North American Journal of Fisheries Management

ISSN: 0275-5947 (Print) 1548-8675 (Online) Journal homepage: http://www.tandfonline.com/loi/ujfm20

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To cite this article: Kenneth R. Kenaston , Robert B. Lindsay & R. Kirk Schroeder (2001) Effect of Acclimation on the Homing and Survival of Hatchery Winter Steelhead, North American Journal of Fisheries Management, 21:4, 765-773, DOI: 10.1577/1548-8675(2001)021<0765:EOAOTH>2.0.CO;2

To link to this article: http://dx.doi.org/10.1577/1548-8675(2001)021<0765:EOAOTH>2.0.CO;2

Published online: 08 Jan 2011.

North American Journal of Fisheries Management 21:765–773, 2001

Effect of Acclimation on the Homing and Survival of Hatchery Winter Steelhead

KENNETH R. KENASTON,* ROBERT B. LINDSAY, AND R. KIRK SCHROEDER

Oregon Department of Fish and Wildlife, 28655 Highway 34, Corvallis, Oregon 97333, USA

Abstract.—We evaluated prerelease acclimation of hatchery winter steelhead *Oncorhynchus mykiss* in Whittaker Creek, a tributary of the Siuslaw River, Oregon, as a management strategy to attract returning adults to a release site where they could be removed. The objective was to reduce the number of hatchery fish in wild steelhead spawning areas while providing hatchery steelhead for recreational fisheries. We found no significant difference in homing rate or survival between hatchery steelhead acclimated for 30 d and those trucked from the hatchery and directly released. For the 1991–1993 broods, a mean of 92% of directly released fish and 97% of acclimated fish were accounted for in Whittaker Creek. In contrast, 15% of adults from hatchery smolts released at four traditional sites in the main-stem Siuslaw River were accounted for in Whittaker Creek. The spatial distribution of the catch in recreational fisheries was similar for the direct and acclimated groups; that catch, however, was nearer Whittaker Creek than the catch from traditional releases. The study shows that acclimation of juveniles is not necessary to achieve a high rate of homing of adult hatchery steelhead to a release site. Direct tributary releases combined with an adult collection facility can be used as a management strategy to minimize effects of hatchery fish on wild stocks, yet still provide recreational harvest.

Acclimation of hatchery fish has been used throughout the Pacific Northwest (Fast et al. 1991; Cuenco et al. 1993; Whitesel et al. 1994) as a management technique to increase survival and to improve the accuracy of homing of anadromous salmonids (Kapuscinski 1997; Reisenbichler 1997; Brannon et al. 1998; Bugert 1998). We define acclimation as the short-term rearing (usually 2–6 weeks) of juvenile salmonids at a release site immediately before their release. Fish are acclimated by holding them in natural or constructed ponds that use water from the home stream. Although several studies have evaluated the use of acclimation to increase survival (Johnson et al. 1990; Fast et al. 1991; Savitz et al. 1993; Whitesel et al. 1994), only one has evaluated its use to improve homing (Savitz et al. 1993).

Acclimation may increase survival by reducing stress associated with transporting hatchery juveniles to release sites (Ayles et al. 1976; Johnson et al. 1990). Transporting juvenile salmonids causes stress in smolts (Barton et al. 1980; Specker and Schreck 1980; Matthews et al. 1986), which may reduce survival if fish are directly released into natural environments. Elevated stress levels return to normal several days to 1 week after transportation (Strange et al. 1978; Barton et al. 1980; Specker and Schreck 1980).

