WINTER STEELHEAD CREEL CENSUS

ON THE HOH RIVER

PROGRESS REPORT

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ABSTRACT

The U.S. Fish and Wildlife Service (FWS), Fisheries Assistance Office, Olympia and Olympic National Park (ONP) conducted a creel census on the Hoh River sport fishery in 1983-84. The main purposes of the census were to (1) evaluate FWS releases of tagged winter steelhead and (2) determine the distribution of various hatchery releases within the river. A secondary objective was to provide estimates of the sport catch of steelhead in the river for both in-season and post-season management and as a comparison to punch card estimates.

All tagged hatchery stocks (Lake Quinault, Cook Creek, and Hoh native) contributed at approximately 1% rates (0.90 to 1.12 percent) from release to harvest at age III. Lake Quinault and Cook Creek stocks entered the sport catch in December and peaked in February. Hoh native stock was caught entirely in March and April.

Release location of smolts strongly influenced the sport/tribal catch ratio. Cook Creek stock, which was released at river mile 19, concentrated somewhat around the release site upon returning. This stock contributed more to the sport catch than to the tribal catch, in about an 80/20 ratio. Some of these fish also strayed into the Park. Stocks released near the mouth of the river (Lake Quinault and Hoh native) were caught mainly in the lower part of the river and contributed more to the Hoh tribal catch than to the sport catch, in about a 70/30 ratio. Some of the Lake Quinault stock, however, strayed upstream into the Olympic National Park but none of the native Hoh stock were recovered there.

Hatchery fish made up about three quarters of the sport catch of 2811 and 71% of the relatively small catch sample taken within the Park. Hatchery fish made up about 86% of the sport catch from December through February but still made up 60% of the catch in March and April.

Sport anglers caught 33% of the total terminal catch, and the Hoh Tribe caught 67%. The sport share was only 17% at the end of December but increased each month until the end of the season.

A large number of unmarked hatchery fish entered the catch. These limited our ability to distinguish various hatchery stocks that influence the distribution and timing of the hatchery catch. Marked release groups accounted for only about 40% of the sport-caught hatchery fish and 20% of the tribal-caught hatchery fish. The rest were returns of either Department of Game releases on the Hoh or various agencies' releases on other rivers. We expect a clearer picture of stock origin from next season's creel census, when virtually all the returning Hoh release groups will have been marked.

ACKNOWLEDGMENTS

Several businesses and agencies collaborated in this study. The owners of the Westward Hoh and Hoh River Resort provided needed information on river conditions. Bob Leland of the Washington Department of Game analyzed the many scale samples and Bill Freymond provided guidance in designing the study and analyzing the data. Special thanks are due to Mike Hinton of Tulalip Tribal Fisheries, Ken Newman of the Northwest Indian Fish Commission, and Sally Zitzer of the University of Washington Computer Center for additional advice on data analysis. Jim Jorgensen of the Hoh Indian Tribe also advised on experimental design and shared valuable information with us throughout the season.

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INTRODUCTION

The U.S. Fish and Wildlife Service (FWS) and the Olympic National Park (ONP) jointly conducted a creel census of winter steelhead on the Hoh River, located on the Pacific Coast of the Olympic Peninsula. The FWS participated in the census to evaluate the success of a hatchery out-plant program into the Hoh River. The ONP collaborated to estimate the extent to which non-native stocks were migrating into the Park and to provide catch data on the sport fishery to improve both in-season and post-season management.

The FWS, Region 1, has set out to evaluate the success of its hatchery programs and their effect on natural production of salmon and steelhead. The Fisheries Assistance Office, Olympia, evaluates the programs of three federal salmon and steelhead hatcheries on the Olympic Peninsula. An important tool in these evaluations are returns of coded-wire tagged fish to the commercial and sport catches and the hatchery.

Quinault National Fish hatchery (NFH) releases steelhead on-station at Cook Creek and off-station into the Hoh River. The on-station program can be evaluated from tag recovery data from the commercial catch and the hatchery because the sport fishery on the Quinault River is very small. In contrast, the off-station releases into the Hoh River cannot be evaluated with commercial catch data alone because the sport fishery on this river is relatively large.

This river is also of special interest because the harvest rates are established to maintain optimum production of the native steelhead stock. The impact of large scale hatchery releases on this objective is unknown but creel census data on straying and catch rates of hatchery fish should shed some light on the potential for interactions. Park managers are particularly interested in the level of interaction between hatchery and wild stocks because a primary fishery management objective of the Park is the maintenance of endemic populations.

A final objective of the program was to provide the Hoh Tribe an evaluation of the distribution and contribution of their releases into Chalaat Creek, an on-reservation tributary of the Hoh.

The Hoh River originates in the Olympic Range and flows westward into the Pacific Ocean (Figure 1). The river supports a viable native winter steelhead run, which has been supplemented by hatchery releases since the 1950's. The Hoh Tribe fishes commercially with gillnets, usually on or near the reservation. A sport fishery operates up to Mount Tom Creek at river mile (RM) 38.0. The Olympic National Park has jurisdiction over the river upstream from the Park boundary at RM 29.6.

