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Coastal Zone and Estuarine Studies

**Imprinting Salmon
and
Steelhead Trout for Homing, 1979**

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Annual Report of Research
Financed by
Bonneville Power Administration
(Contract DE-A179-79-BP-10682)

and

NOAA
National Marine Fisheries Service
Northwest and Alaska Fisheries Center
Division of Coastal Zone and Estuarine Studies
2725 Montlake Boulevard East
Seattle, Washington 98112

August 1980

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INTRODUCTION

The National Marine Fisheries Service (NMFS), under contract to the Bonneville Power Administration (BPA), is conducting research on imprinting Pacific salmon and steelhead for homing. Imprinting is defined as a rapid and irreversible learning experience that provides fish with the ability to return to natal streams or a preselected site. The ability to activate the imprint mechanism at the proper time should assure a suitable homing cue that coupled with transportation (Park et al. 1979) will result in high smolt survival and ensure adequate returns to the homing site or hatchery.

In our study, we use single imprints and sequential imprints. Single imprinting is cueing fish to a unique, single water supply prior to release. Various mechanical stimuli may be used in combination with the unique water source to achieve the single imprint. Sequential imprinting is cueing fish to two or more water sources in a step-by-step process which establishes a series of signposts for the route "home".

The primary objectives of our homing research are as follows:

(1) Determine whether a single imprint or a series of stimuli (sequential imprinting) are necessary to assure homing for various stocks of salmonids.

(2) Determine a triggering mechanism to activate the homing imprint in salmonids.

(3) Determine the relationship between the physiological condition of fish (gill $\text{Na}^+ - \text{K}^+$ ATPase activity, etc.) and their ability to imprint.

Our study began in 1978, and the first year's activities were reported by Slatick et al. (1979) and Novotny and Zaugg (1979). This report covers the research for the second year (1979).

The specific activities of the second year's research were divided into three categories: (1) mark and release additional groups of juvenile salmonids to test imprinting techniques; (2) determine health profiles and monitor smoltification status of juvenile test fish; and (3) monitor and evaluate adult returns, from juveniles marked and released in 1978, to determine the efficacy of the imprinting techniques.

IMPRINT TESTS - 1979

During FY 1979, we marked and released 1,017,023 juvenile salmonids to determine if fish could be imprinted to return to a hatchery of origin, another hatchery, or a homing site other than a hatchery (Table 1 and Figure 1). Marking consisted of excision of the adipose fin and injection of a coded wire tag (CWT). In addition, most fish received a distinctive cold brand to aid in monitoring their return as adults at key observation points. The evaluation of imprinting will be based on a comparison of adult returns from control releases (natural migration) and experimental releases (various imprint treatments).

Tucannon Hatchery - Tucannon Hatchery

The objective was to imprint steelhead for return to the Tucannon Hatchery [Washington Department of Game (WDG)] located on the Tucannon River. Steelhead used in the homing experiment were obtained from the Tucannon Hatchery. The eggs for these steelhead were originally obtained from the Skamania Hatchery (WDG); the adults are primarily 2- and 3-ocean fish. The Tucannon Hatchery water is supplied by springs and the Tucannon River. We utilized the spring water as the imprinting cue, the hatchery of origin as the homing station, and treated the experimental groups as shown in Table 2. With slight modification (held 2 h in tanker instead of 1 h), this is a replicate of the experiment conducted in 1978.

Table 1.--Homing imprint experiment 1979--species, location, numbers of fish marked and released, and years when adults are expected back for evaluation.

Species and (hatchery of origin - homing site)	<u>Fish marked and released</u>		Total (no.)	Adult evaluation (yr.)
	Control (no.)	Experimental (no.)		
SNAKE RIVER SYSTEM				
<u>Steelhead</u>				
(Tucannon-Tucannon)	24,787	42,786	67,573	1980-82
COLUMBIA RIVER SYSTEM				
<u>Steelhead</u>				
(Chelan-Leavenworth)	67,317	70,500	137,817	1980-81
(Wells-Winthrop)	38,350	26,893	65,243	1980-81
<u>Spring Chinook Salmon</u>				
(Carson-Pasco)	39,114	74,567	113,681	1980-82
(Carson-Carson)	40,963	118,719	159,682	1980-82
<u>Fall Chinook Salmon^{a/}</u>				
(Big White Salmon - Stavebolt Creek)	189,876	283,151	473,027	1980-82
<u>Subtotals by species</u>				
Spring chinook salmon			273,363	
Fall chinook salmon			473,027	
Steelhead			<u>270,633</u>	
<u>Grand Total</u>			1,017,023	

^{a/} These fish were marked with a coded wire tag and a clipped adipose fin only--all other groups also received a brand.

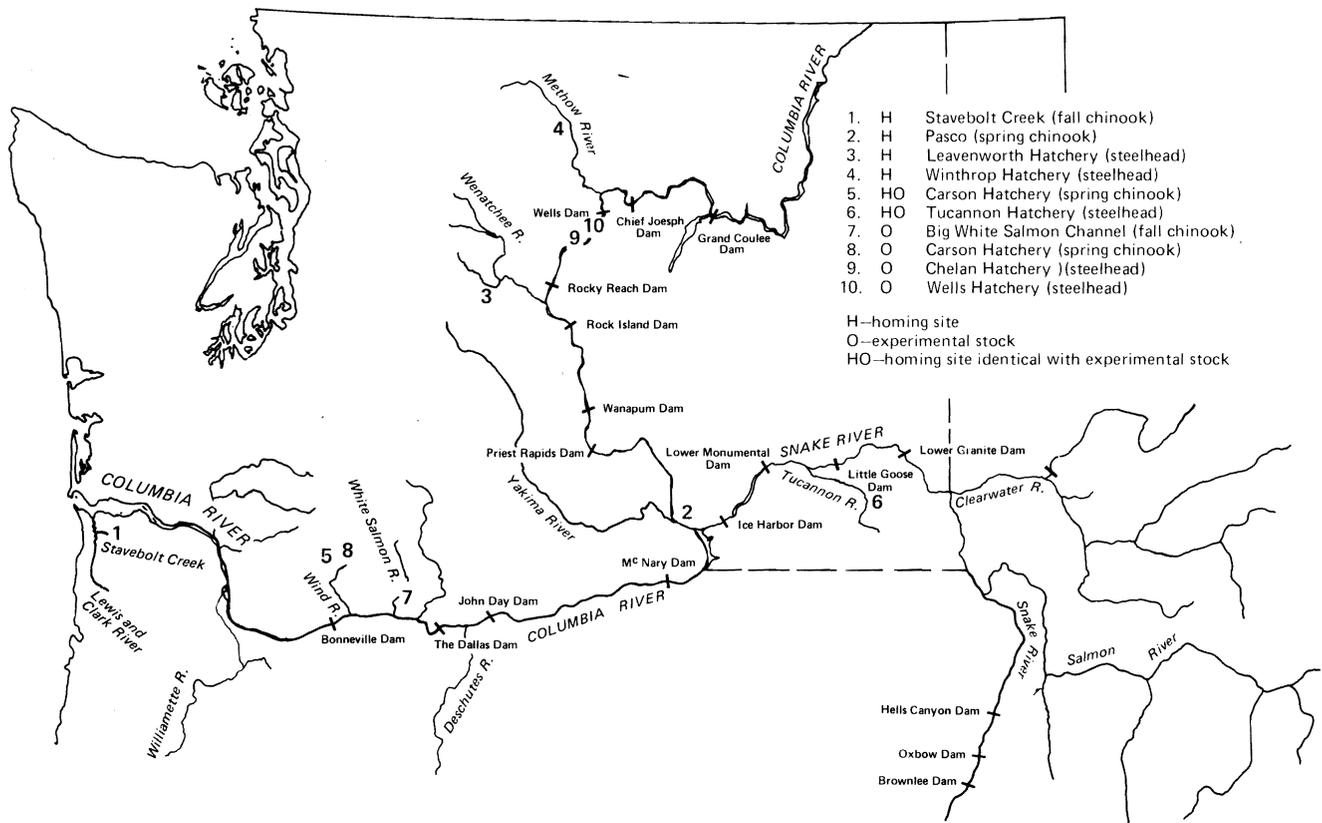


Figure 1.--Area map indicating experimental homing sites and sources of experimental fish (hatcheries).

Table 2.--Steelhead marked in 1979 at Tucannon Hatchery. Test number, mark used, number released, type of imprint, and treatment for various groups are indicated.

Test Control	C.W.T. code ^{a/}	Brand	Number released ^{b/}	Homing imprint	Treatment
Control	W-LB-YW-RD	LA- 	24,787	Natural migration	Released with normal hatchery production into Tucannon River
Test #1	W-LB-XY	RA- 	20,728	Sequential	Loaded into tanker for 2 h; released in pond containing pure spring water for 48 h; trucked with spring water to barge at Lyons Ferry grain terminal; and barged downriver to below Bonneville Dam.
Test #2	W-LB-PK-LB	RA- 	22,058	Sequential	Loaded into tanker for 2 h; released in pond containing 20% spring and 80% river water for 48 h; trucked with Tucannon River water to barge at Lyons Ferry grain terminal; and barged downriver to below Bonneville Dam.

^{a/} Abbreviations for color codes used are shown in Appendix Table 1.

^{b/} Adjusted for initial tag loss.

Chelan Hatchery - Leavenworth Hatchery^{1/}

The objective of the test was to determine the length of time required to imprint steelhead to a homing site other than their hatchery of origin. Steelhead for this experiment were reared in raceways and pre-marked at the Chelan Hatchery (WDG). Three paired (test to control) groups were trucked to Leavenworth National Fish Hatchery (NFH) and held 10 d, 2 d, or 6 h. The test fish were then trucked in hatchery water (Icicle River) to a barge at Richland, Washington and barged downriver and released in the Columbia River below Bonneville Dam. The control fish were released into the Icicle River, a tributary to the Wenatchee River. Specifics on treatments are contained in Table 3. This is a replicate, with minor modification, (Test #3 and Control #3 fish were held 6 h at Leavenworth NFH instead of 4 h) of the experiment conducted in 1978.