Acclimation may also increase the accuracy of homing by conditioning fish to a specific release site (Bugert 1998). Although homing in salmon is not completely understood, it is thought to be an olfactory response to specific chemical characteristics of natal streams (Cooper et al. 1976; Hasler and Scholz 1983). Olfactory imprinting by juvenile fish primarily occurs at the time of smolt transformation and emigration (Hasler and Scholz 1983; Morin and Døving 1992; Dittman et al. 1996). However, some salmon and steelhead *Oncorhynchus mykiss* undergo smolt transformation in areas of a watershed that are distant from the streams where they hatched or reared, yet return to their natal streams as adults (Murray and Rosenau 1989; Scrivener et al. 1994). This indicates homing may have a genetic component (Bams 1976; McIsaac and Quinn 1988) or imprinting may occur before smolt transformation.

Acclimation of hatchery juveniles has been suggested to reduce interactions with wild fish by confining or removing returning hatchery adults at a targeted site (Reisenbichler 1997; Bugert 1998). Under Oregon's Wild Fish Management Policy (ODFW 1992), hatchery programs are being changed to reduce genetic risks to wild populations while providing fish for recreational harvest. We conducted an experiment in a large coastal basin in Oregon to determine if acclimation improved the homing accuracy of adult winter steelhead to a tributary collection site and thereby reduced the

* Corresponding author: kenastonk@fsl.orst.edu

Received March 20, 2000; accepted February 20, 2001

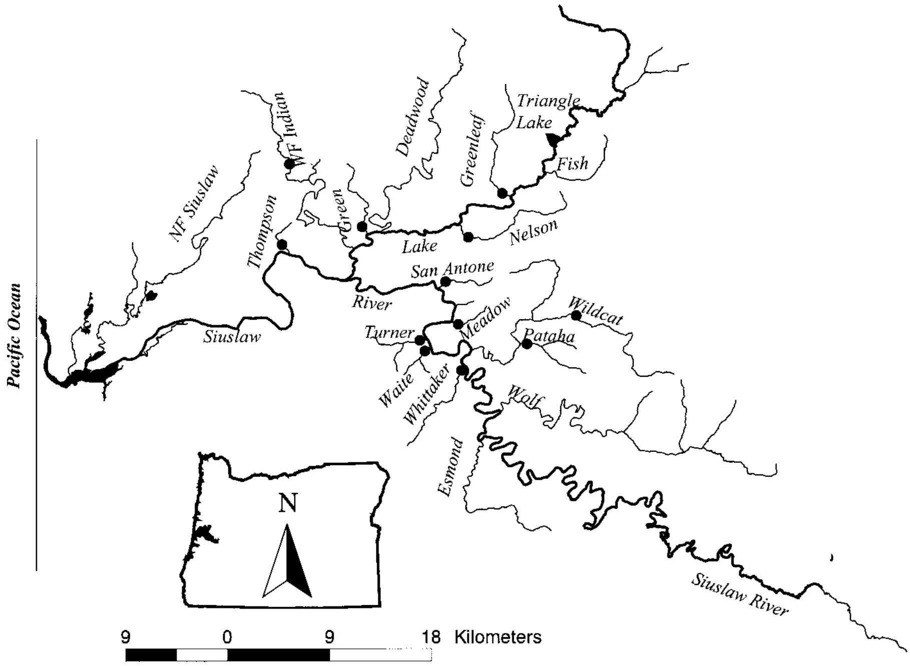

FIGURE 1.—Map of the Siuslaw River showing trap sites (dark circles) for winter steelhead.

number of hatchery fish in wild steelhead spawning areas. Survival of acclimated fish was also evaluated.

Study Site

The study was conducted in the Siuslaw River, a large river that drains a 2,010-km^2 basin on the central Oregon coast (Figure 1). Its estuary extends 35 km inland to the head of tidewater. Lake Creek, a major tributary of approximately the same size as the main stem, flows into the Siuslaw River 12 km above tidewater at river kilometer (rkm) 47. Winter steelhead primarily spawn from January through May in tributaries of the Siuslaw River below Esmond Creek (rkm 92) and in several tributaries of Lake Creek. A popular recreational fishery for steelhead has developed in the Siuslaw River (head of tidewater upstream 39 km to Whittaker Creek) and in Lake Creek (its mouth to Greenleaf Creek 23 km upstream). Other anadromous salmonids present in the Siuslaw River basin include coho salmon *O. kisutch*, chinook salmon *O. tshawytscha*, and cutthroat trout *O. clarki*.

