MIGRATIONAL CHARACTERISTICS AND SURVIVAL OF JUVENILE SALMONIDS ENTERING THE COLUMBIA RIVER ESTUARY DURING 1983

by
Earl M. Dawley
Richard D. Ledgerwood
Theodore H. Blahm
Richard A. Kirn
and
Andris E. Rankis

Annual Report of Research
Financed by
Bonneville Power Administration
Agreement DE-A179-83BP39652

and

Coastal Zone and Estuarine Studies Division
Northwest and Alaska Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
2725 Montlake Boulevard East
Seattle, Washington 98112

July 1984

J

ABSTRACT

Sampling of juvenile salmoids migrating into the Columbia River estuary was conducted in 1983 to evaluate behavior and su vival and amass information important to restoration enhancement and prote tion of salmon. Beach and purse seines were fished at Jones Beach (RKm 75) in November and December 1982, late January - September 1983, and October hrough December 1983. In 1983, the total juvenile salmonid catch was 210,754 fish, of which 4.6% had marks. Summaries of mark recoveries wi.h date ranges, average fork lengths, condition factors, and movement rats are presented as appendixes.

Updated evaluation of sampling efficiency changes in r:lation to river flow showed an average 11% decrease of catch for a 1000 m^3/s increase in flow. Catch adjustment for different river flows is important for comparisons between groups captured at different times.

Fall released hatchery fish generally migrated past Jones Beach in the fall, but large percentages of a few groups, often the smaller fish, overwintered in the river system upstream from Jones Beach and migrated the following spring.

Temporal distribution of spring and summer migrants in 1983 was similar to previous years. Peaks of migration past Jones Beach were 7-13 May for yearling chinook salmon; 14-20 May for coho salmon; 21-27 May for steelhead; and 4-20 May, 6-10 June, and 2-8 July for subyearling chinook salmon.

Increases of survival relative to control groups were observed for: coho and yearling chinook salmon groups released at a later than normal date, fall chinook salmon fed a high salt concentration diet, coho salmon

0

from Eagle Creek NPH reared at low density, and chinook salmon and steelhead transported downstream past dams.

Variation of adult recovery data among replicate mark groups showed a need for more in-depth documentation of rearing and release information prior to using adult recovery data to evaluate the significance of variations of juvenile catches.

TABLE OF CONTENTS

Page

INTRODUCTION 1

OBJECTIVES 1

EXPERIMENTAL AREA AND METHODOLOGY 4

Physical Data 7

Fish Processing 7

Biological Samples for Other Agencies 8

Analysis Procedures 9

Mark Data Expansion 9

Movement Rates 10

Relative Survival 10

Survival to the Estuary for Fall Chinook Salmon 12

RESULTS 13

Variation in Catch Associated with River Flow 16

Migrational Timing 18

Fall Released Chinook Salmon and Steelhead 18

Spring Released Hatchery Fish 20

Wild Fish 22

Size Characteristics 22

Relative Survival Between Groups 22

Effects of Fish Size and Release Timing 24

Effects of Nutrition 24

Effects of Rearing Density 28

Effects of Stock Differences 28

l)

Page

Effects of Chemical Prophylactics 28

Passage at Dams and Through Reservoirs 28

Effects of Transportation Past Dams 31

Survival to the Estuary for Fall Chinook Salmon 31

Juvenile Catches Compared to Adult Recoveries 33

Incidential Catches 34

SUMMARY AND CONCLUSIONS 34

Effects of River Flow 35

Migrational Characteristics 36

Relative Survival Between Groups 36

Juvenile Versus Adult Recoveries 37

Incidental Catches 37

ACKNOWLEDGEMENTS 38

LITERATURE CITED 39

APPENDIX A--Miscellaneous Tables Relating to Migration of Juvenile Salmonids 41

APPENDIX B--Mark Release and Capture Information--Columbia River Estuary at Jones Beach (RKm 75) for 1983 66

APPENDIX C--Summary of Contract Expenditures 87

D

D

INTRODUCTION

To assist in evaluating salmonid fishery protection a d enhancement activities in the Columbia River basin, the National Ma ine Fisheries Service (NMFS) began sampling the juvenile outmigrations entering the estuary at Jones Beach, Oregon, River Kilometer (RKm) 7. (Figure 1). Migrational behavior and comparative survival rates we e evaluated. Sampling began in 1966 and continued annually through 19 21[1]; in 1977, sampling was reestablished with funds from the Pacific Nort west Regional Commission (PNRC) for 1977-1979 (Dawley et al. 1978, 1979, 1 80). PNRC and NMFS funds were used to expand the 1980 sampling to ex mine juvenile migrations in the coastal waters of Washington and Oregon Dawley et al. 1981; Miller et al. 1983). From 1981 to 1983, the Bo neville Power Administration (BPA) funded the project (Dawley et al. 192, 1984). An extensive data base is required to understand catch patterns of experimental and control groups that vary with time and river flow. We believe the observations of survival trends must be examind on a system wide (Columbia River Basin) basis to diminish the var ation between individual treatment groups.

OBJECTIVES

Current objectives were to provide an annual assessmen of research and enhancement activities as outlined in portions of Sect ions 300, 400,

---

1/ Sims, Carl W. August 1979. "Migrational characteristi s of juvenile fall chinook salmon, Oncorhynchus tshawytscha, in the Co umbia River." National Marine Fisheries Service, Coastal Zone and Est arine Studies Division, 2725 Montlake Boulevard East, Seattle, WA 98112. Unpublished manuscript.

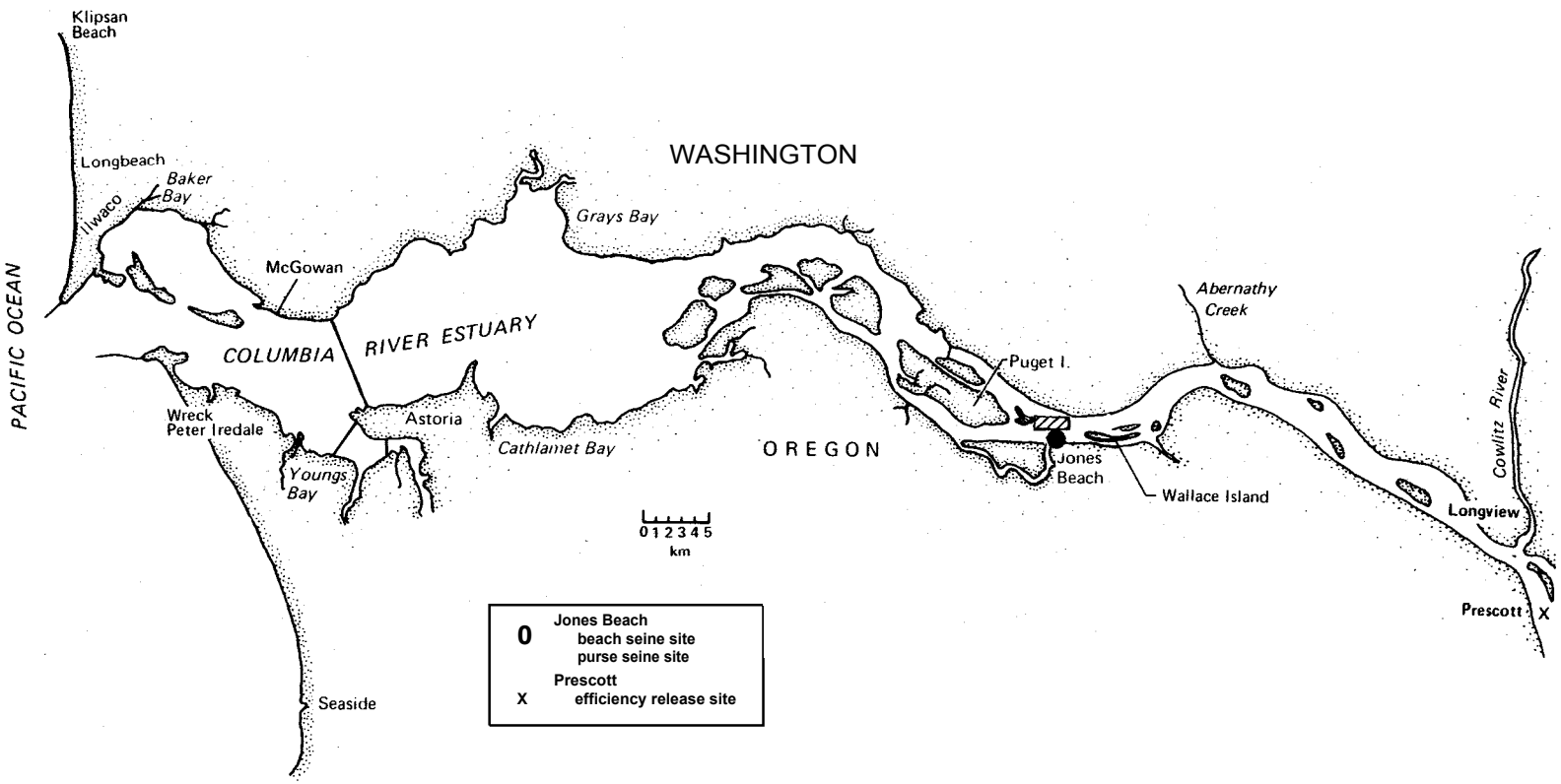


Figure 1.--Lower Columbia River and estuary; Jones Beach sampling site and Prescott release site are indicated at RKm 75 and 115, respectively.

and 700 of the Northwest Power Planning Council's Columbia **River** Basin Fish and Wildlife Program. The specific objectives were as follows:

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

2. Provide capture percentages for marked groups to estimate relative survival of juvenile migrants in relation to:

   a. Fish production at mitigation hatcheries.

   b. Juvenile bypass systems at dams.

   c. Transportation programs.

   d. Fish size, release site, and date.

   e. Survival to adulthood.

   f. River flows and electrical power production.

3. Amass information (examples listed below) on which NMFS and other agencies can partially base management and regulatory practices to expediently protect, enhance, and restore the fishery resources of the Columbia River.

   A. Examine stomach contents of tagged fish to determine the extent of inter- and intra-specific competition for food throughout the migration period and to relate stomach fullness to rate of survival to adulthood.

   b. Collect scales and tissue samples and make **observations** of disease incidence in order for other investigators to ascertain scale patterns prior to seawater entry, determine status of smoltification, and evaluate disease incidence following freshwater migration.

