A STUDY OF APPARENT LOSSES OF CHINOOK SALMON AND STEELHEAD BASED ON COUNT DISCREPANCIES BETWEEN DAMS ON THE COLUMBIA AND SNAKE RIVERS, 1967-1968

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INTRODUCTION

For a number of years state and federal fisheries agencies have been concerned about the discrepancies between counts of salmon and steelhead at successive dams on the Columbia and Snake Rivers. Based on these counts and known disposition of fish between dams, it appears that substantial losses of fish may be occurring between certain dams. In response to concerns over these apparent losses, a special program was initiated in 1967 and continued in 1968 to study the problem as it related to specific species and races of fish in the areas between specific dams.

In 1967-68, the fish of immediate concern were spring and summer run chinook salmon (Oncorhynchus tshawytscha) and steelhead (Salmo gairdneri). Two areas were of major concern: 1) the Columbia River between Bonneville and The Dalles Dams for spring chinook salmon and 2) the Columbia River between McNary and Priest Rapids Dams and the Snake River from its confluence with the Columbia River to Ice Harbor Dam for summer chinook salmon and steelhead (Figure 1). Table 1 shows the count discrepancies from 1962 to 1966 for both areas in question. If these count discrepancies represent actual losses, then they were substantial enough to be detrimental to chinook salmon and steelhead runs migrating up the Columbia River and its tributaries.

No single factor is likely to be responsible for the count discrepancies but rather a combination of several factors contributes to the problem. Known causes of count discrepancies include: tributary turnoff, gill net catches, hatchery returns, fallback, overcounts, etc. However, there are count discrepancies occurring that exceed the estimates from known causes.

Table 1.--Unaccountable losses of spring and summer chinook salmon and steelhead trout for the Columbia River between Bonneville and The Dalles Dams, the Columbia River between McNary and Priest Rapids Dams, and the Snake River from the mouth to Ice Harbor Dam. The losses are based on fish counts at the respective Dams and best estimates of catch and tributary turn off between Dams.

Lower Area -- Bonneville to The Dalles Dams

Species	Year	Bonneville Dam Count (No.)	Estimated Catch 1/ (No.)	Estimated tributary turnoff 2/ (No.)	The Dalles Dam count (No.)	Unaccountable loss (or gain) (No.)	(%)
Spring chinook	1962	91,000	4,000	7,000	69,000	-11,000	-14
	63	75,000	9,000	6,000	53,000	- 7,000	-12
	64	91,000	11,000	7,000	61,000	-12,000	-16
	65	84,000	20,000	7,000	44,000	-13,000	-23
	66	113,000	2,000	9,000	97,000	- 5,000	- 5
Summer chinook	1962	77,000	1,000	4,000	57,000	-15,000	-21
	63	64,000	4,000	5,000	47,000	- 8,000	-15
	64	81,000	7,000	4,000	56,000	-14,000	-20
	65	76,000	7,000	4,000	51,000	-14,000	-22
	66	72,000	1,000	2,000	61,000	- 8,000	-12
Steelhead	1962	164,000	1,000	2,000	163,000	(+ 2,000)	(+ 1)
	63	129,000	9,000	2,000	119,000	(+ 1,000)	(+ 1)
	64	117,000	7,000	2,000	110,000	(+ 2,000)	(+ 2)
	65	166,000	13,000	2,000	141,000	- 3,000	- 2
	66	144,000	3,000	2,000	146,000	(+ 7,000)	(+ 5)

Upper Area -- McNary to Priest Rapids - Ice Harbor Dams

Species	Year	McNary Dam Count (No.)	Estimated tributary turn off 3&4 (No.)	Ice Harbor Dam count (No.)	Priest Rapids Dam count (No.)	Unaccountable loss (or gain) (No.)	(%)
Spring chinook	1962	56,000	3,000	34,000	8,000	-11,000	21
	63	52,000	3,000	27,000	9,000	-13,000	27
	64	54,000	3,000	24,000	12,000	-15,000	29
	65	29,000	3,000	12,000	6,000	- 8,000	31
	66	87,000	3,000	44,000	14,000	-26,000	31

Table 1. (Cont'd)

Upper Area -- McNary to Priest Rapids - Ice Harbor Dams

Species	Year	McNary Dam Count	Estimated tributary turn off 3&4	Ice Harbor Dam count	Priest Rapids Dam count	Unaccountable loss (or gain)	
Summer chinook	1962	53,000	3,000	31,000	21,000	(+2,000)	(+4)
	63	45,000	3,000	21,000	19,000	(+2,000)	(+5)
	64	55,000	3,000	25,000	25,000	-2,000	4
	65	45,000	3,000	15,000	27,000	0	0
	66	61,000	3,000	17,000	33,00	-8,000	14
Steelhead	1962	163,000	1,000	116,000	9,000	-37,000	23
	63	114,000	1,000	75,000	9,000	-29,000	26
	64	101,000	1,000	59,000	6,000	-36,000	36
	65	119,000	1,000	63,000	9,000	-46,000	39
	66	145,000	1,000	66,000	13,000	-65,000	45

1/ Fish Commission of Oregon, and Washington Dept. of Fisheries, Columbia River Fish runs and Commercial Fisheries 1938-70, 1973 Addendum, Vol. 1, No. 4 January 1974.

2/ Junge, Charles O. and Carnegie, Burton E. Dam Operations and Adult fish passage (salmon) 1975. Ore. Depart. of Fish and Wildlife. Corps contract No. DACW 68-75-C-0129.

3/ Fulton, Leonard A., Spawning Areas and Abundance of Chinook salmon in the Columbia River Basin - Past and Present. Dept. of Interior, Fish & Wildlife Service, Special Scientific Report No. 571. 1968.

4/ (Steelhead) Bell, Milo C. et al. Follow-up development program Columbia River tributaries downstream from Grand Coulee Dam, Excluding the Snake and Williamette Rivers. University of Wash. contract Report No. 03-5-208-330, April 1977.

These unknowns may be due to unreported gill net catch, gill net dropout, incorrect estimates of tributary turnoff, unmeasured spawning populations between dams, statistical discrepancies, selective fishing of certain stocks, passage of fish through the navigation locks, and losses due to stress associated with passage over dams and nitrogen supersaturation, etc.

In 1967, the Bureau of Commercial Fisheries (now the National Marine Fisheries Service) undertook a program utilizing sonic tags and sonic tracking procedures to study the unaccountable loss between dams. A lot of alternate techniques were considered, but it was felt that sonic tags and tracking could show behavior patterns in the river between dams better than any other known method. The study was funded for 2 years--1967 and 1968.

In 1967, the plan was to study spring and summer chinook salmon in both problem areas and steelhead trout only in the area above McNary Dam. The study had the following objectives: 1) to locate specific problem areas where losses could occur, 2) define the cause of losses, 3) investigate tributary turnoff, and 4) determine the amount of fish passage through the navigation locks.

The objectives in 1968 were essentially the same as in 1967, but for several reasons the study was limited to the upper problem area between McNary Dam and Ice Harbor-Priest Rapids Dams. The primary reason for restricting the 1968 work to the upper area was that losses of spring chinook salmon in the lower area in 1966 and 1967 were only 5 and 0% respectively, while losses of 31 and 22% occurred in the upper area. Furthermore, it appeared there were two types of losses, those associated with high river flows (affecting spring and summer chinook salmon) and

those associated with low flows and high water temperatures (affecting summer chinook salmon and steelhead). Since the high flow losses occurred in both problem areas and findings in one area could conceivably be applicable to both areas and since the low flow-high temperature problems were more closely related to the upper area, it seemed more logical to do the second year's work where we had the best chance of providing the most useful information. The other major factor that influenced our decision to restrict the study to the upper area was that an intense gill net fishery was again likely in the lower area. In 1967, we learned that the presence of such a fishery severely intefered with our obtaining adequate data from sonic tagged fish.