A temporary acclimation pond was constructed on Whittaker Creek about 100 m upstream from its confluence with the Siuslaw River. Whittaker Creek is a 29-km^2 tributary basin having a mean winter flow of approximately 1.13 m^3/s. In April, when hatchery juvenile steelhead were released, the flow in Whittaker Creek was about 7% of the main-stem Siuslaw River flow at their confluence. A weir with a trap box was constructed in Whittaker Creek about 10 m below the outlet to the acclimation pond to capture returning adults.

Returning adults were also captured at weirs constructed in 11 other tributaries in the Siuslaw River basin (Figure 1). These tributaries were selected because they accounted for almost 80% of the adult steelhead captured in 1990–1991, when 41 tributaries in the Siuslaw River basin above tidewater were trapped or surveyed for spawning steelhead. These tributaries represent a broad area of the steelhead spawning distribution in the Siuslaw River basin. Weirs were operated in 10 tributaries in winter 1993–1994. Two additional weirs (Nelson and West Fork Indian creeks) were added in winter 1994–1995. We abandoned the West Fork Indian Creek site in winter 1995–1996 because of difficulties in trap operation the prior winter. The weir in Waite Creek operated only during January 1996 before high flow destroyed the weir.

Methods

Release of juvenile steelhead.—We used Alsea River winter steelhead reared at Alsea Hatchery for the study. The Alsea River is a large coastal

TABLE 1.—Experimental groups of Alsea Hatchery winter steelhead smolts released to evaluate acclimation in a portable raceway in the Siuslaw River basin. Mark abbreviations are as follows: RP = right pectoral fin, LP = left pectoral fin, RM = right maxillary bone, and LM = left maxillary bone.

Brood year and group	Days acclimated	Date released	Number released	Mean fork length (SE) at release (cm)	Marks
1991					
Direct	0	Apr 1	29,971	19.7 (0.1)	RP, RM
Acclimated	32	Mar 31	29,374	20.5 (0.2)	RP, LM
Main-stem	0	Apr 1	46,333	19.6 (0.1)	LP, RM
1992					
Direct[a]	0	Mar 31	29,691	19.4 (0.4)	RP, RM
Acclimated	33	Mar 29	29,742	18.7 (0.4)	RP, LM
Main-stem	0	Apr 1	45,406	19.2 (0.4)	LP, LM
1993					
Direct	0	Mar 30	30,126	19.6 (0.1)	RP, RM
Acclimated	33	Mar 29	29,846	19.0 (0.2)	RP, LM
Main-stem	0	Mar 30	40,925	19.8 (0.1)	LP, LM

[a] About 7,100 steelhead smolts were mistakenly released into the main-stem Siuslaw River near the mouth of Whittaker Creek.

river near the Siuslaw River. The hatchery is located on the North Fork Alsea River 87 km from the ocean. At the time we conducted the study, hatchery steelhead from the Alsea Hatchery supported recreational fisheries in the Siuslaw River and several other Oregon coastal rivers.

Juvenile hatchery steelhead were transported about 2 h in hatchery trucks from Alsea Hatchery to the Siuslaw River in late winter and early spring. Three groups of steelhead were released for three consecutive years beginning in 1992 (Table 1). One group was transferred to an acclimation pond on Whittaker Creek (acclimated group) in late February and subsequently released into Whittaker Creek in late March. Another group was released directly into Whittaker Creek (direct group) in late March. A third group was released directly into the main-stem Siuslaw River (main-stem group) in late March at sites traditionally used for hatchery smolt releases. We excised a pectoral fin and a maxillary bone in different combinations to identify fish in each group. Fish were marked in mid-November at Alsea Hatchery. Fork lengths were measured on samples from each group just before release. Pathologists examined the groups before transport and cleared them for release.