Objectives relating to relative survival were dependent on the number and types of marked groups released by fishery agencies. In 1983, marked

fish were released at various sites (Figure 2) for studies r-lating to fish size and release timing, nutrition, rearing density, sto.k composition, chemical prophylactics, passage at dams and through r•servoirs, and transportation past dams. Data collected at Jones Beach were also used to improve the evaluation of the effects of river flow on samp ing efficiency and survival of fall chinook salmon from hatchery release sites to the estuary.

This report describes sampling activities and results fir fiscal years 1983 and 1984. Stomach content and fullness research will pie presented in a separate report.

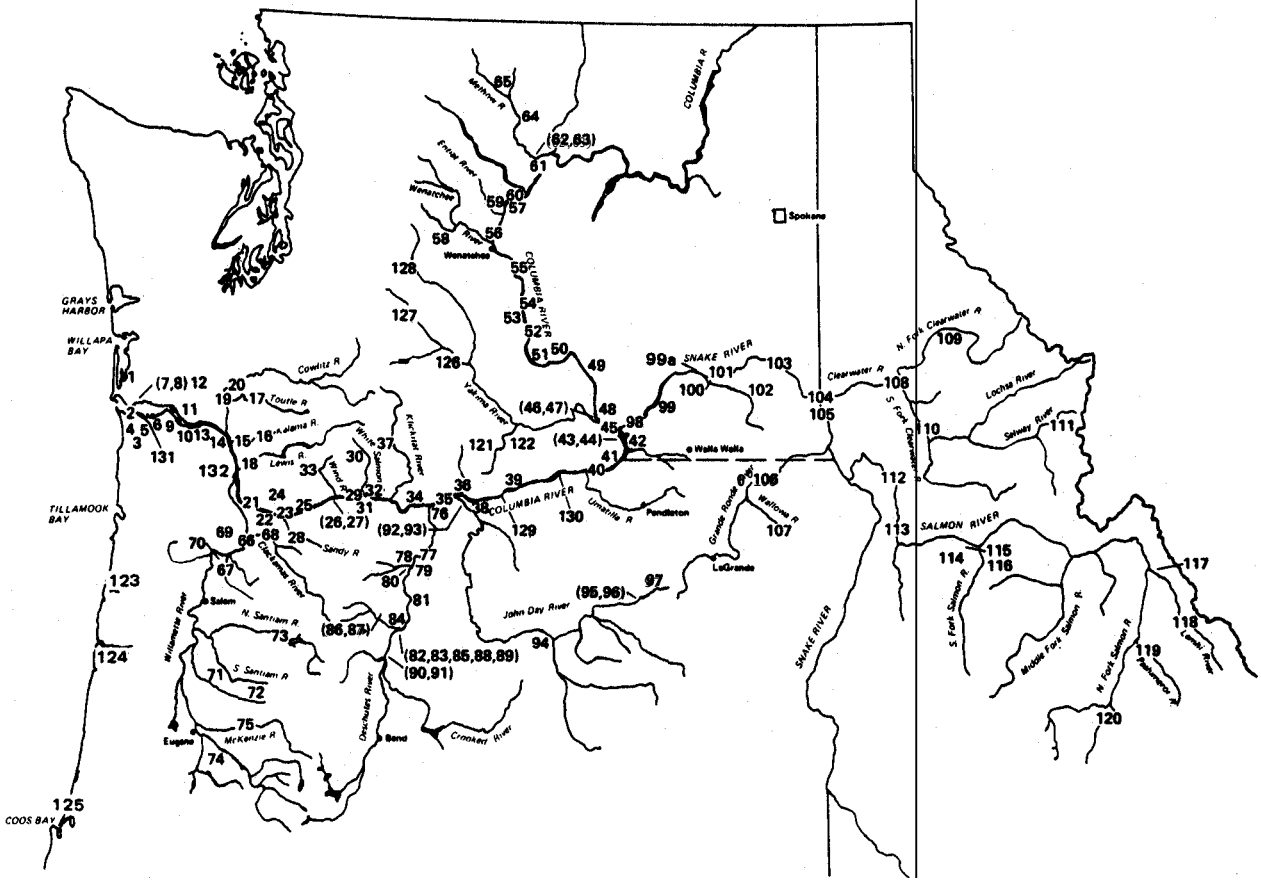
EXPERIMENTAL AREA AND METHODOLOGY

Beach and purse seines were used to sample juvenil salmonids at Jones Beach, Oregon, where the estuary is about 1.6 km wi'e with a 14-m deep central ship channel (Figure 3). Sampling procedures aye described by Dawley et al. (1984).

Sampling was done during the spring and summer out-migration period (April-September) and the fall and winter out-migration period (November 1982-March 1983 and October-December 1983). Beach and purse seining efforts varied weekly (Appendix Tables Al and A2) depending on the number of migrants present and the objectives for the sampling pe iod. Efforts during the fall and winter of 1982-83 averaged seven beach seine sets and three purse seine sets/d, 5 d/week with a break from 14 Dece ber 1982 to 25 January 1982.2/ In April 1983, effort was increased to eight to ten

---

2/ Juvenile sampling data obtained at Jones Beach in 977 and 1978 indicated that few fish (two/set or less) would be captured from mid-December to February.



LEGEND

Release site	Rkm
LOWER COLUMBIA B 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. Gray, RQRM 13	57
8. Grays R@RM 21	68
9. Jones Beach	75
10. Beaver Terminal	84
11. Abernathy Cr	91
12. Elokoein R	94
13. Rainier Ore	109
14. Prescott Ore	115
15. Kslaam RQRM 6	127
16. Kalama RQRM 15	141
17. Green R	160
18. Lewis B	163
19. Cowlits R@RM 47	184
20. Cowlits R8RM 50	189
21. Dalton Pt	206
22. Washougal R@RM 10	213
23. Skamania Light	219
24. Washougal R@RM 15	221
25. Beacon Rock	227
26. Blw Bonn D	230
27. Tanner Cr	231
28. Sandy R	235
29. Lit Wh Sal R@RM 2	261
30. Lit Wh Sal R@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 Shore	375
39. Patterson Slough	448
40. NcNary D	470
41. Port Kelly Wash	501
42. Walla Walla R@Mo	507
43. Casey Pd	516
44. Villiard Slough	521
MID COLUMBIA R 6 TRIBS.	
45. Pasco Wash	522
46. Yakima R@Mo	539
47. Richland Wash	540
48. RiagoldHat	568
49. Wh Bluffs	596
50. Vernita Brid	629
51. Pr Rapid Spew Ch	639
52. Crab Cr	660
53. Wampum D	669
54. Vantage Brid	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 Spew Ch	828
62. Methow R@Mo	838
63. Pateros Ferry	839
64. Methow R@RM 28	893
65. Methow R@Hat	919
WILLAMETTE R 6 TRIBS.	
66. Willamette Falls	207
67. Mollalla R	220
68. Clackamas R	247
69. Tualatin R@Scogg	304
70. Mill Cr	308
71. S Santiam@Spt Id	411
72. S Sentiam@Foster	416
73. N Santiam@Minto	452
74. M Fk William@Dexter	491
75. McKenzie@Leaburg	492
DESCHUTES R 6 TRIBS.	
76. Deschutes R@Mo	330
77. Sherars Falls-Mo	363
78. Deschutes@RM 43	395
79. Oak Springs Hat	404
80. Maupin Trap RN 50	408
81. WaSp R-Sher Fall	425
82. Dry Cr-Wm Sp R	446
83. Deschutes@RM 84	463
84. Warm Spring Trap	464
85. Pelton D-Wm Sp R	473
86. Warm Spring R	479
87. Warm Spring R@Hat	485
88. Deschutes@RM 100	489
89. Beaver Cr-Wm Sp B	494
90. Rnd Butte Ladder	503
91. Rnd Butts Hat	506
JOHN DAY R	
92. John Day R@Mo	349
93. John Day R@RM 16	374
94. JohnDay@Spray Ore	623
95. N Fk John D@RM 60	744
96. M Fk John D@RM 32	749
97. John DBGranite Cr	788
SNAKE R 6 TRIBS.	
98. Ica Harbor D	537
99. Fishhook Park	557
99a. Lyons Ferry	600
100. Texas Rapids	630
101. Lit Goose D	634
102. Tucennon R	691
103. Lo Granite D	693
104. Clarkston Wash	742
105. Asotin Wash	754
106. Grand Ronde R	793
107. Wallowa Hat	940
CLEARWATER R 6 TRIBS.	
108. N Fk Clearwater R	809
109. Clear Cr	868
110. S Fk Clearwater R	1003
111. Lochsa R	1026
SALMON R 6 TRIBS.	
112. Whitebird Trap	908
113. Biggins Trap	959
114. Rapid S Hat	967
115. Lit Sal R	974
116. S Fk Salmon R	1153
117. Lemhi R@Mo	1239
118. Lemhi R	1294
119. Pahsimeroi R	1311
120. Upper Salmon R	1446
YAKIMA R	
121. Status Cr	651
122. Dry Cr	681
OUTSIDE COLUMBIA RIVER BASIN	
123. Siletz R	
124. Yaquina Bay	
125. Coos Bay Ore	
YAKIMA R	
126. Nelson Sp Pd	734
127. Nile Sp Pd	773
128. Ellensburg	776
LOWER COLUMBIA RIVER	
129. Rock Cr	3Rd
130. Biggs	35
131. Tongue Pt	28
132. Cont. B. Fort Lewis	146

Figure 2.--Release sites for marked fish in the Columbia River system. Index numbers correspond to location and Rkm as indicated on legend.

