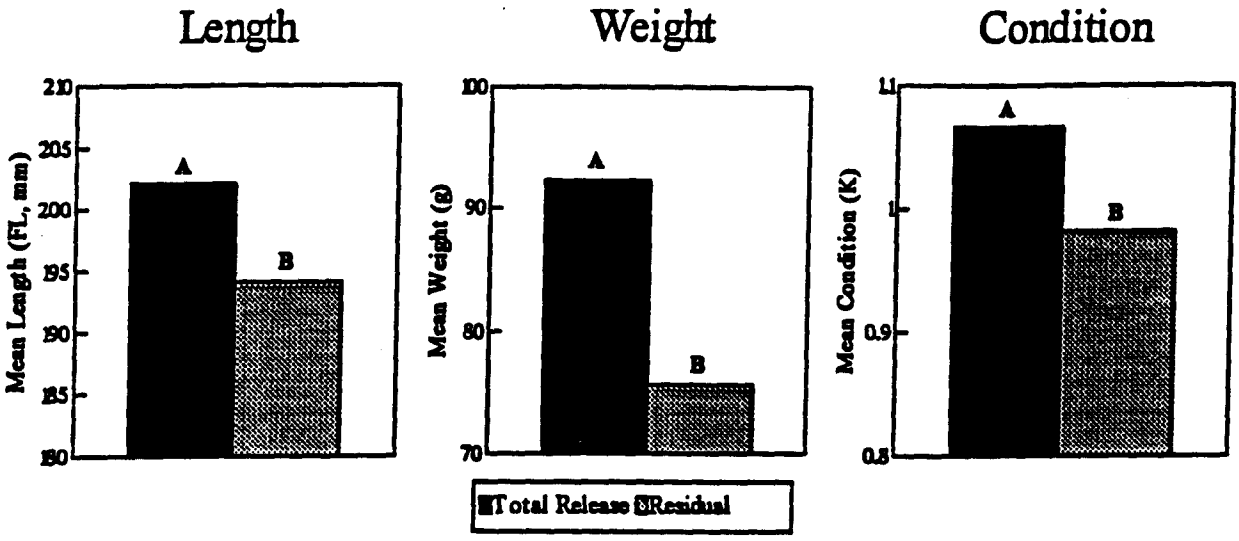


Figure 2. Comparison of steelhead released at Pahsimeroi Fish Hatchery, Idaho, in 1996 and residuals collected at the release site approximately one month later. Means not followed by the same letter are significantly ($P < 0.0001$) different.

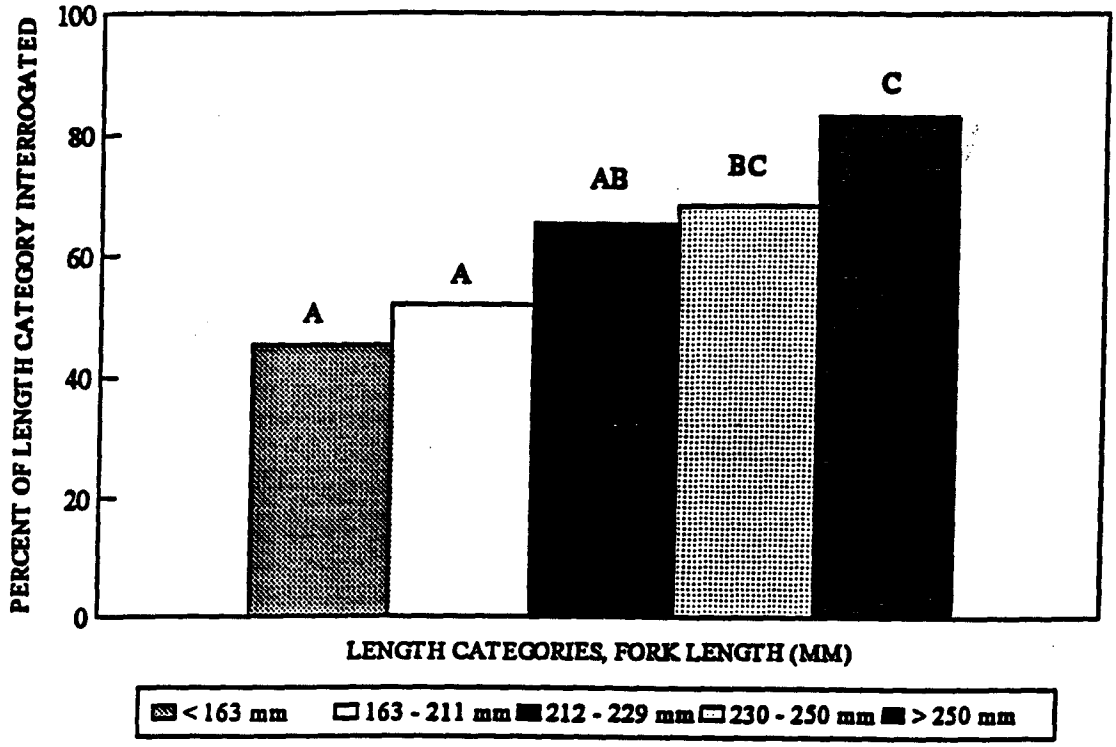
interrogated (i.e., interrogated using Passive Integrated Transponder (PIT) tags). While other factors also affect migration (flows, time of release, temperature, predation, etc.), only fish size is addressed in this paper.

USFWS (Bigelow 1995b) conducted a study at Dworshak National Fish Hatchery, Idaho, to determine migration rates for three different size classes of hatchery steelhead: "small" ≤ 180 mm, fl; "medium" > 180 mm to ≤ 200 mm, fl; "large" > 200 mm, fl. They found that PIT tagged fish from the large and medium size classes were interrogated at downstream dams at significantly ($P < 0.01$) higher rates as compared to the tagged fish in the small size class. In addition, PIT tagged fish interrogated at downstream dams from these releases were significantly ($P < 0.01$) larger than the fish tagged at Dworshak National Fish Hatchery (PIT tagged fish interrogated at the dams are not re-measured; the length and weight at tagging are used in the analysis). USFWS (Bigelow 1995a) also found that mean length of PIT tagged fish detected at downstream dams was significantly ($P = 0.010$) greater than the mean length of fish that were not detected.

IDFG (unpublished) released 6,600 PIT tagged steelhead from four different hatcheries in 1996. Fish were released at 17 different sites (22 separate releases) in the Snake, Clearwater, and Salmon rivers, Idaho, between March 25 - April 28, 1996. For each fish release, the mean size of PIT tagged fish interrogated at downstream dams was significantly greater ($P < 0.05$) than the mean size of PIT tagged fish that were not interrogated (Appendix I). The length distribution of PIT tagged steelhead from the 1996 Hells Canyon Dam release (Niagara Springs Fish Hatchery, Tag file TDR96075.N14) is shown in Appendix J. Length distributions of interrogated, and non-interrogated, fish from this release are shown in Appendix K. These interrogation data were placed into five length categories and the numbers of fish interrogated in each category were tested for significant differences ($\alpha = 0.05$) using a Tukey-type multiple comparison test (Zar 1984) (Figure 3). The proportion of fish interrogated, by length category, increased significantly with fish length. Steelhead in the 230 - 250 mm and the > 250 mm length categories were interrogated at significantly higher ($P < 0.05$) rates than steelhead in the two length categories that included fish less than 211 mm (i.e., < 163 mm and 163- 211 mm). Steelhead in the 163-211 mm length category, the length the NMFS recommends for hatchery steelhead, had an interrogation rate of 52.1% while steelhead between 212 -250 mm, fl, had an interrogation rate of about 66%. Steelhead greater than 250 mm, fl, had an interrogation rate of 83.3% (Figure 3).