EXPERIMENTAL SITE AND EQUIPMENT

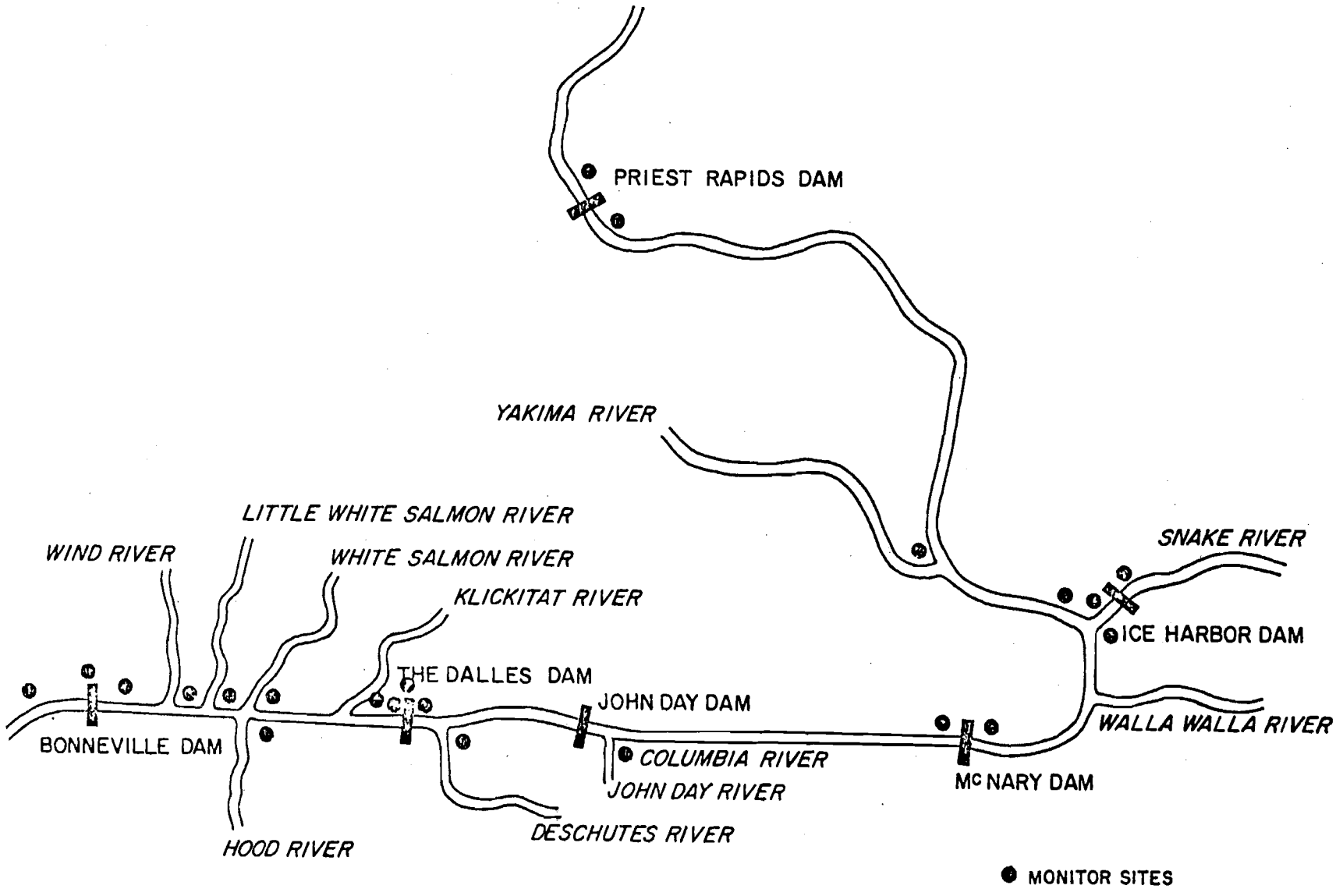
The broad experimental area encompassed approximately 260 miles of the Columbia River from Bonneville Dam to Priest Rapids Dam and 10 miles of the Snake River from its confluence with the Columbia River to Ice Harbor Dam (Figure 1). In 1967, the spring chinook salmon phase of the study covered the entire section with the 47-mile stretch between Bonneville and The Dalles Dams being the major point of interest in relation to unaccountable losses.

The 1967 summer run chinook salmon and steelhead studies and all the 1968 studies were conducted entirely above McNary Dam with the tagging being done at McNary Dam.

FISH TRAPS AND TAGGING BARGE

Fish for the experiment were trapped at the exits to the fishways at Bonneville and McNary Dams. The traps to catch fish for tagging were

Figure 1.--Sketch of study area and monitor sites--the Columbia River from Bonneville Dam to Priest Rapids Dam and the Snake River from the mouth to Ice Harbor Dam (John Day Dam forebay was filled in the spring of 1968).

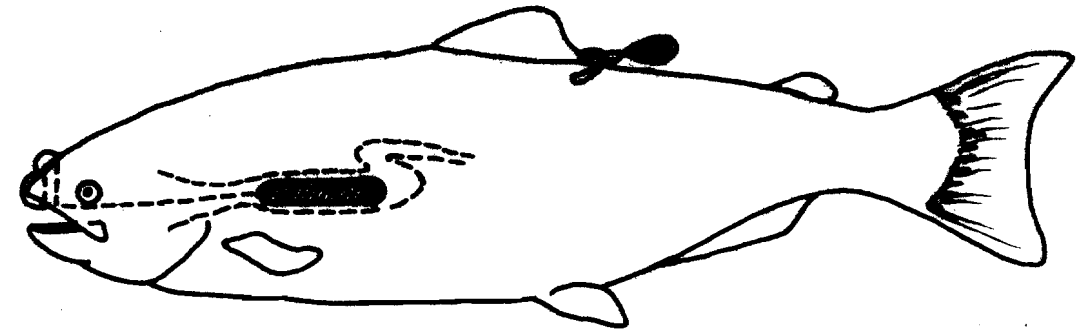


constructed of large pontoons from which a frame containing a spiller type net was suspended (Smith, 1966). The net was made of 2 1/4-inch stretched measure nylon webbing and had a gated throat at the front end. Pulleys and ropes enabled the trap to be pulled up for brailing. When fish were to be trapped, the unit was floated over to the fishway exit and fish were allowed to swim into the net. Periodically the gate at the front of the trap was closed and the unit containing the trapped fish was floated clear of the fishway exit, the trap was raised, and the fish dipnetted out and placed in an anesthetic bath (MS 222) aboard floating tagging barges. Recovery pens, open on one end, were suspended from the sides of the tagging barge so tagged fish could safely recover from the anesthetic and leave at their own volition.

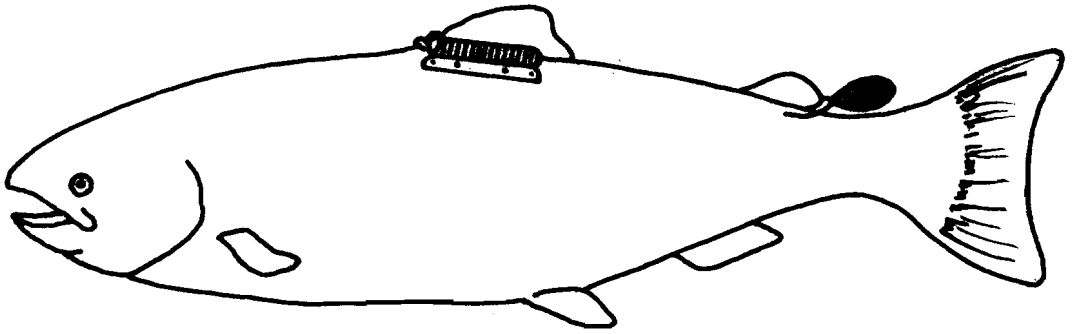
ACOUSTIC TAGS

The sonic tags were high frequency, battery operated, sound transmitters with a life expectancy of approximately 12 weeks. The tags came in five operational codes and were purchased from a commercial source.

