CZES Coastal Zone and Estuarine Studies

EFFECTS OF POWER PEAKING OPERATIONS ON JUVENILE SALMON AND STEELHEAD TROUT MIGRATIONS — PROGRESS 1976

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CONTENTS

INTRODUCTION

Research activities in 1976 continued studies initiated in 1973 to define the effects of dams, power peaking, and flow regulation on juvenile salmon and steelhead trout migrations.

Downstream migrations of juvenile salmon and steelhead trout were sampled in the Salmon, Snake, and Columbia Rivers (Figure 1). Fish were marked and released at various sites to provide information on survival, timing of migrations, and rates of movement. Movement patterns of juveniles within and through reservoirs, diel movement at dams, residualism in reservoirs, and predator fish populations were also investigated.

Studies to define the effect of release size of marked fish on rate of recapture and survival and studies of predations in backroll areas of the tailraces of dams were again postponed because of high flows and resulting spill conditions below the dams during the spring outmigrations. However, most of our research activities were completed as scheduled and considerable information was obtained. This report summarizes the results of the research conducted during 1976.

METHODS

Migrating juvenile salmon and steelhead trout were sampled in the Salmon, Snake, and Columbia Rivers in 1976. Self-cleaning scoop traps were used to sample the juvenile outmigration in the Salmon River at Riggins and Whitebird, Idaho. On the Snake River, turbine intake gatewells at Ice Harbor Dam were dip-netted and the fingerling

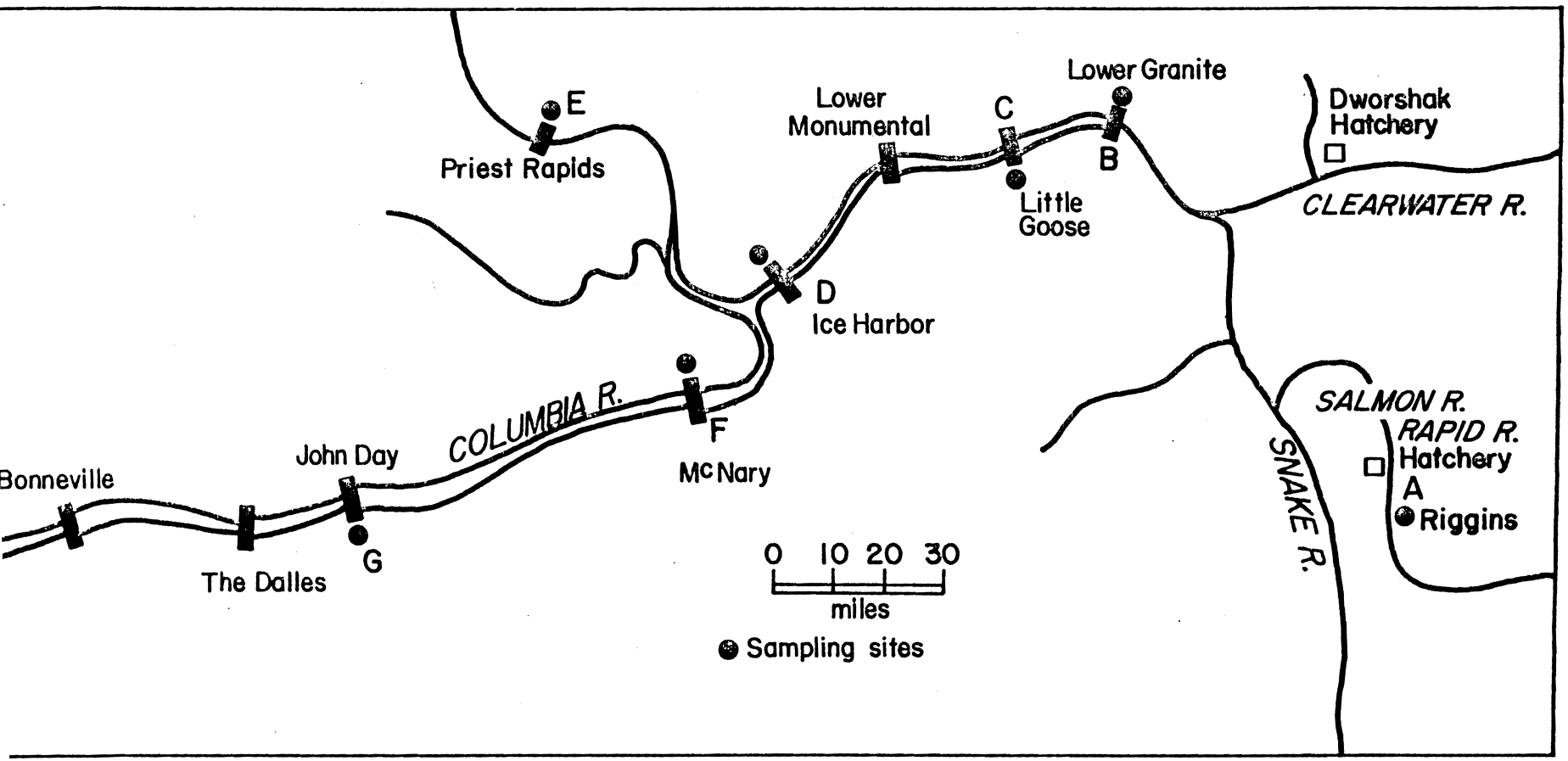

Figure 1.--Juvenile salmonid sampling sites on the Salmon, Snake, and Columbia Rivers, 1976.

collection facilities at Lower Granite and Little Goose Dams were sampled. On the Columbia River, turbine intake gatewells at Priest Rapids[1/], McNary, and John Day Dams were also sampled by dip-netting. The 1976 sampling schedules at the various locations were as follows:

Sampling Site	Sampling Period
Riggins, Idaho (scoop traps)	3/2 - 5/6
Lower Granite Dam	4/12 - 6/8
Little Goose Dam	4/13 - 6/21
Ice Harbor Dam	4/14 - 6/14
Priest Rapids Dam	4/14 - 9/10
McNary Dam	4/16 - 10/4
John Day Dam	4/16 - 12/15

Smolts from our various sampling operations were marked with hot or cold brands and released at various locations. Subsequent recoveries of fish from this marked population provided information relative to the timing, magnitude, travel time, and survival of the various out-migrations. This marking program was supplemented by marked smolts from various hatcheries in the Snake and Columbia River systems.

TRAVEL TIME

Recoveries of marked fish are used to determine the average passage time through a specified section of the river (Figure 1). The median recovery date is subtracted from the date of release in the event of

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1/ Sampling at Priest Rapids Dam funded by Grant, Chelan, and Douglas County P.U.D.'s.

a one-day release or the median date of release when the fish are marked and released over a longer period of time.

TIMING

Peak timing at Lower Granite and Ice Harbor Dams was determined by calculating the date when 50% of the juvenile salmonid outmigration passed the dam. Since collection efficiencies in the gatewells vary with the amount of spill, the number of fish collected is related to prevailing sampling efficiencies to determine when 50% of the outmigration has passed.

Timing of the Snake River outmigration at John Day Dam cannot be determined by this method because downstream migrants from the mid-Columbia and John Day Rivers are entering the gatewells during the same period. Timing of the Snake River stocks at John Day Dam was therefore calculated from recaptures of marked fish released at Ice Harbor Dam during the peak of the outmigration.

POPULATION ESTIMATES

The general methods we used to estimate populations at the various dams are described herein; however, a detailed description can be found in the Progress Report for 1974 (Raymond et al 1975). Population estimates of juvenile salmonids passing Ice Harbor Dam were determined by the recapture rate of marked fish released above the dam. At Lower Granite Dam population estimates were calculated by determining the percentage of marked fish surviving from that

dam to Ice Harbor Dam and applying that factor to the Ice Harbor population estimate. In a similar manner, population estimates of Snake River fish at John Day Dam were made by applying survival estimates derived from mark releases to the calculated Ice Harbor population.