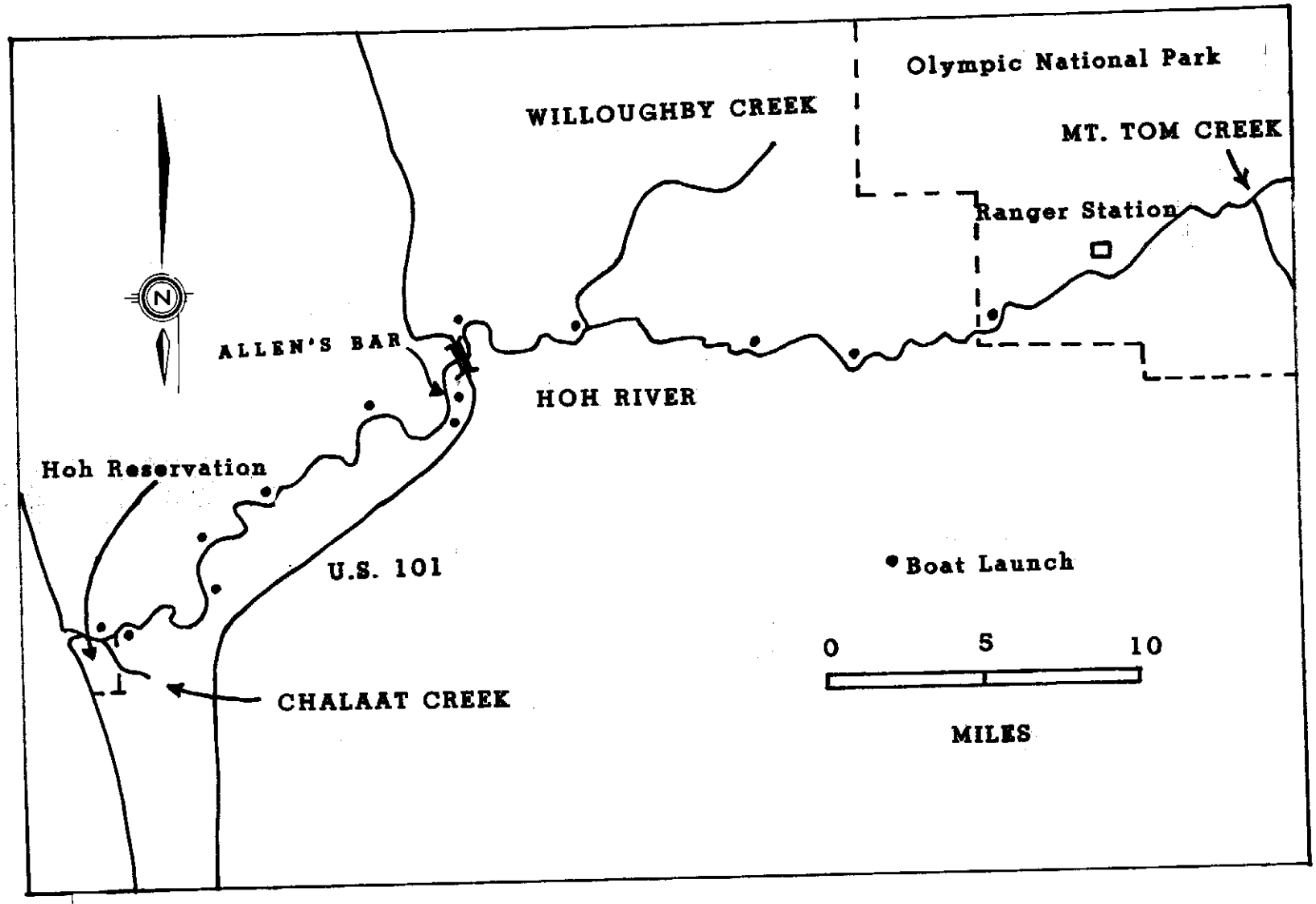

Figure 1. Hoh River, Washington.

Steelhead have been released into the Hoh River by the FWS, Hoh Tribe, and Washington Department of Game (WDG). The Hoh Tribe operates a hatchery at Chalaat Creek. They release native Hoh stock that have been reared on-station. They also began releasing Lake Quinault stock reared in the Quinault Lake Pens and acclimated in Chalaat Creek for about one month before release in 1982. The FWS has released Cook Creek stock at the mouth of Willoughby Creek since 1982. These fish are planted directly from Quinault NFH. In 1982, a portion of each of these groups was marked, and most of them were expected to return in the 1983-84 season. Unmarked release groups of Bogachiel stock were also expected to return. The WDG scatter-planted 32,200 steelhead smolts in 1981 and planted 5,000 below the 101 Bridge in 1982. Table 1 summarizes the in-river releases expected to return as adults in 1983-84.

From a typical hatchery release, most of the resulting adults will return as three-year-olds after about a year and a half at sea. A smaller portion, but still of interest for management, return as four-year-olds after about 2 1/2 years at sea. Thus, for the 1983-84 season, we expect three-year-old returns from the 1982 releases and four-year-old returns from the 1981 releases.

The WDG (1980) conducted a creel census on the Hoh River during the 1979-80 run. However, scarcity of resources coupled with bad weather limited the reliability of their estimates of angler effort and, therefore, of the catch. The current creel census combined the resources of the FWS, NPS, WDG, and the Hoh Tribe, hopefully resulting in a more reliable estimate of angler effort and catch throughout the season.

This progress report includes estimates of:

(1) Total and monthly sport catch;
(2) Hatchery/wild composition, timing, and relative distribution of the sport catch;
(3) Tag group contribution to the sport and commercial fisheries, timing, and relative distribution by river section; and
(4) Age, length, and sex composition of hatchery and wild fish.

Table 1. Smolt releases into Hoh River in 1981 and 1982.

Agency	Release Site	Release Year	Stock	Tag Code	Number Tagged	Number Released
FWS	Willoughby Cr	82	Cook Cr	5-10-42	17,272	50,000
WDG	Scatter a/	81	Bogachiel	none	0	32,200
WDG	Allen's Bar	82	Bogachiel	none	0	5,000
Hoh	Chalaat Cr	81	Hoh	5-7-56	24,520	24,868
Hoh	Chalaat Cr	82	L.Quinault	5-9-61	14,078	69,427
Hoh	Chalaat Cr	82	L.Quinault	5-10-43	20,231	35,330
Hoh	Chalaat Cr	82	Hoh	5-10-44	14,175	20,237
Hoh	Chalaat Cr	81	Hoh	5-7-55	17,568	18,000

a/ Park boundary to 0.5 mile below 101 Bridge

METHODS

Sport Catch Estimation

Creel census is based on the principle that the catch per unit effort in a sample of anglers, multiplied by the estimated total angler effort, equals the total catch. We determined the catch per effort in terms of fish per angler hour. We asked each fishing party how long they had fished that day, how many steelhead they had caught, and how many people were in the party. We only used interviews from parties that had completed their fishing trip. Using data from incomplete trips would have biased the results unless it could be shown that the anglers caught their fish at random times throughout the fishing trip (Robson 1961). Our study did not examine this assumption.

We estimated angler effort in terms of angler hours. Angler hours were calculated by multiplying the estimated number of anglers present at randomly chosen hours by the number of hours available for fishing in the combined weekdays or weekends of each month. The number of hours available for fishing was the average monthly day length times the number of days the river was low and clear enough to be fished.

The number of anglers was estimated by counting their vehicles. We converted the number of vehicles to the number of anglers by multiplying by the number of anglers per vehicle. We determined anglers per vehicle during angler interviews by asking how many anglers and vehicles were in each fishing party.

We normally counted only in index areas which were chosen because many anglers parked there. It was impractical to count all the vehicles on the river every day. We multiplied the index count by an expansion factor to estimate the total count. The expansion factor was derived from periodic counts of all the anglers on the river (by jetboat or helicopter) and dividing by the estimate of the number of anglers in the index area at the same time.