Wells Hatchery - Winthrop Hatchery

The object of this experiment was to imprint fish with a homing cue to a homing station (other than the hatchery of origin) and to determine whether a single or sequential homing imprint is needed to return long-run steelhead to a homing station. In addition, we attempted to determine if fish returning to the Winthrop NFH homing site will disperse throughout the 50-mile section of Methow River below the hatchery during the fall and winter.

Steelhead for this experiment were pond reared at the Wells Hatchery (WDG). One group was marked at Wells Hatchery and released at the hatchery

^{1/} In the hyphenated titles, the first name is the hatchery of origin, and the second name is the homing site.

Table 3.--Steelhead marked in 1979 at Chelan Hatchery and imprinted to the Leavenworth National Fish Hatchery. Test number, mark used, number released, type of imprint, and treatment for various groups are indicated.

Test control	C.W.T. ^{a/} code	Brand	Number released ^{b/}	Homing imprint	Treatment ^{c/}
Control #1	W-LB-YW	LA- I	23,960	Natural migration	Held 10 d at Leavenworth NFH and then released into Icicle River (tributary to Wenatchee River).
Control #2	W-LB-PK	LA- H	19,186	Natural migration	Held 2 d at Leavenworth NFH and then released into Icicle River (tributary to Wenatchee River).
Control #3	W-LB-LG	LA- J	24,171	Natural migration	Held 6 h at Leavenworth NFH and then released into Icicle River (tributary to Wenatchee River).
Test #1	W-LB-W	RA - Y	23,331	Sequential	Held 10 d at Leavenworth NFH; trucked in raceway water (Icicle River) to barge at Richland, WA; and barged downriver to below Bonneville Dam.
Test #2	W-LB-RD	RA - Y	24,335	Sequential	Held 2 d at Leavenworth NFH; trucked in raceway water (Icicle River) to barge at Richland, WA; and barged downriver to below Bonneville Dam.
Test #3	W-LB-OR	RA - A	22,834	Sequential	Held 6 h at Leavenworth NFH; trucked in raceway water (Icicle River) to barge at Richland, WA; and barged downriver to below Bonneville Dam.

^{a/} Abbreviations for color codes used are shown in Appendix Table 1.

^{b/} Adjusted for initial tag loss.

^{c/} Experimental design by Larry Brown, Washington Department of Game.

production site in the Methow River (1/4 mile upstream from the mouth). Three groups were trucked to the Winthrop NFH and held for 48 h before being marked. The water supply for the Winthrop NFH is made up of the following mixture:

Ground water	2200 GPM-55%
Spring water	400 GPM-10%
Methow River water	<u>1400 GPM-35%</u>
Total flow	4000 GPM-100%

The ground water is not from the Methow River, but from another aquifer. Specifics on treatment groups are given in Table 4.

Carson Hatchery - Pasco

The object of this experiment was to imprint fish with a homing cue to Pasco, Washington, a mid-river homing station other than the hatchery of origin, and to determine if a single or sequential homing imprint is needed to return fish this far upriver (about 330 river miles). Spring chinook salmon for this experiment were reared in raceways and pre-marked at the Carson NFH located in the Wind River drainage. The eggs for these spring chinook salmon were obtained from adults which return naturally to the Carson NFH. Specifics on treatment are contained in Table 5. We used coho salmon in similar tests conducted in 1978.

Carson Hatchery - Carson Hatchery

The objective was to imprint spring chinook salmon for return to the Carson NFH. The fish were reared in raceways containing Tyee Springs water (normal hatchery supply) and pre-marked several months before being released. Experimental groups were singly or sequentially imprinted to the

Table 4.--Steelhead marked in 1979 at Wells and Winthrop Hatcheries and imprinted to Winthrop Hatchery. Test number, mark used, number released, type of imprint, and treatment for various groups are indicated.

Test control	C.W.T. ^{a/} code	Brand	Number released ^{b/}	Homing imprint	Treatment
Control #1	WH-LB-PK-YW	RA-IJ	20,052	Natural migration	Wells Hatchery control--released at production release site in the Methow River 1/4 mile upstream from mouth.
Control #2	WH-LB-PK-LG	LA-PI	18,298	Natural migration	Winthrop Hatchery control--held 4 d at hatchery and then released into Methow River at hatchery site.
Test #1	WH-LB-LB	RA-T	9,741	Single	Held 4 d at Winthrop Hatchery and trucked in raceway water directly below Bonneville Dam.
Test #2	WH-LB-VI	RA-H	17,152	Sequential	Held 2 d at Winthrop Hatchery; trucked in raceway water to barge at Richland, WA; and barged downstream to below Bonneville Dam.

^{a/} Abbreviations for color codes used are shown in Appendix Table 1.

^{b/} Adjusted for initial tag loss.

Table 5.--Spring chinook salmon marked in 1979 at Carson Hatchery and imprinted to the Pasco Homing Site. Test number, mark used, number released, type of imprint, and treatment for various groups are indicated.

Test control	C.W.T. ^{a/} code	Brand	Number released ^{b/}	Homing imprint	Treatment
Control	WH-LB-GM	LA-↑	39,114	Natural migration	Held in homing site water (raceway) for 60 h then released to migrate naturally.
Test #1	WH-LB-WH-LB	RA-Y	38,293	Single	Held in homing site water (raceway) for 3 days then trucked in homing site water directly to below Bonneville Dam.
Test #2	WH-LB-BL	RA-Y	36,274	Sequential	Held in homing site water (raceway) for 5 days; trucked in homing site water to barge at Richland, WA; and then barged downriver to below Bonneville Dam.

^{a/} Abbreviations for color codes used are shown in Appendix Table 1.

^{b/} Adjusted for initial tag loss.

hatchery water supply and then transported by truck to a release site in the Columbia River just below Bonneville Dam or near Hammond, Oregon. Specifics on treatments are contained in Table 6.

Big White Salmon River Rearing Channel - Stavebolt Creek

The objective of this experiment was to imprint fish to a lower-river homing site. This is essentially a repeat of the 1978 experiment using fall chinook salmon instead of coho salmon. The study is designed to determine:

1. What time period (hours or days) was necessary to imprint a homing cue.
2. If $\text{Na}^+\text{-K}^+$ ATPase enzyme activity, a biological indicator of smoltification, affects homing.
3. Whether a single homing imprint is sufficient to return adults to a homing location.

Fall chinook salmon used in these experiments were initially reared at the Spring Creek NFH from eggs obtained from naturally returning brood stock. The fish were marked at the Spring Creek NFH and then transferred to the Big White Salmon River Rearing Channels to complete their rearing. Water supply for the channels is from the Big White Salmon River.

The lower river homing site used was Stavebolt Creek, a tributary to the Lewis and Clark River which drains into Youngs Bay near Astoria, Oregon. The imprinting site was a pond supplied by water from Stavebolt Creek (sole source of water). Four floating pens, 10' x 20' x 6', were used to hold the test fish for time periods ranging from 4 to 48 h. During the imprinting time period, the fish were not fed.

Table 6.--Spring chinook salmon marked in 1979 at Carson Hatchery. Test number, mark used, number released, type of imprint, and treatment for various groups are indicated.

Test control	C.W.T. ^{a/} code	Brand	Number released ^{b/}	Homing imprint	Treatment
Control	WH-LB-GN	LA- ←	40,963	Natural migration	Released from Carson NFH into hatchery outlet creek leading into the Wind River.
Test #1	WH-LB-YW-YW	RA-T	40,372	Single	Loaded into tanker for 2 h, then released into raceway containing Tyee Springs water for 48 h minimum and then trucked in Tyee Springs water to release site below Bonneville Dam.
Test #2	WH-LB-YW-XY	RA- →	39,794	Sequential	Loaded into tanker (Tyee Springs water) for 2 h released into raceway (Tyee Springs water) for 48 h minimum, loaded into tanker containing Tyee Springs water for 2 h, released into raceway (Wind River water) for 48 h minimum, and then loaded into tanker (Wind River water) and hauled to release site below Bonneville Dam.
Test #3	WH-LB-XR	RA- ↓	38,553	Sequential	Loaded into tanker (Tyee Springs water) for 2 h, released into raceway (Tyee Springs water) for 48 h minimum, loaded into tanker containing Tyee Springs water for 2 h, released into raceway (Wind River water) for 48 h minimum, and then loaded into tanker (Wind River water) and hauled to release site near Hammond, Oregon.

^{a/} Abbreviations for color codes used are shown in Appendix Table 1.

^{b/} Adjusted for initial tag loss.

Measurements of the $\text{Na}^+\text{-K}^+$ ATPase enzyme activity were taken from 7 February to 19 June 1979 at Spring Creek NFH and from 23 March to 26 June 1979 at the Big White Salmon River Rearing Channels. Both $\text{Na}^+\text{-K}^+$ ATPase profiles were taken to determine if moving fall chinook salmon to a colder water system would delay the onset of the $\text{Na}^+\text{-K}^+$ ATPase enzyme activity. Figure 2 illustrates that instead of delaying the $\text{Na}^+\text{-K}^+$ ATPase activity, the level was depressed and that both profiles showed a definite correlation. Figure 2 also shows the dates of the three test series during which the fall chinook salmon were imprinted and released.

During the third test series the fish sustained outbreaks of Enteric Redmouth disease and gill amoeba; therefore, the release of these fish was delayed to treat the diseases. At the conclusion of treatment, high water temperatures in the Stavebolt Creek holding impoundment prevented planned transfer of test groups, so all fish were released into the Big White Salmon River. Specifics on treatments are contained in Tables 7 to 9.

ADULT RETURNS FROM IMPRINT TESTS - 1978

The degree of success (ability to home and survival enhancement) for the various treatments of experimental fish is based on the returns of adults marked with CWT. Homing of various groups is determined by the rate of return of marked adults to the homing sites. All homing sites are located at permanent facilities (hatcheries) except the ones at Stavebolt Creek, Oregon and Pasco, Washington, where adequate facilities have been constructed. Survival of various groups is measured by the combined total recoveries of CWT's at the homing site; from commercial, sport, and Indian fisheries; from sampling sites at main stream dams; and from hatcheries and spawning grounds.