Acclimated groups were held for about 30 d before release in a portable raceway (3.7 × 15.3 × 1.5 m; Modutank model AB 0313, Aqua Breeder) temporarily erected on the bank of Whittaker Creek. A net was placed over the raceway to prevent bird predation. Two diesel engines pumped 1,750 L/min of water from Whittaker Creek into the raceway. In the 3 years of study, loading in the raceway ranged from 0.92–1.15 $kg \cdot L^{-1} \cdot min^{-1}$ at the time of transfer to 1.23–1.39 $kg \cdot L^{-1} \cdot min^{-1}$ at the time of release. Fish that died during the acclimation period were removed and subtracted from the number initially put into the raceway. In 1992 and 1994 the fish were hand-fed daily every 1.5 h between 0800 and 1800 hours. Fish in 1993 were fed double rations every other day on the same schedule as in 1992 and 1994. On the day of release, a fish retention screen was removed and steelhead were allowed to emigrate through a 15-cm diameter discharge pipe directly into Whittaker Creek. Those not immediately leaving were forced out of the raceway with a seine.

Direct groups were released into Whittaker Creek 1–2 d after acclimated fish were released from the raceway. Direct groups were released into the same pool as acclimated groups; most fish of acclimated and direct groups volitionally left the release pool within 1 d. Any fish remaining after 1 d were forced out of the pool with a seine. In 1993 about 25% of the direct group was mistakenly released into the main-stem Siuslaw River near the mouth of Whittaker Creek rather than into Whittaker Creek.

Main-stem groups were released at four sites throughout the fishery area in the Siuslaw River. These groups were used to make certain that Whittaker Creek was not unusually attractive to returning adult steelhead during the years that the study was conducted. Main-stem control groups were trucked from Alsea Hatchery and released at four sites in the Siuslaw River (rkms 43, 66, 72, and 74) where steelhead had been released in the past. These groups were released within 2 d of acclimated and direct groups.

Recovery of returning adult steelhead.—Adult steelhead from experimental groups returned from 1993 through 1996 and were recovered in spawning tributaries and in the recreational fishery. Sampling ended before the return of 3-salt adults (i.e., those that spent three summers in the ocean) from the 1993 brood year. Three-salt steelhead accounted for 24% of brood year returns from 1991 and 1992. Weirs were used in spawning tributaries in the Siuslaw River basin to recover experimental fish that were not caught in the fishery. Construction details of weirs are described by Schroeder (1996). Recreational harvest was estimated with a statistical creel survey of the Siuslaw River and Lake Creek. Methods were similar to those used by Wagner (1969) on the Alsea River.

We used catch at weirs in tributary streams to estimate the percentage of each group that entered Whittaker Creek for each brood year released. Weirs were usually installed by mid-December and fished through mid-May after most steelhead had spawned. Weir panels were removed and entrances to trap boxes were blocked to allow other species of fish to migrate above trap sites from mid-May through mid-December. Steelhead were examined for clipped fins and maxillary bones, and a scale sample was taken. Circuli patterns on scales were used to determine age (Maher and Larkin 1954) and brood year. Catch was adjusted for trapping efficiency to correct for times when weirs were flooded during high water. Captured adults were externally tagged with plastic, T-bar anchor tags (Floy model FD-68B) and placed above the weirs. Estimates of trapping efficiency were calculated as the ratio of tagged to untagged steelhead captured at the weir as they moved back downstream after spawning. We minimized the probability of statistical bias by requiring three recaptures as the minimum for efficiency estimates (Ricker 1975). Mean trap efficiency, estimated from similarly sized tributaries, was used when fewer than three fish were recaptured at a weir. The weir in Whittaker Creek was assumed to be 100% efficient and catch was not expanded. This weir was installed on an existing concrete dam and fished a much wider range of flows than other tributary weirs.