We stratified the catch estimate by month, day of week (weekday or weekend), and gear type (boat or bank) because these criteria were likely to affect effort and catch per effort. We combined the bank drift and plunk fisheries because the frequency distribution of catch per effort by fishing party was the same for either gear type (Komolgorov-Smirnov two-sample test, p less than 0.05).

We began our creel census on December 1, 1983, and continued until the end of the winter steelhead season on April 15, 1984. We attempted to sample 75 percent of the weekends and 70 percent of the weekdays, which we chose in an unbiased manner over each month. We counted angler vehicles (at 15 index areas) twice a day. We interviewed anglers at these index areas during the rest of the day.

Details of the catch calculation methodology appear in Appendix I.

Catch Composition

We examined the catch to determine hatchery/wild composition and age structure, and to recover tags. The hatchery/wild ratio was estimated in-season by dorsal stubbing. However, in this post-season report we relied on scale analysis, assuming that all fish with one year of freshwater growth were hatchery fish and all those with two or three years were wild.

To study the distribution of hatchery fish and specific tag groups in relation to Olympic National Park and in relation to their release sites, we divided the river into four sections. These were designated as the "Park", "Upper", "Willoughby", and "Lower" sections of the river. The "Park" section began at the boat launch (RM 30.0) located a half mile inside the Olympic National Park and extended upstream to the Ranger Station (RM 35.5). The "Upper" section began at this boat launch and extended downstream to RM 20.3, about a mile above Willoughby Creek. The "Willoughby" section began at RM 20.3 and extended down to the 101 Bridge (RM 15.3). The "Lower" section went from the bridge to the mouth of the river.

We expanded the observed tag recoveries from the sport catch to account for the percent mark sample per month. We calculated the contribution of 1982 Hoh releases to the sport catch by dividing the expanded tag recovery by the percent marked in the release group. Appendix II describes tag expansion methods for both sport and tribal fisheries.

RESULTS

Sport Catch and Timing

Anglers caught an estimated 2,811 winter steelhead on the Hoh River from December 1 to April 15, 1983-84 (Table 2). Monthly catch built up to a peak in February and declined thereafter. Adult fish made up 95.3% of the total catch (2691) and jacks, 4.7% (120). Details of catch by gear type and day of week are presented in Appendix III, Table 1.

Hatchery/Wild Composition, Timing, and Distribution

Hatchery/wild composition was based on analysis of readable scales. This number was considerably less than the mark sample. Hatchery fish made up 77.4 percent of the sport catch and wild fish contributed 22.6 percent. The total estimated hatchery catch was 2,190 fish and the wild catch, 621 fish (Table 3). The hatchery/wild composition of the run changed over the season, falling from about 86% hatchery in the December-February period to about 60% in the March-April period.

The various river sections had different hatchery/wild composition (Table 4). The "Upper" Section had a higher proportion of hatchery fish in the catch than did the other sections even though most hatchery releases were made downstream of this section. The various percentages of wild fish in the four sections differed among themselves at the 6% level of probability.

Age, Length, and Sex Composition

Hatchery and wild fish differed in saltwater age (Table 5). Wild fish tended to stay at sea for two years about twice as frequently as the hatchery fish. However, they were similar in that the majority had spent one year and several months in saltwater.

Size differences within each age class were small with hatchery fish equal to or only slightly smaller than wild fish. Both hatchery and wild fish had essentially the same sex ratio. In both groups, fish that had spent two years at sea tended to have a larger percentage of females.

Table 2. Adult and Total Catch by Month

Month	Total Estimated Catch	Monthly Percent	Percent Adults	Cumulative
Dec.	382	13.6	99.0	382
Jan.	629	22.4	100.0	1,011
Feb.	939	33.4	96.3	1,950
Mar.	504	17.9	90.8	2,454
Apr.	357	12.7	90.3	2,811
TOTAL	2,811		95.3	

Table 3. Estimated wild and hatchery catch of Hoh River steelhead by month, based on scale analysis.

Month	Estimated Wild Catch	%	Estimated Hatchery Catch	%	Estimated Total Catch
Dec.	55	14.3	327	85.7	382
Jan.	83	13.2	546	86.8	629
Feb.	129	13.7	810	86.3	939
Mar.	230	45.7	274	54.3	504
Apr.	124	34.7	233	65.3	357
TOTAL	621		2,190		2,811

Table 4. Hatchery/wild ratio by river section, based on scale analysis.

River Section a/	Hatchery	Wild	Total	Percent Hatchery
Park	10	4	14	71.4
Upper	73	10	83	88.0
Willoughby	107	38	145	73.8
Lower	175	60	235	74.5

a/ See "Methods" section of this report for definition.

$x = 7.390$, $df = 3$, $p = 0.0605$ for H/W ratio by river section.

Table 5. Composition of catch sample by hatchery/wild origin, age, sex, and length.

Percent by Saltwater Age

	Less Than 1	1+	2+a/	Sample Size
Hatchery	3.1	85.8	11.1	350
Wild	6.7	70.7	22.6	104

Fork Length (inches) by Saltwater Age

	Less Than 1	1+	2+a/	Combined
Hatchery	20.4	25.8	30.6	26.2
Wild	20.4	26.9	31.9	27.6

Percent Males by Saltwater Age

	Less Than 1	1+	2+a/	Combined
Hatchery	100.0	47.3	30.8	47.1
Wild	100.0	48.0	33.3	48.1

a/ Includes repeat spawners

Tagged Release Group Contribution, Timing, and Relative Distribution

The FWS release at Willoughby Creek (tag code 5-10-42) made a higher contribution to the sport catch then any of the other tagged releases. This group contributed an estimated 375 fish to the sport fishery (Table 6). All other coded-wire tag releases contributed an estimated 452 fish to this fishery. The sum of the contribution of the FWS and tribal hatchery releases in the Hoh River only amounted to 37.6% of the estimated total hatchery catch.

The Willoughby Creek release contributed to the catch predominantly in February (Table 7). The two Lake Quinault stock groups contributed mainly in January and February, while the Hoh stock was seen in the catch only in March and April.

Four tagged fish were recovered in a sample of 25 (Table 8) from anglers' catch in the "Park" section. Two of these tags were from FWS plants at Willoughby Creek, one was from a Lake Quinault steelhead released in Chalaat Creek and one was from a stray (planted into the Soleduck River). In contrast, Hoh River natives tagged and planted in Chalaat Creek were the only group not recovered above the "Lower" river section.

