# MIGRATIONAL CHARACTERISTICS, BIOLOGICAL OBSERVATIONS, AND RELATIVE SURVIVAL OF JUVENILE SALMONIDS ENTERING THE COLUMBIA RIVER ESTUARY, 1966-1983

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Final Report of Research
Funded by
Bonneville Power Administration
U.S. Department of Energy
Division of Fish and Wildlife
P.O. Box 3621
Portland, Oregon 97208
Contract DE-A179-84BP39652
Project No. 81-102

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

April 1986

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# INTRODUCTION

Natural runs of salmonids in the Columbia River basin have decreased as a result of hydroelectric-dam development, poor land- and forest-management, and over-fishing (Raymond 1979; Netboy 1980). This has necessitated increased salmon culture to assure adequate numbers of returning adults. Hatcheries are now the primary source of salmon for the Columbia River; in the late 1970s, they annually produced about 100 million fall chinook salmon, Oncorhynchus tshawytscha; 21 million spring and summer chinook salmon; 30 million coho salmon, 0. kisutch; and 10 million steelhead, Salmo gairdneri. Even with hatchery production at this level, management agencies agree that, in general, salmonid harvests have deteriorated.

Hatchery procedures and facilities are continually being modified to improve both the efficiency of production and the quality of juveniles produced. Initial efforts to evaluate changes in hatchery procedures were dependent upon adult contributions to the fishery and returns to the hatchery. Since salmonid survival depends on river, estuarine, and ocean habitats,the variations in adult return data are difficult to evaluate and unknown factors may overshadow the impacts of changes in hatchery culture techniques--a better system of evaluation was needed.

From 1966-1972, the National Marine Fisheries Service (NMFS), Northwest and Alaska Fisheries Center, Coastal Zone and Estuarine Studies Division, developed and refined procedures for sampling juvenile salmon and steelhead entering the Columbia River estuary and ocean plume (Fig. 1). The sampling of hatchery fish at the terminus of their freshwater migration assisted in evaluating hatchery production techniques and identifying migrational or behavioral characteristics that influence survival to and through the estuary.

Because of a lack of funds, no sampling was done from 1973 through 1976. From 1977 through 1983, the Northwest Regional Council and the Bonneville Power Administration (BPA) funded the estuarine sampling program to provide assessment of salmonid outmigrations from wild stocks and from mitigation hatcheries experimenting with enhanced cultural procedures. The facilities or procedures implemented for safe juvenile salmonid passage at dams and through reservoirs were also evaluated. Extensive fish marking programs by state and federal fishery agencies provided the capability to assess migrational behavior and relative survival of identifiable hatchery and wild stocks. Fall chinook salmon (subyearlings), particularly, provided a consistent and thorough index because of intensive marking programs to assess contribution (Vreeland 1984).

The Columbia River estuary sampling program was unique in attempting to estimate survival of different stocks and define various aspects of migratory behavior in a large river, with flows during the spring freshet from 4 to 17 thousand cubic meters per second (m3/second). Previous knowledge of estuarine sampling for juvenile salmonids was limited to several small river systems and the evaluation of movement behavior, residence times, and feeding behavior, e.g., Chehalis River, Herr-man 1971; Siuslaw River, Nicholas et al. 1979; Sixes River, Reimers 1973 and Bottom 1981; Nanaimo River, Healey 1980; and Yaquina River, Myers 1980.

During our initial research (1966-1972), various fishing methods (fyke, trawl, gill, and seine nets) were used at many locations throughout the estuary. Procedures and sites used from 1977-1980 and 1981-1983 were adopted from earlier work with the extension of sampling sites into marine waters adjacent to the mouth of the Columbia River.

The specific objectives of the overall study with juvenile salmonids were as follows (objectives were expanded with time; Objectives l-4 apply to research from 1966 through 1972, and Objectives l-10 apply to research from 1977 through 1983):

1. Evaluate sampling equipment, develop procedures, and establish suitable sampling sites which could provide the recovery of representative samples of juvenile salmonid migrants from each fish stock passing through the estuary.

2. Document recovery dates for all marked fish, define migration timing for each species, and examine the differences between identifiable races and stocks in relation to biological, cultural, and migrational variables.

3. Document movement rates between release and sampling sites and evaluate effects from environmental and biological variables.

4. Examine die1 movement patterns at Jones Beach.

5. Evaluate consistency of recovery percentages and determine the effects of river flow.

6. Provide capture percentages of 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.

7. Compare recovery data of marked wild fish to recovery data of hatchery stocks.

8. Examine stomach contents of tagged salmonids to determine the extent of inter- and intra-specific competition for food throughout the 1979-1983 migration period and relate stomach fullness to variables which may have affected feeding habits. Compare observed feeding rates to those of fish from other areas.

9. Provide samples and make biological observations to assist other investigators working on related research projects. (Appendix A)

10. Document catches of non-salmonids collected during sampling.

# GENERAL STUDY AREA

For the purposes of this study, the Columbia River estuary is defined as 75 km of the lower river between the narrows at Jones Beach to the ends of the jetties at the river mouth (Fig. 1). The estuary is approximately 2 km wide at the mouth and nearly 15 km wide at its broadest expanse near the middle. For the most part, it is a shallow (<5 m in depth) system of shifting sand bars, extensive mud flats, and numerous islands. A ship channel is maintained at a depth of 14 m by periodic dredging by the U.S. Army Corps of Engineers. Tides normally reverse river flow as far as 115 km upstream (to Rainier, Oregon), but the seawater intru ion is generally limited to about 38 km upstream from the river mouth.[1/] By this definition, the Columbia River estuary consists of an upper freshwater and a lower brackish water component.

Marine waters sampled were near-shore areas' from the surfline (4 m deep) to 24 km offshore (125 m deep) north and south of the Columbia River mouth. Surface water salinity varied from 17 to 27 $^{o}/oo$.

The sampling sites varied during the various time periods of the study. During the initial stages of the estuarine study ( 1966-1977)) 33 sampling sites were evaluated for providing representative catches of most salmonid stocks migrating into the estuary (Fig. 2). During 1978-1980, there were two primary sampling sites: (1) the upper extreme of the estuary at Jones Beach, River Kilometer (RKm) 75 and (2) near the lower margin of the estuary, in brackish water, at McGowan, WA (RKm 16). Additional sites throughout the estuary, river mouth, and in the Columbia River coastal near-shore plume were sampled in termittently to provide additional information about movement through the es tuary . From 1981 to 1983, only the Jones Beach site was sampled ; evaluation was limited to factors impacting fish during their migration to the estuary, e.g., cultural treatment prior to release, fish size, distance and date of migration, and river flow.

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1/ U.S. Army Corps of Engineers. 1960. Interim report on 1959 current measurement program, Columbia River at mouth, Oregon and Washington. Portland, Oregon.

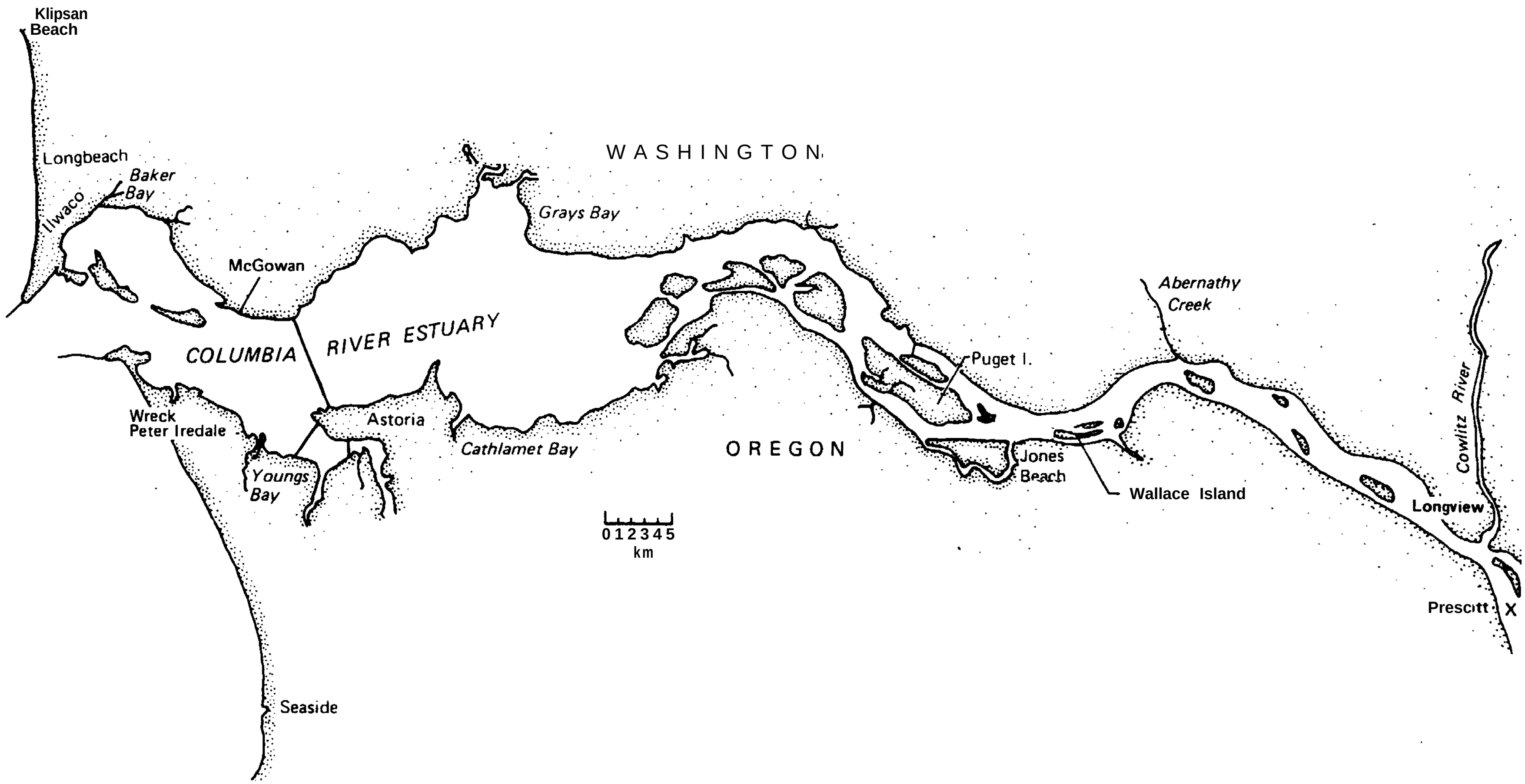



Figure 1.--Map of lower Columbia River and estuary.

