MIGRATIONAL CHARACTERISTICS AND SURVIVAL OF JUVE

SALMONIDS ENTERING THE COLUMBIA RIVER ESTUARY IN

1981

(Appendix not scannable)

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ABSTRACT

National Marine Fisheries Service (NMFS) under funding from the Bonneville Power Administration conducted a study related to migrational behavior and survival of juvenile salmonids entering the Columbia River estuary. Beach and purse seines were used to sample at Jones Beach (RKm 75) from March through November 1981. The total salmonid catch was approximately 200,000 fish, of which 3.3% were marked.

Migration peaks for hatchery yearling chinook and coho salmon and steelhead trout occurred during early May whereas three peaks were recorded for subyearling chinook salmon during April, May, and July. Movement rates were slowest for three groups: (1) those that had wintered in the system, (2) yearling chinook salmon released in March and April, and (3) small subyearling chinook salmon released throughout the spring and summer. Movement rates to the estuary generally increased with increasing river flow and fish size.

Survival rates to the estuary were increased by transportation. Estimated survival rates of transported groups (relative to controls) increased proportionately with the numbers of dams bypassed--averaging 56% for one dam and 311% for eight dams.

The Jones Beach sampling provided survival estimates to other agencies for nutrition, rearing density, and chemical treatment studies.

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INTRODUCTION

Returns of adult salmon and steelhead to the Columbia and Snake Rivers have declined to critical levels during the last decade. One of the most significant factors in this decline is failure of juveniles (smolts) to successfully migrate to the ocean. Dams and their reservoirs are major obstacles to the seaward migration of smolts. In recent years, increased electrical power requirements have necessitated more generating capacity resulting in decreased water flow during the peak migration of juvenile salmonids. Consequently, migration time is extended anf more fish are passing through the turbines at each dam, thus decreasing the survival of juveniles (Raymond 1979). Fishery agencies with the cooperation of power entities have responded by: (1) increasing and improving production at hatcheries, (2) improving turbine bypass systems for smolts, (3) transporting juvenile salmon past dams by truck and barge to downstream sites, and (4) recommending minimum flows during the periud of the spring smolt migration.

In 1977, National. Marine Fisheries Service (NMFS) personnel reestablished an estuarine sampling station at Jones Beach in the upper Columbia River estuary at River Kilometer (RKm) 75 to assist in evaluating some of the above activities taken to increase survival of smolts (Figure 1).

Timing, survival, and migratory behavior of juvenile salmonids from various sites were examined each year through 1980 (Figure 2). Although valuable information relative to smolt behavior and survival was obtained, additional data were needed to more precisely evaluate juvenile survival and migrational behavior in relation to other actions recommended to increase smolt survival.

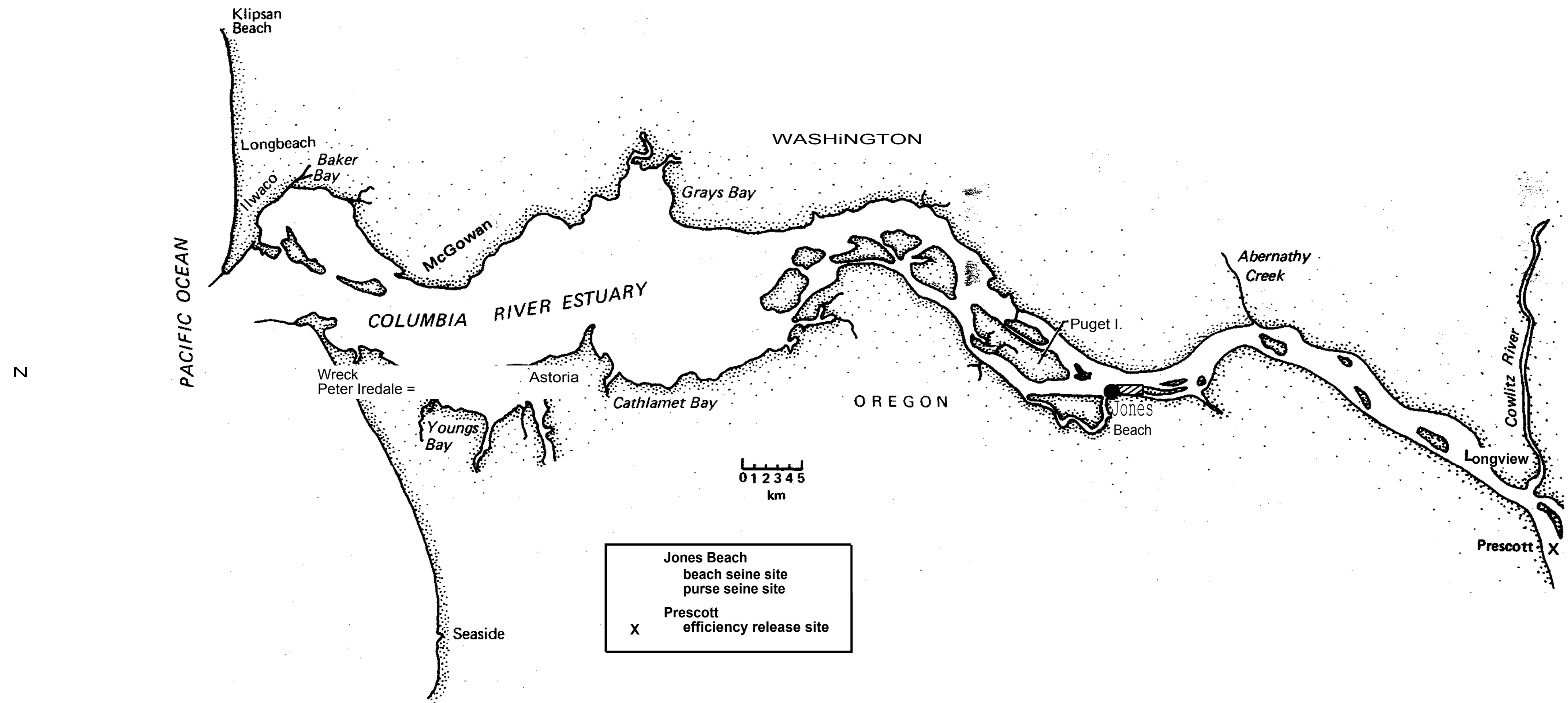

Figure 1.--Map of lower Columbia River and estuary; Jones Beach sampling site and Prescott release site are indicated at Rkm 75 and 115, respectively.

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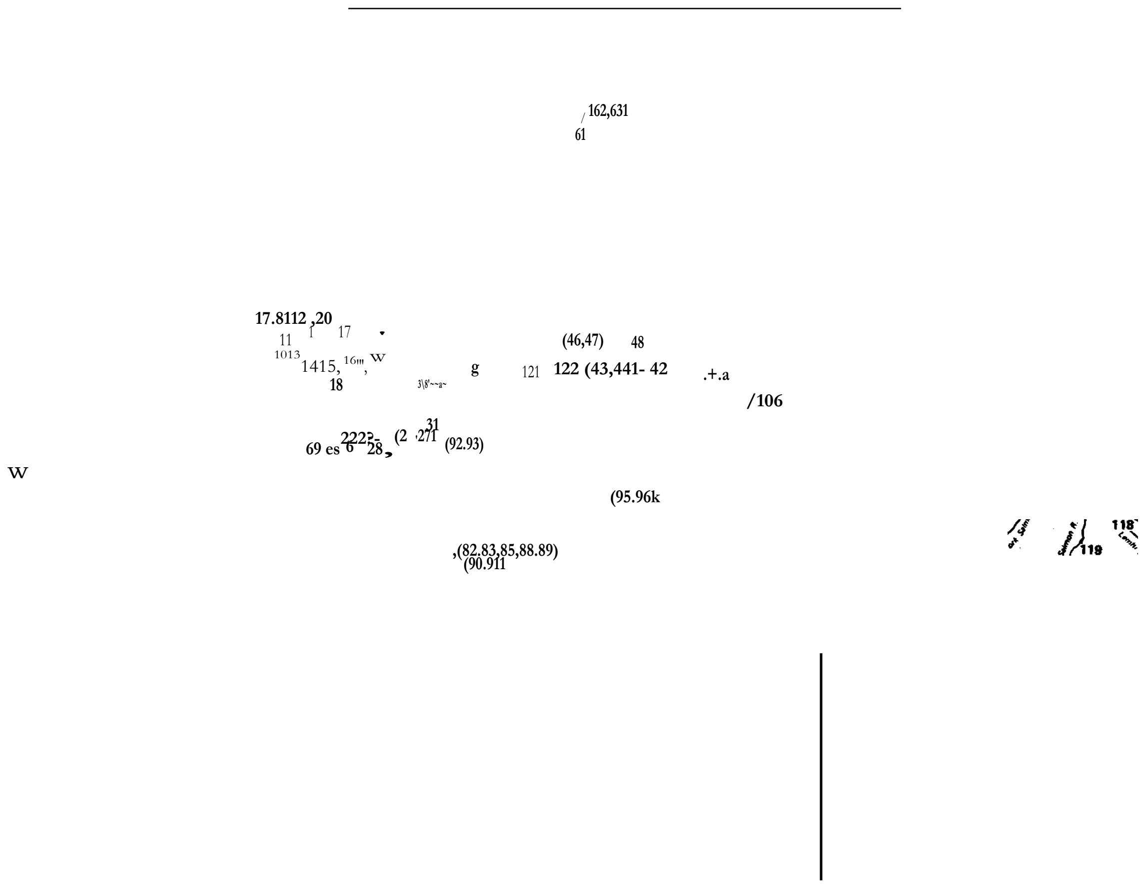

LEGEND

Release site	R101

LOWER COLUMBIA R 6 TRIBS.

1. Chinook R Pd 11
2. Hammond Ore 13
3. Tucker Cr 29
4. Stavebolt Cr 34
5. Klaskanine R 37
6. Big Cr 49
7. Grays RB 1 13 57
8. Grays RCPRM 21 68
9. Jones Beach 75
10. Beaver Terminal 84
11. Abernathy Cr 91
12. Elokomin R 94
13. Rainier Ore 109
14. Prescott ore 115
15. Kalama RgRM 6 127
16. Kalama RPRM 15 141
17. Green R 160
18. Lewis R .163
19. Cowlitz ICPRM 47 184
20. Cowlitz R@RM 50 189
21. Dalton Pt 206
22. Washougal RCRM 10 213
23. Skamania Light 219
24. Washougal RgRM 15 221
25. Beacon Rock 227
26. Blw Bonn D 230
27. Tanner Cr 231
28. Sandy R 235
29. Lit Wh Sal 188RM 2 261
30. Lit Wh Sal RM(5 268
31. Spring Cr Hat 269
32. Big Wh Rear Pd 273
33. Wind R 275
34. The Dallas D 306
35. John Day D 347
36. Towal Wash 351
37. Klickitat R 358
38. Blalock 375
39. Patterson Slough 448
40. McNaryD 470
41. Port Kelly 501
42. Walla Walla Rat Mo 507
43. Casey Pd 516
44. Villiard Slough 521

MID COLUMBIA R 6 TRIBS.