SURVIVAL

Estimates of survival were calculated for Snake River yearling chinook salmon and steelhead trout through four areas: (1) from the Salmon River to Lower Granite Dam, (2) from Lower Granite Dam to Ice Harbor Dam, (3) from Ice Harbor Dam to John Day Dam, and (4) from Lower Granite Dam to John Day Dam (Figure 1). Estimates of survival through these sections of the river were determined from differences in recovery rates of marked fish released in the forebays of Lower Granite, Ice Harbor, and John Day Dams. A detailed explanation of the calculation of survival estimates is contained in the 1974 Progress Report (Raymond et al 1975).

DIEL MOVEMENT AT DAMS

Diel movement patterns of the smolts at John Day Dam were examined prior to and during peaking operations in 1976. Turbine intake gatewells 3A and 3B (both units have vertical barrier screens) were dip-netted at 2-hour intervals over a series of 28-hour test periods.

HOLDOVER AND RESIDUALISM

The effects of river flow on the number of juvenile salmon and steelhead trout holding over or residualizing in reservoirs were measured by sampling in the reservoirs with purse seines and by sampling the turbine intake gatewells at the dams. A residual is defined as a salmon or steelhead trout that never goes to sea, and a holdover as one that remains in a reservoir beyond the usual downstream migration period but which eventually goes to sea. By continuing to sample with comparable effort each year, we attempt to equate the number of holdovers to variations in annual or short-term river regulation. Sampling for residuals and holdovers is scheduled during early spring and late fall. Spring sampling provides information on holdover fish from the previous year; while, fall sampling is aimed at determining how long various groups of fish are delaying in the reservoirs before moving downstream.

PREDATION

Squawfish populations were sampled at several locations in the Snake River during 1976. Merwin traps were fished at two locations in Lower Monumental Reservoir; one was located in the Palouse River arm (15.6 km below Little Goose Dam) and the second on the south shore about 6.4 km further downstream. Purse seines were used below Little Goose and Lower Granite Dams to sample squawfish concentrations adjacent to the dams.

Estimates of squawfish populations below Little Goose Dam are based on recoveries of marked fish. Catch data from both Merwin traps have been combined and population estimates computed according to Chapman's (1948) formula as follows:

$$\hat{N} = nt/s \quad \text{where:}$$

$\hat{N}$ = best estimate

n = number of fish examined

t = number of fish tagged

s = number of tagged fish recaptured

Upper ($\overline{N}$) and lower ($\underline{N}$) confidence limits at the 95% level are calculated by using Chapman's equation number 55 as follows:

$$(\overline{N}, \underline{N}) = \frac{nt}{s^2}\left[s + 1.9208 \pm \sqrt{(s + 1.9208)^2 - s^2\left(1 + \frac{3.8416}{n}\right)} \right]$$

RESULTS

The data collected in 1976 have been analyzed, and the results are presented and discussed in this section (data summaries are in the appendix). However, in 1976, as in 1974 and 1975, river flows were high and the spring outmigration of juveniles in the Snake and Columbia Rivers occurred when flow regimes were not typical of peaking-type river regulation.

TIMING OF MIGRATIONS AND TRAVEL TIME

Yearling Chinook Salmon -- Snake River

The migration of yearling chinook salmon from the Salmon River moved downstream without delay in 1976 (Table 1). Timing of the migration reflected the near normal weather conditions that prevailed throughout the watershed. Scoop trap catches of native yearling chinook salmon at Riggins, Idaho peaked on April 9, about a month earlier than in 1975. Native yearling chinook salmon peaked at Lower Granite and at John Day Dams on April 21 and May 6, respectively. Travel time from Riggins, Idaho to Lower Granite Dam in 1976 was 12 days, with an additional 15 days required to reach John Day Dam. In 1975, it took only 9 days for the fish to travel from Riggins to Lower Granite Dam with an additional 12 days required to reach John Day Dam. The slower rate of travel resulted from lower flows in the Snake River during the migration period in 1976 (110,000 cfs) than in 1975 (160,000 cfs). Rate of travel and river flows in the Columbia River were comparable in both years.

Timing of yearling chinook salmon released from McCall Hatchery in 1976 was later than native fish populations (Table 1). These hatchery fish peaked at Riggins on April 18, at Lower Granite Dam on May 2, and at John Day Dam on May 12. Total travel time of hatchery and native fish from Riggins to John Day Dam was about the same -- 24 days. No information was available on migrations from Rapid River Hatchery in 1976.

Table 1.--Timing of migrations and travel time for yearling chinook salmon and steelhead trout to John Day Dam, 1976.

	Chinook		Steelhead	
	Natives	Hatchery (McCall)	Natives	Hatchery (Dworshak)
Timing[1/]				
Salmon River--Riggins (A)	April 9	April 18	[2/]	
Lower Granite Dam (B)	April 21	May 2	May 10	April 27
Ice Harbor Dam (D)	April 28	May 7	May 17	May 6
John Day (G)	May 6	May 12	May 27	May 15
Travel Time				
A to B[3/]	12 days	14 days	[2/]	
B to D	7 days	5 days	7 days	9 days
D to G	8 days	5 days	10 days	9 days
B to G	15 days	10 days	17 days	18 days
Total A to G	27 days	24 days	[2/]	31 days

1/ Timing based on date of passage of 50% of total outmigration.

2/ Insufficient numbers collected to make estimate.

3/ See Figure 1 for locations.

Steelhead Trout -- Snake River

The outmigration of juvenile steelhead trout (Table 1) from the Snake River was also earlier in 1976 than in 1975. Downstream movement of wild fish from the Salmon River peaked at Lower Granite Dam on May 10, about 10 days earlier than in 1975. Travel time from Lower Granite Dam to John Day Dam was 18 days, about a week longer than in 1975. Migrations of steelhead trout released from Dworshak Hatchery was, as in past years, nearly two weeks earlier than the native fish. Travel time of both hatchery and wild fish was comparable.

Sockeye Salmon -- Mid-Columbia River

The outmigration of juvenile sockeye salmon from the mid-Columbia River was monitored at Priest Rapids[1/], McNary, and John Day Dams. The outmigration at Priest Rapids Dam in 1976 was bimodal (Figure 2). The primary outmigration began in mid-April, peaked on May 19, and was over by July 1. A small secondary migration of sockeye salmon occurred at Priest Rapids Dam in mid-July and early August. The timing of the sockeye salmon outmigration at John Day Dam was also bimodal; the first peak occurred on May 15, and a second smaller peak occurred on August 10. No sockeye were marked at Priest Rapids Dam in 1976. Consequently, rates of movement were not determined.

1/ Timing information at Priest Rapids is from Sims and Miller (1977).