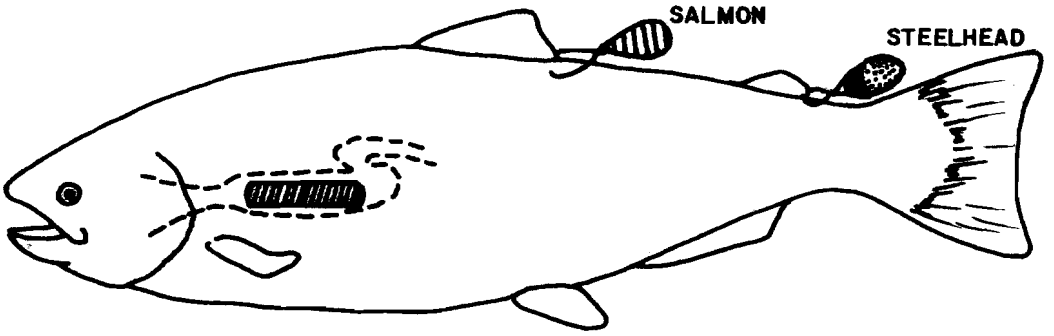
The tags used in 1967 on chinook salmon were internal-external tags that operated on a frequency of 132KHz (Figure 2). The battery and other electronic components were packaged in a cylindrical plastic capsule, 0.625 inch in diameter x 4.28 inches long, which was placed in the fish's stomach. The crystal was contained in a hemispherical plastic button anchored to the fish's nose by two stiff wires which passed through the nose of the fish and were crimped against the roof of the fish's mouth. Small wire leads passed through the fish's esophagus to connect the crystal to the electronics in the fish's stomach.



1967 CHINOOK SALMON



1967 STEELHEAD TROUT



1968 CHINOOK SALMON AND STEELHEAD TROUT

Figure 2.--Sketch showing acoustic tag and flag tag attachment locations on adult chinook salmon and steelhead trout in 1967 and 1968.

The tags used on steelhead in 1967 were composed of two capsules externally mounted on the fish's back (Figure 2). Each capsule was 0.56 inch in diameter x 2.85 inches long. One capsule contained the electronic components and the other held the battery. The wire connection between the capsules was protected with plastic tubing. For balance, one capsule was placed on each side of the fish's dorsal fin, and they were secured to the fish by two pins which passed through the flesh beneath the dorsal fin. These tags also operated at a frequency of 132 KHz.

The acoustic tags used for both species in 1968 were entirely packaged in a cylindrical plastic capsule, 0.75 inch in diameter by 2.92 inches long, placed in the fish's stomach. These tags operated at a frequency of 70 KHz.

FLAG TAGS

Colored coded flag tags were used to visually identify the various groups released, to identify species, and to indicate whether a fish was carrying a sonic tag or was simply a control. The tag was an elliptical plastic flag cemented to vinyl tubing. The tubing was passed through the fish's back and held in place by looping the tubing to itself and securing it with a crimped metal sleeve. Chinook salmon carried the flag tag attached near the dorsal fin while steelhead carried the tag attached near the adipose fin.

MONITORS

Two types of monitors were used: 1) automatic recording monitors and 2) nonrecording monitors. Automatic recording monitors were developed to reduce personnel requirements in determining tagged fish movement on a 24-hour basis past remote areas between dams. In 1967, data were recorded on pressure sensitive tape; the 1968 data were recorded on a magnetic tape system. Each recording monitor was activated by the sonic signal of an approaching tag. Data recorded were tag code, time of passage, and directional movement.

Nonrecording monitors were used for detecting tagged fish in the navigation locks and at the fish counting stations in the fish ladders. Lock operators activated monitors at each lockage and manually recorded the activity they may have observed. Counting station monitors were in operation at all times fish counters were on duty. These units alerted the counters to an approaching sonic tagged fish.

TRACKING EQUIPMENT

Tracking was done from drifting boats with the crew using hand held directional hydrophones, tuneable receivers, and headphones. Incoming signals from sonic tagged fish were picked up by the hydrophone and fed into the receiver where the signal was amplified and converted to an audible tone that the operator monitored via the headset.

GENERAL EXPERIMENTAL PLAN

The study was divided into two parts: 1) the evaluation of spring chinook salmon losses between Bonneville and McNary Dams (1 April to 15 June) with special emphasis in the area between Bonneville and The Dalles Dams and 2) the evaluation of summer chinook salmon and steelhead losses above McNary Dam to Priest Rapids Dam on the Columbia River and Ice Harbor Dam on the Snake River (20 June to 15 October). Plans were to tag approximately 2% of the spring chinook salmon run at Bonneville Dam, then shift the tagging operation to McNary Dam in June to tag 2% of the summer chinook salmon and steelhead runs. The plan was to be carried out in 1967 and repeated in 1968. However, in 1968, due to reasons mentioned previously, including the

extensive gillnet fishery between Bonneville and The Dalles Dams, the decision was made to expend our effort and funds on an extensive study in the upper river only where we felt we had the best opportunity to obtain the desired data.

During the spring of 1967, chinook salmon tagged at Bonneville Dam were divided into three different sonic tag code groups (codes: 1, 2, and 4). At McNary Dam sonic codes 3 and 5 were assigned to summer chinook salmon while sonic codes 1 and 2 were given to steelhead. In 1968 this same coding system was used again; however, the spring chinook salmon were tagged at McNary Dam. Each group of fish consisted of test fish (sonic tagged) and control fish (flag tag only). For visual identification sonic tagged fish also carried a flag tag.

Data on fish loss were to be determined primarily by the difference in numbers of tagged fish recorded past monitor stations. Additional data were to come from flag tag sightings at the dams, boat drift observations, and navigation lock monitoring.

EXPERIMENTAL PROCEDURES

TRAPPING AND TAGGING

Fish for tagging were captured in the barge traps at the exits to the fishways. When not fishing and during tagging operations, the traps were moved away from the exits so fishway passage would not be disturbed. The traps were usually fished in the early morning. Two sets were not uncommon, and on occasion three sets were necessary. Fish were individually dipnetted from the trap, placed in an anesthetic solution (MS 222), checked for nitrogen disease symptoms, and tagged. The tagged fish were then placed in an open end recovery pen where they could recover from the anesthetic

and swim into the forebay at their own volition. During hot weather and warm water conditions, submersible pumps kept water circulating in the pens.

MONITORING

Fish movement was traced primarily with automatic recording devices which were installed at strategic locations along the Columbia River and its tributaries (Figure 1). The monitors were serviced weekly for tape change, maintenance, and repair.

Fishway monitors located at the counting station gave an audible "beeping" signal to alert the counters that a sonic tagged fish was about to pass their station. Counters recorded the time of passage, color of the flag tag and attachment location, species, and condition for all test and control fish they observed.

Navigational lock monitors were turned on only during a lockage by the operator who recorded whether sonic tagged fish were present or not during and after each lockage.

BOAT DRIFTING

In 1967, only occasional boat drifts were made because we were relying on the recording monitors to provide the information on the progress of tagged fish through the area. The number of boat drifts were increased in 1968, and they were conducted on a regular schedule. The drifts started just below Priest Rapids Dam and the crews worked their way down the Columbia River. When they reached the confluence of the Snake River, they motored up the Snake River to Ice Harbor Dam, drifted from there down the Snake River back into the Columbia River, and finished the drift by covering

the area from the Snake River to McNary Dam. A complete drift of the study area took several days during which time the crew listened for tagged fish and recorded their locations on charts of the area. Drift crews were particularly interested in concentrations of tagged fish and tag signals that appeared to stay in one area over the time span of several drifts. The only major problem encountered was keeping to our schedule due to the number of days drifting was impossible because of rough water conditions caused by the high winds that characterize this area of the Columbia River Basin during the time of the study.

GENERAL OBSERVATIONS - 1977

A number of significant problems beset the program in 1967. The biggest problem was the failure of the monitors to adequately provide continuous reliable data. Secondly, an intensive gill net fishery in the lower river caught a disproportionate number of sonic-tagged fish. Thirdly, although the tag attachment was the best available with the state of the art of sonic tags at that time, an unknown but excessive number of tags were shed by the fish. In addition, the unaccountable losses of fish within the study area were less than had been occurring in previous years. This was particularly true for spring chinook salmon in the lower area where the unaccountable loss was essentially zero. Even in the upper area there was a reduction in the losses of spring and summer chinook salmon and steelhead.

The automatic recording monitors had a number of problems. First, the mechanical operation of the pressure sensitive tape system was unreliable under field conditions. Because the units were numerous and spread throughout the study area, we were unable to service them fast enough to keep them in repair. We were also plagued with vandalism; units were destroyed or taken

and hydrophones were pulled out of the water by the cables and either ruined or left high and dry on the river bank. Second, because we had no effective means of examining the tape in situ, we didn't realize just how inadequate the data were until it was too late to do much about it. Constant improvements and repairs were made to the monitors as the season progressed, but they were not enough to make them effective. It was simply a matter of asking too much from the state of our technology at the time.