45. Pasco Wash 522
46. Yakima LMo 539
47. Richland Wash 540
48. Ringo-1d Hat 568
49. Wh Bluffs 596
50. Vernita Brid 629
51. Pr Rapid Spam Ch 639

Release site	umm

52. Crab Cr 660
53. Wanapum D 669
54. Vantage arid 674
55. Rock Island D 725
56. Rocky Reach D 761
57. Turtle Rock Pd 768
58. Icicle Cr 789
59. Entiat R 790
60. Chelan Hat 813
61. Wells Spam Ch 828
62. Methow RM* 838
63. Pateros Ferry 839
64. Methow 891134 28 883
65. Methow RgHat 919

WILLAMETTE R 6 TRIBS.

66. Willamette Falls 207
67. Mollalla R 220
68. Clackamas R 247
69. Tualatin RgScogg 304
70. Mill Cr 308
71. S SantiaM8Spt Ld 411
72. S SantiaS Foster 416
73. N SantiasCMinto 452
74. M Fk Willam_Dexter 491
75. McKenziecLeaburg 492

DESCHUTES R 6 TRIBS.

76. Deschutes RpMO 330
77. Sherars Falls-Mo 363
78. Deschutes 98RM 43 395
79. Oak Spring Hat 404
80. Maupin Trap RM 50 408
81. Wm Sp R-Sher Fall 425
82. Dry Cr-Wm SP R 446
83. Deschutes RSRM 84 463
84. Warm Spring Trap 464
85. Pelton D-Wm Sp R 473
86. Warm Spring R 479
87. Warm Spring R9Hat 485
88. Deschutes 1IRM 100 489
89. Beaver Cr-WmSp R 494
90. And Butte Ladder 503
91. Rnd Butte Hat 506

JOHN DAY R

92. John Day 16Mo 349
93. John Day RgRM 16 374
94. John DaylSpray Ore 623
95. N Fk John CORM 60 744
96. M Fk John DgRM 32 749
97. John D-3oranite Cr 788

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SNAKE R 6 TRIBS.

93. Ice Harbor D 537
99. Fishhook park 557
100. Texas Rapids 630
101. Lit Goose D 634
102. Tucannon R 691
103. Lo Granite D 693
104. Clarkston Wash 742
105. Asotin Id 754
106. Grand Ronde R 793
107. Wallowa Hat 940

CLEARWATER R 6 TRIBS.

108. N Fk Clearwater 809
109. Clear Cr 863
110. S Fk Clearwater 1003
111. Loehsa R 1026

SALMON R 6 TRIBS.

112. Salmon RgRM 53 908
113. Salmon RRRM 85 959
114. Rapid R Hat 967
115. Lit Sal R 974
116. S Fk Salmon R 1153
117. Lemhi R'3MO 1239
118. Lemhi R 1294
119. Pahsimeroi R 1311
120. Upper Salmon R 1446

YAKIMA R

121. Satus Cr 651
122. Dry Cr 681

OUTSIDE COLUMBIA RIVER BASIN

123. Siletz R
124. Yaquina Bay
125. Coos Bay Ore

Figure 2.--Map of release sites for marked fish in Columbia River systems. Index numbers correspond to location and Rkm as indicated on legend.

The initial funds were provided by the Pacific Northwest Regional Commission (PNRC). In 1981, the Bonneville Power Administration (BPA) began funding the sampling in the estuary. The current objectives of this sampling are:

1. Define migration timing and movement rate of various stocks of salmonids from release location to the estuary.

2. Obtain comparative capture percentages for marked groups to evaluate relative smolt survival in relation to:

   a. mitigation hatcheries;

   b. bypass systems at dams;

   c. transportation programs;

   d. fish size, release site, and date;

   e. adult recoveries and;

   f. river flows and electrical power production.

3. Amass information on which to partially base management and regulatory practices which will restore, enhance, and protect the fishery resources of the Columbia River.

This report summarizes sampling activities for 1981 and includes an evaluation of catch data from 1977 to 1981.

EXPERIMENTAL AREA AND METHODOLOGY

The Columbia River at Jones Beach (RKm 75) is about 1.6 km wide and has a central ship channel that is dredged to a depth of 14 m. This location is considered by hydrologists to be the "entrance" to the estuary. The gradually sloped sandy beach and debris-free channel make the site ideal for sampling with both beach and purse seines.

Catches at Jones Beach of marked fish released at many locations throughout the Columbia River system (Figure 2) provided the majority of the data contained in this report.

Equipment and Sampling Procedures

Purse seining was done in water about 9 m deep at the north edge of the ship channel near the upstream tip of Puget Island. The seine was 206 m long and 11 m deep with mesh of 1 to 2 cm stretched measure (Johnsen and Sims 1973). Beach seining was done on the Oregon shore where the water depth was about 6 m at the outer end of the net sweep. The net was 95 m long and 5 m deep with mesh of 1 to 2 cm (Sims and Johnsen 1974). Variations in the amount of water strained by the seines was minimized in relation to water velocity because the nets moved with the river current as each set was made.

From 1977 through 1980, sampling began in March and ended in September except for 1977 and 1978 when sampling continued through the winter and into the following spring. In 1981, sampling at Jones Beach began in March and terminated in December. Seining effort varied weekly depending on the number of migrants present. Initial fishing effort was 4 sets/day, 3 days/week with the beach seine and 2 sets/day, 2 days/week with the purse seine. In May and June, the nets were fished 6 or 7 days/week with an average of 10 sets/day for the beach seine and 4 sets/day for the purse seine. From July to September, the effort reverted to the initial level (Appendix Table A1). Generally, sampling began at sunrise and continued for 7 hours.

Physical Data

Surface water temperatures were measured daily at Jones Beach to + 0.5 °C. Average daily river flow at Bonneville Dam was obtained from the U.S.

Army Corps of Engineers1/. Weekly turbidity measurements for the Columbia River downstream from the Cowlitz River were obtained from NMFS personnel at the Prescott Field Station2/.

Fish Processing

Fish were examined at a permanent fish processing facility on shore; they were anesthetized with ethyl p-aminobenzoate (benzocaine), enumerated by species, and examined for identifying marks. Fork lengths were measured from a subsample of each species. Juvenile chinook salmon were separated into subyearling and yearling categories on the basis of length frequency distributions of fork length; some overlap in age determination occurred and was verified by recovery of marked fish of known age, however, this method generally proved satisfactory. The fish were released after processing. Marks, species, fork length (mm), sampling gear, sampling site, time, and date were recorded for each marked fish. Salmonids with an excised adipose fin, indicating the presence of an implanted coded wire tag (CWT), were passed through a detector to estimate tag retention percentages for each species. When less than 100 CWT per species were captured per day, they were sacrificed for tag identification; when more than 100 CWT per species were caught, subsamples were taken. The data were expanded to represent that portion of the catch that was released.

Samples for other research programs were collected from fish with CWT: (1) gill tissues (Na^{+}-K^{+} ATPase analysis) for the NMFS smoltification study 3/ and (2) scales for Oregon Department of Fish and Wildlife

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1/ U.S. Army Corps of Engineers, NPD, Reservoir Control, 210 Custom House, Portland, OR 97208.

2/ Robert McConnell, NMFS, P.O. Box 1051, Longview, WA 98632. Measurements adjacent to or 8 km downstream from the mouth of the Cowlitz River.

3/ Waldo Zaugg, NMFS, Cook, WA 98605.

(ODFW)4/ and Washington Department of Game (WDG)5/. Sex determinations of coho salmon were made for the U.S. Fish and Wildlife Service V and adult cutthroat trout were jaw tagged and released for WDG.S/•

Portions of the daily catch at Jones Beach were freeze branded; 80% of the yearling chinook salmon, coho salmon, and steelhead and 40% of the subyearling chinook salmon were branded 3 days/week from 1 May to 23 June. Recaptures of these branded fish determined the rate of multiple recapture for each species.

Analysis Procedures

Migration Timing

Migrational timing at Jones Beach for subyearling chinook salmon was based on beach seine catches. Purse seine catches were used for migrational timing of yearling chinook salmon, coho salmon, and steelhead. Catches of marked fish were expanded to represent a standard effort of 10 beach seine and 5 purse seine sets daily.

Movement Rates

Movement rates of marked groups to the estuary were calculated using distance traveled and travel time from the date of release at the hatchery to the date of capture of the median fish at Jones Beach. Seasonal average rates for freshwater migration were calculated for each species, using index groups from particular hatcheries for each year.

4/ Ron Youker, ODFW, Oregon State University, Corvallis, OR 97331.

5/ John Loch, WDG, 1351 Kalama River Rd., Kalama, WA 98625.

6/ Percy Washington, USFWS, Naval Support Activity, Bldg. 204, Seattle, WA 98115.

Relative **Survival**

Relative survival estimates for marked groups released by various fishery agencies were made by comparing catch rates at Jones Beach:

$$\frac{[\%\ \text{Catch (treatment)} - \%\ \text{catch (control)}]}{\%\text{Catch (control)}} \times 100 = \%\ \text{difference of survival}$$

Variation in Catches

evaluate gear efficiency (CPUE) in relation to river flow, comparisons were made for mark groups from the same stock and size migrating at different river flows. Only those groups released downstream from Bonneville Dam were used because of the variation in survival affected by flow conditions at dams (Raymond 1979). We examined each species separately and found no significant differences, then combined the data. An inverse relationship between catch percent and flow was apparent in 27 of 35 observations (Appendix Table A2). The average effect of change is river flow on catch percentages was a 1,000 m^3/s (35,300 ft^3/s) 7
increase in flow results in a 21% decrease in catch percentage. Since only 35 comparisons could be made and variation between **comparisons** was large, the catch/flow relationship is not yet well defined. As the data base increases this measure for the average affect of flow on catch percentages will improve, and an adjustment of catch percentages to reflect river flow changes will be possible.

