UNITED STATES DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service
Northwest Fisheries Program
Tumwater, Washington

Special Report

POPULATION ESTIMATION OF THE 1974-75 NISQUALLY RIVER CHUM SALMON RUN

for the

Nisqually Indian Tribe
Washington

June, 1976

Special Report

POPULATION ESTIMATION OF THE 1974-75 NISQUALLY RIVER CHUM SALMON RUN

Fred E. Olney

Northwest Fisheries Program
U.S. Fish and Wildlife Service
Tumwater, Washington

ABSTRACT

In response to a request from the Nisqually Indian Tribe, the Northwest Fisheries Program, U.S. Fish and Wildlife Service, conducted a chum salmon population study on the Nisqually River (a tributary to southern Puget Sound), from December, 1974, to March, 1975. The study was designed to assist the Nisqually Indian Tribe in the management of their river gill net fishery by obtaining accurate estimates of the run size, the rate of exploitation of the fishery and the escapement. The success of the study was due largely to the cooperation of the Nisqually Tribe and fishermen and through the assistance of the Washington Department of Fisheries.

A total of 4,458 chum salmon, captured by purse seine near the mouth of the river, were tagged with numbered spaghetti-type tags. The tagging operation was conducted over a six-week period. Run size estimates were calculated from recovery of 1,341 tags in a mark sample of 18,005 chum salmon from the river gill net fishery. The estimated run size was 59,864 chum salmon using the Schaefer stratified method and 58,851 for the Petersen method. The catch in the river was 27,750 and the estimated escapement was 32,114 and 31,101 for the two methods, respectively.

From early December, 1974, to January 25, 1975, no closures were imposed upon the 5-day-per-week gill net fishery. During this period the exploitation rate was 50 percent. Limited fishing effort due to periodic closures during the remainder of the season reduced the exploitation rate during that period to 27 percent.

Comparison of weekly sex ratios obtained in the purse seine catch with those obtained in the gill net fishery indicated that surplus male chum

salmon were selectively harvested in the fishery. The composition of the spawning escapement was 59 percent females and 41 percent males. Comparison of length frequency distributions for chum salmon caught by purse seine and in the gill net fishery indicated that the gill nets selectively harvested the larger fish. Analysis of scale samples from the fishery indicated that the age composition of the catch was 21 percent age three chums, 75 percent age four chums and 4 percent age five chums.

Spawning ground surveys indicated that most of the tributary spawning occurred in the lower Nisqually River tributaries (Muck and Yelm Creeks). Helicopter and jetboat surveys revealed that most of the mainstem spawning occurred in the lower ten miles of the river.

Spawning escapement was estimated for the 1971-72, 1972-73 and 1973-74 Nisqually River chum salmon runs by using 1974-75 as the base year. From these escapement estimates it was determined that the exploitation rate of the fishery was about 50 percent in all years except 1971-72.

INTRODUCTION

The Nisqually River, which originates at the base of the Nisqually Glacier on Mt. Rainier, flows northwesterly for seventy-eight miles before entering southern Puget Sound (Figure 1). The river drains a watershed covering 712 square miles. The Nisqually River produces runs of steelhead trout, chinook, pink and coho salmon and one of the largest runs of chum salmon (Oncorhynchus keta) in Puget Sound. Over the past twenty years the total yearly catch in the Nisqually River has averaged over 16,000 chum salmon (Table 1). The Nisqually chum run has been fished almost exclusively by Nisqually Indian fishermen because of its late time of migration through outside areas after other fishing has been closed. The fishermen fish the river from the mouth to river mile 11.0 and have relied heavily upon the chum salmon catch for subsistence and a major source of their income.

In 1974, the Washington Department of Fisheries made its first prediction of the size of the Nisqually chum salmon run. By sampling egg survival and counting chum fry in marine index areas, it was predicted that 39,000 chum salmon would return to the river. Since 30,000 chum salmon were needed to meet the Department's established escapement requirements, only 9,000 remained as the harvestable surplus. This figure was provided to the U.S. District Court in Tacoma, the Nisqually Tribe, and other parties involved in U.S. v. Washington, Civil 9213. The Nisqually Tribe requested that Northwest Fisheries Program conduct a study to obtain more accurate information on the run size to use in regulating their fishery.

A mark and recapture study was conducted on the Nisqually River from December, 1974, to March, 1975. The main objective of the study was to estimate the run size of adult chum salmon returning to the river in order to ensure adequate escapement and maximum utilization of the resource. In addition, data were gathered and analyzed on the size, sex, and age composition of the run and on spawning distribution. The success of the study was due largely to the cooperation of the Nisqually Tribal Council and fishermen and through the assistance of the Washington Department of Fisheries.

METHODS AND MATERIALS

Tagging

Chum salmon milling near the mouth of the Nisqually River in the Nisqually Reach (Figure 1) were captured with a purse seine net, 300 fathoms in length and 15 fathoms deep. The fishing and tagging operation was conducted aboard a 60-foot purse seiner. After the chum salmon were brought alongside the boat, they were dipnetted from the seine net to a 3'x3'x2'

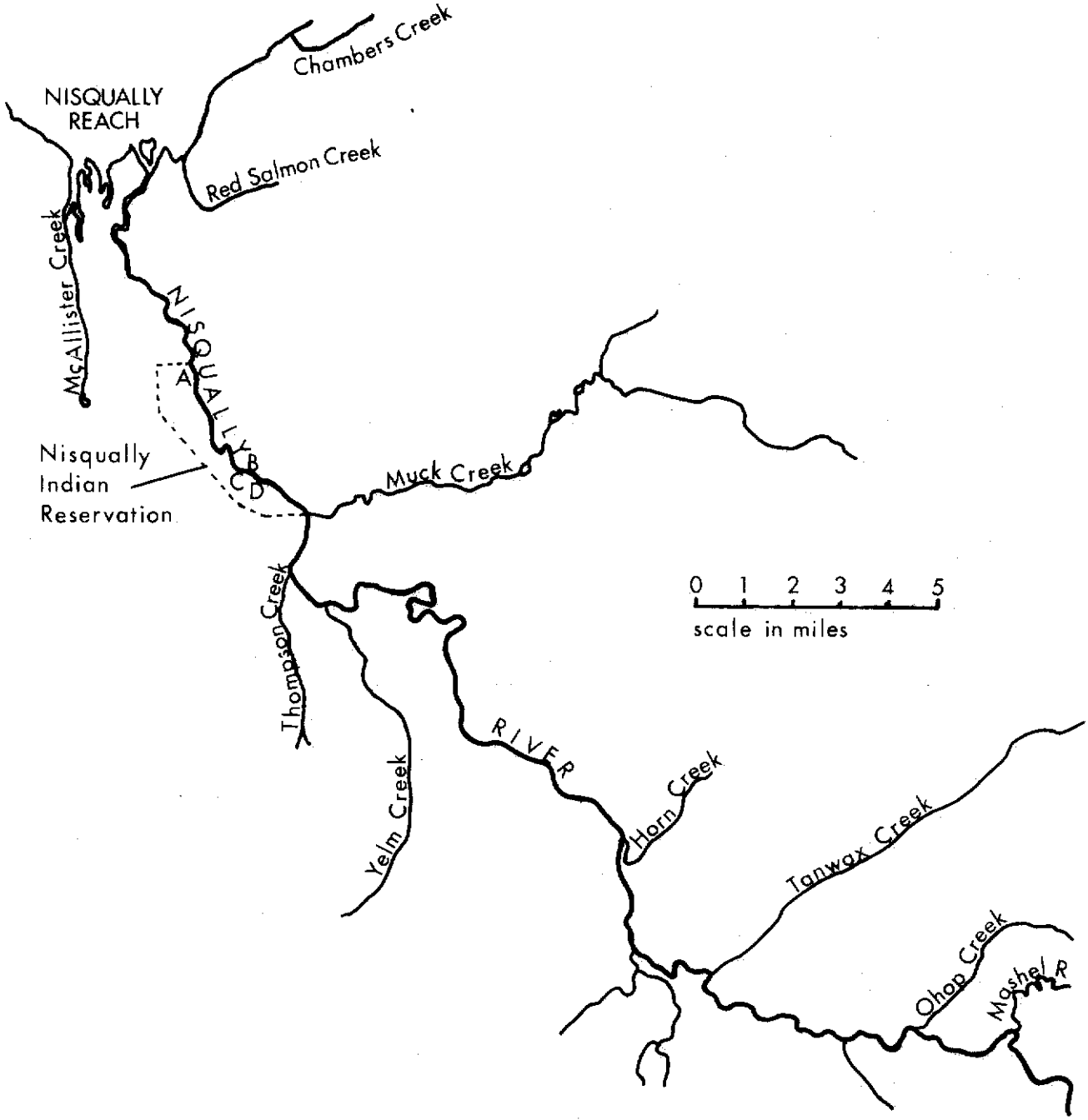

FIGURE 1. Map of the study area showing the Nisqually River and its major tributaries and three small creeks (Chambers, Red Salmon and McAllister Creeks) that flow into Puget Sound adjacent to the river mouth. Locations A, B, C and D indicate where spawning was observed during surveys of the main stem of the Nisqually River.

