CZES Coastal Zone and Estuarine Studies

Imprinting Salmon and Steelhead Trout for Homing, 1980

by
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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 to establish a series of signposts for the route "home".

The primary objectives of our homing research are as follows:

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

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

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

Our study began in 1978, and the first 2 years' activities were reported by Slatick et al. (1979, 1980) and Novotny and Zaugg (1979). This report covers the research for the third year (1980).

Specific activities of the third 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 and 1979 to determine the efficiency of the imprinting techniques.

IMPRINT TESTS - 1980

During FY 1980, the NMFS marked and released 1,493,589 juvenile salmonids to determine if fish could be imprinted to return to a hatchery of origin or a homing site other than a hatchery (Table 1 and Figure 1). This year our research initiated the use of a "limited migration" to implant a homing imprint in juvenile fish. A limited migration means that fish were allowed to migrate downstream for a predetermined distance before being recaptured, marked, and transported. We hypothesized that juvenile fish are imprinted to their home stream early in their downstream migration--perhaps after migrating as little as 100 yards to 1 mile.

It was necessary to mark large numbers of fish in several locations during the spring migration period. Therefore the experimental work in Idaho, relating to limited migrations (spring chinook salmon--Kooskia National Fish Hatchery (NFH) and Rapid River Hatchery; fall chinook salmon--Hagerman NFH; and steelhead--Dworshak NFH) was accomplished under contract with the University of Idaho (Appendix A).

The comprehensive homing imprint experiments conducted in FY 1980 were possible only through a large scale cooperative effort by NMFS, the U.S. Fish and Wildlife Service (USFWS), Oregon Department of Fish and Wildlife (ODFW), Washington Department of Game (WDG), and the Idaho Department of Fish and Game (IDFG).

Table 1.--Homing imprint experiment 1980--species, location, numbers of fish marked and released, and years when adults are expected back for evaluation.

Species and (hatchery of origin - homing site)	Control (No.)	Experimental (No.)	Total (No.)	Adult evaluation (Yr)
		SNAKE RIVER SYSTEM		
Steelhead				
(Tucannon)	16,923	60,363	77,286	1981-82
		COLUMBIA RIVER SYSTEM		
Spring Chinook Salmon				
(Leavenworth)	195,427	296,186	491,613	1981-83
(Carson)	37,499	120,979	158,478	1981-83
Fall Chinook Salmon[a/]				
(Spring Creek)	--	199,286	199,286	1981-84
(Big Creek - Stavebolt Creek)	43,863	99,942	143,805	1981-84
Coho Salmon[a/]				
(Willard)	136,941	286,180	423,121	1980-81

Subtotals by species	
Steelhead	77,286
Spring chinook salmon	650,091
Fall chinook salmon	343,091
Coho salmon	423,121
GRAND TOTAL	1,493,589

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

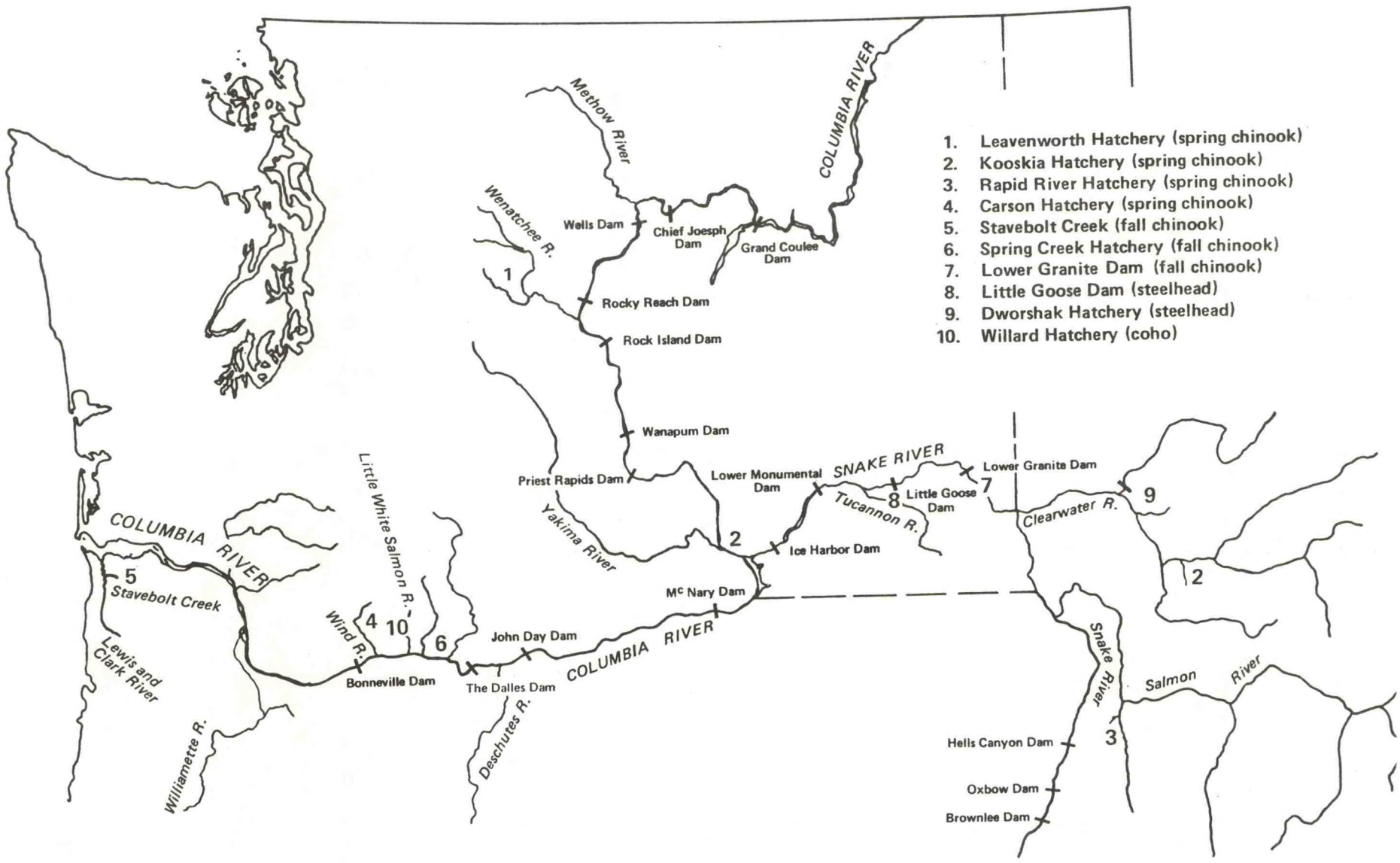

Figure 1.--Area map indicating experimental homing sites, 1980.

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

The object of this experiment was to determine if Na^+-K^+ ATPase enzyme activity in steelhead at the time of the imprint attempt had an effect on their subsequent homing. The steelhead were reared at the Tucannon Hatchery (WDG) from brood stock trapped at Priest Rapids Dam (Chelan Hatchery stock).

Measurements of the Na^+-K^+ ATPase enzyme activity were taken from 7 March to 12 June 1980 at the Tucannon Hatchery. Figure 2 shows the average profile of the Na^+-K^+ ATPase enzyme activity in relation to the releases of the three test groups. The experimental fish were imprinted to the Snake River at Little Goose Dam and transported by truck to a release site at Dalton Point in the Columbia River below Bonneville Dam.

The evaluation sites for returning adults will be the NMFS adult separators at Lower Granite, McNary, and Bonneville Dams; Zone 6 commercial fishery; and sports fisheries (with emphasis on the Walla Walla River). Specifics on treatments are contained in Table 2.

Leavenworth National Fish Hatchery

The object of this experiment was to imprint spring chinook salmon for return to the Leavenworth NFH. The study was designed to determine:

1. The homing-imprint on fish which were allowed to migrate 1 mile vs

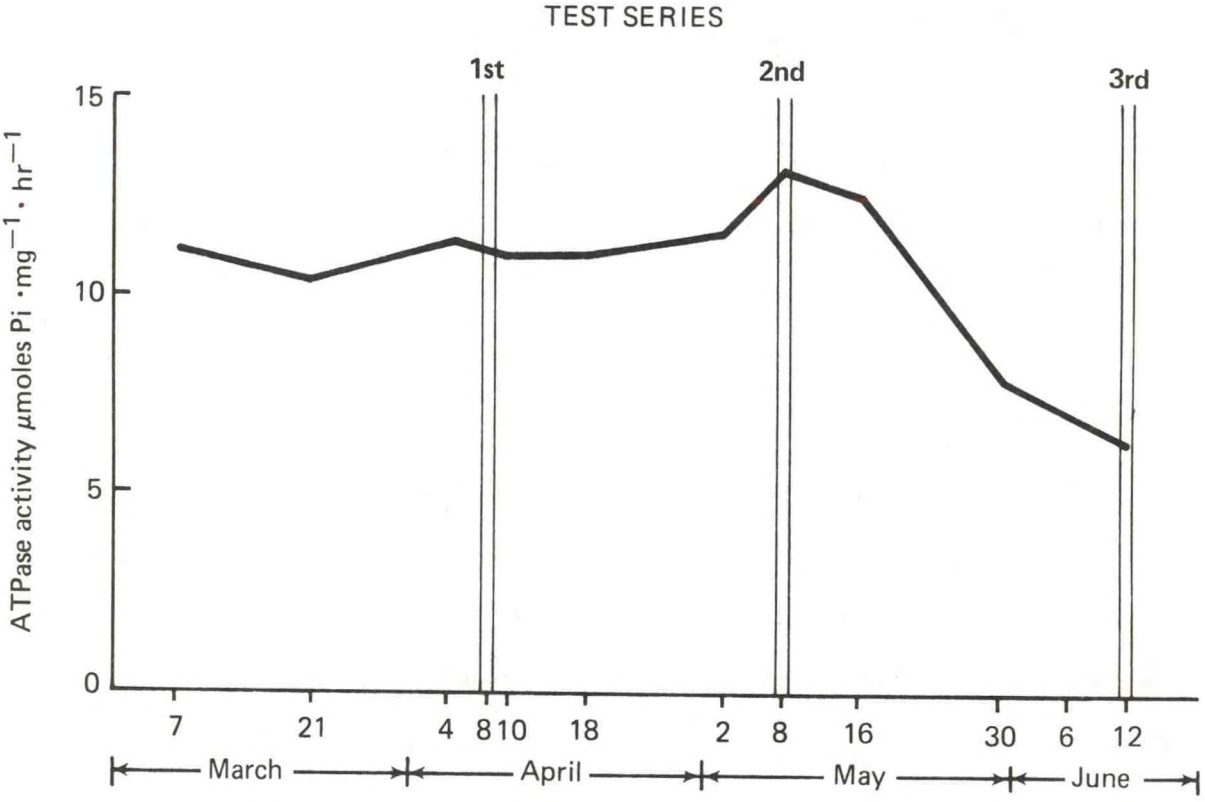

Figure 2.--Composite Na^{+}-K^{+} ATPase profile for steelhead smolts reared at the Tucannon Hatchery, indicating time frame for imprinting tests in 1980. Serial releases of marked fish were made on 8 April, 8 May, and 12 June 1980.

Table 2.--Steelhead trout marked in 1980 at Tucannon Hatchery and then transported to Little Goose Dam and imprinted to the Snake River. 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[b] released	Na^+-K^+ ATPase release series	Date	Homing imprint	Treatment
Control[c]	LA-GD	LA-)(	16,923		17-18 May	Natural Migration	Released into the Walla Walla River
Test #1[d]	PR-YB	RA-L	21,652	1st	8 April	Single	Transported by truck in Tucannon River water to Little Goose Dam and released into raceway containing Snake River water for 8 hr - then trucked in Snake River water to Dalton Point and released into Columbia River.
Test #2	LA-SM	RA-T	19,747	2nd	8 May	Single	Transported by truck in Tucannon River water to Little Goose Dam and released into raceway containing Snake River water for 8 hr - then trucked in Snake River water to Dalton Point and released into Columbia River.
Test #3	LA-DY	RA-⊢	18,964	3rd	12 June	Single	Transported by truck in Tucannon River water to Little Goose Dam and released into raceway containing Snake River water for 8 hr - then trucked in Snake River water to Dalton Point and released into Columbia River.

a/ Each wire tag code incorporates two rare earth elements. The abbreviations used stand for: LA, Lanthanum; PR, Praseodymium; GD, Gadolinium; YB, Ytterbium; SM, Samarium; and DY, Dysprosium.

b/ Adjusted for mortality and tag loss.

c/ These control fish were originally scheduled to be released into the Grande Ronde River.

d/ An estimated 2,000 of these fish escaped into the Snake River at Little Goose Dam.

fish held in pens in a river (Icicle River).

2. The effect on survival of juvenile fish marked in the fall vs smolting fish marked in the spring.

3. The effect on the homing and survival of fish transported and released in the mid-Columbia River below Priest Rapids Dam vs fish transported and released below Bonneville Dam.

During the winter, the hatchery water supply was comprised of a mix of well water and Icicle River water; after 10 April, only Icicle River water was used. The experimental fish were from 80% Leavenworth stock and 20% Carson stock all reared in raceways at the Leavenworth NFH. Two of the groups were premarked--Control #1 in November 1979, and Test #3 in early April 1980. The remaining three groups of fish were marked after having migrated for 1 mile. Experimental groups were given a single imprint to the Icicle River and transported by truck to a release site in the Columbia River either below Priest Rapids Dam at White Bluffs or below Bonneville Dam at Dalton Point. Specifics on treatments are contained in Table 3.

Adult evaluation for tests on spring chinook salmon will be at the three adult collector sites at dams previously mentioned, at Leavenworth NFH, and other hatcheries and natal spawning sites as required.

Carson National Fish Hatchery

The objective was to imprint spring chinook salmon for return to Carson NFH. The fish were reared in raceways containing Tyee Springs water (normal hatchery supply) and were from eggs obtained from naturally returning brood stock. The fish were premarked several months before being released. Experimental groups were singly or sequentially imprinted

Table 3.--Spring chinook marked at Leavenworth Hatchery for release in 1980. Test number, mark used, number released, date released, type of imprint, and treatment for various test groups are indicated.

Test - control	C.W.T. code	Brand	Number released[a/]	Date released	Homing imprint	Treatment
Marked in Fall, 1979						
Control #1	03-61-02	LA-	32,126	24 April	Natural Migration	Released from hatchery into Icicle R.
	03-61-02	LA-	32,238	27 April		
	03-61-02	LA-	32,274	1 May		
Marked in Spring, 1980						
Control #2	03-46-02	LA-	32,795	24 April	Natural Migration	Allowed unmarked fish to migrate naturally for 1 mile in Icicle R. bypass channel. Recaptured, marked, and released from hatchery into Icicle River.
	03-47-02	LA-	32,929	17 April		
	03-51-02	LA-	31,565	1 May		
	03-51-02	RA-	1,500[b/]	1 May		
Test #1	03-49-02	LA-	32,649	24 April	Single	Allowed unmarked fish to migrate naturally for 1 mile in Icicle R. bypass channel. Recaptured, marked, and transported by truck in Icicle R. water to a release site at White Bluffs on the Columbia River (RM 362).
	03-50-02	LA-	35,439	27 April		
	03-48-02	LA-	32,017	1 May		
Test #2	03-52-02	RA-	32,960	24 April	Single	Allowed unmarked fish to migrate naturally for 1 mile in Icicle R. bypass channel. Recaptured, marked, and transported by truck in Icicile R. water to a release site at Dalton Point on the Columbia River (Rm142).
	03-53-02	RA-	32,847	27 April		
	03-54-02	RA-	32,641	1 May		
Test #3	03-43-02	RA-9	32,441[c/]	4/24	Single	Held in live pen in Icicile R. bypass channel for 48 hr, then transported by truck in Icicile R. water to a release site at Dalton Point on the Columbia River (RM 142).
	03-44-02	RA-	32,728	4/27		
	03-45-02	RA-	32,464	5/1		

a/ Adjusted for initial tag loss.

b/ These 1,500 fish were incorrectly branded RA- .

c/ An estimated 400 of these fish escaped into the Icicle River.

to the hatchery water supply and then transported by truck to a release site in the Columbia River, either just below Bonneville Dam or near Hammond, Oregon. This is a replicate, with minor modification (Test #1 and #2 were released at Dalton Point, RM 142, instead of at Bradford Island, RM 145.4), of the experiment conducted in 1979. Specifics on treatments are contained in Table 4.