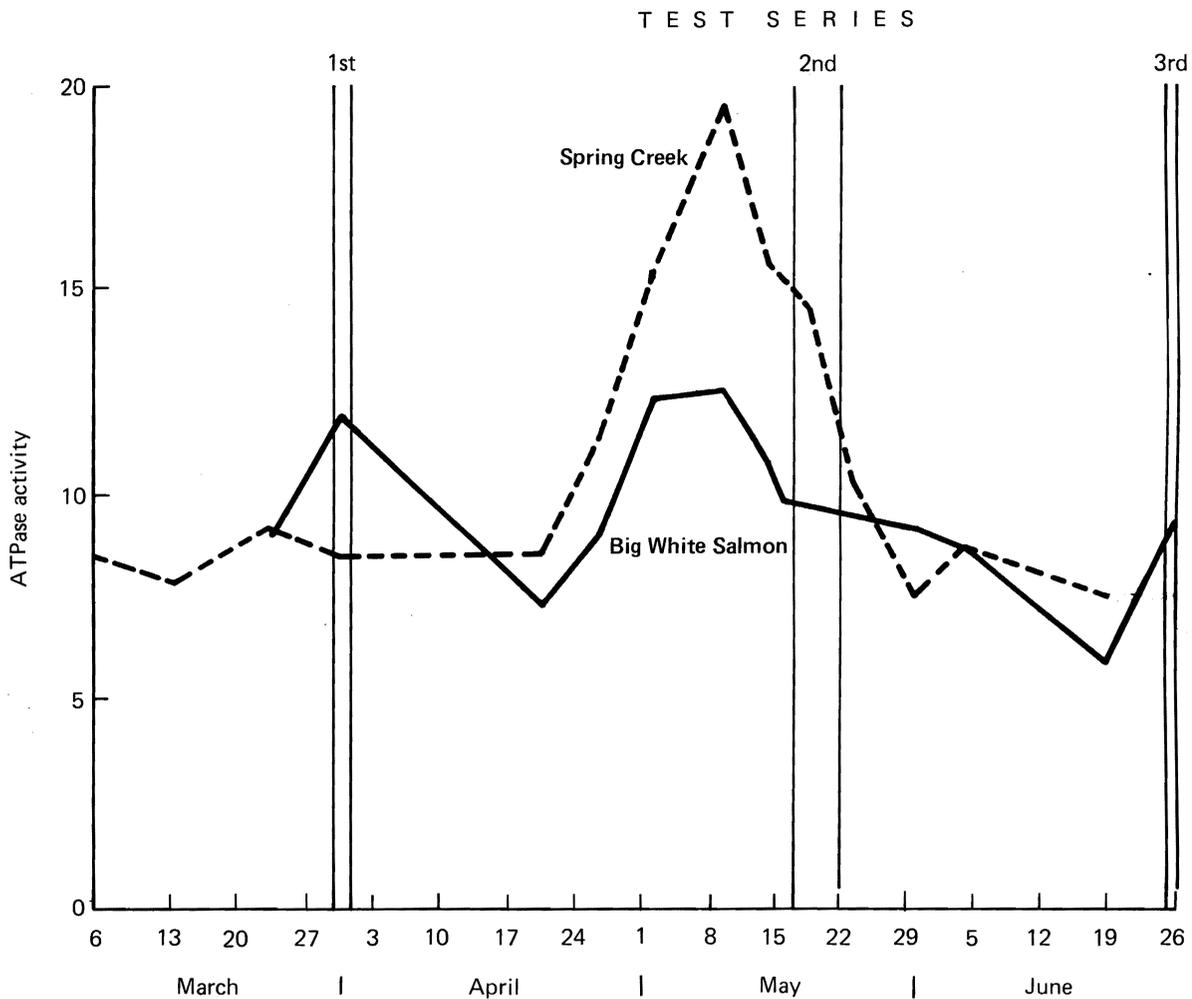


Figure 2.-- $\text{Na}^+\text{-K}^+$ ATPase activity profile for fall chinook salmon smolts reared at Big White Salmon Rearing Channels and Spring Creek Hatchery, indicating time frame for imprinting tests in 1979.

Table 7.--Fall chinook salmon marked in March 1979 at Spring Creek NFH, held at Big White Salmon River Rearing Channel, and then transported and imprinted to the Stavebolt Creek homing site. Test number, mark used, number released, type of imprint, and treatment for various groups are indicated.

Test control	C.W.T. code	Number released ^{a/}	Homing imprint	Treatment
1st Na ⁺ -K ⁺ ATPase Series (released 28 to 31 March 1979)				
Control #1	03/47/01	42,419	Natural migration	Released from Big White Salmon River rearing channel into Big White Salmon River.
Test #1	03/48/01	44,401	Single	Transported from Big White Salmon River rearing channel to Stavebolt Creek; held 48 h; and then trucked to Hammond, Oregon and released into Columbia River.
Test #2	03/49/01	47,337	Natural migration	Transported from Big White Salmon River rearing channel to Stavebolt Creek, held 48 h, and then released into Stavebolt Creek.

^{a/} Adjusted for initial tag loss.

Table 8.--Fall chinook salmon marked in April, 1979 at Spring Creek NFH, held at Big White Salmon River Rearing Channel, and then transported and imprinted to the Stavebolt Creek Homing site. Test number, mark used, number released, type of imprint, and treatment for various groups are indicated.

Test control	C.W.T. code	Number released ^{a/}	Homing imprint	Treatment
2nd Na ⁺ -K ⁺ ATPase Series (release 17 to 22 May 1979)				
Control #2	03/52/01	47,788	Natural migration	Released from Big White Salmon River Rearing Channel into Big White Salmon River.
Test #3	03/51/01	49,300	Single	Transported from Big White Salmon River Rearing Channel to Stavebolt Creek; held 48 h; and then trucked to Hammond, Oregon and released into Columbia River.
Test #4	03/54/01	46,292	Single	Transported from Big White Salmon Rearing Channel to Stavebolt Creek; held 4 h; and then trucked to Hammond, Oregon and released into Columbia River.
Test #5	03/50/01	48,153	Natural migration	Transported from Big White Salmon River Rearing Channel to Stavebolt Creek, held 48 h; and then released into Stavebolt Creek.
Test #6	03/53/01	47,668	Natural migration	Transported from Big White Salmon River Rearing Channel to Stavebolt Creek, held 4 h, and released into Stavebolt Creek.

^{a/} Adjusted for initial tag loss.

Table 9.--Fall chinook salmon marked in May, 1979 at Spring Creek NFH, held at Big White Salmon River Rearing Channel.^{a/} Test number, mark used, number released, type of imprint, and treatment for various groups are indicated.

Test control	C.W.T. code	Number released ^{b/}	Homing imprint	Treatment ^{a/}
3rd Na ⁺ -K ⁺ ATPase Series (Released June 26, 1979)				
Control #3	03/55/01	28,542	Natural migration	Released from Big White Salmon River Rearing Channel into Big White Salmon River.
Control #4	03/56/01	34,779	Natural migration	Released as control from Big White Salmon River Rearing Channel into Big White Salmon River.
Control #5	03/57/01	36,348	Natural migration	Released as control from Big White Salmon River Rearing Channel into Big White Salmon River.

^{a/} Due to outbreaks of Enteric Redmouth and gill amoeba, release of these fish was delayed for remedial treatment. At the conclusion of treatment, high water temperature in Stavebolt Creek holding impoundment prevented transfer of planned test groups, so all fish were released as control groups.

^{b/} Adjusted for initial tag loss.

Steelhead

Data to provide final assessment of homing will not be available until after spawning at hatcheries is completed in the spring of 1981. Evaluation of smolt condition in relation to returning adults will not be made until adult returns to homing sites are complete. However, returns of 1-ocean age steelhead, previously marked at Wells and Chelan Hatcheries, to five in-river sampling locations (Figure 3) provide some worthwhile preliminary information on survival and homing.

Wells-Winthrop Experiment

The object of this experiment was to imprint steelhead from the Wells Hatchery with a homing cue to the Winthrop NFH (a hatchery other than the hatchery of origin - Figure 1) on the Methow River and to determine if a single or sequential homing imprint will cause steelhead to return to the Winthrop NFH homing site.

Our experimental design used five groups of steelhead, two control groups and three test groups of approximately 20,000 fish per group. Details for the experimental design, number of fish per group, etc., are provided in last years report (Slatick et al, 1979).