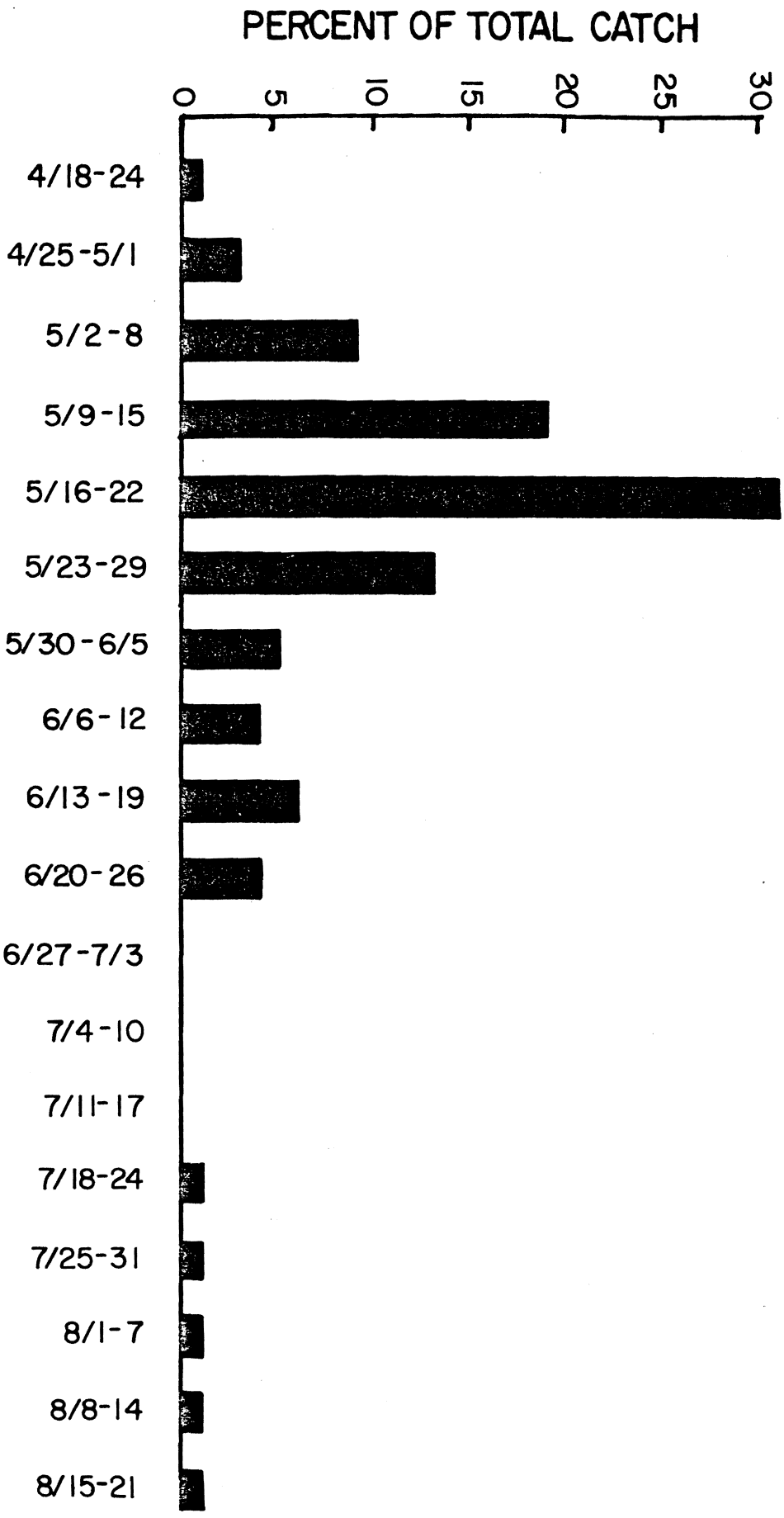

Figure 2.--Temporal distribution of sockeye salmon catches in the turbine intake gatewells at Priest Rapids Dam in 1976.

"0"-Age Chinook Salmon -- Mid-Columbia River

The outmigration of "0"-age chinook salmon from the mid-Columbia River was monitored at Priest Rapids, McNary, and John Day Dams. Migrational timing at Priest Rapids Dam is shown in Figure 3. The 1976 outmigration at Priest Rapids Dam was, as in 1973 and 1974, bimodal (Sims, Johnsen, and Bentley, 1976). However, peaks of movement occurred in August and September in 1976 rather than in July and August as in 1973-74. Again, as in 1975, there was little movement of fish at Priest Rapids Dam in July.

In 1976, "0"-age chinook salmon from the mid-Columbia River moved downstream more slowly than in 1975. Smolting fish marked and released below Priest Rapids Dam during the peak of the outmigration required 14 days to reach McNary Dam in 1976 as compared to 9 days in 1975. An additional 24 days were required for these fish to reach John Day Dam.

RELATIVE MAGNITUDE AND SURVIVAL

Survival of juvenile salmon and steelhead trout in the Snake and Columbia Rivers in 1976, like 1975, was generally good (Figure 4). Several factors contributed to the successful outmigration. High river flows resulted in spill and correspondingly reduced turbine mortality at the dams through most of the outmigration. In addition, nitrogen levels in the Snake River were not critical because of fliplips at Lower Granite and Lower Monumental Dams.

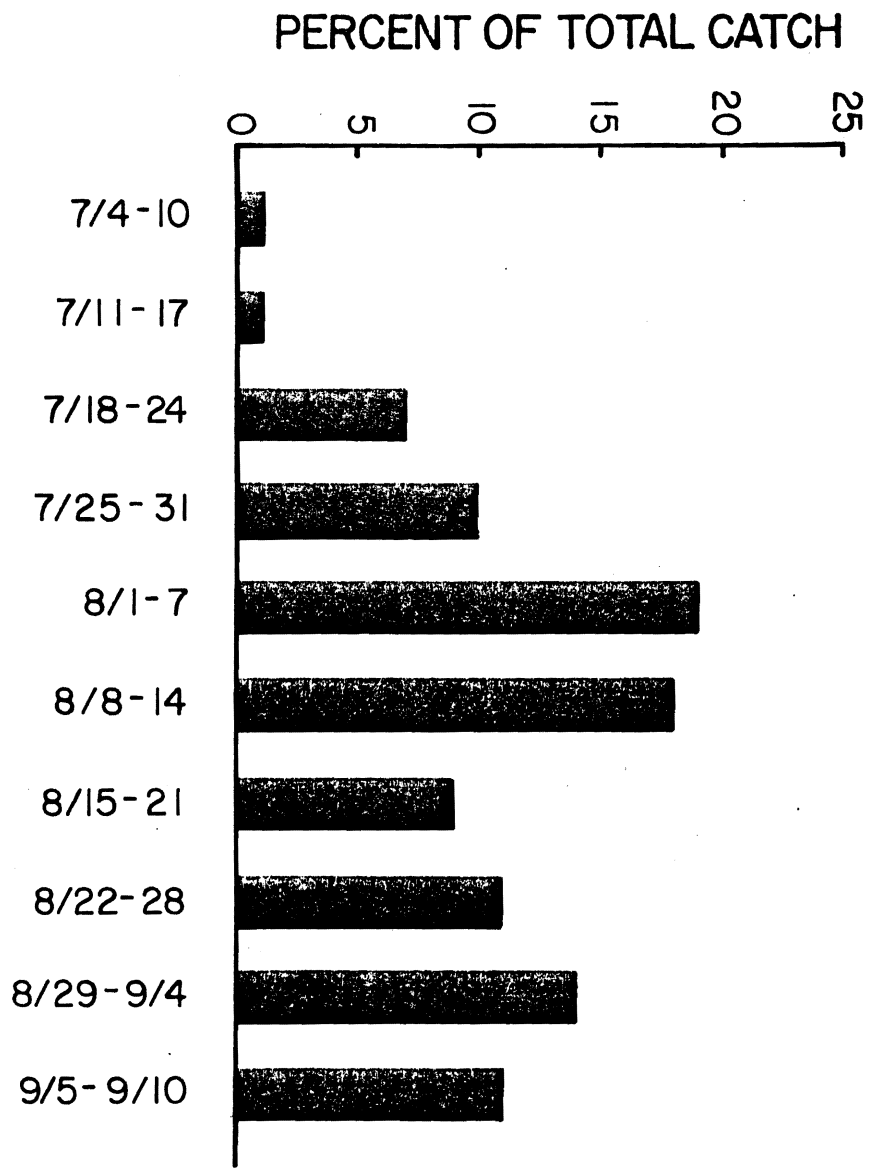

Figure 3.--Temporal distribution of "0"-age chinook salmon catches in the turbine intake gatewells at Priest Rapids Dam in 1976.