Based on tag returns, it was apparent that the externally mounted tag components made the fish more susceptible to the gill net fishery. On some days almost 50% of the fish tagged with sonic tags for the day would be caught by the first fisherman upstream from the tagging station.

Based on observations at fish counting stations and subsequent recoveries of flag tagged fish with sonic tags missing (chinook salmon 39% and steelhead 45%), it was apparent that shedding of tags was a major problem. If we examine the counts of fish at successive dams and compare the precentages with reports of our tagged fish (Table 2), it appears that our tagged fish were not surviving and moving upstream at the same rate as the overall populations of fish being studied. This could have been a result of shed tags, tags with poor visibility, excessive capture in the fishery, or some other factor(s).

Table 3 shows the fish counts and the disposition of fish within the study area for 1967. If we compare these data to data in Table 1, they show there were smaller losses in 1967. In fact, there was no loss of spring chinook salmon in the lower area. In the upper area, there was a sharp reduction in the loss of summer chinook salmon and a moderate reduction in the losses of spring chinook salmon and steelhead.

Table 2. -- A comparison of the survival[1/] of tagged fish with corresponding general populations, based on sightings at Bonneville, The Dalles, McNary, Ice Harbor, and Priest Rapids Dams.

Species	Type Count	Bonneville Count	Survival to The Dalles	Survival to or Count at McNary	Survial to Ice Harbor	Survival to Priest Rapids	Total Survival to Ice Harbor and Priest Rapids
		No.	%	% (count--No.)	%	%	%
Spring Chinook Salmon	Tag	1,413	39	11%	11	4	15
	Population	85,000	85	74%	12	13	55
Summer Chinook Salmon							
	Tag	---	---	(1161)	31	27	58
	Population	---	---	(60,000)	50	43	93
Steelhead							
	Tag	---	---	(1461)	10	3	13
	Population	---	---	(78,000)	56	9	65

1/ Survival is calculated from Bonneville Dam for spring chinook salmon and from McNary Dam for summer chinook salmon and steelhead.

Table 3.--Unaccountable losses of spring and summer chinook salmon and steelhead trout for the Columbia River between Bonneville and The Dalles Dams, the Columbia River between McNary and Priest Rapids Dams, and the Snake River from the mouth to Ice Harbor Dam. The losses are based on fish counts at the respective Dams and best estimates of catch and tributary turn off between Dams.

Lower Area--Bonneville to The Dalles Dams

Species	Year	Bonneville Dam count (No.)	Estimated Catch [1] (No.)	Estimated tributary turnoff [2] (No.)	The Dalles Dam count (No.)	Unaccountable loss (or gain) (No.)	(%)
Spring chinook	1967	85,000	12,000	7,000	72,000	(+24,000)	(+9)
Summer chinook	1967	96,000	10,000	4,000	73,000	- 9,000	-13
Steelhead	1967	122,000	16,000	2,000	122,000	(+18,000)	(+17)

Upper Area--McNary to Priest Rapids-Ice Harbor Dams

Species	Year	McNary Dam Count (No.)	Estimated tributary turnoff [3&4] (No.)	Ice Harbor Dam Count (No.)	Priest Rapids Dam Count (No.)	Unaccountable loss (or gains) No.)	(%)
Spring chinook	1967	63,000	3,000	36,000	11,000	-13,000	-22
Summer chinook	1967	60,000	3,000	30,000	26,000	- 1,000	- 2
Steelhead	1967	78,000	2,000 [4]	44,000	7,000	-25,000	-33

1/ Fish Commisson of Oregon, and Washington Dept. of Fisheries, Columbia River Fish runs and Commercial fisheries, 1938-70, 1973 Addendum, Vol. 1, No. 4 January 1974

2/ Junge, Charles O. and Carnegie, Burton E. Dam Operations and Adult-Fish Passage 1975. Ore. Depart. of Fish and Wildlife, Corps Contract No. DACW68-75-C-0129.

3/ Fulton, Leonard A., Spawning Areas and Abundance of Chinook salmon in the Columbia River Basin-Past and Present. Dept. of Interior Fish & Wildlife Service, Special Scientific Report No. 571. 1968.

4/ Bell, Milo C. et al. Follow-up Development Program Columbia River tributaries downstream from Grand Coulee Dam, excluding the Snake and Willamette Rivers. University of Wash. Contract Report No. 03-5-208-330, April 1977

Even with all the problems, there was some useful information that came out of the study in 1967. The data are only general in nature, but do indicate some probable trends and will be useful as other research is done on the problem.

SPRING CHINOOK SALMON

In 1967, spring chinook salmon were tagged and released at Bonneville Dam. From 7 April until 27 May, 1413 spring chinook salmon (1.7% of the spring chinook salmon run over Bonneville Dam) were tagged in three coded groups--729 sonic tags and 684 control tags (Table 4). Because the delivery of sonic tags from the manufacturer was late, no Code 1 sonic tags were released.

Bonneville to The Dalles Dams

At The Dalles Dam 558 tagged fish (39% of the total tagged) were eventually counted over the dam--293 sonic (40% of number tagged) and 263 control (38% of number tagged). Of the three groups of spring chinook salmon, the Code 2 group had the least sightings per number of fish tagged (Table 5). We believe this was due to the shade of green used for the flag tags which made it difficult (under certain water conditions) to detect the flag as it passed the fishway counting boards.

By examining tag returns, we were able to obtain some accountability of what happened to the tagged fish. Tags from 215 fish (15% of the Bonneville release) were returned from the area downstream from The Dalles Dam. The greatest number of tag returns (183) came from sources associated with the gill net fishery (mostly processing plants). Return rates of sonic and control tags were not the same; three sonic tags were

Table 4.--Summary of tag release data for spring chinook salmon at Bonneville Dam, 1967.

Date of Release	Code No.	Sonic tags (No.) 1/	Control tags (No.)	Total tags released (No.)
7 to 14 April	1	0	294	294
7 April to 7 May	2	533	340	873
7 to 27 May	4	196	50	246
TOTAL		729	684	1,413

1/ No sonic tags released due to late delivery from manufacturer.

Table 5.--Tagged chinook salmon sightings past The Dalles Dam.

Type	CODE No. 1 1/			CODE No. 2			CODE No. 4		
	Tagged (No.)	Sightings (No.)	(%)	Tagged (No.)	Sightings (No.)	(%)	Tagged (No.)	Sightings (No.)	(%)
Sonic	0	0	0	533	201	38	196	94	48
Control	294	138	47	340	99	29	50	26	52
TOTAL	294	138	47	873	300	34	246	120	49

1/ No sonic tags released due to late delivery by manufacturer.

returned from each control tag returned. The high rate of return of sonic tags from the gill net fishery may be due to the sonic tagged fish being more susceptible to the nets by virtue of the external crystal on the fish's nose. In addition, experience has shown a reluctance of the fishery to return flag tags. Apparently the flag tags were removed and either discarded or retained by the fishermen. The sonic tag, which is not visible in the whole fish, remains in the fish's gut and travels with the fish to the processing plant. When the fish is eviscerated at the processing plant, the sonic tag is discovered and returned by plant personnel. Tag returns from the gill net fishery were 13% of the tags released at Bonneville Dam. This figure is probably low due to the reluctance of fishermen to return our tags. Of the remaining 32 tags returned, 19 were from below Bonneville Dam and 13 were from the sport catch and tributaries between Bonneville and The Dalles Dams.

Based on tag sightings at The Dalles Dam and tag recoveries, 773 (55%) of the 1413 spring chinook salmon tagged could be accounted for at The Dalles Dam. However, this figure is low due to the lack of consistent tag returns within the area. Specific areas of losses within the reservoir were not identified except that many of the tags returned from the gill net fishery came from the first nets above Bonneville Dam. There was no appreciable fish passage through the locks.

McNary to Priest Rapids and Ice Harbor Dams

At McNary Dam, 159 spring chinook salmon or 11% of the fish tagged at Bonneville Dam were counted through the fishways (Table 6). Survival of these fish in the McNary pool, based on fishway counts at the two upstream dams (Priest Rapids and Ice Harbor Dams) was over 100%. Again, the difference was largely associated with the Code 2 fish which carried the difficult to see green flag tags.