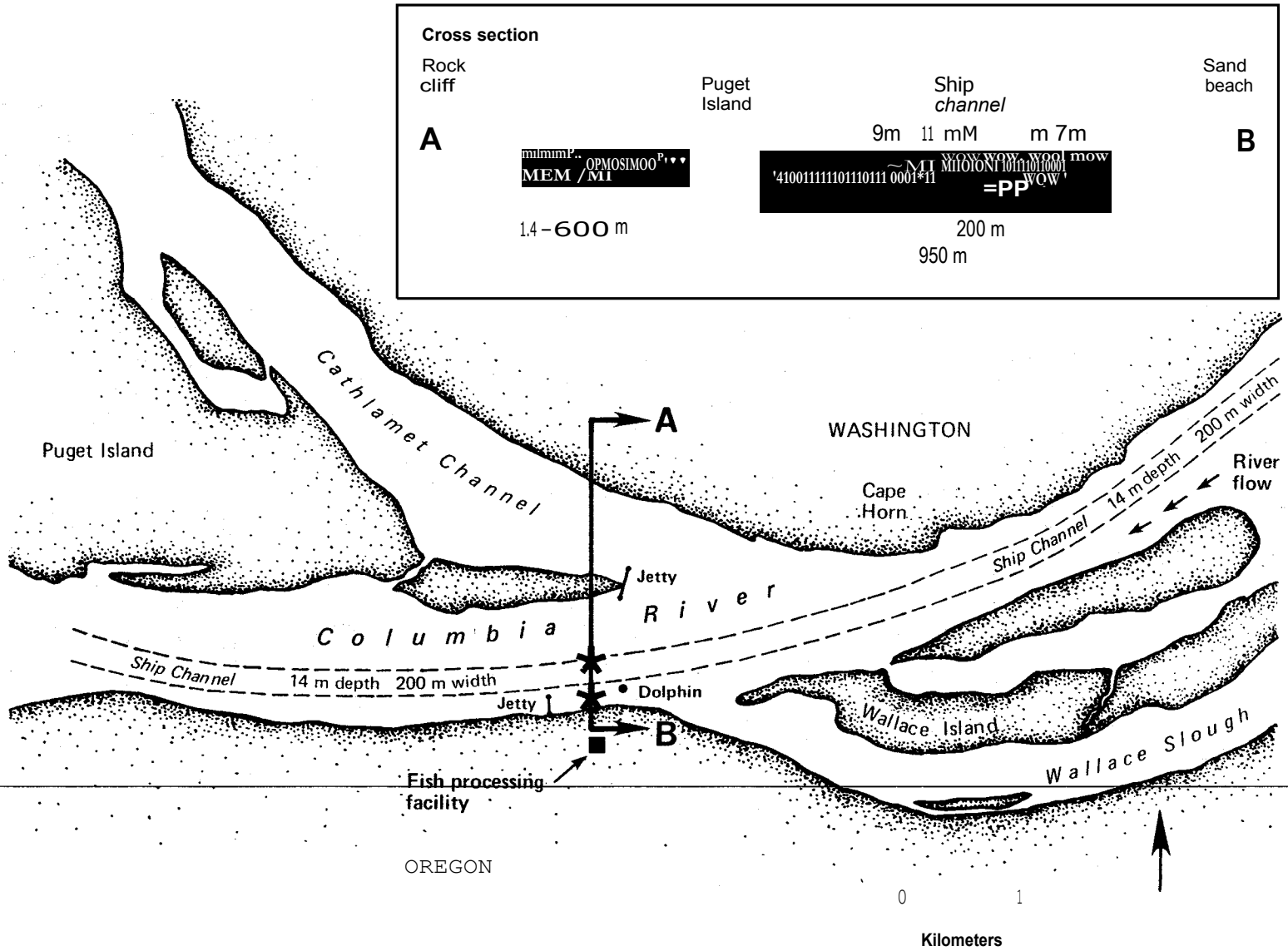


Figure 3.--Jones Beach sampling site. The beach and purse seining areas are denoted on the cross section by the two asterisks.

beach seine and three to five purse seine sets/d, 7 d/week. Purse seine effort was decreased to an average of three sets/d, 5 d/week in late June, and to 3 d/week in late July. From mid-August to mid-September, one or two purse seine sets were made each day, 1-2 d/week. Beach seine effort was decreased in July to eight sets/d, 5 d/week; further reductions in effort were made in late September. Sampling was terminated on 23 September; however, it was re-initiated on 14 October to observe the out-migration of juvenile chinook salmon released from various hatcheries in October and November. Three beach and two purse seine sets were made 3 d/week through 7 December 1983.

Physical Data

Secchi disc readings (cm) and surface water temperatures (+ 0.5° C) were recorded daily. Average daily river flow at Bonneville Dam (+ 0.1 thousand m^3/s) was obtained from the U.S. Army Corps of Engineers (CofE).3/

Fish Processing

If more than 100 fish were captured in a set, they were examined at a permanent processing facility on shore, otherwise they were processed at the sampling site. Fish were anesthetized with a 50 mg/1 solution of benzocaine (varied with water temperature and fish size), enumerated by species, and examined for marks. Fork lengths were measured 3 d/week for all sockeye salmon, Oncorhynchus nerka, and chum salmon, O. keta, and 100 fish subsamples of colic' salmon, O. kisutch; steelhead, Salmo gairdneri; yearling chinook salmon, 0. tshawytscha; and subyearling chinook salmon.

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

Chinook salmon were separated into subyearling and yearling categories on the basis of fork length; about a 4% error rate was observec, based on the percentage of misidentified tagged fish.

Records for marked fish catches include: species, fork length (+ 0.5 mm), sampling gear, site, time of day, and date.

Salmonids with an excised adipose fin, indicating a coded wire tag (CWT), were passed through a magnetic tag detector to estimate tag retention for each species. Those fish containing tags were sacrificed for identification and weighed (+ 0.005 g). In 1983, daily catch of tagged fish did not exceed the daily limit of 100 per species for either beach or purse seine, thus subsampling was unnecessary.

After processing, the remaining live fish were held in a raceway with circulating river water. During May, June, and July, NaCl (6 ppt) was added to reduce handling stress (Long et al. 1977); the water was recirculated and maintained at ambient river temperatLre. At the conclusion of sampling each day, fish were transferred by gravity flow to an amphibious holding tank, transported out of the sampling area, and released. When fish were processed at the sampling site, they were allowed to recover from the anesthetic and immediately transported out of the sampling area and released.

Biological Samples for Other Agencies

Scales from tagged fish were collected for personnel from Oregon Department of Fish and Wildlife (ODFW),[4] University of Washington

---

4/Ron Williams, ODFW, 303 Extension Hall, OSU, Corvallis, OR 97331 and Jeff Zake, 3150 E. Main St., Springfield, OR 97477.

(UW),5/ and Oregon State University (OSU).6/ Carcasses for gill tissue and blood sample extraction were provided to NMFS researchers studying smoltification.Z/ Branded fish were provided to U.S. Fish and Wildlife Service (USFWS)8/ personnel for a bioenergetics study, and some unmarked fish to OSU9/ researchers for disease studies. The incidence of gas bubble disease was monitored during periods of high river flow.

Analysis Procedures

Mark Data Expansion

Expansions of data were made to standardize catches of marked fish groups (tags, brands, and excised fins) for all time periods. The expanded data (adjusted catch and percent) for each unique mark represented an effort of 10 beach seine sets or 5 purse seine sets daily.

(10/Eb) or (5/Ep) x T = A--number of fish with a unique mark, adjusted for designated day.

Where: 10 = Standard beach effort
5 = Standard purse effort
Eb = Actual beach sets--performed on the designated day.
Ep = Actual purse sets--performed on the designated day.
T = Tag--number of tags read with a unique code.

Estimates of recoveries for each unique mark on non-sampling days were an average of the adjusted catch from the closest sampling day before and

5/ Dr. Steve Matthews, UW, College of Fisheries, Seattle, WA 8195.

6/ Joseph Fisher, School of Oceanography, OSU, Corvallis, OR 7331.

2/ Dr. Waldo Zaugg, NMFS, Star Rt., Cook, WA 98605.

8/ Dennis Rondorf, USFWS, National Fisheries Research Center, Willard Substation, Star Rt., Cook, WA 98605.

9/ Dr. J. L. Fryer, OSU, Department of Microbiology, Corvallis, OR 97331.

after. Adjustments for variation of sampling efficiency du: to changes in river flow were not made except where noted in data analyses

Movement Rates

Movement rates for marked fish were calculated using di tance traveled and time between first date of release and the date of mediae fish recovery at Jones Beach. Seasonal average movement rates for each slmonid species were calculated using index groups from particular hatcheriel to facilitate comparisons between river flow and migration rate.

Relative Survival

Relative survival estimates for mark groups given vara were made by comparing catch percentages of control and treament groups.

$$\frac{(\%\ \text{catch treatment} - \%\ \text{catch control})}{\%\ \text{catch control}} \times 100 = \%\ \text{differen}$$

To assess the statistical validity of estimated survival differences, the catch differences were evaluated in relation to cath differences observed between replicate groups previously captured. T. simplify the evaluation an empirical power of the test curve was develo **ped (Figure 4;** Appendix Table A3). Catch ratios (no. caught/no. releasedh of replicate mark groups were averaged (U), then the percentage differen.e between this average and each individual catch ratio was calculated ( ) and plotted against the number of fish captured (X). The curve in Figure 4 represents the 95% confidence level ($P < 0.05$).

The empirical method was used for detecting signific.'nt differences between catch ratios for treatment and control groups. Differences were

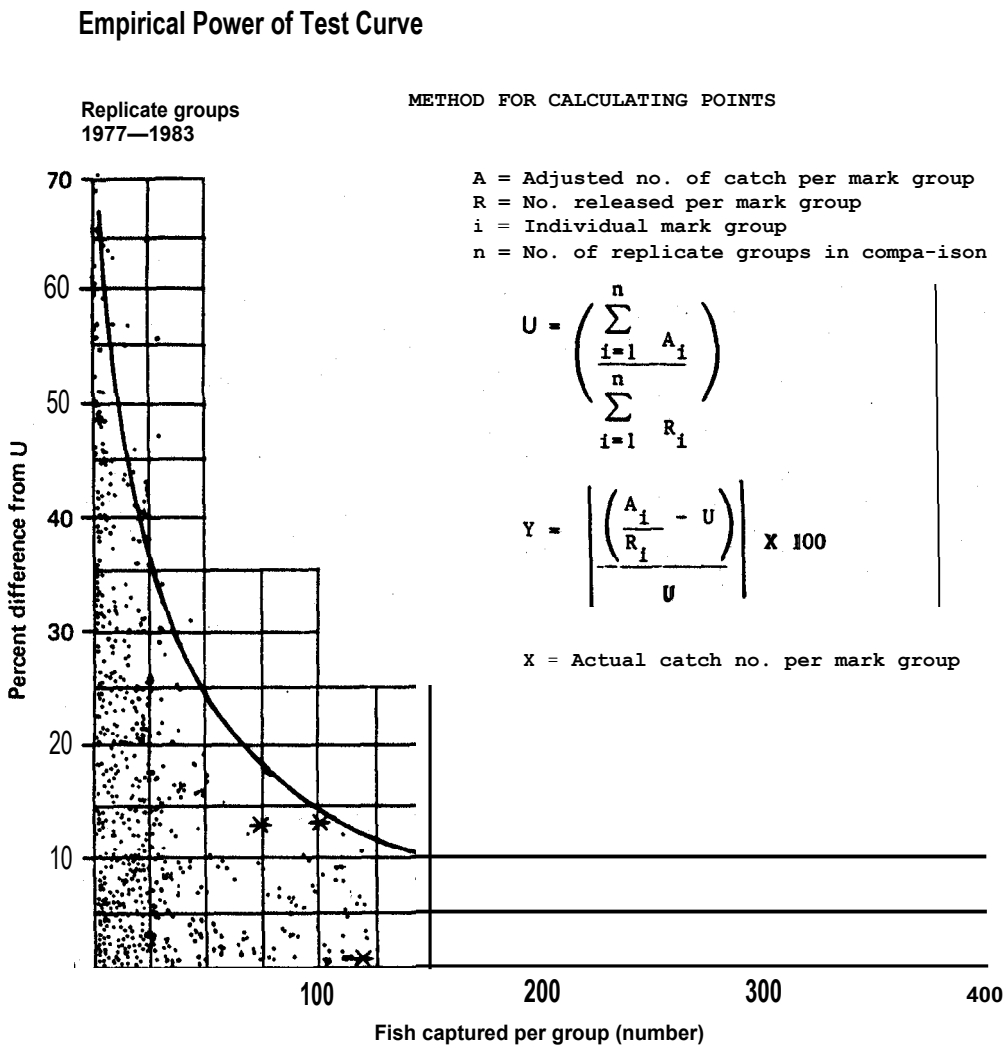


Figure 4.--Empirical power of the test curve, developed by com?acing differences between catch percentages for replicate mark groups to number caught; * = treatment groups from example in text.

