

CZES

Coastal Zone and Estuarine Studies

**IMPRINTING SALMON
AND STEELHEAD TROUT
FOR HOMING**

by
**Emil Slatick
Anthony J. Novotny
and
Lyle G. Gilbreath**

January 1979

ERRATA

The following errors should be corrected in the report, "Imprinting Salmon and Steelhead Trout for Homing", by Emil Slatick, Anthony J. Novotny, and Lyle G. Gilbreath, dated January 1979:

1. Page 6, Table 2, Test #4, Brand position--now reads, "RAL", and it should read RA L.
2. Page 12, Table 6, Control #2, Brand position--now reads, "LA)", and it should read LA).
3. Page 14, Table 7, Test #1, Treatment--now reads, "(raceways)", and it should read (tank).
4. Page 22, line 5--now reads, "Dam in two loads for marking on 19 and 20 May 1976", and it should be Dam in two loads for marking on 19 and 20 May 1976, and transported and released below Bonneville Dam.

IMPRINTING SALMON AND STEELHEAD TROUT FOR HOMING

By

Emil Slatick

Anthony J. Novotny

and

Lyle G. Gilbreath

Annual Report of Research
Financed by
Bonneville Power Administration

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

January 1979

CONTENTS

	Page
INTRODUCTION	1
MARKING OF SMOLTS	2
KOOSKIA HATCHERY	5
DWORSHAK HATCHERY	5
TUCANNON HATCHERY	8
CHELAN-LEAVENWORTH HATCHERIES	8
WELLS-WINTHROP HATCHERIES	11
CARSON HATCHERY-PASCO	13
WILLARD HATCHERY-STAVEBOLT CREEK	13
ADULT RETURNS	21
COHO SALMON JACKS--STAVEBOLT CREEK	21
STEELHEAD RETURNS TO THE SNAKE RIVER FROM JUVENILES	
RELEASED IN 1976	21
MEASUREMENTS OF SMOLT CONDITION	22
SUMMARY	23

INTRODUCTION

During 1978, the National Marine Fisheries Service (NMFS), under contract with the Bonneville Power Administration (BPA), initiated research on imprinting salmon and steelhead trout for homing.

The primary objectives of the 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 ATPase activity, etc.) and their ability to imprint. The ability to activate the imprint mechanism at the proper time should assure a suitable homing cue that, coupled with transportation, will result in high smolt survival and insure adequate return to the homing site or hatchery.

For the purposes of this study, imprinting is accepted to mean a rapid and irreversible learning experience that provides fish with the ability to return to natal streams or a selected site. In our tests, we used single imprints and sequential imprints. Single imprinting means 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 a single imprint. Sequential imprinting means cueing fish to two or more water sources in a step-by-step process which will established a signpost for learning the route "home."

MARKING OF SMOLTS

Research in the first year of study was aimed at determining if various methods of imprinting could return fish to the following sites: 1) the hatchery of origin, 2) other hatcheries, and 3) a homing site other than a hatchery.

Fish were marked prior to release by adipose fin excision and injection with a magnetic coded wire tag. Fish were also branded so their return as adults could be monitored without having to sacrifice the fish at key sampling sites on the river. Evaluation will be based on a comparison between adult returns from control releases (natural migration) and experimental releases (various imprint treatments). A summary of numbers of fish marked and released is given in Table 1.