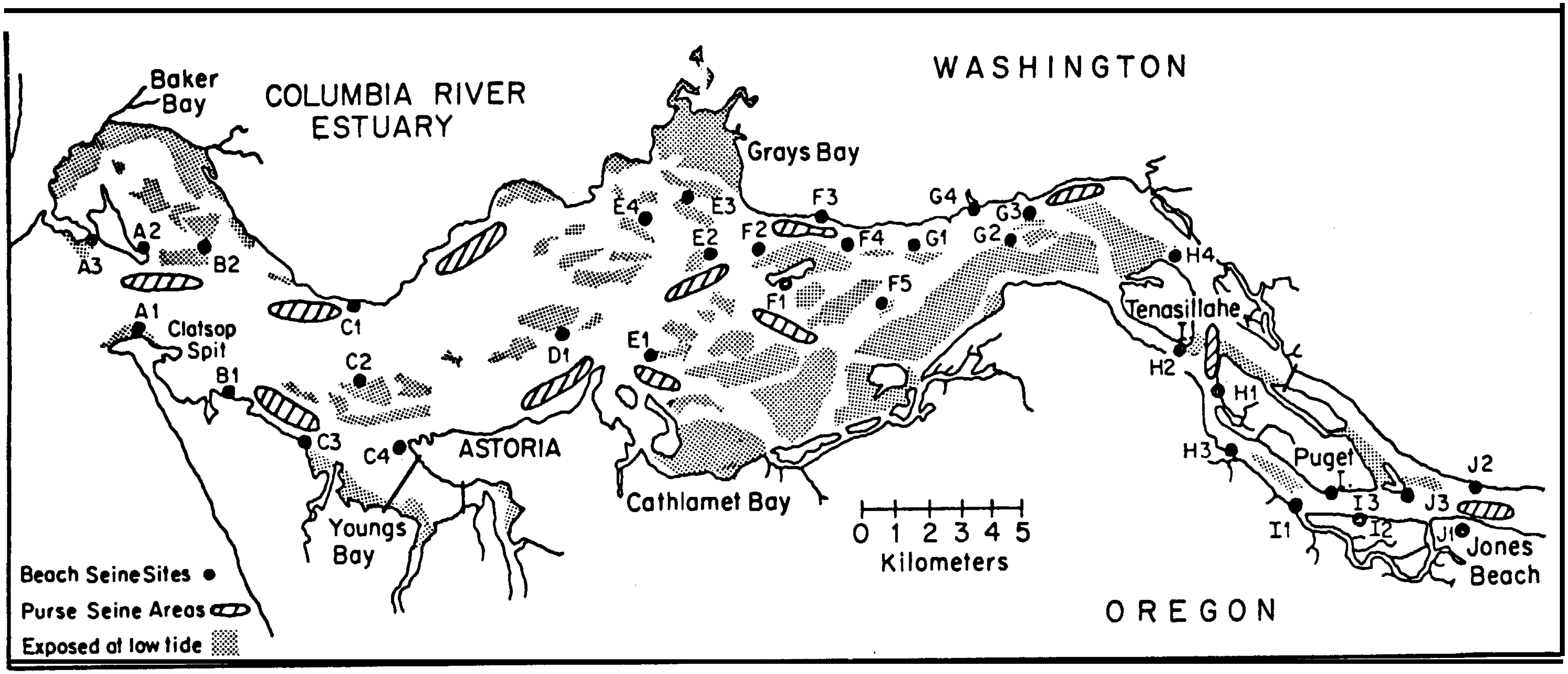



Figure 2.--The Columbia River estuary showing beach seine sampling sites and purse seine sampling areas.

# SECTION I--FALL CHINOOK SALMON, 1966-1972

## Introduction

Fall chinook salmon are an important fishery resource in the Pacific Northwest. The Columbia River has long been recognized as the largest producer of fall chinook salmon in the world. Hydroelectric and other development, however, has seriously reduced the natural production of the Columbia River system. To compensate for this loss, natural production of fall chinook salmon is now supplemented by an extensive system of state and federal hatcheries (Fig. 3). The effectiveness of this hatchery system is dependent upon the continuing development of new and improved management and production techniques. This in turn requires biological and fishery catch studies to evaluate the impact of various production techniques. Cleaver (1969a) provided significant information on the life history and ocean survival of Columbia River fall chinook salmon, and recent papers have examined the contribution of Columbia River hatchery fish to the fishery (Worland et al. 1969; Lander 1970). However, information relative to the migrational behavior of juvenile fall chinook salmon to and through the Columbia River estuary is limited.

Heretofore, most assessments of the effectiveness of hatchery production techniques were based on evaluations of adult returns to the various fisheries and/or hatcheries. Such evaluations must await the return of adult fish which normally spend from 2 to 5 years in the ocean. Although it may be conceded that the ultimate measure of the effectiveness of fish culture operations should be in terms of adult catch and escapement to the hatcheries, assessments of juvenile survival to the estuary could be of distinct help to fishery managers. Relative survival of marked juveniles to the estuary could, for example, provide initial clues to the success or failure of a particular rearing or release technique in relation to the prevailing hatchery and in-river environment. This information would be available to managers within weeks instead of years.

The specific objectives of this study were to provide information on movement rates and survival of juvenile fall chinook salmon during migration to the estuary and to examine migration timing, movement patterns, and residence time in the estuary.

## Methods

The downstream migration of juvenile fall chinook salmon was sampled in the Columbia River estuary from 1966 through 1972. The primary sampling gear was a 95-m variable-mesh beach seine developed and described by Sims and Johnsen (1974). This net fished to a depth of 3 m and was set from the beach with a small outboard-powered boat. Thirty-three beach seine sampling sites were used during the study (Fig. 2). Sampling effort varied as to site and intensity each year, but was primarily concentrated at Jones Beach, Oregon, (Site J-l in the upper estuary). The Jones Beach Site is located approximately 75 km upstream from the river mouth and about 50 km above the

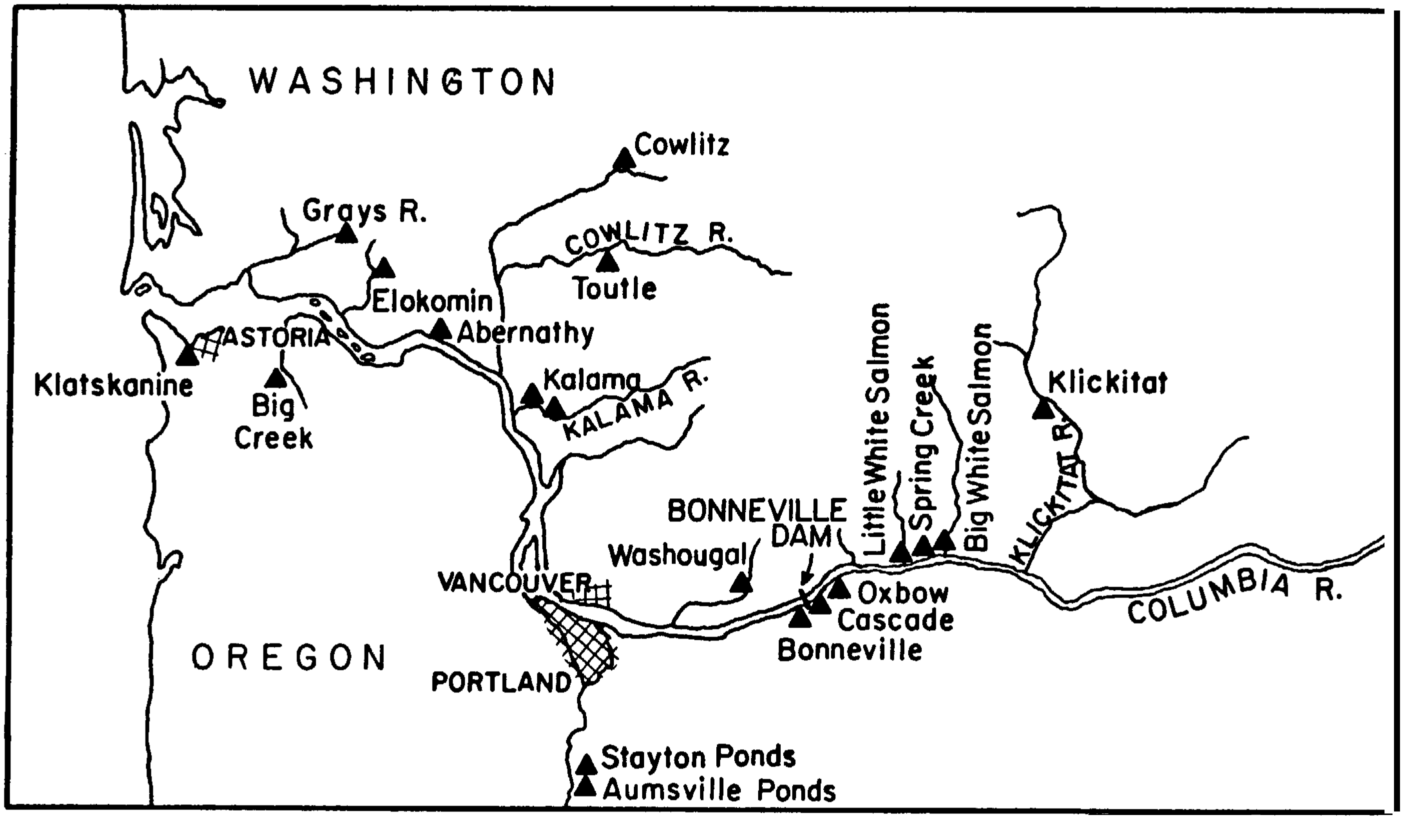



Figure 3.--The lower Columbia River and major fall chinook salmon producing hatcheries.

normal upper limit of saline intrusion. Site H-l on nearby Puget Island and Site J-2 on the Washington shore immediately across the river from Jones Beach were also sampled frequently during various phases of the study. Most beach seining effort in the lower estuary was concentrated in the Clatsop Spit area (Sites A-l and B-l).

In 1967, 1968, and 1969, purse seines were used to sample deep-water channels and other areas where beach seining was not practical. Purse seines of various sizes were used depending on the physical characteristics of the area to be sampled. The basic purse seine was 229 m long by 10 m deep. A 152- by 3-m net was used in shallow or restricted areas. Net design and operational techniques are described by Johnsen and Sims (1973).

A two-door mid-water trawl was used in 1966 to define vertical distribution of juvenile fall chinook salmon in deep water areas. This net had an opening of 3 by 6 m and could be fished from surface to bottom by adjusting door angle and towing speed.

During the first 2 years, beach and purse seine sampling crews processed their catches and recorded all data where the fish were caught. Fish holding and processing facilities were constructed at Jones Beach in 1968. After 1 May 1968, beach and purse seine samples from nearby areas were transported to the beach facility for examination. All juvenile salmonids were anesthetized, identified, enumerated, examined for marks and brands, and a subsample measured to determine length frequencies. Marked or branded fish were given an additional mark by freeze branding (Mighell 1969). Following recovery from effects of the anesthetic, all fish were returned to the river.

## Definition of Stocks

Because of their extended freshwater residence, juvenile spring chinook salmon are generally at least 10 to 20 mm longer than fall chinook salmon when they enter the estuary (Mains and Smith 1964). This characteristic size difference was used to separate fall chinook salmon from spring stocks. Because there is a slight overlap at times in length frequencies of the fall and spring stocks, a small percentage of the fish could have been erroneously identified. Occasionally, small numbers of fall chinook salmon may also hold over for various reasons in fresh water until the following spring. These fish--because of their extended growth--would be classified as spring chinook salmon unless they bore some special identity (fin clip or brand) clearly signifying their fall chinook salmon origin.

Like fall chinook salmon, juvenile summer chinook salmon stocks from the mid-Columbia also migrate downstream as "0" age fish and, therefore, can not be differentiated from fall chinook salmon by size. The relative number of juvenile summer chinook salmon reaching the estuary is small in comparison to fall chinook salmon; for the purpose of this study, they have been classified as fall chinook salmon and included in the fall chinook salmon catch totals.

## Releases of Marked Hatchery Fish

About 6.5 million freeze-branded juvenile fall chinook salmon were released at various hatcheries and other locations by cooperating agencies during 1968, 1969, and 1970. Migrational timing and rates of downstream movement were determined from recoveries of these marks at Jones Beach.

Some releases of branded fish were also designed to examine relative survival of hatchery-reared fall chinook salmon. Groups of fish were divided into duplicate or multiple lots (each lot identical in size distribution to all others). Each lot of fish was given a separate identifying brand and released at various locations upstream from the Jones Beach sampling site. Es tima tes of relative survival of the various lots were based on the percentage of brands recovered at Jones Beach, assuming that survival from those releases closest to Jones Beach was 100%. Survival rates es tima ted in this manner were subject to two additional assumptions : (1) that the distribution of all lots of marked fish from a given subdivided group was the same at the point of sampling and (2) that each lot of fish within a subdivided group was equally vulnerable to capture by the sampling gear. Comparisons of relative survival rates compiled in this manner were valid only for lots within a given subdivided group. Comparisons of groups of fish from different hatcheries or from groups of different size from the same hatchery were not valid because the sampling recovery rate may be variable.