Based on counts at Ice Harbor and Priest Rapids Dams of the tagged fish passing through the McNary pool and continuing their migration in the Columbia or Snake Rivers, 76% of the spring chinook salmon were destined for the Snake River and its tributaries while 24% continued up the Columbia River. Counts of all spring chinook salmon at the dams indicated a split of 77% and 23%, respectively, of spring chinook salmon between the Snake and Columbia Rivers (Table 3).

Tag recoveries from above McNary Dam (Table 7) would indicate that an even larger portion of the spring chinook salmon run entered the Snake River, as 82% (65) of the tags returned were from fish caught in the Snake River or its tributaries. However, differential fishing pressure is not taken into account. A further breakdown of tags returned from the Snake River system shows that the majority of the fish (83%) were bound for the Salmon River.

A special point of interest is the 128% figure for the portion of the McNary Code 2 spring chinook salmon count that was observed crossing Ice Harbor Dam (Table 6). As mentioned earlier, the flag tag color probably caused the difference in count, but if not the fallback rate

Table 6.--Tagged spring chinook salmon crossing McNary Dam, 1967, and the the number and percent subsequently crossing Priest Rapids and Ice Harbor Dams.

Code	Fish over McNary Dam	Fish over Priest Rapids Dam		Fish over Ice Harbor Dam		Fish over both Dams	
	(No.)	(No.)	(%)	(No.)	(%)	(No.)	(%)
Code #1	10	4	40.0	4	40.0	8	80.0
Code #2	80	27	33.8	102	127.5	129	161.3
Code #4	69	21	30.4	55	79.7	76	110.2
TOTAL	159	52	32.7	161	101.3	213	134.0

Table 7.--Location of spring chinook salmon tag recoveries above McNary Dam, 1967.

Tags (No.)	Recovery Locations
1	Between confluence of Snake River and Priest Rapids Dam
5	Above Priest Rapids Dam
7	Snake River above Ice Harbor Dam
54	Salmon River and tributaries
4	Tributaries above Ice Harbor Dam other than Salmon River
4	Yakima River
4	Unknown
TOTAL 79	

would have had to have been 92% at Ice Harbor Dam to get a combined survival of 100% to Priest Rapids and Ice Harbor Dams. The 92% figure is most assuredly high, but some fallback did probably take place as more than 100% of the Code 4 fish were also accounted for based on counts (Table 6).

Table 3 indicates there was about a 22% unaccountable loss of spring chinook salmon in the area. However, neither tag recoveries nor tracking observations indicated any specific locations within the area where excessive losses or delays took place. There was no appreciable fish passage through the locks at Ice Harbor Dam.

SUMMER CHINOOK SALMON AND STEELHEAD

Tagging of summer chinook salmon and steelhead began at McNary Dam on 21 June and terminated on 11 October. From 21 June to 16 August, a total of 1161 summer chinook salmon were tagged and released in two groups: Code 3 (398 fish) and Code 5 (763 fish). Approximately 1.9% of the summer chinook salmon crossing McNary Dam were tagged. Steelhead were also tagged in two groups representing the early fish (A run--15 July to 16 August) and the later fish (B run--5 September to 11 October). About 1.3% of the steelhead run (1461) was tagged--537 fish of the A run (Code 1) and 924 fish of the B run (Code 2). A summary of the tagging data for both species is shown in Table 8.

The relative survival of tagged summer chinook salmon and steelhead based on sightings at the counting stations at Ice Harbor and Priest Rapids Dams provides an indication of excessive tag losses or failure and/or differential mortality between tagged fish and the rest of the population.

Table 8.--Summary of tagging data for summer chinook salmon and steelhead trout at McNary Dam, 1967

Species	Code	Dates of Release	Sonic tags (No.)	Control tags (No.)	Total tags released (No.)
Chinook 1/	3	21 June to 16 Aug.	199	199	398
Chinook 2/	5	21 June to 16 Aug.	381	382	763
					1161
Steelhead "A"	1	15 July to 16 Aug.	251	286	537
Steelhead "B"	2	5 Sept. to 11 Oct.	459	465	924
					1461
TOTAL			1290	1332	2622

1/ All fish tagged were from the Washington fishway.

2/ All fish tagged were from the Oregon fishway.

About 58% of the summer chinook salmon and 13% of the steelhead tagged at McNary Dam were observed going over the upper two dams (Table 9), while Corps counts of the respective runs indicate a survival of 93% for chinook salmon and 65% for steelhead (Table 3). No data were available that indicated any areas of excessive delay or mortality within the area, except for the duration of the temperature block--see TEMPERATURE BLOCK section. There was no appreciable passage of either summer chinook salmon or steelhead through the locks at Ice Harbor Dam.

The split between the Snake River and the upper Columbia River was approximately even for tagged summer chinook salmon, but 80% of the tagged steelhead went up the Snake River. These figures compare favorably with the Corps counts for both runs. Of the 152 tagged steelhead observed at Ice Harbor Dam, 85 or 56% were counted past the Lewiston Dam into the Clearwater River.

A total of 110 tags from summer chinook salmon were returned. Steelhead tag returns from the early run (Code 1) numbered 143, while 278 tags were returned from the later run (B). Most of the returns were from the sports fishery. Table 10 summarizes the data on tag returns.

Returns of summer chinook salmon tagged from the Washington shore ladder at McNary Dam indicated that summer chinook salmon using the Washington shore ladder tended to swim past the Snake River and on up the Columbia River. Those summer chinook salmon tagged from the Oregon shore fish ladder showed a tendency to swim up the Snake River. For example, only 66 recoveries of Washington shore tagged chinook salmon (17%) came from the Snake River while 160 recoveries (40%) came from the Columbia River above the Snake River. Oregon tagged summer chinook salmon returns

Table 9.--Tag sighting data at McNary, Ice Harbor, and Priest Rapids Dams for summer chinook salmon and steelhead trout, 1967.

Species	Fish tagged	Fish over Priest Rapids Dam		Fish over Ice Harbor Dam		Fish over both dams	
	(No.)	(No.)	(%)	(No.)	(%)	(No.)	(%)
Summer chinook	1161	313	27.0	357	30.7	670	57.7
Steelhead	1461	36	2.5	152	10.4	188	12.9

Table 10.--Distribution of tag returns by species, area, and percent of total fish tagged at McNary Dam, 1967.

	Summer Chinook		Steelhead "A"		Steelhead "B"		Total	
	(No.)	(%)	(No.)	(%)	(No.)	(%)	(No.)	(%)
Below Bonneville Dam	1	0.1	0		1	0.1	1	0.1
Bonneville to McNary Dams	2	0.2	14	2.6	13	1.4	27	1.8
McNary Dam to Snake River	0	0	2	0.4	1	0.1	3	0.2
Snake River to Priest Rapids Dam	12	1.0	21	3.9	18	1.9	39	2.7
Yakima River	0	0	8	1.5	10	1.1	18	1.2
Mouth of Snake River to Ice Harbor Dam	3	0.3	1	0.2	0	0	1	0.1
Above Priest Rapids Dam	20	1.7	20	3.7	21	2.3	41	2.8
Above Ice Harbor Dam	70	6.0	74	13.8	211	22.8	285	19.5
Unknown	2	0.2	3	0.6	3	0.3	6	0.4
TOTAL	110	9.5	143	26.2	278	30.1	421	28.9

amounted to 291 recoveries from the Snake River (38%) and 153 recoveries (20%) from the Columbia River above the Snake River. Tagged steelhead did not show this trend.

Since summer chinook salmon tagged from the Washington shore ladder at McNary Dam (red tags) were visibly distinguishable from those tagged from the Oregon shore ladder (yellow tags), we were able to use tag sightings at Priest Rapids and Ice Harbor Dams to confirm that summer chinook salmon from the Washington shore ladder tended to continue up the Columbia River, while those tagged from the Oregon shore ladder tended to enter the Snake River. Of those tagged fish observed at Priest Rapids and Ice Harbor Dams from fish that had been tagged from the Washington shore ladder, 71% were observed at Priest Rapids Dam (Columbia River) and 29% were observed at Ice Harbor Dam (Snake River). The reverse trend was true for those tagged from the Oregon shore; 66% were observed at Ice Harbor Dam (Snake River) and 34% were observed at Priest Rapids Dam (Columbia River).