plotted on Figure 4 to discern if they were greater than those observed between replicate groups. If more than half of the plotted points fell outside the range of replicate group data, there were significant differences among the catches of treatment and control groups. For example, to evaluate the difference between two stocks of steelhead from Hagerman Hatchery released in the upper Salmon River, we have the following data:

Stock	Size (no./lb)	No. released	No. captured actual	No. captured adjusted	U	X	Y
A	2	38,800	74	109	0.00323	74	13
A	5	39,100	104	142		104	13
B	4	37,600	102	119		102	2

All data points fall inside the range of replicate groups (Figure 4); consequently, we conclude that there was no detectable difference survival to the estuary for Stocks A and B, given the sample size. Statistical evaluation using the G statistic (Sokal and Rohlf 1981) provides a similar conclusion but takes longer to calculate and in some instances may provide erroneous conclusions due to adjustment of catches for sampling effort. The empirical evaluation accounts for variation that has affected previous sampling, including random variation; consequently, it provides a more precise evaluation (Efron and Morris 1975).

Survival to the Estuary for Fall Chinook Salmon

Survival of subyearling fall chinook salmon from the release site to the estuary was determined by comparing catch rates of fish from tagged groups released at the hatchery to those of branded fish transported and released 40 km upstream from Jones Beach, at Prescott, Oregon, (RKm 115). Tag groups utilized for this evaluation were the control for a salt diet study originating from Spring Creek National Fish Hatchery (USFWS) during

April and the control for a nutrition study originating from Bonneville Hatchery (ODFW) during May. Additional groups of 50,000 fish from similar populations at each hatchery were freeze branded, using procedures **described by Mighell (1969).** Each group of branded fish waE transported in two lots and acclimated to Columbia River water. After 3 d, brand retention was evaluated, and fish were released in mid-river, coincidental with the passage of the tagged hatchery fish.

RESULTS

From January to December 1983, 1,666 beach seine and 599 purse seine sets were made; 137,081 subyearling chinook salmon, 19,848 yearling Chinook salmon, 29,278 coho salmon, and 24,547 steelhead were captured **(Appendix** Tables Al and A2). About 4.6% (9,799) of the salmonids captured were marked, of which 5,073 had CWT (Table 1). Tag retention was lowest for steelhead (80%) and highest for subyearling chinook salmon (96%). Catch percentages of marked fish groups were generally below 3.5%. Summary information for mark groups is presented in Appendix B.

In 1983, water temperatures at Jones Beach ranged from 5° C in March to 22° C in August, and secchi disk turbidity readings ranged from 22 to 130 cm (Appendix Table A4).

River flows were high from February through May (6.2 and 11.3 thousand m^3/s), similar to 1982. Peak flows subsided by mid-June, and the flow pattern after that was similar to the average for the moderate flow years, 1978-1981 (Figure 5).

Table 1.--Numbers of marked juvenile salmonids recovered at 'Jones Beach (Rkm 75) **in 1983**

Species	Coded wire tags (CWT)	Excised adipose fin wino CWT a>	Bralds	Excised fins	Total
Chinook salmon - subyearling	2,167	93	385	373	3,018
Chinook salmon - yearling	441	43	806	526	1,816
Coho salmon	1v753	189	3	331	2,276
Steelhead	712	178	1,062	731	2,683
Sockeye salmon		0			
Total	5,073	503	2,262	1,961	**9r799**

e} Tag retension, as measured from percentages f fish with excised **adipose** fin and no **detectable** magnetic tag, was lowest for **steelhead** (80%) and highest for subyearling chinomK salmon (96%).

b> Additional CWT (303) and brands (292) **were obtained rom sampling** a **second Q-h shift (afternoon through evening) from 6** my' to 29 May.

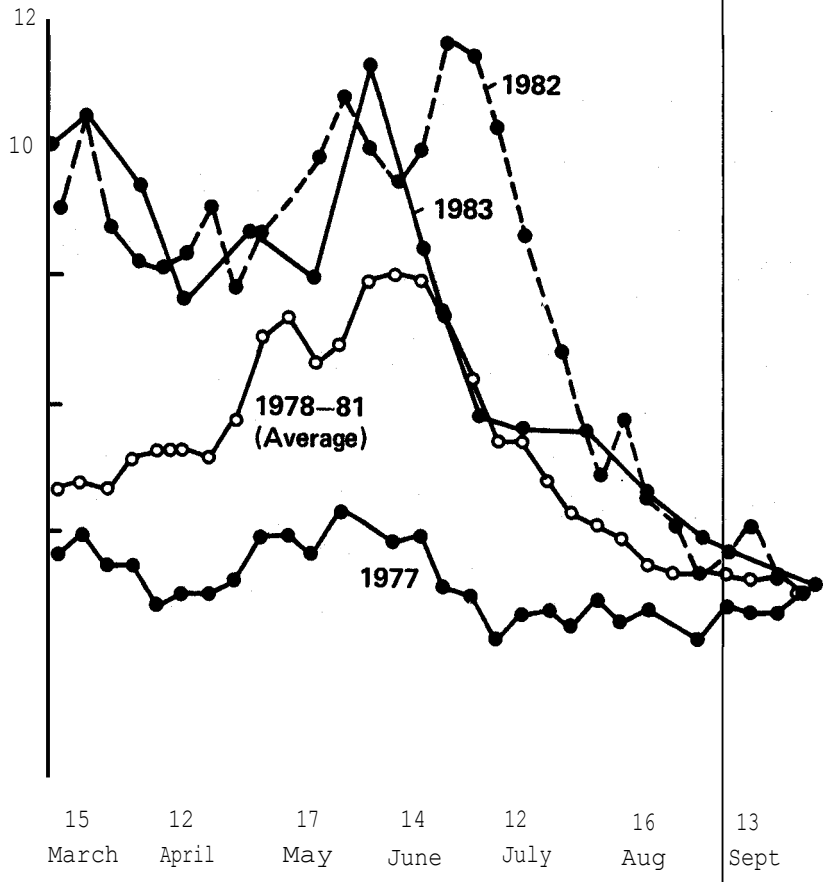


Figure 5.--Weekly average Columbia River flows for 1977, 1978-81 averaged, 1982, and 1983.

Variation in Catch Associated with River Flow

The assessment for effects of river flow on juvenile ca ch percentages was expanded to include data from 1977 to 1983. Two evaluations were made: (1) the ratio of subyearling chinook salmon captured to the -lumber released from hatcheries each year was compared to seasonal average river flow using linear regression and (2) catch percentages from mark groups of similar fish released at different times were compared to diffe ences of flow volumes at the time of recovery.

The first evaluation of the effects of river flow (App-ndix Table A5) indicated that 77% of the variability of catch percentage be ween years was attributable to river flow. The linear relationship (Figure 6) was:

Y (catch percent) = 0.045 X (flow) + 0.614

r (correlation coefficient) = -0.88

Using this equation, an increase in flow from 6,000 to 7,040 m^3/s results in a 13% decrease in catch. This evaluation assumes that (a) survival for the subyearling chinook salmon population reared at hat heries was the same for all years, (b) average river flow for the seaso appropriately represented the conditions encountered by most fish, and (c) wild fish populations were a constant percentage of the catch during .11 years.

The second evaluation involved comparisons of catch percentages of marked fish groups released at different times and rive flows. Only groups which did not pass through the Snake or Columbia Rivr dams, were of the same stock and size, and were released at the same si e were used in the comparisons. The aggregation of data (Appendix Tabl- A6) shows an inverse correlation between river flow and catch percent ge in 30 of 38

D.