SIZE, DEGREE OF SMOLTIFICATION, AND MIGRATION

WDFW (Schuck et al. 1995) found that smolt size, condition factor, and degree of smoltification appear to be strongly related to emigration performance. WDFW (Schuck et al. 1995) found that PIT tagged steelhead classified as smolts were interrogated at downstream dams at significantly ($P < 0.05$) higher rates than steelhead classified as transitional. Smolts were generally longer and leaner than fish classified as transitional. No parr were detected at any downstream dam. Schuck et al. (1995) also examined PIT tag interrogation data for a volitional release study conducted in 1994 (described previously). They reported that the average length of volitional migrant smolts



	LENGTH CATEGORY (FL, MM)				
	< 163	163 - 211	212 - 229	230 - 250	> 250
TOTAL TAGGED	11	121	90	60	18
TOTAL INTERROGATED	5	63	59	41	15
RELEASE STATS	N	MEAN	STD	MEDIAN	
	300	212.55	26.3	215	

Figure 3. Proportion, by length category, of PIT tagged steelhead from Niagara Springs Fish Hatchery (brood year 1995 - Oxbow stock) released at Hells Canyon Dam which were interrogated at Snake and Columbia river dams. Different letters above bars represent significantly different ($P < 0.05$) interrogation rates, by length category. The table below the histogram summarizes tagging and interrogation information and release statistics.

that were interrogated was 236.0 mm, fl; the average length of volitional migrant smolts that were not interrogated was 233.6 mm, fl. Interrogated transitional steelhead (volitional migrants) averaged 244.4 mm in length (fl); transitional steelhead (volitional migrants) that were not interrogated averaged 217.9 mm in length (fl).

IDFG (unpublished) conducted a volitional release experiment in 1996 using PIT tags and classified fish by degree of smoltification following Schuck et al. (1995). Fish classified as smolts were significantly ($P < 0.05$) longer than fish classified as either transitional or parr (Figure 4) and had significantly higher interrogation rates than fish classified as transitional and parr (Figure 5). Steelhead classified as smolts had significantly ($P < 0.05$) faster median travel times to Lower Granite Dam than fish classified as transitional. No steelhead classified as parr were detected at Lower Granite Dam. Fish classified as smolt and transitional had significantly ($P < 0.05$) lower condition factors than fish classified as parr (Figure 4). While condition factor was not significantly different between smolt and transitional fish that were PIT tagged and released, fish that were sacrificed and sexed during the experiment had significantly different condition factors based on the degree of smoltification (Figure 6). Smolts had significantly ($P < 0.05$) lower condition factors than fish classified as transitional and parr. Both IDFG (unpublished) and WDFW (Schuck et al. 1995) found that fish length, condition factor, and the degree of smoltification influenced interrogation rates.

CONCLUSIONS

The steelhead length data presented in this paper originated primarily from releases made in 1994, 1995, and 1996. We believe these data adequately encompass the size range of juvenile steelhead released from hatcheries and are adequate for examining the relationship between fish size and residualism. Also, post-release migration conditions were likely very different for each of the three cohorts. We cannot state that any of the three cohorts migrated under "normal" conditions, however, these data represent a small range of migration conditions. We draw the following conclusions based on the findings in this paper:

1) Steelhead residuals were significantly smaller than migrants and were predominantly male,
2) Migrating juvenile steelhead were significantly larger than non-migrants,
3) Juveniles classified as smolts were significantly longer than fish classified as transitional and parr,
4) Juveniles classified as smolts were interrogated at significantly higher rates than fish classified as transitional or parr, and
5) Juveniles classified as smolts had significantly faster median travel times than fish classified as transitional and parr.

In summary, we believe the upper size limit proposed by the NMFS (220 mm total length) is too restrictive, and may act to increase the residualism rate. Our studies indicated larger fish are less likely to residualize (few very large fish were observed or tested in this study). Hatchery practices designed to grow fish that are 170 - 220 mm total length at release may actually produce a greater

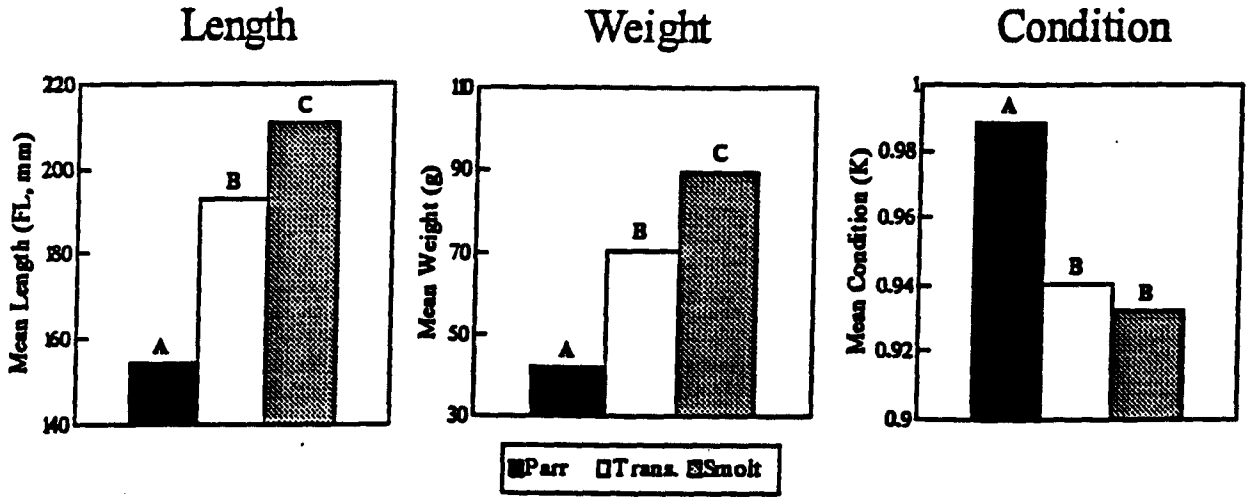


Figure 4. Comparison of steelhead classified as parr, transitional, and smolt from fish PIT tagged and released at Sawtooth Fish Hatchery, Idaho, for the 1996 volitional release experiment. Means not followed by the same letter are significantly ($P < 0.05$) different.

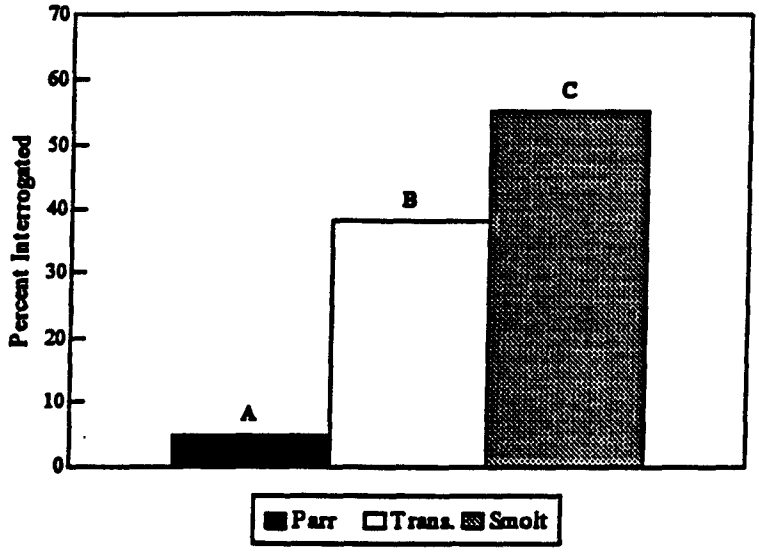


Figure 5. Comparison of PIT tag interrogation rates for steelhead classified as parr, transitional, and smolt from the Sawtooth Fish Hatchery, Idaho, 1996 volitional release experiment. Interrogation rates not followed by the same letter are significantly ($P < 0.001$) different.