Temperature Block

In mid-July, drift crews began to notice a concentration of sonic-tagged fish in the Columbia River at its confluence with the Snake River. Water temperature measurements at the time indicated that the Snake River was warming at a faster rate than the Columbia River. As time went on, it was apparent that a significant temperature block was forming in the mouth of the Snake River. This block interfered with the early or "A" group steelhead and to some extent with the latter portion of the summer chinook salmon run.

The block that formed in mid-July persisted until about mid-September. During this time, large numbers of sonic-tagged fish could be heard in the cooler waters of the Columbia River just off the mouth of the Snake River. At the beginning of the block, the water temperature in the Snake River was 71° F. while the temperature of the Columbia River water was only 63° F. By mid-August the block was well formed and the water temperature at the mouth of the Snake River had risen to 79° F. and the Columbia River had reached 72° F. At the breakup of the block in mid-September, the water temperatures in both the Columbia River and the Snake River were near 70° F.

During the block, the fish appeared to stay primarily in the cooler Columbia River water with an occasional penetration into Snake River water. The disposition of tagged fish in the area on 2 August is shown in Figure 3. The total number of steelhead receiving sonic tags was 710 and represented 0.9% of the total run. Therefore, each sonic-tagged fish heard in the river represented about 109 untagged fish. Based on these calculations, about 2,000 steelhead were holding off the mouth of the Snake River on 2 August. In mid-to-late August, the concentration dwindled somewhat as fish moved up the Columbia River into the Ringold Springs vicinity and above or to a lesser extent drifted downstream toward McNary Dam.

When the block lifted, most of the tagged fish that we could still hear and that had remained in the area moved up the Snake River. Steelhead tagged after the temperature block dissipated experienced little or no delay in entering the Snake River and passing over Ice Harbor Dam. Fish counts at Ice Harbor Dam for the period of the block are shown in Table 11. It is interesting to note that tagged steelhead from the "A"

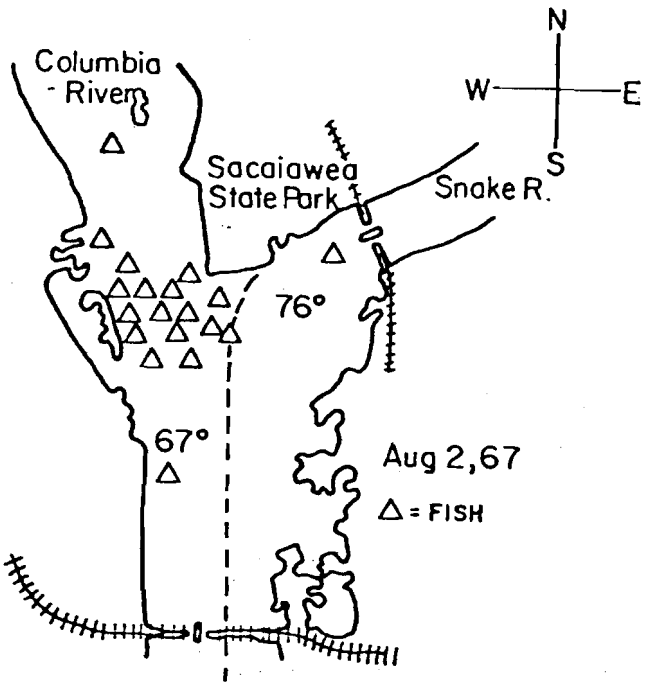


Figure 3.--Concentration of tagged steelhead at the confluence of the Columbia and Snake Rivers during the temperature block.

Table 11.--Water temperatures and steelhead counts at Ice Harbor Dam during the temperature block, 1967.

Date	Water Temp. (°F)	Steelhead count (No.)	Date	Water Temp. (°F)	Steelhead count (No.)
July 15	69	32	Aug. 17	74	72
16	70	31	18	76	56
17	70	39	19	76	41
18	71	30	20	76	50
19	72	27	21	76	55
20	72	32	22	76	46
21	72	10	23	76	11
22	72	6	24	76	5
23	72	20	25	76	16
24	72	14	26	76	14
25	72	14	27	76	7
26	72	45	28	76	10
27	72	62	29	76	17
28	73	42	30	75	19
29	73	63	31	75	29
30	73	38	Sep. 1	76	31
31	73	53	2	74	63
Aug. 1	73	36	3	74	113
2	74	42	4	74	100
3	74	24	5	74	64
4	74	24	6	74	107
5	74	41	7	74	199
6	74	37	8	73	147
7	74	47	9	73	162
8	74	28	10	73	81
9	74	22	11	72	198
10	74	20	12	72	257
11	74	19	13	72	172
12	74	19	14	71	142
13	74	32	15	71	92
14	74	58	16	69	104
15	74	27	17	69	87
16	74	29	18	69	220
			19	69	1820
			20	69	1300
			21	69	1304

group (blocked) had a greater tendency to be recovered downstream from McNary Dam than did the "B" group ("A" group 2.4% and "B" group 1.1%). Also, the percentage of "A" group (blocked) tags returned from above Ice Harbor Dam was only about one-half that from the "B" group.

FALLBACK

Fallback apparently occurred at Bonneville, The Dalles, McNary, and Ice Harbor Dams. This was evident when fish that had been tagged and released above a particular dam were caught below that dam or observed going across the counting board of that dam. Sufficient data were not available to assess the fallback rate at the various dams. Overcount such as occurred at Ice Harbor Dam (Table 6) can also be an indication of fallback.

GENERAL OBSERVATIONS--1968

Significant improvements were made in the study for 1968. The monitors were converted to a less troublesome magnetic tape system. The housing for the monitors were rebuilt out of heavy gauge steel. When the monitors were installed in the field, concealed locations were chosen, a concrete pad was poured, the cases were bolted to the pad, and the cables were buried in conduit until they were out into the river. However, we were still bothered by vandalism. Wave action along the river bank sometimes exposed the cables to the curious and destructive, and they searched for and found our monitors. The heavy metal boxes and concrete pads stopped the theft of the monitors, but did not prevent their

destruction by blasts from shotguns or high-powered rifles. We were still dependent upon data from the monitors, but to a lesser degree because we incorporated regularly scheduled drifting into the study.

A breakthrough in tag design allowed us to build the tags so they could be placed entirely in the stomach of the fish. Experiments conducted in the laboratory indicated that the fish accepted these tags and we expected good results from them, and in fact tag retention was greatly improved. The only external tags that were used were the vinyl flag tags attached to the fish's backs.

To avoid the intensive gill net fishery, we restricted our operations to the upper area between McNary Dam and Priest Rapids-Ice Harbor Dams. Restriction of the study to the upper area also allowed us to concentrate our efforts in the area where we were most likely to obtain the best results.

Even though the study went much better in 1968, there were still significant problems. The experiment, as originally conceived, was expected to monitor the losses of fish when they ranged from 15 to 45%, but losses of spring chinook salmon were sharply down from 22% in 1967 to only 10% in 1968. The losses of summer chinook salmon were only 2% and steelhead losses were only 16%. Detecting the reasons for losses which ranged from 2 to 16% was difficult with the degree of sophistication of the techniques available.

SPRING CHINOOK SALMON

A total of 836 chinook salmon, or approximately 1.2% of the spring run over McNary Dam, was tagged in three code groups and released between

16 April and 31 May. Of these, 372 test fish carried acoustic and flag tags and 464 control fish carried flag tags only (Table 12).

Survival of tagged spring chinook salmon in the McNary pool was better than it was in 1967, but tagged fish survival still did not compare well with the survival of the total population as indicated by fish counts at the upstream dams (Table 13). Sixty-four percent of the tagged fish were accounted for at Ice Harbor and Priest Rapids Dams, while 85% of the overall population was accounted for. Code 2 had the least number of sightings at the dams--probably due, at least in part, to the dark blue shade of flag tag used.

When all known estimates of fish leaving the McNary pool are accounted for, the unaccountable loss rate is not as high as would be indicated by fish counts at the upstream dams. Data in Table 14 indicate there was about a 10% unaccountable loss of spring chinook salmon in the study area. Tracking data failed to identify any specific area of loss for spring chinook salmon within the McNary reservoir.

The division of tagged fish between the Snake and upper Columbia Rivers was 67% and 33%, respectively, while the overall population split 75% to 25%. The reason for the difference between the tagged fish and the rest of the population was the low count for the Code 2 fish at Ice Harbor Dam. Once again, the flag tag color could have caused the difference.