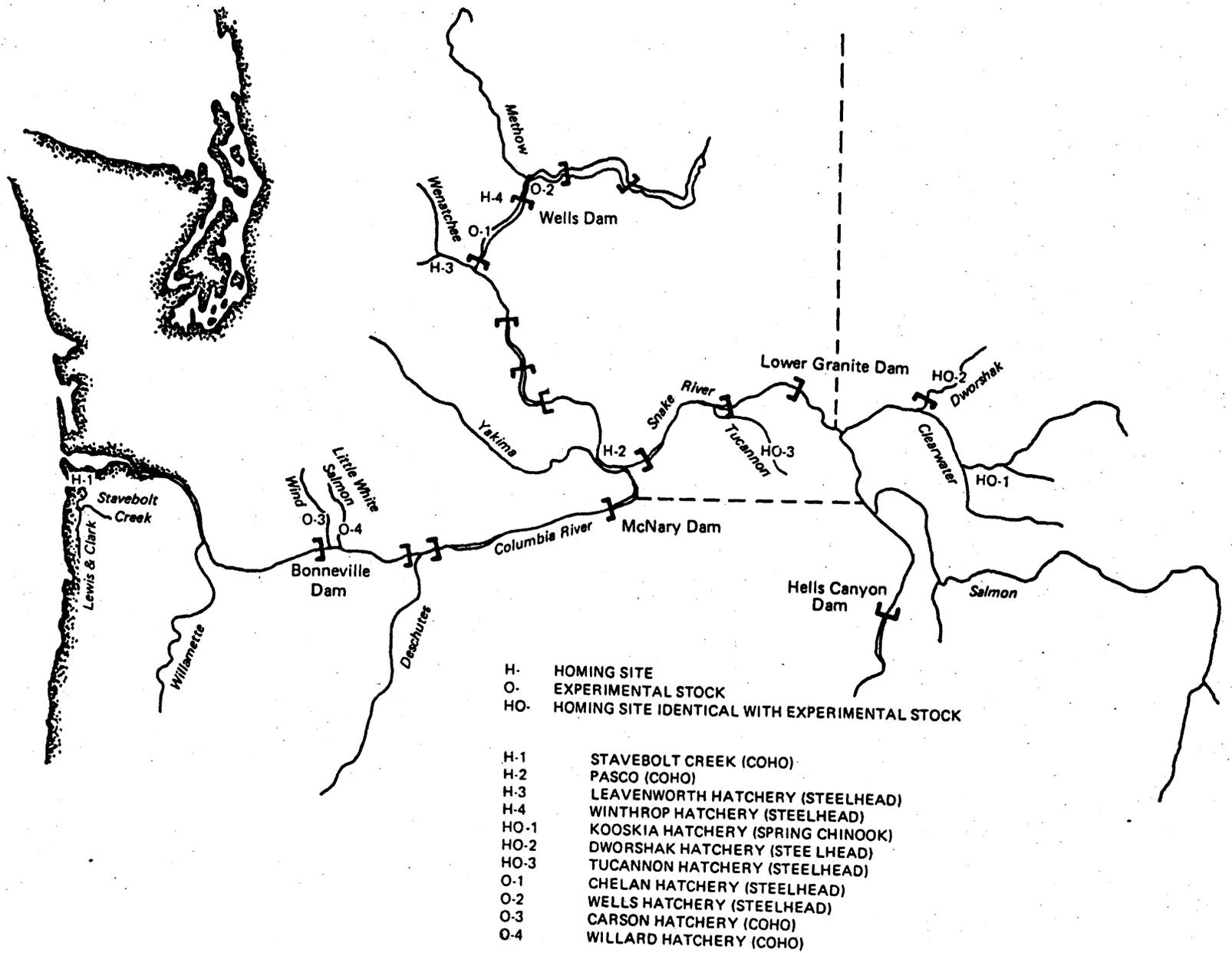
Experiments to imprint fish to return to the hatchery of origin were conducted with spring chinook salmon from Kooskia Hatchery and steelhead trout from Dworshak and Tucannon Hatcheries. Experiments to imprint fish to return to a hatchery other than their hatchery of origin were conducted with steelhead trout from Chelan and Wells Hatcheries. Experiments to imprint fish to a specific homing site other than a hatchery were conducted with coho salmon from Carson and Willard Hatcheries. Locations of hatcheries and release sites are given in Figure 1. Specifics on individual treatments by hatchery are covered in this report.

Table 1.--Homing Imprint Experiment 1978--species, location and numbers of fish marked and released, and years when adults are expected back for evaluation.