TABLE 1. The Indian catch of chum salmon in the Nisqually River for the 1955-1956 to the 1974-1975 runs. (Obtained from Washington Department of Fisheries catch records.)

Run Year	CATCH							
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
55-56	6	21	0	0	1,133	126	0	1,286
56-57	0	0	0	1,174	10,159	2,885	169	14,387
57-58	17	37	49	5,265	9,421	62	0	14,851
58-59	0	1	84	15,650	16,134	0	0	31,869
59-60	0	3	109	4,186	7,661	30	0	11,989
60-61	65	9	44	4,877	9,522	754	0	15,271
61-62	1	34	75	2,980	8,835	1,388	45	13,358
62-63	7	91	1,664	8,054	6,605	518	0	16,939
63-64	1	17	80	7,793	7,941	0	0	15,832
64-65	2	3	6	575	4,973	277	5	5,841
65-66	2	14	0	738	5,441	1,564	5	7,765
66-67	0	1	2	3,448	13,113	2,219	26	18,812
67-68	1	8	19	5,190	11,369	852	2	17,443
68-69	0	1	29	6,506	11,786	1,386	8	18,716
69-70	0	0	7	5,030	9,240	542	0	14,819
70-71	0	0	41	3,743	10,372	1,158	103	15,417
71-72	4	1	203	1,822	8,606	1,934	0	12,570
72-73	5	17	378	5,272	16,675	3,519	65	25,932
73-74	7	96	61	9,105	14,495	1,111	21	24,896
74-75	14	47	505	7,999	17,167	1,642	0	27,374 1/
							Average	16,268

1/ Catch was compiled by Northwest Fisheries Program from fish tickets provided by Washington Department of Fisheries.

plywood box lined with thick foam rubber and securely fastened to the deck of the seiner (Figure 2). The wet foam rubber helped to prevent injury to the fish. While in the box, fish were inspected for tags and general condition and were then passed through vinyl tubes leading to tagging cradles (Figure 3). The design and operation of the tubes and the cradles minimized the possibility of injury to the fish.

While the fish were securely held in the tagging cradle, the fork length was measured to the nearest centimeter, the adipose fin removed, and each fish was tagged with a numbered yellow spaghetti type tag. The spaghetti type tag was chosen because it does not cause the fish to be selectively taken by gill nets. The average time from removal from the seine net to tagging and release was 30 seconds.

Many fish captured and tagged during the study were sexually mature. The advance stage of maturity of the fish, the speed of the operation, and the ease of handling through the use of special equipment to prevent injury, eliminated the need for anesthetic. Because of the above factors and the good condition of the fish at release, delayed mortality from the tagging operation was assumed to be negligible.

Tag Recovery

The migration of the chum run into the Nisqually River (mid-December to early March) is later than most chum salmon runs to other southern Puget Sound streams. Because of this, we were confident that most of the fish tagged in the area adjacent to the river mouth were destined for the Nisqually River. However, since a small number of tagged chum salmon returning elsewhere would bias an estimate of the Nisqually chum population, several small streams in the vicinity of the Nisqually River were surveyed extensively for tagged fish. Records from other streams in southern Puget Sound surveyed by the Washington Department of Fisheries were also examined.

The majority of the tag recoveries occurred in the Indian fishery in the Nisqually River. The Indian fishermen used both set and drift gill nets made of braided nylon. Most of the fishermen used 6¼-inch stretch mesh but a few fished with 6½-inch. Northwest Fisheries Program biologists and technicians checked the fish for tags, missing adipose fins, and tagging marks as they were transferred from the fishing boats to the fish buyers along the river (Figure 4). Some tags were also voluntarily returned by Indian fishermen, fish buyers, and sportsmen.

The run size was estimated by using a stratified method of population estimation developed by Schaefer (1951). Using the Schaefer method, both time of tagging and time of tag recovery are stratified into successive weeks to obtain weekly estimates of the run size. In the Nisqually chum tagging

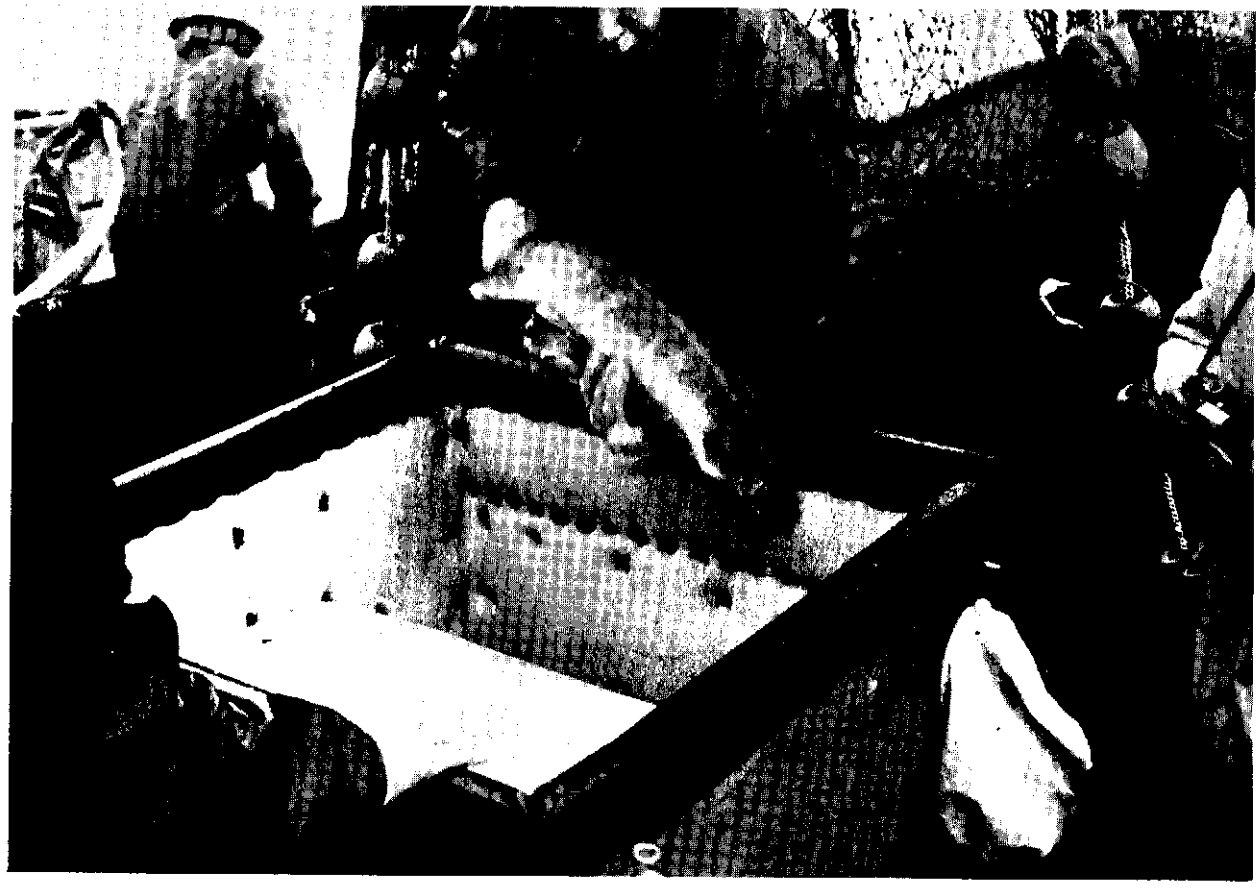

FIGURE 2. The chum salmon were transferred from the purse seine net alongside the boat to a special padded box designed to prevent injury to the fish. After the fish were examined in the box for tags and other marks, they were passed through a tube to a tagging cradle.