We used estimated catch in the Siuslaw River recreational fishery, standardized for numbers of smolts released, as a survival index of each group for each brood year released. Because all groups were available to the recreational fishery downstream of weir locations, catch in the fishery provided relative indices of their abundance. Two creel clerks surveyed the fishery each day from December 1 through March 31, when the fishery closed. Each steelhead observed was examined for marks, and a scale sample was taken to determine its brood year. The fishery area was divided into three sections (the lower Siuslaw River from head of tide to the mouth of Lake Creek, the upper Siuslaw River from the mouth of Lake Creek to Whittaker Creek, and Lake Creek from its mouth to Greenleaf Creek; Figure 1) and differences in catch distribution of the groups were determined among sections.

We used a one-way analysis of variance (ANOVA) with years as replicates to compare homing to Whittaker Creek and survival among groups. We applied an arcsine-square root transformation to proportional data before analysis.

Results

Over 2,800 adult steelhead were handled in 3 years of trapping at weirs (Table 2). Sampling efficiency of weirs ranged from 3% to 100% and varied among years at individual sites. About 12% (354) of the captured steelhead were of wild origin.

A high proportion of direct and acclimated groups caught in tributary traps returned as adults to their release site in Whittaker Creek. The percentage of brood year returns captured in Whittaker Creek averaged 92% for direct and 97% for acclimated groups (Table 3). The difference between the two groups was not significant ($F_{1,4} = 1.61$, $P = 0.27$). A mean of 15% of the main-stem group was recovered in Whittaker Creek, significantly less than the direct ($F_{1,4} = 98.04$, $P < 0.01$) and acclimated ($F_{1,4} = 248.50$, $P < 0.01$) groups.

Accurate homing was also evident from the spatial distribution of adult recoveries in the fishery. Few adults from direct and acclimated groups were caught in Lake Creek (Table 4). Recreational catch in Lake Creek averaged 4% and 0% of the total Siuslaw River basin catch of direct and acclimated groups, respectively. In contrast, 23% of the total basin catch of the main-stem group occurred in Lake Creek, significantly greater than the direct ($F_{1,4} = 7.63$, $P = 0.05$) and acclimated ($F_{1,4} = 25.46$, $P < 0.01$) groups.

Releasing steelhead into Whittaker Creek altered the distribution of recreational catch and effort in the Siuslaw River compared with traditional releases. Releases into Whittaker Creek increased angling effort on returning adults in the 3-km reach of the Siuslaw River below the mouth of Whittaker Creek. As a result, a mean of 82% and 90% (dif-

TABLE 2.—Number of experimental hatchery (direct, acclimated, and main-stem) and wild steelhead captured in traps at weirs and the sampling efficiency of those weirs on tributaries to the Siuslaw River and Lake Creek, 1993–1994 through 1995–1996 run years. Blanks indicate that the stream was not trapped.

Tributary	Basin size (km^2)	Total number captured by group				Sampling efficiency (%) of weirs by run year		
		Direct	Acclimated	Main-stem	Wild	1993–1994	1994–1995	1995–1996
Siuslaw River								
Thompson	7.8	1	0	20	8	44	77	64
San Antone	10.4	4	4	58	23	82	62	53
Meadow	5.2	1	0	6	7	63[a]	50	56[a]
Turner	13.0	4	0	12	6	63[a]	60	50
Waite	7.8	2	1	18	5	100	77	
Pataha	18.1	12	3	81	11	100	46	21
Wildcat	44.0	8	2	44	1	40[a]	23[a]	9[a]
Whittaker	28.5	935	1,100	120	130	100	100	100
Lake Creek								
W.F. Indian	36.3	0	0	0	30		16	
Green	13.0	4	2	17	17	73	20	22
Nelson	41.4	0	0	6	5		23[a]	3
Greenleaf	31.0	0	1	3	111	40	23[b]	15