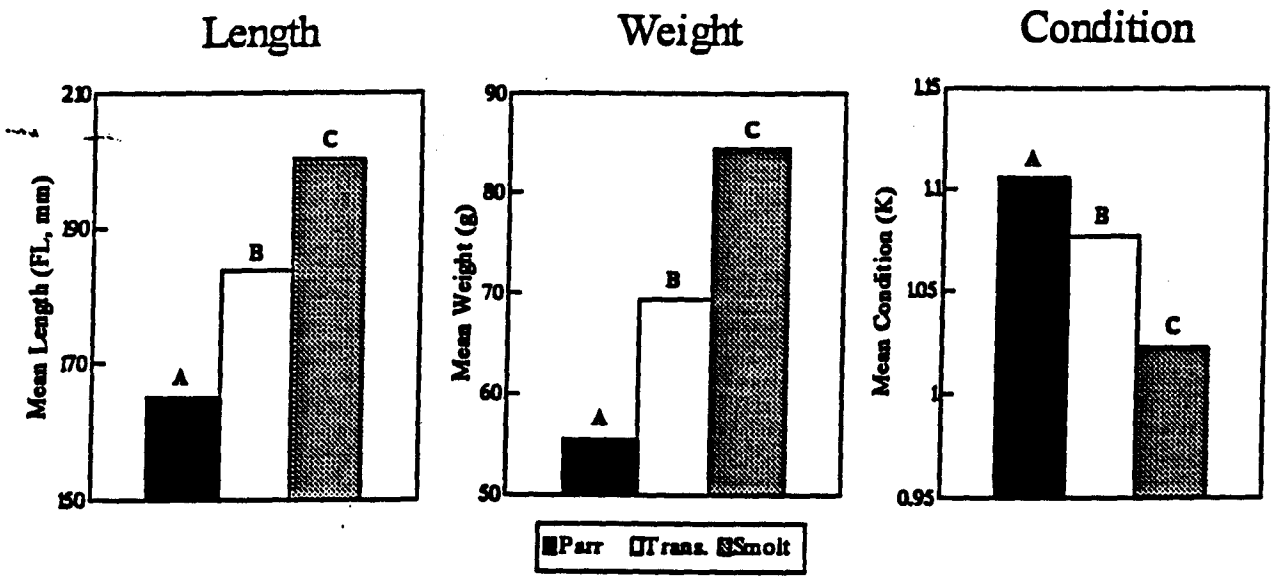


Figure 6. Comparison of steelhead classified as parr, transitional, and smolt from fish sacrificed at Sawtooth Fish Hatchery, Idaho, for the 1996 volitional release experiment (sex ratio sampling). Means not followed by the same letter are significantly ($P < 0.05$) different.

proportion of "small" fish, which have been shown to residualize at a higher rate than larger fish. We cannot specify an optimum size at release to minimize residualism at this time, but we feel an upper size at release limit of 220 mm total length will preclude hatcheries from releasing many of the most actively migrating fish.

It is important that any size at release restrictions placed on steelhead smolts take into account the hatchery rearing environment where the fish are reared and characteristics of the release and migration environments. The analyses and conclusions we provide above pertain only to steelhead reared at Magic Valley and Niagra Springs hatcheries, and released in the Salmon River and its tributaries. Clearwater Anadromous Fish Hatchery (CAFH), located on the Clearwater River at Ahsahka, Idaho, Produces steelhead juveniles for release into the Clearwater River and its tributaries. Fork length statistics of steelhead reared at CAFH are significantly different from similar statistics for steelhead reared at Magic Valley and Niagra Springs hatcheries. Brood year 1995 steelhead reared at CAFH averaged about 170 mm fl at the time of tagging, and the distribution of sizes was tightly clustered about the mean (coefficient of variation range = 7.9% - 13.1% for three groups). The PIT-tag detection rate for each of the three groups was 71%. Preliminary analyses indicate that a greater relative proportion of the smaller fish may have gone undetected.

In addition to the high detection rates, showing that at least a major proportion of the release groups were actively migrating, these fish are released in areas that are not important juvenile salmon rearing areas. Therefore, we expect very minimal interaction between any steelhead that do residualize and rearing juvenile salmon. Lastly, the Idaho Department of Fish and Game is concerned with producing high quality hatchery steelhead smolts that actively migrate when released. A special condition of our NMFS Section 10 permit for release of fish from Idaho Power Company hatcheries is that "IDFG must operate hatcheries located along the Snake and Columbia River migration corridor in a manner that emphasizes the production and release of smolts that are ready to migrate to the ocean and spend a minimum amount of time in the freshwater environment. This should minimize interactions and, thus, impacts to listed and unlisted natural fish in the migration corridor." Our hatchery research and management objectives are focused on producing fish that actively migrate, and have the potential to contribute to adult returns.

LITERATURE CITED

Bigelow, P.E. 1995a. Survival to Lower Granite Dam of wild and straying and non-straying Dworshak National Fish Hatchery steelhead. Pages 59-76 *in* Interactions of hatchery and wild steelhead in the Clearwater River of Idaho. United States Fish and Wildlife Service and Nez Perce Tribe. United States Fish and Wildlife Report. Fisheries Stewardship Project. 1994 Progress Report. Ahsahka, Idaho.

Bigelow, P.E. 1995b. Migration to Lower Granite Dam of Dworshak National Fish Hatchery Steelhead. Pages 42-58 *in* Interactions of hatchery and wild steelhead in the Clearwater River of Idaho. United States Fish and Wildlife Service and Nez Perce Tribe. United States Fish and Wildlife Report. Fisheries Stewardship Project. 1994 Progress Report. Ahsahka, Idaho.

Cannamela, D.A. 1992. Potential impacts of releases of hatchery steelhead trout "smolts" on wild and natural juvenile chinook and sockeye salmon. White paper, Idaho Department of Fish and Game, Fisheries Research, Boise, Idaho.

Cannamela, D.A. 1993. Hatchery steelhead smolt predation of wild and natural juvenile chinook salmon fry in the upper Salmon River, Idaho. Idaho Department of Fish and Game, Fisheries Research, Boise, Idaho.

Chrisp, E.Y. and T.C. Bjornn. 1978. Parr-smolt transformation and seaward migration of wild and hatchery steelhead trout in Idaho. Forest, Wildlife, and Range Experiment Station. Project F-49-12, Salmon and Steelhead Investigation. Final Report. Moscow, Idaho.

Jonasson, B.C., R.W. Carmichael, and T.A. Whitesel. 1994. Residual hatchery steelhead: Characteristics and potential interactions with spring chinook salmon in northeast Oregon. United States Fish and Wildlife Service, Lower Snake River Compensation Plan. Contract Number 14-48-0001-93538. Oregon Department of Fish and Wildlife, Annual Progress Report, Portland, Oregon.

Jonasson, B.C., R.W. Carmichael, and T.A. Whitesel. 1995. Residual hatchery steelhead: Characteristics and potential interactions with spring chinook salmon in northeast Oregon. United States Fish and Wildlife Service, Lower Snake River Compensation Plan. Contract Number 14-48-0001-94543. Oregon Department of Fish and Wildlife, Annual Progress Report, Portland, Oregon.