Differences between treatment groups, with respect to relative survival and homing, are illustrated by the test to control ratios at each of the sampling locations (Figure 4). Although the test to control ratios are not constant, they do indicate up to 6.8 times higher survival for the test groups (transported) than the control groups (non-transported) at the three lower-river sampling locations (Bonneville Dam, Indian fishery, and McNary Dam). Further, the test/control ratios at each of the lower-river

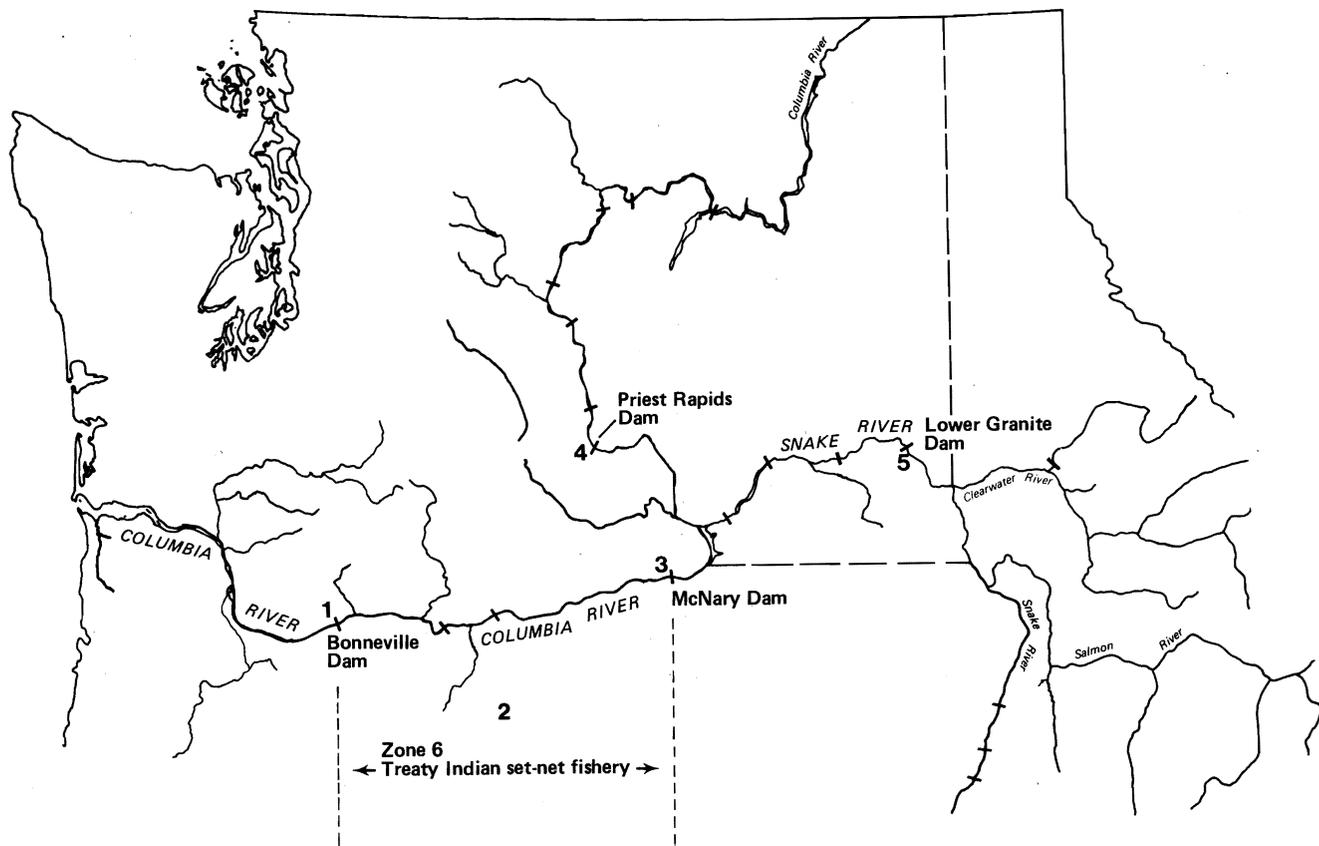


Figure 3.--Map of Columbia River system showing location of five in-river sampling locations.

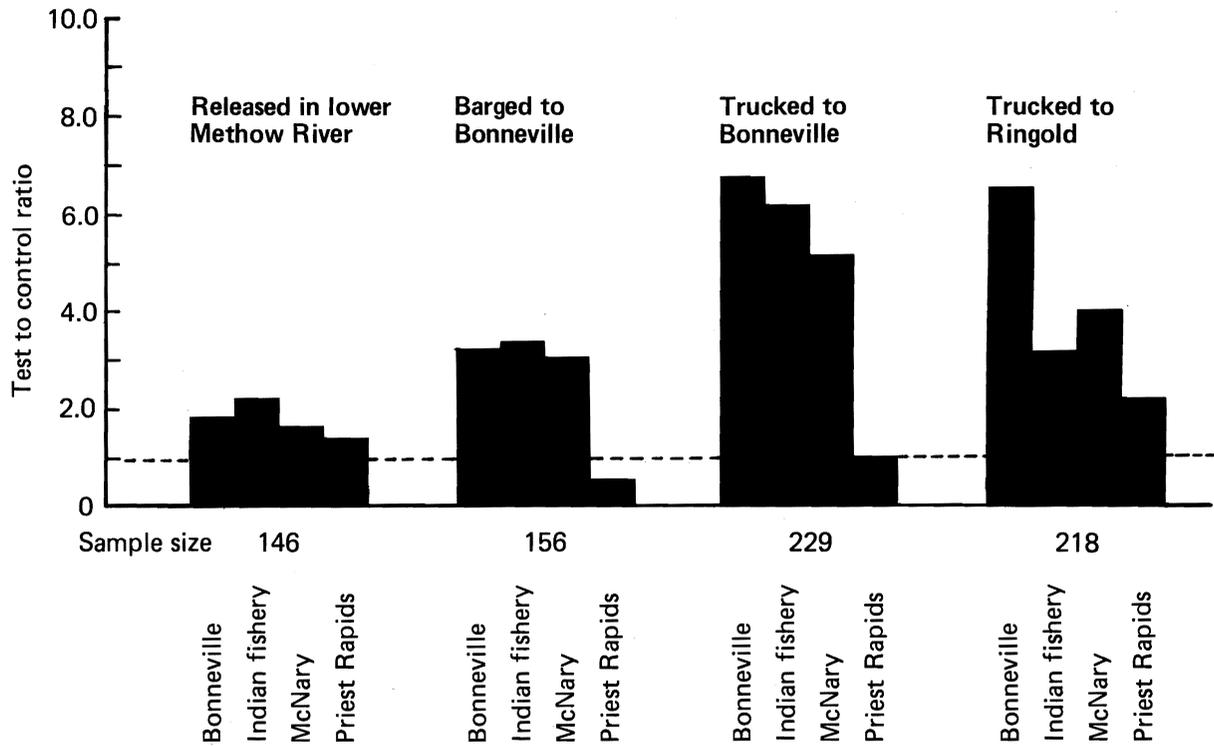


Figure 4.--Test to control ratios for preliminary returns to four sampling locations on the Columbia River of 1-ocean age steelhead from control and test releases of smolts from the Wells Hatchery which were imprinted to the Winthrop Hatchery Homing Site on the Methow River. Recoveries were from June to 30 November 1979. Control fish were all released at the Winthrop Hatchery. The broken line indicates the level of return for control fish.

sampling sites were quite consistent within groups of fish transported by barge or truck below Bonneville Dam, indicating their homing was not impaired as far upstream as McNary Dam.

Tests to control ratios declined significantly by the time steelhead passed over Priest Rapids Dam, 104 miles upriver from McNary Dam. This indicates that homing was impaired, resulting in either delay in migration or actual straying as indicated by the 35 recoveries of test fish at Lower Granite Dam (Appendix Table 2). Only one test group (trucked to Ringold) showed a positive test to control ratio (2.24:1) at Priest Rapids Dam. However, this ratio was still far lower than ratios measured at the three lower river sampling locations indicating homing of these fish was also impaired. Final determination of the effect of treatments on homing will not be available until after the spring of 1980 when sport fishing returns from the Methow River and returns to Winthrop NFH are complete. Details on numbers of adults recovered at each homing site are contained in Appendix Table 2.

Chelan-Leavenworth Experiment

The object of this experiment was to determine the length of time required to imprint steelhead from the Chelan Hatchery with a homing cue to the Leavenworth NFH homing site (a hatchery other than the hatchery of origin) and to determine if holding fish at Leavenworth NFH in combination with a sequential homing imprint (induced by barging) will cause adult steelhead to return to the Leavenworth NFH homing site. Our experimental design used three paired test to control groups, of approximately 24,000 fish per group, held 10 d, 2 d, and 4 h (Slatick et al. 1979).

Relative survival between treatment groups is illustrated by the test to control ratios at each of the sampling locations (Figure 5). At the two lower-river sampling locations (Bonneville Dam and the Indian fishery) survival of test groups (transported) was greater than the control group (non-transported). Test to control ratios at Bonneville Dam ranged from 1.89:1 for the 4-h imprinted group to 8.33:1 for the 2-day imprinted group.

Although survival of test groups was much greater than control groups (as measured at Bonneville and Indian fishery sampling sites), the returns to date at up-river sites (McNary and Priest Rapids Dams) indicate a loss of homing for test groups. Final determination, though, will not be possible until returns from the sport fishery in the Wenatchee River and the hatchery are complete. Details on numbers of adults recovered at each sampling site are contained in Appendix Table 3.

Coho Salmon

The returns of adult coho salmon to their homing sites at Pasco, Willard NFH, and Stavebolt Creek are complete for the 1978 experiments. Catch data from the ocean and river commercial and sport fisheries for these experimental groups are still preliminary and figures for coho salmon used in the following tables under commercial and sport fishery captions are raw data. However, these data presently provide insight into the contribution of each group to the fishery and a measure of relative survival between groups. Final survival estimates will be reported later when all the data and catch expansion figures are received from the sampling agencies.