Evaluation of the **overall** consistency of Jones Beach catch percentages was made using the G statistic [modification of chi-square for small sample size (Sokal and Rohlf 1969)] to establish the validity of the hypothesis: H_o = no difference, in catch percentages of identical groups (replicates) released with different marks as opposed to the alternative hypothesis, H_A = there were significant differences between catch percentages of replicate groups. Homogeneity of catch percentages was found in 161 of 180 **comparisons** at the **95% rejection** level.

To simplify analysis procedures, we developed an empirical method for comparing catch percentages. Catch percentages of replicate mark groups were averaged (U), then the difference between this average and each individual catch percentages was calculated (Y) and plotted against actual number of fish captured (X). Figure 3 shows that variation between catch percentages of relicate groups is large (as high as 71% difference) when 25 or fewer fish were captured, and small (12% difference or less) when 100 or more fish were captured. The curve on Figure 3 represents the 95% level of confidence. We recommend that researchers plot catch percentage differences for treatment and control groups on Figure 3 to ascertain whether observed differences are greater than normally observed between replicate groups. For example, to evaluate the difference between two stocks of steelhead from Hagerman Hatchery released at the Pahsimeroi River:

Treatment	No. released	No. captured Actual	No. captured Adjusted	U	Xi	Yi
Stock A	38,400	13	19	0.00072	13	31
Stock B	49,600	30	44		30	23

Both data points fall inside the range for replicate groups in Figure 3, thus we conclude difference in survival to the estuary for Stocks A and B could not be detected. G statistic evaluation provides the same conclusion, but would be time consuming to calculate if more than two groups were compared. The empirical evaluation takes into account the variation that has affected consistency of sampling in the past (including random variation), consequently it provides a more precise evaluation.

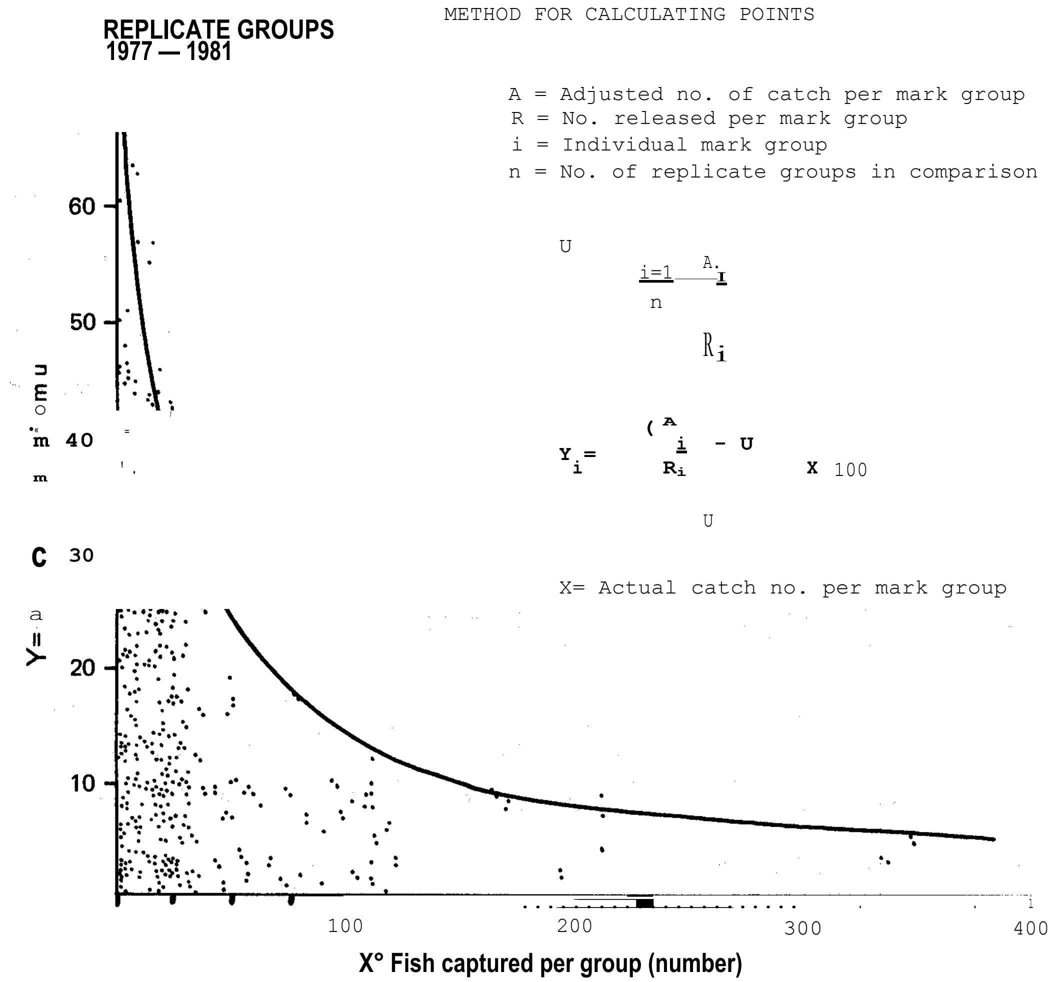

Figure 3.--Differences between catch percentages for replicate mark groups compared to number in catch.

RESULTS OF SAMPLING IN 1981 RELATED TO DATA SINCE 1977

Numbers of marked and unmarked fish captured in 1981 were similar to 1980 but substantially less than 1977-79 (Figure 4). Effort levels throughout the peak migration period were similar for all 5 years, but river flows were substantially higher in 1980 and 1981, and the eruption of Mount St. Helens decreased catches in 1980 (Dawley.et al. 1981).

The sampling at Jones Beach from March through December 1981, (1199 beach seine sets and 379 purse seine sets) resulted in catches of: 123,483 subyearling chinook salmon; 16,541 yearling chinook salmon; 37,633 coho salmon; and 12,312 steelhead (Appendix Tables A3 and A4). Catch percentages of marked fish groups were generally below 0.5% of the number released (Appendix B); marked fish recaptured included 4,808 CWT and 1,696 external marks (Table 1). Recapture of fish sampled and marked at Jones Beach was less than 0.6%.

In 1981, water temperatures at Jones Beach ranged from 8°C in March to 21°C in August and were similar to temperature patterns observed in other years (Appendix Table A5). Turbidity levels ranged from 2.5 to 20 Jackson Turbidity Units (JTU) during the spring and summer migration period--not substantially different than in years prior to the eruption of Mount St. Helens during May of 1980.

Migration Timing

Temporal distributions of migrations of salmon and steelhead (Figure 5) were similar to 1980 (Appendix Table A6). The major differences were that 25% fewer steelhead were caught during their peak migration period, and a sudden decrease in catch rates of coho salmon and steelhead did not occur as was observed in 1980 coincident with increased river turbidity following the eruption of Mount St. Helens.

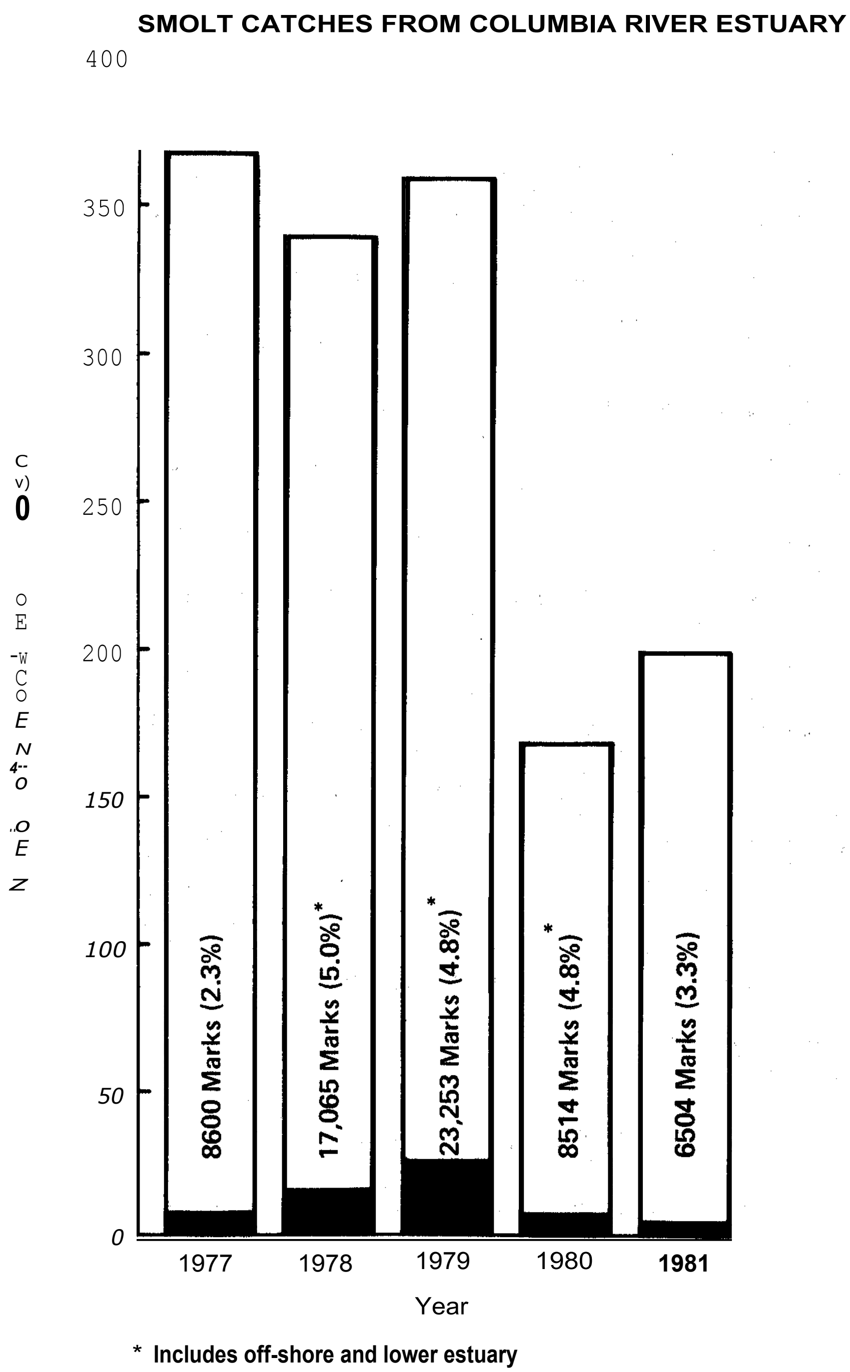

Figure 4.--Numbers of marked (darkened area) and unmarked salmonids captured at Jones Beach, 1977-81. Percentage of marked fish in total catch is shown in parenthesis.