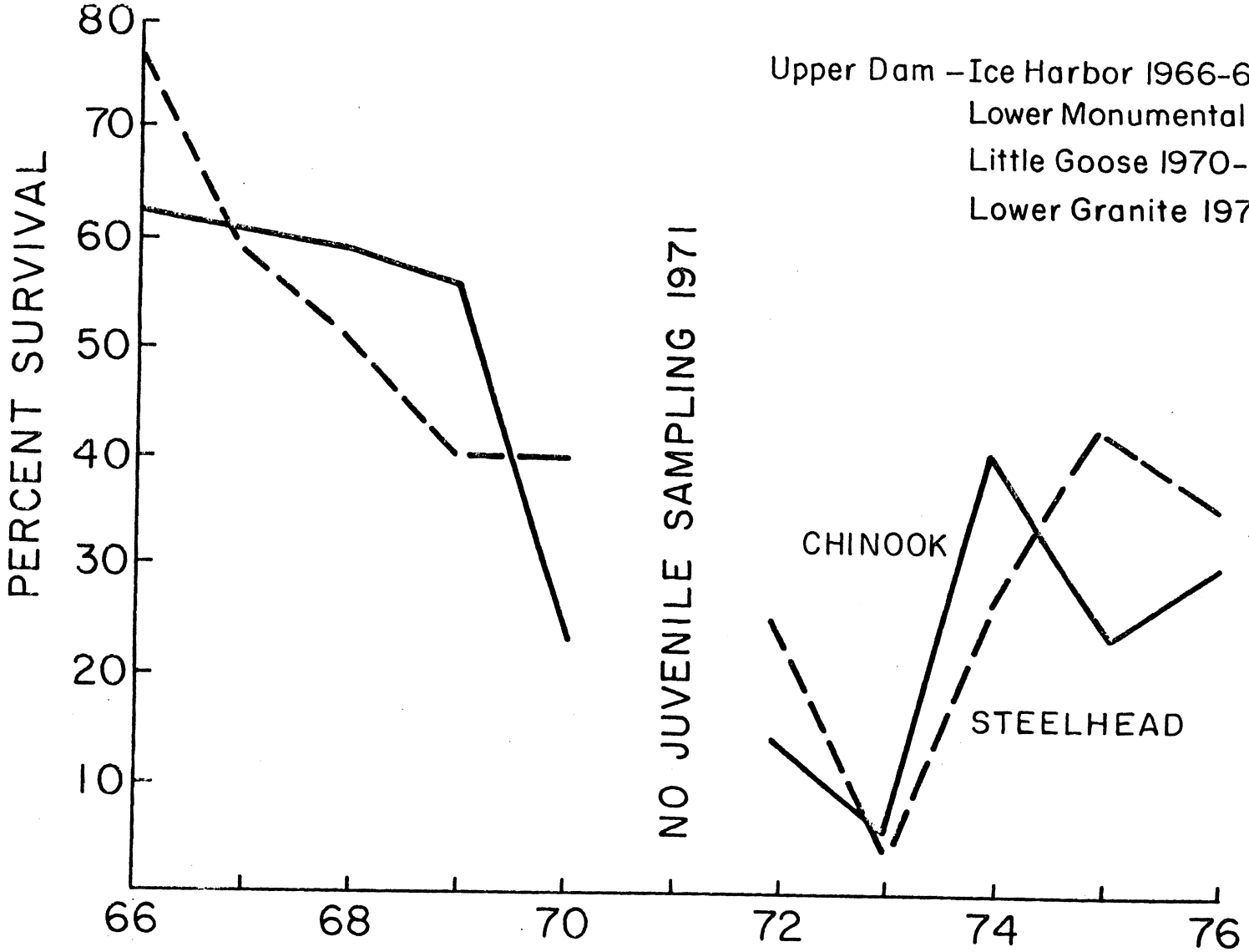

Figure 4.--Survival of juvenile chinook salmon and steelhead trout from the upper Snake River Dam to The Dalles Dam (1966-75) and John Day Dam (1976).

Yearling Chinook Salmon -- Snake River

Approximately 5.0 million yearling chinook salmon smolts were estimated to have reached Lower Granite Dam in 1976 (Table 2) -- a million more smolts than were estimated in 1975 (Table 3). In 1976, about 800,000 chinook salmon smolts were collected at Lower Granite and Little Goose Dams and transported downstream by truck. About 2.7 million smolts survived to reach Ice Harbor Dam; while, 1.3 million were estimated to have reached John Day Dam. Overall survival from Lower Granite Dam to John Day Dam was 30% in 1976 (Table 4). This compares to 25% survival to The Dalles in 1975.

Steelhead Trout -- Snake River

A relatively low survival of Dworshak Hatchery releases to Lower Granite Dam and a reduced run of native fish from the Snake River resulted in a less-than-average number of steelhead trout smolts reaching John Day Dam (0.9 million versus 1.1 million in 1975). Only about 3.0 million steelhead trout smolts were estimated to have reached Lower Granite Dam in 1976; approximately 500,000 of these were collected at Lower Granite and Little Goose Dams and transported downstream. Of the 2.5 million smolts left to continue their downstream migration, 1.8 million survived to Ice Harbor Dam and 0.9 million survived to John Day Dam for an overall survival rate of 36%.

"0"-Age Chinook Salmon -- Mid-Columbia River

The outmigration of "0"-age chinook salmon at Priest Rapids Dam has been characterized in the past by a bimodal peak; one in early

Table 2.--Estimated number of Snake River yearling chinook salmon and steelhead trout smolts passing Lower Granite, Ice Harbor and John Day Dams in 1976.

	Millions of fingerlings				
	Lower Granite	Transported	1/	Ice Harbor	John Day
	(A)	(B)	A-B		
Chinook					
Rapid River	3.36	0.55	2.81	1.77	0.85
Native & other hatcheries	1.74	0.25	1.49	0.93	0.45
Total	5.10	0.80	4.30	2.70	1.30
Steelhead					
Dworshak	1.30	0.20		0.80	0.39
Niagara Springs	1.00	0.17		0.43	0.30
Native	0.70	0.13		0.57	0.21
Total	3.00	0.50	2.50	1.8	0.90

1/ Numbers of fingerling remaining to migrate downstream from Lower Granite and Little Goose Dams after deducting number transported.

Table 3.--Estimated numbers of Snake River chinook salmon and steelhead trout smolts passing Little Goose[1/], Ice Harbor, and The Dalles Dams from 1966 to 1976.

	No. of chinook (millions of smolts)		
	Little Goose	Ice Harbor	The Dalles[2/]
1966	---	3.0	1.9
1967	---	2.3	1.4
1968	---	2.7	1.6
1969	---	2.1	1.4
1970	5.0	1.6	1.2
1971	4.0	1.9	---
1972	5.0	1.8	0.75
1973	5.0	0.6	0.25
1974	3.5	1.7	1.4
1975	4.0	1.3	0.9
1976	5.1	2.7	1.3

	No. of steelhead (millions of smolts)		
	Little Goose	Ice Harbor	The Dalles[2/]
1966	---	1.8	1.4
1967	---	2.7	1.6
1968	---	3.7	1.9
1969	---	2.2	1.0
1970	4.7	4.0	1.9
1971	5.5	3.4	---
1972	2.5	1.5	0.5
1973	5.5	1.4	0.22
1974	5.0	4.0	1.35
1975	3.2	1.7	1.1
1976	3.0	1.8	0.9

1/ Lower Granite Dam in 1975-76.

2/ John Day Dam for 1976 only.

Table 4.--Survival of Snake River yearling chinook salmon and steelhead trout smolts to John Day Dam in 1976.

River section	Chinook	Steelhead
	(%)	(%)
From:		
Lower Granite Dam to Ice Harbor Dam[1/]	63	72
Ice Harbor Dam to John Day Dam	48	50
Lower Granite Dam to John Day Dam	30	36

1/ 800,000 chinook salmon and 500,000 steelhead trout smolts transported below Bonneville Dam subtracted from total smolts passing Lower Granite Dam for calculations of survival.