FIGURE 3. A total of 4,458 chum salmon captured near the mouth of the Nisqually River were tagged with a spaghetti-type tag and then released.

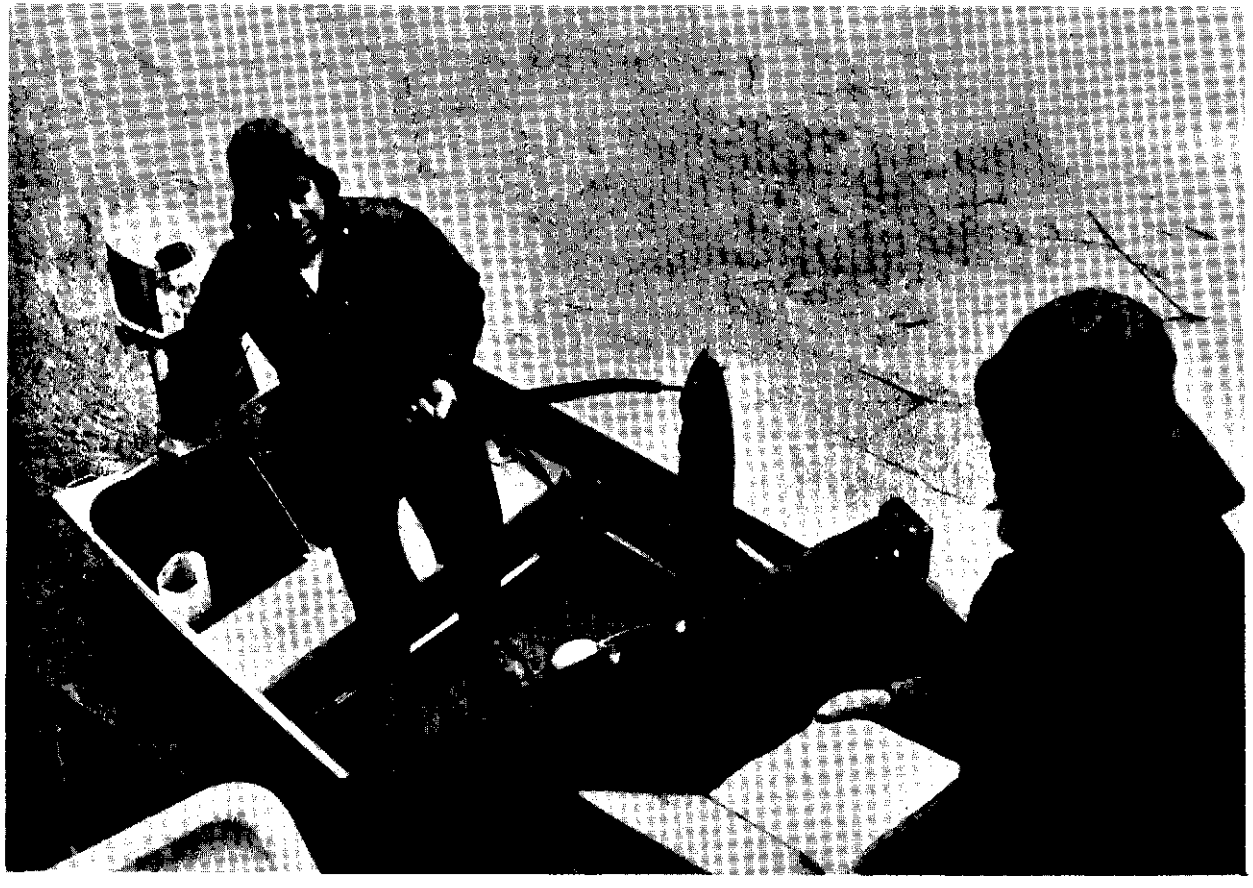

FIGURE 4. A total of 18,005 chum salmon captured in the Nisqually River gill net fishery were examined for tags. Technicians checked the fish for tags as they were landed by Nisqually fishermen.

study few tags were recovered on the spawning grounds because of low tag retention, therefore, the estimate of run size was made from weekly tag recoveries in the Indian fishery. To provide a comparison of run size estimating techniques, the Petersen mark-recapture method was also used to estimate the run size. The Petersen method estimates the total run size without stratifying the tag and recovery data. The final population estimates were adjusted to account for tagged fish returning to other streams and for a small part of the run that had ascended the river prior to tagging.

Records were kept of the fork length and the sex ratio of a large sample of the gill net catch each week. In order to analyze fish size selectivity of the river gill nets, length frequency distributions from the gill net and purse seine catch were compared.

Frequent spawning ground surveys on foot, by boat, helicopter, and airplane, were conducted throughout the study. Counts of both live and dead chum salmon were made on each survey. The dead fish were examined for tags, missing adipose fins, and tagging scars. The caudal fins of the dead fish were excised to eliminate duplication in counting during subsequent surveys.

Escapement estimates were calculated for the 1971-72, 1972-73, and 1973-74 Nisqually River chum salmon runs by using 1974-75 as the base year. Other years were not included because of limited data. Live fish counts in spawning index areas were used as indices of the number of chum salmon in the spawning escapement. Abundance curves were constructed from the counts over time and the area under the curve was used as the index value. The index value for the 1974-75 run represented an escapement of 32,114 chum salmon. Index values from the 1971-72, 1972-73, and 1973-74 chum salmon runs were compared to the 1974-75 base year index value to estimate escapement.

POPULATION ESTIMATES

Tagging in the Nisqually Reach was conducted on December 17, 18, 23, 30, and January 6, 15, and 21. The total number of chum salmon tagged each week and recovered in successive weeks in the Indian fishery is presented in Table 2. Sixteen unreadable tags and twenty-one fish recovered with missing tags were added to the cells in Table 2 in proportion to all other tags recovered. Using the tag recoveries from each cell of Table 2, the portion of the population available for tagging in period (i) and available for recovery in period (j) was calculated using the Schaefer method (Table 3). The sum of these cells is the total population estimate and the equation is:

$$N = N_{ij} = \left(R_{ij} \cdot \frac{M_i}{R_i} \cdot \frac{C_j}{R_j}\right)$$

where,

N = the run size

M_i = the number of fish marked in the ith period of marking

C_j = the number of fish caught and examined for marks in the jth period of recovery

R_i = total recaptures of fish marked in the ith period

R_j = total recaptures during the jth period

R_{ij} = the number of fish marked in the ith marking period which are recaptured in the jth recovery period

The column on the right in Table 3 is the estimated number of chum salmon entering the Indian fishery each week and the sum at the bottom of the column is the estimated total run size (60,869).

For comparison, the Petersen method was also used to obtain an estimate of the run size. The equation is:

$$N = \frac{mc}{r}$$

where,

N = the total run size

m = the total number of fish marked

c = the number of fish examined for marks in the fishery

r = the number of marked fish recovered in the sample (c)

TABLE 2. Recoveries of chum salmon tagged in successive weeks at the mouth of the Nisqually River and separated into the week of recovery in the Indian fishery. Also included is the total number tagged each week (M_i) and the number of chum salmon recovered and examined for tags (C_j).

	Week of Tagging (i)								
	1	2	3	4	5	6	Total Tagged Fish Recovered	Total Fish Recovered	Tag Recovery Ratio
Week of recovery (j):							R_j	C_j	C_j/R_j
1. (Dec 17-23)	41						41	1,178	28.73
2. (Dec 24-30)	100	52					152	2,511	16.52
3. (Dec 31-Jan 6)	159	86	49				294	3,893	13.24
4. (Jan 7-13)	103	39	92	99			333	3,602	10.82
5. (Jan 14-20)	39	34	129	138	24		364	4,151	11.40
6. (Jan 21-27)	5	5	44	36	27	4	121	1,278	10.56
7. Jan 28-Feb 3)	0	0	2	5	9	3	19	412	21.69
8. (Feb 4-10)	0	0	0	2	8	3	13	588	45.23
9. (Feb 11-Mar 12)	0	0	0	0	4	0	4	392	98.00
Total tagged fish recovered R_i	447	216	316	280	72	10	1,341	18,005	
Total tagged fish M_i	1348	740	1018	957	298	97			
M_i/R_i	3.02	3.43	3.22	3.42	4.14	9.70			

TABLE 3. Computed estimates of chum salmon entering the recovery area (Nisqually River Indian fishery) in successive weeks.