[a] Estimated from one or more tributaries of similar basin size because of insufficient recaptures.
[b] Interpolated on the basis of the annual variation observed in San Antone and Pataha creeks.

ference not significant: $F_{1,4} = 1.34$, $P = 0.32$) of the catch of the direct and acclimated groups, respectively, occurred in the upper Siuslaw River above Lake Creek (Table 4). In contrast, a mean of 49% of the catch of the main-stem group occurred in the upper section, significantly less than the direct ($F_{1,4} = 18.70$, $P = 0.01$) and acclimated ($F_{1,4} = 24.71$, $P < 0.01$) groups. The remainder of the main-stem group was harvested in the lower Siuslaw River (28%) and in Lake Creek (23%).

Although releasing steelhead smolts into Whittaker Creek concentrated recreational catch of these fish in the upper Siuslaw River, total recreational catch of adults from these releases was greater than that from the main-stem group (Table 5). The mean annual catch per smolt released of direct and acclimated groups was 87% (range, 13–192%) and 41% (range, 19–69%) greater, respectively, than the main-stem group.

The similarity in spatial catch distribution between acclimated and direct groups allowed us to compare survival indexes based on the recreational catch of these two groups. Although survival of acclimated groups was higher than direct groups in two of three brood years (Table 5), the difference was not significant ($F_{1,4} = 0.49$, $P = 0.52$). However, the power of the statistical test was low. We did not estimate a survival index for main-stem groups because their spatial harvest distribution differed significantly from that of the other two groups. Differences in harvest could reflect differences among river sections in angler effort or in physical characteristics that influence catch rather than differences in survival.

TABLE 3.—Percentage of total weir catches observed in Whittaker Creek for each of three experimental groups released into the Siuslaw River.

Brood year	Release group		
	Direct	Acclimated	Main-stem
1991	96	98	19
1992	84[a]	99	18
1993	96	95	8

[a] About 25% were mistakenly released as smolts into the main-stem Siuslaw River instead of into Whittaker Creek.

TABLE 4.—Distribution (%) of the recreational catch by fishery section for direct, acclimated, and main-stem groups.

River section	Release group		
	Direct	Acclimated	Main-stem
1991 brood year			
Lower Siuslaw	18	21	35
Upper Siuslaw	76	79	56
Lake Creek	6	0	9
1992 brood year			
Lower Siuslaw	7	7	32
Upper Siuslaw	92	93	44
Lake Creek	1	0	24
1993 brood year[a]			
Lower Siuslaw	18	2	16
Upper Siuslaw	77	98	48
Lake Creek	5	0	36

[a] No 3-salt adults are included.

TABLE 5.—Adult returns from experimental groups of steelhead smolts released to evaluate acclimation in the Siuslaw River basin and captured in recreational fisheries or in weir traps in the tributaries. Numbers were adjusted to a standard 30,000 smolt release.

Capture method	Adult returns by release group		
	Direct	Accimated	Main-stem
	1991 brood year		
Tributaries	297	357	155
Fisheries	157	167	141
	1992 brood year		
Tributaries	330	294	87
Fisheries	165	90	56
	1993 brood year[a]		
Tributaries	360	459	344
Fisheries	115	123	73

[a] No 3-salt adults are included.

Discussion

Steelhead smolts released directly into a tributary stream (without acclimation) returned to the release site as successfully as fish that had been acclimated for a month. This suggests that steelhead smolts imprint rapidly and that an extended acclimation period at the release site is not required to achieve a high rate of homing of returning adults. The release site in this study was a pool in a tributary stream where fish could orient before emigrating downstream. Most fish had emigrated within a day after their release, and those remaining were forced out with a seine. Consequently, the direct release group was exposed to Whittaker Creek for less than 24 h, which was evidently enough time for successful imprinting. Coho salmon exposed to morpholine for 2 d during smoltification imprinted successfully upon return as adults (Cooper et al. 1976). In another study, coho salmon smolts released into the Columbia River after being held for 36–48 h in a pond fed by a small spring (<760 L/min) homed to the site despite the spring's small size (Jensen and Duncan 1971).