July consisting mostly of summer chinook salmon from Wells Hatchery and a second in early August consisting mostly of native chinook salmon (Raymond et al, 1975). The absence of the early July peak in 1975 was attributed to poor survival of Wells Hatchery fish (Sims et al, 1976). Since there were no marked releases from the Wells Hatchery in 1975, this could not be verified. However, again in 1976, the early July peak did not materialize, but marked fish had been released from the Wells Hatchery and survival was measured at only 13% (Sims and Miller 1977) -- this confirms the assumptions made in 1975.

By contrast, survival of wild "0"-age chinook salmon and fish from the Priest Rapids spawning channel appears to have been excellent. Three times as many fish were taken from the gatewells at Priest Rapids and McNary Dams in 1976 than in 1975 when survival was considered to have been good. In 1976, more than 107,500 "0"-age fish were collected at McNary Dam after August 1. This compares to 33,000 in 1975, 631 in 1974, and 1,059 in 1973 with comparable sampling effort.

DIEL MOVEMENT PATTERNS OF JUVENILE SALMON AND STEELHEAD TROUT

Diel movement of juveniles was again examined at John Day Dam in 1976 (Figure 5). As in 1975, movement through the turbines was very consistent and occurred, for the most part, after dark. Yearling chinook salmon and steelhead trout movement peaked between midnight and 3:00 a.m. and then dropped off. Movement of "0"-age chinook salmon was relatively even throughout the night. In 1976, as in 1975, higher turbine loading during the daytime did not induce increased movement nor did reduced loading at night inhibit movement.

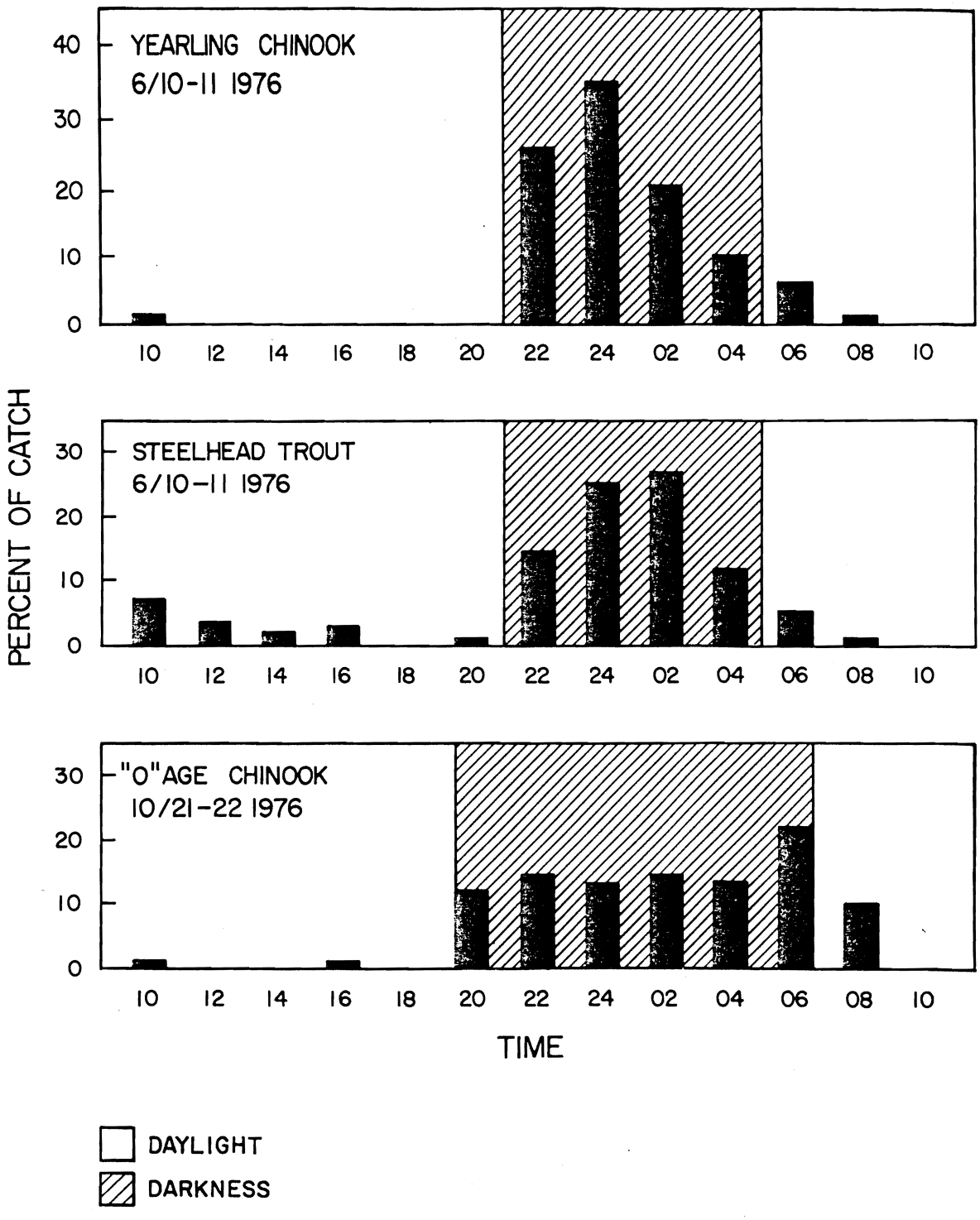

Figure 5.--Diel movement of juvenile salmon and steelhead trout at John Day Dam, 1976.

HOLDOVER AND RESIDUALISM

No evidence of residualism was found in the Snake River or Columbia River reservoirs in 1976, and holdover in the Snake River reservoirs was also minimal. However, as in previous years, a significant holdover of "0"-age chinook salmon from the mid-Columbia River occurred in John Day Reservoir.

Snake River Chinook Salmon and Steelhead Trout

Holdover of chinook salmon and steelhead trout smolts in the Snake River reservoirs was minimal in 1976 as it was in 1975. Sampling with purse seines at our index site in Lower Monumental Reservoir in November and December produced only 26 juvenile chinook salmon and no steelhead trout (Table 5). Turbine intake sampling at Ice Harbor Dam from October 27 to November 26, 1976 produced 994 chinook salmon and 48 steelhead trout (Table 6). The size of these chinook salmon (155 mm average fork-length) was much smaller than the size of the chinook salmon taken with the purse seine in Lower Monumental Reservoir (192 mm average fork-length). For this reason, we feel that most of them were from the late September releases from the Decker Flats Hatchery in Idaho.

"0"-Age Chinook Salmon -- Mid-Columbia River

Significant numbers of "0"-age chinook salmon held over in John Day Reservoir in 1976. The extent of this holdover may be seen by examining the data from a group of chinook salmon from the Priest

Table 5.--Purse seine sampling at index site in forebay of Lower Monumental Dam - 1976.

Date	Number of chinook taken			
	Set 1	Set 2	Set 3	Total
Nov.				
23	2	4	5	11
24	3	2	8	13
Dec.				
3	1	0	1	2
8	0	0	0	0
	6	6	14	26*

* Mean length, 190.80 mm.

Table 6.--Fall sampling of turbine intake gatewells at Ice Harbor Dam, 1976.

Date	Chinook*	Steelhead	Sockeye	Coho	Total
	(no.)	(no.)	(no.)	(no.)	(no.)
Oct.					
27	154	18	5	0	177
29	40	4	0	0	44
Nov.					
1	64	7	3	0	74
4	192	1	1	0	194
8	65	4	1	0	70
11	31	3	1	0	35
15	164	1	4	1	170
19	208	4	3	0	215
22	55	4	4	0	63
26	21	2	4	0	27
	994	48	26	1	1069

* Chinook mean length - 155.16 mm.