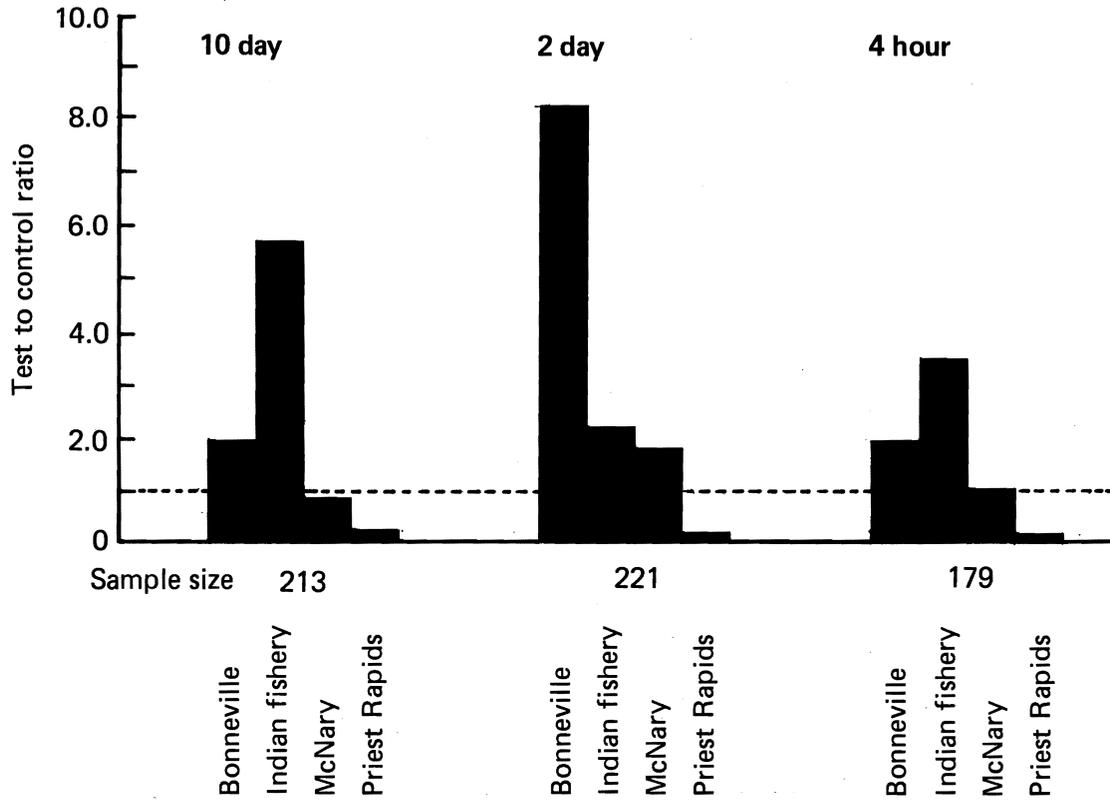


Figure 5.--Test to control ratios for preliminary returns to four sampling locations from control and test releases of smolts from the Chelan Hatchery which were imprinted to the Leavenworth Hatchery Homing Site for 10-d, 2-d, and 4-hr time periods. Recoveries were from June to 30 November 1979. Control fish were all released into the Icicle River. The broken line indicates the level of return for control fish.

Carson - Pasco Experiment

The objectives of this experiment were to determine if coho salmon from Carson NFH could be imprinted to Pasco, Washington with a single or sequential homing cue, (Pasco, Washington is a mid-river homing site 173 miles farther up the Columbia River than the hatchery of origin) and to determine relative survival (from returns in the fishery) of the various release groups.

Our experimental design used three groups of coho salmon: a control group of 43,961 fish released at Pasco and two test groups of approximately 29,000 fish transported by truck and barge to below Bonneville Dam. The fish were released 1-4 May 1978 when they had a $\text{Na}^+ - \text{K}^+$ ATPase value of 11.1 ± 1.3 (Novotny, 1979).

A total of 16 coho salmon from the experiment returned to the Pasco homing site, 6 jacks and 10 mature adults. All 16 fish were identified by wire tags as controls, for a return of 0.036% to the homing site (Table 10). Four control fish from this experiment were identified and marked with a jaw tag at the McNary Dam adult trapping facility. Of these, three were later recovered at the Pasco Homing Site. No test fish returned to the homing site at Pasco, however, three coho salmon were recovered at river sampling sites; one each from the barged and trucked groups at Bonneville Dam and one from the barged group at McNary Dam. From these data, it is apparent that the coho salmon used in the truck (single imprint) or barge (sequential imprint) experiments did not experience an adequate homing imprint to the Pasco water supply.

Table 10.--A comparison between recoveries of control and test groups of adult coho salmon from marked groups of juveniles reared at the Carson Hatchery and imprinted to the Pasco Homing Site. Recoveries were from September 1978 to February 1980.

Release site	Number released	Commercial & sport fishery				T/C ratio	Adult traps Bonneville & McNary Dams no.	Stray to hatcheries no.	Pasco homing site no.	Total combined return		T/C ratio
		Ocean no.	River no.	Combined no.	%					no.	%	
Pasco (Control)	43,961	76	13	89	0.202		4	1	16	110	0.250	
Bonneville (Test)												
Trucked	28,927	23	5	28	0.097	0.48:1	1	3	0	32	0.110	0.44:1
Barged	29,706	17	3	20	0.067	0.33:1	2	1	0	23	0.080	0.32:1
TOTAL	102,594	116	21	137			7	5	16	165		

25

To date, five coho salmon have been recovered as strays at hatcheries in the Bonneville Pool area. A control fish was recovered at the Little White Salmon NFH and four test fish were recovered at the Cascade Hatchery [Oregon Department of Fish and Wildlife (ODFW)].

As of February, 1980, a total of 116 tags have been recovered from the ocean commercial and sport fishery and 21 tags from the Columbia River gill net fishery, Zone 1-6. The control group contributed twice as many fish to the fishery as the best test group did. This lack of fishery contribution of test fish probably resulted from poor survival of test fish after release below Bonneville Dam. Sampling of juveniles in the estuary at Jones Beach (mile 47) also indicated that survival of control fish was twice that of test fish. Cause of the apparent mortality is unknown. Test fish appeared in good shape at time of release.

Willard - Stavebolt Creek Experiment

The objectives of these experiments were as follows:

1. Determine if the length of time fish were held at a homing site was critical to imprinting; if so, what time period (hours or days) was needed.

2. Determine if the $\text{Na}^+ - \text{K}^+$ ATPase enzyme activity of juvenile coho salmon at time of release affects subsequent homing as returning adults.

3. Determine if a single or natural homing imprint would return coho salmon adults to a homing site other than their hatchery of origin.

4. Determine relative survival (contribution to the fishery) of the various test and control releases of marked fish.

The experimental design to measure the above called for release of six test groups and one control group of approximately 20,000 marked coho salmon each. The control group was released at Willard NFH. Test fish were transported to Stavebolt Creek and held in live pens for imprint time periods ranging from 4 h to 48 h and then released in two locations: (1) natural imprint--a direct release from the holding pen into Stavebolt Creek; and (2) single imprint--reloaded into a tanker, transported, and released into the Columbia River at Hammond, Oregon. These treatments were replicated three times, each at a different level of $\text{Na}^+ - \text{K}^+$ ATPase enzyme activity.

The first two replicates were carried out smoothly. The third replicate had to be abandoned because of high water temperatures in Stavebolt Creek. An alternate special test was substituted. Control fish were released at Willard NFH. Three of the test groups, already in Stavebolt Creek, were released into the creek for a natural imprint. Two of the remaining three test groups at Willard NFH were imprinted to raceway water for 4 h, then trucked to separate release sites; one below Bonneville Dam and one at Hammond, Oregon (single imprint). The third test group was hauled directly from the hatchery to the release site below Bonneville Dam (no imprint). Additional detail on the experimental design may be found in Slatick et al. (1979).

Homing.--Test fish released at a homing site should return as adults to that site at a comparable rate to control fish returning to the hatchery, in order for homing tests to be a success. Adult returns from single imprint tests indicate that the methods used in 1978 were unsuccessful in returning coho salmon back to either Stavebolt Creek or to

the Little White Salmon homing sites. On the average, one test fish returned to the homing site for every 26 control fish that returned to the hatchery. Four adults returned to Stavebolt Creek out of 160,000 juveniles imprinted for 4 h to 48 h in Stavebolt Creek and then transported and released at Hammond, Oregon. By contrast, 26 fish returned to the hatchery out of 40,000 juveniles released there (Table 11). Only one adult returned to the Little White Salmon River out of 59,000 juveniles released below Bonneville Dam or at Hammond, Oregon. This compares to nine adults returning to the hatchery out of about 20,000 juveniles released there (Appendix Table 4).

Adult returns from natural imprint tests indicate that homing sites other than hatchery of origin can be developed for coho salmon by a 4-h to 48-h homing imprint prior to release. Adults from four out of five groups released in the 1st and 3rd $\text{Na}^+\text{-K}^+$ ATPase releases returned to the homing site at about the same rate as control releases back to the hatchery (Table 11). Adults from the 2nd $\text{Na}^+\text{-K}^+$ ATPase release, though, returned at less than half the rate of those returning back to the hatchery. Since survival among test releases was comparable based on returns in the fishery (discussed later), it appears that imprinting of those fish in the 2nd release was not as complete. Additional detail on returns from specific releases may be found in Appendix Table 4.

Results from sampling the Youngs Bay fishery indicated that although the single imprint method used in these experiments was not successful in returning fish to the homing site, it did implant a limited homing cue which caused coho salmon to return to the geographic area adjacent to the homing site, i.e., Youngs Bay. The limited imprint of the Hammond release apparently made them more susceptible to the fishery than those imprinted and released in Stavebolt Creek. Nearly five times more Hammond releases

Table 11.--A comparison between test groups of adult coho salmon returning to Stavebolt Creek after having received single or natural homing imprint as juveniles.

Homing imprint	No. groups	No. released	Adults recovered	
			No.	%
<u>Na⁺-K⁺ ATPase, 1st Release</u>				
Control	1	19,908	8 ^{a/}	0.040
<u>Single</u>				
4 & 12 h	2	39,364	0	0.0
24 & 48 h	2	40,280	3	0.007
<u>Natural</u>				
4 & 48 h	2	40,245	15	0.037
<u>Na⁺-K⁺ ATPase, 2nd Release</u>				
Control	1	19,943	18 ^{a/}	0.090
<u>Single</u>				
4 & 12 h	2	39,854	0	0.0
24 & 48 h	2	39,832	1	0.003
<u>Natural</u>				
4 & 48 h	2	41,555	15	0.036
<u>Na⁺-K⁺ ATPase, 3rd Release</u>				
Control	1	19,781	9 ^{a/}	0.045
<u>Natural</u>				
5 - 6 h	2	37,857	16	0.042
	1	17,165	1	0.006

^{a/} Control fish were recovered at Little White Salmon NFM.

than Stavebolt releases were captured in the fishery (Appendix Table 4). Similar data were obtained in an experiment by Vreland and Wahle (1980).

One obvious application of using a technique that gives a limited homing cue is to provide a site specific fishery. As an example, fish surplus to an up-river hatchery's need could be transported down to Youngs Bay, given a limited homing imprint, and released. This should provide more adults by reducing dam related mortalities to smolts while providing an area where fish could be efficiently harvested without impacting other runs of fish.