Species and (Hatchery of origin - Homing site)	Groups marked		Total (No.)	Adult Evaluation (Yr.)
	Control (No.)	Experimental (No.)		
SNAKE RIVER SYSTEM				
<u>Spring chinook salmon</u>				
(Kooskia)	40,080	146,517	186,597	1980-81
<u>Steelhead trout</u>				
(Dworshak)	30,074	44,667	74,741	1980-81
(Tucannon)	--	36,686	36,686	1980-81
COLUMBIA RIVER SYSTEM				
<u>Steelhead trout</u>				
(Chelan-Leavenworth)	69,863	68,086	137,949	1979-80
(Wells-Winthrop)	40,231	56,747	96,978	1979-80
<u>Coho salmon</u>				
(Carson-Pasco)	43,961	58,633	102,594	1978-79
<u>Coho salmon^{1/}</u>				
(Willard-Stavebolt Creek)	59,632	355,275	414,907	1978-79
<u>Subtotals by species</u>				
Spring chinook salmon			186,597	
Coho salmon			517,501	
Steelhead trout			<u>346,354</u>	
Grand total			1,050,452	

1/ These fish were marked with a coded wire tag and a clipped adipose fin only. The other groups also received a brand.

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



KOOSKIA HATCHERY

The objective was to imprint spring chinook salmon for return to Kooskia Hatchery, located on a tributary of the Clearwater River. The hatchery water supply is obtained from Clear Creek, a tributary of the Middle Fork of the Clearwater. Experimental groups of fish were singly and sequentially imprinted to the hatchery water supply, and then either transported by truck directly to a release site in the Columbia River below Bonneville Dam or trucked to a barge at Lewiston, Idaho and barged down river and released below Bonneville Dam. The barge used a flow-through system utilizing river water enroute. Specifics on various imprint treatments are given in Table 2.

DWORSHAK HATCHERY

The objective was to imprint steelhead trout to return to Dworshak Hatchery on the Clearwater River. Dworshak Hatchery receives its water supply from the North Fork of the Clearwater River. Experimental groups of fish were imprinted to the hatchery water supply and then either trucked directly to the release site below Bonneville Dam or to a barge at Lewiston, Idaho (approximately 40 river miles) and barged down river and released below Bonneville Dam. Specifics on treatments are contained in Table 3.

Table 2.--Spring chinook salmon marked in 1978 at Kooskia Hatchery--test number, mark used, number released, type of imprint, and treatment for various groups are indicated.

Test Control	C.W.T. Code	Brand	Number Released ^{1/}	Homing Imprint	Treatment
Control	10-3-30	LA)	40,080	natural migration	Released with normal production into Clear Creek (tribuary to Middle Fork of Clearwater River).
Test #1	WH-RD-YW	RA T	35,426	single	Normal production rearing. Trucked with Clear Creek water directly to below Bonneville Dam.
Test #2	WH-RD-XY	RA H	37,128	sequential	Normal production rearing. Sequentially imprinted in truck with Middle Fork of Clearwater River water then Snake River water for 2 h (at Little Goose Dam) and then trucked to below Bonneville Dam.
Test #3	WH-RD-LB	RA L	37,031	sequential	Normal production rearing. Trucked with Clear Creek water to barge at Lewiston and then barged downstream to below Bonneville Dam.
Test #4	WH-RD-PK	RA H	<u>36,932</u>	sequential	Normal production rearing. Trucked with Middle Fork of Clearwater River water to barge at Lewiston and then barged downstream to below Bonneville Dam.
	Total		186,597		

^{1/} Number released adjusted for initial tag loss.

Table 3.--Steelhead trout marked in 1978 at Dworshak Hatchery--test number, mark used, number released, type of imprint, and treatment for various groups are indicated.

Test Control	C.W.T. Code	Brand	Number Released ^{1/}	Homing Imprint	Treatment
Control	10-2-31	LA)	30,074	natural migration	Released with normal hatchery production into North Fork Clearwater River.
Test #1	WH-RD-XY	RA Z	20,661	single	Normal production treatment. Held in raw North Fork water 48 h and then trucked in North Fork water directly to below Bonneville Dam.
Test #2	WH-RD-YW	RA N	<u>24,006</u>	sequential	Normal production treatment. Held in raw North Fork water 48 h, trucked in North Fork water to barge at Lewiston, and then barged down river to below Bonneville Dam.
		Total	74,741		

^{1/} Number released adjusted for initial tag loss.