Spring Creek National Fish Hatchery

The objective was to imprint fall chinook salmon for return to the Spring Creek NFH. Several springs are utilized as the hatchery water source. Juvenile salmon were reared at the Spring Creek NFH from eggs obtained from naturally returning brood stock. The fish were premarked in March 1980. One experimental group was loaded directly from the raceways into a barge; the second group passed through a 350-ft transport channel before being loaded into the barge. Both groups were given sequential homing cues by being transported by barge initially containing Spring Creek water to a release site below Bonneville Dam. The control group used was marked by USFWS personnel as part of the fall chinook salmon hatchery evaluation study. Specifics on treatments are contained in Table 5.

Big Creek Hatchery - Stavebolt Creek

The object of this experiment was to determine if a limited short migration would imprint fall chinook salmon for return to a lower-river homing site. Fall chinook salmon used in these experiments were reared at the Big Creek Hatchery (ODFW) from eggs obtained from naturally returning brood stock.

The lower-river homing site used was Stavebolt Creek, a tributary to the Lewis and Clark River which drains into Youngs Bay near Astoria,

Table 4.--Spring chinook salmon marked at Carson Hatchery for release in 1980. Test number, mark used, number released, date released, type of imprint, and treatment for various groups are indicated.

Test - control	C.W.T. code	Brand	Number released[a/]	Date released	Homing imprint	Treatment
Control	03-57-02	LA-ω	37,499	12 May	Natural Migration	Released from Carson NFH into hatchery outlet creek leading into the Wind River.
Test #1	03-58-02	RA-L	36,262	12 May	Single	Loaded into tanker for 2 hr, then released into raceway containing Tyee Springs water for 48 hr minimum and then trucked in Tyee Springs water to release site at Dalton Point on the Columbia River.
Test #2	03-59-02	RA-⊢	41,537	14 May	Sequential	Loaded into tanker (Tyee Springs water) for 2 hr, released into raceway (Tyee Springs water) for 48 hr minimum, loaded into tanker containing Tyee Springs water for 2 hr, released into raceway (Wind River water) for 48 hr minimum, then loaded into tanker (Wind River water) and hauled to release site at Dalton Point on the Columbia River.
Test #3	03-60-02	RA-T	43,180	15 May	Sequential	Treatment same as in Test #2 except fish were released near Hammond, Oregon, on the Columbia River.

a/ Adjusted for initial tag loss.

Table 5.--Fall chinook salmon marked at Spring Creek Hatchery for release in 1980. Test number, mark used, number released, date released, type of imprint, and treatment for various groups are indicated.

Test - control	C.W.T. code	Number[a/] released	Date released	Homing imprint	Treatment
Control[b/]	05-06-41	60,500	9 May	Natural Migration	Released from Spring Creek NFH into Columbia River (RM 166).
Test #1	05-06-48	99,583	19 May	Sequential	Fish were loaded directly from a raceway into a barge containing Spring Creek Hatchery water. Pumps for Columbia River water started 20 min. after fish were loaded. Fish were barged to a release site below Bonneville Dam (RM 140).
Test #2	05-06-49	99,703	19 May	Sequential	Fish traveled 350 ft through a transport channel (crowded with a seine) then were loaded into a barge containing Spring Creek Hatchery water. Pumps for Columbia River water started 1 hr 55 min. after fish were loaded. Fish were barged to a release site below Bonneville Dam (RM 140).

a/ Adjusted for initial tag loss.

b/ This group was marked by the USFWS for the fall chinook salmon hatchery evaluation study.

Oregon. Experimental groups were imprinted to Stavebolt Creek, recaptured, marked, and released back into Stavebolt Creek or transported by truck to a release site in the Columbia River at Astoria, Oregon. Details of treatments are contained in Table 6.

Willard National Fish Hatchery

The primary objective of this experiment was to imprint coho salmon for return to the Little White Salmon River. The study was designed to determine:

1. Effectiveness of various methods used to activate a homing imprint in coho salmon.

2. Effect of various release locations on the homing ability and survival of coho salmon.

3. Effect on survival of fish marked in the fall as juveniles vs the fish marked as smolting fish in the spring.

The fish were reared in raceways at the Willard NFH and were from eggs obtained from naturally returning brood stock to the Little White Salmon NFH. Both of these hatcheries are on the Little White Salmon River and utilize the river as the hatchery water source. The Little White Salmon NFH is located near the mouth of the river and recovers all returning adults from both hatchery releases.

Experimental groups were provided imprint cues to Little White Salmon River water (hatchery water supply), and then transported by truck and barge to release sites in the Columbia River below Bonneville Dam (RM 140 and 142, respectively), or by truck to Beaver Terminal (RM 50) or Hammond, Oregon (RM 8). Specifics on treatments are contained in Table 7.

Table 6.--Fall chinook salmon marked at Stavebolt Creek and Big Creek Hatcheries for release in 1980. Test number, mark used, number released, date released, type of imprint, and treatment for various groups are indicated.

Test-control	C.W.T. code	Number released [a/]	Date released	Homing imprint	Treatment
Premarked in spring 1980					
Control #1 [b/]	07-21-60	143,400	13-23 May	Natural Migration	Released from Big Creek Hatchery into Big Creek.
Released after marking					
Control #2	03-42-02	43,863	23 May	Natural Migration	Released from Big Creek Hatchery into Big Creek.
Test #1	03-40-02	49,528	12-19 May	Single	Allowed unmarked fish to migrate naturally for 600 ft in Stavebolt Creek. Recaptured, marked, and transported by truck in Stavebolt Creek water to the Columbia River at the West Mooring Basin release site located in Astoria, Oregon.
Test #2	03-41-02	50,414	12-19 May	Natural Migration	Allowed unmarked fish to migrate naturally for 600 ft in Stavebolt Creek. Recaptured, marked, and released smolts back into Stavebolt Creek above its confluence with the Lewis and Clark River.

a/ Adjusted for initial tag loss.

b/ This group was marked by the ODFW for the fall chinook salmon hatchery evaluation study.

Table 7.--Coho salmon marked at Willard and Little White Salmon Hatcheries for release in 1980. Test number, mark used, number released, date marked, date released, type of imprint, and treatment for various groups are indicated.

Test - control	C.W.T. code	Number released[a/]	Date marked	Date released	Homing imprint	Treatment
Marked in Fall 1979						
Control #1	05-03-58	43,045	31 Oct - 6 Nov 79	14 May	Natural Migration	Trucked from Willard Hatchery and released into L. W. Salmon River below lower barrier at L. W. Salmon Hatchery.
Control #2	05-03-59	42,371	2-5 Nov 79	23 May	Natural Migration	Released from Willard Hatchery into L. W. Salmon River.
Marked in Spring 1980						
Control #3	05-06-54	51,525	5-6 May 80	23 May	Natural Migration	Released from Willard Hatchery into L. W. Salmon River.
Test #1	05-06-55	51,417	20-22 May 80	25 May	Sequential	At Willard Hatchery unmarked fish were passed through 175 ft of pipe and held for 4 days, then trucked to L. W. Salmon Hatchery where they were marked and held for 4½ days. Fish were then trucked and loaded into a barge in the L. W. Salmon River and held for 19 h 18 min, then barged downstream to a release site below Bonneville Dam (RM 140).
Test #2	05-06-60	33,732	22-23 May 80	25 May	Sequential	Limited migration - unmarked fish were released from Willard Hatchery into L. W. Salmon River, migrated 6 mi and were recaptured below lower barrier at L. W. Salmon Hatchery, marked and held for 2-5 days. They were then trucked and loaded into barge in the L. W. Salmon River and held 18 h 53 min, then barged downstream to a release site below Bonnevile Dam (RM 140).

Table 7.--Continued.

Test - control	C.W.T. code	Number[a/] released	Date marked	Date released	Homing imprint	Treatment
Marked in Spring 1980						
Test #3	05-06-50	47,923	21-22 April 80	25 May	Sequential	Trucked directly from Willard Hatchery and loaded into a barge in the L. W. Salmon and held for 21 h 1 min, then barged downstream to a release site below Bonneville Dam (RM 140).
Test #4	05-06-51	50,786	23-24 April 80	21 May	Single	Loaded in truck for 2 h then release into raceway containing L. W. Salmon River water for 48 h minimum then transported by truck (L. W. Salmon River water) to a release site at Hammond, Oregon on the Columbia Rive (RM 142).
Test #5	05-06-53	50,619	1-3 May 80	23 May	Single	Loaded in truck for 2 h then release into raceway containing L. W. Salmon River water for 48 h minimum then transported by truck (L. W. Salmon River water) to a release site at Hammond, Oregon on the Columbia Rive (RM 8).
Test #6	05-06-52	51,683	24 April - 1 May 80	22 May	Single	Loaded in truck for 2 h then release into raceway containing L. W. Salmon River water for 48 h minimum then transported by truck (L. W. Salmon River water) to a release site at Beaver Terminal, Ore., (RM 50) on th Columbia River (upstream of the salt water intrusion).

a/ Adjust for intial tag loss.

ADULT RETURNS FROM IMPRINT TESTS

The degree of success (ability to home and survival enhancement) for the various treatments of experimental fish is based on the returns of adults previously 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 mainstream dams; and from hatcheries and spawning grounds.

Steelhead

Data to provide final assessment of homing will not be available until after spawning at hatcheries is completed in the spring of 1982. However, preliminary recoveries of 1- and 2-ocean age steelhead from hatcheries and the sport fishery are completed for the adult migrating season of 1979-80. Evaluation of returning adults in relation to smolt condition will not be made until total adult returns to homing sites are complete. Preliminary data on survival and homing of 1- and 2-ocean age steelhead in the fall of 1980 are obtained from returns of steelhead to five in-river sampling locations (Figure 3).

Dworshak - 1978 Experiment

Steelhead reared at Dworshak NFH migrate 504 miles before reaching seawater. Previous NMFS studies (Park et al. 1980) showed that steelhead of Dworshak NFH origin that were intercepted at Lower Granite Dam (RM 431)

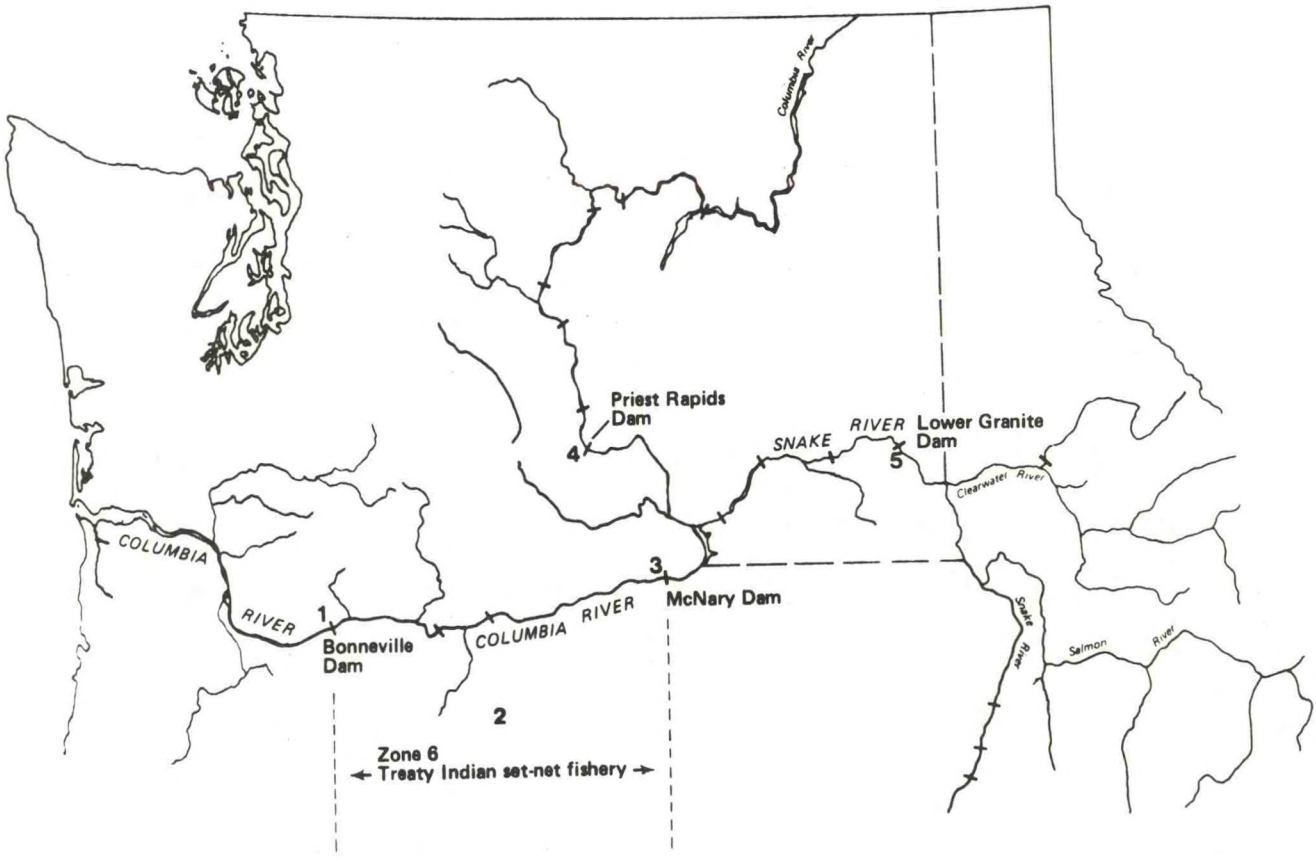

Figure 3.--Map of Columbia River system showing location of five in-river sampling locations.

and transported to Bonneville Dam (RM 145) homed successfully to Dworshak NFH. The goal of the 1978 work at Dworshak NFH was to determine if exposure to at least 48 h of home stream water would assure homing in juvenile steelhead that were denied all natural migration above Bonneville Dam.

The 1978 test design included a control group released at Dworshak NFH into the North Fork of the Clearwater River and two test groups transported from Dworshak NFH to a release site below Bonneville Dam (Appendix Table B1). Test fish were taken off the normal reconditioned water supply in System #3 by pumping them through irrigation pipe into raw North Fork Clearwater River water in System #2 raceways, where they were held for 6 days prior to transport. One test group was moved to Lewiston, Idaho, (RM 463) by truck, then barged through the normal migration route. The other test group was moved by truck to the release site below Bonneville Dam.

The major portion of the adult return from 1978 Dworshak NFH releases is complete. The 1980 steelhead run passed our Columbia River sampling stations and began entering Dworshak NFH to spawn in March of 1981. Spawning should be completed on the 1980 fish by late May. An additional small number of 3-ocean age adults are expected to return with the 1981-82 run.