Table 6. Contribution of Hoh release groups to sport fishery.

Tagcode	Agency	Release Site	Release Year	Stock	Observed Recoveries	Expanded Recoveries	Estimated Contribution to Sport Fishery	Percent
5-10-42	FWS	Willoughby	82	Cook Cr.	27	130	375	17.1
5-9-61	Hoh	Chalaat	82	Quin.	10	50	246	11.2
5-10-43	Hoh	Chalaat	82	Quin.	11	55	95	4.3
5-10-44	Hoh	Chalaat	82	Hoh	14	66	94	4.3
5-7-56	Hoh	Chalaat	81	Hoh	1	5	5	0.2
5-11-32	Hoh	Chalaat	83	Hoh	2	10	12	0.5
Total estimated contribution of FWS and tribal releases							827	37.6
Other hatchery catch							1,363	62.4
Total hatchery catch							2,190	100.0

Table 7. Timing of tag recoveries in sport catch, expressed as percentage of total expanded recoveries for each tag group.

Tag Group	Percent of Expanded Recoveries				
	Dec.	Jan.	Feb.	Mar.	Apr.
5-10-42 a/	17.9	10.0	65.0	3.6	3.6
5-9-61 b/	22.2	38.9	29.6	1.8	0.0
5-10-43 b/	13.6	23.7	54.2	8.5	0.0
5-10-44 c/	0.0	0.0	0.0	38.0	62.0

a/ FWS release of Cook Creek stock at Willoughby Creek

b/ Hoh Tribe release of Lake Quinault stock at Chalaat Creek

c/ Hoh Tribe release of Hoh stock at Chalaat Creek

Table 8. Distribution of observed tag recoveries.

Tagcode	Release Site	Park	Upper	Willoughby	Lower	Total
5-10-42 a/	Willoughby	2	2	14	9	27
5-9-61 b/	Chalaat Cr.	1	0	3	6	10
5-10-43 b/	Chalaat Cr.	0	2	2	7	11
5-10-44 c/	Chalaat Cr.	0	0	0	13	13
Strays	Outside Hoh	1	0	3	3	7
Mark Sample Size d/		25	97	172	291	

a/ Cook Creek stock

b/ Lake Quinault stock

c/ Hoh stock

d/ Sample includes all fish checked, regardless of dorsal stubbing or scale analysis

DISCUSSION

Evaluation of Tagged Release Groups

Contribution to the sport and tribal fisheries of the FWS group released at Willoughby Creek and harvested at age III in the tribal and sport fisheries combined was 0.94%. This is comparable to the two releases of Lake Quinault stock into Chalaat Creek (Table 9). Rates for these groups were only slightly below that of the Hoh natives (1.12%). Percent contribution of the 1982 Willoughby Creek release to the total Hoh River catch in 1983-84 was less than the percent contribution of each of the 1982 Lake Quinault and Cook Creek on-station releases to the Quinault River commercial catch in 1983-84 (Table 10).

The Willoughby Creek plants did contribute far more heavily to the sport fishery than the other three 1982 Hoh releases (Table 9). The Chalaat Creek plants contributed far more to the tribal fishery than to the sport fishery. Apparently, releasing fish well upriver makes them far more available to the sport fishery than planting them near the mouth of the river.

The early timing of the FWS release group was similar to the timing of Lake Quinault and Bogachiel stocks. The timing of the native Hoh release group was very late because the 1981 broodstock was taken from the latter part of the run.

The marked hatchery groups released into the Hoh contributed less (21%) to the tribal catch of hatchery fish (see Appendix II) than they did to the sport catch (38%) of hatchery fish. Dip-ins at the river mouth may explain the difference between sport and tribal contribution. Or, this difference may be attributable to the unmarked Bogachiel stock. Reportedly high 1983-84 returns to the Bogachiel Ponds support this theory. We will not have to be so concerned about unmarked release groups in the Hoh next season when few unmarked fish are expected to return.

Distribution of Hatchery Fish in Hoh Sport Catch

The high percentage of hatchery fish in the upper two river sections suggests that straying into the Park is extensive under the present level and method of enhancement. The observation that a greater proportion of hatchery fish occurred in the catch upstream of the uppermost planting site further points up the tendency for hatchery fish to migrate well upriver. However, the large proportion of the hatchery run that cannot be directly attributed to releases on the Hoh confuses the analysis of distribution of hatchery fish in the system.

Upriver release may increase the risk of fish straying into the Park, but we could not recover enough marked fish to be sure of this (Table 8). The distribution of marked recoveries does strongly suggest, however, that extended rearing at one site (group 5-10-44) resulted in much lower rates of straying from that site. On the other hand, fish that had not been reared for some time at the release site (group 5-10-42) tended to scatter

Table 9. Contribution of 1982 Hoh tagged release groups to age 3 catch.

Group	Released	Catch			Contribution (percent) to Harvest		
		Tribal a/	Sport	Total	Tribal	Sport	Total
5-10-42 b/	50,000	96 (20.4)	375 (79.6)	471	0.19	0.75	0.94
5-9-61 c/	69,427	429 (63.6)	246 (36.4)	675	0.62	0.35	0.97
5/10/43 c/	35,330	224 (70.2)	95 (29.8)	319	0.63	0.27	0.90
5-10-44 d/	20,237	133 (58.6)	94 (41.4)	227	0.66	0.46	1.12
Mean of Chalaat Creek releases		(64.1)	(35.9)		0.64	0.36	

a/ Source: Jim Jorgensen, Hoh Tribe, personal communication

b/ FWS release of Cook Creek stock at Willoughby Creek

c/ Hoh tribal release of Lake Quinault stock from Chalaat Creek

d/ Hoh tribal release of Hoh stock from Chalaat Creek

Table 10. Cook Creek and Lake Quinault on-station releases to age 3 harvest on Quinault River. a/

Release Site	Total Release	Estimated Contribution to Quinault Tribal Catch	Percent Contribution
Lake Quinault	34,318	600	1.75
	34,181	845	2.47
	34,275	778	2.27
Mean of Groups			2.16
Cook Creek	211,400	5,842	2.76

a/ Source: Marge McBride, Quinault Tribe, personal communication

up and down the river. This was true even if the fish had been reared about a month (groups 5-9-61 and 5-10-43) at the site before release. Each of these groups tended to concentrate somewhat in the river section where they were released. This indicates that distribution can be controlled to a limited degree by choice of release site. However, if hatchery outplants with little or no acclimation continue, straying must be expected. The problem is compounded by the probable entry of hatchery strays from other rivers into the Hoh. The migration of these groups within the Hoh River is probably uncontrollable.