Na⁺-K⁺ ATPase.--An attempt was made to make releases of coho salmon coinciding with rising, high, and declining Na⁺-K⁺ ATPase enzyme activity to determine its potential effect on homing. Data from adult returns of those fish released as controls at the hatchery show that the 2nd release had the best return rate (highest survival) both back to the hatchery and in the fishery (Figure 6). Whether this was a function of time of release (9 May, 25 May, or 7 June) or enzyme activity is not known. Conversely, rate of return of test fish to homing sites and in the fishery for all three release periods was about the same, indicating time of release or enzyme activity did not have any effect on homing of the various treatment groups released in 1978.

Straying.--The relationships of the homing-imprint treatments to straying of adult coho salmon were examined by monitoring returns to hatcheries in the Columbia River system and by spawning ground surveys in the Youngs Bay drainage system (Figure 7). A total of eight strays were recovered, four from the 1st release and four from the 3rd release series (Appendix Table 4). There were no strays recovered from the three control groups released from the Willard NFH (Little White Salmon River).

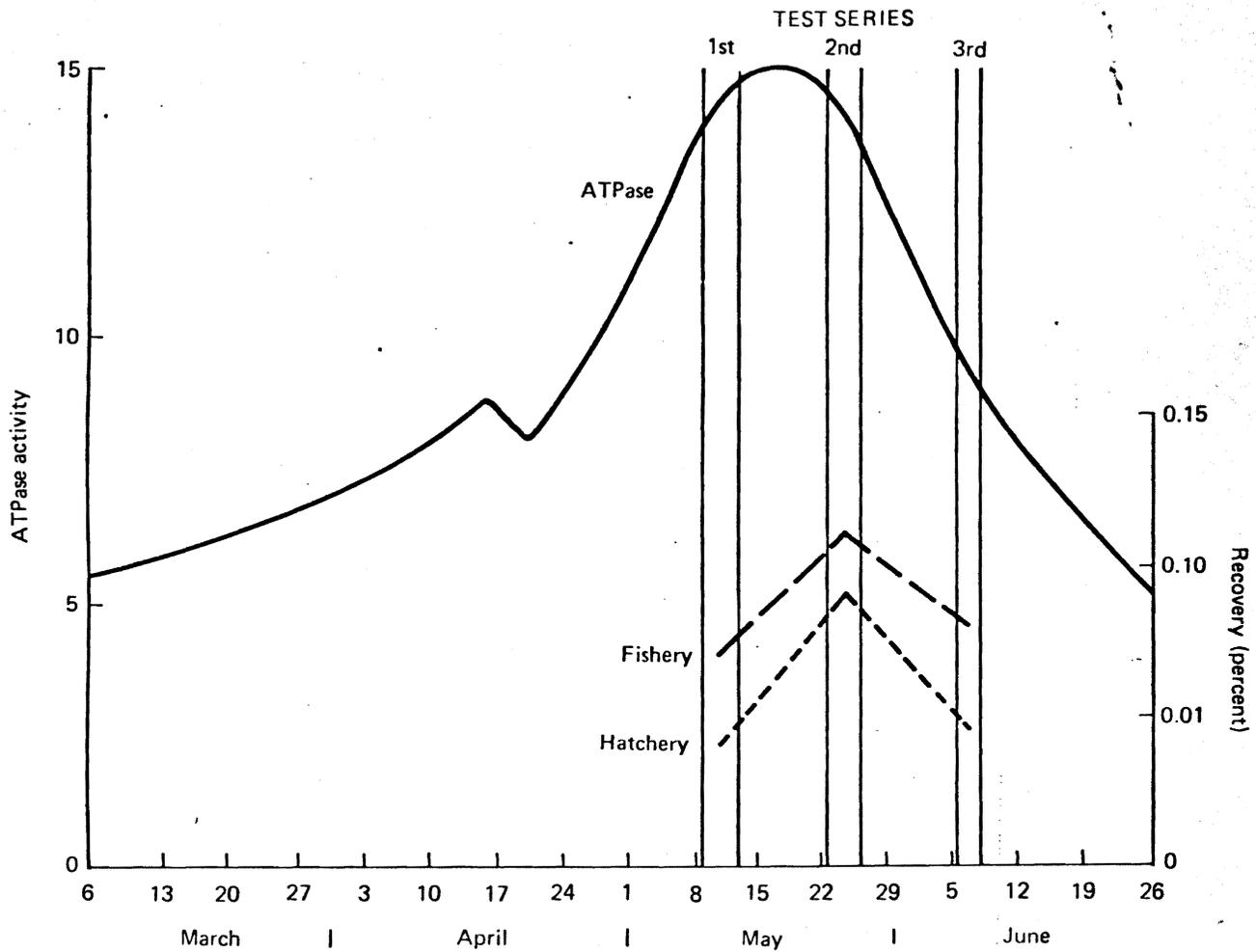


Figure 6.-- $\text{Na}^+\text{-K}^+$ ATPase activity profile for coho salmon reared at Willard Hatchery indicating time frame for releasing imprinted fish for 1st, 2nd, and 3rd replicates in 1978. This figure also illustrates the correlation between recoveries of adult coho salmon at the Little White Salmon Hatchery and in the Ocean and Columbia River fisheries in relation to the $\text{Na}^+\text{-K}^+$ ATPase activity profile of the juvenile fish released as controls from the Willard Hatchery. Recoveries are from September 1978 to March 1980.

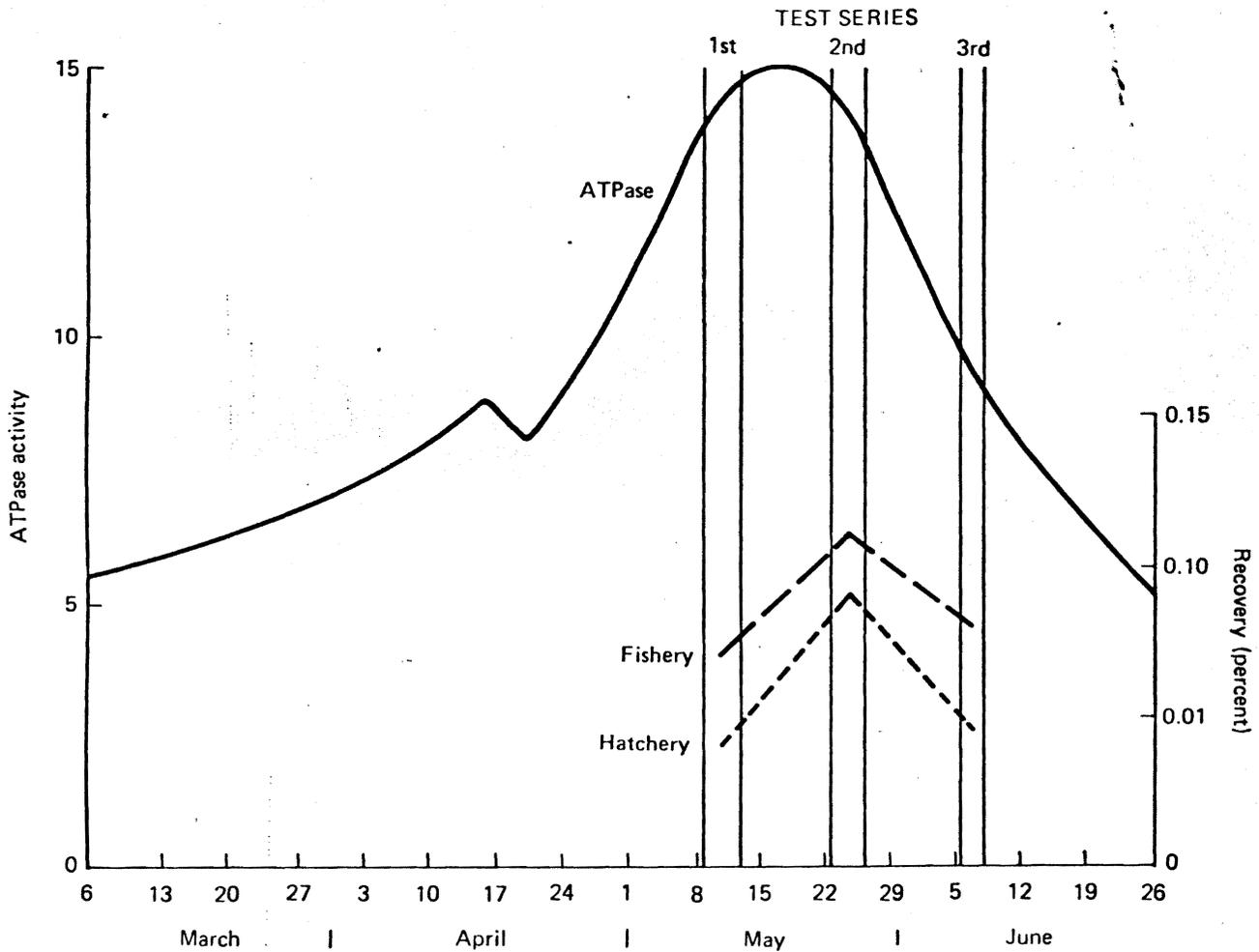


Figure 6.-- $\text{Na}^+\text{-K}^+$ ATPase activity profile for coho salmon reared at Willard Hatchery indicating time frame for releasing imprinted fish for 1st, 2nd, and 3rd replicates in 1978. This figure also illustrates the correlation between recoveries of adult coho salmon at the Little White Salmon Hatchery and in the Ocean and Columbia River fisheries in relation to the $\text{Na}^+\text{-K}^+$ ATPase activity profile of the juvenile fish released as controls from the Willard Hatchery. Recoveries are from September 1978 to March 1980.