Messmer, S.W., R.C. Carmichael, and M.W. Flesher. 1989. Lower Snake River Compensation Plan, Oregon evaluations studies. United States Fish and Wildlife Service, Lower Snake River Compensation Plan. Contract Number 14-16-0001-88518 (RWG). Oregon Department of Fish and Wildlife, Annual Progress Report, Portland, Oregon.

National Marine Fisheries Service. 1995. Proposed recovery plan for Snake River salmon. United States Department of Commerce. National Oceanic and Atmospheric Administration.

Partridge, F.E. 1985. Effects of steelhead smolt size on residualism and adult return rates. United States Fish and Wildlife Service, Lower Snake River Compensation Plan. Contract Number 14-16-001-83605. Idaho Department of Fish and Game, Boise, Idaho.

Partridge, F.E. 1986. Effects of steelhead smolt size on residualism and adult return rates. United States Fish and Wildlife Service, Lower Snake River Compensation Plan. Contract Number 14-16-001-83605. Idaho Department of Fish and Game, Boise, Idaho.

Schuck, M.L., A.E. Viola, and M.G. Keller. 1995. Lyons Ferry Trout Evaluations Study. United States Fish and Wildlife Service, Lower Snake River Compensation Plan. Contract Number 14-16-0001-93540. Washington Department of Fish and Wildlife, 1993-94 Annual Report, Olympia, Washington.

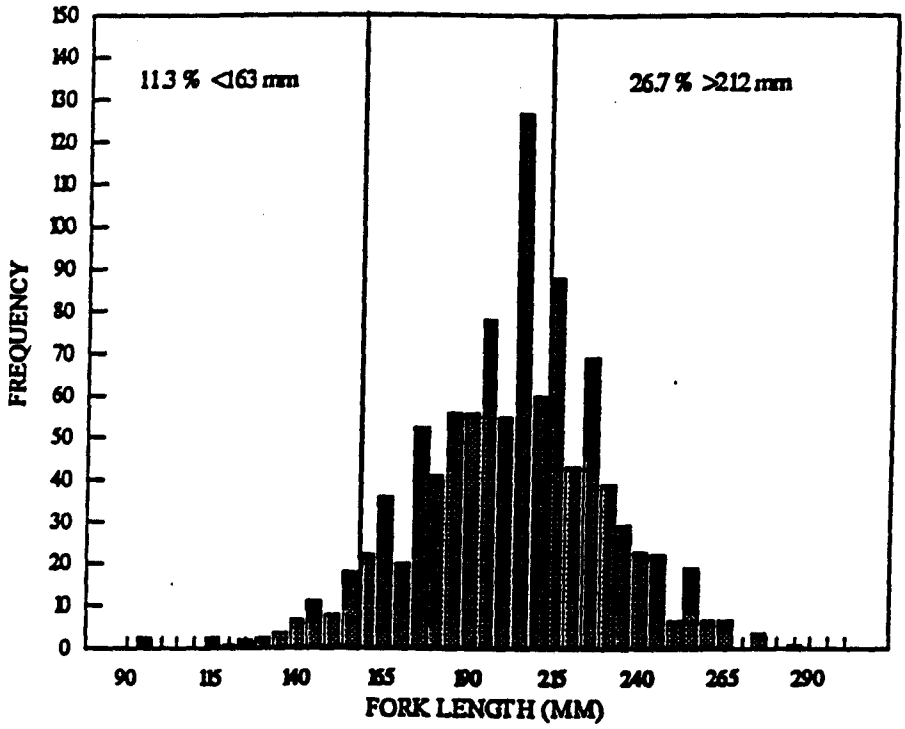
Viola, A.E. and M.L. Schuck, 1995. A method to reduce the abundance of residual hatchery steelhead in rivers. North American Journal of Fisheries Management 15:488-493.

Whitesel, T.A., B.C. Jonasson, and R.W. Carmichael. 1993. Residual hatchery steelhead: Characteristics and potential interactions with spring chinook salmon in northeast Oregon. United States Fish and Wildlife Service, Lower Snake River Compensation Plan. Contract Number 14-16-0001-92541. Oregon Department of Fish and Wildlife, Annual Progress Report, Portland, Oregon.

Zar, J.H. 1984. Biostatistical analysis, Second Edition. Prentice hall, Englewood Cliffs, New Jersey.

APPENDICES

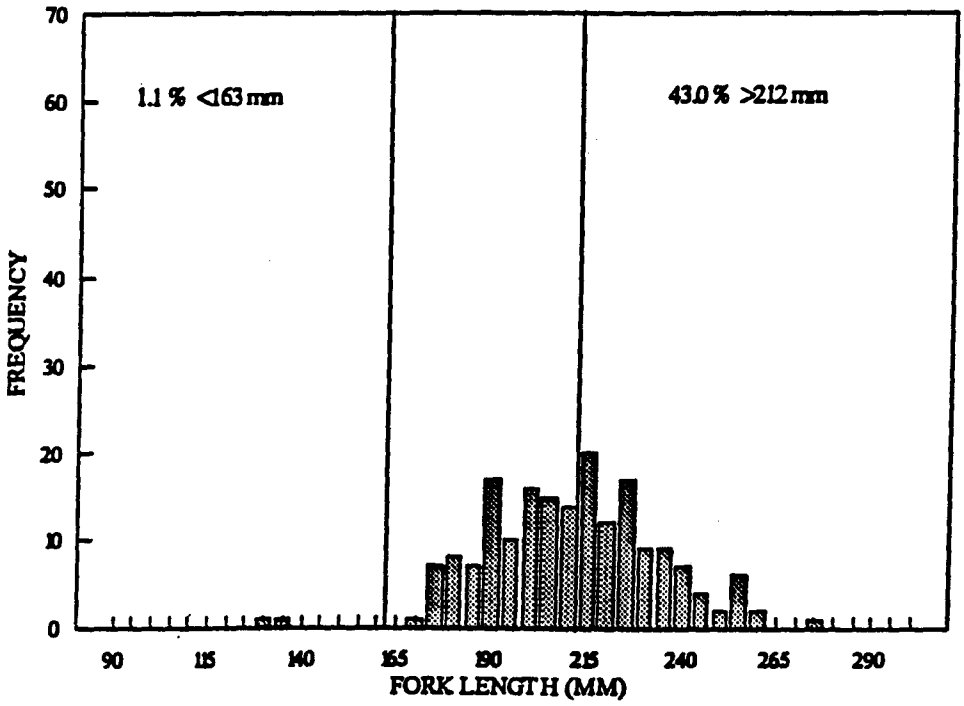
Appendix A. Length frequency distribution for steelhead (brood year 1994 - Dworshak, East Fork, and Pahsimeroi stocks) from Magic Valley Fish Hatchery, April, 1995. The table below the histogram summarizes length statistics and lower and upper length bounds at 70%, 80%, and 90% of the central distribution.