We hypothesize that the short exposure of the direct release group to Whittaker Creek was sufficient for imprinting because steelhead smolts were released during their sensitive period. In Atlantic salmon *Salmo salar*, olfactory imprinting occurred during a 7-d period that coincided with peak levels of thyroid activity (Morin et al. 1989b) and took place 21–28 d after the onset of smoltification (Morin et al. 1989a). Salmon must migrate during this sensitive period for optimal imprinting to occur (Dittman et al. 1996). Optimal release dates for hatchery steelhead in Oregon were based on early studies of stocking time and its effect on survival (Wagner 1968).

Some studies have suggested that adult salmon can recognize water conditioned by the presence of large numbers of their own species (Dizon et al. 1973). Although fish may be attracted to these conspecific odors (Quinn et al. 1983), these odors are not singularly responsible for homing to a particular stream (Brannon et al. 1998). Unnaturally high levels of conspecific odors did not influence the high homing rates for our experimental releases. Adult hatchery steelhead were trapped in Whittaker Creek and transported downstream or to landlocked lakes out of the Siuslaw River basin. In addition, we acclimated steelhead smolts in a portable raceway that was dismantled each year. Smolts would have been in the portable raceway only in 1994 when adult steelhead from earlier releases were returning to Whittaker Creek. Even in this case, most of the adult steelhead would have already entered Whittaker Creek by the time smolts were transferred from Alsea Hatchery to the portable raceway.

Our calculations of the proportion of fish from each brood year that entered Whittaker Creek was dependent on the accuracy of efficiency estimates at other tributary weir sites. Efficiency estimates were used to expand weir catches in all tributaries except Whittaker Creek to account for fish missed during floods. In tributaries where we did not get three recaptures, we used a mean weir efficiency estimated from similarly size tributaries. This may have resulted in errors in catch expansions for these tributaries. However, we found the estimated proportion of fish that returned to Whittaker Creek for direct and acclimated groups was insensitive to large errors in efficiency estimates in other tributaries. For example, if catch efficiencies at weirs other than Whittaker Creek were 50% of what we estimated, the estimated number of direct and acclimated fish recovered outside Whittaker Creek would double. However, because the homing rate of direct (92%) and acclimated (97%) groups was high, this would reduce the estimated proportions in Whittaker Creek by 8% for the direct group and by 3% for the acclimated group. In addition, although we assumed catch efficiency in Whittaker Creek was 100%, the weir did flood in some years and probably resulted in an underestimate of return to Whittaker Creek.

Our calculations of the proportion of fish from each brood year that entered Whittaker Creek also depended on the proportion of the spawning population we sampled with tributary traps. Prior sampling in 1990–1991 indicated that about 80% of the steelhead we counted in the basin were found in the 12 tributaries we trapped in 1994–1996. Because comprehensive surveys were only done in 1990–1991, the spawning distribution during our study may have differed. As with efficiency estimates, however, the high proportions of direct and acclimated fish in Whittaker Creek were insensitive to changes that may have occurred in spawning distribution. For example, if by sampling more spawning tributaries we had doubled the numbers of direct and acclimated steelhead captured outside of Whittaker Creek, then the estimated proportions of recoveries in Whittaker Creek would have been reduced by 8% for the direct and 3% for the acclimated groups.

We found that acclimation did not significantly increase survival based on a survival index, but the power of the statistical test was low. Previous studies have not consistently demonstrated survival advantages for acclimated steelhead. The return rate of steelhead smolts acclimated for 4 d in tidal waters of the Chilliwack River, British Columbia, was similar or lower than that of steelhead smolts directly released near the mouth of the river (Ward and Slaney 1990). In contrast, steelhead smolts acclimated for 37–39 d survived to adulthood better than direct tributary releases in two Oregon streams (Whitesel et al. 1994), possibly because the acclimated smolts were larger at release. However, more recent returns from these groups have indicated no clear survival advantage for acclimated groups (T. Whitesel, Oregon Department of Fish and Wildlife, personal communication).