Although there was no measure for the difference in fishing pressure between the Snake and Columbia Rivers, the number of tags returned from the Snake River (168) would indicate a division of 88% of the tagged fish into the Snake River. Tags from 190 fish tagged during the spring run

Table 12.--Fish tagged at McNary Dam, 1968.

Species	Date Release	Flag Color	Code	Sonic Tags (no.)	Control Tags (no.)	Total (no.)
Spring Chinook	4/16 - 4/25	orange	1	1	79	80
	4/26 - 5/15	blue	2	232	256	488
	5/16 - 5/31	white	4	139	129	268
Summer Chinook	6/17 - 7/15	red	3	172	180	352
	7/16 - 8/5	yellow	5	138	143	281
Steelhead	7/16 - 8/20	orange	1	257	569	826
	9/4 - 10/4	blue/white	2	248	254	502

Table 13.--Percent of tagged fish accounted for by counts at upstream dams, and total sighted.

Species		No. tagged	Tags over Priest Rapids		Tags over Ice Harbor		Tags over both dams	
			(No.)	(%)	(No.)	(%)	(No.)	%
Spring Chinook	1	80	15	19	81	101	96	120
	2	488	75	15	143	29	218	45
	4	268	40	15	185	69	225	84
		836	130	16	409	49	539	64
Corps Counts		67,000	12,000	18	45,000	67	57,000	85
Summer Chinook	3	352	131	37	197	56	328	93
	5	281	133	47	78	28	211	75
		633	264	42	275	43	539	85
Corps Counts		61,000	27,000	44	30,000	49	57,000	93
Steelhead	1	826	114	14	287	35	401	49
	2	502	8	2	114	23	122	24
		1,328	122		401	30	523	39
Corps Counts		113,000	11,000	10	82,000	73	93,000	82

Table 14.—Unaccountable losses of spring and summer chinook salmon and steelhead trout for the Columbia River between McNary Dam and Priest Rapids Dam and Ice Harbor Dam on the Snake River. The losses are based on fish counts at the respective dams and the best estimates of catch and tributary turn off between dams.

Species	Yr.	McNary Count	Estimated Tributary Turnoff 1/	Ice Harbor Count	Priest Rapids Count	Unaccountable Loss	
		(No)	(No)	(No)	(No)	(No)	%
Spr.chinook	1968	67,000	3,000	45,000	12,000	-7,000	-10
Smr.chinook	1968	61,000	3,000	30,000	27,000	-1,000	- 2
Steelhead	1968	113,000	2,000	82,000	11,000	-18,000	-16

1/ Fulton, Leonard A. Spawning areas and abundance of chinook salmon in the Columbia River Basin - Past and present. Department of Interior, Fish and Wildlife Service, Special Scientific Report No. 571, 1968. Bell, Milo C. et al. Follow-up Development Program Columbia River Tributaries Downstream from Grand Coulee Dam, Excluding the Snake and Willamette Rivers. University of Wash. Contract Report No. 03-5--208-330, April 1977.

(23%) were returned (Table 15). Most of the returns came from sports fishermen. Based on tag returns, a minimal estimate of 1% can be made for tributary turnoff into the Yakima River.

In general, tagged spring chinook salmon moved through the study area in less than a week. The largest groups of sonic tagged fish heard by the drift crews were in the area between McNary Dam and Ice Harbor Dam. Each code group moved through the study area within the tagging period, except for two fish from the Code 3 group which were still in the Snake River downstream from Ice Harbor Dam on 20 June, 20 days after the end of tagging.

SUMMER CHINOOK SALMON AND STEELHEAD

The summer tagging program covered a period from 17 June through 4 October. A total of 633 chinook salmon were tagged in two groups (Codes 3 and 5) representing about 1.3% of the summer run chinook salmon passing over McNary Dam during the tagging period (Table 13). Steelhead tagging began 16 July and 1,328 fish were tagged with Codes 1 and 2, representing the A (16 July to 15 August) and B (9 September to 4 October) run steelhead, respectively. This was approximately 4.1% of the steelhead crossing McNary Dam during the tagging period.

The relative survival of tagged summer chinook salmon to the rest of the population based on sightings at counting stations at Ice Harbor and Priest Rapids Dams did not indicate an excessive differential mortality, but the survival rate of tagged steelhead to the general population did indicate a difference. About 85% of the summer chinook salmon and 39% of the steelhead tagged at McNary Dam were observed going over the upper dams (Table 13) while the fish counts of the respective runs indicated 93% and

Table 15.--Distribution of 1968 tag returns by area and species.

	SPRING CHINOOK SALMON (no.)	SUMMER CHINOOK SALMON (no.)	STEELHEAD TROUT "A" Run (no.)	STEELHEAD TROUT "B" Run (no.)
Below McNary Dam	0	0	2	1
McNary Dam to Snake River	0	2	0	1
Snake R. to Priest Rapids Dam	0	2	54	3
Yakima R.	11	0	11	3
Mouth of Snake R. to Ice Harbor Dam	0	1	1	0
Above Priest Rapids Dam	7	15	31	7
Above Ice Harbor Dam	168	46	127	141
Unknown	4	2	1	0
Total	190	68	227	156

83%. When known estimates of tributary turnoff are added to the fish counts, the survival rate of summer chinook salmon is 98% and the steelhead survival rate is 84% (Table 14).

In 1968, as in 1967, the division of tagged fish between the upper Columbia and Snake Rivers was comparable to the fish counts at Ice Harbor and Priest Rapids Dams. The summer chinook salmon split evenly between the two while over 75% of the steelhead entered the Snake River .

The trend for summer chinook salmon to enter the Snake River if they were tagged from the Oregon ladder at McNary Dam was not evident in 1968. However, the sample of tags returned from summer chinook salmon was too small to say that the trend did not exist (44 compared to 670 in 1967).

Drift data indicate that summer chinook salmon move through the area in less than 3 weeks, but some were still in the study area during the 21 October drift (Figure 4). During the period that the river temperatures were warmest (10 July - 18 August), the fish were concentrated in the area between Port Kelly and Richland, Wash. After the river temperatures cooled (18 August) the fish remaining in the study area were spread between Port Kelly and Priest Rapids Dam. Code 1 steelhead (A run) moved through the study area the slowest, with many still present 6 weeks after they were tagged. Their main holding area was in the Columbia River from the mouth of the Snake River to the Vernita Bridge (Figure 4). Tagged fish observed at Priest Rapids and Ice Harbor Dams accounted for 49% of the A run steelhead tagged. The B run steelhead (Code 2) that did not move immediately through the study area were holding in specific areas within 2 weeks after tagging, and they remained there until the study ended. Concentrations