# Results and Discussion

Sampling in the Columbia River estuary from 1966 to 1972 captured more than a million juvenile fall chinook salmon(Table1); included were more than 30,000 marked fingerlings, representing 59 separate marked releases. The beach seine was by far the most effective sampling gear used to capture fall chinook salmon in the estuary and accounted for almost 98% of the total sample . The beach seine was adaptable to near-shore areas throughout the estuary, and fish taken by this gear were generally in good condition and suffered little mortality. Beach seines were also effective in capturing yearling coho salmon, but took relatively few juvenile spring chinook salmon or s teelhead trout.

From 6 June to 19 July 1968, 18 groups of juvenile fall chinook salmon were taken from the beach seine catches at Jones Beach, marked with a thermal brand, and released at Beaver Terminal about 4.5 km above the Jones Beach site (Table 2). Analysis of the recovery data from these releases indicates that the sampling variability of the beach seine was closely related to size of fish--the smaller the fish the higher the rate of capture (Fig. 4)--and was not significantly affected by river flow (Fig. 5).

## Distribution

Juvenile fall chinook salmon were found concentrated in the shallow, near-shore areas throughout the estuary. The concentration of fall chinook salmon along the beaches is illustrated by comparing adjacent beach and purse

Table l.-- Sampling effort and catches of juvenile fall chinook salmon in the Columbia River estuary, 1966-72.

| | Type of gear | | | | | |
|---|---|---|---|---|---|---|
| | Beach seines | | Purse seines | | Trawls | |
| Year | No. sets | Catch | No. sets | Catch | No. sets | Catch |
| 1966 | 1,867 | 139,058 | 0 | | 465 | 4,171. |
| 1967 | 1,425 | 76,988 | 100 | 1,716 | 0 | |
| 1968 | 2,359 | 314,334 | 439 | 9,323 | 0 | |
| 1969 | 2,460 | 283,386 | 164 | 4,038 | 0 | |
| 1970 | 2,509 | 229,880 | 0 | | 0 | |
| 1971 | 1,242 | 131,425 | 0 | | 0 | |
| 1972 | 945 | 97,299 | 0 | | 0 | |
| Totals | 12,807 | 1,272,370 | 703 | 15,077 | 465 | 4,171 |

Table 25.—Release information and Jones Beach recovery information for marked subyearling chinook salmon groups used in correlation analyses of movement rate, and catch percent to variables of fish size, recovery date, river flow, and spill volume, 1977-1983.

| Release information: Tag a/ (Ag,D1,D2) Brand (Loc Sym Rot) | Release information: Site b/ description | Release information: Site b/ (Rkm) | Release information: Size (no/lb) | Recovery dates c/: 10th percent (da,mo) | Recovery dates c/: 10th percent (jul) | Recovery dates c/: 50th percent (da,mo,yr) | Recovery dates c/: 50th percent (jul) | Movement Rate d/ (km/day) (10%) | Movement Rate d/ (km/day) (50%) | Recovery (no) | Recovery (%) | River flow @ Jones Beach (kcms) e/ | Flow adjust. recov. (%) f/ | Flow @ Bonneville Dam: Total @ 10% rec (kcms) | Flow @ Bonneville Dam: Total @ 50% rec (kcms) | Flow @ Bonneville Dam: Spill: total ratio g/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | |
| **Abernathy Salmon Cultural Development Center h/** | | | | | | | | | | | | | | | | |
| 05/50/01 | Hatchery | 91 | 69 | | | 22APR78 | 112 | | | 101 | 0.105 | 7.2 | 0.107 | - | 6.5 | - |
| 05/59/01 | " | 91 | 44 | | | 10MAY78 | 130 | | | 30 | 0.028 | 9.2 | 0.033 | - | 6.8 | - |
| 05/04/51 | " | 91 | 43 | | | 6MAY79 | 126 | | | 35 | 0.090 | 9.7 | 0.111 | - | 6.2 | - |
| 05/04/50 | " | 91 | 10 | | | 7MAY79 | 127 | | | 60 | 0.119 | 9.7 | 0.146 | - | 7.6 | - |
| 05/04/44 | " | 91 | 27 | | | 16MAY80 | 137 | | | 18 | 0.091 | 7.6 | 0.096 | - | 6.8 | - |
| 05/06/46 | " | 91 | 70 | | | 16MAY80 | 137 | | | 42 | 0.060 | 7.6 | 0.063 | - | 6.8 | - |
| 05/07/44,45 | " | 91 | 69 | | | 1MAY81 | 121 | | | 59 | 0.085 | 7.9 | 0.092 | - | 6.9 | - |
| 05/10/58,59 | " | 91 | 55 | | | 3JUN82 | 154 | | | 1129 | 0.109 | 11.0 | 0.146 | - | 10.0 | - |
| **Aumsville / Stayton Rearing Ponds** | | | | | | | | | | | | | | | | |
| 09/16/12,13 | Will. Falls | 200 | 74 | 12MAY | 132 | 19MAY77 | 139 | 14 | 3 | 209 | 1.160i/ | 4.5 | 0.914 | 4.0 | 3.7 | - |
| 07/17/08,10 | " | 200 | 47 | 8JUN | 159 | 12JUN78 | 163 | 10 | 13 | 96 | 0.153 | 8.3 | 0.170 | 7.3 | 7.3 | - |
| 07/18/41 | Vari.sites Will.R. | 264 | 67 | | | 17MAY79 | 137 | | | 250 | 0.109 | 8.1 | 0.119 | - | 6.9 | - |
| 07/20/55 | " | 264 | 100 | | | 19MAY80 | 140 | | | 57 | 0.037 | 7.6 | 0.039 | - | 6.8 | - |
| 07/23/35 | " | 264 | 75 | | | 17MAY81 | 137 | | | 169 | 0.082 | 6.7 | 0.080 | - | 6.1 | - |
| 07/26/62 | " | 0 | 80 | | | 15MAY82 | 135 | | | 204 | 0.081 | 10.9 | 0.100 | - | 9.9 | - |
| 07/23/20,30-34 | " | 264 | 79 | | | 15MAY83 | 135 | | | 94 | 0.059 | 9.2 | 0.070 | - | 8.0 | - |
| **Bonneville Hatchery—Early Release** | | | | | | | | | | | | | | | | |
| 09/16/05 | Hatchery | 231 | 91 | 15MAY | 134 | 20MAY77 | 140 | 16 | 10 | 9 | 0.470i/ | 4.5 | 0.370 | 3.7 | 3.7 | - |
| 07/16/08 | " | 231 | 70 | 6MAY | 126 | 9MAY79 | 129 | 32 | 20 | 120 | 0.167 | 9.7 | 0.205 | 6.2 | 7.6 | - |
| 07/21/56 | " | 231 | 73 | 30APR | 120 | 1MAY81 | 121 | 27 | 22 | 148 | 0.121 | 7.9 | 0.130 | 6.9 | 6.9 | - |
| 07/24/07 | " | 231 | 80 | 28APR | 118 | 1MAY82 | 121 | 32 | 20 | 262 | 0.254 | 10.0 | 0.319 | 7.8 | 8.7 | - |
| LU60D T 1,2 | ds Bonn. Dam | 233 | 80 | 28APR | 87 | 1MAY82 | 121 | 32 | 20 | 794 | 0.383 | 10.0 | 0.481 | 7.8 | 8.7 | - |
| 07/26/63 | Umatilla R. | 467 | 92 | | | 10MAY82 | 161 | | | 137 | 0.138 | 10.2 | 0.176 | - | 9.2 | - |
| 07/27/29,30 | Hatchery | 231 | 74 | 7MAY | 127 | 9MAY83 | 127 | 50 | 30 | 87 | 0.087 | 10.4 | 0.112 | 9.3 | 9.3 | - |
| **Bonneville Hatchery—Late Release** | | | | | | | | | | | | | | | | |
| 07/18/42 | Hatchery | 231 | 80 | | | 2JUN79 | 153 | | | 499 | 0.208 | 7.6 | 0.219 | - | 6.8 | - |
| 07/21/57 | " | 231 | 75 | 31MAY | | 1JUN80 | 153 | | | 56 | 0.085 | 9.0 | 0.099 | 8.2 | 8.2 | - |
| 07/23/29 | " | 231 | 48 | 10MAY | 130 | 21MAY81 | 141 | 27 | 19 | 57 | 0.092 | 7.7 | 0.097 | 6.1 | 6.6 | - |
| 07/24/08 | " | 231 | 80 | | | 3JUN82 | 154 | | | 182 | 0.192 | 11.0 | 0.257 | - | 10.0 | - |
| 07/28/26 | Vernita Br. | 629 | 100 | | | 13JUL83 | 194 | | | 47 | 0.070 | 6.5 | 0.075 | - | 5.7 | - |
| **Cowlitz Salmon Hatchery** | | | | | | | | | | | | | | | | |
| 63/18/02 | Hatchery | 109 | 133 | 30JUN | 181 | 11JUL78 | 192 | 15 | 5 | 311 | 0.417 | 6.8 | 0.410 | 6.4 | 6.4 | - |
| 63/19/42 | " | 109 | 85 | 15JUL | 196 | 2AUG79 | 214 | 7 | 3 | 278 | 0.373 | 3.6 | 0.265 | 3.6 | 3.3 | - |
| 63/22/55 | " | 109 | 77 | | | 5JUL81 | 186 | | | 195 | 0.248 | 7.8 | 0.265 | - | 7.2 | - |
| 63/21/56 | " | 109 | 86 | 1JUL | 182 | 5JUL81 | 186 | 33 | 15 | 494 | 0.493 | 7.8 | 0.527 | 8.2 | 7.2 | - |
| 63/24/62 | " | 109 | 90 | | | 14JUL82 | 195 | | | 525 | 0.353 | 9.7 | 0.434 | - | 8.7 | - |
| 63/20/32 | " | 109 | 98 | 8JUL | 189 | 26JUL82 | 207 | 9 | 4 | 136 | 0.526 | 6.6 | 0.508 | 10.4 | 6.2 | - |
| 63/25/03 | " | 109 | 72 | | | 6JUL83 | 187 | | | 522 | 0.493 | 7.2 | 0.501 | - | 6.3 | - |
| **Hagerman Hatchery** | | | | | | | | | | | | | | | | |
| 05/04/20 | ds Bonn. Dam | 230 | 84 | 28MAY | 148 | 31MAY79 | 151 | 22 | 15 | 74 | 0.177 | 3.6 | 0.126 | 3.4 | 6.8 | - |
| 05/04/21 | Asotin | 754 | 92 | | | 2JUL79 | 183 | | | 3 | 0.010 | 4.2 | 0.008 | - | 3.7 | - |
| 05/05/28 | ds Bonn. Dam | 230 | 59 | | | 15JUN80 | 166 | | | 34 | 0.084 | 3.7 | 0.060 | - | 8.4 | - |
| 05/05/27 | Asotin | 754 | 60 | | | 24JUN80 | 176 | | | 6 | 0.021 | 9.1 | 0.025 | - | 8.5 | - |
| 10/22/11 | ds Bonn. Dam | 230 | 51 | 5JUN | 156 | 7JUN81 | 158 | 20 | 16 | 67 | 0.132 | 12.4 | 0.193 | 11.1 | 11.1 | - |
| 10/22/10 | Lo. Granite Res. | 699 | 34 | | | 16JUN82 | 167 | | | 21 | 0.061 | 10.9 | 0.081 | - | 10.0 | - |
| 05/10/23 | " | 699 | 38 | | | 28JUN82 | 179 | | | 115 | 0.197 | 12.2 | 0.284 | - | 11.5 | - |
| 05/10/22 | Asotin | 754 | 37 | | | 29JUN82 | 180 | | | 84 | 0.156 | 12.2 | 0.225 | - | 11.5 | - |
| 10/25/15 | Clear Creek | 860 | 25 | | | 6JUL83 | 187 | | | 27 | 0.200 | 7.2 | 0.203 | - | 6.3 | - |