Evaluation of Total Sport Catch

The 1983-84 sport catch through the end of March was estimated to be 2,454 fish which surpassed any catch during the previous ten years based on punch card returns for the same period. The average catch through March from 1974-75 through 1982-83 was 1,125 steelhead. We compared the catch only to the end of March because in many years the fishery was closed in April.

The entire season's estimated sport catch, 2,811 fish, was considerably less than the tribal catch of 5,452 fish. The percentage distribution was 33.9/66.1. The sport catch was, as expected, considerably later than the tribal catch. This caused the sport share to be small at first and increase monthly (Table 11). The unusually late sport catch this season exaggerated this effect.

The hatchery/wild ratios of the sport and tribal fisheries were practically identical. The sport fishery had 22.6% wild fish and the tribal fishery, 22.2%. The tribal fishery catch shifted from predominantly hatchery fish to about an equal mix of hatchery and wild fish in February (Jim Jorgensen, Hoh Tribe, personal communication), but the sport catch did not make this shift until March. The Tribe may have caught a greater percent of hatchery fish than reported, because evaluation of dorsal stubbing -- the method used by the Tribe to classify hatchery versus wild -- tends to be slightly biased toward calling a hatchery fish wild.

Accuracy of Methods

This creel census probably estimated the 1983-84 Hoh River steelhead catch as well as could be expected with the available resources. However, confidence limits could not be set around the catch. To date, no variance calculation has won general acceptance among statisticians (Ken Newman, Northwest Indian Fish Commission, personal communication). The WDG method uses the variance or covariance between (1) daily index angler estimate; (2) daily catch reported in interviews; (3) daily angler hours reported in interviews; and (4) daily index angler hours. However, our procedure measured a number of other random variables which the equation does not include. For instance, the number of vehicles per boat, the number of anglers per vehicle, and the "spot rig" visibility factor are all estimated values with an associated variance.

Table 11. Cumulative timing of tribal versus sport catch.

Month	Cumulative Catch				Percent of Terminal Catch	
	Sport	% of Sport Total	Tribe	% of Tribal Total	Sport	Tribe
Dec.	382	13.6	2,255	41.4	14.5	85.5
Jan.	1,011	36.0	3,939	72.2	20.4	79.6
Feb.	1,950	69.4	4,653	85.3	29.5	70.5
Mar.	2,454	87.3	5,397	99.0	31.3	68.7
Apr.	2,811	100.0	5,452	100.0	34.0	66.0

Next year's survey will have fewer random variables. Instead of counting all vehicles and separating them by gear type according to angler interview data, we will count boat trailers and bank anglers directly. This will eliminate sampling errors associated with spot rig visibility, vehicles per boat, and anglers per vehicle. However, problems in estimating anglers per boat will remain.

We could not break the catch down by river section for several reasons. First, when we tried to calculate boat fishery vehicles in the upper section, a hidden bias caused us to calculate more boat vehicles than total vehicles. This contradiction occurred even after assigning spot rigs to the Willoughby and Lower sections based on the distribution of reported boat trips over the various river sections. We could not determine the source of this problem or make any assumptions to correct for it.

Second, if we had split up the river there probably would not have been enough completed angler trips reported from each section to calculate catch per effort for every stratum. We would have had to use incomplete trips, which would have introduced an unknown degree of bias into the catch-per-effort estimate.

Finally, a catch estimate by river section would require a separate index expansion for each section. This is impossible in the boat fishery because at the moment a drift boat is observed from jetboat or helicopter it is impossible to assign it to a boat trailer in the appropriate river section. Many boats covered two or three river sections in one trip. Moreover, few bank anglers fished the Park, Upper, and Willoughby sections, so an expansion factor there would probably not be very reliable. Relatively few anglers fished the Park section, making it impractical to reliably calculate a separate catch there.

Hatchery/wild designation could not be accurately determined based on dorsal stubbing. If we assume that all fish that reared one year in freshwater were hatchery fish and those that reared two or three years were wild fish, then our technicians were right 82.5% of the time, based on a sample of 474 fish. When they were wrong, they erred most often (81.9% of the errors) by calling a hatchery fish non-stubbed.

	Scale Analysis	
Field Observation	Hatchery	Wild
Stubbed	294	15
Not stubbed	68	97

Coded-wire tagging and creel census should continue for several more seasons. Large numbers of tagged fish will produce larger mark-samples and a higher degree of accuracy in 1984-85.

Management Implications

The 1983-84 Hoh River steelhead creel census results have interesting harvest management and enhancement implications. The current constant effort commercial fishery and the probable tendency of the sport fishery to become more effective later in the run is resulting in very large surpluses of hatchery fish under the current enhancement strategy. Substantially more hatchery origin steelhead went unharvested than the entire wild escapement in the 1983-84 season. These planted fish are apparently straying well above their release locations based on the census results. If they are spawning successfully, the implications may be very significant for the native steelhead run. Both competition during the juvenile rearing stages and interbreeding with wild fish are potential impacts. Although these effects are only speculation at the present time, the potential for interaction appears great enough to warrant further investigation. If significant interactions are shown to be occurring, current enhancement strategies should be altered. If significant interactions were occurring, with significant risk of negative impact, alternative enhancement strategies should be investigated so that strategies with less potential for negative impact may be employed as necessary.

Also apparent from the 1983-84 census is that the sport/commercial catch ratio can be altered based on smolt release location. Unfortunately, releasing smolts further upstream to increase the sport catch appears to exacerbate the straying of hatchery fish upriver.

Exploitation Rates

The total exploitation rate for the wild run was 33.4%, with the Tribe harvesting 22.1% and the sport fishery, 11.3%. This is based on a wild sport catch of 621, a wild tribal catch of 1,219, and a wild escapement of 3,667 (Jim Jorgensen, Hoh Tribe, personal communication). Both tribal and sport exploitation rates were near the lowest reported since record-keeping began nine years ago (Jorgensen et al. 1984).

The total exploitation rate for the Chalaat Creek native hatchery run was 37.2%, with the Tribe harvesting 21,8% of the run and the sport fishery, 15.4%. This is based on a sport catch of 94, a tribal catch of 133, and an escapement to the Chalaat Creek weir of 383 (Jorgensen, personal communication). Exploitation for the early hatchery runs, that is, Lake Quinault and Cook Creek stock, could not be estimated because no escapement estimate was available for the months of January and February when most fish from these runs were expected to spawn.