Homing.--Preliminary returns of adult steelhead into the Dworshak NFH indicate the test methods used were successful in varying degrees in returning steelhead to the Dworshak NFH homing site. Test fish which were trucked to Lewiston, Idaho, and then barged, showed a test/control benefit ratio of 1.63:1 compared to 0.84:1 for the test group which was trucked only (Table 8). Returns from the barged groups provided the first evidence

Table 8.--Preliminary returns to the Dworshak Hatchery homing site and sport fishery of steelhead from control and test releases of smolts imprinted to the Dworshak NFH in 1978. Recoveries were from September 1978 to 13 April 1981.

Sampling location and experiment	Control or test	Number juveniles released	No. of adults[a/] recaptured			Adult return (% of juveniles)	Test to control ratio
			1-ocean age	2-ocean age	Total 1 & 2's		
Dworshak homing site							
Dworshak	Control	100,600	26	210	236	0.235	
Trucked	Test	20,661	1	40	41	0.198	0.84:1
Barged	Test	24,006	6	86	92	0.383	1.63:1
Snake River sport fishery							
Dworshak	Control		0	10	10	0.010	
Trucked	Test		0	0	0	0.000	
Barged	Test		0	1	1	0.004	0.40:1
Clearwater River sport fishery							
Dworshak	Control		0	60	60	0.060	
Trucked	Test		0	8	8	0.039	0.65:1
Barged	Test		0	25	25	0.104	1.73:1
Strays (above McNary Dam)							
Dworshak	Control		0	0	0		
Trucked	Test		0	2	2	0.010	
Barged	Test		0	2	2	0.008	
	Total		33	444	477		

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

that fish which were imprinted and transported directly from a hatchery will return as adults in greater numbers than fish which migrated naturally (Control).

Distribution and Contribution to Fishery.--Returns to date from the sport fishery above Lower Granite Dam show that the majority of the test and control fish were recovered in the Clearwater River. Test to control ratios in this fishery were comparable to ratios at the hatchery.

Straying.--A total of four steelhead recovered in the sport fisheries above McNary Dam were listed as strays. Three were recovered in the upper mid-Columbia River--one trucked fish at the mouth of the Methow River and one each trucked and barged fish from the Ringold, Washington, area. One barged fish was recovered in the Rapid River Hatchery (IDFG) trap in Idaho. As an item of interest, data from the ocean sampling show that one fish from the barged group was recovered in the Puget Sound, Washington, net fishery.

Survival.--Preliminary recoveries of returning steelhead from the 1978 outmigration at four in-river sampling locations on the Columbia River System indicate differences between treatment groups with respect to relative survival and homing (Table 9). Test/control ratios indicate up to 7.2 times higher survival for the test groups (transported) than the control group (nontransported) at the two lower-river sampling locations (Bonneville Dam and Indian fishery).

Although the test/control ratios at McNary Dam (147 miles upriver from Bonneville Dam) showed a positive benefit (ranging from 1.34:1 for the trucked group to 2.41:1 for the barged group), these lower ratios indicate that homing of the test groups was impaired. Test/control ratios showed a

Table 9.-- Preliminary returns to four sampling locations of steelhead from control and test releases of smolts imprinted to the Dworshak NFH in 1978. Recoveries were from September 1979 to 13 April 1981.

Sampling location and experiment	Control or test	Number juveniles released	No. of adults[a/] recaptured			Adult[d/] return (% of juveniles)	Test to control ratio
			1-ocean age	2-ocean age	Total 1 & 2's		
Bonneville Dam[b/]							
Dworshak	Control	30,074	1	13	14	0.047	
Trucked	Test	20,661	1	14	15	0.342	7.28:1
Barged	Test	24,006	1	8	9	0.169	3.60:1
Indian fishery[c/]							
Dworshak	Control	100,600[e/]	0	31	31	0.031	
Trucked	Test	20,661	1	44	45	0.218	7.03:1
Barged	Test	24,006	2	51	53	0.221	7.13:1
McNary Dam[b/]							
Dworshak	Control	30,074	3	18	21	0.070	
Trucked	Test	20,661	0	4	4	0.094	1.34:1
Barged	Test	24,006	1	8	9	0.169	2.41:1
Lower Granite Dam[b/]							
Dworshak	Control	30,074	14	170	184	0.612	
Trucked	Test	20,661	2	15	17	0.375	0.61:1
Barged	Test	24,006	1	47	48	0.972	1.59:1
Total branded		74,741	27	423	450		
Wire-tagged only		70,526					

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

b/ Data from branded fish only.

c/ Data from coded wire tags only.

d/ Adjusted for the difference in detectability between binary and color-coded wire tags as indicated by returns to Dworshak Hatchery.

e/ The control group for the experiment was branded (30,074 of 100,600 fish originally tagged for hatchery production contribution); however, branded fish are not recorded in the Indian Fishery samples so the entire group must be considered.

further decline by the time fish passed over Lower Granite Dam on the Snake River (139 miles upriver from McNary Dam). Steelhead from the barged group still showed a positive test/control benefit ratio of 1.59:1, but the truck group had a negative ratio of 0.61:1. These latter ratios are comparable to ratios noted in the sport fishery and at the hatchery--indicating little or no additional homing impairment to fish migrating as far upstream as Lower Granite Dam.

Discussion.--Returns of adult steelhead to the Dworshak NFH homing site and to the upper river as measured at Lower Granite Dam show that the barged test group was successful in returning more fish than the control group. The data also indicate that juveniles which were sequentially imprinted by barging returned 2.5 times as many adults to the upper river than juveniles which received a single imprint and then were trucked directly to below Bonneville Dam.

A preliminary analysis of the decline in the test/control ratios from the high levels observed in the lower river (Bonneville Dam) to the much lower level in the upper river (Dworshak NFH homing site) may indicate that a large proportion of the test fish did not receive a homing imprint. This was demonstrated by the large number of test fish which were recovered in the Indian gill-net fishery during March 1981, indicating that steelhead which were not imprinted to the Dworshak NFH homing site are returning to the area near their point of release as juveniles.

Under normal conditions steelhead smolts in the Snake River system migrate over an extended period of time (approximately mid-April to mid-June). Within a given population, the proportion of juveniles physiologically able to imprint a homing cue may vary within the migration

time period. Therefore, the time period in which juveniles are exposed to an imprint cue before being transported downriver would influence the proportion of juveniles which would receive a homing cue that would enable them to return as adults to the homing site.

For example, if we accept as true the hypothesis that all juveniles in the control release received a homing imprint, and that the rate of survival for all adult steelhead (in the Columbia River system) with a homing imprint to the Dworshak NFH is equal, then the difference between survival as indicated by the test/control ratios of the barged group at Bonneville Dam and at Dworshak NFH will indicate the proportion of juveniles which received a homing imprint.

$$(1.63 \div 3.60) \times (100) = 45.3\%$$

If 45.3% of the barged group were imprinted, that would be an effective release of 10,875 imprinted smolts. As of 13 April, with about 33% of the fish spawned, we have recovered 92 adults from the barged group at the Dworshak NFH. This translates to a rate of return to the hatchery of 0.846%, and a test control benefit ratio of 3.60:1 for imprinted smolts which were barged. If the present rate of return continues through the remaining period of spawning, the total rate of return should be in excess of 2%. This is a very good rate of return for steelhead and is more than twice that of the highest previous return to the hatchery. It is all the more impressive when you consider that an estimated 66.7% of the control fish which survived to Lower Granite Dam were collected and transported to below Bonneville Dam via the regular transportation program. The test/control ratio for returning adults from the 1978 outmigration which

were transported from the collector dams was 3.22:1. This means that approximately three out of four returning adult steelhead from our control release received the benefit of being transported around hydroelectric dams on the Snake and Columbia Rivers. It is apparent that without the benefit from transportation, the return of control fish to the hatchery would have been substantially lower.

Although this experiment shows a definite benefit for the barged test group, we recommend additional experimentation using the barge transport method to determine when the greatest proportion of the fish are able to accept a homing imprint. This experiment should have a series of releases throughout the migration period and be combined with physiological examinations of the fish in an effort to devise an index by which we could determine the most appropriate time when the greatest proportion of the population would accept a homing imprint.

The successful conclusion of this study could lead to a management program which would significantly increase the rate of return of this stock of steelhead and thereby provide an increased benefit to all the user groups who now utilize these fish. If a significant portion of the Dworshak NFH steelhead smolts were transported from the hatchery, it would help reduce the congestion at the collector dams. This would be especially beneficial in aiding the collection and transportation of chinook salmon smolts since the peak of the Dworshak NFH steelhead smolt migration closely coincides with the peak of the chinook salmon outmigration. This could prove to be quite significant in the future as the proposed mitigation hatcheries start releasing fish and increase the number of juvenile salmonids arriving at the collector dams.

Tucannon - 1978 Experiment

The objective of the 1978 Tucannon Hatchery (WDG) homing test was to determine if sequential exposure to hatchery and migration route waters prior to release would ensure homing of returning adult steelhead.

The spring water portion of the hatchery water supply was used as the initial homing cue. Two groups of fish which had been maintained on 100% Tucannon River water were removed from the hatchery ponds and held in a tank truck while the composition of the water supply to the ponds was altered. The fish were then returned to the ponds, one of which contained 100% spring water, and the other a 20:80% mixture of spring and Tucannon River water. Following a 48-hour holding period, the fish were transported by truck around the 34 miles of the Tucannon River they would have encountered during a natural outmigration, and loaded into a barge moored at RM 386. Ensuing barge transport to the release site below Bonneville Dam (RM 140) provided sequential exposure of test fish to Snake and Columbia River waters along the barge route. A control release into the Tucannon River was not possible, but a group of steelhead released into the Grande Ronde River (RM 493) was marked. These fish will provide data on survival and behavior for naturally imprinted steelhead of the same stock as our test releases. Further details of the experimental design are given in Appendix Table B2.

Steelhead used for this test were Skamania stock (WDG), the majority of which return as 2- or 3-ocean age adults. Two-ocean age fish from this test are currently returning with the 1980-81 steelhead run. Preliminary returns to various sampling locations are summarized in Table 10. Steelhead which home successfully to the Tucannon Hatchery will not be recovered until spring 1981.

Table 10.--Observed return to sampling locations of 1978 Tucannon Hatchery homing test steelhead. Preliminary return data through November 1980.

Sampling location[a]	Marked groups[b]							
	100 % spring water		80% spring 20% river water		Combined test groups		Control	
	Number	% of release	Number	% of release	Number	% of release	Number	% of release
In-river locations								
Lower Columbia River sport fishery	3	0.02	0	0.00	3	0.01	2	0.004
Bonneville Dam	27	0.15	6	0.03	33	0.09	9	0.02
Zone 6 Indian fishery	8	0.04	9	0.05	17	0.05	0	0.00
McNary Dam	2	0.01	7	0.04	9	0.02	1	0.002
Lower Granite Dam	34	0.19	10	0.05	44	0.12	86	0.16
Subtotal	74	0.41	32	0.17	106	0.29	98	0.18
Miscellaneous recoveries								
Bonneville Hatchery	0	0.00	1	0.01	1	0.003	0	0.00
Cascade Hatchery	5	0.03	5	0.03	10	0.03	0	0.00
Deschutes River sport fishery	16	0.09	7	0.04	23	0.06	0	0.00
Quinault River	0	0.00	0	0.00	0	0.00	1	0.002
Subtotal	21	0.11	13	0.07	34	0.09	1	0.002
Total	95	0.52	45	0.24	140	0.38	99	0.18

a/ Steelhead sampled at Bonneville, McNary and Lower Granite are jaw-tagged prior to release to prevent duplication of data if the fish are sampled at another location.

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

Adult steelhead returning to date indicate that a substantial portion of those fish from test releases will not home to the Snake River or to the Tucannon Hatchery. It appears likely that observed recoveries in the Deschutes River sport fishery, at Bonneville and Cascade Hatcheries (ODFW), and in the Zone 6 Indian fisheries represent fish which did not imprint to the Snake River. Observed recoveries (51 test fish, no controls) and the early return of adults from the control release (79% had passed Lower Granite Dam by 1 September 1980) support our rationale. The majority of returning adults from the control release, bearing a positive upriver imprint, moved through the lower Columbia River before the Zone 6 Indian fishery was opened on 29 August 1980. A portion of returning adults from the test releases apparently halted or delayed migration in this area, where they were available to the Zone 6 Indian fishery, and eventually entered the Deschutes River and the Bonneville and Cascade Hatcheries.

Another portion of the adult returns from the test releases is continuing its upriver migration. The observed return of test fish to Lower Granite Dam (45 miles upstream from the mouth of the Tucannon River) amounted to 0.12% of the release as opposed to 0.16% for the control group (Table 10). Although these test fish have overshot their home stream, they are returning to the Snake River--evidence that homing cues may have been acquired during barge transport. Adult steelhead migrating similar distances, but choosing the mainstem Columbia River would have to pass the Priest Rapids Dam sampling station. To date, none have been observed at Priest Rapids Dam or recovered in the WDG's creel census efforts above Priest Rapids Dam.

At this time, it is unknown if test fish are going to enter the Tucannon River or return to the hatchery. A determination of the success

of the initial imprint treatment and further consideration of the data will await hatchery returns in the spring of 1981. It should be noted that of our 1981 steelhead returns, the Skamania stock is returning at a considerably lower rate than middle Columbia River or Dworshak NFH stocks. This was not expected at the time our tests were undertaken, and if 3-ocean age adults do not make a significant contribution to the total return, then data available for analysis will be limited.

Wells-Winthrop - 1978 Experiment

The object of this experiment was to imprint steelhead from the Wells Hatchery (WDG) with a homing cue to the Winthrop NFH (a hatchery other than the hatchery of origin) on the Methow River and 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. One control group was held 2 days at Winthrop NFH prior to release at the hatchery. The second control was the production release made directly into the Methow River 0.25 mile upstream from the mouth. Test groups were held 2 to 8 days at the hatchery in an attempt to imprint them to the hatchery water prior to transporting them downriver by barge or truck. One test group was then trucked in raceway water and released at Ringold, Washington; the second was trucked in raceway water to a barge at Richland, Washington, and barged downstream to below Bonneville Dam; the third test group was trucked in raceway water to a release site below Bonneville Dam.

Homing.--Test fish imprinted to a hatchery homing site and transported to a downriver release site should return as adults to that homing site at

a comparable rate to control fish returning to the hatchery for the homing tests to be a success. Preliminary returns of 1-ocean age steelhead indicate that the methods used in 1978 were unsuccessful in returning the test groups of steelhead to the Winthrop NFH homing site. Only one fish from each test group returned to the hatchery compared to 18 (0.09%) of the Winthrop NFH control fish (Table 11).

The results from sampling both 1- and 2-ocean age adult steelhead at dams indicated that although the imprint methods used in these experiments were not successful in returning fish to the homing site, they did implant a limited homing cue which enabled the transported fish to return to areas above McNary Dam without impairment of homing. This is based on the fact that test/control ratios at each of the lower-river sampling sites were quite consistent within groups transported by barge or truck below Bonneville Dam. Homing above that point was impaired as indicated by a decline in test/control ratios for all three transport groups at Priest Rapids Dam (Figure 4). The difference in test/control ratios at Priest Rapids Dam reflects the varying degree of homing cues that resulted from each treatment; Test Group Three (Ringold) (2.4:1) was highest, followed by Test Group One (Bonneville trucked) (1.3:1), and then Test Group Two (barged from Richland) (0.6:1).