Table 25.--cont.

| Tag a/ (Ag,B1,B2) Brand (Loc Sym Rat) | Release information: Site b/ description | Site b/ (Rkm) | Size (no/lb) | Recovery dates c/: 10th percent (da,mo) | 10th percent (jul) | Recovery dates c/: 50th percent (da,mo,yr) | 50th percent (jul) | Movement Rate d/ (km/day) (10%) | Movement Rate d/ (km/day) (50%) | Recovery (no) | Recovery (%) | River flow @ James Beach (kcms) e/ | Flow adjust. recov. (%) f/ | Flow @ Bonneville Dam: Total @ 10% rec (kcms) | Total @ 50% rec (kcms) | Spill: total ratio g/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Ringold Rearing Pond | | | | | | | |
| 63/17/45 | Hatchery | 568 | 35 | | | 14JUL78 | 195 | | | 24 | 0.065 | 6.8 | 0.064 | - | 6.4 | - |
| | | | | | | | | | Round Butte Hatchery | | | | | | | |
| 07/28/36 | Deschutes R. | 506 | 19 | | | 8JUN83 | 159 | | | 45 | 0.210 | 10.6 | 0.274 | - | 3.1 | - |
| | | | | | | | | | Speelyai Hatchery | | | | | | | |
| 63/21/60 | Lewis R. | 146 | 148 | 24JUL | 206 | 5AUG80 | 218 | 11 | 5 | 197 | 0.292 | 4.0 | 0.218 | - | 3.7 | - |
| | | | | | | | | | Spring Creek Hatchery--March Release | | | | | | | |
| 05/43/01 | Hatchery | 269 | 111 | 16APR | 106 | 5MAY77 | 125 | 7 | 4 | 169 | 0.191i/ | 4.7 | 0.154 | 3.1 | 4.0 | 0.00 |
| 05/56/01 | " | 269 | 104 | 29MAR | 88 | 15APR78 | 105 | 25 | 8 | 174 | 0.153 | 7.7 | 0.162 | 6.5 | 7.1 | 0.30 |
| 05/04/46 | " | 269 | 125 | 28MAR | 87 | 7APR79 | 97 | 25 | 12 | 229 | 0.174 | 6.4 | 0.165 | 5.7 | 5.3 | 0.15 |
| 05/06/39 | " | 269 | 123 | 18MAR | 78 | 26MAR80 | 86 | 25 | 13 | 123 | 0.201 | 4.0 | 0.150 | - | 3.8 | 0.22 |
| 05/07/40,48,50,51 | " | 269 | 99 | 2APR | 92 | 4APR80 | 94 | 25 | 21 | 92 | 0.096 | 6.2 | 0.089 | 4.9 | 4.9 | 0.17 |
| 05/10/50 | " | 269 | 110 | 29MAR | 88 | 15APR82 | 105 | 49 | 10 | 106 | 0.099 | 10.4 | 0.128 | 8.2 | 8.3 | 0.57 |
| | | | | | | | | | Spring Creek Hatchery--April Release | | | | | | | |
| 05/44,45,49/01 | Hatchery | 269 | 86 | 17APR | 107 | 30APR77 | 120 | 22 | 8 | 638 | 0.416i/ | 4.7 | 0.335 | 3.1 | 4.0 | 0.00 |
| 05/50/01,RD U 4 | ds Bonn.Dam | 230 | 83 | 17APR | 107 | 1MAY77 | 121 | 26 | 7 | 304 | 0.627 | 4.7 | 0.504 | 3.1 | 4.0 | - |
| 05/60/01,62/01 | Hatchery | 269 | 64 | 24APR | 114 | 1MAY78 | 121 | 33 | 16 | 328 | 0.213 | 8.8 | 0.246 | 6.7 | 7.8 | 0.40 |
| 05/54/01 | " | 230 | 79 | 25APR | 115 | 1MAY78 | 121 | 32 | 14 | 201 | 0.249 | 8.8 | 0.287 | 6.7 | 7.8 | - |
| 05/04/34,44 | " | 269 | 78 | 28APR | 118 | 3MAY79 | 123 | 25 | 16 | 477 | 0.258 | 8.8 | 0.297 | 6.7 | 6.2 | 0.10 |
| 05/06/40 | " | 269 | 83 | 17APR | 108 | 24APR80 | 115 | 28 | 17 | 108 | 0.299 | 7.3 | 0.307 | 4.8 | 5.9 | 0.00 |
| 05/07/41,49 | " | 269 | 71 | 23APR | 113 | 28APR81 | 118 | 25 | 17 | 113 | 0.126 | 6.5 | 0.121 | 5.4 | 5.4 | 0.04 |
| 05/10/51,53,54 | " | 269 | 72 | 20APR | 110 | 25APR82 | 115 | 39 | 21 | 223 | 0.196 | 9.4 | 0.236 | 9.1 | 7.8 | 0.34 |
| 05/08/51 | Umatilla R. | 467 | 79 | | | 4MAY82 | 124 | | | 48 | 0.103 | 10.0 | 0.129 | - | 8.7 | 0.00 |
| 05/10/57 | " | 467 | 79 | | | 7MAY82 | 127 | | | 106 | 0.105 | 10.2 | 0.134 | - | 9.2 | 0.00 |
| 05/11/42,43 | Hatchery | 269 | 54 | 3MAY | 123 | 5MAY83 | 125 | 39 | 31 | 109 | 0.108 | 9.6 | 0.132 | 8.7 | 8.7 | 0.16 |
| RD&LD U 1 | ds Bonn. Dam | 230 | 64 | 7MAY | 127 | 8MAY83 | 128 | 39 | 26 | 115 | 0.110 | 10.4 | 0.142 | 9.3 | 9.3 | - |
| | | | | | | | | | Spring Creek Hatchery--May Release | | | | | | | |
| 05/46/01 | Hatchery | 269 | 42 | 30MAY | 150 | 31MAY77 | 151 | 34 | 27 | 42 | 0.092i/ | 5.1 | 0.077 | 4.2 | 4.2 | 0.21 |
| 05/57/01 | " | 269 | 56 | 22MAY | 142 | 24MAY78 | 144 | 52 | 31 | 106 | 0.088 | 8.7 | 0.101 | 7.9 | 7.9 | 0.41 |
| 05/04/33 | " | 269 | 50 | 21MAY | 141 | 22MAY79 | 142 | 61 | 47 | 98 | 0.087 | 8.4 | 0.097 | 7.3 | 7.3 | 0.40 |
| 05/06/41 | " | 269 | 51 | 11MAY | 132 | 13MAY80 | 134 | 86 | 55 | 55 | 0.129 | 8.8 | 0.149 | 8.0 | 8.0 | 0.45 |
| 56/48/09 | ds Bonn. Dam | 230 | 45 | 22MAY | 143 | 24MAY80 | 144 | 39 | 33 | 71 | 0.080 | 8.1 | 0.087 | 7.2 | 7.2 | - |
| 05/07/42 | Hatchery | 269 | 65 | 9MAY | 129 | 11MAY81 | 131 | 49 | 32 | 105 | 0.171 | 7.2 | 0.174 | 6.5 | 6.5 | 0.44 |
| 05/07/46 | Rock Creek | 368 | 75 | | | 18MAY81 | 138 | | | 56 | 0.046 | 6.7 | 0.045 | - | 6.1 | 0.00 |
| 05/07/43 | " | 368 | 75 | | | 23MAY81 | 143 | | | 10 | 0.050 | 7.7 | 0.053 | - | 6.6 | 0.00 |
| 05/10/52 | Hatchery | 269 | 49 | 23MAY | 143 | 25MAY82 | 237 | 65 | 41 | 73 | 0.128 | 11.9 | 0.181 | 10.8 | 10.8 | 0.44 |
| | | | | | | | | | Spring Creek Hatchery--August Release | | | | | | | |
| 05/03/39,40,41 | Hatchery | 269 | 16 | 22AUG | 234 | 25AUG78 | 237 | 49 | 32 | 19 | 0.043 | 3.9 | 0.032 | 3.5 | 3.5 | 0.00 |
| 05/04/45 | " | 269 | 19 | 17AUG | 229 | 19AUG79 | 230 | 49 | 33 | 33 | 0.181 | 3.2 | 0.123 | 2.9 | 2.9 | 0.00 |
| 05/06/42 | " | 269 | 19 | 10AUG | 223 | 13AUG80 | 226 | 65 | 32 | 9 | 0.144 | 3.7 | 0.104 | 3.6 | 3.4 | 0.12 |
| | | | | | | | | | Toutle Hatchery | | | | | | | |
| 63/16/40 | Hatchery | 160 | 117 | 17JUL | 198 | 5AUG77 | 217 | 5 | 3 | 606 | 0.658 | 3.4 | 0.457 | 2.9 | 3.1 | - |
| 63/17/63 | " | 160 | 98 | 27JUN | 178 | 5JUL78 | 186 | 11 | 7 | 457 | 0.559 | 6.1 | 0.516 | 6.4 | 5.7 | - |
| 63/18/01 | " | 160 | 72 | 16JUL | 197 | 30JUL78 | 211 | 10 | 4 | 164 | 0.267 | 4.5 | 0.210 | 5.3 | 4.2 | - |
| 63/18/54,19/41,54 | " | 160 | 160 | 2JUL | 183 | 12JUL79 | 193 | 6 | 3 | 866 | 0.822 | 4.0 | 0.612 | 3.7 | 3.6 | - |

Table 25.--cont.