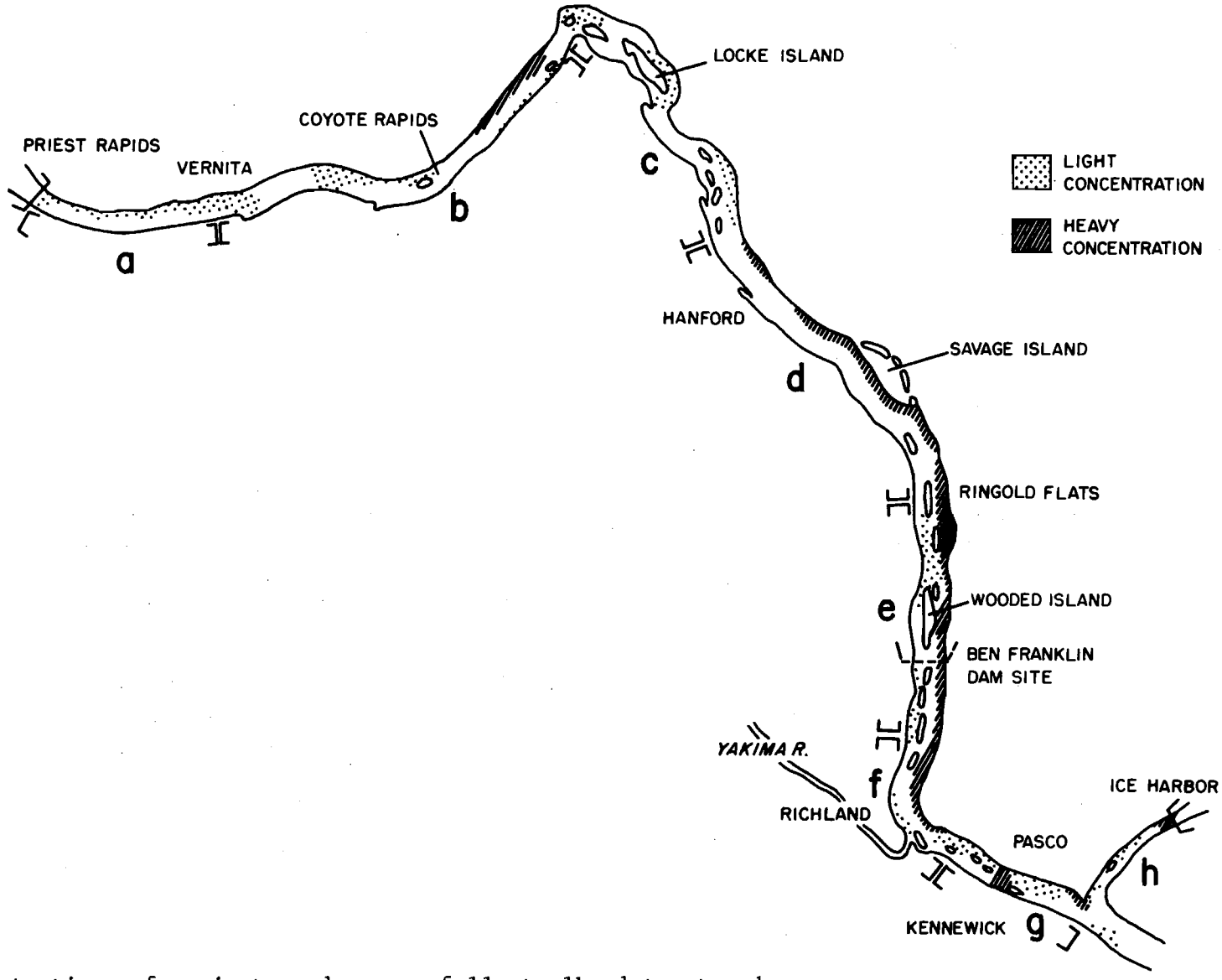


Figure 4.--Concentrations of sonic tagged summer-fall steelhead trout and summer chinook in the Columbia River between the Snake River mouth and Priest Rapids Dam covering a period from July through October, 1968.

of tagged fish developed in the Snake River below Ice Harbor Dam, downstream from the Vernita Bridge, and to a lesser extent in the forebay near McNary Dam. Twenty-five percent of the tagged B run steelhead had been observed over the upper dams when the study was terminated.

Temperature Block

Drift boat data on 22 July indicate the beginning of a concentration of sonic tagged fish at the confluence of the Snake and Columbia Rivers. Water temperatures at the time were 70° F. in the Snake River and 65° F. in the Columbia River. Water temperatures in the rivers continued to rise until 2 August when the temperatures peaked at 75° and 68° F. in the Snake and Columbia Rivers, respectively. As the temperatures decreased and reached 69° F. in the Snake River and 65° F. in the Columbia River, between 19 and 26 August, the concentrations of sonic tagged fish were reduced by passage over Ice Harbor Dam.

During the period of high temperatures, only 4 of the 257 sonic tagged steelhead were recorded in the Snake River below Ice Harbor Dam while 9 of the 310 sonic tagged summer chinook salmon were heard (Figure 4). While information from the drift sampling tends to indicate that summer chinook salmon are more tolerant to high water temperatures than steelhead, daily counts at Ice Harbor Dam do not support that premise. Chinook salmon counts at Ice Harbor Dam did not increase appreciably over those that occurred during the blockage until early September when the temperature difference between the two rivers was less than 3° (69° F. in the Snake River and 66° F. in the Columbia River) (Table 16). Counts for steelhead increased when temperatures were still 72° F. in the Snake River and 67° F. in the

Table 16.--Water temperature and steelhead and summer chinook salmon counts at Ice Harbor (IH) Dam during temperature block, 1968.

Date	Water temp I.H. °F	I.H. Stlh count No.	I.H. Chin. count No.	Date	water temp. I.H. °F	I.H. Stlh count No.	I.H. Chin count No.
July 20	70	31	1,100	Sept 1	69	280	195
21	70	34	942	2	69	310	116
22	70	24	1,013	3	69	286	203
23	70	33	1,420	4	69	639	151
24	70	33	743	5	70	465	208
25	70	35	634	6	69	711	228
26	71	48	507	7	70	982	375
27	71	21	218	8	70	1,227	592
28	71	45	202	9	70	1,457	504
29	72	96	414	10	68	1,712	563
30	72	100	781	11	68	1,848	1,177
31	74	121	161				
Aug 1	74	105	259				
2	75	52	182				
3	75	79	172				
4	75	137	148				
5	75	159	160				
6	75	202	141				
7	75	62	85				
8	75	86	61				
9	75	35	91				
10	75	41	61				
11	75	36	81				
12	75	72	63				
13	72	153	91				
14	72	218	134				
15	72	306	123				
16	72	400	96				
17	72	422	71				
18	72	248	52				
19	72	325	105				
20	70	290	84				
21	69	293	115				
22	69	511	130				
23	68	637	192				
24	68	735	147				
25	68	527	87				
26	67	422	83				
27	67	417	98				
28	67	366	91				
29	67	400	66				
30	68	261	121				
31	68	310	43				

Columbia River. The increases in counts for chinook salmon and steelhead at Ice Harbor Dam correspond with the dates set to differentiate the summer and fall run chinook salmon and the A and B run steelhead in the Snake River so it is difficult to say which was the cause of the increased count and which was the affect. In any event, the effects of the increased temperatures in the Snake River were not as pronounced as during 1967.

FALLBACK

In 1968, as in 1967, some fallback was indicated by the reascents of tagged fish over McNary Dam and over 100% passage at Ice Harbor Dam for some spring chinook salmon (Code 1) (Table 13). Taking into account that 15 of the 80 fish tagged crossed Priest Rapids Dam, the fallback rate for Code 1 chinook salmon had to be at least 25%. Reascents over McNary Dam by code are as follows: Code 1, 2.5%; Code 2, 0.6% (group with the poor flag tag color); and Code 4, 3.1% during the spring run. Summer run chinook salmon reascended the dam at a rate of 0.4% for Code 3 and 1.1% for Code 5. Steelhead "A" run (Code 1) reascent was 4.0% even when flows past McNary Dam averaged only 150,000 cfs during the tagging period. The "B" run (Code 2) steelhead reascended at a rate of 1.0%. There was little to no spill during the time of the "B" run fish.

CONCLUSIONS

The following primary conclusions can be drawn in relation to the objectives of the study:

1. The formation of a temperature block at the mouth of the Snake River (mid-July to mid-September) that effected passage and survival of summer chinook salmon and steelhead into the Snake River to a substantial degree in 1967 and a lesser degree in 1968 was the only major problem detected.
2. Insufficient data were acquired to accurately assess tributary turnoff.
3. Passage of adult spring and summer chinook salmon and steelhead through the navigation locks of the dams within the study area was negligible and is not a significant contributing factor to the unaccountable losses.
4. The state-of-the-art for electronically monitoring fish behavior using acoustic fish tags was not advanced enough at the time this study was carried out to provide sufficient and sophisticated enough data for a study of this magnitude.[1/]

In addition, the following secondary conclusions can be drawn as a result of this study:

1. Fallback of adult salmonids occurs in varying amounts at the dams within the study area. This experiment was not designed to define the exact amounts. However, future experiments should address this problem.

1/ At the time this paper is being written (August 1978), the multi-frequency radio fish tag has been perfected, and tried and proven techniques for application, direct observations, and remote monitoring have been developed and are readily available.

2. Adult summer chinook salmon passing McNary Dam via the Oregon fishway are more likely to continue their migration up the Snake River than up the upper Columbia River. The reverse is true for summer chinook salmon passing McNary Dam via the Washington fishway.
3. Automatic monitors are of little or no value for remotely gathering data on fish passage unless their absolute security can be guaranteed.
4. Externally attached electronic tags are less desirable than internally carried electronic tags for behavior studies of adult salmonids in river situations.
5. Experiments should be designed so only highly visible external flag tags are required. Dependence upon visual identification of marginally visible tags leads to invalid data.

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