N	MEAN	STD	MEDIAN
1021	198.72	27.28	201.87

	LENGTH BOUNDS	
DISTRIBUTION	LOWER	UPPER
70% OF CENTRAL	172.53	226.32
80% OF CENTRAL	162.75	231.21
90% OF CENTRAL	153.00	241.00

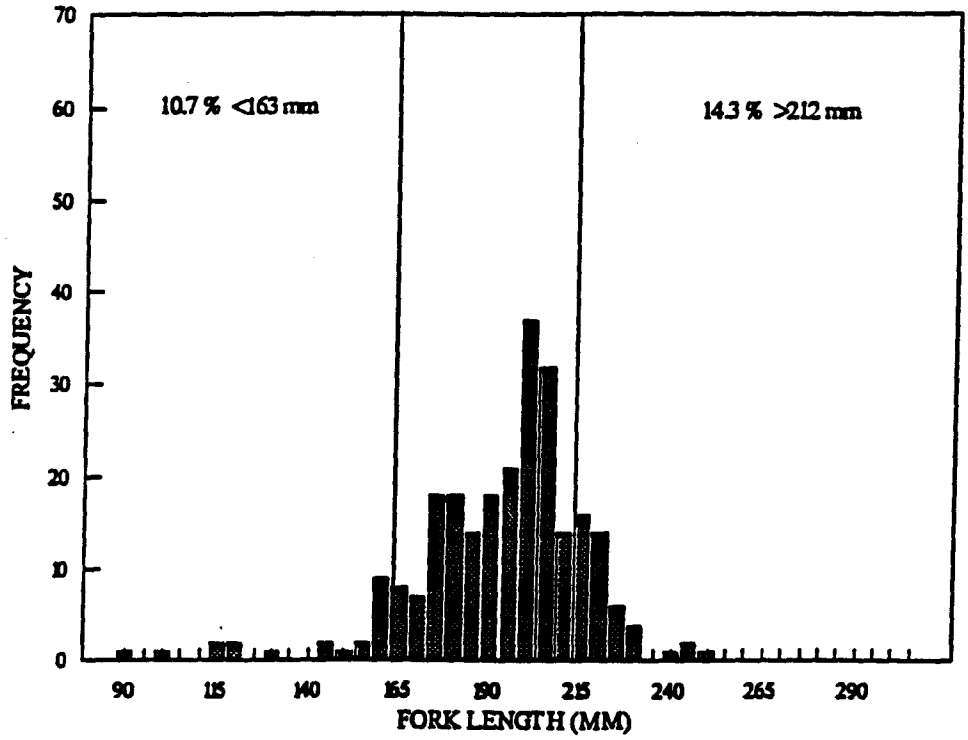
Appendix B. Length frequency distribution for steelhead (brood year 1994 - Oxbow stock) from Niagara Springs Fish Hatchery, March, 1995. The table below the histogram summarizes length statistics and lower and upper length bounds at 70%, 80%, and 90% of the central distribution.



N	MEAN	STD	MEDIAN
186	208.47	22.7	207.74

	LENGTH BOUNDS	
DISTRIBUTION	LOWER	UPPER
70% OF CENTRAL	186.22	231.22
80% OF CENTRAL	180.36	238.06
90% OF CENTRAL	174.49	248.82

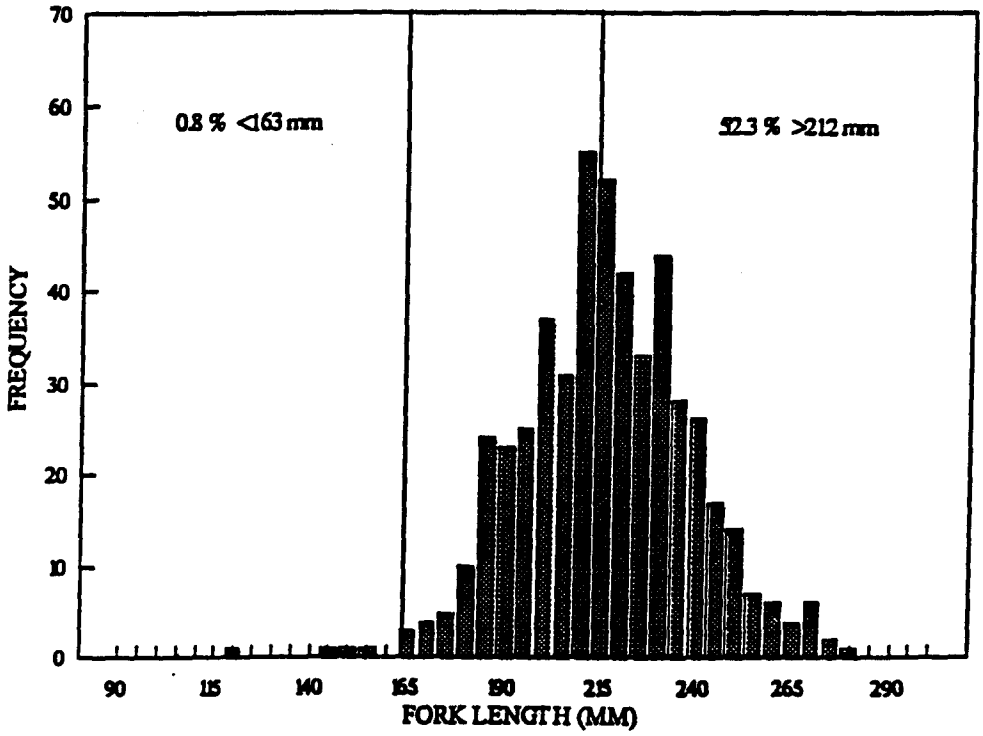
Appendix C. Length frequency distribution for steelhead (brood year 1994 - Pahsimeroi stock) from Niagara Springs Fish Hatchery, March, 1995. The table below the histogram summarizes length statistics and lower and upper length bounds at 70%, 80%, and 90% of the central distribution.



N	MEAN	STD	MEDIAN
252	190.64	23.5	195.03

	LENGTH BOUNDS	
DISTRIBUTION	LOWER	UPPER
70% OF CENTRAL	171.55	211.65
80% OF CENTRAL	161.77	216.54
90% OF CENTRAL	155.90	221.43

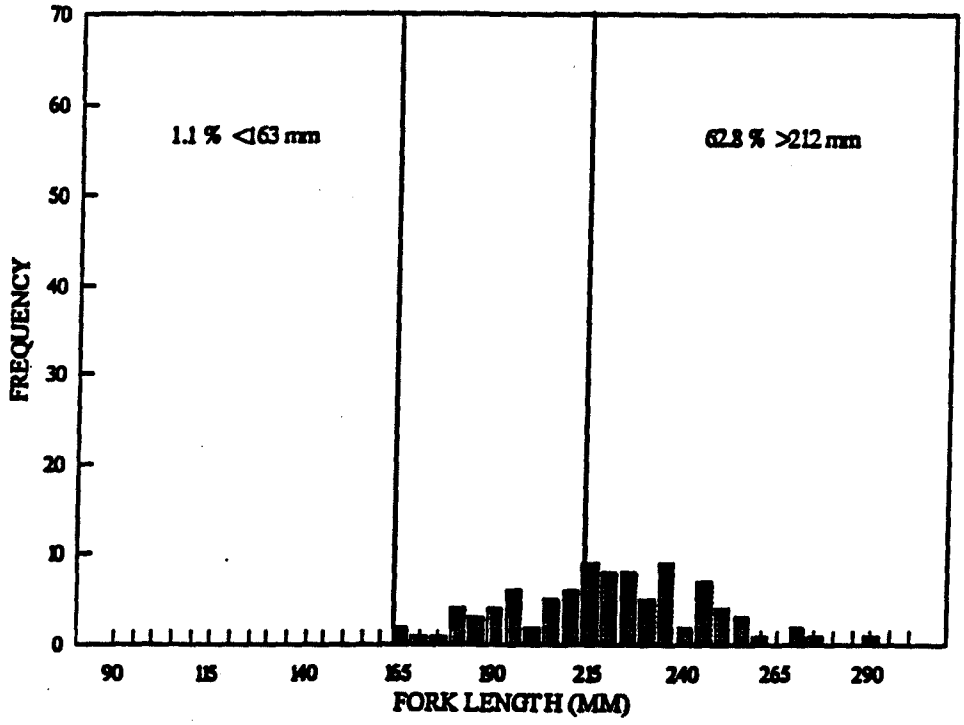
Appendix D. Length frequency distribution for steelhead (brood year 1995 - Dworshak stock) from Magic Valley Fish Hatchery, April, 1996. The table below the histogram summarizes length statistics and lower and upper length bounds at 70%, 80%, and 90% of the central distribution.