| Tag a/ (Ag,D1,D2) Brand (Loc Sym Rot) | Site b/ description | Site b/ (Rkm) | Size (no/lb) | Recovery dates c/ 10th percent (da,mo) | 10th percent (jul) | Recovery dates c/ 50th percent (da,mo,yr) | 50th percent (jul) | Movement Rate d/ (km/day) (10%) | Movement Rate (km/day) (50%) | Recovery (no) | Recovery (%) | River flow @ Jones Beach (kcms) e/ | Flow adjust. recov. (%) f/ | Flow @ Bonneville Dam Total @ 10% rec (kcms) | Total @ 50% rec (kcms) | Spill: total ratio g/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Kalama Falls Hatchery** | | | | | | | | | | | | | | | | |
| 63/16/55 | Hatchery | 141 | 76 | 2JUL | 183 | 14JUL77 | 195 | 8 | 3 | 131 | 0.207 | 3.1 | 0.138 | 2.4 | 2.8 | - |
| 63/16/39 | " | 141 | 113 | 5JUL | 186 | 26JUL77 | 207 | 6 | 2 | 697 | 0.718 | 2.9 | 0.468 | 2.4 | 2.6 | - |
| 63/17/46 | " | 141 | 108 | 19JUL | 199 | 3AUG78 | 215 | 10 | 3 | 541 | 0.631 | 4.5 | 0.497 | 5.3 | 4.2 | - |
| 63/19/57 | " | 141 | 180 | 8JUL | 189 | 27JUL79 | 208 | 4 | 2 | 2229 | 1.429 | 3.8 | 1.040 | 3.7 | 3.4 | - |
| 63/21/05 | " | 141 | 115 | 26JUN | 178 | 12JUL80 | 193 | 17 | 4 | 163 | 0.239 | 5.3 | 0.204 | 6.8 | 4.9 | - |
| 63/20/36 | " | 141 | 119 | 26MAY | 146 | 31MAY81 | 151 | 17 | 8 | 175 | 0.117 | 9.0 | 0.137 | 8.2 | 10.1 | - |
| 63/24/60 | " | 141 | 130 | 14JUN | 165 | 7JUL82 | 188 | 17 | 3 | 185 | 0.153 | 11.0 | 0.205 | 10.0 | 10.4 | - |
| **Klickitat Hatchery** | | | | | | | | | | | | | | | | |
| 63/16/05 | Hatchery | 358 | 92 | 4JUL | 185 | 19AUG77 | 23 | 10 | 4 | 38 | 0.059i/ | 3.2 | 0.040 | 2.4 | 2.9 | 0.00 |
| 63/16/63 | " | 358 | 87 | 21JUN | 172 | 7JUL78 | 188 | 21 | 12 | 97 | 0.169 | 6.1 | 0.156 | 7.4 | 5.7 | 0.42 |
| 63/19/49 | " | 358 | 80 | | | 7JUN79 | 158 | | | 224 | 0.127 | 4.2 | 0.097 | - | 5.6 | 0.35 |
| 63/19/47 | " | 358 | 85 | 3JUN | 154 | 9JUN80 | 161 | 42 | 24 | 64 | 0.066 | 9.0 | 0.077 | 8.2 | 8.3 | 0.50 |
| 63/20/08 | " | 358 | 78 | 12JUN | 163 | 18JUN81 | 169 | 47 | 30 | 30 | 0.032 | 11.2 | 0.043 | 10.8 | 9.9 | 0.59 |
| 63/21/57 | " | 358 | 83 | | | 13JUN82 | 164 | | | 214 | 0.111 | 10.9 | 0.148 | - | 10.0 | 0.31 |
| **Kooskia Hatchery** | | | | | | | | | | | | | | | | |
| 05/04/27 | ds Bonn. Dam | 230 | 40 | 16MAY | 136 | 21MAY79 | 141 | 14 | 9 | 38 | 0.117 | 8.4 | 0.131 | - | 7.3 | - |
| 05/04/26 | Clear Creek | 868 | 40 | | | 16JUN79 | 167 | | | 31 | 0.062 | 5.5 | 0.054 | - | 5.0 | - |
| 10/22/18 | " | 868 | 36 | | | 18JUN81 | 169 | | | 11 | 0.043 | 11.2 | 0.058 | - | 9.9 | - |
| **Little White Salmon Hatchery** | | | | | | | | | | | | | | | | |
| 05/47/01 | Hatchery | 261 | 122 | 11JUN | 162 | 21JUN77 | 172 | 7 | 6 | 267 | 0.127i/ | 3.6 | 0.090 | 4.0 | 3.2 | 0.00 |
| 05/03/46,47,48 | " | 261 | 115 | 31MAY | 151 | 7JUN78 | 158 | 32 | 14 | 330 | 0.358 | 7.9 | 0.385 | 6.7 | 7.3 | 0.45 |
| 05/03/43,44,45 | " | 261 | 135 | 1JUN | 152 | 8JUN78 | 159 | 27 | 13 | 334 | 0.348 | 7.9 | 0.375 | 6.7 | 7.3 | 0.45 |
| 05/03/55,56,57 | " | 261 | 100 | 24JUL | 205 | 31JUL78 | 212 | 17 | 10 | 61 | 0.109 | 4.5 | 0.086 | 4.7 | 4.7 | 0.21 |
| 05/04/48 | " | 261 | 105 | 29JUN | 180 | 3JUL79 | 184 | 28 | 17 | 254 | 0.210i/ | 4.2 | 0.160 | 4.4 | 3.7 | 0.02 |
| 05/04/49 | " | 261 | 123 | 1JUL | 182 | 4JUL79 | 185 | 22 | 16 | 412 | 0.223 | 4.2 | 0.170 | 4.4 | 3.7 | 0.02 |
| 05/06/43 | " | 261 | 101 | 16JUN | 168 | 19JUN80 | 171 | 32 | 22 | 94 | 0.073 | 9.1 | 0.086 | 8.4 | 8.5 | 0.51 |
| 05/07/47,49,50 | " | 261 | 94 | 9JUN | 157 | 11JUN81 | 162 | 38 | 28 | 164 | 0.072 | 12.4 | 0.105 | 11.1 | 10.8 | 0.57 |
| 05/04/35,36 | " | 261 | 93 | 7JUN | 158 | 10JUN82 | 161 | 38 | 21 | 267 | 0.136 | 10.2 | 0.173 | 9.5 | 9.5 | 0.38 |
| **Lower Kalama Hatchery h/** | | | | | | | | | | | | | | | | |
| 63/17/42 | Hatchery | 127 | 61 | 31MAY | 151 | 5JUN78 | 156 | | 18 | 136 | 0.136 | 7.9 | 0.146 | 6.7 | 7.3 | - |
| 63/20/06 | " | 127 | 150 | 7JUN | 158 | 13JUN80 | 166 | | 8 | 209 | 0.195 | 9.1 | 0.230 | 8.3 | 8.4 | - |
| 63/22/54 | " | 127 | 100 | 4JUN | 155 | 19JUN81 | 170 | | 4 | 175 | 0.133 | 11.2 | 0.180 | 11.1 | 9.9 | - |
| 63/24/63 | " | 127 | 117 | 15JUN | 166 | 25JUN82 | 176 | | 6 | 191 | 0.162 | 12.6 | 0.239 | 10.0 | 11.5 | - |
| **Priest Rapids Spawing Channel** | | | | | | | | | | | | | | | | |
| 63/17/41 | ds Priest Rap. Dam | 639 | 124 | | | 26JUL78 | 207 | | | 20 | 0.055 | 5.1 | 0.046 | - | 4.7 | - |
| 63/18/21 | " | 639 | 74 | | | 17JUL79 | 198 | | | 12 | 0.045 | 4.1 | 0.034 | - | 2.7 | - |
| 63/20/17 | " | 639 | 77 | | | 30JUL79 | 211 | | | 6 | 0.025 | 3.6 | 0.018 | - | 3.3 | - |
| 63/19/48 | " | 639 | 88 | | | 4JUL80 | 186 | | | 11 | 0.028 | 5.7 | 0.025 | - | 5.2 | - |
| 63/22/61 | " | 639 | 67 | | | 7JUL81 | 188 | | | 13 | 0.083 | 7.8 | 0.089 | - | 7.2 | - |
| 63/21/55 | " | 639 | 115 | | | 9AUG81 | 221 | | | 33 | 0.073 | 5.5 | 0.064 | - | 5.1 | - |
| 63/24/56 | " | 639 | 67 | | | 23JUN82 | 174 | | | 35 | 0.099 | 12.6 | 0.146 | - | 11.7 | - |
| 63/22/52 | " | 639 | 87 | | | 5JUL82 | 217 | | | 93 | 0.073 | 11.0 | 0.098 | - | 10.4 | - |
| 63/26/11 | " | 639 | 84 | | | 17JUN83 | 168 | | | 141 | 0.096 | 9.3 | 0.115 | - | 8.5 | - |
| 63/26/12 | " | 639 | 63 | | | 20JUL83 | 201 | | | 86 | 0.103 | 7.5 | 0.107 | - | 6.7 | - |

seine catches (Table 3). Relative abundance of fall chinook salmon was about 15 times greater in near-shore waters at Jones Beach than in the adjacent channel area during the 1968 sampling season. By contrast, yearling chinook salmon, coho salmon, and steelhead were most abundant in the offshore channel areas.

When in deep water, juvenile fall chinook salmon were found to concentrate near the surface. Trawl samples from the channel off Tongue Point, Clatsop Spit, and Jones Beach (Fig. 2) in 1966 showed that more than 95% of all juvenile fall chinook salmon were within 3 m of the surface (Table 4).

## Diel Movement Patterns

Two tests were made in 1966 to examine die1 movement patterns of migrating fall chinook salmon fingerlings in the Columbia River estuary. The first test ran from 26 to 29 May at Site H-1 on lower Puget Island (Fig. 2). A single beach seine set was made each hour, on the hour, for the duration of a 30-h test period. This procedure was repeated at the Jones Beach site on 13 to 16 June. To compensate for possible tidal influence on movement patterns, the Puget Island test was started on a flood tide cycle and the Jones Beach test on an ebb tide cycle. About 90% of the fall chinook salmon taken during both tests were caught during daylight hours (Fig. 6). The pattern of movement was almost identical at both sites--peak movement in the morning between 0800 and 1100 h, followed by an afternoon decline and a second, though smaller, peak in the evening between 1800 and 2000 h. Tidal conditions did not affect this movement pattern. Purse seine fishing in the ship channel adjacent to Jones Beach in 1968 and 1969 substantiated this daytime movement.

An additional experiment was made during 1 day of each test. Groups of fall chinook salmon fingerlings from the beach seine catches were marked and released back into the seining area at 0800 and 2200 h. Recaptures of these marked fish showed that fish released in darkness remained in the area much longer than those released during daylight (Table 5). Both experiments indicated little movement of fall chinook salmon in the estuary after dark.

## Migration Timing

Timing of the juvenile fall chinook salmon migration into the estuary from 1966 to 1972 is shown in Figure 7. This information is based upon morning (0550-1200 h) beach seine catches each year at the Jones Beach site from 28 April through 2 September. Sampling over the entire year showed that approximately 80% of the juvenile fall chinook salmon entering the estuary do so during this period.

Movement into the estuary is generally bimodal--an early peak in May and early June, a decline later in June, and a second and usually higher peak in late July or early August. The seaward migration remains heavy to September and then gradually declines. The decline in the number of fall chinook salmon entering the estuary in June is unexplained but could be associated with the high river flows that generally occur during this period.

Table 3.-- Beach seine and purse seine catch per effort (average number of fish per set) at Jones Beach, Oregon, 1 May-31 July 1968.

| Type of fishing gear and month | Number of sets | Catch per set | | | |
|---|---|---|---|---|---|
| | | Fall chinook | Yearling chinook | Steelhead | Coho |
| Beach seine | | | | | |
| May | 139 | 177.6 | 2.1 | 1.1 | 25.1 |
| June | 178 | 164.4 | 0.1 | 0.0 | 0.6 |
| July | 147 | 497.0 | 0.0 | 0.0 | 0.2 |
| Average | | 274.0 | 0.7 | 0.3 | 7.8 |
| Purse seine | | | | | |
| May | 120 | 15.7 | 12.1 | 31.3 | 61.3 |
| June | 100 | 24.9 | 0.4 | 1.4 | 1.5 |
| July | 114 | 14.1 | 0.1 | 0.1 | 0.2 |
| Grand Average | | 17.9 | 4.5 | 11.7 | 22.6 |

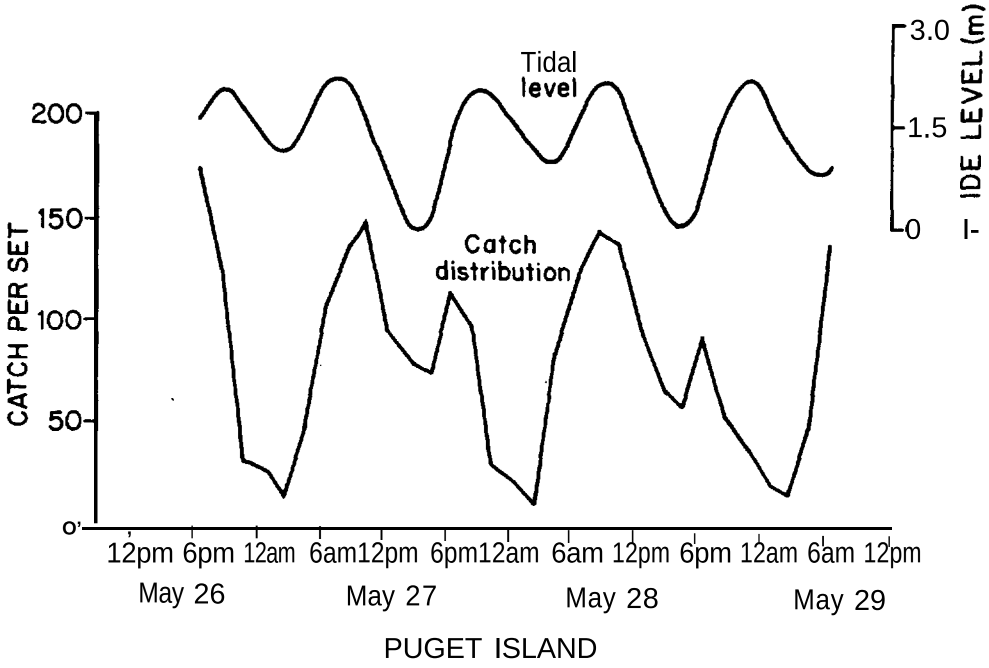
Table 4.-- Mid-water trawl catches of juvenile fall chinook salmon at various depths and locations in the Columbia River estuary, 1 June - 31 July 1966.

| Fishing depth | Jones Beach[a] | | Tongue Point[a] | | Clatsop Spit[a] | |
|---|---|---|---|---|---|---|
| | No. fish | Percent | No.. fish | Percent | No. fish | Percent |
| Surface (0 - 3 m) | 1,510 | 96.3 | 662 | 95.2 | 321 | 97.9 |
| Mid-depth (3 - 6 m) | 57 | 3.6 | 33 | 4.8 | 6 | 1.8 |
| Bottom (below 6 m) | 1 | 0.1 | 0 | 0.0 | 1 ' | 0.3 |

a/ Catch represents 10 trawl hauls at each depth at each location.