Table 1.--Numbers of marked juvenile salmonids captured in the Columbia River estuary (Rkm 75) during 1981.

Species	Coded wire tags (CWT)[a/]	Ad clip (no CWT)	Brands	Fin clips	Total
Chinook salmon-subydarlings	3,232	232	304	4	3,772
Chinook salmon-yearlings	464	49	31	471	1,015
Coho salmon	830	60	18	22	930
Steelhead	282	47	76	382	787
Sockeye salmon		0	0	0	0
Total	4,808	388	429	879	6,504

a/ Retention of CWT was lowest for steelhead (83%) and highest for subyearling chinook and coho salmon (93%).

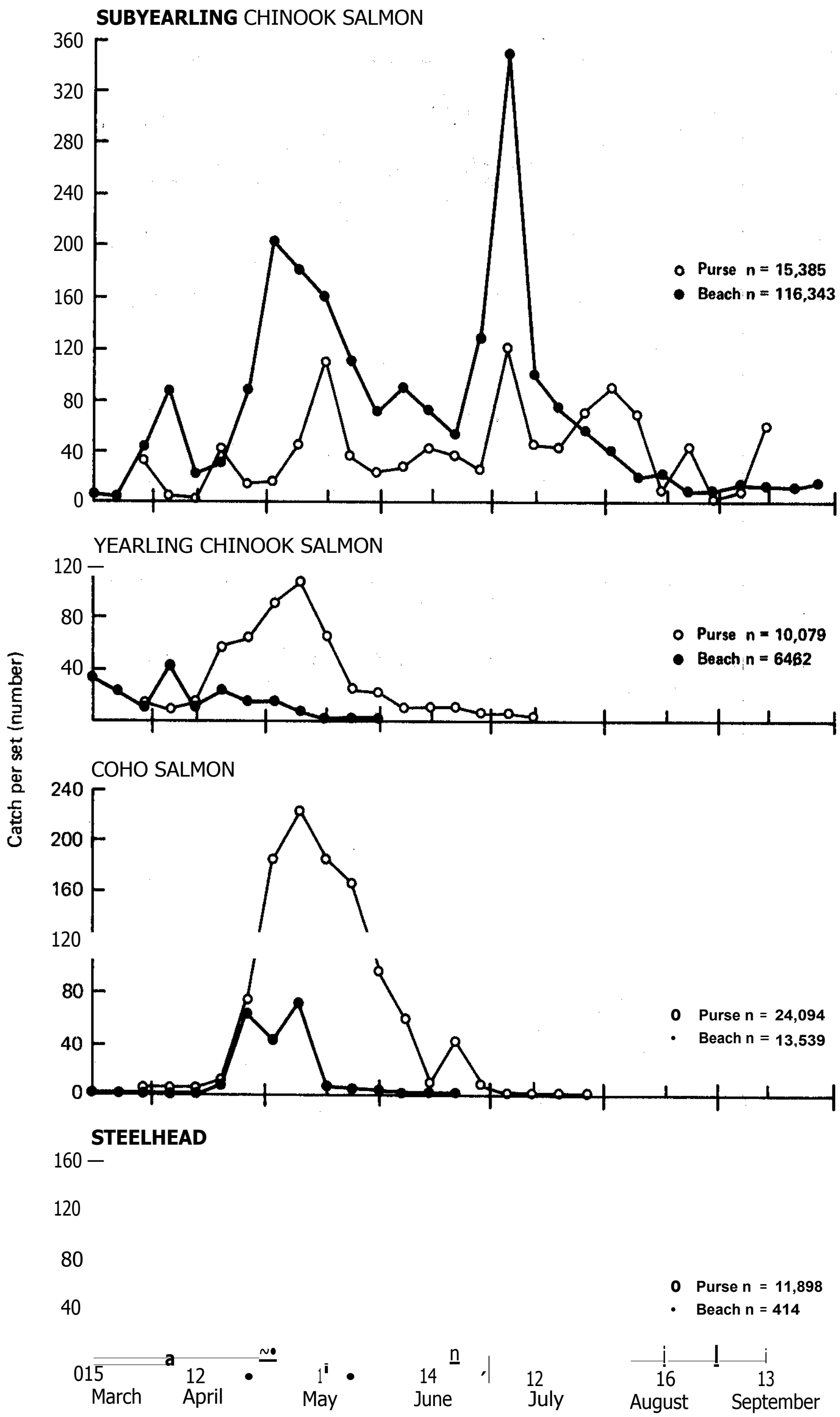

Figure 5.--Weekly catch per set averages for subyearling chinook, yearling chinook, and coho salmon and steelhead caught by beach and purse seines at Jones Beach in 1981.

Subyearling Chinook Salmon

Subyearling chinook salmon became prevalent in catches the last week in March coincidentally with mark recoveries from the March release at Spring Creek Hatchery; beach seine catch per set (CPS) peaked at 88 and had decreased to about 25 fish by mid-April. A second peak CPS of 200 fish occurred during the first week in May, which related to April and May fall chinook salmon releases from Spring Creek and Bonneville Hatcheries. Catches decreased in late May and June coincident with the sudden increase in river flow (Appendix Table A7). Fish groups from Kalama Falls, Little White Salmon, and Klickitat Hatcheries were the principal groups passing during this period. Catch percentages for marked fish from these groups were substantially below those of previous years except for the Little White Salmon group released in 1980, which was about equal to 1981 (Table 2).

In early July, a CPS of 350 fish coincided with the passage of marked fish from Washougal and Cowlitz Hatcheries; the CPS decreased to about 15 fish in early August (Appendix Table A3).

Yearling Chinook Salmon

In mid-March, beach seine CPS averaged 35. Through the first week in April it fluctuated between 12 and 44 and then decreased (Appendix Table A3).

Initial purse seine CPS (late March) was 15; it began to increase during the third week of April (Appendix Table A4). Peak CPS (164) occurred during the second week of May and declined to 22 by the first week in June; the last fish was caught on 30 July 1981.

Coho Salmon

Coho salmon juvenile catches began in late April and peaked at 224 CPS during the second week in May. The migration was essentially complete by mid-June; however, a few fish were captured in late June and early July from the sequential release studies at Washougal and Cascade Hatcheries.

Steelhead

Steelhead were present in catches by the first week in April, peaked at 144 CPS during the second week in May, and were completely absent from catches by mid-July.

Movement Rates

Movement rates of CWT groups ranged from less than 1 km/day to greater than 80 km/day. The fastest moving groups were steelhead captured at Lower Granite and McNary Dams. These fish were subsequently tagged and released at various sites in the Columbia River (Appendix B). Extremely fast movement rates (greater than 200 km/day) were measured for some groups released in Idaho, but these data were no doubt affected by transportation of the fish from Lower Granite and McNary Dams to downstream of Bonneville Dam. The slowest movement rates measured were for: (1) individuals that resided in the Columbia River or its tributaries over winter and migrated in the spring (Appendix Table A8), but do not necessarily represent group movement rate due to lack of catch data from the 1980-81 winter; (2) yearling chinook salmon released in March and April; and (3) groups of fall chinook salmon released at a small size (119 and 100/lb)[7] during May and June from Kalama Falls and Lower Kalama Hatcheries, respectively.

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[7] Number per pound was used throughout this report because that unit of measure is in common usage at all salmon and steelhead hatcheries in the Columbia River system.

Though movement rates for subyearling chinook salmon generally increase with fish size (Dawley et al. 1978), both increasing and decreasing trends of daily mean length were observed within various marked groups (Figures 6 and 7). Previous observations of smolt behavior by **Shapovalov** and Taft (1954) and Salo and **Bayliff (1958) indicate** that the larger fish within a population migrated faster than the smaller fish.

The movement rate of subyearling chinook salmon appears directly correlated with river flow. A comparison of movement rates of fish from Little White Salmon, Kalama Falls, and Klickitat Hatcheries with flows occurring during migrations from 1977-1981 indicated a positive correlation. [(r = 0.85, r = 0.88, and r = 0.38, respectively (Table 2)]. Below average flows observed in 1977 (Appendix Table A7) may have caused decreased movement rates for fall chinook salmon which substantially increased the duration of migration between release site and the estuary. For example, migration period (days, from date of release to date of median catch) for groups passing Jones Beach in August 1977 increased an average of 170% over the longest migration period measured in 1978 through 1981 (Table 3); average river flows during July and August 1977 were 21% less than the least flow during 1978-1981.

Sims[8] found that during normal flow, subyearling chinook salmon of similar size that migrated the greatest distance moved fastest. However, in 1977 when river flow was below average the marked group that migrated the farthest (Klickitat fall chinook salmon--283 km) **displayed** the longest migration period as well as a very slow movement rate.

Movement rates of subyearling chinook salmon also tend to increase in relation to elevated gill Na^+-K^+ ATPase levels at time of release (Zaugg 1981).

8/ Carl W. Sims. NOAA, NMFS, Northwest and Alaska Fisheries Center, Coastal Zone and Estuarine Studies, 2725 Montlake **Blvd.** E., Seattle, WA 98112. Unpublished report, July 1977.

Table 2.--Correlation between flow and movement rate of fall chinook salmon for Little White Salmon NFH, Kalama Falls, and Klickitat Hatchery groups, 1977 to 1981.

Release date	Size (no./lb)	Catch (%)	Date of med. recapt.	Flow 1,000 m^3/	Mov. rate (km/day)
			Little White Salmon NFH		
15 May 77	122	0.11	21 Jun	3.2	5
25 May 78	125	0.35	8 Jun	7.3	13
22 Jun 79	123	0.22	4 Jul	3.7	16
10 Jun 80	101	0.07	19 Jun	8.5	21
05 Jun 81	94	0.07	11 Jun	10.8	27
			Correlationcoefficient r=0.85		
			Kalama Falls Hatchery		
22 Jun 77	113	0.67	26 Jul	2.6	2
22 Jun 77	76	0.19	14 Jul	2.8	3
12 Jul 78	108	0.63	3 Aug	6.4	3
22 Jun 79	180	1.43	27 Jul	3.4	2
13 Jun 80	115	0.24	11 Jul	4.9	2
22 May 81	119	0.12	31 May	10.1	7
			Correlation coefficient r=0.88		
			Klickitat Hatchery		
03 Jun 77	92	0 28[a/]	18 Aug	2.9	4
06 Jun 78	87	0.17	2 Jul	5.7	14
01 Jun 79	80	0.13	7 Jun	5.6	52
27 May 80	85	0.07	8 Jun	8.3	25
05 Jun 81	78	0.03	18 Jun	9.9	29
			Correlation coefficient r=0.38		

a/ No purse seine effort during this period. Purse seine catches for other years averaged 55% of the total catch of Klicktat fall chinook salmon.