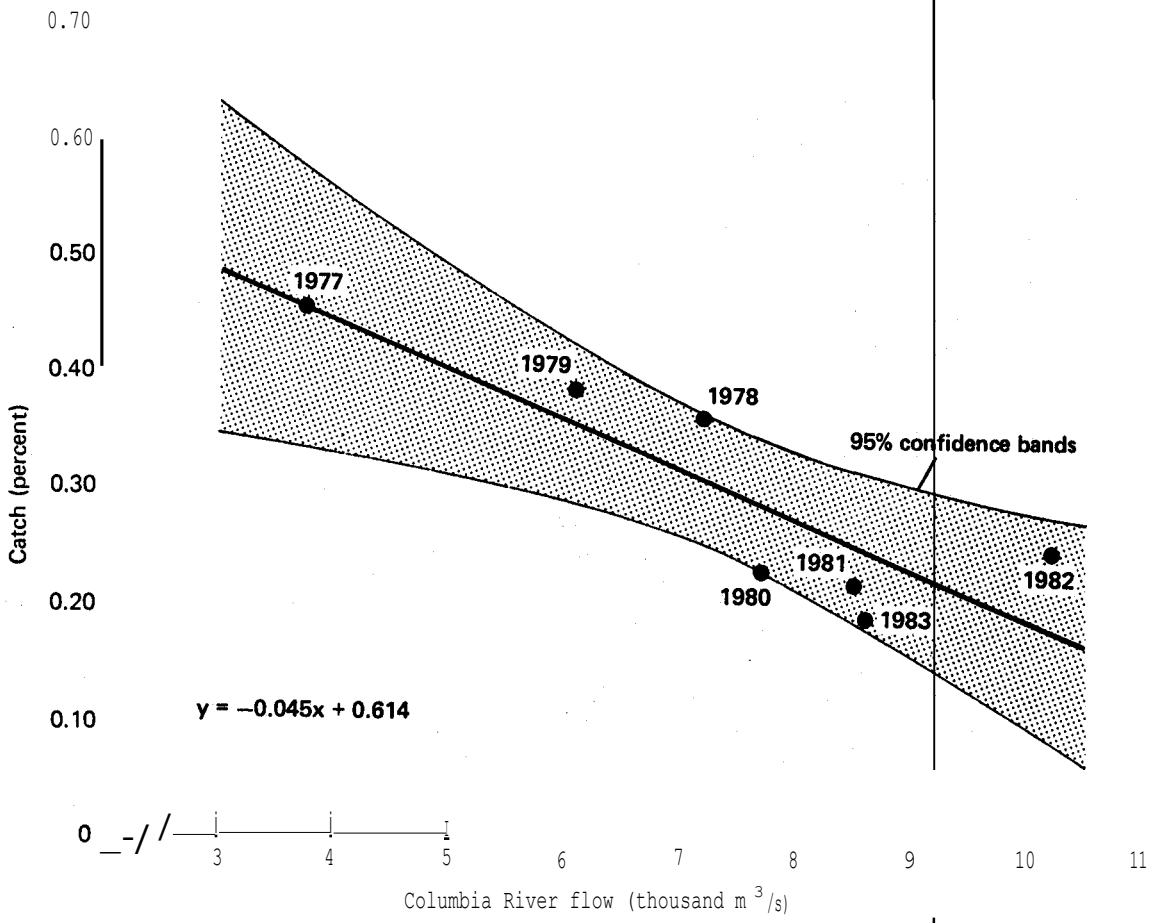


Figure 6.--Subyearling chinook salmon catch at Jones Beach as percent of total hatchery release number by year; plotted against seasonal average Columbia River flow at Bonneville Dam 1977-1983.

groups. Mean difference of catch percentage associate. with a flow increase of 1,000 m^3/s, was 8.8% (SD 35%); variation was assumed to be linear over the range of flow volumes. Change of catch p-rcentages less than 100% per 1,000 m^3/s were used in this analysis. We w ll refine this analysis in the project completion report by incorporating adult recovery data and an index of survival for tempering the variatio s between mark groups. We will differentiate effects for several differnt flow volume ranges, if possible.

Migrational Timing

Temporal distributions of salmonids migrating past Jones Beach in late 1982 and in 1983 are depicted in Figure 7 [catch per set (PS) averages]. CPS averages throughout the sampling period are inflated or deflated in association with variations of river flow. Effort, total catch, and CPS for beach and purse seines are listed in Appendix Tables Alnd A2.

Fall Released Chinook Salmon and Steelhead

Attempts to decrease costs of rearing juveniles and increase adult returns prompted renewed efforts in the 1970s and 1980s t determine the effect of releasing salmonids during the fall (Smith 1979; Hansen et al. 1979). Preliminary recovery data indicated benefits in some instances (Smith and Zakel 1981) and none in others (Hansen 1982). R-searchers were concerned that some of the fall released juveniles woul. overwinter in tributaries downstream from the release point and compete with wild stocks. Observations of residualism were made at the Pelton Ladder . the Deschutes River (Hart et al. 1980) and at Jones Beach (Dawley et al. 1978).

To examine the timing and relative success of the fall released fish, sampling at Jones Beach was extended into the fall, win er, and early

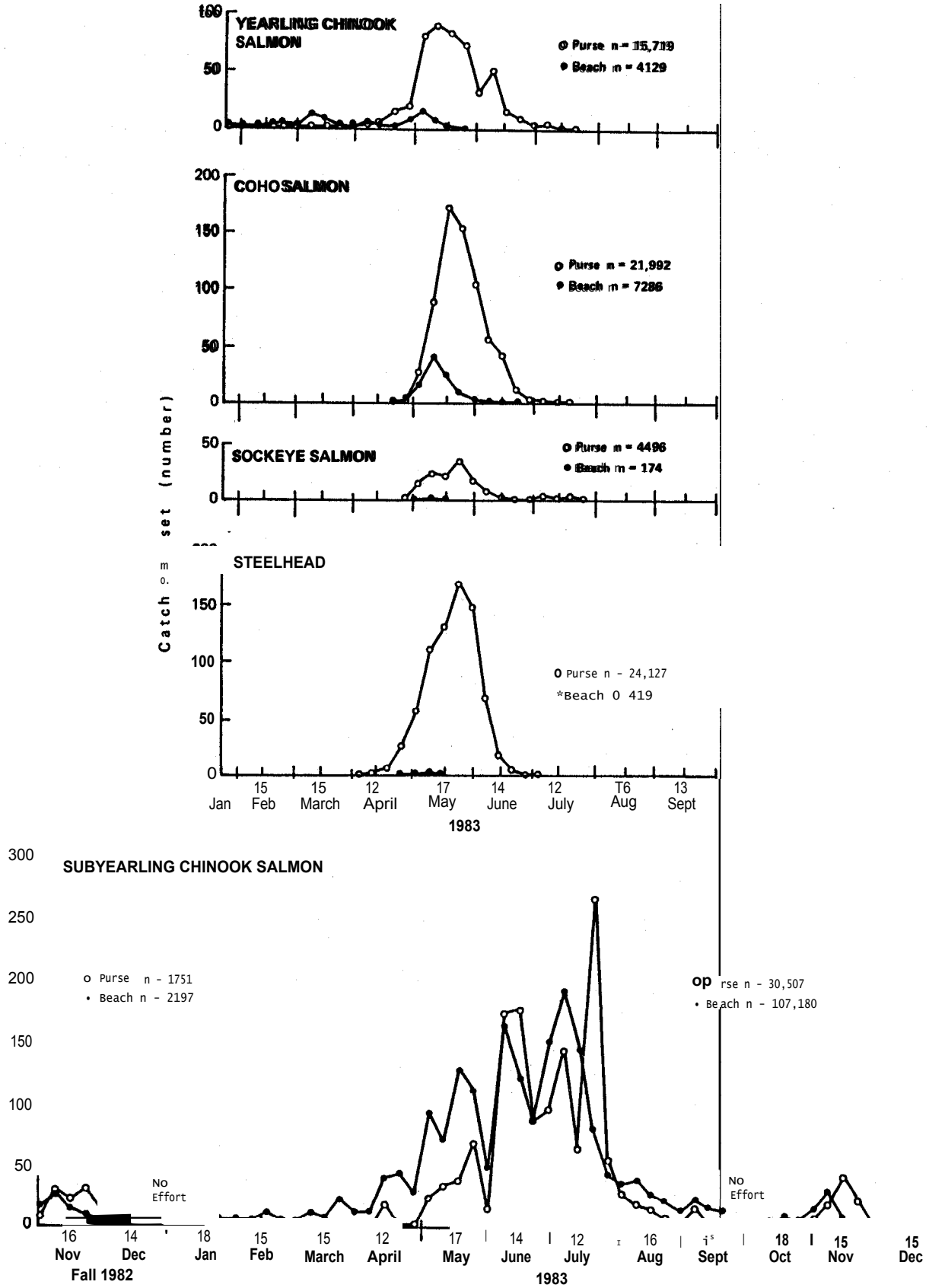


Figure 7.--Weekly catch per set averages for subyearling chinook, yearling chinook, coho, and sockeye salmon and steelhead caught by beach and purse seines at Jones Beach, 1983.

spring of 1978-79, 1981-82, and 1982-83. We found that most fish released in the fall migrated past Jones Beach before 15 December, aO the remainder passed primarily in late February, March, and April (Appekix Table A7). However, it appears that large portions of a few groins overwintered upstream from Jones Beach and migrated during the spring. In 1982-83 when sampling effort was substantial throughout most of the mi gration period, catch data indicated that nearly 50% of the spring chinook'Isalmon from the Big White Rearing Facility and the McKenzie Hatchery, and all from Dworshak NFH migrated in the spring. The smaller fish of most sucks showed the greatest tendency to migrate the following spring. Further evaluation of recovery percentages in relation to river flow, fish size, and stock will be presented in the project completion report.

Spring Released Hatchery Fish

In 1983, the dates of peak recovery for each species were similar to those for 1982 and were primarily influenced by hatcheryl release dates. Dates of peak migration at Jones Beach were: 7-13 May for yearling chinook salmon; 14-20 May for coho salmon; 21-27 May for steelhead: and 14-20 May, 6-10 June, and 2-8 July for subyearling chinook salmon. Movement rates and dates of passage for many hatchery release groups were obt ained from mark recoveries (Appendix B).

Average movement rates for spring released fish werej derived from a series of mark groups obtained in consecutive years. Movement rates for 1983 were similar to the years 1978-1982 (Table 2), but not all groups were represented. Correlation of movement rate to seasonal average river flow could only be made for subyearling chinook salmon, and that relationship

Table 2.--Average and range of migration rates for setcted groups of marked juvenile salmon and steelhead from re ease site to Jones Beach, 1978-1981, 1982 and 1983.

	Chi nook salmon						
	__Subyenrling				Yearling		
	a> 15?77_197	3-1	1_1S~8^?__12E33		15?'	5?~31_i982	__1983
Average km/day	7	18	16	22	20	16	18
Range km/day	2-27	2-48	2-41	4-31	-46	8-25	10-24
No. mark group b>	10	49	12	3	41	9	

	__ Coho salmon __ _ _				Steel head	
	1977_15?78y1"~431_15?	3;?__1h~83		12	e:&2g 1_12f3 2_ _	19~33
Average km/day	19	14	17	33	36	35
Range km/day	6-57	5-25	7-29	-63	26-45	27-53
No. mark group	26	8	7	23	3	5

a> River flows were generally low for 1977, moderate f r 1978-1981 and 1983, and high for 1982; averages for May-June were 3.8, 7.2, 6.1, 7.7, 8.5, 8.6 and 10.2 thousand m^3/s, respectively.

b> Marked groups representing large releases (:•10,000) and released at similar sites 1977-1983; calculated date of median ish capture. Not all groups used as indicies were represented al years; several groups are missing for steelhead in 1982 and yearn g and subyearling chinook in 1983.

(direct) was only evident when data from 1977, a very low flow year, were included. Movement rates for yearling fish groups in 1977 were not available because purse seine effort was not consistent through the migration period. Movement rates in relation to water flow will be further evaluated in the project completion report.

Wild Fish

Sockeye salmon, assumed to be wild fish, were recovered primarily in May and the first week of June (4,670 total). Branded fish from McNary Dam were recovered from 16 to 26 May; migration rates ranged from 30 to 50 km/day.