N	MEAN	STD	MEDIAN
503	214.92	22.2	214.0

	LENGTH BOUNDS	
DISTRIBUTION	LOWER	UPPER
70% OF CENTRAL	192.00	238.00
80% OF CENTRAL	187.00	242.00
90% OF CENTRAL	180.00	251.00

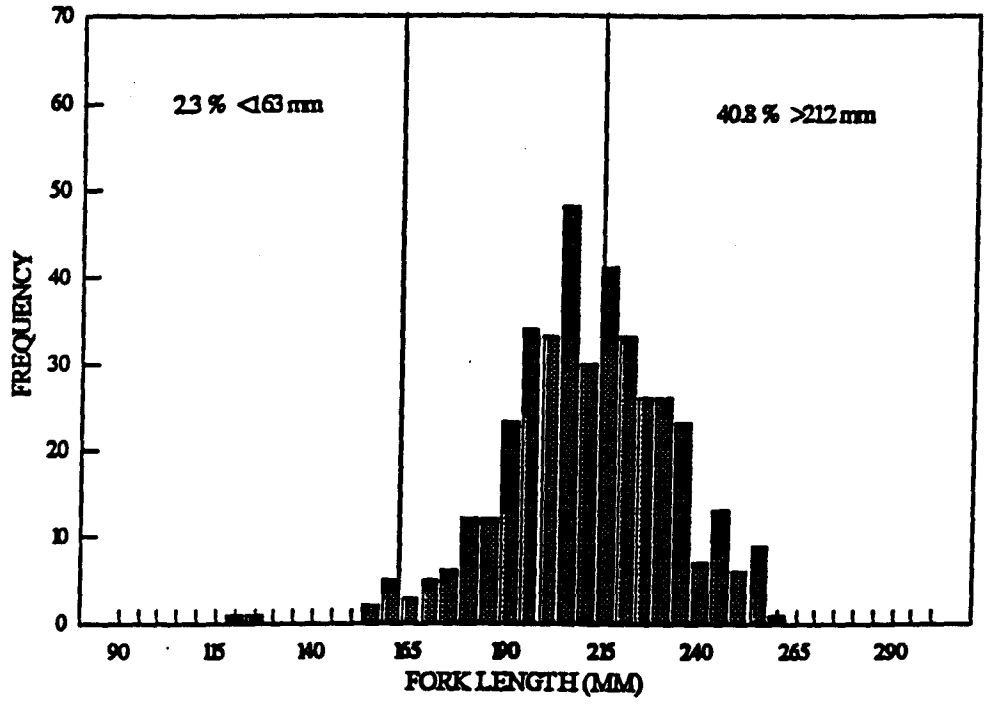
Appendix E. Length frequency distribution for steelhead (brood year 1995 - East Fork stock) from Magic Valley Fish Hatchery, April, 1996. The table below the histogram summarizes length statistics and lower and upper length bounds at 70%, 80%, and 90% of the central distribution.



N	MEAN	STD	MEDIAN
94	217.67	25.4	218.0

	LENGTH BOUNDS	
DISTRIBUTION	LOWER	UPPER
70% OF CENTRAL	190.00	243.00
80% OF CENTRAL	182.00	246.00
90% OF CENTRAL	177.00	260.00

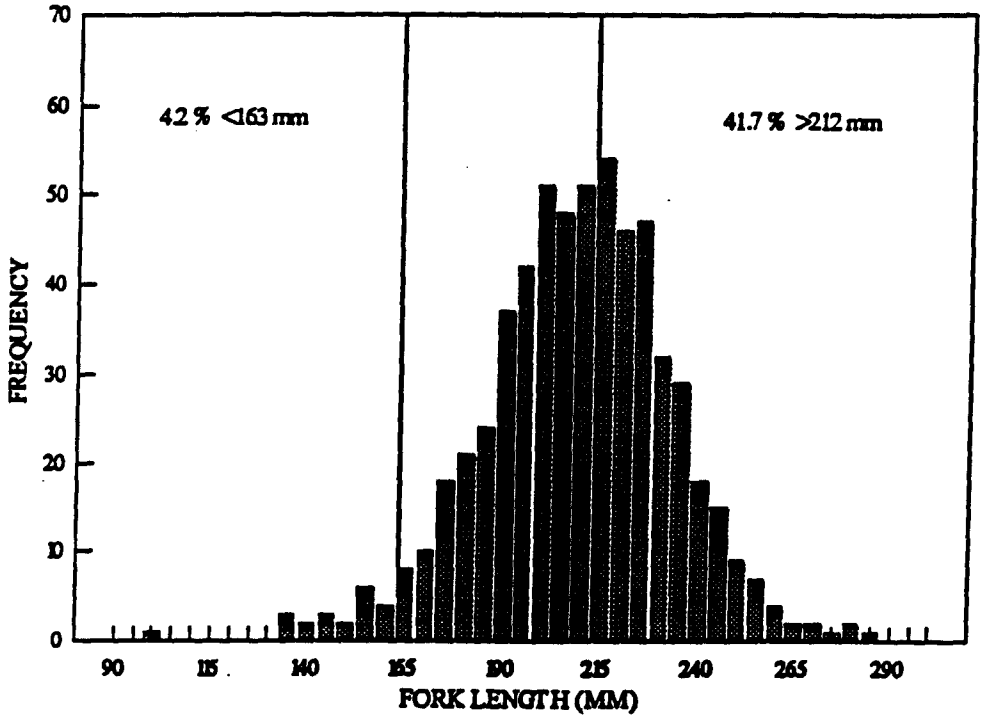
Appendix F. Length frequency distribution for steelhead (brood year 1995 - Pahsimeroi stock) from Magic Valley Fish Hatchery, April, 1996. The table below the histogram summarizes length statistics and lower and upper length bounds at 70%, 80%, and 90% of the central distribution.



N	MEAN	STD	MEDIAN
400	208.39	21.3	208.0

	LENGTH BOUNDS	
DISTRIBUTION	LOWER	UPPER
70% OF CENTRAL	188.00	230.00
80% OF CENTRAL	182.00	234.50
90% OF CENTRAL	174.50	243.00