CONCLUSIONS

1. Cook Creek smolts reared at Quinault NFH and released on the Hoh River at Willoughby Creek contributed to the catch as three year olds in the combined Hoh River tribal and sport fisheries at a rate of 0.94%. This was:

   a. slightly less than Lake Quinault stock released from Chalaat Creek in the same year,

   b. slightly less than Hoh native stock released from Chalaat Creek in the same year,

   c. less than the contribution of Cook Creek stock released on station from Quinault NFH in the same year and caught in the Quinault River tribal fishery, and

   d. less than the contribution of Lake Quinault stock released on station in the same year and caught in the Quinault River tribal fishery.

2. The FWS 1982 release group contributed 80% to the sport catch and 20% to the tribal catch. The three 1982 Hoh Tribal release groups contributed an average of only 36% to the sport catch and 64% to the tribal catch.

3. The FWS 1982 release contributed 375 adults to the 1983-84 sport catch, and Hoh tribal releases contributed 452 fish to the season's sport catch. The contribution of WDG releases could not be determined.

4. The marked hatchery release groups on the Hoh together accounted for only 38% of the sport catch of hatchery origin. These same releases together accounted for only 21% of the Hoh tribal catch of hatchery origin. This suggests that large numbers of hatchery fish may be entering the Hoh after release on other river systems and/or unmarked releases of Bogachiel stock had a higher than expected rate of survival and contributed disproportionately to the tribal fishery.

5. Cook Creek and Lake Quinault stock entered the sport catch primarily in January and/or February, based on coded-wire tag recoveries. This would be expected from the timing of these stocks in the Quinault system. In contrast, the Hoh stock entered the sport catch only in March and April.

6. Hatchery fish made up at least 70% of the catch in all sections of the river, even in that section which included the Olympic National Park.

7. Insufficient coded-wire tags were recovered from the "Park" section of the river to evaluate the extent of straying into the Park by specific tagged releases. The data does suggest the possibility of significant straying into the Park for all release groups except the Hoh natives released at Chalaat Creek. Long-term rearing at the release site appears to be the only means to minimize straying upstream.

RECOMMENDATIONS

1. Continued creel census is required to evaluate the four-year-old contribution of 1982 smolt releases and the three-year-old contribution of 1983 releases.

2. The following changes in procedure should yield more complete data, more efficiently than the 1983-84 methods:

   a. Intensify catch sampling within the National Park to better determine rate of straying of coded-wire tagged fish to that section of the river.

   b. Give preference to helicopter flights over jetboat trips in determination of total angler effort, if resources are available.

   c. Eliminate several index areas that had little angler use in 1983-84, or were accessible only by four-wheel-drive vehicles.

   d. Interview only those boat anglers that have completed their trip.

   e. Ask each fishing party at what time during the trip each fish was caught. This will help determine whether catch per effort data from incomplete fishing trips should be used in the catch estimate.

   f. Determine index area angler effort through counts of boat trailers, bank drift anglers, and plunk poles. This method will eliminate the complex calculations required to convert vehicle counts to angler estimates.

   g. During jetboat surveys, ask each boat party above Willoughby Creek where they launched their boat. Thus, if the survey must be terminated at some point below the Park boat launch, a minimum estimate can be made of the number of boats remaining above the cutoff point and, therefore, not counted in the jetboat survey.

3. An effort should be made to evaluate the impact of the large unharvested surplus of hatchery fish on the wild run. If these fish are spawning successfully or interbreeding with the native stock, alternative enhancement strategies should be employed.

LITERATURE

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APPENDIX I: CATCH ESTIMATION

The method used in this study to estimate the total catch relies upon estimates of the catch per effort reported by a sample of anglers and the total effort.

$$C = \sum_{m=1}^{5} \sum_{g=1}^{2} \sum_{w=1}^{2} (C/H)mgw\ Hmgw$$

where: C = catch
m = month (1 = December; 2 = January, etc.)
g = gear type (1 = boat; 2 = bank)
w = day of week (1 = weekday; 2 = weekend)
Note: m, g, and w are subscripts to the variables C/H and H, and define the strata by which the catch was estimated.
C/H = fish per angler hour reported by anglers interviewed
H = angler hours estimated by expanded index area vehicle counts

We determined the catch per angler hour by asking each fishing party (1) how many steelhead they had caught and kept (virtually all anglers kept their catch), (2) how many anglers were in the party, and (3) how many hours they had fished that day. We attempted to conduct these interviews on 70 percent of the weekdays and 75 percent of the weekends and holidays, chosen at random. We tried to spread our effort without bias over all major bank fishing spots and boat landings.

We estimated the total angler hours of fishing effort in each stratum by estimating the mean instantaneous number of anglers fishing at randomly chosen times and multiplying by the number of hours in the stratum available for fishing. This method does not require the assumption that the average angler fishes a certain number of hours each day. Rather, we calculate anglers and fishing hours independently, assuming that (1) all daylight hours are available for fishing on days when the river is low and clear enough; and (2) the mean instantaneous angler count is not biased toward any time of day but rather, represents the mean fishing pressure over the whole stratum. Because our angler counts are instantaneous, we do not need to know how long the average angler stays on the river. Thus:

$$Hmgw = (Anglers)mgw\ (Hours)mw$$

where: (Anglers)mgw = instantaneous total anglers
(Hours)mw = hours available for fishing, by stratum

We had to estimate the instantaneous total anglers by expanding an index count, because our technicians could not count all the anglers often and quickly enough by car. However, they could count all the anglers' vehicles at the most popular fishing spots and boat landings in an hour and a half or less. Helicopter and jetboat surveys, on the other hand, could count all the anglers in a short time. However, the cost, weather, and river conditions made it impossible to rely on these alone. Therefore, we scheduled two index counts at random hours, one before noon and one after noon, on every angler interview day, and made jetboat or helicopter surveys

along with an index count 14 times over the season. With these estimates we developed a ratio of total effort to index effort. Thus the total number of anglers is the index count times the expansion factor:

$$(\text{Anglers})_{mgw} = E_{mgw} B_g$$

where: E_{mgw} = instantaneous index area angler count

B_g = index expansion factor

To get index angler counts by gear type from index angler vehicle counts requires a conversion based on the number of vehicles per boat trailer and the number of anglers per vehicle, as reported by the anglers interviewed.