Recoveries of tagged fish in the sport fishery provided additional data on homing of the various test groups to areas above McNary Dam. The major sport fisheries between McNary and Priest Rapids Dams are at Ringold, Washington, and a stretch of several miles immediately below Priest Rapids Dam. The major sport fishing areas above Priest Rapids Dam are in the Wenatchee, Washington, area and at the mouths of the Entiat and Methow Rivers (Figure 5).

Table 11.--Estimated recovery of 1-ocean age steelhead returning from control and test releases of juveniles from the 1978 Wells-Winthrop experiment in seven sampling locations. Recoveries were from June 1979 to May 1980.

Control or test groups	Number[a] juveniles released (N)	Indian fishery (N)	Sport fishery					Hatchery[b] brood-stock (N)	Winthrop homing site (N)	Total recovery		Test to control ratio
			Lower Columbia River (N)	Ringold area (N)	Wenatchee area (N)	Rocky Reach pool area (N)	Methow area (N)			(N)	(%)	
Lower Methow (Control #1)	19,901	37	0	17	14	2	108	13	1	192	0.965	2.31:1
Winthrop (Control #2)	20,330	17	0	0	0	0	46	4	18	85	0.418	
Truck to Bonneville (Test #1)	19,131	99	0	68	54	2	15	13	1	252	1.317	3.15:1
Barge to Bonneville (Test #2)	19,979	58	7	85	9	0	2	3	1	165	0.826	1.98:1
Truck to Ringold (Test #3)	17,637	47	7	34	47	6	35	13	1	190	1.077	2.58:1
TOTAL	96,978	258	14	204	124	10	206	46	22	884	0.912	

[a] Adjusted for initial tag loss.

[b] From steelhead trapped at Priest Rapids Dam for Chelan Hatchery broodstock.

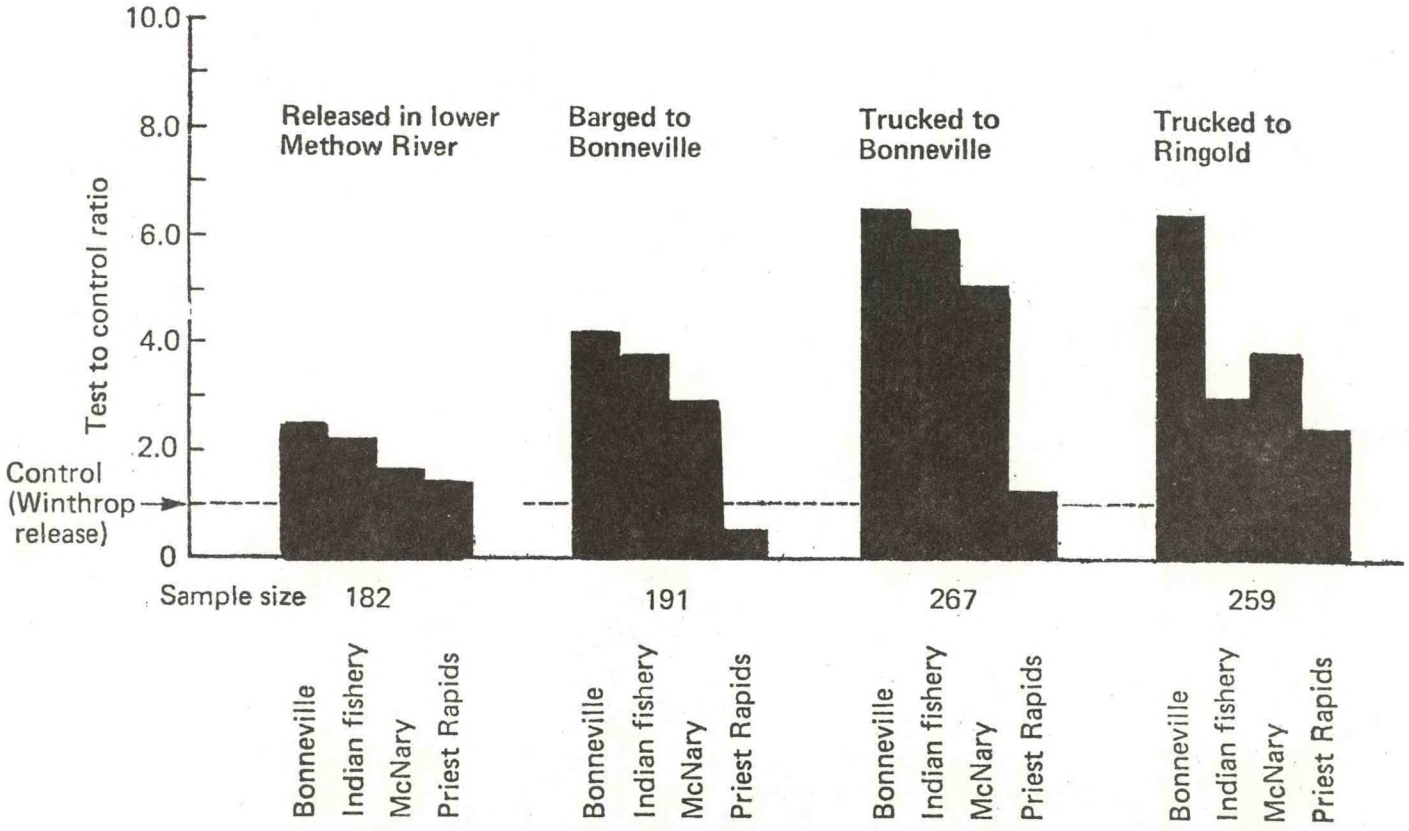

Figure 4.--Test to control ratios for returns to four sampling locations on the Columbia River of combined 1- and 2-ocean age steelhead from control and test releases from the Wells Hatchery which were imprinted to the Winthrop NFH homing site on the Nethow River in 1978. Recoveries were from June to 30 November 1980. Control fish were released at the Winthrop NFH. The broken line indicates the level of return for control fish.

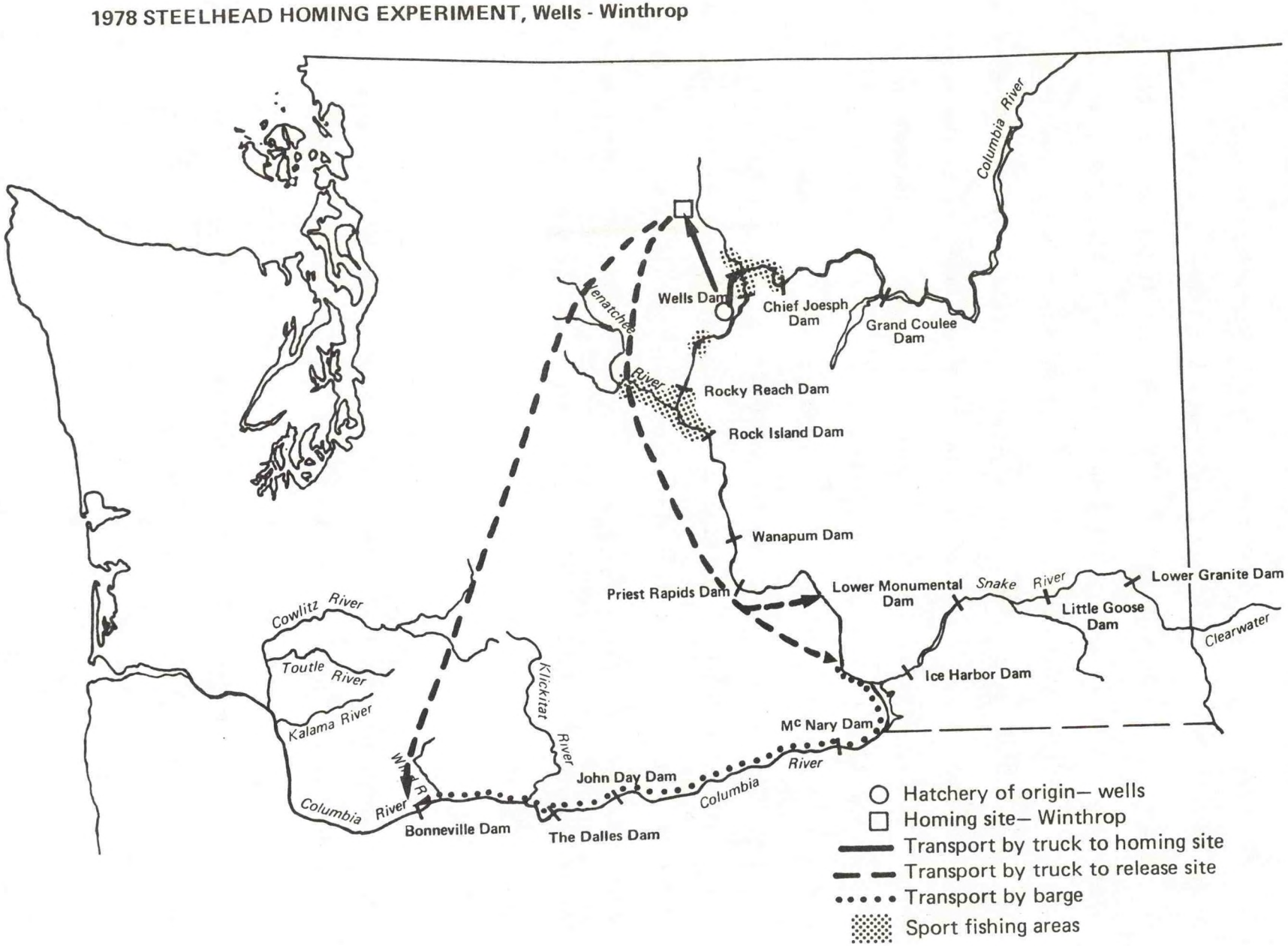

Figure 5.--Study area germane to 1978 homing experiment with steelhead from Wells-Winthrop Hatcheries.

Estimated recoveries of 1-ocean age fish in the sport fishery are summarized in Table 11. These numbers were adjusted for sampling effort. The data obtained generally verified the data obtained from sampling at Priest Rapids Dam; i.e., Ringold, Washington, releases had the highest proportion (68%) that homed to areas above Priest Rapids Dam (88 fish); trucked fish released at Bonneville Dam were next at 51% (71 fish); whereas only 11% (11 fish) of the barged fish found their way to areas above Priest Rapids Dam. Of those fish that were imprinted to areas above Priest Rapids Dam, more than twice as many of the Ringold group, compared to the other two test groups, were able to home to the Methow River as evidenced by the sport catch (35 fish from Ringold, Washington, vs 15 from those trucked to Bonneville Dam and only two from those barged to Bonneville Dam.)

Straying.--Fish straying into the Snake River system were monitored at Lower Granite Dam (Snake River Mile 107). Recovery of marked fish shows that some straying occurred from all the test and control groups; the only major number of strays (estimate 0.55%) were from the trucked to Bonneville Dam test group (Table 12). Two of the strays tagged at Lower Granite Dam were later recovered at Dworshak NFH (one each from the groups barged or trucked to Bonneville Dam).

Survival and Contribution to Fishery.--Recoveries of returning 1- and 2-ocean age adult steelhead from the 1978 outmigration at four in-river sampling locations on the Columbia River are completed. Differences between treatment groups, with respect to relative survival and homing, are illustrated by the test to control ratios at each of the four sampling locations (Figure 4). Although the tests to control ratios are not constant, they do indicate up to 6.5 times higher survival for the test

Table 12.--Adult 1-ocean age steelhead trout from the 1978 Wells-Winthrop experiment which strayed into the Snake River and were recaptured at Lower Granite Dam (RM 107), 1979-80.

Control Test	Number of 1-ocean age adults recovered	Adult Return in % of Juveniles Released	
		Observed	Estimated[a/]
Released at Winthrop Hatchery (Control)	2	0.010	0.018
Released in Lower Methow River (Control)	1	0.005	0.009
Barged to Bonneville (Test)	3	0.015	0.026
Trucked to Bonneville (Test)	60	0.314	0.550
Trucked to Ringold (Test)	5	0.028	0.049

a/ Park et al. 1980.

groups (transported) than the control groups (nontransported) at the three lower-river sampling locations (Bonneville Dam, Indian fishery, and McNary Dam).

Loss of homing above McNary Dam lowered the test/control ratios at Priest Rapids Dam and resulted in fewer transported fish contributing to the sport fishery in the Methow River. However, the limited homing imprints along with the higher survival of the transport groups resulted in the transported fish contributing significantly to the Wenatchee and Ringold sport fisheries and to the Indian set-net fishery (Table 11). Overall, the total contribution from the transport releases to various user groups was 607 fish or over 1% of those released. Mainly because of lower survival, the contribution of control fish was less (277 fish--about 0.7% of those released). Less than half as many Winthrop controls were caught in the sport or commercial fishery as those released at the traditional Methow River release site. The difference probably was poorer survival, since adult recoveries of Winthrop releases were lower than recoveries of Methow River releases at each of the sampling sites.

The Ringold and Bonneville Dam trucked groups contributed about equally to the Wenatchee and Ringold fisheries; whereas, the barged fish contributed mainly to the Ringold fishery. Increased survival of the transported groups to Bonneville Dam resulted in these groups contributing two to three times as many fish to the Ringold sport fishery as those released at Ringold (Appendix Table B3). The ability to increase the sport harvest in selected areas by providing a limited homing imprint and enhancing survival by transporting smolts around dams could be a useful tool for future management of these mid-Columbia River stocks.

Wells-Winthrop - 1979 Experiment

The 1979 experimental design was identical to the 1978 design except there was no Ringold release in 1979. The two control groups were made up of approximately 20,000 fish each, and the two test groups were made up of 10,000 trucked fish to Bonneville Dam and 17,000 barged fish to Bonneville Dam.

Returns of 1-ocean age fish from both the 1978 and 1979 experiments at the four in-river sampling locations indicate that overall survival of the various treatment groups in 1979 was only about one-third that of the 1978 release. In 1980, a total of 122 fish (0.18%) from all treatment groups of the 1979 experiment were recovered at the four sampling sites. In 1979, with comparable sampling effort, a total of 582 fish (0.6%) from all treatment groups of the 1978 experiment were recovered (Table 13, Appendix Table B4). The apparent difference in survival between the 2 years cannot be explained at this time. Data from returns of 2-ocean age fish in 1981 and recoveries in the sport fishery are needed before final conclusions can be drawn on possible differences in survival between 1978 and 1979.

Because of the poor returns of 1-ocean fish from 1979, there was insufficient data to provide any meaningful comparisons between treatment groups except possibly at Priest Rapids Dam (Table 13); data collected indicated that survival of the lower Methow River control group was only about one-third the survival of the Winthrop control group. By comparison, the Methow River control release returned at a higher rate than the Winthrop control release in 1978 (Table 11, Appendix Table B4). Data collected on these fish during their downstream migration at McNary Dam (RM 293) and John Day Dam (RM 215) indicated that the apparent mortality

Table 13.--Preliminary returns to four 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 in 1979. Recoveries were from June to November 1980.