Rapids spawning channel that were released below McNary Dam on July 22 (Table 7). The first recoveries from this release were made at John Day Dam on August 10, 14 days after release. The median recovery date at John Day Dam was October 12--an average holdover of about 75 days. Recoveries from this release were still being made at John Day Dam when sampling was terminated in mid-December. Survival of these fish to John Day Dam appears to have been good; the recovery rate at John Day Dam was almost 1% higher than many of our efficiency-test releases for John Day Dam. Growth of these fish in the reservoir was also excellent; the average fork-length was 70 mm at the time of release, and by October 1, the fish recovered at John Day Dam averaged 155 mm in length.

SQUAWFISH STUDIES

Definition of the distribution, abundance, and movement patterns of squawfish in the Snake and Columbia Rivers continued in 1976. Data from fish ladder counts, purse seines, and Merwin traps were used to examine squawfish populations at various locations.

Fish ladder counts at the dams on the Snake and Columbia Rivers are shown in Table 8. All dams except John Day Dam show an increase in the number of squawfish entering the fish ladders in 1976 over 1975. Squawfish catches in the Merwin trap located in the Palouse Arm of Lower Monumental Reservoir were also larger in 1976 than in 1975 -- 10,033 in 1976 (Table 9) as compared to 4,804 during a similar sampling period in 1975. In 1976, an additional 19,985 squawfish were taken by the trap located in the main reservoir (Table 10).

Table 7.--Fish recovered at John Day Dam from a release of 68,508 "0"-age chinook salmon below McNary Dam on 22 July 1976.

Week of recovery	Number recovered
8/8 - 14	2
8/15 - 21	0
8/22 - 28	40
8/29 - 9/4	26
9/5 - 11	8
9/12 - 18	16
9/19 - 25	9
9/26 - 10/2	31
10/3 - 9	80
10/10 - 16	43
10/17 - 23	69
10/24 - 30	61
10/31 - 11/6	36
11/7 - 13	5
11/14 - 20	8
11/21 - 27	3
11/28 - 12/4	5
12/5 - 11	7
12/12 - 18	15

Table 8.--Counts of squawfish in the fish ladders at various dams on the Snake and Columbia Rivers in 1976.

Dam	April	May	June	July	Aug.	Sept.	Oct.	Total
	(no.)	(no.)	(no.)	(no.)	(no.)	(no.)	(no.)	(no.)
The Dalles	139	3,862	14,674	4,746	1,114	952	828	26,315
John Day	553	5,402	13,886	6,159	2,534	1,917	1,052	31,503
McNary	1	527	2,595	5,571	3,371	639	403	13,107
Ice Harbor	0	108	382	1,573	1,098	280	113	3,554
Lower Monumental	286	1,439	2,716	3,468	1,739	3,128	1,456	14,232
Little Goose	78	458	1,181	6,493	841	405	219	9,675
Lower Granite	2	192	569	934	410	391	142	2,640
GRAND TOTAL	1,059	11,988	36,003	28,944	11,107	7,712	4,213	101,026

Table 9.--Squawfish mark and recapture statistics for the Palouse Merwin trap, 1976.

Date	Catch						Catch disposition	
	Unmarked (no.)	Marked (origin & no.)				Total (no.)	Sacrificed for stomach samples (no.)	Marked & released (no.)
		This trap	Other trap	L.Goose tailrace	1975 releases			
4/18 - 24	106	1	0	0	8	115	8	98
4/25 - 5/1	600	39	1	0	12	652	8	592
5/2 - 8	1,312	199	22	0	35	1,568	14	1,298
5/9 - 15	1,665	586	49	0	45	2,345	29	1,637
5/16 - 22	284	57	4	0	11	356	1	283
5/23 - 29	1,047	142	37	3	16	1,245	35	1,012
5/30 - 6/5	710	130	14	0	18	872	36	674
6/6 - 12	532	110	12	0	11	665	22	510
6/13 - 19	372	79	25	0	12	488	15	357
6/20 - 26	470	109	21	1	10	611	22	448
6/27 - 7/3	301	83	14	0	10	408	26	275
7/4 - 10	233	45	12	2	4	296	31	202
7/11 - 17	203	36	9	0	9	257	39	164
7/18 - 24	106	34	5	0	9	154	17	89
Totals	7,941	1,650	225	6	210	10,032	303	7,639

Table 10.--Squawfish mark and recapture statistics for the Mainstem Merwin trap, 1976.

Date	Catch						Catch disposition	
	Unmarked (no.)	Marked (origin & no.)				Total (no.)	Sacrificed for stomach samples (no.)	Marked & released (no.)
		This trap	Other trap	L. Goose tailrace	1975 releases			
4/18 - 24	6	0	0	0	0	6	6	0
4/25 - 5/1	389	39	4	0	3	435	1	388
5/2 - 8	748	151	7	0	11	917	0	748
5/9 - 15	822	120	16	0	8	966	19	803
5/16 - 22	127	42	4	0	1	174	1	126
5/23 - 29	481	90	28	0	6	605	12	469
5/30 - 6/5	766	96	20	1	8	891	24	742
6/6 - 12	1,577	150	35	0	8	1,770	124	1,453
6/13 - 19	1,060	216	27	3	8	1,314	25	1,035
6/20 - 26	720	131	31	0	5	887	76	644
6/27 - 7/3	1,367	256	59	3	13	1,698	35	1,332
7/4 - 10	1,750	338	47	4	7	2,146	88	1,662
7/11 - 17	934	190	30	1	10	1,165	97	837
7/18 - 24	957	258	28	3	7	1,253	73	884
7/25 - 31	846	336	32	1	7	1,222	72	774
8/1 - 7	829	324	31	2	4	1,190	31	798
8/8 - 14	1,025	385	61	2	7	1,480	33	992
8/15 - 21	726	281	36	2	7	1,052	16	710
8/22 - 28	542	232	33	3	4	814	25	517
Totals	15,672	3,635	529	25	124	19,985	758	14,914

A total of 22,503 squawfish were marked and released in the upper Lower Monumental pool during 1976. Of these fish, 6,070 were recaptured in the Merwin traps during the season. An additional 334 marked squawfish were recovered from mark releases made in 1975. Based on these mark recoveries, population estimates at the two traps are as follows:

Mainstem Trap		Palouse Trap	
$\hat{N}$	= 81,996	$\hat{N}$	= 46,449
$\overline{N}$	= 84,450	$\overline{N}$	= 48,553
$\underline{N}$	= 79,628	$\underline{N}$	= 44,454

Based on these estimates, we determined that the squawfish population in the upper half of Lower Monumental reservoir was 133,000 squawfish in 1976 as compared to an estimate of 120,000 squawfish in 1975.

As in 1975, catches at the two Merwin traps were 90% males during April and early May. By mid-June, the sex ratio was 50/50. Temporal catch distribution at the traps indicates an upstream movement of squawfish in April and May, followed by a downstream movement in July and August (Figure 6). These movement patterns are substantiated by mark recoveries at the two traps (Tables 9 and 10).

Squawfish collected below Lower Granite Dam with purse seines in 1976 were found to be feeding extensively on juvenile salmonids (Table 11). Twenty-one percent of the 1,442 squawfish stomachs examined contained salmonid remains.