Index area vehicle counts consisted of the number of (1) vehicles with boat trailers, (2) vehicles without boat trailers, and (3) boat trailers without vehicles attached. These counts were broken down by gear type by estimating the vehicles in the boat fishery and assigning the others to the bank fishery. There are two basic types of boat fishery vehicles: those that are parked with the boat trailer attached, called "trailer rigs", and those that are parked at the other end of the drift from the trailer, called "spot rigs".

There are two kinds of spot rigs: (1) those that detach their trailer at one end on the drift and park at the other end because there is only one vehicle in the party, and (2) those that leave one vehicle and trailer together at one end of the drift and park at the other end because there are more vehicles than boats in the party. There are as many type (1) spot rigs as there are trailers without a vehicle attached. The number of type (2) spot rigs equals the number of trailer rigs times the quantity "one less than the number of vehicles per trailer" as reported by the boat anglers interviewed.

In other words, $V_{bt} = 0.80(T + V_t(v/b - 1)) + V_t$

where V_{bt} = vehicles observed in index area and assigned to boat fishery;

T = boat trailers without vehicle attached;

V_t = vehicles with boat trailers attached; and

v/b = vehicles per boat by month and weekday/weekend, reported by boat anglers interviewed.

and $V_{bk} = V_{tot} - V_{bt}$

where V_{bk} = vehicles observed in index areas and assigned to bank fishery, and

V_{tot} = total vehicles observed in index area.

Appendix I, Table 1. "Spot Rig" visibility factor calculation.

Date	Total Boats	Index Boat Trailers
11-29	1	1
12-2	2	3
12-3	6	5
12-15	0	0
12-18	13	9
1-12	3	4
2-4	47	36
2-17	16	13
3-3	12	7
3-11	21	21
3-31	19	13
TOTAL	140	112

Index trailers per total boats = 0.80

We can now calculate the index anglers by gear type by multiplying the index vehicles by the number of anglers per vehicle reported by the bank or boat anglers interviewed. In other words, Ag = Vg (a/v)g

where A = index anglers by gear type;

V = index vehicles by gear type; and

(a/v) = anglers per vehicle as reported by anglers interviewed.

Finally, the daily index angler count, Emgw, is calculated as the mean of the two Ag values for the day.

Index expansion factors were calculated as the slope of the regression line of total anglers versus index area anglers observed at the same time. One factor was calculated for the boat fishery and another for the bank fishery. Total anglers were counted or estimated for the entire fishable length of river; that is, up to the Hoh Ranger Station. Total anglers were counted when a helicopter was available. When a jetboat had to be used, total counts were made as far upriver as the jetboat could proceed. Snags and shallow stretches prevented counting anglers all the way upstream to the ranger station.

Therefore, we had to estimate the total anglers above the stopping point on these occasions. To do this we assumed that the anglers we counted from the jetboat were from the index vehicles we counted up to and including the stopping point. We estimated the number of anglers from a total car count above the stopping point around the time the jetboat stopped. This estimate followed the "methods" section of this report, except that an individual car count, instead of a stratum total, was the base of the calculations (Table 2). We added this estimate to the jetboat count to get the total effort.

One Pearson regression was made for bank anglers and another for boat anglers. Parameters are in Table 2 of this Appendix. Total bank effort was estimated as 1.229 times the index effort, while total boat effort was 1.173 times the index effort (Table 3).

We calculated the number of hours available for fishing in each stratum as

$$(\text{Hours})mw = Fm\ Dmw$$

where

F = number of fishable hours per day, and

D = number of fishable days per stratum

Fishable hours per day were set as the day length on the fifteenth of each month except April, when the seventh was used since the season ended on the 15th.

Appendix I, Table 2. Data to estimate total anglers for index expansion.

Date	Upper Limit of Survey (River mile in parenthesis)	Boat Fishery		Bank Fishery	
		Angler Count	Total Vehicle Count	Angler Count	Total Vehicle Count
11/29	Park boat access (30.0)	2	0	1	0
12/2	"	5	0	7	0
12/3	"	13	0	18	0
12/15	"	0	0	7	0
12/18	"	29	0	16	0
1/12	Park boundary (29.7)	6	2	20	1
1/15	a/	0	108	0	55
1/21	a/	0	54	0	20
2/1	Park boat access	3	41	15	1
2/4	Ranger station (35.5)	111	0	40	0
2/17	Spruce Creek (26.5)	36	0	28	1
3/3	"	31	3	35	0
3/11	Park boat access	44	0	23	2
3/31	Oxbow (15.5)	40	9	9	0

a/ Total vehicle count was made over entire river

Appendix I, Table 3. Calculation of index expansion factors: angler count data.

	Anglers			
	Boat Fishery		Bank Fishery	
Date	Index Estimate a/	Total Count b/	Index Estimate a/	Total Count c/
11/29	0	2	5	1
12/2	6	5	7	7
12/3	9	13	16	18
12/15	0	0	5	7
12/18	22	29	18	16
1/12	5	8	13	21
1/15	94	108	36	55
1/21	51	54	14	20
2/1	46	44	11	16
2/4	77	111	38	40
2/17	27	36	13	29
3/3	17	34	30	35
3/11	47	44	24	25
3/31	41	49	14	9
Regression slope	1.173		1.229	
Correlation coefficient	0.971		0.900	
	$p < 0.01$		$p < 0.01$	

a/ From index area vehicle count during jetboat or helicopter survey

b/ From Table 2, sum of columns (c) and (d)

c/ From Table 2, sum of columns (e) and (f)

The number of fishable days in the time stratum was defined as the total number of calendar days minus the washout days. Washout days occur when river conditions prevent fishing. In practical terms, this happened when either of two conditions prevailed:

(1) The river was higher than any stage at which fishing had occurred during the season. This was 6.2 feet at the gaging station. If the stage was not measured but visibility was, visibility had to be either less than 12 inches at the gaging station or 16 inches at the Olympic National Park boundary; or

(2) Both technicians agreed the river was not fishable, based on their experience.

To summarize,

$$C = \sum_{m=1}^{5} \sum_{g=1}^{2} \sum_{w=1}^{2} (C/H)mgw\ Emgw\ Bg\ Fm\ Dmw$$

This is the formula of WDG (1978). The main difference between their procedure and ours is that they separate out plunk and drift components of the bank fishery, while we found this unnecessary.