Table 5.--Beach seine recoveries of marked fall chinook salmon released during daylight and darkness at Puget Island (26 May 1966) and at Jones Beach (14 June 1966).

| Area and time of release | No. of fish released | No. hours from release to recapture | | | | | | | | | Total recaptures | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Number | Percent |
| | | Number of fish | | | | | | | | | | |
| Puget Island | | | | | | | | | | | | |
| 0800 hours | 500 | 5 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 9 | 1.8 |
| 2200 hours | 500 | 53 | 36 | 17 | 18 | 5 | 3 | 0 | 1 | 1 | 134 | 26.8 |
| Jones Beach | | | | | | | | | | | | |
| 0800 hours | 500 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 0.8 |
| 2200 hours | 500 | 61 | 33 | 27 | 21 | 8 | 0 | 0 | 3 | 0 | 153 | 30.6 |



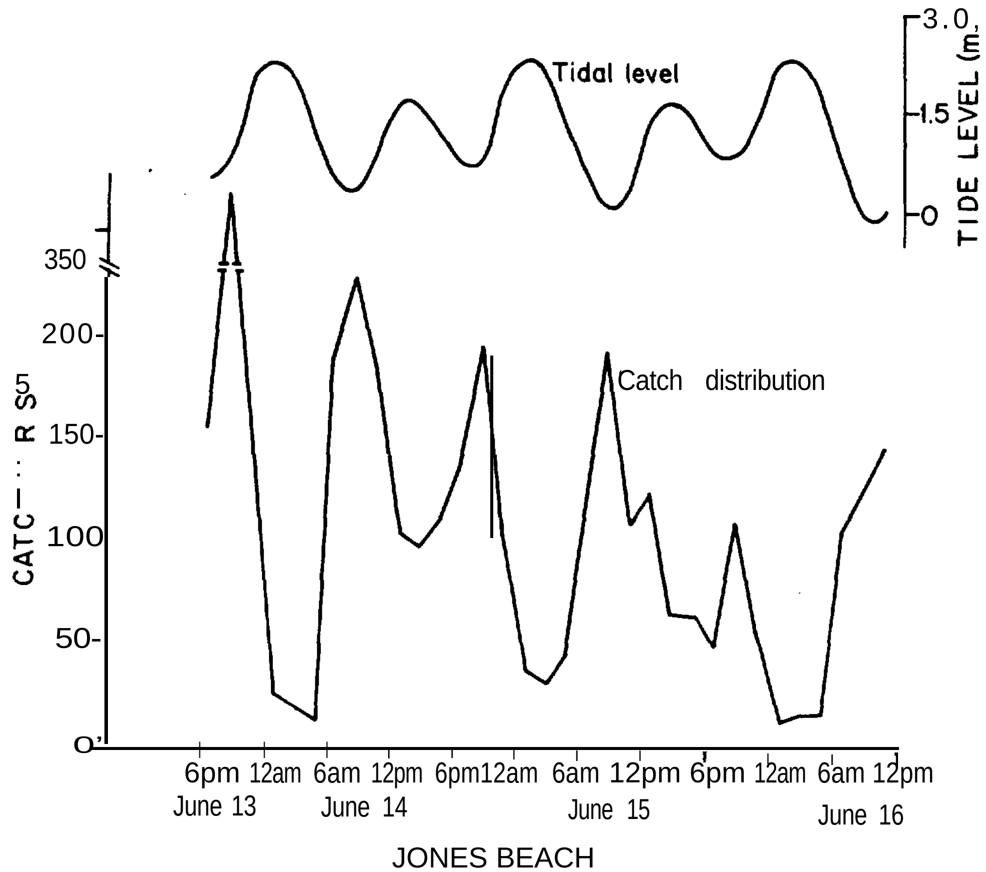




Figure 6.--Beach seine catch distribution of juvenile fall chinook salmon at Puget Island (26 and 29 May 1966) and Jones Beach, Oregon, (13-16 June 1966) and corresponding tidal levels during the catch period.

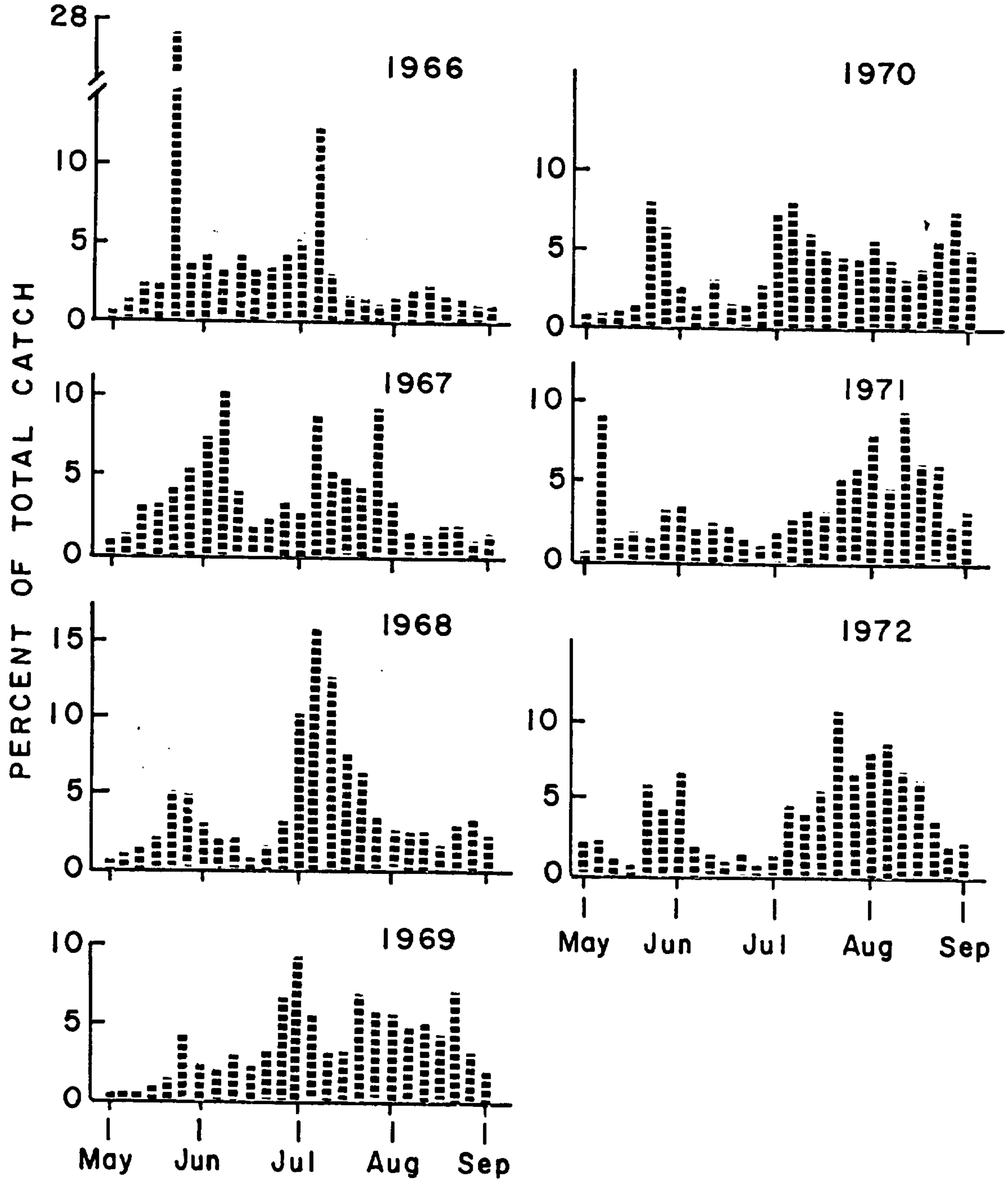



Figure 7.--Temporal catch distribution of juvenile fall chinook salmon entering the Columbia River estuary from 1 May through 1 September, based on beach seine catches at Jones Beach, Oregon, 1966-1972.

Fall chinook salmon fry began to enter the Jones Beach area in late February. These fish were not actively migrating but were apparently moving out of the smaller tributary streams and utilizing the upper estuary as a rearing area. Reimers and Loeffel (1967) reported very short residence periods by fall chinook salmon fry in certain tributary streams of the lower Columbia River. Based on Jones Beach sampling, the total number of fry residing in the estuary is very small in comparison to the total number that migrate.

Beach seine catches at Jones Beach from 1966 to 1972 indicate a trend toward later entry of juvenile fall chinook salmon into the estuary (Fig. 8). Over the study period, the percentage of seaward migrants entering the system during May and June declined, whereas the number of fish entering in August increased significantly. This apparent shift in the time of migration is not well defined, but may result from variation of seasonal river flows during the study period.

The effect of hatchery releases on the timing of the fall chinook salmon migration in the estuary can be seen by comparing the temporal catch distribution in 1971 with that of other years sampled (Fig. 7). In 1971, almost 90% of the total production of hatchery fall chinook salmon were released prior to 5 May. With the exception of a single S-day period in early May) the effect of these early releases on the overall distribution of the migration in the estuary was negligible.

## Rates of Downstream Movement

Releases of marked fall chinook salmon fingerlings were made in 1968, 1969, and 1970 at hatcheries of the Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fisheries (WDF) , and the U.S. Fish and Wildlife Service (USFWS) in cooperation with this study. Recovery of these marked fish at Jones Beach provided considerable information on passage times and rates of movement of hatchery-reared fall chinook salmon to the estuary. Variation in rate of movement of fish from the various hatcheries was considerable (Tables 6, 7, and 8). The time required for individual groups to reach Jones Beach ranged from 3 to 24 days. Rate of downstream movement varied from 5 to 36 km per day.

Effect of Size at Release.--A multiple release of branded fall chinook salmon at Little White Salmon National Fish Hatchery (USFWS) in 1969 illustrates the effect of size on the rate of downstream movement. Three groups of fish (average fork lengths 77, 64, and 56 mm, respectively) were released at the hatchery (Fig. 3) on 24 June 1969, and a fourth group (average fork length 67 mm) was released on 25 June approximately 28 km downstream from the hatchery. The relationship of the size of these fish and their rate of downstream movement to the estuary is shown in Figure 9. A strong positive correlation of increased rate of movement with an increase in fish size is evident. The largest migrants (77 mm) moved 12 km per day faster than the smallest (56 mm).