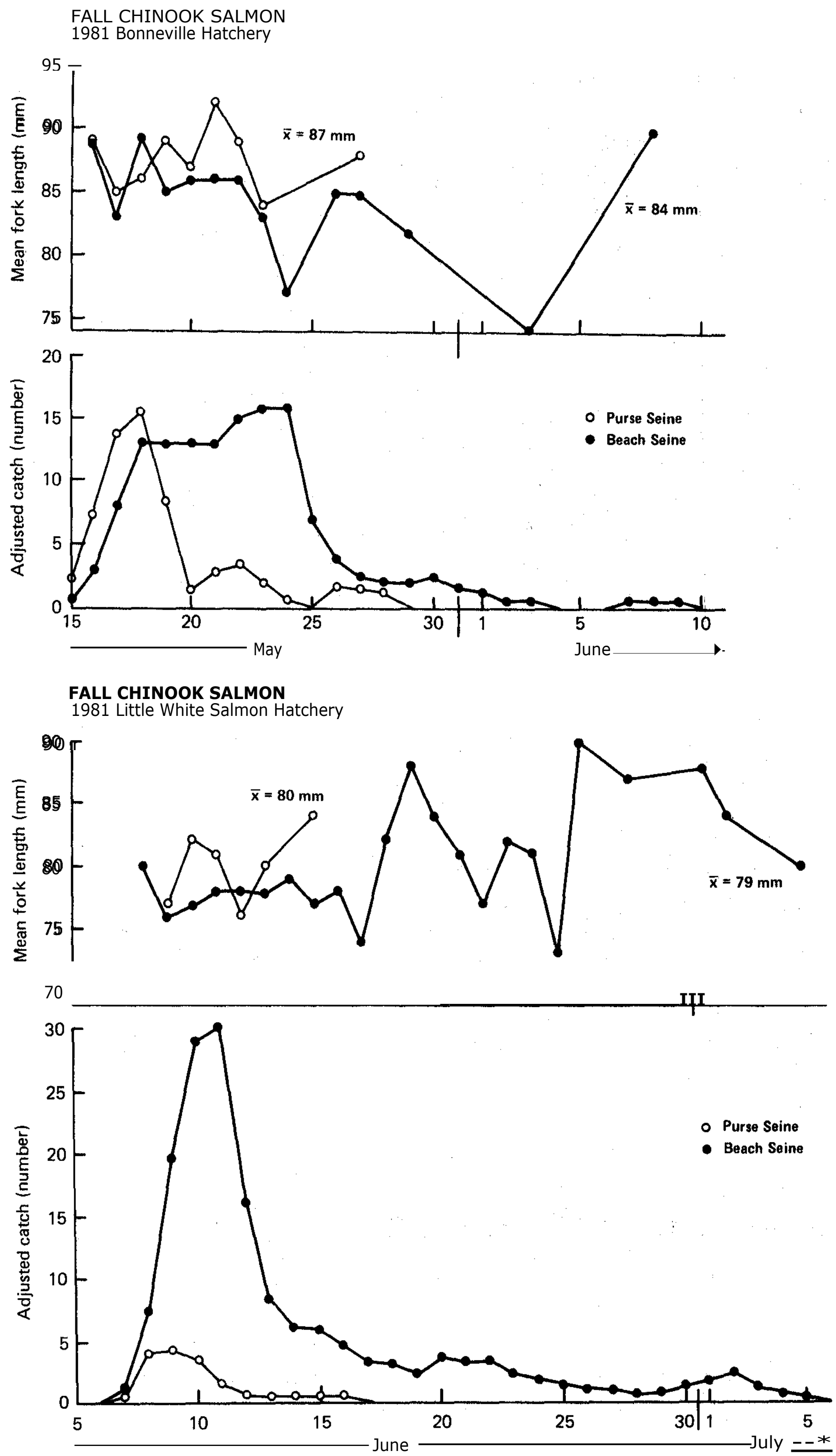

Figure 6.--Daily catch and mean fork lengths for beach and purse seines catches of two marked groups of subyearling chinook salmon at Jones Beach.

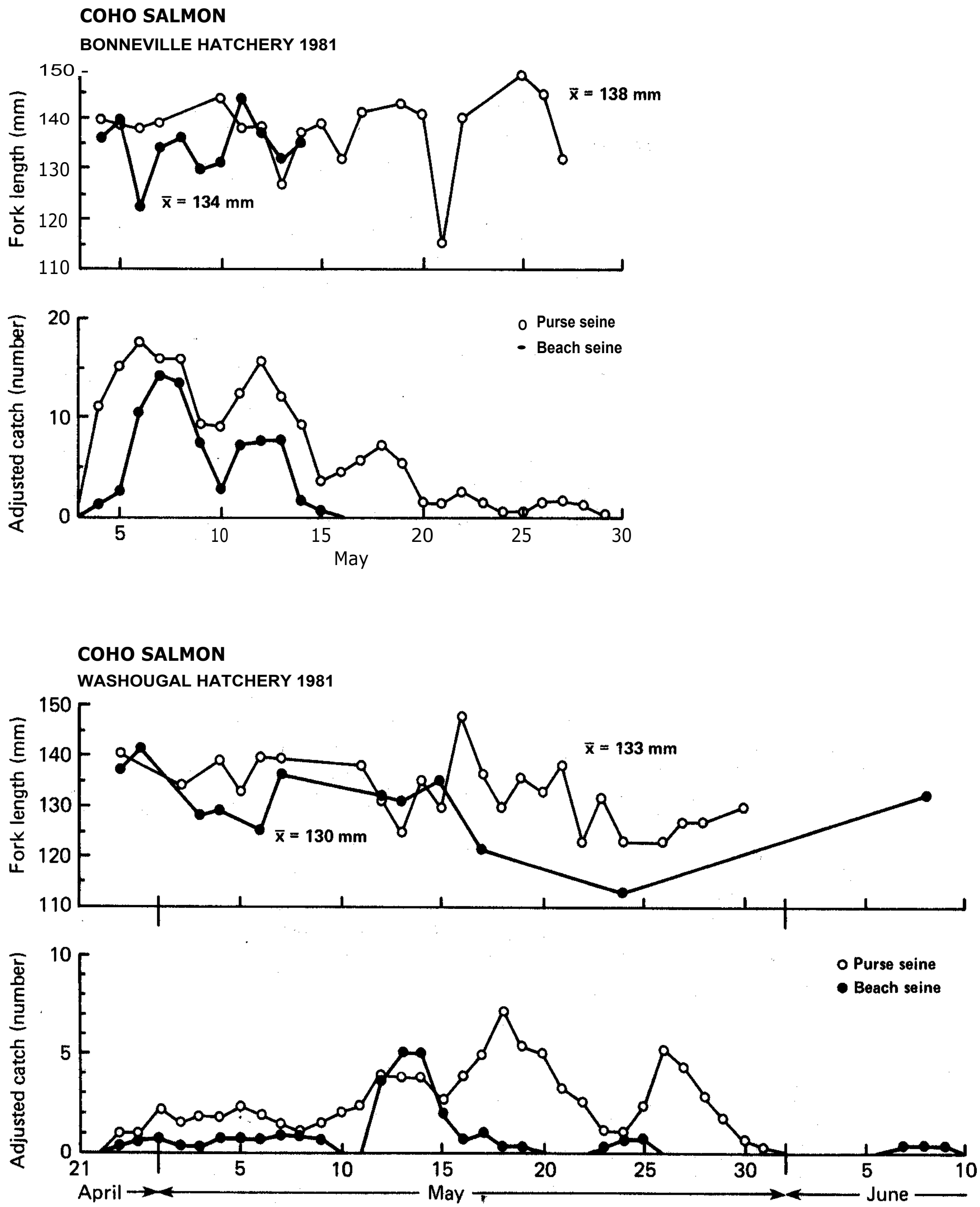

Figure 7.--Daily catch and mean fork lengths for beach and purse seine catches of two marked groups of coho salmon at Jones Beach.

Table 3.--River flow in relation to migration time from various hatcheries to Jones Beach for fall chinook salmon; 1977 compared to 1978 to 1981.

Release site/source	Average size at release (no./lb)	Distance of migration (km)	1977 Date of median recapt.	Migration period days to median fish recapt.	Movement[a] rate km/day	River[b] flow (kcros)	1978-1981 Migration period days to median fish recapt. (range)	Movement[s] rate km/day (range)	River ' flow kcros (range)
Klickitat	84	283	18 Aug	76	4	2.9	6-20	14-47	5.6-8.3
Spring Creek-March	112	194	5 May	48	4	4.0	9-24	8-22	4.0-7.1
Spring Creek-April	77	194	1 May	23	8	4.0	13-14	14-15	5.4-7.8
Spring Creek-May	53	194	31 May	7	28	4.2	4-6	32-49	6.5-8.0
Little White	113	186	21 Jun	37	5	3.2	7-14	13-27	3.7-10.8
Bonneville (early)	79	156	20 May	15	10	3.7	7-8	19-22	6.8-6.9
Washougal	74	146	9 Aug	42	3	2.7	9-22	7-16	4.4-5.4
Cowlitz	95	114	20 Jun	31	4	3.2	8-36	3-14	3.3-6.4
Toutle	125	85	5 Aug	61	1	3.1	16-25	3-5	3.6-5.7
Kalama Falls	110	66	26 Aug	34	2	2.6	9-22	3-7	3.4-10.1

Groups released over more than a 7-day period were not included.

Seven day average of total river flow at Bonneville Dam during week of median fish recapture.

Because of the various factors affecting movement rates, seasonal averages using index **groups** for each species **(Appendix Table A9) should** only be used for general comparisons between years.

Size Characteristics

Generally unmarked fish captured in mid-river with the purse seine were 5 to 20 mm larger than those captured near shore with the beach seine (Figure 8). Mean fork lengths of marked fish captured in mid-river were also consistently larger than their marked counterparts captured near shore (Appendix B); indicating that generally the larger fish of each species tend to migrate more towards the center of the river.