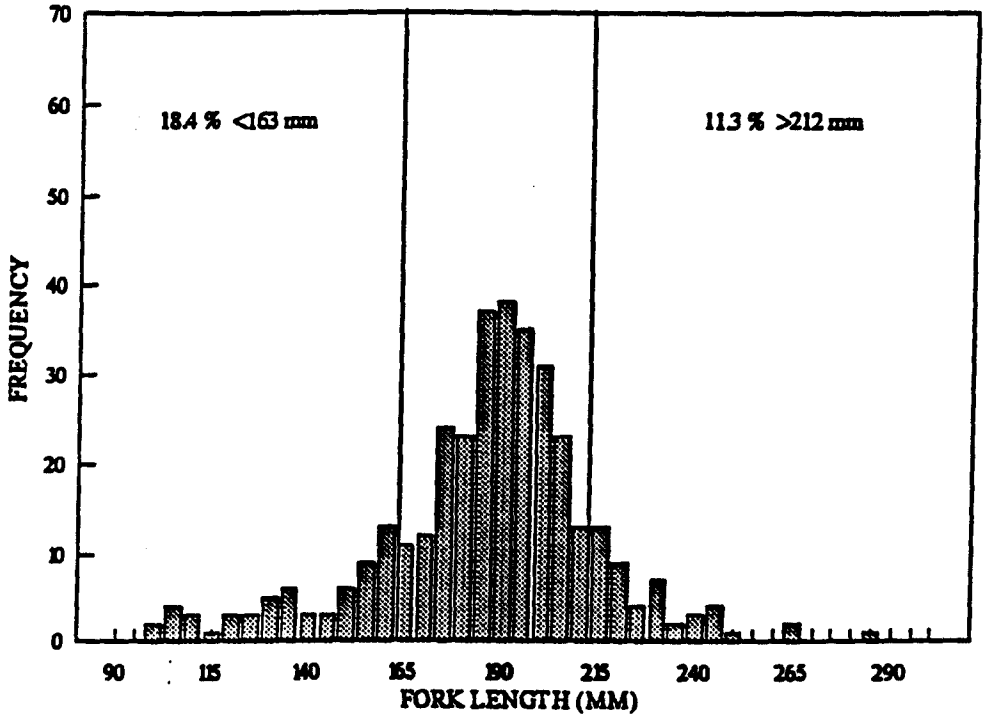
Appendix G. Length frequency distribution for steelhead (brood year 1995 - Oxbow stock) from Niagara Springs Fish Hatchery, April, 1996. The table below the histogram summarizes length statistics and lower and upper length bounds at 70%, 80%, and 90% of the central distribution.



N	MEAN	STD	MEDIAN
600	206.41	24.4	207.74

	LENGTH BOUNDS	
DISTRIBUTION	LOWER	UPPER
70% OF CENTRAL	182.66	230.12
80% OF CENTRAL	176.00	235.13
90% OF CENTRAL	165.85	245.00

Appendix H. Length frequency distribution for steelhead (brood year 1995 - Pahsimeroi stock) from Niagara Springs Fish Hatchery, March, 1996. The table below the histogram summarizes length statistics and lower and upper length bounds at 70%, 80%, and 90% of the central distribution.



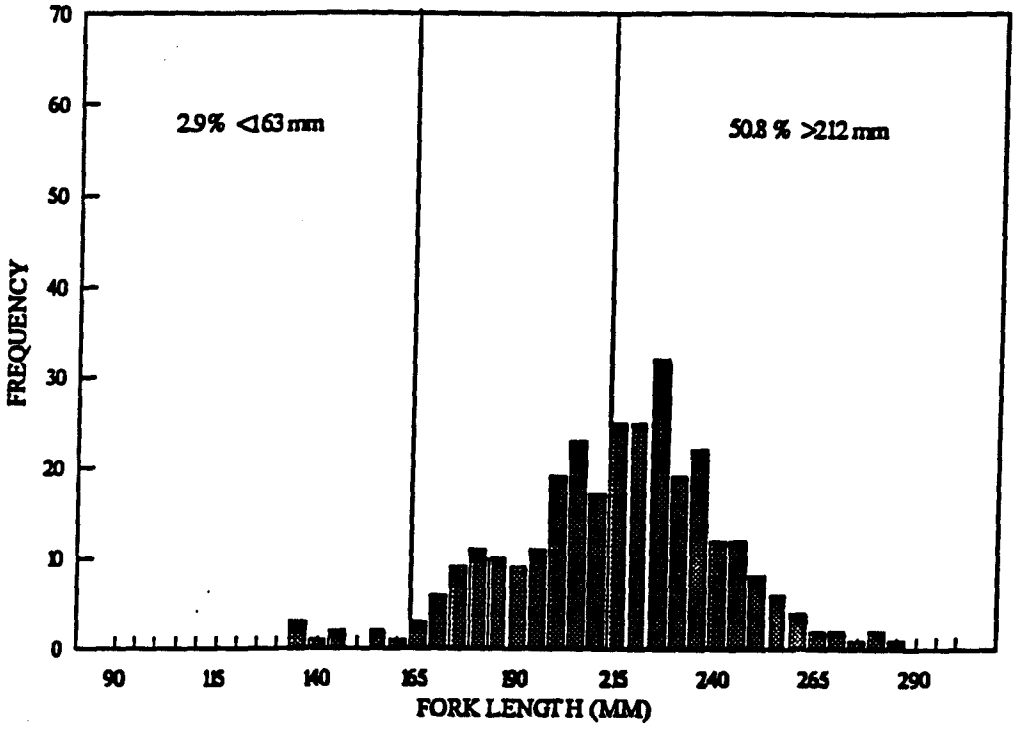
N	MEAN	STD	MEDIAN
354	183.46	28.3	187.0

	LENGTH BOUNDS	
DISTRIBUTION	LOWER	UPPER
70% OF CENTRAL	158.00	207.00
80% OF CENTRAL	147.00	215.00
90% OF CENTRAL	126.00	225.35

Appendix I. Summary of migration year 1996 (brood year 1995) Idaho hatchery steelhead PIT tag release and detection information. P-values reported are testing mean length of fish not interrogated vs. mean length of fish interrogated.

					Length Information								
					Fish Not Interrogated				Fish Interrogated				
Tag File	Release Site	Rel. Date	#Tag	#Rel	n	Mean	S.D.	S.E.	n	Mean	S.D.	S.E.	prob > | t |
NAGARA SPRINGS FH													
TDR96074.N06	PAHSIMEROI WEIR	04/18/96	300	299	103	195.14	24.85	2.44	196	202.64	21.55	1.54	0.0438
TDR96075.N10	L.SAL.WARM SPR.	03/25/96	300	300	123	165.92	30.74	2.77	177	187.42	18.70	1.41	0.0001
TDR96075.N14	HELLS CANYON	04/02/96	300	290	107	205.53	27.81	2.57	183	217.04	24.34	1.80	0.0003
TDR96O75.N19	HAMMER CR	04/28/96	300	300	104	161.72	27.35	2.67	196	175.10	17.54	1.25	0.0001
HAGERMAN NFH													
TDR96073.H55	SAWTOOTH WEIR	04/19/96	301	301	158	174.98	22.51	1.79	143	187.17	18.19	1.52	0.0001
TDR96073.H58	SAL. R. TORREY'S	04/19/96	300	300	151	164.56	19.13	1.56	149	176.60	19.58	1.60	0.0001
TDR96073.H61	SAWTOOTH WEIR	04/16/96	301	301	147	170.95	24.60	2.04	154	186.84	20.20	1.63	0.0001
TDR96074.H74	SAWTOOTH WEIR	04/19/96	302	302	121	187.84	22.38	2.03	181	199.29	23.03	1.71	0.0001
TDR96074.H77	L.SAL.WARM SPR.	04/10/96	300	300	104	186.47	27.16	2.66	196	196.28	23.75	1.70	0.0072
TDR96074.H80	L.SAL.WARM SPR.	04/12/96	300	300	94	182.74	33.84	3.49	206	194.97	22.13	1.54	0.0006
MAGIC VALLEY FH													
TDR96078.04E	SLATE CR.	04/27/96	306	306	145	186.13	24.76	2.06	161	200.37	17.91	1.41	0.0001
TDR96079.07W	L.SAL.HAZARD CR.	04/11/96	304	304	117	192.62	25.83	2.39	187	204.06	22.14	1.62	0.0002
TDR96078.10E	E. FORK (LANDFILL)	04/24/96	300	300	139	189.63	21.38	1.81	161	201.24	20.23	1.59	0.0001
TDR96078.11E	E. FORK TRAP	04/24/96	300	300	158	180.80	29.72	2.35	142	199.42	22.18	1.86	0.0001
TDR96079.12W	N.FK.SAL. MOUTH	04/16/96	300	300	106	191.32	31.65	3.07	194	202.68	21.47	1.54	0.0005
TDR96078.14E	LEMHI R.	04/22/96	300	299	107	198.29	26.00	2.51	192	206.47	17.79	1.28	0.0159
TDR96079.14W	McNABB PT.	04/17/96	300	300	142	188.87	27.10	2.27	158	204.90	19.37	1.54	0.0001
TDR96079.16W	SAL.R. @ BRUNO	04/18/96	300	300	212	185.65	21.36	1.47	88	200.39	14.47	1.54	0.0001
CLEARWATER FH													
DAC96072.C12/.C22	S.FK.CLWTR.	04/17/96	300	300	87	166.40	16.90	1.81	213	172.79	11.33	0.78	0.0073
DAC96071.10W/.W10	CLEAR CR.	04/24/96	300	300	86	149.53	24.97	2.71	214	175.83	15.08	1.03	0.0001
DAC96072.C11/.C21	COTTONWOOD CR.	04/18/96	300	300	87	164.29	16.84	2.03	213	172.89	13.56	0.93	0.0009
DAC96071.9W/.9WC	S.FK.CLWTR. STITES	04/18/96	300	300	109	155.18	24.25	2.32	191	169.76	13.13	0.95	0.0001