TUCANNON HATCHERY

Steelhead used in the homing experiment on the Tucannon River were obtained from the Tucannon Hatchery. The eggs for these steelhead were obtained from the Skamania Hatchery, and the steelhead are primarily 2- and 3-ocean fish. The water supply for the Tucannon Hatchery is from springs and the Tucannon River. Our experiments utilized the spring water supply as an imprinting cue. The experiment used the hatchery of origin as the homing station, and the experimental groups were treated as shown in Table 4.

CHELAN-LEAVENWORTH HATCHERIES^{1/}

Steelhead for this experiment were reared in raceways and pre-marked at the Chelan Hatchery. The object of the test was to determine the length of time required to imprint steelhead to a homing site other than their hatchery of origin. Three paired (test to control) groups were trucked to Leavenworth Hatchery and held 10 d, 2 d, or 4 h. The test fish were then trucked in hatchery water (Icicle River) to a barge at Richland, Washington and then 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 5.

To answer specific questions about short term delayed mortality in this group of fish, about 100 fish were dipped out of the tankers at Richland from the 10-d, 2-d, and 4-h test groups and held in live pens for 24 h. At the end of the holding period there were no mortalities in any of the pens.

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

Table 4.--Steelhead trout marked in 1978 at Tucannon Hatchery. Test number, mark used, number released, type of imprint, and treatment for various groups are indicated.

Test Control ^{1/}	C.W.T. Code	Brand	Number Released ^{2/}	Homing Imprint	Treatment
Test #1	WH-OR-YW-YW	RA 9	18,137	sequential	Loaded into tanker for 1 h, then released in pond containing pure spring water for 48 h, then trucked with spring water to barge at Lyons Ferry grain terminal, and then barged downriver to below Bonneville Dam.
Test #2	WH-OR-YW-RD	RA 9	<u>18,549</u>	sequential	Loaded into tanker for 1 h, then released into pond containing 20% spring and 80% river water for 48 h, then trucked with Tucannon River water to barge at Lyons Ferry grain terminal, and then barged downriver to below Bonneville Dam.
		Total	36,686		

^{1/} A shortage of test fish precluded specific controls for this group of fish.

^{2/} Adjusted for initial tag loss.

Table 5.--Steelhead trout marked in 1978 at Chelan Hatchery and imprinted to the Leavenworth Hatchery.

Test number, mark used, number released, type of imprint, and treatment for various groups are indicated.

Test Control	C.W.T. Code	Brand	Number Released	Homing Imprint	Treatment
Control #1	WH-OR-YW-OR	LA 4	24,119	natural migration	Held 10 d at Leavenworth Hatchery and then released into Icicle River (Tributary to Wenatchee R.)
Control #2	WH-OR-LG-OR WH-OR-YW-GN	LA 5	23,787	natural migration	Held 2 d at Leavenworth Hatchery and then released into Icicle River (tributary to Wenatchee R.)
Control #3	WH-OR-BL-OR	LA 7	21,957	natural migration	Held 4 h at Leavenworth Hatchery and then released into Icicle River (tributary to Wenatchee R.)
Test #1	WH-RD-PK	RA 2	22,841	sequential	Held 10 d at Leavenworth Hatchery, trucked in raceway water (Icicle R.) to barge at Richland, and then barged downriver to below Bonneville Dam.
Test #2	WH-RD-LB	RA 3	21,694	sequential	Held 2 d at Leavenworth Hatchery, trucked in raceway water (Icicle R.) to barge at Richland, and barged downriver to below Bonneville Dam.
Test #3	WH-OR-YW-LB	RA 7	<u>23,551</u>	sequential	Held 4 h at Leavenworth Hatchery, trucked in raceway water (Icicle R.) to barge at Richland, and barged downriver to below Bonneville Dam.
		Total	137,949		

WELLS-WINTHROP HATCHERIES

Steelhead trout for this experiment were pond reared and marked at the Wells Hatchery. One group was released at the hatchery production site in the Methow River (10 miles upstream from the mouth). We attempted to imprint the four other groups to a homing cue to the Winthrop Hatchery located 50 miles up the Methow River. The Winthrop Hatchery water supply is comprised 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.