Sampling location and experiment	Homing site	Control or test	Number juveniles released	Number adults recaptured [a/]	Adult return (% of juveniles released)	Test to Control ratio
Bonneville Dam						
Winthrop NFH	Winthrop	Control	18,298	0	0.0	
L. Methow River	Methow R.	Control	20,052	1	0.005	
Truck to Bonneville	Winthrop	Test	9,741	8	0.082	
Barge to "	Winthrop	Test	17,152	7	0.041	
Indian fishery						
Winthrop NFH	Winthrop	Control	18,298	0	0.0	
L.Methow River	Methow R.	Control	20,052	0	0.0	
Truck to Bonneville	Winthrop	Test	9,741	3	0.031	
Barge to "	Winthrop	Test	17,152	16	0.093	
McNary Dam						
Winthrop NFH	Winthrop	Control	18,298	2	0.011	
L. Methow River	Methow R.	Control	20,052	0	0.0	
Truck to Bonneville	Winthrop	Test	9,741	2	0.021	
Barge to "	Winthrop	Test	17,152	19	0.111	
Priest Rapids Dam						
Winthrop NFH	Winthrop	Control	18,298	28	0.153	
L. Methow River	Methow R.	Control	20,052	10	0.050	0.33:1
Truck to Bonneville	Winthrop	Test	9,741	15	0.154	1.07:1
Barge to Bonneville	Winthrop	Test	17,152	11	0.064	0.42:1

a/ Because of differences in sampling efficiency at each recovery site, results are not comparable between sites.

occurred during their downstream migration between the point of release and McNary Dam. Estimated survival of the Winthrop control to McNary Dam was twice that of the lower Methow River control group. Whether the mortality was dam related or resulted from lack of smolting or failure to migrate is not known at this time. Judging from a similar lack of returning transported fish that had been protected from dams, and a higher rate of return from the 1979 Chelan-Leavenworth experiment, it appears that perhaps a good portion of the Wells Hatchery fish used for the experiment in 1979 were not ready to migrate at the time of release.

Chelan-Leavenworth - 1978 Experiments

The object was to determine the length of time required to imprint steelhead from Chelan Hatchery (WDG) 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-control groups, of approximately 24,000 fish per group, held at Leavenworth NFH 10 days, 2 days, and 4 h. The test groups were transported by truck from the Leavenworth NFH homing site to a barge at Richland, Washington, and then down river to a release site below Bonneville Dam. Controls were released directly into the Icicle River. Additional details for the experimental design, number of fish per group, etc. are provided in a previous report (Slatick et al. 1979).

Homing.--Recoveries of 1-ocean age steelhead at the Leavenworth NFH homing site in the spring of 1980 indicate that the imprint method used,

combined with a truck-barge transport of fish, was unsuccessful in returning steelhead to the homing site. Only one fish from each test group was recovered, compared to 20 (0.083%), 23 (0.097%), and 20 (0.091%) for the 10-day, 2-day, and 4-h control groups, respectively. An examination of test/control ratios of returning adults at Bonneville, McNary, and Priest Rapids Dams illustrates the increasing loss of homing as these fish moved upstream (Figure 6). For all three treatment groups combined, the test/control ratios were 2.66:1 at Bonneville Dam, 1.34:1 at McNary Dam, and 0.15:1 at Priest Rapids Dam.

The most apparent loss of homing for the transported groups occurred in the 104-mile section of river between McNary and Priest Rapids Dams. This was verified by the 0.15:1 test/control ratio at Priest Rapids Dam and the recoveries of test and control fish in the major sport fishery areas (Table 14). Most of the test fish were caught below Priest Rapids Dam in the free-flowing stretch between Ringold and Priest Rapids Dam. In contrast, most of the control fish continued their upriver migrations and were caught in the Wenatchee sport fishing area, or returned to the hatchery.

Straying.--Straying into the Snake River was minimal based on recoveries at Lower Granite Dam (Snake River Mile 107). No fish from the control groups were recovered, and fish from only two of the barged groups were observed.

Survival and Contribution to Fishery.--Relative differences in survival between treatment groups of 1- and 2-ocean age steelhead returning to the Columbia River system are illustrated by differences in the test/control ratios of the treatment groups at Bonneville and McNary Dams. Survival was highest for the 2-day imprint group: 6.69:1 vs 1.59:1 and

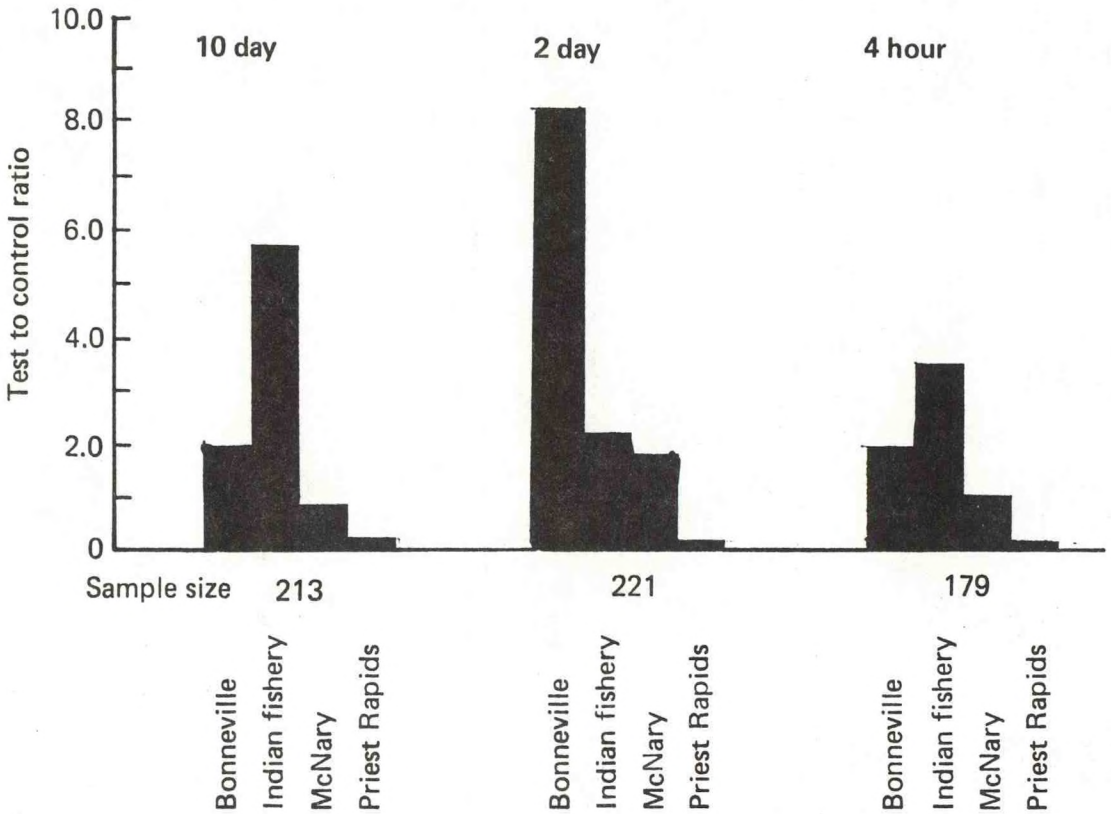

Figure 6.--Test to control ratios for returns to four sampling locations on the Columbia River of combined 1- and 2-ocean age steelhead from control and test releases of smolts from the Chelan Hatchery which were imprinted to the Leavenworth NFH homing site for 10-day, 2-day, and 4-h time periods in 1978. Recoveries were from June 1979 to 30 November 1980. The broken line indicates the level of return for control fish.

Table 14.--Estimated recovery of 1-ocean age steelhead returning from control and test releases of juveniles from the 1978 Chelan-Leavenworth experiment, in six sampling locations. Recoveries were from June 1979 to May 1980.

Control or test groups	Number juveniles released (N)	Sport fishery[a/]					Hatchery broodstock (N)	Leavenworth homing site (N)	Total recovery		Test to control ratio
		Indian fishery (N)	Ringold area (N)	Wenatchee area (N)	Rocky Reach pool area (N)	Methow area (N)			(N)	(%)	
10-DAY IMPRINT (Control #1)	24,119	30	0	157	0	0	10	20	217	0.900	
2-DAY IMPRINT (Control #2)	23,787	58	34	212	2	8	6	23	343	1.441	
4-HOUR IMPRINT (Control #3)	21,957	41	0	161	4	15	3	20	244	1.111	
10-DAY IMPRINT (Test #1)	22,841	164	34	9	0	2	0	1	210	0.919	1.05:1
2-DAY IMPRINT (Test #2)	21,694	110	102	9	0	0	1	1	223	1.028	0.71:1
4-HOUR IMPRINT (Test #3)	23,551	153	153	26	0	0	1	1	334	1.418	1.28:1
TOTAL	137,949	556	323	574	6	25	21	66	1,571	1.139	

a/ Data supplied by WDG.

1.81:1 at Bonneville Dam, and 2.03:1 vs 1.12:1 and 1.06:1 at McNary Dam (Appendix Table B5).

The impaired homing above Bonneville Dam resulted in an accompanying delay in migration. As a result of this delay, test fish, especially the 10-day imprint group, were more vulnerable or available to the Indian gill-net fishery as evidenced by the 5.76:1 test/control ratio measured for this group and the large number of test fish recoveries from all treatments in this fishery (Table 14, Appendix Table B5).

Overall recovery of 1-ocean age steelhead to the various user groups was quite high, ranging from 0.9 to 1.44% of the juveniles released (Table 14). Control releases (1.15%) and test releases (1.14%) contributed equally to the user groups. Most of the sport fish recoveries of test fish were in the Ringold fishery. Increased survival of the transported fish to Bonneville Dam, as with the Wells-Winthrop groups, resulted in these groups contributing up to four times the recovery rate of fish released directly at Ringold (Appendix Table B3). The ability to increase the sport harvest in selected areas by methods used in this experiment could be a useful tool for future management of those mid-Columbia River stocks.

Chelan-Leavenworth - 1979 Experiment

Our experimental design used three paired test/control groups of approximately 24,000 fish per group held 10 days, 2 days, and 6 h. This is a replicate of the experiment conducted in 1978 with a minor modification (a control and test group were held 6 h at Leavenworth NFH instead of 4 h).

Adult returns from this experiment are preliminary and consist of recoveries of 1-ocean age steelhead in the Columbia River. Test/control ratios from the four sampling locations illustrate the relative differences in survival between treatment groups and the progressive loss of homing of

all groups as the fish moved upstream (Figure 7). The test/control ratios for the 6-h and the 10-day imprint groups were comparable to the 1978 release. Test/control ratios for the 2-day imprint group in 1979 were much different than for the 1978 release. Apparent survival of test fish was less than the controls as indicated by the 0.86:1 and 0.81:1 test/control ratios at Bonneville and McNary Dams. In contrast, the 2-day imprint group released in 1978 had the highest relative survival of the treatment groups.

The decline in test/control ratios above Bonneville Dam combined with the high test/control ratio in the Indian fishery (up to 5.03:1) were similar to the 1978 release, and again indicated that homing was impaired causing a delay in migration, making these test fish more vulnerable to the Indian gill-net fishery.

By the time these steelhead passed over Priest Rapids Dam (104 miles above McNary Dam), test/control ratios declined significantly. This is also consistent with the returns from the 1978 release and indicate a nearly complete loss of homing by the time the test groups reached Priest Rapids Dam. Final determination will not be possible until returns from the sport fishery in the Wenatchee River and hatchery are complete.

In 1979, a total of 626 fish (0.45%) from all treatment groups of the 1978 experiment were recovered (Appendix Table B5 and B6). In 1980, with comparable sampling efforts, a total of 470 fish (0.34%) from all treatment groups from the 1979 experiment were recovered at the four sampling sites. The 25% decline between the 1978 and 1979 Chelan-Leavenworth experiments was much less than the decline noted between the 1978 and 1979 Wells-Winthrop experiments. This would indicate that fish condition or their degree of smoltification at time of release can significantly affect the results of any homing experiments.

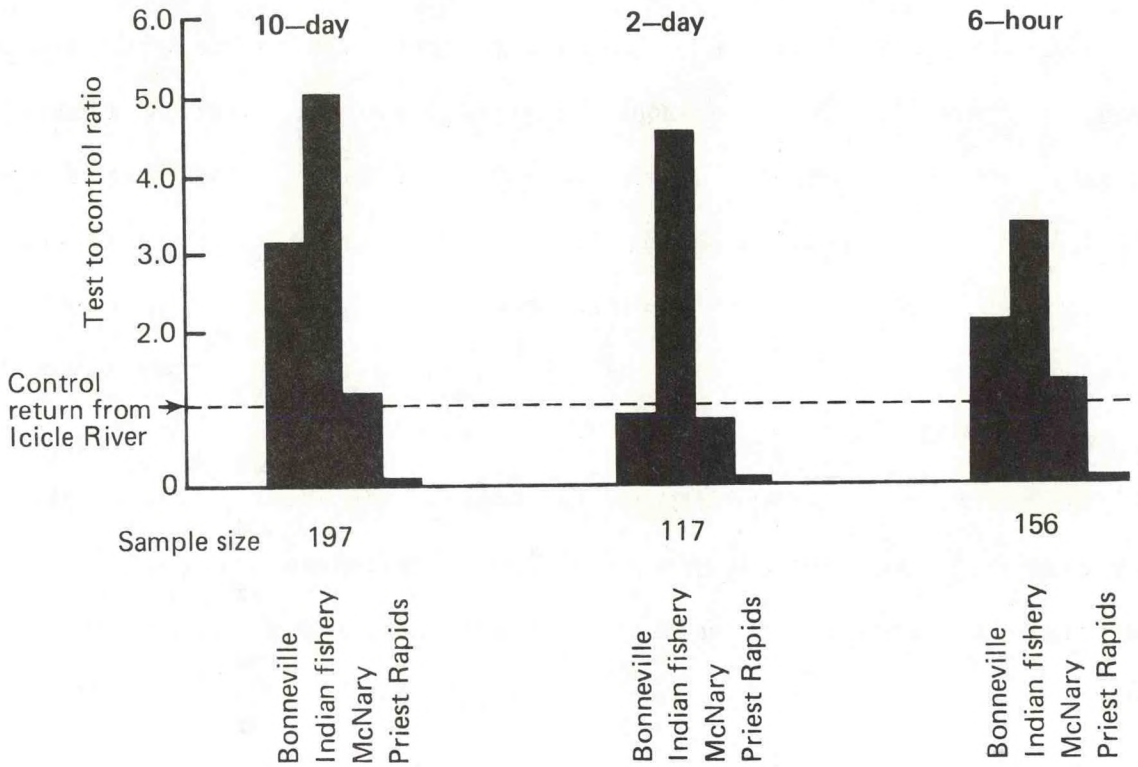

Figure 7.--Test to control ratios for preliminary adult returns for four sampling locations from control and test releases of smolts from the Chelan Hatchery which were imprinted to the Leavenworth Hatchery homing site for 10-day, 2-day, and 6-h time periods in 1979. Recoveries were from June to 30 November 1980. Control fish were all released into the Icicle River. The broken line indicates the level of return for control fish.

Salmon

Data on adult returns to homing sites from releases of juvenile salmon are still preliminary. The majority of adult salmon will return between 1981 and 1984.

Spring Chinook Salmon - Kooskia - 1978 Experiment

The goal of the 1978 experiment at Kooskia NFH was to determine if single or sequential exposures to early migration route waters would ensure homing in juvenile spring chinook salmon transported directly from the hatchery (RM 541) to below Bonneville Dam (RM 145). The test design included a control group released from the hatchery into Clear Creek, a tributary of the Middle Fork Clearwater River, and four test groups released below Bonneville Dam. Details of the test design are given in Appendix Table B7.

The return of jacks and 2-ocean age adults from this test is complete. Data currently are limited, but will likely represent about 75% of the adult return (personal communication, Bruce McCloud, USFWS[1/]). To date, seven fish have returned from the control release, and four fish from the test groups. The single test fish returning to Kooskia NFH had been sequentially imprinted by adding Middle Fork Clearwater River and Snake River waters during the course of truck transport from the hatchery to the release site below Bonneville Dam.