Appendix J. Length frequency distribution of PIT tagged steelhead (brood year 1995 - Oxbow stock) from Niagara Springs Fish Hatchery, April, 1996. The table below the histogram summarizes length statistics and lower and upper length bounds at 70%, 80%, and 90% of the central distribution.

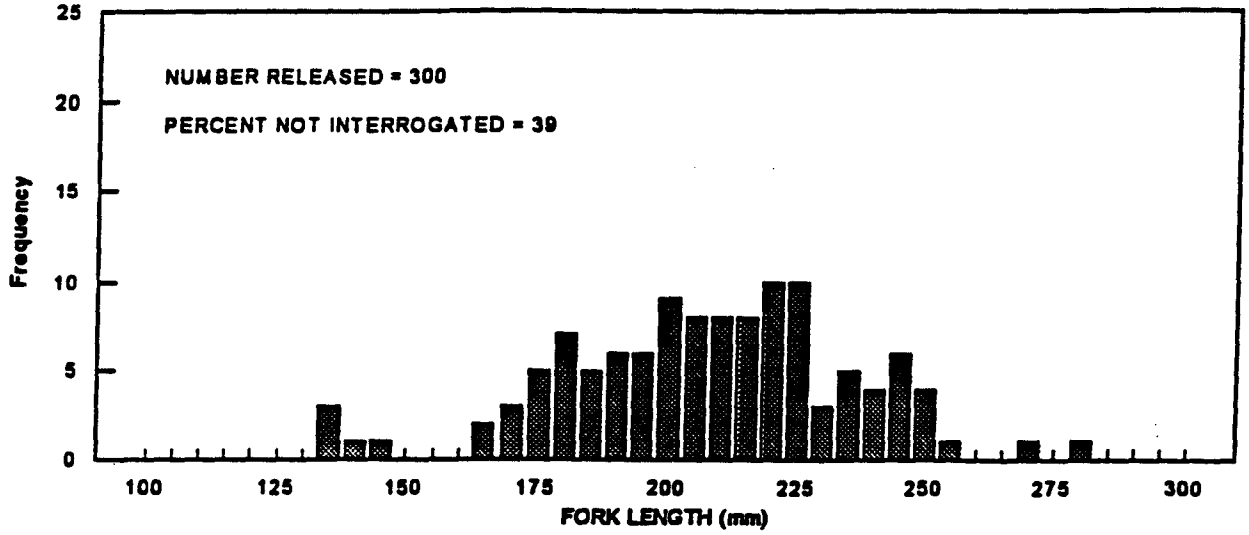


N	MEAN	STD	MEDIAN
300	212.55	26.3	215.0

	LENGTH BOUNDS	
DISTRIBUTION	LOWER	UPPER
70% OF CENTRAL	184.50	237.00
80% OF CENTRAL	176.00	244.00
90% OF CENTRAL	169.00	251.50

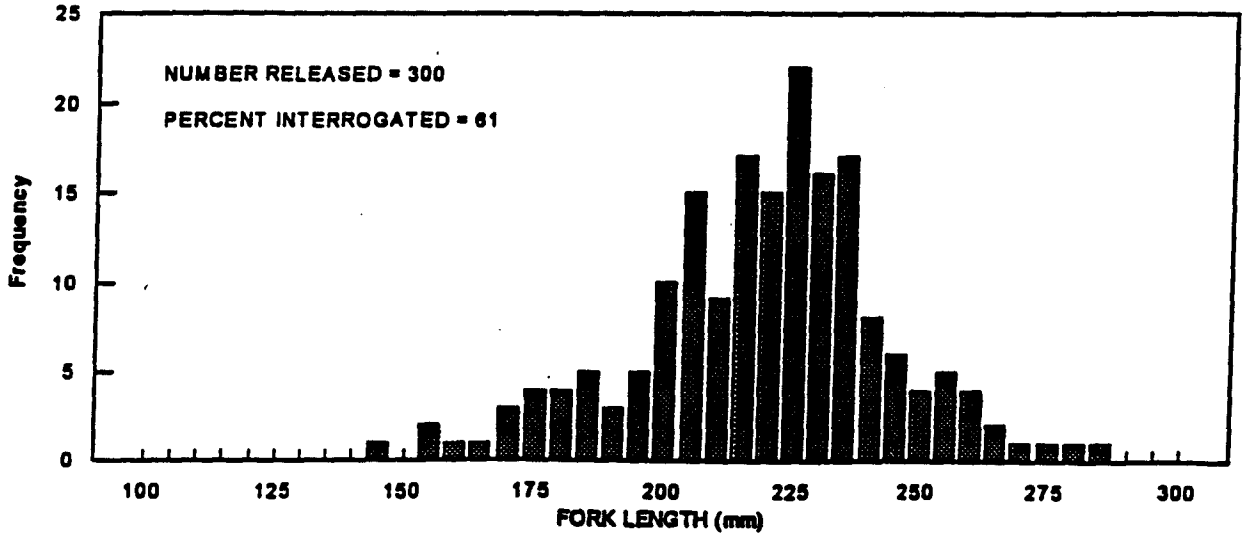
Appendix K. Length frequency distribution of PIT tagged steelhead (brood year 1995 - Oxbow stock) from Niagara Springs Fish Hatchery that were interrogated and not interrogated. The table below each histogram summarizes length, weight, and condition factor statistics.

NOT INTERROGATED



VARIABLE	UNITS	COUNT	MINIMUM	MAXIMUM	MEAN	SD
LENGTH	MM	117.00	133.00	279.00	205.54	27.81
WEIGHT	GRAMS	44.00	23.00	168.00	99.61	35.84
C.FACTOR	K	44.00	0.83	1.17	1.04	0.08

INTERROGATED



VARIABLE	UNITS	COUNT	MINIMUM	MAXIMUM	MEAN	SD
LENGTH	MM	183.00	144.00	282.00	217.04	24.34
WEIGHT	GRAMS	66.00	51.00	211.00	109.68	31.10
C.FACTOR	K	66.00	0.90	1.31	1.03	0.07