Weekly mean fork lengths of subyearling chinook salmon captured throughout the sampling period fluctuated in relation to the fish size of major hatchery release populations (Figure 8). There was a shift from beach seine catches to purse seine catches with increased size; those groups released at a large size (less than 60/lb) were usually caught in greater percentages by purse seine than by beach seine. **However,** RKm of release site and degree of smoltification sometimes had an overriding effect on this tendency.

Certain groups which migrated over a long period (3 months) showed an increase in size attributable to riverine growth (Dawley et al. 1980).

Survival Estimates for Selected Hatchery Stocks

Survival estimates for fall chinook salmon from the hatchery to Jones Beach during 1978 and 1979 were presented by Dawley et al. (1979, 1980). The estimates from 1980 data were affected by the Mount St. Helens eruption (18 May 1980). In 1981, there was such wide variation in the calculated survival that the estimates are questionable. We intend to continue making

(D

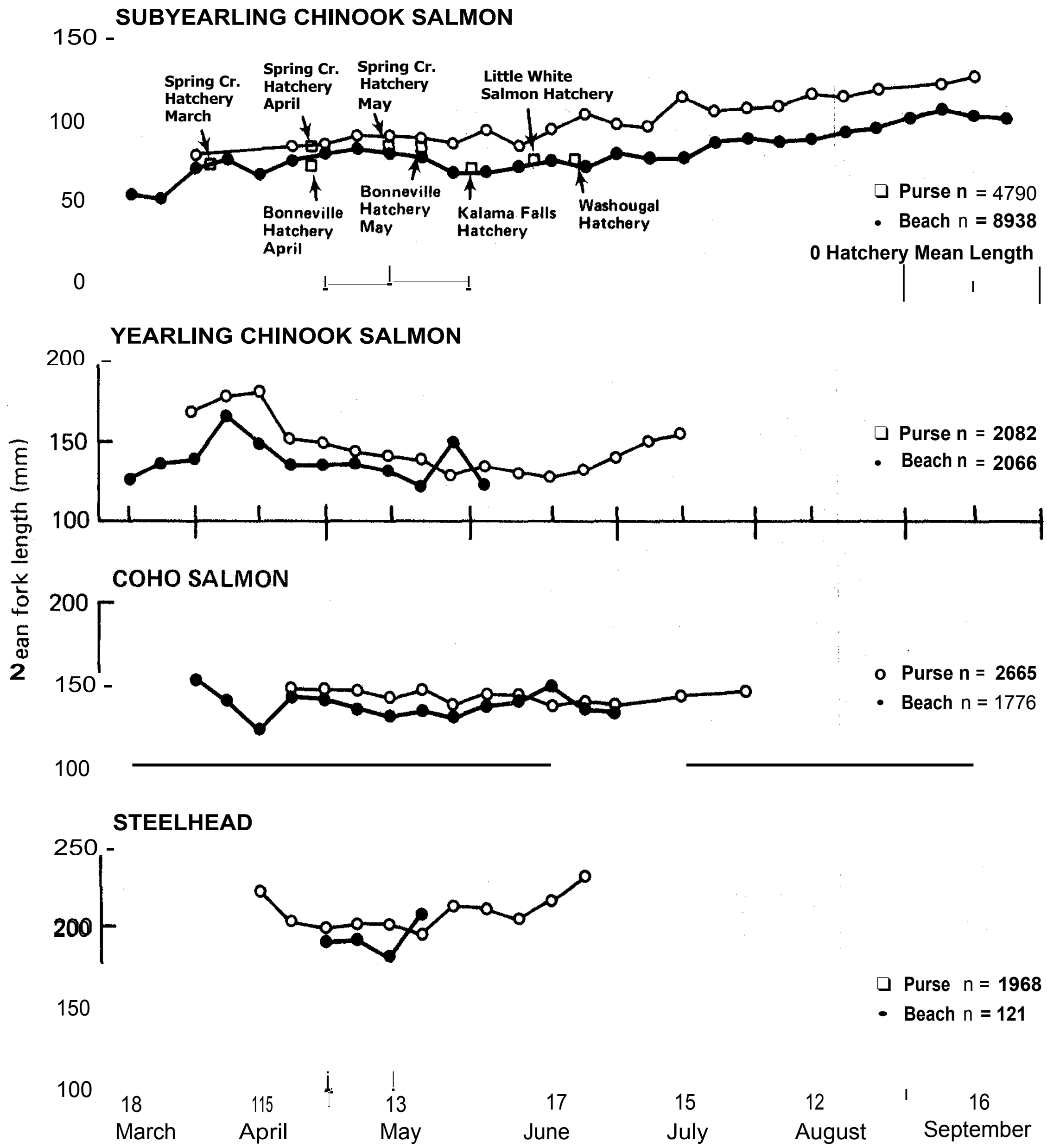

Figure 8.--Weekly mean fork lengths of subyearling chinook, yearling chinook, and coho salmon and steelhead caught in beach and purse seines at Jones Beach in 1981.

these estimates in 1982 then compare 1978 through 1982 using adult return information.

Relative Survival Between Groups

Catch data presented in Appendix B have been used by many researchers to evaluate survival differences of various experimental groups during their migration to Jones Beach in the Columbia River as well as to better understand migration behavior of the snolts (Appendix Table 10). We examined the data for relative survival trends (1977-1981) correlated with effects of fish size at release, transportation past dams, nutrition, rearing density, and chemical treatments; the significant observations are presented. The conclusions reported herein are based on recoveries at Jones Beach. The prime researchers may come to different conclusions based upon their knowledge of all the factors relating to their research.

Effects of Fish Size

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There appears to be a positive relationship between survival to the estuary and increased body size at the time of release for spring chinook, fall chinook, and coho salmon and steelhead. Estuarine catch data indicate that the smaller individuals from certain release populations are missing from the migrant populations passing Jones Beach. Length frequency distributions for yearling and subyearling chinook salmon, coho salmon, and steelhead compared before and after migration are presented in Appendix Figures Al, A2, A3, and A4; in each figure, Group A is a mark group that showed a size shift after migration with proportionately fewer of the smaller fish in the catch; Group B is a mark group that showed little or no size shift.

Gear selectivity appears unrelated to observations of size shift within the population after freshwater migration. Beach seine efficiency for subyearling chinook salmon is inversely correlated with size, which tends to make the observed loss of smaller fish conservative (Dawley et al. 1981). Changes of purse seine efficiency within the size range of yearling fish appears to be insignificant based on the following: (1) several instances length distribution of purse seine catches correlate well with length distributions prior to hatchery release (Appendix Figures A2, A3, and A4; Group B)--if the shift in length distribution was associated with selectivity it should be apparent in all groups observed; and (2) substantial numbers of subyearling fish as small as 60 mm were captured in the purse seine (Figure 5).

Spring chinook salmon groups graded for size and marked for size/survival research at various hatcheries in the Willamette and Deschutes River systems showed higher catch percentages (at Jones Beach) in relation to increased weight in 7 of 10 experiments (Table 4).

A minimum fork length threshold for survival is hypothesized for steelhead smolts by Buchanan (1981). Buchanan reported a release threshold minimum of 180 mm for steelhead of Willamette River origin. However, our observations indicate that this threshold size may not be the same for steelhead of Snake River origin. In some of the Snake River groups, individuals as small as 110 mm migrated successfully to Jones Beach. There seemed to be no size selective mortality for a group of Dworshak steelhead ranging in size from 110 mm to 240 mm (Figure 9).

Similar threshold data are being compiled by Percy Washington for coho salmon 10/.

10/ Percy Washington, Phd thesis *in preparation,* University of Washington College of Fisheries, Seattle, Washington.

Table 4.--Jones Beach catches for spring chinook salmon smolts related to size at time of release from hatcheries.

Release site/source	Release date (day./mo/yr)	Juveniles[a/] catches at Jones Beach (no.)	(%)	Average size at release (no./lb)	(g)
Leaburg, OR/ McKenzie Hat.	15 Mar 80	18	0.153	3	151
" "	"	13	0.112	4	113
"	"	13	0.079	11	41
" "	16 Mar 81	11	0.078	4	113
" "	"	4	0.029	6	76
" "		11	0.075	9	50
Minto, OR/ Marion Fks. Hat.	16-24 Mar 81	10	0.053	14	30
" "	"	10	0.041	14	-30
		7	0.025	20	20
Dexter Pd./Oakridge Hat. (Oakridge stock)	20 Mar 79	32	0.173	12	38
	"	40	0.178	14	32
Dexter Pd./Oakridge Hat. (Dexter Stock)	20 Mar 79	36	0.299	6	76
	"	50	0.282	8	57
Dexter Pd./Oakridge Hat. (Oakridge stock)	10Mar80	15	0.145	4	113
	"	25	0.202	8	58
Dexter Pd./Oakridge Hat. (Dexter stock)	10 Mar 80	20	0.148	9	50
		18	0.134	16	28
Dexter Pd./Oakridge Hat. (Oakridge stock)	16 Mar 81	12	0.096	4	113
	"	9	0.063	7	65
Dexter Pd./Oakridge Hat. (Dexter stock)	16 Mar 81	14	0.104		65
	"	17	0.133		50
Round Butte Hat.	31 May 81	31	0.183	24	19
" " "	"	33	0.122	28	16
"	"	34	0.121	32	14

a/ Actual number captured beach and purse seine and adjusted percent captured.

SNAKE RIVER ORIGIN STEELHEAD 1981

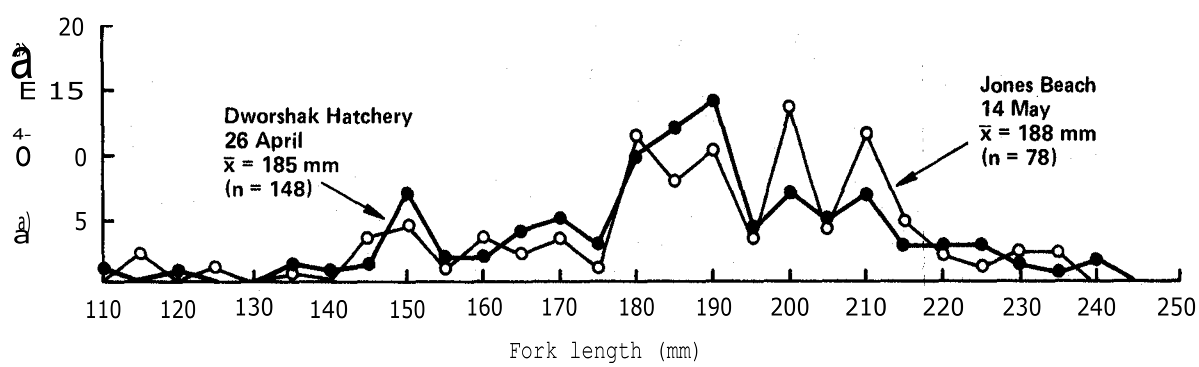

Figure 9.-Fork lengths of Snake River steelhead before and after migration showing little change in length frequencies for the portion of the population less than 180 mm.