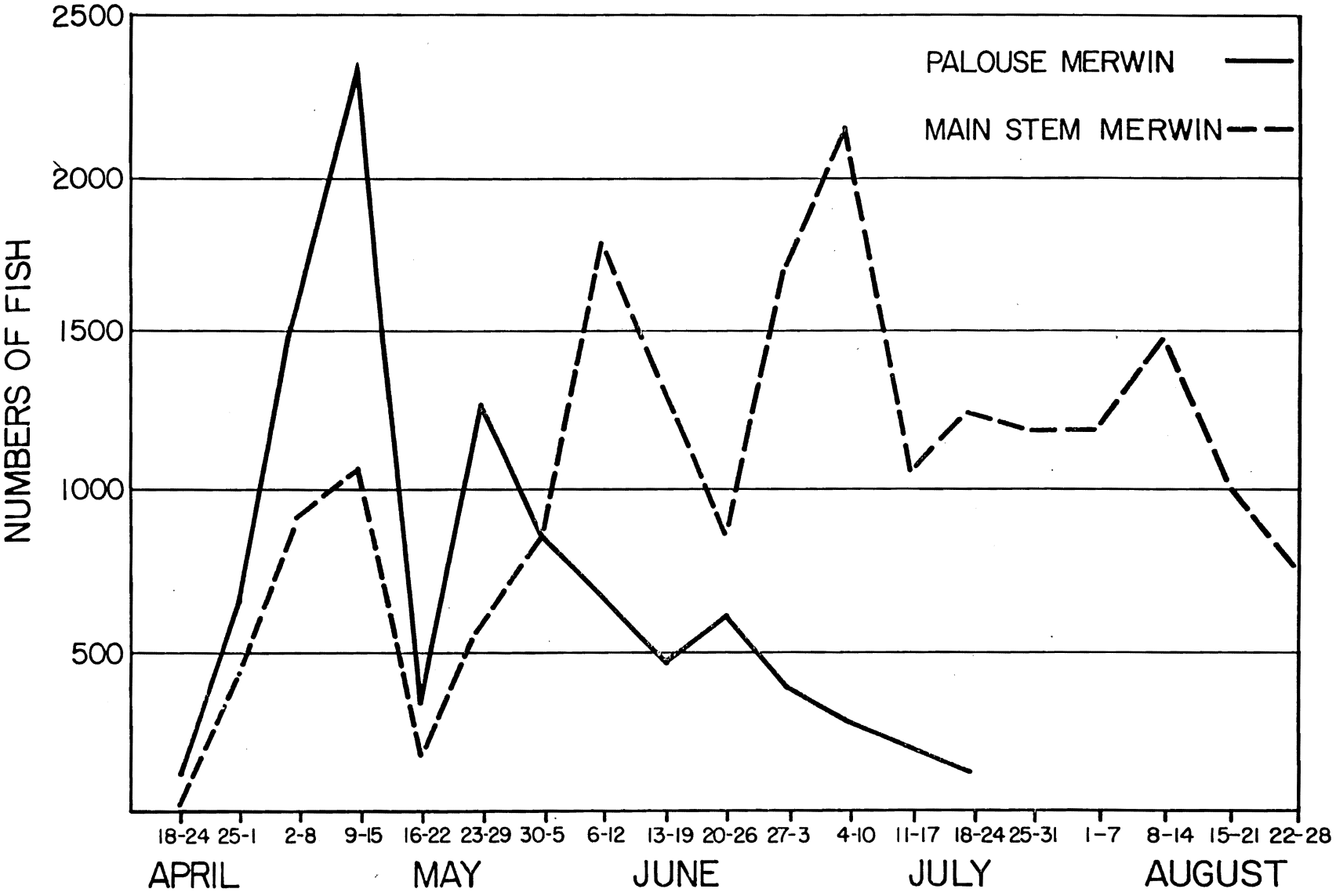

Figure 6.--Weekly squawfish catches at the Palouse and Main Stem Merwin traps in Lower Monumental Reservoir in 1976.

Table 11.--Results of stomach analysis of 1,442 adult squawfish (180 mm long or greater) captured with purse seines below Lower Granite Dam in 1976.

Date	Number of fish sampled	Fish with salmonid remains in stomach	
		(No.)	(%)
5/6	29	8	27.6
5/13	13	1	7.7
5/19	90	2	2.2
5/21	62	2	3.2
5/26	360	52	14.4
6/12	40	12	30.0
6/4	27	9	30.0
6/8	149	48	32.2
6/10	342	91	26.6
6/23	330	83	25.0
Totals	1,442	298	20.7

SUMMARY

River flows in 1976 were above average and comparable to those in 1975. Like 1975, power peaking did not occur until mid-July, well after the spring outmigration was completed. Juvenile salmon and trout migrations were sampled in the Salmon, Snake, and Columbia Rivers in 1976. Information was obtained relative to migrational timing, travel time, magnitude, survival, and diel movement. Residualism in reservoirs and predator fish populations were also examined. Results are summarized as follows:

1. The outmigration of native yearling chinook salmon in the Snake River moved downstream without delay. Peak movement occurred in the Salmon River on April 9, at Lower Granite Dam on April 21, and at Ice Harbor Dam on April 28. Travel time from Riggins, Idaho to John Day Dam was 27 days.

2. The outmigration of native steelhead trout from the Snake River peaked at Lower Granite Dam on May 10, at Ice Harbor Dam on May 17, and at John Day Dam on May 27. Travel time from Lower Granite Dam to John Day Dam was 17 days.

3. Downstream movement of juvenile sockeye salmon in the mid-Columbia River peaked at Priest Rapids Dam on May 19. A small, secondary peak occurred in mid-July. Timing of sockeye salmon at John Day Dam was also bimodal with a primary peak occurring on May 5 and a secondary peak occurring on August 10.

4. Migrational timing of "0"-age chinook salmon in the mid-Columbia River showed peak movement at Priest Rapids Dam in August and September. Based on mark recaptures, travel time from Priest Rapids Dam to McNary Dam was 14 days. An additional 24 days were required to reach John Day Dam.

5. About 5.1 million yearling chinook salmon smolts reached Lower Granite Dam. Overall survival from Lower Granite Dam to John Day Dam was estimated to be 30%.

6. Three million steelhead trout smolts reached Lower Granite Dam. Survival of these fish to John Day Dam was estimated to be 36%.

7. Survival of "0"-age chinook salmon from Wells Hatchery to McNary Dam was only 13%. Survival of wild fish and Priest Rapids spawning channel releases appeared excellent.

8. Diel tests at John Day Dam showed peak movement of yearling chinook salmon and steelhead trout between midnight and 3:00 a.m. The "0"-age chinook salmon moved into the gatewells throughout the night.

9. No significant holdover of Snake River stocks occurred in the Snake River reservoirs sampled (Ice Harbor and Lower Monumental).

10. Large numbers of "0"-age chinook salmon delayed in John Day Reservoir. One group of marked fish showed an average holdover of 75 days.

11. In comparison to 1975 counts, squawfish counts in the fish ladders increased at all dams except John Day Dam.

12. The squawfish population in the upper half of Lower Monumental Reservoir was estimated at 133,000 fish.

13. The percentage of squawfish examined that had salmonid remains in their stomachs ranged from 2.2 to 32.2%.

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APPENDIX

Weekly catch summaries of juvenile salmon and steelhead trout taken at various locations locations in 1976.

Table A1.--Weekly catches of juvenile salmon and steelhead trout at Lower Granite Dam in 1976.

Table A2.--Weekly catches of juvenile salmon and steelhead trout at Little Goose Dam in 1976.

Table A3.--Weekly catches of juvenile salmon and steelhead trout at Ice Harbor Dam in 1976.

Table A4.--Weekly catches of juvenile salmon and steelhead trout at Priest Rapids Dam in 1976.

Table A5.--Weekly catches of juvenile salmon and steelhead trout at McNary Dam in 1976.

Table A6.--Weekly catches of juvenile salmon and steelhead trout at John Day Dam in 1976.

Table A7.--Weekly scoop trap catches of juvenile salmon and steelhead trout from the Salmon River at Riggins, Idaho, in 1976.

Table A1.--Weekly catches of juvenile salmon and steelhead trout at Lower Granite Dam in 1976.

Date	Chinook	Steelhead
	(no.)	(no.)
April 11 - 17	40,735	17,868
18 - 24	51,790	17,200
25 - May 1	119,720*	26,257
May 2 - 8	105,164	71,453
9 - 15	43,403	62,224*
16 - 22	9,350	38,214
23 - 29	5,654	27,444
30 - June 5	3,480	10,836
June 6 - 8	763	2,614
Totals	380,059	274,110

*
Period when 50% of total outmigration had passed.