The object of this experiment was to imprint the 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 trout to a homing station. In addition, we will attempt to determine if the fish returning to the Winthrop Hatchery homing site will disperse throughout the 50 mile section of Methow River below the hatchery during the fall and winter months. If they will, another 50 miles of prime sportfishing area will be added to this section of Washington. Specifics on treatment groups are given in Table 6.

Table 6.--Steelhead trout marked in 1978 at Wells Hatchery 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. Code	Brand	Number Released ^{1/}	Homing Imprint	Treatment
Control #1	WH-OR-LG-YW	RA ♂	19,901	natural migration	Wells Hatchery control-released at production release site in the Methow River 10 miles upstream from the mouth.
Control #2	WH-OR-OR-XY	LA)(20,330	natural migration	Winthrop Hatchery control-held 48 h at the hatchery, then released into Methow River at the hatchery site.
Test #1	WH-OR-GN-OR	RA ♂	19,131	single	Held 48 h at Winthrop Hatchery and then trucked in raceway water directly to below Bonneville Dam.
Test #2	WH-OR-YW-LG	RA L	19,979	sequential	Held 48 h at Winthrop Hatchery; trucked in raceway water to barge at Richland, WA; and then barged downstream to below Bonneville Dam.
Test #3	WH-OR-OR-RD	RA T	<u>17,637</u>	sequential	Held 48 h at Winthrop Hatchery, trucked in raceway water to Ringold area, and then released into Columbia River to migrate naturally.
		Total	96,978		

12

^{1/} Adjusted for initial tag loss.

CARSON HATCHERY-PASCO

Coho salmon for this experiment were reared in raceways and pre-marked at the Carson Hatchery. The eggs for these fish came from the Little White Salmon Hatchery. The object of this experiment was to imprint fish with a homing cue to Pasco, Wash. 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. Specifics on treatment are contained in Table 7.

WILLARD HATCHERY-STAVEBOLT CREEK

Coho salmon used in these experiments were reared in raceways at the Willard Hatchery. Eggs used were taken from adults spawned at the Little White Salmon Hatchery. Both of these hatcheries are on the Little White Salmon River (this river water is used for both hatchery water supplies). Little White Salmon Hatchery is near the mouth of the river and recovers all returning adults from both hatchery releases.

The objectives of these experiments were as follows:

1. Determine if imprinting of a homing cue is a rapid irreversible process.
2. Determine at what period during smoltification a fish would accept a homing cue.
3. Determine what time period (hours or days) was necessary to imprint a homing cue.
4. Determine if the ATPase enzyme activity would prove to be a biological indicator of smoltification with regards to homing.
5. Determine if a single or sequential homing imprint was necessary to return adults to a homing location.

Table 7.--Coho salmon marked in 1978 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. Code	Brand	Number Released ^{1/}	Homing Imprint	Treatment
Control	WH-OR-LG-OR	LA \propto	43,961	natural	Held in homing site water (caged in creek) for 48 h and then released to migrate naturally.
Test #1	WH-OR-BL-OR	RA Γ	28,927	single	Held in homing site water (tank) for 48 h and then trucked in homing site water directly to below Bonneville Dam.
Test #2	WH-OR-OR-XY	RA L	<u>29,706</u>	sequential	Held in homing site water (tank) for 48 h; then trucked in homing site water to barge at Richland, WA; and then barged downriver to below Bonneville Dam.
	Total		102,594		

^{1/} Adjusted for initial tag loss.

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.

Measurements of the ATPase enzyme activity were taken from 6 March to 26 June 1978. All samples were obtained at the Willard Hatchery. Figure 2 show the ATPase profile and the dates of the three test series during which the coho salmon were imprinted and released. Each test series consisted of one control release at the hatchery and six treatments (Tables 8 to 10).

During the third test series, hot weather in the first week of June raised the water temperature in the Stavebolt Creek pond to 70°F (surface temperature) while water temperature at the Willard Hatchery was only 47°F. Before being released into the net-pens, the three test groups of fish were tempered for 2 h in the truck. However, after being in the pens for about 5 h the fish appeared to be distressed so the test was aborted, and the fish were released into Stavebolt Creek. (The fish very quickly migrated downstream into the Lewis and Clark River, which was only 60°F.) Since three test groups remained at the Willard Hatchery and Stavebolt Creek could not be used, another experimental design was developed for these groups using Willard Hatchery as a homing site (Table 11).