Effects of Transportation

Relative survival differences for marked fish groups transported by truck or barge past dams in the Columbia River system, (1977-1981) were calculated from catch percentages at Jones Beach (transport groups with 10 or fewer fish captured were not used). Highly variable catch percentages were observed for transported groups which moved rapidly passed Jones Beach (2 days or less for 50% of the catch). We hypothesize that those fish migrate so rapidly from release sites close to the sampling site that wide dispersion in the river did not occur. If the majority of individuals within a group passed during nonfishing hours, a limited catch percentage resulted. If the majority passed during fishing hours, an inflated catch percentage resulted. Consequently, the catch did not represent the number of individuals passing Jones Beach. Transported fish groups from which 50% of the catch was made in 2 days or less evoked catch percentages smaller than control groups in 5 of 11 instances, and estimated survival increase for 2 of these 11 groups were greater than 1800%. In all but 5 of 34 instances, transported groups from which 50% of the catch was attained in longer than 2 days had higher catch percentages than the controls. Only two group had estimated survival increases greater than 300%, and the control for these groups migrated through eight reservoirs and dams which the transported groups bypassed.

In summary, we examined effects from transportation for all marked groups recovered at Jones Beach with the exceptions of those from which 50% of the catch was made in 2 days or less and groups from which 10 or fewer fish were recovered. Survival estimates generally increased with the number of dams bypassed; the average increase for one dam bypassed was 56% (10 transport groups) and for eight dams 311% (7 transport groups) (Table 5).

Effects of Nutrition

In 1980 and 1981, relative survival comparisons were made from Jones Beach catches for a diet study using fall chinook salmon at Bonneville Hatchery. In both years, catch percentages of replicate groups were higher for one diet than for the other; the differences were statistically significant at the 95% level (G - statistic) for 1980 groups. Catch percentages for groups reared in 1981 with a third diet formulation varied significantly, and comparison to catch rates of the other diets was not meaningful (Table 6).

Statistically significant differences in relative survival were not observed for coho salmon sm lts reared with various diets and released from Sandy Hatchery (1977-1981) (Table 6).

Effects of Rearing Density

Differences in catch percentages of coho salmon reared at high to low pond loading densities from Eagle Creek Hatchery were not statistically significant at the 95% level (G-statistic), nor were groups of spring chinook and coho salmon from the Cowlitz and Sandy Hatcheries released in previous years (Table 7).

Effects of Chemical Treatments

We found no significant differences, using the G-statistic, in catch rate of groups involved with prophylactic treatments or chemical cues for homing following freshwater migration to Jones Beach (Table 8).

Table 5.--Survival differences between fish groups transported past dams[a] and those not transported; from catch percentages at Jones Beach, Oregon, 1977-1981.-

Release site/ source	Date (Da, mo, yr)	Jones Beach catch[b] (No.)	Jones Beach catch[b] (Adj. %)	Dams bypassed (No.)	Estimated survival change from control (%)
	Spring chinook salmon				
Pasco/Carson Hat. Upstream[c]					
(Control)	23 Apr 79	33	0.107		
Carson Hat. (Downstream Release)	3 May	28	0.090	3	-16
Below Bonneville Dam (Transport)	21 Apr-7 May	126	0.102	4	-5
Entiat Hat.	25-26 Apr 78	43	0.049		
Vernita Bridge (Transport)	2 May	13	0.102	4	108
Kooskia Hat. (Control) -	12 Apr 78	61	0.073		
Below Bonneville Dam (Transport)	26-28 Apr	83	0.067		-8
Kooskia Hat. (Control)[d]	16 Apr 80	14	0.044		
Below Bonneville Dam (Transport)	14 Apr	26	0.072	8	63
Leavenworth Hat. (Control)'	25 Apr 78	67	0.090		
Leavenworth Hat.; Hauled 4 h					
(Treatment)	25 Apr	47	0.070	0	-22
Below Priest Rapids (Transport)	8 May	80	0.115	3	28
Leavenworth Hat. (Control)'	26 Apr 79	104	0.142		
Leavenworth Hat.; Hauled 4 h					
(Treatment)	26 Apr	86	0.115	0	-19
Below Priest Rapids (Transport)[e]	15 May	164	0.209	3	47
Leavenworth Hat. (Control)/	24 Apr-1 May 80	30	0.032		
White Bluffs (Transport)	24 Apr-1 May	41	0.085	3	168
Dalton Point (Transport)	24 Apr-3 May	141	0.115	7	262
Pateros Ferry/Leavenworth Hat e/					
(Control)	5-13 May 80	23	0.041		
Below Priest Rapids Dam					
(Transport)	22-27 May	48	0.090	5	120
Richland, WA (Transport)	22-29 May	40	0.074	5	80
Round Butte Hat. /	22 May 78	91'	0.218		
Below Bonneville Dam (Transport)	30 May	110	0.215	2	-1
Round Butte Hat.[f]	23-31 May 79	240	0.282		
Below Bonneville Dam (Transport)	30 May	149	0.338	2	20
Foster, OR/S. Santiam Hat.'					
(Control)	13 Mar 78	26	0.084		
Below Willamette Falls (Transport)	13 Mar	67	0.237	1	182

Table 5.--Continued.

Release site/ source	Date Da mo	Jones Beach catch-[b] No.	Ad	bypassed No.	Estimated survival change from control (%)
Foster, OR/S. Santiam Hat[L]					
(Control)	7 Nov 78	8	0.009		
Below Willamette Falls (Transport)	7 Nov	18	0.018	1	100
Foster, OR/Oakridge Hat.[f/]					
(Control)	21 Mar 78	94	0.168		
Below Willamette Falls (Transport)	23 Mar	15.1	0.265		58
Foster, OR/S. Santiam Hat.[f/]					
(Control)	14 Mar	42	0.1,84		
Below Willamette Falls (Transport)	14 Mar	66	0.271	1	47
Winthrop Hat. (Control)[e/]	20 Apr 79	34	0.065		
Methow R.; Hauled 4 h (Treatment)	24 Apr	16	0.033		-40
Below Priest Rapids Dam (Transport)	16 May	73	0.111	5	101
Fall chinook salmon					
Above Willamette Falls/Aumsville[f/]					
(Control)	4 Apr 77	209	0.434		
Below Willamette Falls (Transport)	4 Apr	504	0.567	1	28
Asotin, WA/Hagerman Hat.[/]					
(Control)	21 May 79	3	0.012		
Below Bonneville Dam (Transport)	20 May	74	0.177	8	1,375
Asotin, WA/Hagerman Hat..[g/]					
(Control)	3 May 80	6	0.023		
Below Bonneville Dam (Transport)	6 Jun	34	0.084	8	265
Asotin, WA/Hagerman Hat.[/]					
(Control)	26 May 81	21	0.066		
Below Bonneville Dam (Transport)	28 May	67	0.132	8	100
Kooskia Hat. (Control)-	29 May 79	31	0.058		
Below Bonneville Dam (Transport)	3-20 May	38	0.102	8	76
Above Willamette Falls/S. Santiam-Hat. (Control)	1 Jun 78	96	0.154		
Below Willamette Falls (Transport)	1 Jun	64	0.187	1	22
Spring Creek Hat. (Control)-[/]	8 Apr 77	215	0.404		
Below Bonneville Dam (Transport)	8 Apr	304	0.558	1	38

Table 5.--Continued.

Release site/ source	Date (Da, mo, yr)	Jones Beach catch[b/] (No.)	(Adj. %)	Dams bypassed (No.)	Estimated survival change from control (%)
Spring Creek Hat. (Control)- [1]	18 Apr 78	175	0.232		
Below Bonneville Dam (Transport)	20 Apr	201	0.247		
Rock Creek/Spring Creek Hat. [A/]					
(Upstream Control)	21 Apr 81	66	0.045		
Spring Creek Hat. (Downstream release)	15 Apr	113	0.126	2	181
I, I II 11	5 May	105	0.171	2	276
	Coho salmon				
Pasco, WA/Carson Hat. (Control)/	3 May 78	47	0.139	4	
Below Bonneville Dam (Transport)	1-4 May	23	0.053		-62
Willard Hat. /	24 May-8 Jun 78	13	0.053		
Below Bonneville Dam (Transport)		21	0.084	1	58
Willard Hat. /	14-23 May 80	21	0.033		
Below Bonneville Dam (Transport)	24-25 May	29	0.039	1	18
	Steelhead				
Icicle Cr. (Chelan Hat.)'	26 Apr 79	55	0.106		
Below Bonneville Dam	28 Apr	80	0.139	1	31
Dworshak Hat. [a/]	17 Apr-29 Apr 80	140	0.125		
Below Bonneville Dam (Transport)	29 Apr-2 May	95	0.510	8	304
Methow R. (Wells channel)-'	27 Apr-8 May 78	17	0.058		
Ringold Hat.	5 May	11	0.079	5	36
Methow R. (Wells channel)-/	9-44 May 79	13	0.042.		
Below Bonneville Dam	12 May	12	0.'155		269

a/ Transport groupp.with time period from first to median fish. capture at Jones Beach 2 days or less were not included in analysis.
b/ Actual number captured, beach and purse seine; adjusted Pcent captured comparisons not made for actual catch less than 10 transport fish. Mark groups were combined where possible to exceed the minimum.
c/ National Marine Fisheries Service.
d/ Idaho Department of Fish and Game.
e/ Washington Department of Fisheries.
f/ Oregon Department of Fish and Wildlife.
g/ United States Fish and Wildlife Service.
hi Washington Department of Game.

Table 6.--Catches of marked fish from nutrition studies.