	Week of Tagging (i)						
	1	2	3	4	5	6	Total
Week of recovery (j):							
1. (Dec 17-23)	3,557						3,557
2. (Dec 24-30)	4,989	2,947					7,936
3. (Dec 31-Jan 6)	6,358	3,906	2,089				12,353
4. (Jan 7-13)	3,366	1,447	3,205	3,663			11,681
5. (Jan 14-20)	1,343	1,329	4,735	5,380	1,133		13,920
6. (Jan 21-27)	159	181	1,496	1,300	1,180	410	4,726
7. (Jan 28-Feb 3)	0	0	140	371	808	631	1,950
8. (Feb 4-10)	0	0	0	390	1,498	1,316	3,123
9. (Feb 11-Mar 12)	0	0	0	0	1,623	0	1,623
	19,772	9,810	11,665	11,023	6,242	2,357	60,869

The total Petersen population estimate was 59,856 with a range of 57,226 to 62,486 at the 95 percent confidence level.

It was necessary to adjust the above total estimates to account for tagged fish returning to other streams and for the portion of the population entering the Nisqually River prior to the initiation of tagging on December 17, 1974. In addition to the Nisqually River, tags were recovered in Chambers, Red Salmon, and McAllister Creeks, which are all located near the Nisqually River (Figure 1). All chum salmon entering Chambers Creek were counted at a trap by personnel of the Washington Department of Game. However, only seven of nine tagged fish observed were examined close enough to obtain the tag numbers and close examination was not made to detect missing tags. Weekly counts of live and dead fish were made in McAllister and Red Salmon Creeks. It was not possible to examine all of the fish that entered these streams for tags. No tags were found in other streams of southern Puget Sound during Washington Department of Fisheries spawning ground surveys.

To adjust the population estimates, chum salmon counted entering Chambers Creek after December 16, 1974, (1,330), along with the number of chum salmon estimated to have returned to McAllister and Red Salmon Creeks (1,500) were subtracted from the population estimate. It was assumed that tagged fish returned to these areas in the same proportion as those returning to the Nisqually River. The estimated number of fish entering the fishery in successive weeks (Table 3) was then adjusted by subtracting a proportional amount of the total adjustment (2,830) from each week's value.

The run size to the Nisqually River from December 1, 1974, to December 17, 1974 (1,825) was estimated by dividing the catch in this period by the rate of exploitation of the week of December 17-23. A small number of chum salmon that were taken from earlier returns to the river in September, October and November were not included in the estimate. Adding this latter estimate (1,825) and subtracting the number representing the run size (2,830) of the three creeks only slightly altered the original total population estimates but some changes in the weekly estimates occurred (Table 4). The adjusted Schaefer estimate was 59,864 and the adjusted Petersen estimate was 58,851.

The total catch of chum salmon in the Nisqually River was 27,750 which includes an estimated subsistence and ceremonial catch of 883 1/ and a sport catch in the river estimated from punch card data of 59 2/ chum salmon. By subtracting the total catch from the estimated run size, the spawning escapement was calculated at 32,114 for the Schaefer method and 31,101 for the Petersen method.

1/ Data provided by the Nisqually Tribe.
2/ Data provided by the Washington Department of Fisheries.

TABLE 4. Estimated run size, adjusted run size, catch, escapement and rate of exploitation calculated for the Nisqually River chum salmon run (1974-75).

Recovery Period	Estimated Run Size	Adjusted Run Size	Catch	Escapement	Rate of Exploitation
Dec. 1-16		1,825	1,169	656	0.64
Dec. 17-23	3,557	3,392	2,173	1,219	0.64
Dec. 24-30	7,936	7,567	3,752	3,815	0.50
Dec. 31-Jan. 6	12,353	11,779	6,454	5,325	0.55
Jan. 7-13	11,681	11,138	5,517	5,621	0.50
Jan. 14-20	13,920	13,273	5,324	7,949	0.40
Jan. 21-27	4,726	4,506	1,623	2,883	0.36
Jan. 28-Feb. 3	1,950	1,859	441	1,418	0.24
Feb. 4-10	3,123	2,978	771	2,207	0.26
Feb. 11-Feb. 28	1,623	1,547	526	1,021	0.34
TOTAL	60,869 [1/]	59,864	27,750[2/]	32,114	

[1/] Run size was estimated by the Schaefer method.

[2/] Catch was compiled for the period from December 1, 1974 to the end of the chum run.

The rate of exploitation of the fishery was calculated for each recovery period (Table 4). Limited fishing effort from January 25 to February 1 and from February 6 to the 16th, due to closures, increased escapement during these periods. During the time period from December 17 to January 21, no limitation was imposed upon the 5-day per week fishery. The average rate of exploitation during this period was 0.50.

SEX, SIZE, AND AGE COMPOSITION

Sex Ratio

A comparison of the sex ratio of chum salmon caught by purse seine and by river gill nets indicated that gill nets selectively harvested the males. The percentage of females in the purse seine catch increased steadily from 51 percent on December 17 and 18 to almost 60 percent on January 21 (Table 5). In the river gill net catch, males predominated throughout most of the season (Table 6). Early migration of males, which is common for many anadromous species, would account for the higher percentage of males in the gill net catch and in the purse seine catch during the early part of the run. However, the continued high percentage of males in the gill net catch through the remainder of the season while the percentage in the purse seine sample was declining, indicates that male chum salmon were selectively taken by the gill nets. This is expected since it is commonly known that gill nets are highly selective for male salmon when their secondary sexual characters (elongated jaws, hooked snout, and humped back) begin to develop as they approach maturity.

Spawning ground surveys indicated that the selective harvest of males caused a higher percentage of females than males in the escapement. Dead fish counts for three major survey areas, Yelm Creek, Exeter Springs (Muck Creek), and the mainstem Nisqually River, ranged from 58 to 80 percent female. A similar result was obtained by calculating the sex ratio of the escapement. Since the average purse seine sex ratio was a reliable representation of conditions in the total population (the gear is non-selective), the sex ratio in the escapement was derived by subtracting the number of males and females estimated in the catch from the number estimated in the total population (Table 7). The result was that there were 1.4 females (58.8%) for every male chum salmon on the spawning grounds. The larger proportion of female chum salmon in the Nisqually River escapement probably did not cause any adverse effects on the spawning success or the fertilization of the eggs. Accordingly, the river gill nets harvested a large number of surplus male chum salmon.

Size Composition

Length frequency distributions were calculated for 4,408 chum salmon sampled by purse seine and 3,050 sampled from the river gill net fishery (Figures 2 and 3). The length frequency distribution of the purse seine catch is a close approximation of the length frequency distribution of the entire population since the sampling gear is not size-selective. By comparing the length frequency distribution of the purse seine and gill net catches, it is then possible to determine if the gill nets were size-selective.

TABLE 5. The percentage of male and female chum salmon captured in the Nisqually Reach by purse seine.

Date	Sample Size	Percent Male	Percent Female
Dec. 17-18	1,342	49.0	51.0
Dec. 23	735	48.7	51.3
Dec. 30	953	45.5	54.5
Jan. 6	974	45.0	55.0
Jan. 15	304	42.6	57.4
Jan. 21	99	40.4	59.6
TOTAL	4,408	46.7	53.3

TABLE 6. The percentage of male and female chum salmon in the catch from the Nisqually River gill net fishery.

Date	Sample Size	Percent Male	Percent Female
Dec. 16-20	390	57.2	42.8
Dec. 23-27	435	54.5	45.5
Dec. 30-Jan. 3	557	50.6	49.4
Jan. 6-10	476	51.5	48.5
Jan. 13-17	569	54.1	45.9
Jan. 20-24	342	49.4	50.6
Feb. 3-7	281	60.5	39.5
TOTAL	3,050	53.7	46.3
Weighted Percentage 1/		53.1	46.9

1/ The weighted percentage was obtained by weighting the weekly percentages by the proportion of the catch in each week.

TABLE 7. The estimated number of male and female chum salmon in the Nisqually River gill net catch and in the escapement.