YOUNGS BAY DRAINAGE
Clatsop County, Oregon

- Stavebolt Creek trap site
- Stray Coho capture site
- ▬ Stream surveys
- Fish passage barriers

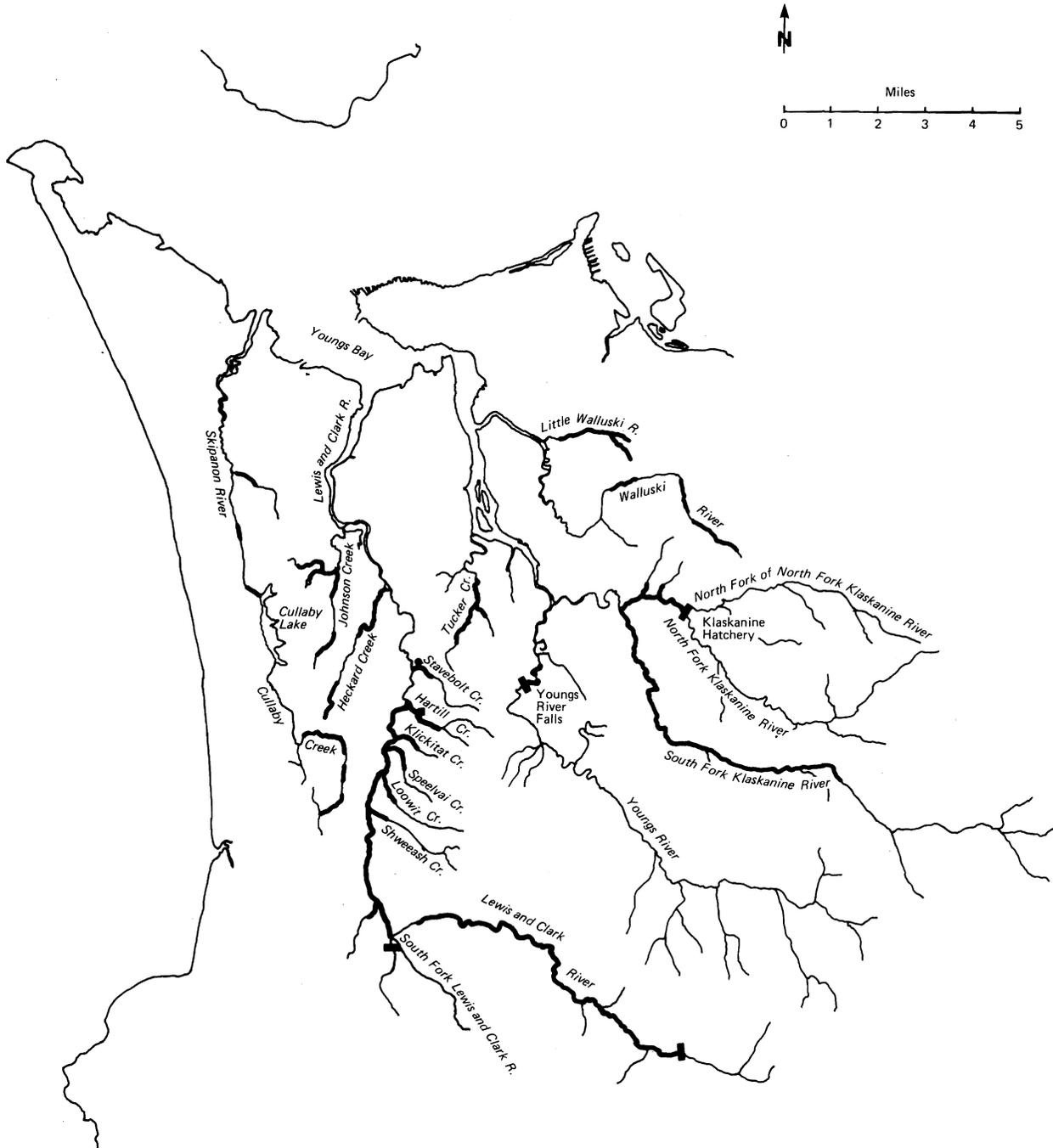


Figure 7.--Map of Youngs Bay drainage system and stream area covered in spawning ground surveys. March to December 1979.

In the 1st release series, all strays were from the single imprint groups released at Hammond, Oregon. One fish from the 4-h imprint group (Test 1) was recovered at the Big Creek Hatchery (ODFW). Three strays were from the 12-h imprint group (Test 2); one was recovered at the Big Creek Hatchery, and two were recovered at the Little White Salmon NFH.

In the 3rd release series, two of the four strays were from those hauled directly from the hatchery to Bonneville Dam (no imprint--Test A-1) one was from the 4-h imprint, hauled to Bonneville (Test A-2), and one was from the release into Stavebolt Creek (Test 15). The strays from Bonneville Dam were recovered at Cascade Hatchery just upstream from the dam. The stray from Stavebolt Creek was recovered in Hartill Creek which is located 1.0 mile upstream from Stavebolt Creek (Figure 7).

Survival.--Survival between treatment groups is indicated by the proportion of fish caught in the various fisheries in relation to the number of smolts released in each test group. To date, we have received 440 coded wire tags - 360 from the ocean fishery and 80 from the Columbia River fishery (Appendix Table 4). Ocean recoveries are from the Washington, Oregon, and California commercial and sport fisheries. Columbia River recoveries are from the gill net fisheries Zones 1 through 6 and the Youngs Bay fishery. Actual survival measurements will not be available until all tag returns are complete and the sampling intensity of the fishery is known. These will be reported as soon as this information is available. Relative differences in survival between treatment groups though can be compared and are reported here.

As indicated previously, the second release of control fish had the highest survival both in the fishery and back to the hatchery. Increased

survival averaged 47% in the fishery and 113% to the hatchery (Figure 6). Whether the higher survival is related to enzyme activity or time of release (differences in river survival) is unknown.

No difference in survival of test fish was noted between the 1st and 2nd release series. However, a comparison between test and control groups (test/control ratio) showed a higher survival of test fish in the 1st release (1.64:1) and 3rd release (1.27:1), but no survival enhancement of the 2nd release (0:99:1), (Table 12).

Recoveries from the alternate tests during the 3rd release series showed that releasing coho salmon below Bonneville Dam instead of at the Willard NFH (a distance of 21.6 miles) appeared to improve their survival by 63 to 69% (Table 12). It should be cautioned though that these fish failed to home back to their hatchery of origin.

MEASUREMENTS OF SMOLT CONDITION

A significant portion of our analysis for this phase of the research is pending receipt of data from cooperating laboratories and/or agencies. When the analysis is complete, we will provide the data as a supplement to this report.

SUMMARY

During the 2nd year of research on imprinting salmon and steelhead for homing, a total of 1,017,023 salmonids were marked and released. Of these, 273,363 were spring chinook salmon, 473,027 fall chinook salmon, and 270,633 were steelhead. The primary objectives of the research are: 1) determine whether a single imprint of sequential imprinting is necessary to assure homing for various stocks of salmonids; 2) determine a triggering mechanism to activate the homing imprint in salmonids; and 3) determine the relationship between the physiological condition of the fish and imprinting.

Table 12.--A comparison between control and test groups of coho salmon taken in the ocean and river fishery. Recoveries are from September, 1978 to December, 1979.

Experimental groups	No. released	Adults recovered		
		No.	%	T/C
<u>Na⁺-K⁺ ATPase, 1st Release</u>				
Control (Little White Salmon River release)	19,908	14	0.070	
Single imprint (Hammond release)	79,644	86	0.108	1.54:1
Natural imprint (Stavebolt release)	40,245	52	0.129	1.84:1
COMBINED TESTS	119,889	138	0.115	1.64:1
<u>Na⁺-K⁺ ATPase, 2nd Release</u>				
Control (Little White Salmon River release)	19,903	22	0.110	
Single imprint (Hammond release)	79,686	81	0.102	0.93:1
Natural imprint (Stavebolt release)	41,555	52	0.125	1.13:1
COMBINED TESTS	121,241	133	0.110	1:1
<u>Na⁺-K⁺ ATPase, 3rd Release</u>				
Control (Little White Salmon River release)	19,781	16	0.081	
Natural imprint (Stavebolt release)	55,022	46	0.084	1.04:1
No imprint (Bonneville release)	19,771	27	0.137	1.69:1
Single imprint (Bonneville release)	19,730	26	0.132	1.63:1
(Hammond release)	19,622	18	0.092	1.14:1
COMBINED TESTS	114,115	117	0.103	1.27:1

In 1979, experimental groups of juvenile steelhead were given a homing imprint to the Tucannon Hatchery on the Tucannon River, Leavenworth NFH on the Icicle River, and Winthrop NFH on the Methow River. Spring chinook salmon were imprinted to the Pasco homing site and Carson NFH on the Wind River. Fall chinook salmon were imprinted to the Big White Salmon River and Stavebolt Creek, a tributary to the Lewis and Clark River.

Preliminary returns of 1-ocean age steelhead from the 1978 homing experiments were assessed at five in-river sampling locations on the Columbia and Snake Rivers, from June through November, 1979. A total of 610 steelhead were examined from the Wells-Winthrop experiment and 613 steelhead from the Chelan-Leavenworth experiment. Test to control ratios indicated higher survival for these test groups (transported) than the control groups (non-transported) at the two lower-river sampling locations (Bonneville Dam and the Indian gill net fishery). Lower test to control ratios at recovery sites from Priest Rapids Dam upstream indicate that a large number of test fish remained in the Columbia River below Priest Rapids Dam, indicating a loss of homing for test groups. However, final assessment of whether homing was actually impaired will not be possible until returns from the sport fishery, homing sites, and hatcheries are complete (July, 1980).

Return of coho salmon to their homing sites are completed for the 1978 experiments. Recovery data from the ocean and river fisheries are still preliminary. However, these data presently provide insight into the contribution of each group to the fishery and a measure of relative survival between groups. Total survival estimates will be reported at a later date when all the data and catch expansion figures are received from the sampling agencies.

Adult coho salmon returns to the Pasco homing site consisted only of fish from the control release. The control group also contributed twice as many fish to the ocean and river fisheries as the best test group did.