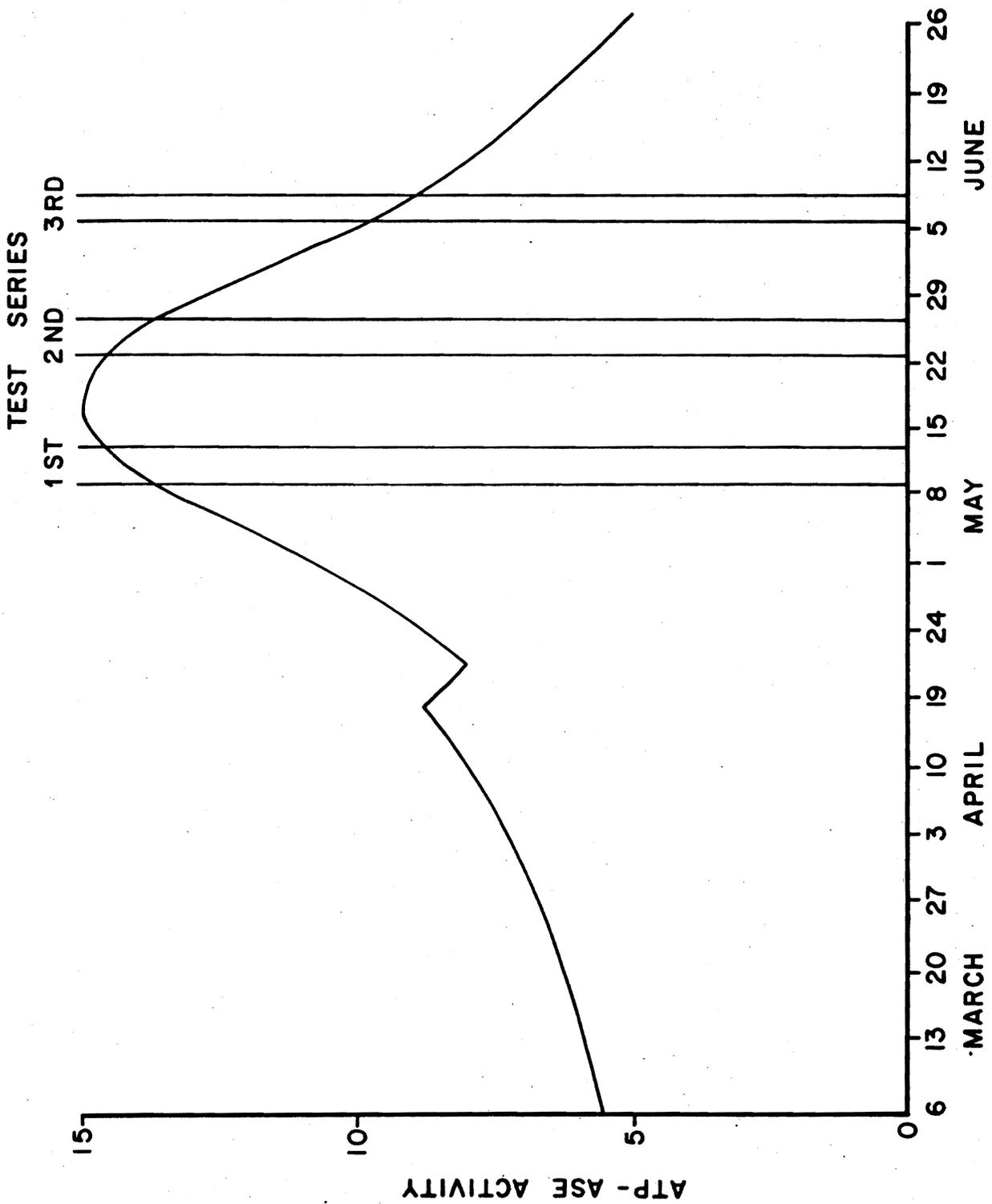


Figure 2.--ATPase activity profile for coho salmon smolts reared at Willard Hatchery indicating time frame for imprinting tests in 1978.