	Number of Fish	Percent Male	Percent Female	Number of Males	Number of Females
Run Size	59,864 1/	46.7 2/	53.3 2/	27,956	31,908
Total Catch	27,750	53.1 3/	46.9 3/	14,735	13,015
Escapement	32,114	41.2	58.8	13,221	18,893

In Figure 2, the length frequency distribution curve for female chums caught in the gill net fishery falls to the right of the length frequency curve for the purse seine catch for almost all lengths. Thus, larger females made up a higher percentage of the gill net catch than of the purse seine catch. The mean fork length of females in the purse seine catch was 73.9 cm and 74.6 cm in the gill net catch. A Student's t-test indicated that females in the gill net catch were significantly larger at the 95 percent confidence level.

The two length frequency distributions for male chum salmon (Figure 3), coincided except for the area at the mode of each curve and for very small fork lengths. The mean fork length of males in the purse seine catch was 79.2 cm and 79.5 cm in the gill net fishery. A Student's t-test of the mean fork lengths showed that males from the gill net fishery were significantly larger at the 95 percent confidence level.

Most of the fish sampled by purse seine were nearly sexually mature. A majority of the males exhibited advanced stages of the characteristic hooked snout and elongated jaws. It is possible that some growth of the jaws occurred between the purse seine sampling period and the gill net fishery, which might account for some of the increase in their length. Very little growth would be expected to occur in the case of females, however, they showed the greatest difference in mean length between the two gear types, thus indicating that some size-selectivity occurred.

1/ The adjusted run size obtained using Schaefer's method.

2/ The average percentage of each sex from the purse seine catch in the Nisqually Reach.

3/ The weighted average percentage of each sex from the river gill net catch.

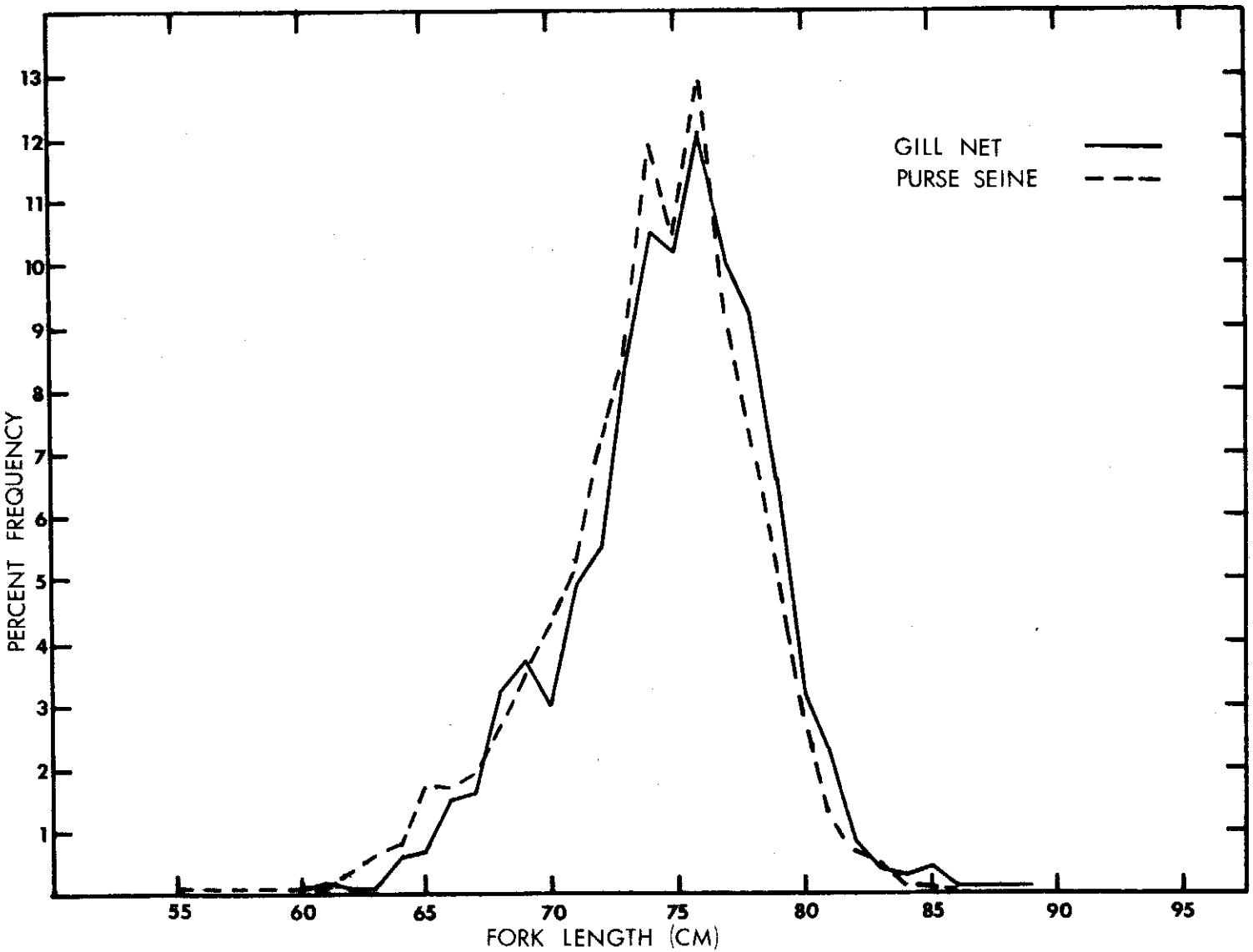

FIGURE 6. Length frequency distributions for female chum salmon captured by purse seine in the Nisqually Reach and by gill net in the Nisqually River.