Adult returns will not be sufficient to evaluate the test. In 1980 (the major adult return year for 1978 releases), only 60 adult spring chinook salmon returned to Kooskia NFH. Low returns of spring chinook

1/ Bruce McCloud, Kooskia National Fish Hatchery, Route 1, Box 98-A, Kooskia, ID 83539, pers. comm.

salmon from releases in 1978 were a generalized problem in the Snake River drainage and were probably related to high estuary or early ocean mortality (Park 1980). A high incidence of bacterial kidney disease in the spring chinook salmon released from Kooskia NFH in 1978 was also noted (Novotny and Zaugg 1979) and could be a contributing factor to the low adult returns.

Fall Chinook Salmon - Stavebolt Creek - 1979 Experiment

The 1979 Stavebolt Creek homing test utilized 11 marked groups totaling 473,027 fall chinook salmon of Spring Creek NFH origin. The first release series was made between 28 and 31 March, the second between 17 and 22 May, and the third on 26 June (Table 15). Additional details of the experimental design are given in a previous report (Slatick et al. 1980). Objectives were to: (1) determine if Na^+-K^+ ATPase enzyme activity could be used to indicate time periods when fish would be most receptive to homing cues, (2) determine if 4- or 48-h exposures to Stavebolt Creek water would provide an adequate imprint, and (3) determine if an imprint to Stavebolt Creek would result in homing of fish that were denied exposure to the Lewis and Clark River and Youngs Bay (intermediate routes between Stavebolt Creek and the release point on the Columbia River).

Recoveries reported to date are for jack chinook salmon. Adult returns in 1981-83 will contribute to these data and provide the basis for analysis of the test. Initial recoveries indicate a substantial contribution from the first release series; although involving only 28% of the test fish released, they account for 92% of the recoveries (Table 15). During the fall of 1980 there were no recoveries at the Stavebolt Creek homing site, and no test fish were observed during stream surveys of the

Table 15.--Preliminary recoveries of fall chinook jack salmon (1-ocean age) in the ocean and Columbia River fisheries from control and test releases of smolts from the 1979 Big White Salmon Rearing channel — Stavebolt creek experiment. Recoveries were from June through 31 December 1980.

Marked group	Number released	Recoveries: Ocean fisheries	Youngs Bay	Columbia River Zones 1 - 3	Columbia River Zone 6	Hatchery recoveries (strays)	Total recoveries N
First $NA^+ - K^+$ ATPase series (released 28 to 31 March 1979)							
Control #1 1/	42,419	8	0	1	2	3	14
Test #1 2/	44,401	13	16	4	0	0	33
Test #2 4/	47,337	18	18	5	0	0	41
Subtotal		39	34	10	2	3	88
Second $NA^+ - K^+$ ATPase series (released 17 to 22 May 1979)							
Control #2 1/	47,788	2	0	1	0	1	4
Test #3 2/	49,300	0	0	0	0	0	0
Test #4 3/	46,292	0	0	0	0	0	0
Test #5 4/	48,153	0	1	0	0	0	1
Test #6 5/	47,668	1	1	0	0	1	3
Subtotal		3	2	1	0	2	8
Third $NA^+ - K^+$ ATPase series (released 26 June 1979)							
Control #3 1/	28,542	0	0	0	0	0	0
Control #4 1/	34,779	0	0	0	0	0	0
Control #5 1/	36,348	0	0	0	0	0	0
Subtotal		0	0	0	0	0	0
TOTAL		42	36	11	2	5	96

1/ Control groups were released into the Big White Salmon River.
2/ Stavebolt Creek imprint (48 h) - Hammond, OR. release.
3/ Stavebolt Creek imprint (4 h) - Hammond, OR. release.
4/ Stavebolt Creek imprint (48 h) - Stavebolt Creek release.
5/ Stavebolt Creek imprint (4 h) - Stavebolt Creek release.

Lewis and Clark River or other tributaries of Youngs Bay. The Youngs Bay commercial fishery was sampled intensively, and 36 marked fish were recovered, 34 of which were from the first release series. These returns indicate a nearly equal contribution to the Youngs Bay fishery from the natural migrant group and from the single imprint group released at Hammond, Oregon. Recoveries in the various fisheries from the first test series also indicated test fish were contributing much more than control fish.

Although no fish were recovered at the Stavebolt Creek homing site, the data indicate that the single imprinted group did receive a limited homing cue which enabled these fall chinook salmon jacks to return to the geographic drainage area in which the homing site was located, i.e., Youngs Bay. This type of homing behavior is similar to that exhibited by adult coho salmon from the 1978 Stavebolt Creek experiment (Slatick et al. 1980).

Coho - Willard - 1980 Experiment

To date six jacks have been recovered at Little White Salmon NFH, the homing site for this test. Adult returns to Little White Salmon NFH in 1981 will provide the basis for analysis of this test.

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 analyses are complete, we will provide the data as a supplement to this report.

SUMMARY

During the third year of research on imprinting salmon and steelhead for homing, a total of 1,493,589 salmonids were marked and

released--650,091 spring chinook salmon, 343,091 fall chinook salmon, 423,121 coho salmon, and 77,286 steelhead. The primary objectives of the research were to: (1) determine a triggering mechanism to activate the homing imprint in salmonids, (2) determine whether a single imprint or sequential imprinting is necessary to assure homing for various stocks of salmonids, and (3) determine the relationship between the physiological condition of the fish and imprinting.

In 1980, experimental groups of juvenile spring chinook salmon were given a homing imprint to the Leavenworth NFH on the Icicle River and Carson NFH on the Wind River. Fall chinook salmon were imprinted to the Spring Creek NFH and to Stavebolt Creek, a tributary to the Lewis and Clark River. Coho salmon were imprinted to the Little White Salmon River. Steelhead were imprinted to the Snake River. This year our research initiated the use of a "limited migration" to implant a homing imprint in juvenile fish.

Preliminary returns of 1- and 2-ocean age steelhead from the 1978 and 1979 homing experiments were assessed at five in-river sampling locations on the Columbia and Snake Rivers from June 1979 through November 1980. A total of 3,085 steelhead were examined; 821 from the Wells-Winthrop experiment, 1,186 from the Chelan-Leavenworth experiments, 208 from the Tucannon experiments, and 870 from the Dworshak experiment. Generally test/control ratios indicated higher survival for the test groups (transported) than the control groups (nontransported) at the two lower-river sampling locations (Bonneville Dam and the Indian gill-net fishery). At Priest Rapids Dam, sampling showed lower test/control ratios indicating a large number of test fish remained in the river system below

the sampling site, and there is a loss of homing for the test groups. Final assessment of whether homing was actually impaired for fish returning in this migration year will not be possible until returns from the sport fishery, homing sites, and hatcheries are complete (July 1981).

On the Snake River, however, returns of steelhead (1978 experiment) to Lower Granite Dam and to Dworshak NFH indicate fish transported by barge are returning at a higher rate than the hatchery control group. Although returns are not complete at Dworshak NFH for these groups, the data suggest a significant breakthrough in efforts to transport fish direct from hatcheries while assuring substantial adult returns and therefore homing ability of the fish.

Although the homing of the test groups was impaired in regard to returning adult fish to the tributary rivers where the homing sites were located (Wenatchee and Methow Rivers), a large number of these fish apparently received a "limited imprint' which enabled them to return to the mid-Columbia River above McNary and Priest Rapids Dams (RM 292 and 397, respectively) and contribute significantly to the sport fishery in the Ringold and Wenatchee areas.

Straying of 1-ocean age steelhead into the Snake River from experimental groups of fish imprinted to the upper mid-Columbia River system was minimal. The only exception was the group imprinted to the Winthrop NFH and trucked to below Bonneville Dam. Recoveries at Lower Granite Dam (Snake River Mile 107) indicated that an estimated 105 fish (0.55%) from this group entered the Snake River.

The exploitation rate of these experimental groups of 1-ocean age steelhead by various user groups in Washington was quite high. Even though homing was impaired to various degrees on the test groups, the survival

resulting from transporting smolts around dams to Bonneville Dam resulted in the transport groups contributing more to the sport fishery at Ringold than those fish originally released as juveniles at Ringold. The ability to increase the sport harvest in selected areas by methods used in these experiments could be a useful tool for future management of these mid-Columbia River stocks.

Adult returns of spring chinook salmon to the Kooskia NFH are insufficient to evaluate the experiment. Low adult returns from the 1978 outmigration of spring chinook salmon were a general problem in the Snake River drainage.

Preliminary returns of jack fall chinook salmon to Stavebolt Creek and jack coho salmon to the Little White Salmon NFH were inconclusive. Principal returns of adults from these experiments are expected in ensuing years (1981 to 1984).

RECOMMENDATIONS

There is a definite need to expand the homing imprint research at Dworshak NFH. The encouraging results from the 1978 test were from fish barged in one load in late April 1978. It is not known whether this is the optimum date for direct barging or how much time is available for barging while still retaining sufficient imprinting of fish so they will return to the hatchery. This information is required before a meaningful recommendation can be made for production operations. Serial releases of several barge loads of fish extending over a 30-day period bracketing the normal hatchery release period should provide the necessary answers.

In future operations where managers desire to barge all fish from Dworshak NFH, at least six loads would be required to transport the current

levels of production. Such a project would take one barge operating continuously about 1 month. Therefore, it is clear that a much more complex experiment is needed before meaningful recommendations can be made for production operations.

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APPENDIX A

ROLE OF SHORT DISTANCE MIGRATION ON THE HOMING OF SALMON AND STEELHEAD

A completion report
submitted to
National Marine Fisheries Service
Contract 80-ABC-00115

by

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ABSTRACT

Eight groups of salmon and steelhead smolts were marked and released in 1980 to evaluate the effect of a short distance seaward migration on homing. Four of the groups migrated normally from their respective hatcheries or usual release points and the other four were allowed to voluntarily migrate a short distance from the hatchery ponds before being collected, marked (if not already) and transported to the Lower Columbia River. The shortest distance voluntary migration amounted to merely migrating out of a raceway at Lower Granite Dam. Other groups migrated across the hatcheries in discharge flumes and then entered traps. The Rapid River chinook migrated out of the hatchery ponds and down Rapid River about three miles before they were trapped, marked, and transported.

More of the short distance migration-transport fish of all stocks were recaptured by National Marine Fisheries Service personnel near the estuary compared to the normal migration fish. Fish were collected near the estuary by purse and beach seining.

Adult returns from the 1980 and prior year releases will be monitored through 1984 to evaluate the number of adults produced and the ability of those adults to return to their natal area. Downriver fisheries, Idaho sport fisheries and returns to hatcheries or dams will be monitored for marked adult fish.

INTRODUCTION

Studies to evaluate the role of seaward migration on the acquisition of homing cues for chinook salmon and steelhead trout were expanded in 1980. Our objective is to determine if smolts pick up sufficient cues for satisfactory homing when they initiate their seaward migration. Three groups of chinook salmon and one group of steelhead trout smolts were allowed to migrate a short distance voluntarily before they were collected and transported to the Lower Columbia River. Control groups for each of the short distance migration-transport groups were allowed to migrate seaward naturally.

Two general observations led us to believe that salmon and steelhead smolts can pick up the cues they need for homing once they start their seaward migration and the acquisition of cues may occur in a short time period. The first observation was that salmon and steelhead usually return to the point of release. Fish released at the hatchery normally return to the hatchery, but fish taken from the hatchery and released at other locations usually return to the point of release. In some coastal streams, smolts transplanted to a different drainage than the one the hatchery is located in may spend as little as one day migrating before they reach the ocean. Despite the short time they spend in the stream of release, the transplanted fish are able to acquire the cues they need to lead them back to the release point.

The second observation was that transporting salmon and steelhead smolts from Lower Granite and Little Goose Dams on the Snake River around the remainder of the dams to below Bonneville Dam apparently has not impaired their homing as adults. Even though the smolts do not migrate through the Lower Snake River, the Snake-Columbia rivers confluence area, or the Columbia River

upstream from Bonneville Dam, they successfully return as adults to their natal areas. In some cases the smolts have migrated less than 100 miles and as few as 4-5 days when they are collected at Lower Granite Dam and transported to the lower river. These Snake River fish have apparently already acquired the cues they need for successful homing by the time they reach Lower Granite Dam.

Another instance that led us to believe that smolts acquire homing cues rapidly at the onset of seaward migration seemed to be contradictory at first glance. Steelhead trout smolts collected in the outlet trap of Barnaby Slough rearing facility adjacent to the Skagit River in Washington were transported by truck to a release point upstream from the slough. When the adults returned to the slough rather than the upstream release point, we wondered why this case was an exception to the general observation that fish return to the release point. In subsequent studies in the Clearwater River of Idaho, we found that fish transported to an upstream release point will bypass the hatchery where they were reared and return to the release point. In the Barnaby Slough case, the smolts had to migrate voluntarily out of the slough into the trap before they could be transported to the upstream release site. We suspect that the smolts acquired their primary homing cues when they migrated out of the slough and that is the reason they returned to the slough and not the upstream release point. In the Clearwater River case, the fish were pumped into trucks from the rearing pond and did not initiate any seaward migration until released upstream from the hatchery.

Whatever cues the fish use for homing, retention of those cues apparently begins with the onset of migration. In 1977 and later years, Slatick et al. (1980) conducted experiments to determine if transporting fish from the

hatchery to the Lower Columbia River in tank trucks or barges with water from the various sections of river they would normally pass through would enable fish to home back to the hatchery. Although the fish were subjected to the olfactory cues of the river water as they were transported, they apparently did not retain sufficient cues because relatively few returned as adults to the hatcheries compared to control groups (Slatick et al. 1980, Idaho Cooperative Fishery Research Unit, unpublished data). Fish transported in the barges with recirculating river water and open-top compartments also apparently failed to retain the cues that were available and thus considered the barge as merely another rearing container rather than the start of their seaward migration.

In 1979, a group of steelhead from Dworshak NFH and a group of spring chinook from Kooskia NFH were transported to the lower Columbia River following a short voluntary migration at their hatcheries. Adult returns from the 1979 and 1980 smolt releases will be evaluated before additional testing is undertaken. If the short distance migration fish return at rates similar to the normally migrating fish, then additional testing might be necessary to determine the extent of migration necessary.

FISH MARKED AND RELEASED

Spring Chinook - Rapid River SFH

A group of fish marked by Idaho Department of Fish and Game (IDFG) personnel for a contribution to fisheries study was used as the normal migration group from Rapid River State Fish Hatchery (SFH). The normal migration group was tagged, fin clipped (adipose) and branded in November, 1979. The fish were taken from a rearing pond, processed through the marking trailer and then released into an effluent channel. The channel was not screened so the fish could leave and migrate downstream during the winter or early spring if they chose to do so. Voluntary migration out of the rearing ponds during the fall and winter is allowed normally at Rapid River SFH. The normal migration group consisted of 82,360 fish tagged with coded wires with binary codes 10/21/13 and 10/21/14 (Table 1). Sixty-one thousand of the fish with coded wire tags (CWT) were also branded (LA 1U 1st position).

Because some of the November marked fish could migrate downstream before the usual spring seaward migration when the test group was released, we also branded (RA 1U 1st position) 10,300 fish and released them for normal migration in April, 1980 (Table 1). We wanted to compare the relative survivals to Lower Granite Dam and the estuary of normal migrating fish, some of which left the hatchery in the winter versus those released in April the same as the test group.