Table 8.--Coho salmon marked in 1978 at Willard Hatchery 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 ^{1/}	Homing Imprint	Treatment
1st ATPase Series				
Control #1	WH-RD-XY	19,908	natural migration	Released from Willard Hatchery into Little White Salmon River.
Test #1	WH-OR-RD-RD	19,710	single	Transported from Willard Hatchery to Stavebolt Creek; held 4 h; and then trucked to Hammond, OR and released into Columbia River.
Test #2	WH-RD-YW	19,654	single	Transported from Willard Hatchery to Stavebolt Creek; held 12 h; and then trucked to Hammond, OR and released into Columbia River.
Test #3	WH-OR-LB-OR	19,956	single	Transported from Willard Hatchery to Stavebolt Creek; held 24 h; and then trucked to Hammond, OR and released into Columbia River.
Test #4	WH-OR-YW-RD	20,324	single	Transported from Willard Hatchery to Stavebolt Creek; held 48 h; and then trucked to Hammond, OR and released into Columbia River.
Test #5	WH-OR-OR-LB	20,274	natural migration	Transported from Willard Hatchery to Stavebolt Creek; held 4 h; and released into Stavebolt Creek.
Test #6	WH-OR-YW-YW	<u>19,971</u>	natural migration	Transported from Willard Hatchery to Stavebolt Creek; held 48 h; and released into Stavebolt Creek.
	Subtotals	139,797		

^{1/} Adjusted for initial tag loss.

Table 9.--Coho salmon marked in 1978 at Willard Hatchery 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 ^{1/}	Homing Imprint	Treatment
2nd ATPase Series				
Control #2	WH-RD-LB	19,943	natural migration	Released from Willard Hatchery into Little White Salmon River
Test #7	WH-OR-LG-YW	19,946	single	Transported from Willard Hatchery to Stavebolt Creek; held 4 h; and then trucked to Hammond, OR and released into Columbia River.
Test #8	WH-OR-YW-LB	19,908	single	Transported from Willard Hatchery to Stavebolt Creek; held 12 h; and then trucked to Hammond, OR and released into Columbia River.
Test #9	WH-OR-OR-RD	19,890	single	Transported from Willard Hatchery to Stavebolt Creek; held 24 h; and then trucked to Hammond, OR and released into Columbia River.
Test #10	WH-OR-WH-OR	19,942	single	Transported from Willard Hatchery to Stavebolt Creek; held 48 h; and then trucked to Hammond, OR and released into Columbia River.
Test #11	WH-OR-GN-OR	19,244	natural	Transported from Willard Hatchery to Stavebolt Creek; held 4 h; and released into Stavebolt Creek.
Test #12	WH-OR-RD-OR	<u>22,311</u>	natural	Transported from Willard Hatchery To Stavebolt Creek; held 48 h; and released into Stavebolt Creek.
	Subtotal	141,184		

^{1/} Adjusted for initial tag loss.

Table 10.--Coho salmon marked in 1978 at Willard Hatchery 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 ^{1/}	Homing Imprint	Treatment ^{2/}
3rd ATPase Series				
Control #3	WH-OR-LB-YW	19,781	natural migration	Released from Willard Hatchery into Little White Salmon River.
Test #13	WH-OR-RD-YW	18,571	natural migration	Transported from Willard Hatchery to Stavebolt Creek, held 5-6 h, and released into Stavebolt Creek.
Test #14	WH-OR-OR-WH	17,165	natural migration	Transported from Willard Hatchery to Stavebolt Creek, held 5-6 h, and released into Stavebolt Creek.
Test #15	WH-OR-YW-LG	<u>19,286</u>	natural migration	Transported from Willard Hatchery to Stavebolt Creek, held 5-6 h, and released into Stavebolt Creek.
	Subtotal	74,803		

^{1/} Adjusted for initial tag loss.

^{2/} Due to high water temperatures (70°F) in Stavebolt Creek pond and fish showing signs of being distressed, planned tests #13, 14, and 15 were aborted, and the fish were released into Stavebolt Creek to migrate naturally.

Table 11.--Coho salmon marked in 1978 at Willard Hatchery. Test number, mark used, number released, type of imprint, and treatment for various groups are indicated.