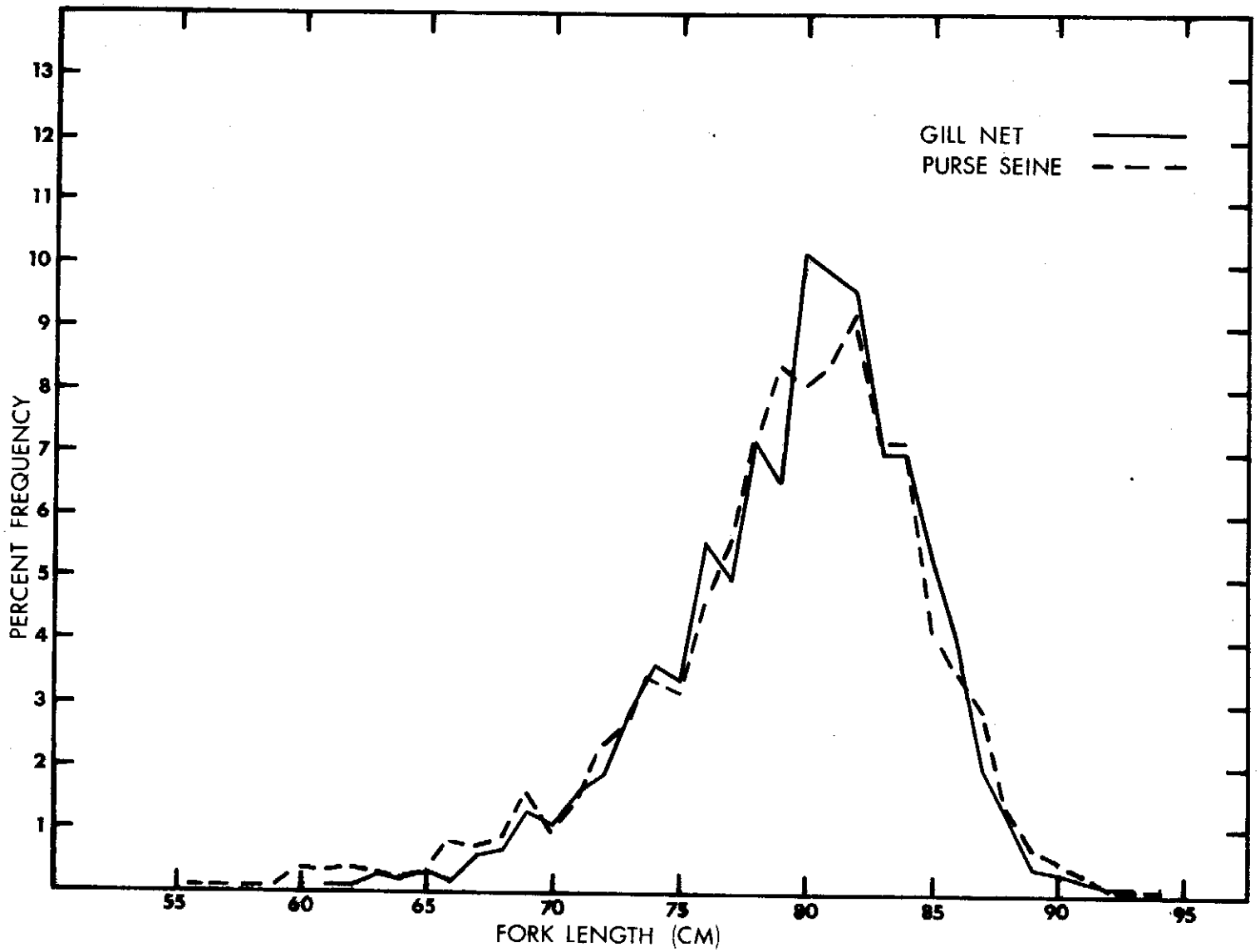

FIGURE 5. Length frequency distributions for male chum salmon caught by purse seine in the Nisqually Reach and by gill net in the Nisqually River.

The average length of fish in the future chum runs is not expected to progressively decrease because much of the escapement occurs during fishing closures or flooding. In addition, since the degree of size selectivity is small, genetic variability and natural selective forces would probably mask small differences in the length of spawning populations. However, the alteration of the mesh size from 6¼ inches for chum salmon runs on the Nisqually River to a larger or smaller mesh size could increase the magnitude of this size-selectivity. If this occurs during future fisheries, length frequency distributions, together with spawning ground sex ratios, should be determined for comparison with this year's base data.

Age Composition

Age was determined for a sample of 403 male chum salmon and 349 female chum salmon captured in the gill net fishery between November 26, 1974 and January 6, 1975. Scale readings for age determination were conducted by the Washington Department of Fisheries. The age composition of the catch was 21 percent age three chums, 75 percent age four chums and 4 percent age five chums. The mean fork length of the males was 72.8 cm for three-year-olds and 80.4 cm for fours. The mean fork length for females was 69.5 cm and 75.6 cm for threes and fours, respectively.

SPAWNING GROUND SURVEYS

Surveys

A total of 60 separate surveys were conducted on the spawning grounds of the Nisqually River and its tributaries. In addition, Red Salmon (Mounts) Creek and McAllister Creek were surveyed on 28 separate occasions. Spawning ground surveys were conducted to examine carcasses for tags and to obtain counts of live and dead chum salmon to evaluate escapement. However, because of a low rate of tag retention (20 percent) on the spawning grounds, few tags were recovered.

The main stem of the Nisqually River was surveyed by boat and helicopter from the mouth of the river to Yelm Creek; the area above Yelm Creek was surveyed only by helicopter. Observations of spawning fish and redds in the lower river were comparable for both methods. Surveys of the tributaries of the Nisqually River and adjacent streams were conducted on foot. Counts of the number of live and dead chum salmon from each survey are included in Appendix A, Table 1.

Spawning Distribution

The largest numbers of chum salmon were observed spawning in the lower river tributaries (Yelm and Muck Creeks). The peak live count in Exeter Springs was 807 chum salmon, and the highest count in Yelm Creek was 137 chum salmon. Upper river tributaries were also surveyed but only 10 chum salmon were observed spawning in one tributary (Tanwax Creek).

Surveys of chum salmon spawning in the main stem of the Nisqually River indicated that spawning was concentrated in the lower ten miles of the river. Spawning was observed at four locations (Fig. 1). All of the spawning sites were located in the lower river; none were observed during helicopter surveys above Yelm Creek. Spawning was very light at locations A, C, and D, where only one or two redds were observed during all of the surveys. Heavy spawning was noted at location B, where a peak count of 32 redds and 7 live chum salmon was made on February 18, 1975. During a boat survey on January 28, 1975, several redds were visible about three feet above the water line, indicating that spawning had occurred in previous weeks during high water.

During a helicopter survey conducted on February 23, 1975, 135 carcasses were counted from the mouth of the Nisqually River to the Mashel River. The majority of the carcasses (130) were observed along the gravel bars of the Nisqually Indian Reservation. Only 2 carcasses were observed on gravel bars from the upper boundary of the Nisqually Reservation to the Mashel River and 3 carcasses were counted in the lower river, from the mouth to the lower Reservation boundary.

The distribution of live fish, redds and carcasses indicates that very little spawning occurred in the main stem of the upper Nisqually River, and that some spawning occurred in the lower river; however, it is difficult to determine the magnitude of this spawning. The high carcass counts in the lower river do not necessarily mean that a large amount of spawning occurred in that area, since some of the carcasses may have originated from Muck Creek or Yelm Creek. The origin of the carcasses found in the upper main stem is also unknown, but the low count is expected, since only a few salmon were observed spawning in one of the tributaries above Yelm Creek, and none in the upper mainstem. Poor visibility was the major factor complicating efforts to determine the magnitude of the spawning in the main stem; therefore, surveys of the main stem spawning should be intensified if water clarity improves so that spawning chum salmon can be observed in deep water.

On April 30, 1975, a hydraulic survey was made at location B to determine the survival of the eggs. Redds were still visible, but all were located from a few inches to five or six feet above the water level of the river. Several chum salmon fry and a few eggs were sampled with a hydraulic probe from a small water-filled depression next to the river's edge, but sampling over the rest of the area where heavy spawning was observed in February produced no additional fry or eggs. The reduction in flow after the chum salmon spawned, which left the redds exposed, probably is a major factor limiting the fry production in the main stem of the river.

Escapement Estimates

Spawning escapement was estimated for the 1971-72, 1972-73 and 1973-74 chum salmon runs in the Nisqually River by using 1974-75 as the base year (Table 8). Only the Exeter Springs and Yelm Creek index areas were included in the estimates of escapement, because in the past, counts were infrequent or absent in many of the other index areas.

Abundance curves were constructed using counts of live fish from each index area (Figures 7 and 8). The area under each abundance curve was chosen as the index value since it reflects both the magnitude and duration of spawning. The equation for estimating the escapement in each year was:

$$E_i = I/I_i \ (32{,}114)$$

where,

E_i = the estimated escapement in the ith year.

I = the sum of the base year (1974-1975) index values for Exeter Springs and Yelm Creek.

I_i = the sum of the index values for Exeter Springs and Yelm Creek in the ith year.