Table 6.-- Rate of downstream movement of various groups of marked hatchery fall chinook salmon based on beach seine catches at Jones Beach, Oregon, 1968.

| | Release information | | | Recovery information | | | |
|---|---|---|---|---|---|---|---|
| Hatchery of origin. | Place | Date | Number of fish | Number of fish | Distance traveled (km) | Travel time (days) | Rate of movement (km/day) |
| Ringold (WDF)[a] | Hatchery | 14 May | 90,000 | 7 | 490 | 15.0 | 32.7 |
| Ringold | Below Bonneville Dam | 16 May | 90,000 | 144 | 162 | 8.1 | 20.0 |
| Kalama (WDF) | Hatchery | 17 June | 78,850 | 62 | 46 | 8.7 | 5.3 |
| Kalama | Hatchery | 12 July | 80,000 | 73 | 46 | 6.4 | 7.2 |
| Washougal (WDF) | Hatchery | 17 June | 77,900 | 97 | 132 | 11.4 | 11.6 |
| Washougal | Hatchery | 17 June | 78,700 | 101 | 132 | 11.0 | 12.0 |
| Washougal | Camas Slough | 17 June | 76,500 | 144 | 120 | 9.2 | 12.5 |
| Washougal | Below Camas Slough | 17 June | 77,700 | 237 | 115 | 9.1 | 13.1 |
| Spring Creek (FWS)[b] | Hatchery | 13 June | 159,000 | 80 | 192 | 9.3 | 20.6 |
| Abernathy (FWS) | Hatchery | 15 May | 200,300 | 2,276 | 15 | 3.1 | 4.8 |
| Abernathy | Hatchery | 15 May | 200,400 | 559 | 15 | 3.0 | 5.0 |
| Little White Salmon (FWS) | Cook, Wa. | 22 June | 217,200 | 402 | 190 | 9.3 | 20.4 |
| Little White Salmon | Drano Lake | 22 June | 107,500 | 295 | 188 | 10.9 | 17.2 |
| Little White Salmon | Below Bonneville Dam | 24 June | 101,700 | 558 | 162 | 8.6 | 18.8 |
| Little White Salmon | Mouth of Willamette R. | 25 June | 102,000 | 551 | 91 | 7.4 | 12.3 |
| Little White Salmon | Prescott, Or. | 26 June | 99,700 | 505 | 36 | 5.7 | 6.3 |
| Little White Salmon | Beaver, Or. | 27 June | 192,700 | 1,170 | 14 | 2.5 | 5.6 |
| Oxbow (ODFW)[c] | Hatchery | 4 June | 128,000 | 64 | 171 | 7.5 | 22.8 |
| Oxbow | Below Bonneville Dam | 5 June | 110,000 | 116 | 162 | 5.2 | 31.1 |
| Bonneville (ODFW) | Hatchery | 17 June | 116,300 | 63 | 162 | 8.1 | 20.1 |

a/ Washington Department of Fisheries

b/ Fish and Wildlife Service

c/ Oregon Department of Fish and Wildlife

Table 7.-- Rate of downstream movement of various groups of marked hatchery fall chinook salmon based on beach seine catches at Jones Beach, Oregon, 1969.

| Hatchery of origin | Release information: Place | Release information: Date | Release information: Number of fish | Recovery information: Number recovered | Recovery information: Distance traveled (km) | Recovery information: Travel time (days) | Recovery information: Rate of movement (km/day) |
|---|---|---|---|---|---|---|---|
| Ringold | Hatchery | 12 May | 201,200 | 60 | 490 | 14.3 | 34.3 |
| Ringold | Below Bonneville Dam | 16 May | 66,800 | 75 | 162 | 4.6 | 35.2 |
| Oxbow | Below Bonneville Dam | 19 May | 152,000 | 481 | 162 | 6.2 | 26.1 |
| Oxbow | Below Bonneville Dam | 19 May | 151,100 | 1,271 | 162 | 5.9 | 27.5 |
| Oxbow | Below Bonneville Dam | 19 May | 154,800 | 395 | 162 | 5.9 | 27.5 |
| Oxbow | Rainier, Or. | 20 May | 155,900 | 485 | 36 | 2.5 | l-4.4 |
| Spring Creek | Hatchery | 3 June | 199,700 | 417 | 190 | 5.4 | 35.6 |
| Little White Salmon | Hatchery | 24 June | 198,500 | 252 | 190 | 13.0 | 14.6 |
| Little White Salmon | Hatchery | 24 June | 196,800 | 215 | 190 | 7.0 | 27.1 |
| Little White Salmon | Below Bonneville Dam | 25 June | 76,000 | 148 | 162 | 6.9 | 23.5 |
| Little White Salmon | Hatchery | 24 June | 114,800 | 156 | 190 | 8.3 | 22.9 |
| Little White Salmon | Rainier, Or. | 27 June | 41,300 | 228 | 36 | 4.3 | 8.4 |

Table 8.-- Rate of downstream movement of various groups of marked hatchery fall chinook salmon based on beach seine catches at Jones Beach, Oregon, 1970.

| Hatchery of origin | Release information | | | Recovery information | | | |
|---|---|---|---|---|---|---|---|
| | Place | Date | Number of fish | Number recovered | Distance traveled (km) | Travel time (days) | Rate of movement (km/day) |
| Spring Creek | Hatchery | 14 April | 152,500 | 1,441 | 192 | 23.8 | 8.1 |
| Spring Creek | Hatchery | 22 June | 144,600 | 131 | 192 | 8.8 | 21.8 |
| Spring Creek | Hatchery | 22 June | 152,100 | 284 | 192 | 8.7 | 22.1 |
| Oxbow | Below Bonneville Dam | 15 May | 75,700 | 85 | 162 | 7.3 | 22.2 |
| Oxbow | Below Bonneville Dam | 15 May | 75,000 | 55 | 162 | 6.8 | 23.8 |
| Little White Salmon | Hatchery | 22 June | 183,900 | 646 | 190, | 10.5 | 18.1 |
| Little White Salmon | Hatchery | 22 June | 187,000 | 914 | 190 | 13.8 | 13.8 |
| Little White Salmon | Below Bonneville Dam | 23 June | 156,000 | 594 | 162 | 8.2 | 19.8 |

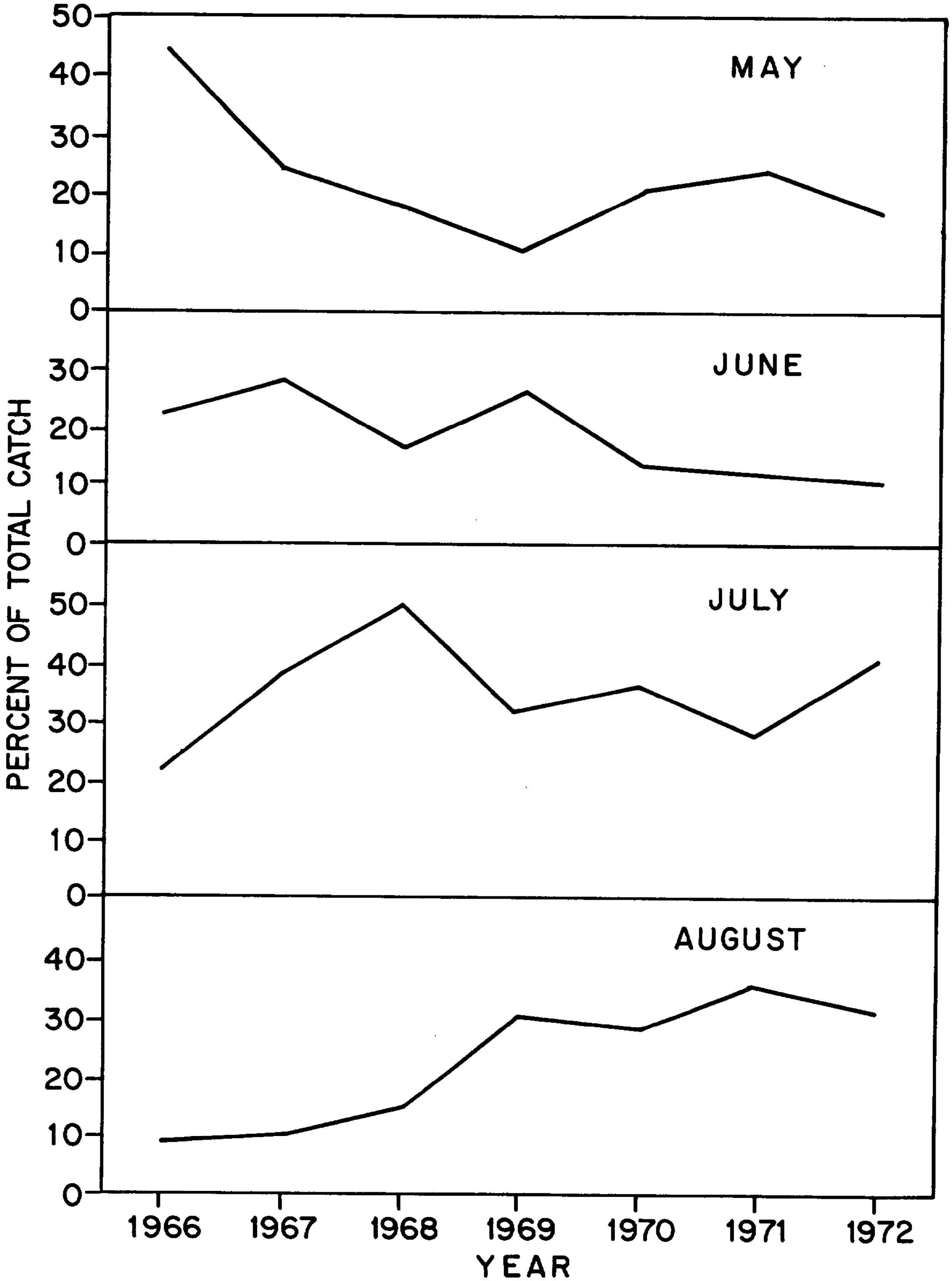



Figure 8.--Annual variation in the migrational timing of juvenile fall chinook salmon at Jones Beach, Oregon, 1966-1972.

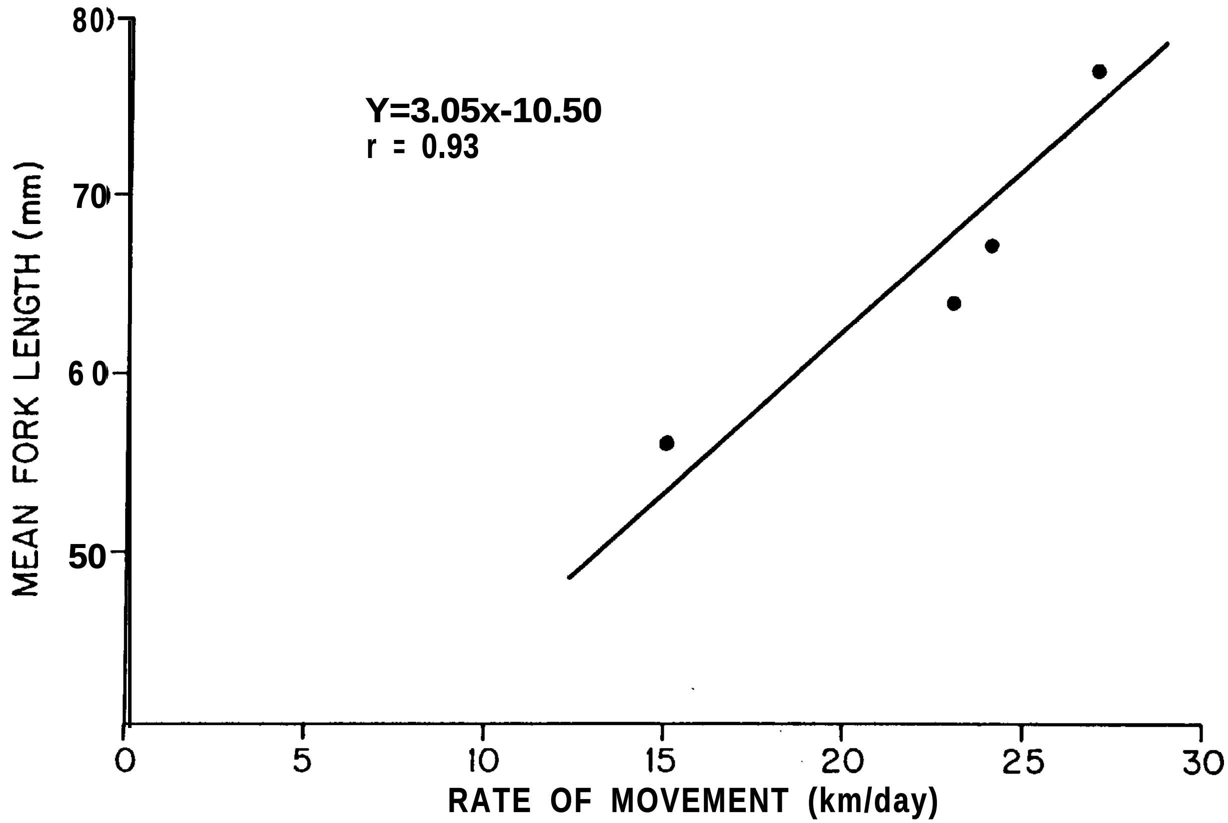



Figure 9.--Relationship of size at release and rate of downstream movement to the estuary of four size groups of branded fall chinook salmon released from Little White Salmon Hatchery on 24-25 June 1969.