Chum salmon, also assumed to be from wild stocks, were recovered primarily in March, April, and May (18 total).

Individuals of the other anadromous salmonid species were identified as wild from marks only. Yearling chinook salmon were recovered from the John Day river (n = 5, 30 April-13 May, 123 mm mean fork length) and the Warm Springs River (n = 2, 2-5 June, 114 mm mean fork length). Subyearling chinook salmon were captured from the Lewis River (n = 245, 8 July-2 October, 86 mm mean fork length).

Size Characteristics

Temporal length distributions from subsamples of the catch throughout the migration period are shown in Figure 8. Mean condition factor was calculated for most tag groups (Appendix Table A8).

Relative Survival Between Groups

Differences in catch percentages between treatment and control groups were examined to detect survival differences during migration (from release

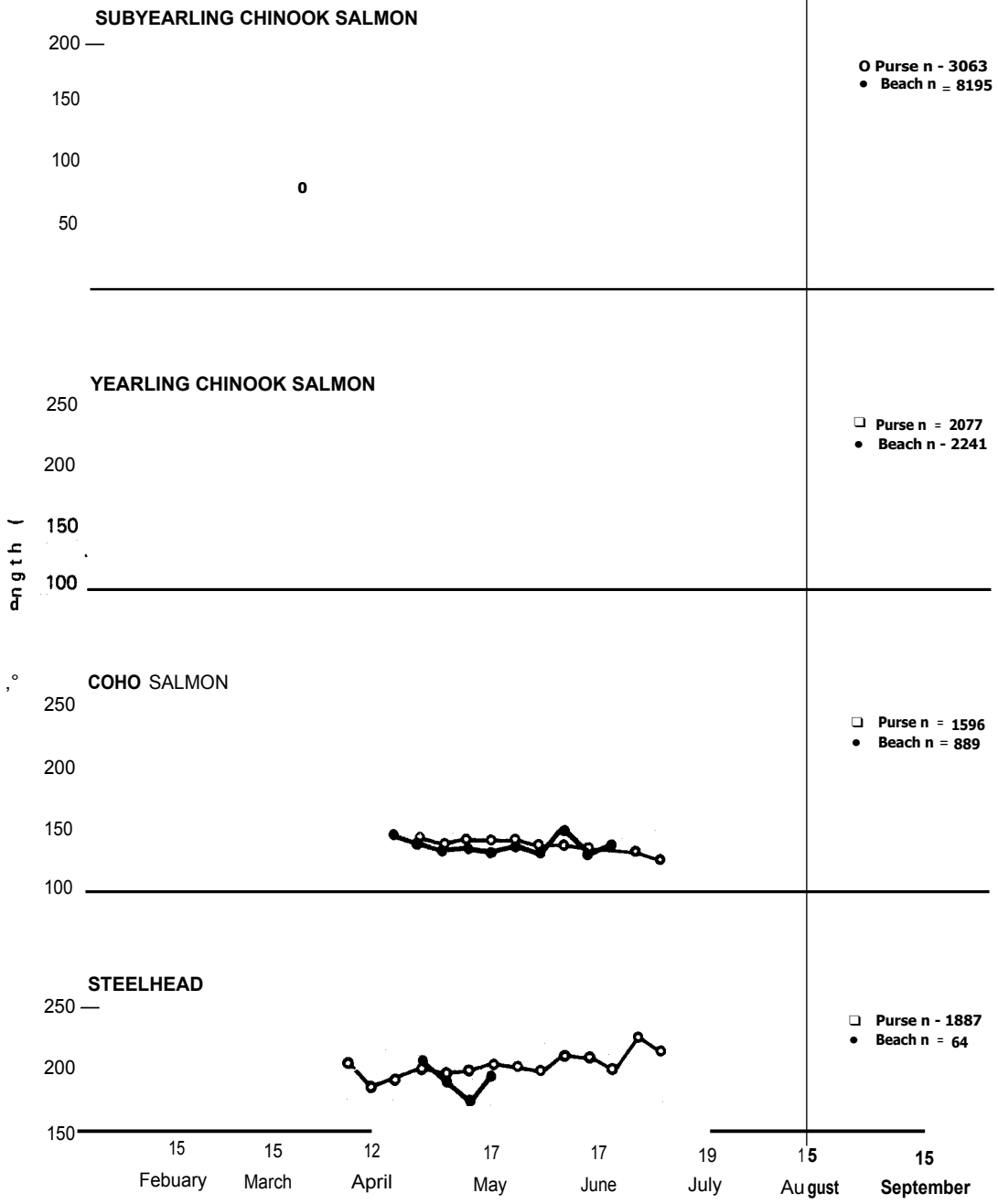


Figure 8.--Weekly mean fork lengths of subyearling chinook, yaarling chinook, and coho salmon and steelhead caught in beach and ?urse seines at Jones Beach in 1982; n = number measured.

site to Jones Beach). The treatments examined were: va'iation of fish size, release timing, nutrition, rearing density, s ock, chemical prophylactics, passage at dams and through reservoirs, and transportation past dams.

Effects of Fish Size and Release Timing

The numbers of fish recovered from studies on size .t release were insufficient to detect significant differences between groups, Table 3.

Recovery percentages for delayed releases were consistently higher than for fish released at an earlier date (size of fish r leased was the same for both groups) Table 4. One group of Washougal Hatch-ry coho salmon showed the opposite trend, but river flow was higher f.r the delayed release. If catch percentage is adjusted, assuming a 9% de rease in catch percentage per 1,000 m^3/s flow increase (discussed earlier), the later release produced the greatest recovery percentage.

Decreased catch percentages were recorded for delay d releases of subyearling chinook salmon that were released at a larger size; however, no conclusions were drawn concerning relative survival diffe ences due to a greater tendency for larger fish to migrate in midriver.

Effects of Nutrition

In previous years, estuarine recoveries of nutrition tudy fish have shown differences between OMP 2 and OMP 4 diet groups f fall chinook salmon from Bonneville Hatchery. In 1983, significant diff rences were not observed, but were observed between fall chinook salmon fe a diet with a high salt concentration and controls at Spring Creek Hatc ery (Table 5). Coho salmon nutrition study groups have not shown signifi ant differences in any year of estuarine sampling.

Table 3.--Jones Beach catch data for juvenile salmonids from size at release studies, 1983 and late 1982.

Site (source)	Treatment/ stacK	Size (no_/l.b)	No. rel. (thou)	No.	%[a]	Date range (10^9U%)	Mean fk.ln. (mm)	Movement rate (Km/d)
			Steelhead					
Sal. R. (Hagerman Hat.)	A stock 18-20 Apr	2	38.8	84	0.281	28 May-06 Jul	254	27
Sal. R. (Hagerman Hat.)	A stock 18-20 Apr	5	39.1	104	0.363	28 May-24 Jun	225	26
			Yearling chinooK salmon					
McKen. R. (McKenzie H.)	Size&Time 08-18 Nov	7	32.0	13	0.088	27 Nov-01 Mar		
McKen. R. (McKenzie H.)	Size&Time 08 Nov	11	32.3	9	0.046	26 Nov-11 Mar		
McKen. R. (McKenzie H.)	Size&Time 08 Nov	16	31.9	11	0.072	02 Dec-20 Mar		
McKen. R. (McKenzie H.)	Size&Time 14 Mar	4	36.2	9	0.057	18 Mar-18 Apr	200	58
McKen. R. (McKenzie H.)	Size&Time 14 Mar	6	32.1	4	0.023	03-25 Apr	158	14
McKen. R. (McKenzie H.)	Size&Time 14 Mar	10	30.0	14	0.095	21 Mar-23 Apr	171	12

[a] Actual catch (purse seine plus beach seine) and adjusted percentage catch.

Table 4.--Jones Beach catch data for juvenile salmonids from time of release studies, 1983.

Site (source)	Release information: Treatment/ stock	Date	Size (no/lb)	No. rel. (thou)	Jones Beach recovery information: No.	a>	Date range (10-907.)	Mean fk.ln. (mm)	Mvmt. Tate (km/d)	River flow (1000m^3/s)
				Coho salmon						
Bonneville Hat.	Production	02 May	15	26+9	22	0.081	06 - 22 May	144	17	9.3
Bonneville Hat.	Production	31 May	16	27.3	28	0.112	02 - 09 Jun	144	51	11.3
Washougal Hat.	Ocean Mgmt	15-30 Apr	18	50.9	40	0.081	26 Apr-19 May	144	7	8.7
Washougal Hat.	Density	27 May	19	303.0	185	0.074	30 May-13 Jun	134	29	11.3
				Chinook salmon						
Bonneville Hat.'	Late Fall	16 Jun	80	100.3	111	0.168	23 Jun-17 Jul	93	10	6.3
Bonneville Hat.	Late Fall	01 Aug	44	99.0	39	0.130	11 Aug-10 Nov	106	10	4+7
Cowlitz Hat.	Fall	06-25 Jun	72	150.2	522	0.493	28 Jun-24 Aug	88	4	6.3
Cowlitz Hat.	Fall	02 Nov	20	146.4	30	0.131	03 - 15 Nov	128	39	4.1
Lit.Wh.Sal-. Hat.	Subyr. Spr.	04 May	68	48.1	42	0.090	13 - 25 May	86	13	8.9
Lit.Wh.Sal. Hat.	Subyr. Spr.	24 Jun	44	46.1	44	0.194	08 Jun-12 Jul	110	15	6.3
				141.r		.		8-		
Washougal Hat.	Fall	11 Oct	23	100.6	68	0.449	16 Oct-06 Nov	119	15	3.1
Washougal Hat.	Fall	02 Nov	22	100.3	72	0.496	06 - 15 Nov	122	21	4.1

a> Actual catch (purse seine plus beach seine) and adjusted percentage catch.

Table 5.--Jones Beach catch data for juvenile salmonids from nutrition studies, in 1983.

Release information					Jones Beach Recovery information[a]				
Site(source)	Diet	Date (da/mo)	Size (no./lb)	Mod. (thou.)	No.	%[b]	Date range (10-90%)	Mean fk.ln. (mm)	Movement rate (Km/d)
				Fall chinook salmon					
Spring Cr. H.	7% Salt	28 Apr	55	104.0	171	0.164	3 - 8 May	92	32
Spring Cr. H.	Control	28 Apr	55	101.0	136	0.134	3 - 9 May	91	31
Bonneville H.	OMP4	04 May	70	100.8	172	0.171	7 -13 May	83	30
Bonneville H.	Control	04 May	74	100.0	171	0.171	7 -14 May	83	30
				Coho salmon					
Sandy Hat.	Sal. Meal	29 Apr	17	109.5	67	0.061	12-21 May	143	9
Sandy Hat.	Abernathy	29 Apr	17	108.8	73	0.067	12-25 May	148	9
Sandy Hat.	OMP2	29 Apr	17	109.6	78	0.071	11-22 May	142	9

a> Actual catch (purse seine plus beach seine) and adjusted percent catch.
b> Number and percent include fish captured during the extended beach seine effort period in May; not comparable to recoveries from other years.