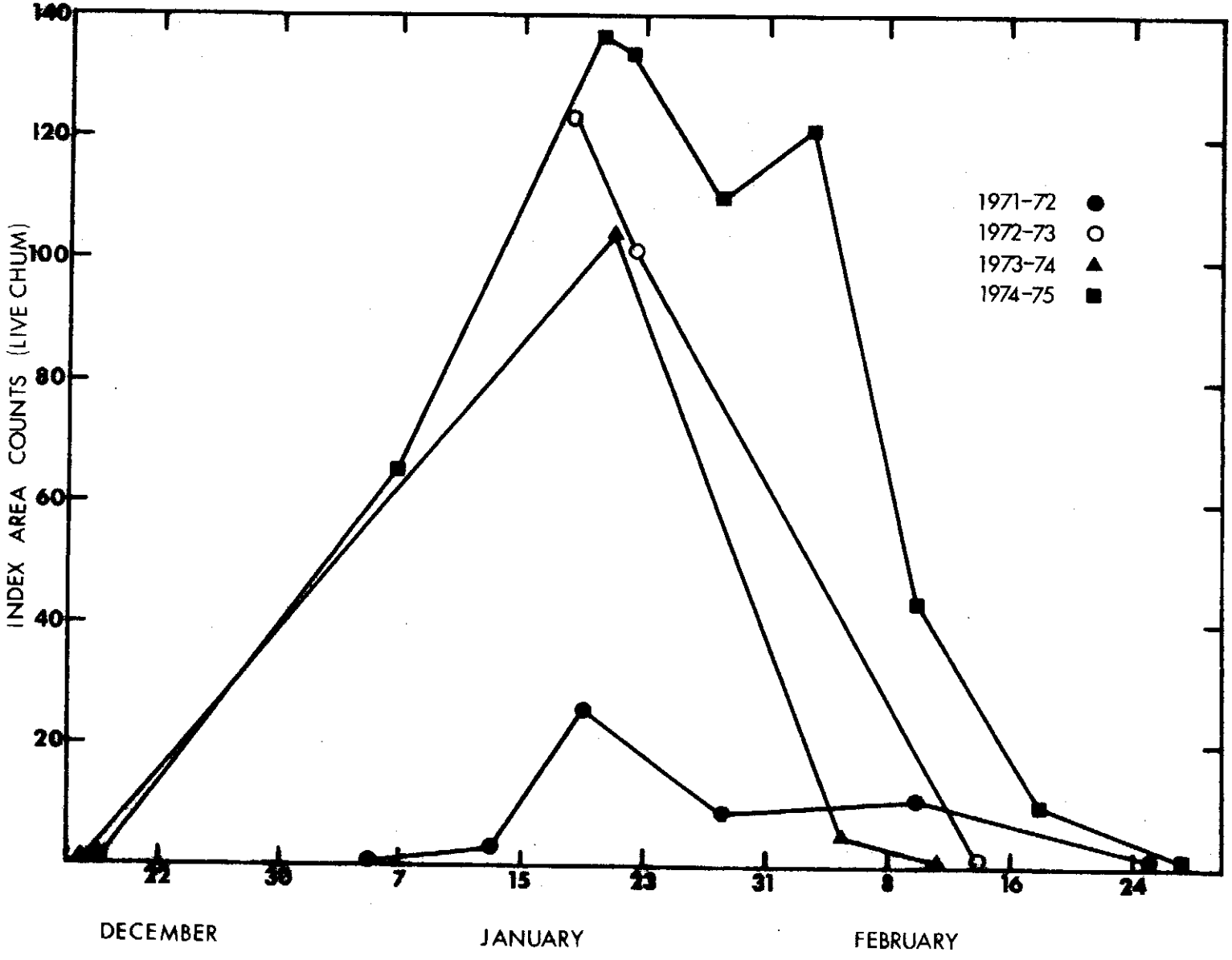

FIGURE 7. Abundance curves constructed from counts of live chum salmon in the Yelm Creek index area for the 1971-72, 1972-73, 1973-74 and 1974-75 Nisqually River chum salmon runs.

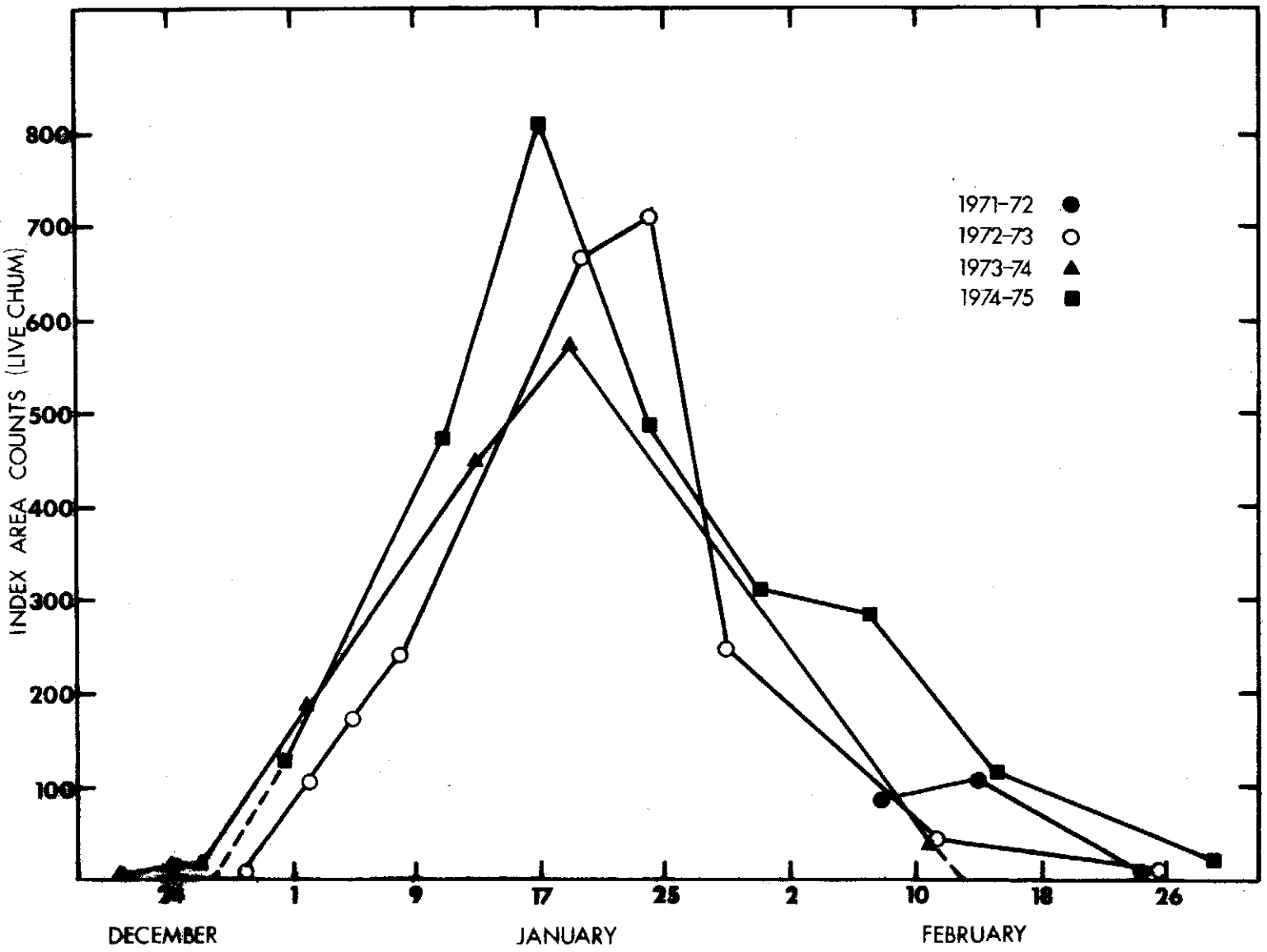

FIGURE 8. Abundance curves constructed from counts of live chum salmon in the Exeter Springs index area for the 1971-72, 1972-73, 1973-74 and 1974-75 Nisqually River chum salmon runs.

TABLE 8. The index value, estimated escapement, catch and rate of exploitation calculated for the 1971-72, 1972-73, 1973-74, and 1974-75 chum salmon runs in the Nisqually River.

Year	Index Area	Index Value	Estimated Escapement	Catch[1/]	Rate of Exploitation
1971-72	Exeter Springs	1,077 (Feb. 8-)			
	Yelm Creek	477			
	Total	1,554	7,343	12,362	0.63
1972-73	Exeter Springs	14,938			
	Yelm Creek	1,660 (Jan. 18-)			
	Total	16,598	24,064	25,531	0.51
1973-74	Exeter Springs	14,295			
	Yelm Creek	2,566			
	Total	16,861	22,705	24,727	0.52
1974-75	Exeter Springs				
	Feb. 8 - Season	2,314 19,366			
	Yelm Creek				
	Jan. 18 - Season	2,784 4,482	32,114	27,750	0.50[2/]

1/ Catch was compiled for the period from December 1 to the end of the chum fishery for each year.

2/ The rate of exploitation was calculated for the period between December 17 and January 21 when no limitation was imposed upon the 5-day per week fishery.

During the 1971-72 run, counts were not made in the Exeter Springs index area until February 8, 1972 (Figure 8). The Yelm Creek index area was not surveyed until January 18, 1973, during the 1972-73 chum run (Figure 7). For these late counts, the area under the curve was calculated for the period from the initial survey to the end of the spawning season. The base year (1974-75) index values were calculated for the same time periods to estimate escapement (Table 8).

The exploitation rate of the fishery was nearly 50 percent in all years except 1971-72 (Table 8). The accuracy of the 1971-72 estimate is questionable because of limited surveys in that year. Although precise data on effort is not available, the number of landings reported on fish tickets increased between the 1971-72 and 1974-75 seasons. It is likely that physical characteristics of the river limit the efficiency of the fishery.