The test group of spring chinook, referred to as the migration-transport group, at Rapid River SFH migrated voluntarily from the hatchery ponds in April, were collected from Rapid River after they had migrated downstream 3 miles and were then marked and transported by truck and barge

Table 1. Spring chinook salmon smolts marked at Rapid River SFH, 1979-80, as part of the migration-homing study.

	Normal migration groups			Migration-transport group
	CWT[a] 10/21/13 Brand LAlU	CWT 10/21/17 Brand LAIU	Brand RAIU	CWT 10/21/15 Brand LAΠI
Number of fish marked				
CWT	39,204	43,156	-	39,206
Brand	39,204	21,804	10,304	39,206
Date fish released	11/5/79[b]	11/5/79[b]	4/15/80	4/15/80
Mean total length at release (mm)	130 (n=383)	130	149 (n=366)	144 (n=369)
Fish recaptured:				
At Lower Granite Dam	2[c]	804[d] 132[c]	114	4[c]
Estuary netting	1[c]	13[d] 6[c]	10	25
Estimated number collected at Lower Granite Dam		6391[e]	1703[e]	-

[a]CWT - binary wire tag code.

[b]Marked fish placed in effluent channel at hatchery after marking. Fish could leave the channel and some did during the fall and winter. The remainder left in the spring.

[c]Sacrificed fish with ad clips and CWT.

[d]Branded fish that were not sacrificed.

[e]Based on brand recoveries.

to below Bonneville Dam. The migration-transport fish were tagged with CWT (code 10/21/15) and branded (LA 1U 3rd position) (Table 1). About 13,000 of the migration-transport fish had to be released in Blalock Slough, an arm of the John Day Pool, when a tank truck malfunctioned. Some mortality was observed and the fish may have had some difficulty finding the culvert leading to John Day Reservoir.

Normally migrating fish might also be thought of as migration-transport fish because some are transported to the Lower Columbia River if collected at one of the dams. Normally migrating fish differ from our migration-transport test fish in that the normal migration fish must migrate to the dam(s) and some are not collected and transported.

Normal migrating fish averaged 130 mm total length when tagged in November, 1979 and those sampled in April, 1980 averaged 151 mm. Migration-transport fish averaged 144 mm when tagged in April, 1980.

Spring Chinook - Kooskia NFH

Both the normal migration group and the migration-transport group of spring chinook released from Kooskia National Fish Hatchery (NFH) in 1980 were tagged (CWT) and fin clipped before any migration was allowed. The normal migration group (CWT code 5/5/32) was flushed from the raceways and out of the hatchery on April 16, 1980 (Table 2). The migration-transport group (CWT code 5/5/29) was then allowed to migrate voluntarily out of the raceways and across the hatchery in the effluent flume (approximately 100 meters) before they were trapped, placed in a truck, and transported to the Lower Columbia River. Voluntary migration of the migration-transport group took place over a 12 day period (April 23 to May 5). Fish used in the 1980 releases were yearling smolts that averaged 131 mm total length when released.

Table 2. Spring chinook salmon smolts marked at Kooskia NFH, 1980, as part of the migration-homing study.

	Normal migration group	Migration-transport group
Number of fish marked		
Coded wire tag	61,300	62,300
Wire tag code	5/5/32	5/5/29
Date fish released	16 April 80	23 April - 5 May 80
Mean total length at release (mm)	131	131 (n=505)
Fish recaptured:		
At Lower Granite Dam	373[a]	37[a]
Estuary netting	19[a]	44[a]
Estimated number collected at Lower Granite Dam	10,863	364

[a]Recoveries of fish with coded wire tags.

Fall Chinook - Hagerman NFH

Fall chinook salmon released in 1980 were fish reared at Hagerman National Fish Hatchery (NFH) as part of the Snake River fall chinook egg bank program. Adults were collected in September, 1979 at Ice Harbor Dam and transported to Tucannon SFH. Eyed eggs were then shipped to Hagerman NFH, where the fish were reared until they appeared to be smolts. The fish were tagged (CWT) in May 1980 and then transported from the hatchery in early June.

The normal migration group (CWT code 5/5/27) was released in the Snake River near Asotin on June 3, 1980 (Table 3). The fish averaged 93 mm when released. After release, these fish had to migrate down the Snake River at least to Lower Granite Dam. If collected at the dams they were transported to the Lower Columbia River.

The migration-transport group (CWT code 5/5/28) was transported to Lower Granite Dam on June 5, 1980 and placed in the upper end of a raceway at the collection facility. Three plywood baffles were placed in the raceway at mid point, lower quarter, and tail end so that fish would have to drop over them to leave the raceway. When fish moved over the last baffle at the lower end of the raceway they went through a pipe into a waiting truck and were then transported to the Lower Columbia River. Migration from the upper to the lower end of the raceway occurred over a period of 17 days. Most of the fish migrated voluntarily from the raceway at night in the first 5 days. Fish remaining in the raceway were fed each day. Fish released into the raceway averaged 91 mm in length. The fish fed actively and appeared healthy while in the raceway.

Table 3. Fall chinook salmon smolts marked at Hagerman NFH in 1980 as part of the migration-homing study.

	Normal migration group	Migration-transport group
Number of fish marked		
Coded wire tags	58,360	55,640
Wire tag code	5/5/27	5/5/28
Date released	3 June 80	6-23 June 80
Mean total length at release (mm)	93 (n=326)	91 (n=399)
Fish recaptured:		
Estuary netting	7[a]	40[a]

[a]Fish with coded wire tags.

Steelhead Trout - Dworshak NFH

Steelhead trout used in the 1980 migration-homing studies were age I fish produced in system II at Dworshak NFH. The fish released in 1980 were in good health and should provide reliable results.

The normal migration group was tagged by IDFG personnel for their hatchery contribution studies. The 59,100 fish with wire tags (code 5/4/55) were released on April 17, 1980 by flushing the ponds into the main stem Clearwater River. The fish averaged 185 mm total length when released.

The migration-transport group was tagged (code 10/21/19) after the fish had voluntarily migrated out of the three ponds in system II, down an effluent sluiceway and into our trap. We started trapping and marking migrants on April 28 and finished on April 30. During the 3 days, 40,010 migrants were trapped and wire tagged with 8,490 of the tagged fish also branded (LD 4 4th position) (Table 4). The marked fish were hauled to Lower Granite Dam April 29 through May 2 and transferred to the barges or trucks for transport to the Lower Columbia River.

The migration-transport group is not strictly comparable with the normal migration group but sufficient information will result to determine if further testing of the short distance migration concept is worthwhile. The migration-transport group was made up of voluntary migrants that were probably smolts, whereas the normal migration group were flushed from the ponds and probably included some fish that didn't become smolts. The migration-transport fish were larger (199 mm total length) when released than the normal migration group (185 mm), probably a result of the selection of voluntary migrants.

Table 4. Steelhead trout smolts marked at Dworshak NFH in 1980 and released as part of the migration-homing study.

	Normal migration group	Migration-transport group
Number of fish marked		
Coded wire tags	59,125	40,010
Brands	-	8,490
Wire tag code	5/4/55	10/21/19
Brand used	-	LD ⊣
Date released	17 April 80	29 April - 2 May 80
Mean total length at release (mm)	185	199 (n=446)
Fish recaptured:		
At Lower Granite Dam	280[a]	0[a]
Estuary netting	69[a]	119[a]

[a]Recovery of CWT fish

RECAPTURE OF SMOLTS AT DAMS AND ESTUARY

Spring Chinook - Rapid River SFH

Normal migration spring chinook released from Rapid River SFH were recaptured in relatively large numbers at Lower Granite Dam in the spring of 1980. Fish marked in the fall of 1979 (LA 1U brand) that could have left the hatchery during the fall, winter or spring began showing up at the Dam in early April as soon as collections began. Fifty percent of the fish had been collected by April 23 and 90 percent by April 30. Fifty percent of the fish marked in mid April (RA 1U brand) and released for normal migration had been collected by April 29 and 90 percent by May 6. Fish that may have left the hatchery in fall or winter apparently held up in the rivers upstream from Lower Granite Dam during the winter and then resumed their downstream migration in the spring.

Based on estimated numbers of marked smolts collected at Lower Granite Dam, a smaller proportion of the fall marked fish arrived at the dam in the spring than the fish marked and released in mid April. We estimate 7.2 percent of the 61,6000 fish branded (LA 1U) in the fall were collected at Lower Granite Dam versus 16.3 percent of the 10,300 fish branded (RA 1U) in April and released. NMFS personnel estimate 10.5 percent of the fall marked fish and 16.5 percent of the fish marked in April were collected.

Because of the differential recapture rates between the fish marked in the fall versus those marked in the spring, the value of the normal migration group as a control for the migration-transport group is somewhat impaired. Assuming brand retention and readability was equal for the two groups and that the fall marked fish migrated past Lower Granite Dam only in the spring

of 1980, survival of the fall marked fish from time of marking to recapture at the Dam was not as high as the fish marked in April. The estimated collection rate of fall marked fish with coded wire tags (10/21/14) but without brands was 11.4 percent, a collection rate similar to the 10.5 percent for branded fish indicating that brand retention was high. Additional evidence of good brand retention was obtained on April 9, 1980 when we colledted 563 adipose clipped migrants from Rapid River that had been tagged and branded the prior fall. Twenty percent of those adipose clipped fish didn't have a brand. Seventy-four percent of the fish tagged in the fall were branded so that we expected to find 26 percent of the fish sampled without brands.

Ideally, equal numbers of normal migrating fish and migration-transport fish would start seaward in the spring. Fewer numbers of the fall marked fish were apparently alive to migrate in the spring than were marked in the fall. Since it is normal practice at Rapid River SFH to allow fish to leave when they wish, the comparison between the fall marked fish and the migration-transport fish marked in the spring may be appropriate for that station.

Only four of the migration-transport fish (code 10/21/15) were collected at Lower Granite Dam in 1980. A few marked fish escaped into Rapid River during marking when a holding screen collapsed at the marking site.

Since the migration-transport fish were transported from Rapid River to Bonneville Dam, the estuary sampling by NMFS personnel provides the only comparison of the relative success of the groups in reaching the ocean. Fourteen of the 82,360 normal migration fish marked in the fall, 10 of the 10,300 marked in the spring, and 25 of the 39,210 migration-transport fish were recaptured in the estuary sampling program. If all groups had been

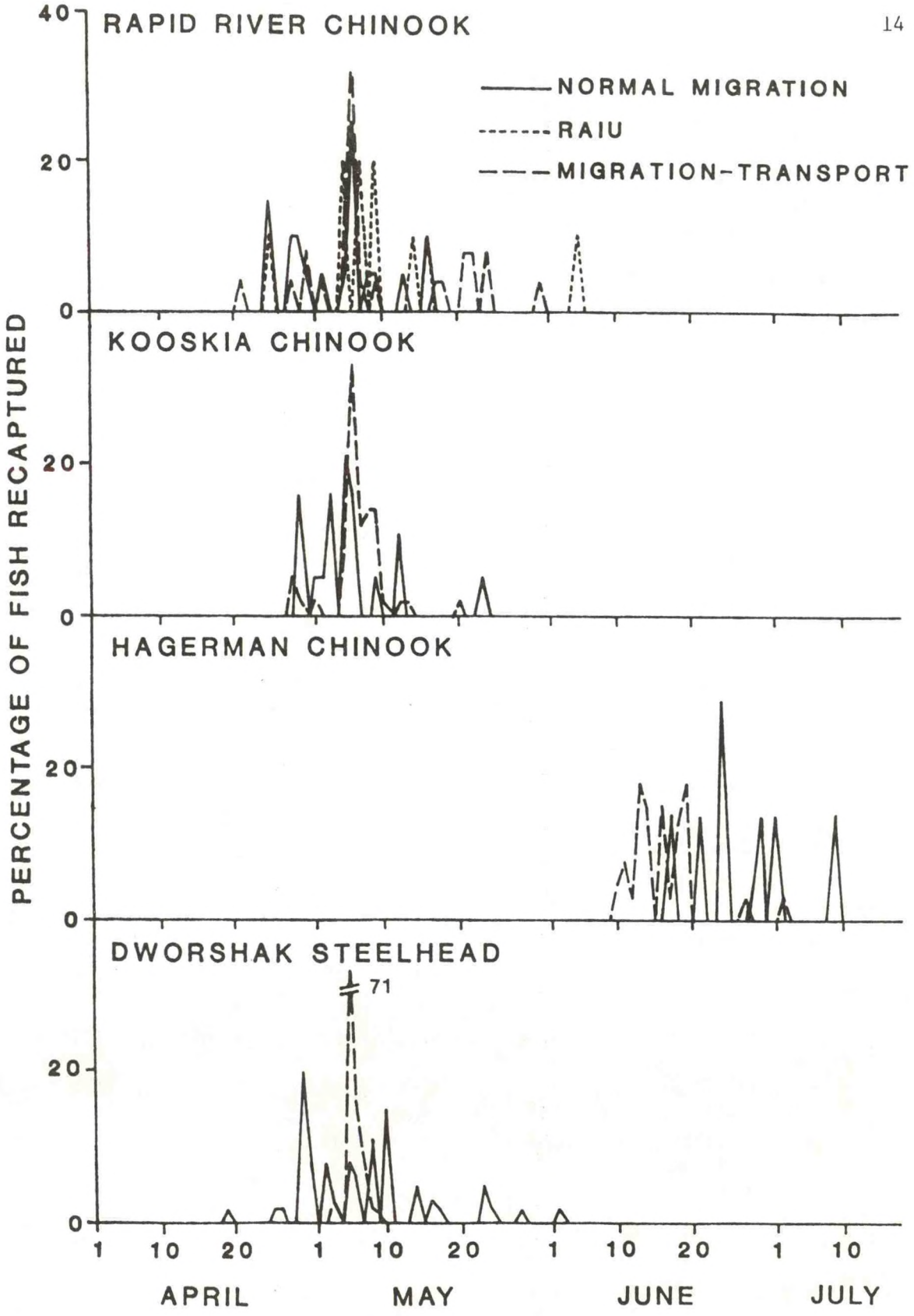

Figure 1. Timing of recapture of normal migration and migration-transport fish by NMFS personnel in the Columbia River estuary, 1980.

recaptured at the same rate as the normal migration group, there would have been 14, 2, and 7 fish recaptured, respectively, rather than the 14, 10 and 25. A larger proportion of both groups marked in April made it to the estuary.

The timing of recaptures in the estuary differed between the three groups of fish (Figure 1). The normal migration group marked in the fall passed through the estuary earlier than the normal migration fish marked in the spring or the migration-transport group.

Spring Chinook - Kooskia NFH

At Lower Granite Dam, 373 of the normal migration fish were recaptured and examined and 37 of the migration-transport fish. About 2000 of the migration-transport fish must have still been in the underground flume at the hatchery when we stopped trapping and hauling that group downstream. They subsequently left the hatchery and migrated downstream.

National Marine Fisheries Service personnel estimated that the 373 normal migration fish examined meant that 10,536 had been collected at the dam and transported downstream. They estimate that 29,300 of the 61,300 fish released (48%) survived and arrived at Lower Granite Dam. Collection efficiency for chinook at the dam was estimated to be 36 percent at the time those fish were migrating.

In the estuary sampling by NMFS personnel at Jones Beach (Columbia River km 75) and Astoria (river km 16), 19 of the normal migration fish were collected and 44 of the migration-transport fish (Table 2). With adjustments for sampling rates at Jones Beach, the total recaptures at both sites would have been 32 and 62, respectively. Nearly twice as many of the migration-transport fish made it to the estuary as the normal migration fish.