Coho salmon imprinted and released in Stavebolt Creek returned to that homing site at about the same rate as control releases back to the hatchery. Coho salmon imprinted in the creek for varying periods of time and transported to Hammond, Oregon failed to return to the Stavebolt Creek homing site. Recoveries from the Youngs Bay fishery indicated that even though these fish did not return to the Stavebolt Creek homing site, they did receive a limited homing imprint which enabled the adults to return to Youngs Bay.

Spawning ground surveys in the Youngs Bay drainage system and lack of recovery of test fish at hatcheries indicated very little straying of fish from test groups imprinted to Stavebolt Creek.

To date, we have received a total of 440 CWT from treatment groups involved in the Stavebolt Creek experiment. These were obtained from the ocean and Columbia River fishery sampling. Test to control ratios of fish recovered in the fishery showed a relatively higher rate of survival of the test fish than the control fish from the 1st and 3rd release series. Recoveries in the fishery showed that releasing coho salmon below Bonneville Dam instead of at the Willard NFH (a distance of 21.6 miles) improved their survival by 63-69%. The highest survival rate of coho salmon from control groups released at Willard Hatchery in both the fishery and returns to the hatchery was from the 2nd release series. Of the three test release sites used, the survival of fish released at the Hammond site was lower than from fish released either below Bonneville Dam or at Stavebolt Creek.

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APPENDIX TABLES

(TABLES 1-4)

Appendix Table 1.--List of color codes uses on coded wire tags with standardized abbreviations adopted by the Pacific Marine Fisheries Commission.

<u>Color</u>	<u>Code</u>
Black	BK
Blue	BL
Brown	BR
Chrome Yellow	CY
Dark Green	DG
Dark Red	DR
Gold	GD
Gray	GY
Green	GR
Lavender	LA
Light Blue	LB
Light Green	LG
Medium Orange	MO
Medium Green	MG
Metallic Gray	GM
Mixed	MX
Orange	OR
Oxide Brown	XB
Oxide Red	XR
Oxide Yellow	XY
Pink	PK
Purple	PU
Red	RD
Tan	TN
Violet	VI
White	WH
Yellow	YW

Appendix Table 2.--Preliminary returns to five sampling locations of 1-ocean age steelhead from control and test releases of smolts from the Wells Hatchery which were imprinted to the Winthrop Hatchery Homing Site and the Methow River. Recoveries were from June to November 1979.

Sampling location and experiment	Homing site	Release location	Control or test	Number juveniles released	Number adults recovered	Adult return % of juveniles	Test to control ratio
<u>Bonneville Dam</u>							
Winthrop NFH	Winthrop	Winthrop	Control	20,330	4	0.020	
L. Methow R.	Methow R.	Methow R.	Control	19,901	7	0.035	1.75:1
Barge	Winthrop	Bonneville	Test	19,979	13	0.065	3.25:1
Truck	Winthrop	Bonneville	Test	19,131	26	0.136	6.80:1
Truck	Winthrop	Ringold	Test	17,637	23	0.130	6.50:1
<u>Indian Fishery</u>							
Winthrop NFH	Winthrop	Winthrop	Control		5	0.025	
L. Methow R.	Methow R.	Methow R.	Control		11	0.055	2.20:1
Barge	Winthrop	Bonneville	Test		17	0.085	3.40:1
Truck	Winthrop	Bonneville	Test		29	0.152	6.08:1
Truck	Winthrop	Ringold	Test		14	0.079	3.16:1
<u>McNary Dam</u>							
Winthrop NFH	Winthrop	Winthrop	Control		18	0.089	
L. Methow R.	Methow R.	Methow R.	Control		28	0.141	1.58:1
Barge	Winthrop	Bonneville	Test		53	0.265	2.98:1

Appendix Table 2.--continued--Preliminary returns to five sampling locations of 1-ocean age steelhead from control and test releases of smolts from the Wells Hatchery which were imprinted to the Winthrop Hatchery Homing Site and the Methow River. Recoveries were from June to November 1979.

Sampling location and experiment	Homing site	Release location	Control or test	Number juveniles released	Number ^{a/} adults recovered	Adult return % of juveniles	Test to control ratio
<u>McNary Dam - continued</u>							
Truck	Winthrop	Bonneville	Test		86	0.450	5.06:1
Truck	Winthrop	Ringold	Test		63	0.357	4.01:1
<u>Priest Rapids Dam</u>							
Winthrop NFH	Winthrop	Winthrop	Control		31	0.152	
L. Methow R.	Methow R.	Methow R.	Control		42	0.211	1.39:1
Barge	Winthrop	Bonneville	Test		15	0.075	0.49:1
Truck	Winthrop	Bonneville	Test		30	0.157	1.03:1
Truck	Winthrop	Ringold	Test		60	0.340	2.24:1
<u>Lower Granite Dam</u>							
Barge	Winthrop	Bonneville	Test		1	0.005	
Truck	Winthrop	Bonneville	Test		29	0.152	
Truck	Winthrop	Ringold	Test		5	0.028	
<u>TOTAL</u>					96,978	610	

^{a/} Because of differences in sampling intensity (efficiency) at each trapping site, results are not comparable between sites.

Appendix Table 3.--Preliminary returns to five sampling locations of 1-ocean age steelhead from paired control and test releases of smolts from the Chelan Hatchery which were imprinted to the Leavenworth Hatchery homing site. The test juveniles were transported from the Leavenworth Hatchery by truck to a barge at Richland, WA and then barged downstream to below Bonneville Dam. Recoveries were from June to November 1979.

Experiment and sampling location	Control or test	Number juveniles released	Number ^{a/} adults recovered	Observed adult return in % of juveniles released	Test to control ratio
<u>10-DAY IMPRINTING</u>					
Bonneville Dam	Control	24,119	15	0.062	1.90:1
	Test	22,841	27	0.118	
Indian Fishery	Control		9	0.037	5.68:1
	Test		48	0.210	
McNary Dam	Control		34	0.141	0.81:1
	Test		26	0.114	
Priest Rapids Dam	Control		45	0.187	0.21:1
	Test		9	0.039	
TOTAL		46,960	213		
<u>2-DAY IMPRINTING</u>					
Bonneville Dam	Control	23,787	5	0.021	8.33:1
	Test	21,694	38	0.175	
Indian Fishery	Control		17	0.071	2.08:1
	Test		32	0.148	
McNary Dam	Control		31	0.130	1.74:1
	Test		49	0.226	
Priest Rapids Dam	Control		43	0.181	0.23:1
	Test		5	0.023	
Lower Granite Dam	Control		0		—
	Test		1	0.005	
TOTAL		45,481	221		
<u>4-HOUR IMPRINTING</u>					
Bonneville Dam	Control	21,957	6	0.027	1.89:1
	Test	23,551	12	0.051	
Indian Fishery	Control		12	0.055	3.47:1
	Test		45	0.191	
McNary Dam	Control		26	0.118	1.04:1
	Test		29	0.123	
Priest Rapids Dam	Control		42	0.191	0.16:1
	Test		7	0.030	
TOTAL		45,508	179		
GRAND TOTAL		137,949	613		

a/ Because of differences in sampling intensity (efficiency) at each trapping site, results are not comparable between sites.

Appendix Table 4.--A comparison between control and test groups of coho salmon recovered at Stavebolt Creek, Little White Salmon Hatchery, commercial and sport fisheries, and as strays. These returns are based on 21 groups of juvenile coho salmon from the Willard Hatchery which were imprinted to a specific homing site and released at four different release sites in 1978. Recoveries are from September 1978 to 11 March 1980.

Homing site	ATPase release series	Test or control no.	Release site	Hours held	Number ^{a/} smolts released	Number adults recovered at homing sites		Number of adults recovered in fisheries				
						Stavebolt Creek	L. White Salmon Hatchery	Number adults straying	Youngs Bay	River Fisheries Zone 1-6	Ocean	Total all fisheries
L. W. Salmon R	1st	Control 1	L. W. Salmon	0	19,908	0	8	0	1 ^{b/}	0	13	14
Stavebolt Cr	1st	Test 1	Hammond	4	19,710	0		1	3	5	22	30
"	1st	Test 2	Hammond	12	19,654	0		3	4	0	16	20
"	1st	Test 3	Hammond	24	19,956	2		0	2	3	11	16
"	1st	Test 4	Hammond	48	20,324	1		0	2	0	18	20
"	1st	Test 5	Stavebolt	4	20,274	7		0	1	4	13	18
"	1st	Test 6	Stavebolt	48	19,971	8		0	1	3	30	34
L. W. Salmon R	2nd	Control 2	L. W. Salmon	0	19,942	0	18	0	0	3	19	22
Stavebolt Cr	2nd	Test 7	Hammond	4	19,946	0		0	4	2	20	26
"	2nd	Test 8	Hammond	12	19,908	0		0	5	0	9	14
"	2nd	Test 9	Hammond	24	19,890	0		0	4	1	16	21
"	2nd	Test 10	Hammond	48	19,942	1		0	2	3	15	20
"	2nd	Test 11	Stavebolt	4	19,244	5		0	1	3	20	24
"	2nd	Test 12	Stavebolt	48	22,311	10		0	0	6	22	28
L. W. Salmon R	3rd	Control 3	L. W. Salmon	0	19,781	0	9	0	0	2	14	16
Stavebolt Cr	3rd	Test 13	Stavebolt	5-6	18,571	8		0	2	0	12	14
"	3rd	Test 14	Stavebolt	5-6	17,165	1		0	0	0	6	6
"	3rd	Test 15	Stavebolt	5-6	19,286	8		1	3	1	22	26
L. W. Salmon R	3rd	Test A-1	Bonneville	0	19,771			2	0	2	25	27
"	3rd	Test A-2	Bonneville	4	19,730		1	1	0	2	24	26
"	3rd	Test A-3	Hammond	4	19,622				0	5	13	18
TOTAL					414,907	51	36	8	35	45	360	440

^{a/} Adjusted for tag loss.

^{b/} This fish could properly be listed stray. As a fish released from Little White Salmon Hatchery, it should not be expected in the Youngs Bay fishery.