CONCLUSIONS AND RECOMMENDATIONS

The study showed that mark and recapture methods can be used to accurately estimate the size of the Nisqually chum run and escapement. Chum salmon were readily captured and tagged near the mouth of the river and a large number of fish was sampled for tags in the river gill net fishery. The spawning escapement goal (30,000) established by the Washington Department of Fisheries was achieved by using the estimate of the run size in the management of the fishery. It is probable that mark and recapture studies can be conducted on other river systems to obtain similar kinds of information.

In addition to estimating the run size and the exploitation rate of the fishery, we found that the gill net fishery selectively harvested a large number of surplus male chum salmon. Gill net selectivity must be taken into consideration when evaluating escapement or establishing escapement goals. When selectivity of males has occurred, spawning densities from spawning ground surveys might appear to be at or below the optimum density when actually, because of a high percentage of females in the escapement, over-escapement may have occurred. The actual escapement of females would be grossly under-estimated if a one-to-one sex ratio was assumed under these conditions.

After considering the results from this work, we have the following recommendations for future studies:

1) Mark and recapture studies should be conducted on the Nisqually River for at least the two succeeding years to determine the accuracy of using index counts on the spawning grounds to estimate escapement.

2) Other less costly methods of estimating the run size should be explored. For example, cumulative catch curves or limited early-season tagging could be used to estimate the run size at a relatively low cost.

3) Spawning densities should be measured in as many areas as possible over a number of years to determine the adequacy of the escapement goal.

4) The type of tag used in future work should have a high rate of retention on the spawning grounds in order to determine if there are differences in timing and spawning distribution of the different segments of the population.

5) Mark and recapture studies are valuable to management and should be conducted on other river systems to obtain run size and escapement estimates.

Prepared by:

Frederick E. Olney
Fishery Management Biologist

Noted:

James L. Heckman
Program Manager

LITERATURE CITED

Schaefer, M.B. 1951. Estimation of the size of animal populations by marking experiments. U.S. Fish Wildl. Serv. Fish Bull. 52: 189-203

APPENDIX

APPENDIX A

TABLE 1. Spawning ground counts of chum salmon conducted in the Nisqually River and its tributaries and in two adjacent streams (Red Salmon and McAllister Creek) during the 1974-75 spawning season.

Date	Area Description	Method	Distance	Turbidity	Fish Counts Live	Fish Counts Dead
	Red Salmon Creek					
1/8/75	Headwaters to 2nd bridge	Foot	0.2 mile	Clear	100	17
1/14/75	" "	"	"	"	197	47
1/21/75	" "	"	"	"	221	175
1/28/75	" "	"	"	"	119	97
2/3/75	" "	"	"	"	78	92
2/4/75	Railroad grade to fence	"	0.25	"	37	60
2/12/75	Headwaters to railroad grade	"	0.45	"	12	53
2/20/75	" "	"	"	"	2	14
2/26/75	" "	"	"	"	0	8
3/4/75	" "	"	"	"	0	1
	McAllister Creek					
12/31/74	Waterworks outlet and pool below	"	0.1	"	20	0
1/7/75	" "	"	"	"	60	21
1/9/75	Waterworks outlet, pool and two springs	"	0.2	"	147	32
1/14/75	" "	"	"	"	Not Ctd.	39
1/16/75	" "	"	"	"	120	15
1/20/75	" "	"	"	"	100	97
1/23/75	" "	"	"	"	120	55
1/29/75	" "	"	0.2	"	89	61
2/5/75	" "	"	"	"	57	34
2/11/75	" "	"	"	"	54	21
2/18/75	" "	"	"	"	14	7
2/26/75	" "	"	"	"	2	0

TABLE 1. Continued

Date	Area Description	Method	Distance	Turbidity	Fish Counts Live	Fish Counts Dead
	McAllister Creek, cont'd.					
3/3/75	Waterworks outlet, pool and two springs	Foot	0.2 mile	Clear	2	0
3/10/75	" "	"	"	"	2	0
1/9/75	Mainstem, headwaters to Steilacoom Road bridge	Float	1.75	"	0	2
1/9/75	Trapper Bob's Creek	Foot	0.5	"	120	3
1/31/75	" "	"	0.5	"	32	125
2/21/75	" "	"	0.5	"	0	19
	Nisqually River					
1/29/75	Mainstem, Yelm Cr. to Brown's Fish House	Jet Boat	5.0	Turbid	0	29
2/3/75	Mainstem, mouth to Military Br.	"	11.6	"	0	70
2/10/75	" "	"	"	"	18	85
2/18/75	" "	"	"	"	22	45
2/24/75	" "	"	"	"	0	49
3/3/75	" "	"	11.6	Sl. turbid	0	3
2/3/75	Mainstem, mouth to McKenna	Helicopter	21.8	Turbid	2	132
2/3/75	Mainstem, McKenna to Mashel R.	"	17.8	"	0	2
2/13/75	Mainstem, mouth to McKenna	"	21.8	"	5	95
2/24/75	" "	"	"	"	3	73
	Muck Creek					
12/19/74	1st bridge to mouth	Foot	0.7	Clear	0	0
12/31/74	" "	"	"	"	60	0
1/7/75	" "	"	"	Sl. turbid	76	0

TABLE 1. Continued

Date	Area Description	Method	Distance	Turbidity	Fish Counts Live	Dead
	Muck Creek, cont'd.					
1/14/75	1st bridge to mouth	Foot	0.7 mile	Turbid	Not surveyed.	
1/22/75	" "	"	"	"	"	"
1/29/75	" "	"	"	"	"	"
2/4/75	" "	"	0.7	Sl. turbid	128	209
2/11/75	" "	"	"	"	57	95
2/21/75	" "	"		Turbid	Not surveyed.	
2/26/75	" "	"	0.7	Sl. turbid	15	54
3/11/75	" "	"	"	"	5	5
1/10/75	Johnson Creek, culvert to mouth	"	0.25	Sl. turbid	0	0
1/23/75	" "	"	"	"	7	0
2/5/75	" "	"	"	"	3	15
2/14/75	" "	"	"	"	0	1
3/11/75	" "	"	"	"	0	0
1/30/75	Nixon Spring, below Pincus Rd.	"	0.1	"	Not Ctd.	104
2/14/75	" "	Raft	"	"	8	50
2/21/75	" "	"	"	"	10	91
3/5/75	" "	"	"	Turbid	0	15
1/29/75	Halverson Marsh, outlet below marsh	Foot	0.3	Clear	35	11
2/5/75	" "	"	"	"	16	8
1/27/75	Hwy. 507 to Nixon Spring	Raft	1.7	Sl. turbid	158	82
2/6/75	" "	"	"	"	90	114
2/14/75	" "	"	"	"	6	12
12/31/74	Exeter Springs	Foot	0.2	Clear	118	0
1/11/75	"	"	"	"	478	174
1/17/75	"	"	"	"	807	330
1/24/75	"	"	0.2	"	486	330
1/31/75	"	"	"	"	312	132
2/7/75	"	"	"	"	287	87

TABLE 1. Continued

Date	Area Description	Method	Distance	Turbidity	Fish Counts Live	Fish Counts Dead
	Muck Creek, cont'd.					
2/15/75	Exeter Springs	Foot	0.2 mile	Clear	117	60
3/1/75	"	"	"	"	23	30
	Yelm Creek					
11/27/74	Mouth to log dam	"	0.4	"	0	0
12/19/74	" "	"	"	"	1	0
1/7/75	" "	"	"	"	66	15
1/14/75	" "	"	"	Turbid	Not surveyed.	
1/20/75	" "	"	"	Sl. turbid	137	59
1/22/75	" "	"	"	"	134	18
1/28/75	" "	"	"	"	110	64
2/3/75	" "	"	"	Clear	121	54
2/10/75	" "	"	"	Sl. turbid	44	102
2/18/75	" "	"	"	Clear	10	33
2/27/75	" "	"	"	"	1	19
3/3/75	" "	"	"	"	0	1
	Miscellaneous Tributaries					
1/22/75	Tanwax Cr., mouth to first house on left bank	Foot	0.06	Turbid	10	2
2/10/75	" " "	"	"	"	0	1
1/22/75	Thompson Cr., powerlines to mouth	"	1.5	Clear	0	0
3/11/75	" " "	"	"	"	0	0
1/31/75	Mashel River, mouth to first br.	"	0.7	Sl. turbid	0	0