Test Control	C.W.T. Code	Number Released ^{1/}	Homing Imprint	Treatment
3rd ATPase Series-Alternate Experiment				
Control #3	WH-OR-LB-YW	19,781 ^{2/}	natural migration	Normal production rearing. Fish were released from hatchery into Little White Salmon River.
Test A-1	WH-OR-YW-GN	19,771	single	Normal production rearing. Fish were trucked in hatchery water directly to release site below Bonneville Dam.
Test A-2	WH-OR-YW-OR	19,730	single	Fish were loaded into a truck for 2 h, released into a raceway for 4h, and then trucked in hatchery water directly to release site below Bonneville Dam.
Test A-3	WH-RD-PK	<u>19,622</u>	single	Fish were loaded into a truck for 2 h; released into a raceway for 4 h; and then trucked in hatchery water directly to the Hammond, OR release site.
	Subtotal	78,904		

^{1/} Adjusted for initial tag loss.

^{2/} Tagged group also serves as control for 3rd ATPase series at Stavebolt Creek (Table 10).

ADULT RETURNS

The degree of success for the various treatments of experimental fish will be based on the returns of adults. The first jack (1-ocean) coho salmon returns occurred in the fall of 1978 and significant returns of other adults related to the study are expected annually over a 5 to 6-year period. All of the homing sites are located at permanent facilities (hatcheries) except the ones of Stavebolt Creek, Washington, and Pasco, Washington, where adequate facilities had to be constructed.

COHO SALMON JACKS--STAVEBOLT CREEK

First coho salmon jacks returned to the Stavebolt Creek trap in 1978. Among the returns were six fish from the early ATPase groups. Of these, three were from groups released at Hammond following imprinting with Stavebolt Creek water (24 to 48 h). While the data are certainly preliminary, these few returns do indicate that coho salmon can be manipulated to a relatively high degree and still cue to the desired homing site.

STEELHEAD RETURNS TO THE SNAKE RIVER FROM JUVENILES RELEASED IN 1976

In the spring of 1976, an exploratory homing experiment that is germane to this report was initiated prior to this contracted study using steelhead trout from the Tucannon Hatchery. The steelhead trout raised at the Tucannon Hatchery, in 1976, were from the Washington Department of Game's "Chelan Stock." The objective of the experiment was to determine if smolting steelhead could be imprinted with a homing cue by the addition of a new water source (spring water) to their regular rearing water (Tucannon River).

The fish were reared on Tucannon River water and spring water was added for the last 8 d before marking and release. The water mix used for the homing imprint during the 8-d period was 1/e spring water and 2/3 river water. The fish were then hauled in Tucannon River water to Little Goose Dam in two loads for marking on 19 and 20 May 1976 and subsequently transported to and released below Bonneville Dam.

Based on the return of 1-ocean age steelhead, it is apparent that the fish were not imprinted to the Tucannon Hatchery spring water. However, the data does indicate that these steelhead smolts imprinted a homing cue to the Snake River at the marking facility at Little Goose Dam (1.4% return-246 fish).

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 our current report.

SUMMARY

In the first year of research on imprinting salmon and steelhead trout for homing, a total of 1,050,452 salmonids were marked and released. Of these, 186,597 were spring chinook salmon, 517,501 coho salmon and 346,354 steelhead trout. The primary objectives of the research are: (1) determine whether a single imprint or 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 physiological condition of the fish and imprinting.

Experimental groups of steelhead trout were given a homing imprint to: Dworshak Hatchery on the North Fork of the Clearwater River; Tucannon Hatchery on the Methow River; and Leavenworth Hatchery on the Icicle River. Spring chinook salmon were imprinted to the Kooskia Hatchery on Clear Creek, a tributary to the Middle Fork of the Clearwater River. Coho salmon were imprinted to: the Pasco Homing Site; Willard Hatchery on the Little White Salmon River; and Stavebolt Creek, a tributary to the Lewis and Clark River.

Preliminary returns of jack coho salmon to Stavebolt creek were inconclusive. Principal returns of adults from all tests are expected in ensuing years (1979-81).

Experimental data relating physiological condition of fish to imprinting are still being analyzed, and the results will be provided at a later date as a supplement to this report.