Effects of Rearing Density

In past years, estuarine recoveries of fish groups reared at different densities have not shown significant differences. This trend held true in 1983, except for coho salmon study groups from Eagle Creek Hatchery (Table 6). Catch percentages for these groups increased with decreased density, and the groups reared at low density were significantly different from the groups reared at high density. The 1982 catch percentages of Eagle Creek coho salmon reared at a low density were 13% greater than high density fish; however, the difference was not statistically significant at the 95% confidence level.

Effects of Stock Difference

Differences were observed between catches of tule stock and late fall stock (brights) chinook salmon released at Bonneville Hatchery and between catches of Wells stock and Wallowa stock steelhead released at Lyons Ferry. Greatest catch percentages were from tule and Wallowa stocks respectively. Recovery numbers were insufficient to detect significant differences between other groups (Table 7).

Effects of Chemical Prophylactics

Numbers of spring chinook salmon recovered from a McKenzie Hatchery study examining effects of erythromycin were insufficient to detect differences between test and control groups.

Passage at Dams and Through Reservoirs

Catch percentages were used to estimate survival differences between fall chinook salmon groups (from Spring Creek Hatchery) released into the

Table b. ¯Jones Beach catch data for juvenile salmonids from rearing density studies, 1983.

		Anf9mmali					Juvenile catches sl_Jsms			
	Date	Size	No.	Rearing			Date range		Mean fK.ln.	Movement rate KmLsll
___PAIsA^{g}mIsEl__S^{g}s/A^{g}l_Sn9la - - bsuAlAtnIAIx_ --J0= - - - -							°(i2=9			
				Coho salmon b)						
				lb/ft^{3}/in (fish/wat2rLm.fK.len.)						
Eagle Cr. Hat.	04 May	13	41.2	0.15	68	0.187	17 May-0	Jun	154	7
		14	80.2	0.30	110	0.155	19 May-0	Jun	152	7
		15	123.3	0.45	154	0.135	18 May-0	Jun	150	7
				c> gol6giae_Rond						
Willard Hat.	07 Jun	20	137.2	200	111	0.103	12 Jun-0	Jul	137	24
		20	135.3	400	112	0.099	12 Jun-0	Jul	135	25
		20	131.7	600	123	0.089	12 Jun-0	Jul	153	29
				d> lbs/gal/min (filhLwaler)						
Cowlitz Hat.	03 May	20	52.1	9.2	80	0.161	07 May-2	Jun	137	7
		20	51.7	11.7	86	0.176	07 May-11	Jun	141	7
		17	52.1	14.3	71	0.152	06 May-2	Jun	141	9
		17	51.5	15.0	80	0.159	06 May-12	Jun	133	9
		17	51.1	16.0	72	0.145	05 May-1	Jun	141	10
		17	52.4	22.9	84	0.174	06 May-22	Jun	140	7
Washougal Hat.	27 May	19	39.8	6.0	29	0.085	31 May-O	Jun	133	31
		19	48.5	6.8	24	0.060	31 May-1	Jun	133	27
		19	59.3	8.8	30	0.071	30 May-1	Jun	138	29
		19	51.3	10.6	32	0.076	31 May-12	Jun	135	30
		19	52.0	12.5	32	0.073	30 May-1	Jun	135	27
		19	52.1	14.3	38	0.084	30 May-12	Jun	132	27
				Yearling chinook salmon e>						
				lb/ft^{3}/in (fish4wsitgr ug.fk.len.)						
Kooskia Hat.	4-12 Apr	15	14.7	0.289	11	0.075	04 May-1' May		160	21
		13	8.0	0.075	4	0.050	04 May-1 May		161	25

a> Actual catch (beach plus purse seine) and adjusted percent catch with replicates combined.
b> Jamieson Holway, USFWS, Eagle Creek Hatchery, At. 1 Box 610, Estacada OR 97203. Production density about 0.45 lb/ft^{3}/in.
c> Joe Banks, USFWS, Abernathy SCDC, 1440 Abernathy Roadr Longview, WA 9632. Production density about 400 gal/min per pond.
d> Robert Foster, WDF, 115 General Admin. Bldg., Olympia, WA 98504. Production densities about 20, 18, and 14-18 lb/gal/min for Cowlitz, Lower Kalama and Wash ugal Hatcheries.
e> Ted Bjorn, U of I, Idaho Co-op Fish. Research, Moscow, ID. 83843. Production density about 0.3.

Table 7.--Jmnes Beach catch data for juvenile salmonids from stock comparison studies, 1983 and late 1982.

Site(source)	Stock	Date	Size (no./Ib)	No. rel. (thou)	Jones Beach reCovery information				
						a>	Date range	Mean fk.ln.	Movement rate
ChinmmK salmon									
Pr. Rapid Spuw Ch.	Production	24 May	84	204,1	141	0~096	11 Jun-19 Jul	97	24
Pr. Rapid Spaw Ch.	Wild	21 Jun	63	202.4	86	0.103	08 Jul-03 Nov	118	10
Bonneville Hut.	Tule	1 Nov	11	45,9	123	0.560	05 - 23 Nov	145	17
Bonneville Nat.	Late Fall	1 Nov	12	50.7	107	0.448	04 - 25 Nov	146	25
Bonneville Hut.	Tule	8 Mar	7	37.5	44	0.226	10 - 25 Mar	173	18
w8onoeville Hmt.	Late Fall	23 Mar	6	49.9	13	0.052	28 Mar-28 Apr	186	13
Steelhead									
Lyons Ferry	Wallowa	1-20 May	4	54.6	68	0.104	13 May-15 Jun	222	19
Lyons Ferry	Wells	1-20 May	4	51.6	7	0.016	15 May-05 Jul	239	23
Up. Salmon A. (Hagerman Hat.)	A stock	18-20 Apr	5	39.1	104	0.363	28 May-24 Jun	220	26
E. FK. Salmon R. (Hagerman Hat.)	B stock	12-13 Apr	4	37.6	102	0.316	14 May-13 Jun	243	27

a> Actual catch (purse seine plus beach seine) and adjusted percentage catch.

U

juvenile fish bypass system at the Bonneville Dam Second Powerhouse and similar groups released in the tailrace (Appendix B). Beach seine sampling was extended to 16 h/d (20 sets) to ensure adequate sample size. Significant differences were not observed.

Recovery data from fish groups released by Public **Utility** Districts to test systems mortality are listed in Appendix B.

Effects of Transportation Past Dams

Mark recoveries from tranportation studies indicated that survival was increased for group& of hatchery reared chinook salmon and steelhead released downstream from dams (Table 8). One steelhead group transported upstream past two Snake River dams to Wallowa Hatchery did not show decreased survival over the control group that was released downstream at Lyons Ferry. This comparison may have been affected by the inadvertent transport of Wallowa Hatchery fish from Lower Granite and Little Goose Dams to a site downstream from Bonneville Dam.

Subyearling chinook salmon transported from McNary Dam to a site downstream from Bonneville Dam averaged a 28% increase in survival compared to controls that migrated through three reservoirs and dams ;Appendix Table A9). Numbers of marked fish collected at Jones Beach were insufficient to detect a statistically significant difference between transport and control groups. In previous years, survival increases for subyearling chinook salmon transported from McNary Dam were substantially greater.

Survival to the Estuary for Fall Chinook Salmon

Survival rates for fall chinook salmon from Spring Creek and Bonneville Hatcheries following migration to the estuary were estimated to

Table o,--Jo" es Beach recoveries of juvenile salmonids transported pest dams and their controls in 1983; with estimates of survival increase from transportation.

a>	Treatment/	Size	No. rel.		b>	Bete range	f(.1n.	rate	No. dams	increase
					Chinook salmon					
coz.n./vernitu or, Bonneville xut.	Trans./rule 02 Jun	100	100.2	47	0.078c>	16 Jun-22 Jul	1 17	16		- 54
	Control	16 Jun 80	100.3	Ill	0,168	23 Jun-17 Jul	3	10		
Bonneville Hat.	Control/Late Fall	23 mer	6	49.9	13	0.052	28 Mar-28 Apr	186	13	3
Umatilla R.	Transport	24 Mar-18 Apr	6	99.6	19	0,019	01-25 May	233	n	- 63
					Steelhead					
Methow (Wells Sp.Ch.)	Control	19-27 Apr	5	20.0	23	0.122	07-20 May	226	31	
ozw, Pr. Rapid D.	Transport	19-27 Apr	5	22.4	49	0.224	04-21 May	35	24	5 100
Wallowa H(Lyon Ferry)	Transport	9-13 May	5	65.0	174	0.305c>	15 May-20 Jun	217	53	-2 54
Lyons Ferry Hat.	Control	1-20 May	4	54.6	68	0.141	m mu,-15 Jun	222	19	

o> Fish groups with 2 days or less between 1st and median fish recapture are not included.
u> Actual catch (purse seine plus beach seine) and adjusted percentage cutch.
C> Some fish may have been transported past all dams by mass transportation project frov Lower Granite, Little Goose, and McNary dams; estimated percentages of fish transport were for the (ley.

be 96 and 78%, respectively. Evaluation of the precision of annual survival estimates made for subyearling chinook salmon fr.m 1978 to 1983 will be presented in the project completion report.

Juvenile Catches Compared to Adult Recoveries

The objectives of comparing juvenile catches to adult ecoveries were: to discern if larger or smaller than average catches o a mark group indicate **abnormal** adult **survival**, to document the limits of **sensitivity** for predicting adult return rates, and to document the type of treatment **groups** from **which juvenile** catch rates may **provide** erroneou- inferences of **survival to adulthood.**

Juvenile and adult **recovery data** for **replicate group:** were examined for **consistency** (138 sets of replicates, 338 **groups** total- **Appendix Table** A3). We found that the adult and juvenile catch percentage: varied in the same direction (positive or negative) from their respe tive replicate averages (U, Figure 4) 59% of the time. The variation, assuming true replicates, should be random, and a large set of comparis•ns should have varied in the same direction about 50% of the time. Juve ile recoveries for 9 of the 138 sets of replicates showed significant dif erences at the **90% confidence** level **(P** < 0.10). Adult recoveries **varied** in the same direction from U as juvenile recoveries in five of the nine nstances. Two of these adult groups were also significantly different, whi h may indicate a survival difference that was detected at Jones Beach an manifested in adult recoveries.