APPENDIX II. Marked Recoveries on the Hoh

Sport Fishery

Observed tags (Table 1) were expanded to account for the sampling rate. We expanded each month's recoveries by a separate sampling rate for that month. The sampling rate equalled the mark sample divided by the total estimated monthly catch. The expansion factors and results appear in Appendix II, Table 2.

To calculate the contribution of the release group represented by a tag code, we further expanded the recovered tags to account for the untagged fish released. That is, we divided the expanded tags recovered from Appendix II, Table 2 by the percentage of the release group that was tagged. Results of all Hoh River tagged releases recovered in the sport catch appear in Appendix II, Table 3. The total contribution was 827 fish.

Tribal Fishery

Observed tags were expanded to account for the sampling rate (Appendix II, Table 4). The sampling rate was calculated separately for each month. The contribution was calculated as in the sport fishery for all tag groups released on the Hoh.

Appendix II, Table 1. Tag recoveries by river of origin.

Tagcode	Release Site	Release Year	Sport Catch Recoveries
Missing	Unknown	Unknown	6
5-7-56	Chalaat Creek a/	81	1
5-7-62	Lake Quinault	"	1
5-9-57	Lake Quinault	82	1
5-9-58	Salmon River	"	1
5-9-61	Chalaat Creek	"	10
5-10-42	Willoughby Creek b/	"	27
5-10-43	Chalaat Creek a/	"	11
5-10-44	Chalaat Creek a/	"	14
5-11-32	Chalaat Creek a/	"	2
62-17-09	Skykomish River	"	1
62-52-02	Humptulips River	80	1
62-55-02	Soleduck River	81	2
TOTAL			78
TOTAL HOH RELEASES			65
TOTAL STRAYS			7

a/ Enters Hoh River at RM 0.5. All Chalaat releases by Hoh Tribe.

b/ Enters Hoh River at RM 19.3. Release by FWS.

Appendix II, Table 2. Expanded tag recoveries of Hoh River releases by month in the sport fishery.

Percent Sampled		26.1	15.8	20.1	23.9	19.8
Group	Release Location	Dec.	Jan.	Feb.	Mar.	Apr.	Total
5-7-56 c/	Chalaat Cr.	0	0	0	0	5	5
5-9-61 a/	Chalaat Cr.	11	19	15	5	0	50
5-10-42 b/	Willoughby Cr.	23	13	84	5	5	130
5-10-43 a/	Chalaat Cr.	7	13	30	5	0	55
5-10-44 c/	Chalaat Cr.	0	0	0	25	41	66
5-11-32 c/	Chalaat Cr.	0	0	0	10	0	10

a/ Lake Quinault stock

b/ Cook Creek stock

c/ Hoh River stock

Appendix II, Table 3. Contribution of Hoh River tagged release groups to the sport fishery.

Group	Release Location	Number Released	Number Tagged	Expanded Tag Recoveries	Contrib.
5-7-56	Chalaat Cr.	24,868	24,520	5	5
5-9-61	Chalaat Cr.	69,427	14,078	50	246
5-10-42	Willoughby	50,000	17,272	130	375
5-10-43	Chalaat Cr.	35,330	20,231	55	95
5-10-44	Chalaat Cr.	20,237	14,175	66	94
5-11-32	Chalaat Cr.	4,222	3,589	10	12
TOTAL					827

Appendix II, Table 4. Contribution of Hoh tagged release groups to 1983-84 tribal catch.

Group	Tagged Releases	Total Released (Tagged & Untagged)	Tags Recovered in Tribal Fishery a/	Contribution	% of Hatchery Catch
5-4-41	3,011	22,222	1	7	0.2
5-7-55	17,568	18,000	15	15	0.4
5-7-56	24,520	24,868	4	4	0.1
5-9-61	14,078	69,427	87	429	10.0
5-10-42	17,272	50,000	33	96	2.2
5-10-43	20,231	35,330	128	224	5.2
5-10-44	14,175	20,237	93	133	3.1
5-11-32	3,589	4,222	1	1	0.0
Bogachiel '81 rel.		32,200	-	-	
Bogachiel '81 rel.		5,000	-	-	
Total estimated contribution of Hoh River tagged release groups				909	21.2
Other hatchery catch				3,364	78.8
Total hatchery catch				4,273	100.0

Expansion Factors

Month	Recorded Catch	Mark Sample	Expansion Factor
Nov.	69	41	1.68
Dec.	2,186	1,535	1.42
Jan.	1,684	1,327	1.27
Feb.	714	591	1.21
Mar.-Apr.	799	726	1.10

a/ Incl. November catch
b/ See Text, Table 6 footnote for calculation

Appendix III, Table 1. Catch estimate by stratum.

Stratum										
Mo.	WE/ WD	Bank/ Boat	Index Anglers (E)	Fishable Hours (F)	Exp. Factor (B)	Total Est. Daily Angler Hours	Rpt. Catch (C)	Rpt. Effort (H)	Fishable Days (D)	Catch (C)
12	WD	Bt	11.9	8.4	1.173	117	5.20	53.9	20	226
		Bk	6.2	8.4	1.229	64	1.30	15.4	20	108
	WE	Bt	8.43	8.4	1.173	83	1.71	36.7	10	39
		Bk	7.43	8.4	1.229	77	0.143	12.3	10	9
1	WD	Bt	19.9	8.8	1.173	205	2.88	46.2	17	218
		Bk	10.8	8.8	1.229	117	1.50	22.6	17	132
	WE	Bt	39.0	8.8	1.173	403	10.3	151.0	8	220
		Bk	23.3	8.8	1.229	252	1.0	34.3	8	59
2	WD	Bt	15.7	10.2	1.173	188	8.89	78.9	16	339
		Bk	10.4	10.2	1.229	130	0.889	10.8	16	172
	WE	Bt	52.6	10.2	1.173	629	15.4	276.0	7	246
		Bk	28.8	10.2	1.229	361	1.20	16.7	7	182
3	WD	Bt	13.3	11.9	1.173	156	5.38	78.6	21	267
		Bk	7.8	11.9	1.229	114	0.385	17.1	21	54
	WE	Bt	19.0	11.9	1.173	265	7.83	152.0	8	109
		Bk	16.0	11.9	1.229	234	1.33	33.6	8	74
4	WD	Bt	11.7	12.2	1.173	167	9.50	104.4	10	152
		Bk	10.8	12.2	1.229	162	0.833	15.9	10	85
	WE	Bt	13.3	12.2	1.173	190	12.0	106.0	5	108
		Bk	15.3	12.2	1.229	229	0.333	31.6	5	12
TOTAL										2,811