Two studies with salmon suggest that acclimation increases survival. Acclimated spring chinook salmon in the Yakima River, Washington, returned at a higher rate than direct releases (Fast et al. 1991). However, differences in release location, time of release, and disease histories between the two groups confounded comparisons. Acclimating coho salmon for 6 weeks coupled with a volitional release increased survival relative to groups released directly after being trucked from a hatchery (Johnson et al. 1990). Unlike that study, we forced steelhead out of the acclimation pond by pulling the standpipe and slowly herding them with a seine toward the drain. The short-term increase in density may have increased stress in our acclimated group similar to that experienced by a direct release group (i.e., during loading at the hatchery, trucking to the river, and draining of the liberation tank). However, Evenson and Ewing (1992) found no significant difference in survival between winter steelhead volitionally released and those forced from raceways at Cole River Hatchery on the Rogue River, Oregon.

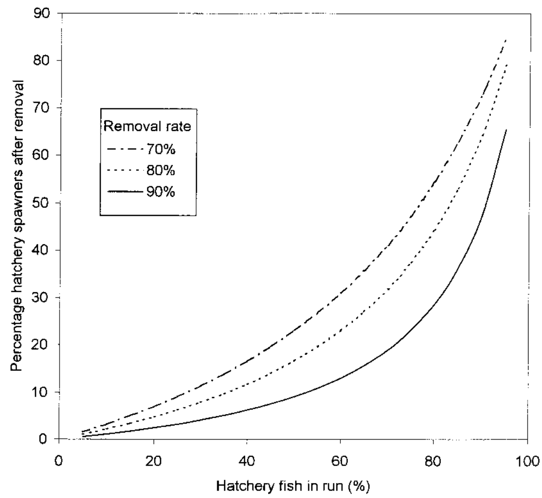

FIGURE 2.—Relationship between the percentage of hatchery steelhead in spawning areas and the percentage in the run when hatchery fish are removed at three hypothetical rates before spawning.

The use of acclimated or direct releases into tributaries where returning adults can be removed will reduce the number of hatchery steelhead that spawn with wild fish. The magnitude of this reduction depends on the initial percentage of hatchery fish in the basin and on the proportion of those fish that can be removed (Figure 2). For example, about 70% of the steelhead run in the Siuslaw River basin was hatchery fish before the time we began our study (Lindsay et al. 2001). If 90% of these—the approximate homing rate we observed for direct groups—were removed at their tributary release site, the proportion of hatchery fish in the Siuslaw River basin would be reduced to 19%, a 73% reduction in potential hatchery spawners in the basin.

The findings from our experiment do not support the use of acclimation to improve homing or survival of winter steelhead. Streamside acclimation facilities are often expensive to build and operate. The risk of losing fish can be high, especially at remote sites. Our study shows that direct tributary releases in conjunction with a facility to capture returning adults can be used to reduce the number of hatchery fish spawning with wild fish and provide recreational fisheries. The distribution of angler effort and catch in these fisheries may be altered, depending on the location of the release site.

Acknowledgments

Numerous individuals assisted with this project. Field technicians operated weirs and interviewed anglers. Many private landowners in the Siuslaw River basin provided stream access and allowed trapping on their property. Tom Nickelson and Mario Solazzi reviewed earlier drafts of the manuscript. Mary Buckman reviewed the statistical analyses. We thank three anonymous reviewers for their constructive suggestions. Funding for this work was provided in part by the Sport Fish and Wildlife Restoration Program administered by the U.S. Fish and Wildlife Service (Project F-120-R-11).

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