There were 54 sets of replicates for which adult recoveries showed significant differences (P < 0.10) between groups. Thirty-three of these (61%) varied in the same direction from U as juvenile recoveries.

By definition of $P < 0.10$, there should be about 10% of the sets of true replicates which fall outside the boundaries of no difference between groups. The juvenile catch data were of this magnitude (7%), but adult recoveries were about four times higher than expected (39%). We have asked the respective fishery agencies for verification of the similarity of treatment for all sets of replicate groups which showed large variation in recovery percentages. We see no reason to suspect that juvenile data are not normally distributed with expected variation. Adult recoveries show greater than expected variation within sets of replicate groups. We will complete the juvenile adult recovery evaluation for treatment groups versus controls in the project completion report.

Incidental Catches

Non-salmonids comprised nearly 40% of the total catch (Appendix Tables A10 and A11). Adult and juvenile threespine stickleback, *Gasterosteus aculeatus,* and peamouth, *Mylocheilus caurinus,* were captured in large numbers year-round. Large catches of American shad, *Alosa sapidissima,* juveniles were obtained during their migration period (May through November). Seven eastern banded killifish, *Fundulus diaphanus,* were captured in the beach seine in 1983 (Ledgerwood and Rankis 1984); the Columbia River is not described as part of the normal geographical range for this species (Scott and Crossman 1973).

SUMMARY AND CONCLUSIONS

During fiscal year 1983, BPA and NMFS funded a study of juvenile salmonid migrants entering the Columbia River estuary. The general

objectives were to: (1) define migration timing and movement rates; (2) obtain catch percentages for marked groups to evaluate snolt survival to the estuary and subsequently compare to adult recoveries; and (3) amass information on which concepts may be developed to protect, enhance, and restore the salmonid resources of the Columbia River.

Beach and purse seines were used to sample at Jones Beach (RKm 75). Sampling was done during the spring and summer out-migration period (April-September) and the fall and winter out-migration period (November 1982-March 1983 and October-December 1983). Subsamples of fish tissues and observations of disease incidence were made for other researchers. Catches during the calendar year 1983 were: 137,081 subyearling chinook salmon, 19,848 yearling chinook salmon, 29,278 coho salmon, and 24,547 steelhead--about 4.6% of the total salmonids were marked fish.

Effects of River Flow

Catch data from 1983 were added to the evaluation of sampling efficiency in relation to river flow. Two evaluation methods were used: (1) comparison of annual catches of unmarked subyearling chinook salmon (as a percentage of the total number released from hatcheries) to seasonal river flow, 1977 to 1983 and (2) comparisons of catch percentages between years, in relation to river flow differences, for mark groups released downstream from Bonneville Dam (subyearling and yearling ohinook and coho salmon and steelhead) from the same stock and fish size migrating about the same time of year during different years. From the two methods, we estimated that an increase of 1,000 m^3/s of river flow caused sampling efficiency to decrease about 11%.

Migrational Characteristics

Fall released fish groups generally migrated past Jones Beach in the fall; however, large portions of a few groups overwintered in the river system and migrated in the spring. The smallest fish from several groups overwintered prior to migration.

Spring released fish and identifiable wild stocks migrated into the estuary primarily during May, June, and July. Dates of peak- migration at Jones Beach were: 7-13 May for yearling chinook salmon; 14-20 May for coho salmon; 21-27 May for steelhead; and 14-20 May,6-10 June, and 2-8 July for subyearling chinook salmon. Movement rates were similar to past years--average rates were 22, 18, 17, and 35 km/d for subyearling chinook, yearling chinook, and coho salmon and steelhead, respectively. Summary data are presented for each mark group, including: release information; number and percent captured, with and without expansion; dates of 10, 50, and 90% recovery; mean fork length of individuals recovered; average movement rate from release site to Jones Beach; and average condition factor of individuals recovered.

Relative Survival Between Groups

We compared catch percentages of treatment and control groups to identify survival differences following migration to the estuary. We found: (1) higher recovery percentages for all groups for which the release dates were delayed (size held constant between test and control), (2) a significant difference between fall chinook salmon groups fed a diet with high salt concentration (highest catch) and their controls (lowest catch) from Spring Creek NFH, (3) a significant difference between coho

salmon reared at a low density (highest catch) and those reared at a high density (lowest catch) from Eagle Creek NFH, and (4) higher recovery percentages (average 64%) for most groups released at sites downstream from dams compared to their counterparts that migrated throug:i the dams and reservoirs. Estimates of survival to the estuary for fall chinook salmon from Spring Creek and Bonneville Hatcheries were 96 and 78%, respectively.

Juvenile Versus Adult Recoveries

Recoveries of replicate groups from juvenile sampling showed normal variation among groups, although adult recovery data for the same groups showed four times the expected variability. We have asked the fishery agencies. for verification on the similarity of treatment for groups which showed large variations. Differences of catch percentages between replicates varied in the same direction, negative or positive, for both juvenile and adult data in 59% of the observations. Nine sets of replicate groups showed statistical differences in juvenile catches, five of which showed adult catches varied in the same direction fron the mean of replicates and two with statistically significant differences.

Incidental Catches

Non-salmonids, mostly threespine stickleback, peamouth, and American shad comprised about 40% of the total catch. A total of seven eastern banded killifish were captured with beach seines in May, June, and July.

ACKNOWLEDGMENTS

Support for this research came from the regions electrical ratepayers through the Bonneville Power Administration.

Thanks to Elmo Barney and the staff at Spring Creek NFH and Ray Sheldon and the staff at Bonneville Hatchery for assistance in branding fish groups used in the fall chinook salmon survival evaluation.

LITERATURE CITED

Dawley, E. M., C..W. Sims, and R. D. Ledgerwood.
1978. A study to define the migrational characteristics of chinook and coho salmon and steelhead in the Columbia River estuary. Annual Report to PNRC by NMFS, 2725 Montlake Boulevard East, Seattle, Washington 98112. 23 p.

Dawley, E. M„ C. W. Sims, R. D. Ledgerwood, D. R. Miller, and F. P. Thrower.
1979. A study to define the migrational characteristics of chinook and coho salmon and steelhead in the Columbia River estuary. Annual Report to PNRC by NMFS, 2725 Montlake Boulevard East, Seattle, Washington 98112. 35 p.

Dawley, E. M., C. W. Sims, R. D. Ledgerwood, D. R. Miller, and J. G. Williams.
1980. A study to define the migrational characteristics of chinook and coho salmon and steelhead in the Columbia River estuary. Annual Report to PNRC by NMFS, 2725 Montlake Boulevard East, Seattle, Washington 98112. 35 p.

Dawley, E. M., C. W. Sims, R. D. Ledgerwood, D. R. Miller, and J. G. Williams.
1981. A study to define the migrational characteristics of chinook and coho salmon and steelhead in the Columbia River estuary. Annual Report to PNRC by NMFS, 2725 Montlake Boulevard East, Seattle, Washington 98112. 35 p.

Dawley, E. M., R. D. Ledgerwood, T. H. Blahm, and A. L. Jensen.
1982. Migrational characteristics and survival of juvenile salmonids entering the Columbia River estuary in 1981. Natl. Mar. Fish. Serv., Report to Bonneville Power Administration, September 1982 (Agreement DE-A179-81BP30578). 43 p. plus Appendixes.

Dawley, E. M., R. D. Ledgerwood, T. H. Blahm, R. A. Kirn, A. E. Rankis, and F. J. Ossiander.
1984. Migrational characteristics and survival of juvenile salmonids entering the Columbia River estuary during 1982. Natl. Mar. Fish. Serv., Report to Bonneville Power Administration, January 1984 (Agreement DE-A179-82BP30578). 49 p. plus Appendixes.

Efron, B., and C. Morris.
1975. Data analysis using Stein's estimator and its generalizations. Jr. Amer. Stat. Assoc., 70:311-319.

Hansen, H. L., R. D. Ewing, and J. T. Martin.
1979. Bonneville Hatchery evaluation. Oregon Dept. of Fish and Wildlife. 506 S. W. Mill St., P. O. Box 3503, Portland, Oregon 97208. Federal Aid Progress Report, Fisheries. Annual Report to U.S. Army Corps of Engineers. 22 p.

Hansen, H. L.
1982. Bonneville Hatchery evaluation. Oregon Department of Fish and Wildlife, 506 S. W. Mill St., P. O. Box 3503, Portland, Oregon 97208. Progress Report, Annual Report. 21 p.

Hart, C. E., Greg Concannon, C. A. Fustich, and R. D. Ewing.
1980. The use of a model system for studying seaward migration of Deschutes River juvenile spring chinook salmon (Oncorynchus tshawytscha). Oregon Department of Fish and Wildlife, 506 S. W. Mill St., P. O. Box 3503, Portland, Oregon 97208. Information Report 80-5. 20 p.

Ledgerwood, R. D., and A. E. Rankis.
1984. Banded killifish Fundulus diaphanus, increasing in the Lower Columbia River. Manuscript in preparation.

Long, C., J. McComas, and B. H. Monk.
1977. Use of salt water to reduce mortality of chinook salmon, Oncorhynchus tshawytscha, during handling and hauling. Marine Fisheries Review, 1255, Vol. 39, No. 7, July.

Mighell, J. L.
1969. Rapid cold-branding of salmon and trout with liquid nitrogen. J. Res. Board Can., 26:2765-2769.

Miller, D. R., J. G. Williams, and C. W. Sims.
1983. Distribution, abundance, and growth of juvenile salmonids off the coast of Oregon and Washington, summer 1980. Fisheries Research, 2(1983)1-17.

Scott, W. B., and E. J. Crossman.
1973. Freshwater fishes of Canada. Bull. Fish. Res. Board of Can. 184, 966 p.

Smith., Eugene M.
1979. Willamette River spring chinook evaluation; Marion Forks Hatchery evaluation and McKenzie River Hatchery evaluation. Oregon Department of Fish and Wildlife, 506 S. W. Mill St., P. O. Box 3503, Portland, Oregon 97208. Federal Aid Progress Report, Fisheries. Annual Report. 23 p.

Smith, E. M. and J. C. Zakel.
1981. Willamette River spring chinook evalution. Oregon Department of Fish and Wildlife, 506 S. W. Mill St., P. O. Box 3503, Portland, Oregon 97208.. Progress Report, Annual. 32 p.

Sokal, R. R., and F. J. Rohlf.
1981. Biometry. W. H. Freeman and Co., San Francisco, California. 779 p.

D