The timing of migration through the estuary was similar for both the normal migration and migration-homing groups (Figure 1). Voluntary migration from the raceways of the migration-transport group was not allowed to start until April 23 to insure that the normal migration fish released April 16 had left the hatchery. Had both groups left the hatchery on the same date, the migration-transport group probably would have reached the estuary first.

Normal migration spring chinook from Kooskia NFH reached Lower Granite Dam at about the same rate (48%) as the normal migration fish branded and released in Rapid River in April (46% according to NMFS data). NMFS personnel estiamted only about 30 percent of the fall marked fish from Rapid River SFH reached the dam (29% of the fish with brands and tags, 31% of the fish with only tags).

Fall Chinook - Hagerman NFH

Nose tagged fish were not sacrificed at Lower Granite Dam when the fall chinook were moving downstream in 1980. However, most, if not all, the fish with adipose clips that entered the collection facility during June and early July were probably fall chinook released at Asotin. NMFS personnel estimated, on the basis of adipose clipped fish collected during June, that 3,425 of the 58,360 fall chinook released at Asotin were collected at Lower Granite Dam. They estimate collection efficiency for fall chinook was 18 percent, thus 19,000 (32%) of the fish released may have reached Lower Granite Dam.

Fall chinook that migrated out of the raceway at Lower Granite Dam and were then transported to Bonneville Dam were recaptured in larger numbers in the estuary sampling than those released at Asotin. Only 7 of the Asotin

released fish were collected in the estuary samples versus 40 of the migration-transport fish (Table 3). With adjustments for sampling rates at Jones Beach, NMFS personnel estimate total recaptures of 14 fish from the Asotin release and 52 of the migration-transport fish. Nearly four times more of the migration-transport fish made it to the estuary than the fish released at Asotin.

Migration-transport fish passed through the estuary earlier than the fish released at Asotin in 1980 (Figure 1). The median date of collection for the Asotin fish was June 24 versus June 18 for the fish hauled from the raceway at Lower Granite Dam. No fish of either group were collected after July 2. In 1979, fall chinook released at Asotin and recaptured in the estuary had a median date of capture of July 3 compared to a May 27 date for fish transported to below Bonneville Dam (Dawley, et al. 1980). The two groups were hauled from the hatchery on May 20 and 21, respectively.

Steelhead Trout - Dworshak NFH

A relatively high percentage (63%) of the normal migration fish arrived at Lower Granite Dam in 1980. Two hundred eighty normal migration fish (code 5/4/55) were found in the sample of adipose clipped fish sacrificed at the dam. None of the migration-transport fish were collected at the dam.

At the estuary, NMFS personnel collected 69 marked fish from the normal migration group and 119 fish from the migration-transport group (Table 4). Nearly twice as many migration-transport fish reached the estuary compared to normal migration fish, but part of that difference was likely due to the fact that few, if any, of the fish in the migration-transport group were not smolts. Since the migration-transport fish were all voluntary migrants

from the hatchery ponds, most were probably smolts. The normal migration group included all fish in the ponds and likely included some fish that didn't become smolts in 1980. Losses of fish between the hatchery and dams would account for the remainder of the difference in estuary catches from the two groups.

The timing of migration through the estuary was spread through five weeks for the normal migration fish and one week for the migration-transport fish (Figure 1). The normal migration fish were released from Dworshak NFH on April 17. The first fish was collected in the estuary on April 24, most were collected by May 10, and the last fish June 2. All of the migration-transport fish were collected between May 3 to 9. The migration-transport fish were hauled from Dworshak NFH to trucks or barges at Lower Granite Dam April 29 through May 2.

ADULT RETURNS

Adult salmon from the 1980 releases will be returning in the fall of 1981 as jacks, 1982 and 1983. Adult steelhead will return as one-year-in-ocean fish into the Columbia River in fall 1981 and to the hatchery in spring 1982. Two-ocean fish will be back to the hatchery in 1983 and three-ocean fish in 1984.

If the short distance migration undertaken by the migration-transport fish does nothing to improve their homing, then we expect most of those fish will return to the release site downstream from Bonneville Dam, but few will make it back to their respective hatcheries or upstream release sites. Relative recapture rates in ocean fisheries, the zone 1-5 commercial fishery (if allowed), the zone 6 fishery (if allowed), Idaho fisheries, and to hatcheries will be monitored to compare homing of the normal migration fish versus the migration-transport fish.

Rapid River spring chinook were branded on the left anterior side of the fish in hopes that the brands could be seen through the counting window at Bonneville Dam. We will observe the fish at Bonneville in the spring of 1981 to determine if the brands can be seen and identified. Observations at the counting window may be warranted in 1982 and 1983. Otherwise, the number returning as far as Bonneville Dam will have to be assessed at the north shore ladder if sampling is done there.

Returning fall chinook cannot return to Hagerman NFH so returning fish must be recaptured at Ice Harbor Dam (fall chinook egg bank trapping) or at Lower Granite Dam. Jacks from the 1980 release will return in the fall of 1981. Jacks are not normally trapped at Ice Harbor Dam so we plan to

sacrifice the nose tagged jacks that enter the adult trapping facility at Lower Granite Dam in 1981. In 1982 and 1983, if fish are trapped at Ice Harbor Dam, sufficient marked fish may be obtained from normal trapping operations to eliminate the need for collecting fish at Lower Granite Dam. If it is necessary to collect fish at Lower Granite Dam in 1982 and 1983, we will recommend that the nose tagged adults be hauled to a hatchery for spawning after which the tags can be obtained.

A final report will be prepared after adult returns are complete.

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APPENDIX B

(TABLES B1-B7)

Appendix Table B1.--Steelhead marked in 1978 at Dworshak NFH-- test number, mark used, number released, type of imprint, and treatment for various groups are indicated. [a/]

Test – control	C.W.T. code	Brand	Number released[b/]	Homing imprint	Treatment
Control	10-2-31	LA ✕	30,074[c/]	natural migration	Released with normal hatchery production into North Fork Clearwater River.
Test #1	WH-RD-XY	RA N	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 Z	24,006	sequential	Normal procution 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		

a/ The brand rotation on the test fish was reported incorrectly in Table 3, Slatick et al. (1979). Also the total number of control fish that were wire tagged was omitted.

b/ Number released adjusted for initial tag loss.

c/ A total of 100,600 were wire tagged for the hatchery control release, of this number 30,074 were branded for inriver adult evaluation.

Appendix Table B2.--Steelhead marked in 1978 at Tucannon Hatchery. Test number, mark used, number released, type of imprint, and treatment for various groups are indicated. [a/]

Test-control [b/]	C.W.T. code	Brand	Number released [c/]	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 6	18,549	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.
Hatchery production control	W-YW-OR-PK W-YW-PK-LB	LD▷⊢ LD▷⊢	22,555 33,002	natural	Normal hatchery release into Grande Ronde River
	Total		92,243		

a/ The hatchery production control release was inadvertently omitted from Table 4, Slatick et al. (1979).

b/ A shortage of test fish precluded a special control release from the hatchery into the Tucannon River for this experiment.

c/ Adjusted for initial tag loss.

Appendix Table B3.--Ringold sports fishery catch estimates.[a/]

Test group	Brand	Tag code	Number released	Number in sample recovery	Number in estimated catch	% of release
Ringold						
1977 Release	--	13/8/1	35,600	2	34	0.096
1978 Release	--	63/17/7	41,660	4	68	0.16
Methow						
Control #1	RAL-2	OR-LG-YW	19,901	1	17	0.085
Control #2	LA)(-1	OR-OR-XY	20,330	0	--	--
Test #1[b/]	RAL-4	OR-GN-OR	19,131	4	68	0.36
Test #2[c/]	RAL-1	OR-YW-LG	19,979	5	85	0.43
Test #3[d/]	RAL-3	OR-OR-RD	17,637	2	34	0.19
Wenatchee						
Control #1	LA4-1	OR-YW-OR	24,119	0	--	--
Control #2	LA4-2	OR-LG-OR OR-YW-GN	23,787	2	34	0.14
Control #3	LA4-3	OR-BL-OR	21,957	0	--	--
Test #1	RA2-1	RD-PK	22,841	2	34	0.15
Test #2	RA2-2	RD-LB	21,694	6	102	0.47
Test #3	RA2-3	OR-YW-LB	23,551	9	153	0.65
Other						
Tucannon	RD T	YW-PK-PK	21,756	1	17	0.078

a/ From Hisata et al. 1979-1980.

b/ Trucked to Bonneville.

c/ Trucked to Richland then barged to Bonneville.

d/ Trucked to Ringold.

Appendix Table B4.--Complete returns to four sampling locations of 1- and 2-ocean age steelhead from control and test releases of smolts from the Wells Hatchery which were imprinted to the Winthrop NFH homing site and the Methow River in 1978. Recoveries were from June 1979 to 30 November 1980.

Experiment and sampling location	Homing site	Control or test	Number juveniles released	Number adults [a/] recaptured			Adult returns (% of juveniles)	Test to control ratio
				1-ocean age	2-ocean age	Total 1 & 2's		
Bonneville Dam								
Winthrop NFH	Winthrop	Control	20,330	4	1	5	0.025	
L. Methow River	Methow R.	Control	19,901	8	4	12	0.060	2.4:1
Truck to Bonneville	Winthrop	Test	19,131	26	5	31	0.162	6.5:1
Barge to Bonneville	Winthrop	Test	19,979	14	7	21	0.105	4.2:1
Truck to Ringold	Winthrop	Test	17,637	23	5	28	0.159	6.4:1
Indian fishery								
Winthrop NFH	Winthrop	Control		5	1	6	0.030	
L. Methow River	Methow R.	Control		11	2	13	0.065	2.2:1
Truck to Bonneville	Winthrop	Test		29	4	33	0.172	5.7:1
Barge to Bonneville	Winthrop	Test		17	5	22	0.110	3.7:1
Truck to Ringold	Winthrop	Test		14	2	16	0.091	3.0:1
McNary Dam								
Winthrop NFH	Winthrop	Control		18	2	20	0.098	
L. Methow River	Methow R.	Control		28	5	33	0.166	1.7:1
Truck to Bonneville	Winthrop	Test		85	4	89	0.465	4.7:1
Barge to Bonneville	Winthrop	Test		52	5	57	0.286	2.9:1
Truck to Ringold	Winthrop	Test		62	4	66	0.374	3.8:1
Priest Rapids Dam								
Winthrop NFH	Winthrop	Control		33	5	38	0.187	
L. Methow River	Methow R.	Control		44	11	55	0.276	1.5:1
Truck to Bonneville	Winthrop	Test		32	13	45	0.235	1.3:1
Barge to Bonneville	Winthrop	Test		14	8	22	0.110	0.6:1
Truck to Ringold	Winthrop	Test		63	17	80	0.454	2.4:1
TOTAL			96,978	582	110	692		

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

Appendix Table B5.--Complete returns to four sampling locations of 1- and 2-ocean age steelhead from paired control and test releases of smolts from the Chelan Hatchery which were imprinted to the Leavenworth NFH homing site in 1978. The test juveniles were transported from the Leavenworth NFH by truck to a barge at Richland, Washington, and then barged downstream to below Bonneville Dam. Recoveries were from June 1979 to 30 November 1980.

Experiment and sampling location	Control or test	Number juveniles released	Number adults [a/] recaptured			Observed adult returns (% of juveniles)	Test to control ratio
			1-ocean age	2-ocean age	Total 1 & 2's		
10-DAY IMPRINTING							
Bonneville Dam	Control	24,119	16	2	18	0.075	
	Test	22,841	27	4	31	0.136	1.81:1
Indian fishery	Control		9	1	10	0.041	
	Test		48	6	54	0.236	5.76:1
McNary Dam	Control		32	3	35	0.145	
	Test		27	10	37	0.162	1.12:1
Priest Rapids Dam	Control		47	2	49	0.203	
	Test		9	0	9	0.039	0.19:1
TOTAL		46,960	215	28	243		
2-DAY IMPRINTING							
Bonneville Dam	Control	23,787	5	2	7	0.029	
	Test	21,694	38	4	42	0.194	6.69:1
Indian fishery	Control		17	2	19	0.080	
	Test		32	7	39	0.180	2.25:1
McNary Dam	Control		31	3	34	0.143	
	Test		52	11	63	0.290	2.03:1
Priest Rapids Dam	Control		47	10	57	0.240	
	Test		5	1	6	0.028	0.12:1
TOTAL		45,481	227	40	267		
4-HOUR IMPRINTING							
Bonneville Dam	Control	21,957	6	1	7	0.032	
	Test	23,551	12	0	12	0.051	1.59:1
Indian fishery	Control		12	1	13	0.059	
	Test		45	4	49	0.208	3.50:1
McNary Dam	Control		26	5	31	0.141	
	Test		29	6	35	0.149	1.06:1
Priest Rapids Dam	Control		47	2	49	0.203	
	Test		7	2	9	0.038	0.19:1
TOTAL		45,508	184	21	205		
GRAND TOTAL		137,949	626	89	715		

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

Appendix Table B6.--Preliminary returns to four 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 NFH homing site in 1979. The test juveniles were transported from the Leavenworth NFH by truck to a barge at Richland, Washington, and then barged downstream to below Bonneville Dam. Recoveries were from June to 30 November 1980.

Experiment and sampling location	Control or test	Number juveniles released	Number [a/] adults recaptured	Adult returns (% of juveniles released)	Test to control ratio
10-DAY IMPRINTING					
Bonneville Dam	Control	23,960	9	0.038	
	Test	23,331	27	0.116	3.05:1
Indian fishery	Control		7	0.029	
	Test		34	0.146	5.03:1
McNary Dam	Control		20	0.083	
	Test		23	0.099	1.19:1
Priest Rapids Dam	Control		71	0.296	
	Test		6	0.026	0.09:1
TOTAL		47,291	197		
2-DAY IMPRINTING					
Bonneville Dam	Control	19,186	11	0.057	
	Test	24,335	12	0.049	0.86:1
Indian fishery	Control		4	0.021	
	Test		23	0.095	4.52:1
McNary Dam	Control		7	0.036	
	Test		7	0.029	0.81:1
Priest Rapids Dam	Control		52	0.271	
	Test		1	0.004	0.01:1
TOTAL		43,521	117		
6-HOUR IMPRINTING					
Bonneville Dam	Control	24,171	4	0.017	
	Test	22,834	8	0.035	2.06:1
Indian fishery	Control		9	0.037	
	Test		28	0.123	3.32:1
McNary Dam	Control		19	0.079	
	Test		24	0.105	1.33:1
Priest Rapids Dam	Control		60	0.248	
	Test		4	0.018	0.07:1
TOTAL		47,005	156		
GRAND TOTAL		137,817	470		

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

Appendix Table B7.--Spring chinook salmon marked in 1978 at Kooskia NFH released, type of imprint, and treatment for various groups are indicated.[a/]

Test – control	C.W.T. code	Brand	Number released[b/]	Homing imprint	Treatment
Control	10-3-30	LA ⋋	40,080	natural migration	Released with normal production into Clear Creek (tributary to Middle Fork of Clearwater River).
Test #1	WH-RD-YW	RA ⊤	35,426	single	Normal production rearing. Trucked with Clear Creek water directly to below Bonneville Dam.
Test #2	WH-RD-XY	RA ⊥	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 ⊢	36,932	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		

a/ The total number of wire-tagged control fish was reported incorrectly in Table 2, Slatick et al. (1979). A total of 123,775 were wire tagged for the hatchery control release; of this number, 40,080 were branded for in-river evaluation.

b/ Number released adjusted for initial tag loss.