Table A2.--Weekly catches of juvenile salmon and steelhead trout at Little Goose Dam in 1976.

Date	Chinook	Steelhead	Sockeye
	(no.)	(no.)	(no.)
April 11 - 17	17,950	8,079	633
18 - 24	51,368	22,484	395
25 - May 1	86,057	12,959	221
May 2 - 8	134,804*	32,991	109
9 - 15	88,663	83,263*	224
16 - 22	25,117	40,475	744*
23 - 29	19,919	37,664	1,048
30 - June 5	3,745	15,192	180
June 6 - 12	2,509	6,467	85
20 - 21	1,339	492	26
TOTALS	431,471	260,066	3,665

* Period when 50% of total outmigration had passed.

Table A3.--Weekly catches of juvenile salmon and steelhead trout at Ice Harbor Dam in 1976.

Date	Chinook "0"	Chinook "1"	Steelhead	Sockeye	Coho
	(no.)	(no.)	(no.)	(no.)	(no.)
April 11 - 17	0	435	252	193	4
18 - 24	3	3,695	933	344	0
25 - May 1	1	8,312	2,413	293	7
May 2 - 8	1	12,374*	6,134	311*	8
9 - 15	0	7,384	20,504	249	4
16 - 22	0	3,105	17,018*	202	13
23 - 29	4	1,363	7,815	251	20
30 - June 5	26	407	2,453	97	15*
June 6 - 12	42+	610	1,923	74	39
13 - 16	50	399	1,317	24	14
TOTALS	127	38,084	60,762	2,038	124

* Period when 50% of total outmigration had passed.

Table A4.--Weekly catches of juvenile salmon and steelhead trout at Priest Rapids Dam in 1976.[1/]

Date	Chinook "0"	Chinook "1"	Steelhead	Sockeye	Coho
	(no.)	(no.)	(no.)	(no.)	(no.)
April 11-17	0	3,581	22	53	9
18-24	0	3,372	293	292	2
25-May 1	0	2,196	642	710	17
May 2-8	0	3,969	1,151	2,480	5
9-15	0	3,690*	1,731*	4,980	5
16-22	25	7,384	1,616	8,466*	8,603*
23-29	8	2,331	568	3,326	1,619
30-June 5	4	711	332	1,377	328
June 6-12	7	752	253	1,132	285
13-19	35	790	20 4	1,482	68
20-26	56	1,434	116	1,010	129
27-July 3	64	933	49	230	61
July 4-10	18	153	18	31	77
11-17	202	415	11	46	83
18-24	2,480	91	12	164	175
25-31	3,881	53	6	139	96
Aug. 1-7	7,254	1	1	227	91
8-14	6,572*	0	5	295	74
15-21	3,460	0	0	112	19
22-28	4,037	0	2	107	4
29-Sept. 4	5,195	0	0	54	1
Sept. 5-10	4,086	0	0	57	0
TOTALS	37,384	31,856	7,032	26,770	11,751

* Period when 50% of total outmigration had passed.

[1/] From Sims and Miller, 1976.

Table A5.--Weekly catches of juvenile salmon and steelhead trout at McNary Dam in 1976.

Date	Chinook "0"	Chinook "1"	Steelhead	Sockeye	Coho
	(no.)	(no.)	(no.)	(no.)	(no.)
April 11-17	0	485	29	14	1
18-24	0	2,312	237	68	7
25-May 1	0	7,906	645	259	40
May 2-8	0	20,534*	2,633	406*	152
9-15	0	8,591	2,403*	94	55
16-22	167	1,954	1,163	61	875
23-29	111	1,468	1,044	83	1,811*
30-June 5	175	525	405	44	222
June 6-12	127	1,322	624	53	163
13-19	561	1,683	844	63	134
20-26	1,193	1,293	397	41	75
27-July 3	2,729	616	158	44	23
July 4-10	3,625	83	100	25	25
11-17	1,946	17	41	20	15
18-24	4,435	45	27	46	20
25-31	31,534	0	18	105	33
August 1-7	28,405	0	3	121*	26
8-14	23,626*	0	5	89	7
15-21	22,720	0	3	148	17
22-28	10,724	0	1	47	12
29-Sept. 4	9,794	0	3	37	4
Sept. 5-11	4,114	0	1	39	1
12-18	2,441	0	1	15	0
19-25	1,168	0	0	4	0
26-Oct. 2	3,410	0	0	18	0
Oct. 3-9	1,126	0	1	8	0
TOTALS	154,131	48,834	2,632	967	776

* Period when 50% of total outmigration had passed.

Table A6.--Weekly catches of juvenile salmon and steelhead trout at John Day Dam in 1976.

Date	Chinook "0"	Chinook "1"	Steelhead	Sockeye	Coho
	(no.)	(no.)	(no.)	(no.)	(no.)
Jan. 4-10	0	35	0	0	0
11-17	0	35	1	0	0
18-24	0	514	1	0	1
25-31*	---	---	---	---	---
Feb. 1-7 *	---	---	---	---	---
8-14	0	176	0	1	0
15-21	0	47	0	0	0
22-28*	---	---	---	---	---
29-March 6	0	66	1	0	0
March 7-13*	---	---	---	---	---
14-20*	---	---	---	---	---
21-27	0	25	1	2	0
28-April 3*	---	---	---	---	---
April 4-10	0	33	0	1	0
11-17	0	106	14	3	0
18-24	0	108	47	5	1
25-May 1	30	3,809	1,571	420	0
May 2-8	0	6,329	3,407	1,339	12
9-15	37	7,619	11,338	1,748	13
16-22	89	4,630	7,534	1,190	357
23-29	115	3,428	4,377	574	2,316
30-June 5	124	1,451	2,622	520	415
June 6-12	94	1,040	1,528	290	127
13-19	154	960	492	241	56
20-26	152	1,392	241	195	37
27-July 3	1,141	936	14	90	6
July 4-10	2,333	362	13	65	5
11-17	2,702	28	8	55	8
18-24	651	73	4	40	5
25-31	8,262	4	2	32	10
Aug. 1-7	12,321	4	2	24	17
8-14	9,140	6	0	18	9
15-21	6,286	40	2	23	7
22-28	13,836	3	2	61	5
29-Sept. 4	6,975	1	9	51	13
Sept. 5-11	2,854	0	5	11	2
12-18	5,346	0	2	20	3
19-25	2,219	0	0	9	1
25-Oct. 2	5,045	0	1	22	1
Oct. 3-9	3,577	0	0	16	0

Continued---

Table A6. Continued.

Date	Chinook "0"	Chinook "1"	Steelhead	Sockeye	Coho
	(no.)	(no.)	(no.)	(no.)	(no.)
Oct. 10-16	1,653	0	0	7	0
17-23	3,237	0	1	14	3
24-30	2,686	0	3	10	2
31-Nov. 6	2,857	0	3	8	4
Nov. 7-13	784	0	0	4	0
14-20	1,116	0	1	1	0
21-27	379	0	0	1	0
28-Dec. 4	582	0	0	6	0
Dec. 5-11	298	0	0	1	0
12-18	531	0	0	6	1
TOTALS	97,606	33,260	33,247	7,124	3,437

* Did not fish.

Table A7.--Weekly scoop trap catches of juvenile salmon and steelhead trout from the Salmon River at Riggins, Idaho, in 1976.

Date	Chinook	Steelhead
	(no.)	(no.)
Feb. 29 - March 6	136	0
March 7 - 13	296	0
14 - 20	205	0
21 - 27	3,969	0
28 - April 3	1,589	0
April 4 - 10	23,671	119
11 - 17	6,617	173
18 - 24	3,065	20
25 - May 1	1,204	30
May 2 - 8	2,162	624
TOTALS	42,914	966