Tag (Ag/D1/D2) [a]	Release site (source)	Date (da/mo/yr)	Juvenile catches at Jones Beach [b] No.	%
	FALL CHINOOK SALMON			
	Bonneville Hatchery			
07/21/33	OMP 2	27MY80	12	0.042
34	OMP 2		14	0.047
35	OMP 4		24	0.086
36	OMP 4		26	0.096
07/23/41	OMP 2	12MY81	45	0.111
42	OMP 2		45	0.100
43	OMP 4		59	0.137
44	OMP 4		55	0.128
45	Presscake		41	0.098
46	Presscake		58	0.146
	COHO SALMON			
	Sandy Hatchery			
09/05/13	herring 8%	06MY77	23	0.076
06/06	herring 4% soy 4%		24	0.086
07	herring 6% soy 2%		26	0.091
08	soy 8%		25	0.085
09	herring 2% soy 6%		24	0.081
09/16/44	soy 6% herring 2%	02my78	25	0.091
45	herring 8%		14	0.051
46	soy 4% herring 4%		16	0.063
47	soy 2% herring 6%		26	0.102
48	soy 8%		18	0.072
09/16/49	menhaden oil 6%	04MY78	21	0.080
50	soy oil 6%		24	0.096
51	herring oil 6%		19	0.074
52	anchovy oil 6%		22	0.085
07/17/49	anchovy oil 6%	01MY79	28	0.133
50	menhaden oil 6%		25	0.114
51	soy 6%		32	0.151
52	herring 6%		28	0.121
07/20/31	OMP 4	01MY80	16	0.142
33	OMP 4		15	0.135
32	OMP 2 fresh & frozen		16	0.129
34	OMP 2 fresh & frozen		17	0.143
35	OMP 2 acid		12	0.082
36	OMP 2 acid		20	0,160
37	OMP 2 frozen		13	0.108
38	OMP 2 frozen		20	0.143

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Table 6.--Continued.

Tag (Ag/Dl/D2)[a]	Release site (source)	Date (da/mo/yr)	Juvenile catches at Jones Beach[b] No.	%
	COHO SALMON			
	Sandy Hatchery			
07/22/55	OMP 2 frozen	01MY81	21	0.120
57	OMP 2 frozen		16	0.082
56	OMP 2 acid		20	0.086
58	OMP 2 acid		12	0.060
59	Presscake		34	0.135
62	Presscake		25	0.111
60	OMP 4		17	0.083
63	OMP 4		18	0.071
61	OMP 2 frozen & fresh		20	0.089
07/23/01	OMP 2 frozen & fresh		22	0.093

a/ Binary tag AC=agency code; D1=,data 1 and D2=data 2.

b/ Number is actual catch; % represents adjust catch.

Table 7.-Catch percentages of marked fish from rearing **density** studies, 1977-1981.

Tag (Ag/Dl/D2)	Release site (source)	Density	Date (da/mo/yr)	Juvenile catches at Jones Beach a/ No.	%
		SPRING CHINOOK SALMON			
13/13/01	Cowlitz Hat.	(low)	08MR77	12	0.092
04		(low)		12	0.132
09/14		(med)		31	0.119
11/04		(med)		24	0.097
09/11		(high)		44	0.152
12		(high)		36	0.113
63/16/12	Cowlitz Hat.	(low)	08MR78	34	0.320
13		(low)		27	0.293
17/17		(med low)			0.308
18		Oiled low)		64	0.329
11		(med high)		77	0.408
12		(med high)		85	0.488
09		(high)		124	0.453
10		(high)		109	0.383
		COHO SALMON			
09/05/14	Sandy Hat..	(low)	27AP77	8	0.075
09/06/01		(low)		7	0.053
09/05/15		(med)		8	0.060
09/06/03		(med)		6	0.057
02		(high)		6	0.048
04		(high)		10	0.101
05/08/27	Eagle Cr, gat,	(low)	22AP81	62	0.186
28		(med)		136	0.219
26		(high)		180	0.185

a/ Actual catch and adjusted percentage catch, purse seine plus beach seine..

Table 8.--Catch percentages of marked fish from chemical treatment studies, 1977-1981.

Tag (Ag/D1/D2)	Chemical tre4t}nent	Release site (source)	Species	Release date (da/mo/yr)	Juvenile catches at Jones Beach [1] No.	%
Hemorrhagic Septicemia Vaccine						
63/16/02	Vaccine	Klickitat Hat	Sp. Chinook	31MR78	76	0.070
01	Control				73	0.060
Erythromycin Treatment						
63/18/15	Erythromycin	Cowlitz Hat.	Sr' Chinook	23AP79	34	0.194
16					36	0.195
17	Control				35	0.200
18	Control				34	0.191
05/04/38	Erythromycin	Carson Hat.	Sp Chinook		50	0.088
37	Control			28AP80	38	0.067
Vibrio Vaccine						
10/21/18	Vaccine	McCall Hat.	Sp. Chinook	06AP81	18	0.055
28	Control				19	0.050
10/21/36	Vaccine	Rapid R. Hat.	Sp Chinook	12AP81	3	0.011
37	Control			12AP81	7	0.031
7/16/11	Vaccine	Round Butte Hat.	Sp. Chinook	31MY78	33	0.122
12	Control				34	0.121
05/44/01	Vaccine	Spring Cr. Hat.	F. Chinook	08AP77	216	0.350
45/01	Control				207	0.360
05/60/01	Vaccine	Spring Cr. Hat.	F. Chinook	18AP78	153	0200
62/01	Control				175	2L!
05/20/04	Vaccine	Willard Hat.	Coho	03MY77	.20	0.055
21/04	Control				21	.0.047
10/22/41	Vaccine	Niagara Spr. Hat.	SteelheadT	30MR81	32	0.121
42	Control				19	0.073
Morpholine						
10/21/25	Morpholine	Hayden Pd.	Sp. Chinook	01AP80	2	0.012
26	Control				4	0.019
10/22/22	Morpholine	Hayden Pd,	Sp. Chinook	8AP81	7	0.022
21	Control				7	0.021
05/42/01	Morpholine	Big White Pd.	F...Chinook	18AP77	333	0.492
/41/01	Control	(Spring Cr)			358	0.558
Enteric Red Mouth Vaccine						
05/04/34	Vaccine	Spring Cr.	F.Chinook	20AP79	196	0.261
44	Control				281.	0.257

a/ Actual catch and adjusted percentage catch,. purse seine plus beach seine.

Juvenile Catches Compared to Adult Recoveries

Compilation of adult recovery information to help verify precision of estuarine survival observations is in process. We expect to have a preliminary statistical evaluation in the annual report for estuarine sampling in 1982.

Incidental Catch

Nonsalmonid species were a large part of our catch in 1981 (Appendix Tables All and Al2). Increases in catch of northern squawfish, Ptychocheilus oregonensis; suckers, Catostomus sp.; sculpins, Cottus asper; and pea mouth, Mylocheilus caurinus, were noted in 1980 and'were associated with the eruption of Mount St. Helens. Catches of northern squawfish and peamouth continued to increase in 1981. The increased catches in 1980 and 1981 have a poor correlation to river flow, and it appears that resident populations of these species may be increasing.

SUMMARY AND CONCLUSIONS

NMFS and BPA cooperated in a study of juvenile salmonid migrants entering the Columbia River estuary during 1981. The objectives were: (1) define migration timing and movement rates; (2) obtain catch percentages for marked groups to evaluate smolt survival to the estuary, and compare to adult returns; and (3) amass information on which concepts may be developed to restore, enhance, and protect the salmonid resources of the Columbia River. Marked fish recoveries were the basis for evaluations to meet these objectives.

Beach and purse seines were used for sampling at Jones Beach (RKm75); 10 and 4 sets daily (respectively) during May and June; fewer sets were made during March, April, July, August, September, and November. Total catch was 132,483 subyearling chinook salmon; 16,541 yearling chinook salmon; 37,633 coho salmon; and 12,312 steelhead. About 3.3% of the fish were marked.

Variation in Catch Percentages

Increased river flow generally caused a decrease in catch per unit effort (CPUE). The average of the observations was a 21% decrease in catch percentage with a 1,000 m^3/s (35,300 ft^3/s) increase of river flow; continued data collection is required to assess the effect of flow over a wide range of river flow volumes.

G statistic analysis of catch percentages for replicate mark groups (1977-1981) indicates good consistency; in 161 of 180 comparisons no significant difference was found at the 5% reject level. We concluded that catch percentages of marked fish were consistent with the total population of marked fish passing Jones Beach at any particular time. The range of variation for catch percentage was identified in relation to number of fish recovered (Figure 3) and may be used to evaluate the significance of differences between catch percentage of treatment and control fish groups.

Migration Characteristics

Peaks of migration past Jones Beach for hatchery reared yearling chinook and coho salmon and steelhead occurred during the first 2 weeks of May. Three peaks of migration occurred for subyearling chinook salmon: about 5 April, 3 May, and 5 July. Fastest movement rates were measured for fish groups collected and marked at fish trapping facilities during migration. Slowest rates were: (1) individuals that resided over winter in the Columbia River system; (2) yearling chinook salmon released in March and April; and (3) groups of small subyearling chinook salmon released throughout the spring and summer. Fish captured in mid-river were generally larger than those captured near shore. There was no consistent daily increase or decrease in fork lengths of marked fish within individual groups.

In general, we concluded that: (1) fluctuations in catch and average fork lengths of unmarked subyearling chinook salmon were directly attributable to magnitude, time, and fish size of hatchery releases; (2) movement rates to the estuary generally increased with increasing river flows; and (3) movement rates increased with fish size, however, within a single population the larger fish were not always the earliest migrants nor the smaller fish the latest.

Size Relative to Survival

Changes in size composition of marked fish populations migrating from release site to Jones Beach indicated that larger fish probably have better survival during migration to the estuary than smaller fish of the same population. Verification of this conclusion by adult return data is needed. Minimum fork length thresholds for survival of steelhead smolts have been hypothesized; however, differences in fork lengths of fish captured at Jones Beach indicate threshold size may fluctuate between stocks of steelhead migrating from various locations in the Columbia River system.

Transportation Relative to Survival

Estimated survival rates of transported groups (relative to controls) increased with the number of dams bypassed; averaging 56% for 1 dam and 311% for eight dams. We concluded that transportation increased smolt survival. However, data from Jones Beach sampling can not be used to evaluate some transportation research projects because of the rapid migration of the transported fish groups past the sampling site.

Nutrition, Rearing Density, and Chemical Treatments Relative to Survival

Estimates of survival at Jones Beach for most treatment groups from nutrition, rearing density, or chemical treatment research were not statistically different from those of controls.

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