Effect of Release Location.--Mark recovery data also indicated that the rate of downstream movement of hatchery juvenile chinook salmon may be associated with point of release (Fig. 10). Fish reared and released from hatcheries near the estuary moved downstream at a slower rate than those from hatcheries farther upstream. For example, fall chinook salmon from Abernathy Hatchery (USFWS), about 15 km above the Jones Beach sampling site, moved downstream at an average rate of about 5 km per day; whereas fish released at Ringold (WDF), 490 km above the estuary, moved downstream at almost 33 km per day (Table 6).

Effect of River Flow.--Raymond (1968) showed a positive correlation between water flow and rate of downstream movement of yearling chinook salmon in upper Columbia and Snake Rivers. A similar correlation is difficult to demonstrate in relation to juvenile fall chinook salmon in the lower Columbia River. Releases of marked fall chinook salmon of comparable body lengths at two Federal hatcheries (Little White Salmon and Spring Creek) failed to show a clear relationship between river flow and rate of downstream movement (Table 9). This is probably the result of variations in the number of smolting fish within the release groups. Some groups of fish released during periods of high river flow moved downstream at a slower rate than other groups released during lower river flows. If all fish were actively migrating seaward at the time of release, the effect of river flow on downstream movement might be more evident (samples from later years suggested a relationship).

## Size and Estuarine Residency

Fork-length measurements were taken each year from May to September to examine size characteristics of juvenile fall chinook salmon in the estuary. Mean fork-lengths of juveniles entering the estuarine system at Jones Beach from 1966 to 1972 are shown in Figure 11. Average sizes of fall chinook salmon entering (Jones Beach) and leaving (Clatsop Spit) the estuary are compared in Figure 12. These relationships show that the average length of fall chinook salmon in the estuary approaches 75 mm by mid- to late-May each year and does not increase significantly until late July.

There are two hypotheses that would account for the constant size of juvenile fall chinook salmon in the estuary over such an extended period: (1) growth rate of fall chinook salmon rearing in the estuary is substantially reduced or (2) juvenile fall chinook salmon rear to smolting size in areas above the estuary and pass quickly through the estuary once they enter the system. Reimers (1973) reported a similar size pattern for fall chinook salmon in the Sixes River estuary in southern Oregon and related this pattern to decreased growth rates during an extended period of estuarine residence. He further hypothesized that this reduction in growth rate resulted in high population densities in the estuary during this period.

Mark recoveries during this study suggest that the majority of juvenile fall chinook salmon entering the Columbia River estuary remain within the system for a relatively short period of time. Recoveries from 16 groups of marked hatchery fall chinook salmon in 1970 showed that these fish began to

Table 9.-- Rate of downstream movement and average river flow at time of release of six groups of similar sized marked fall chinook salmon released into the Columbia River during 1968, 1969, and 1970.

| Hatchery and year of release | Number of fish released | Date of release | Number of marks recovered | Average rate of movement (km/day) | River flow a/ ($m^3/s \times 1000$) |
|---|---|---|---|---|---|
| Spring Creek | | | | | |
| 1968 | 159,000 | 13 June | 80 | 20.6 | 10.6 |
| 1969 | 199,716 | 3 June | 417 | 35.6 | 10.1 |
| 1970 | 152,079 | 22 June | 284 | 22.1 | 7.9 |
| Little White Salmon | | | | | |
| 1968 | 217,000 | 22 June | 402 | 20.4 | 9.8 |
| 1969 | 196,800 | 24 June | 215 | 27.1 | 8.4 |
| 1970 | 186,950 | 22 June | 914 | 18.1 | 7.9 |

a/ Average daily flow at Bonneville Dam for 20-day period after release. Flow data from Annual Fish Passage Reports, 1969-70, North Pacific Division U.S. Army Corps of Engineers processed report.

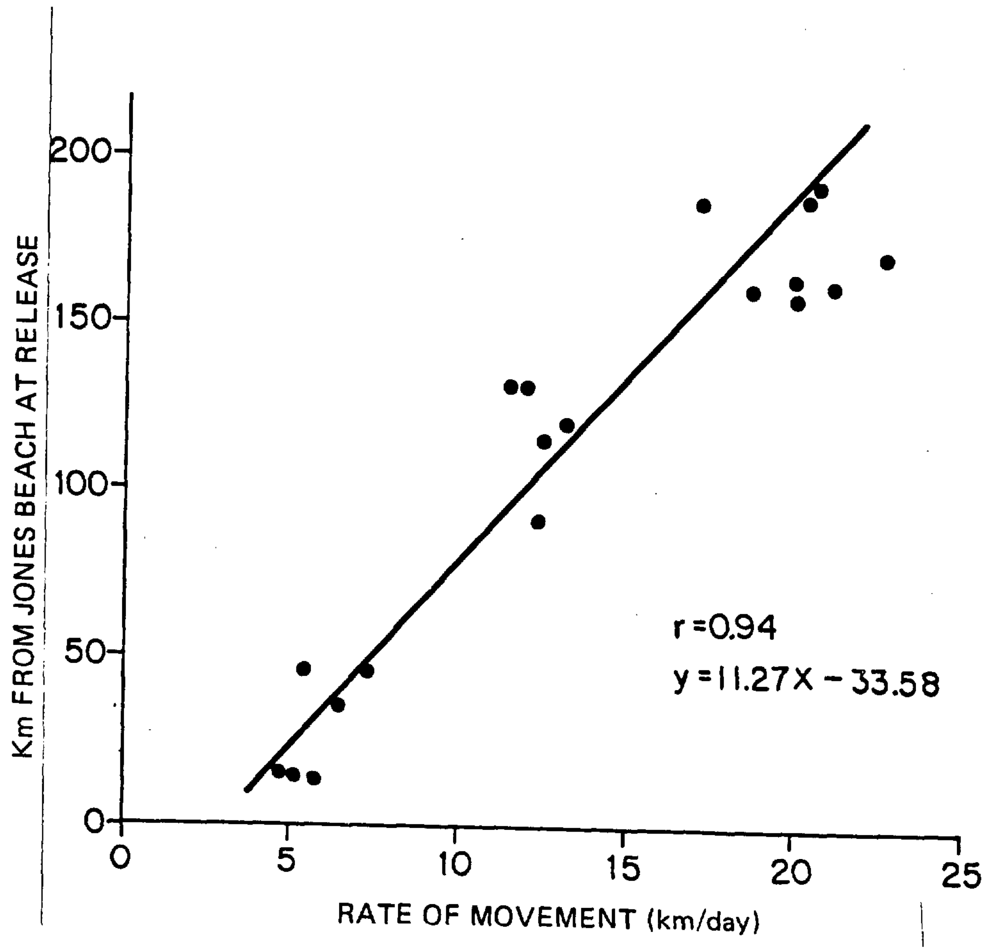



Figure 10.--Relationship of distance from the estuary at release to rate of downstream movement of 12 groups of branded fall chinook salmon released from various hatcheries on the Columbia River in May and June 1968.

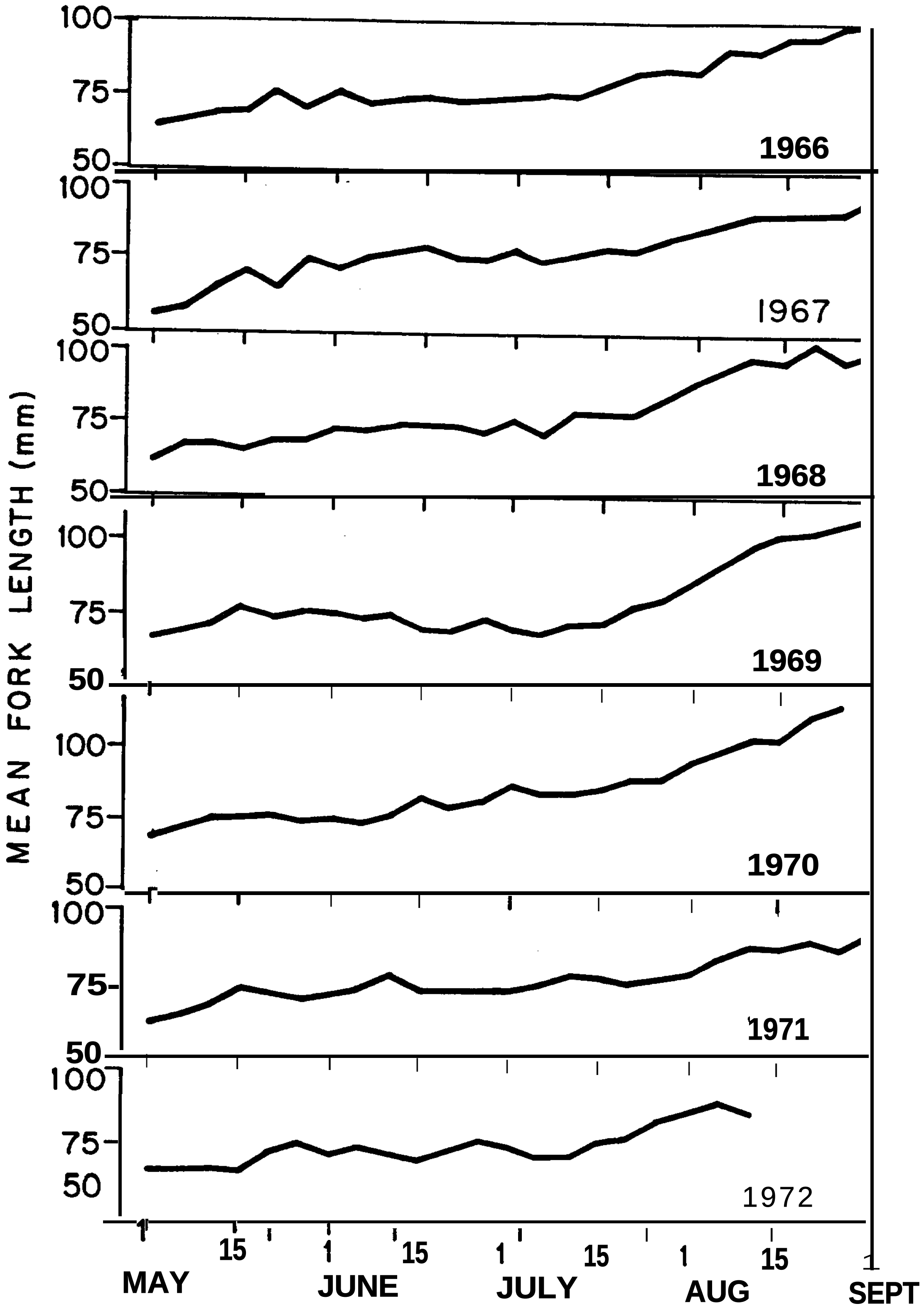



Figure 11 .--Mean fork-length of juvenile fall chinook salmon captured with beach seines at Jones Beach, Oregon, 1966-1972.

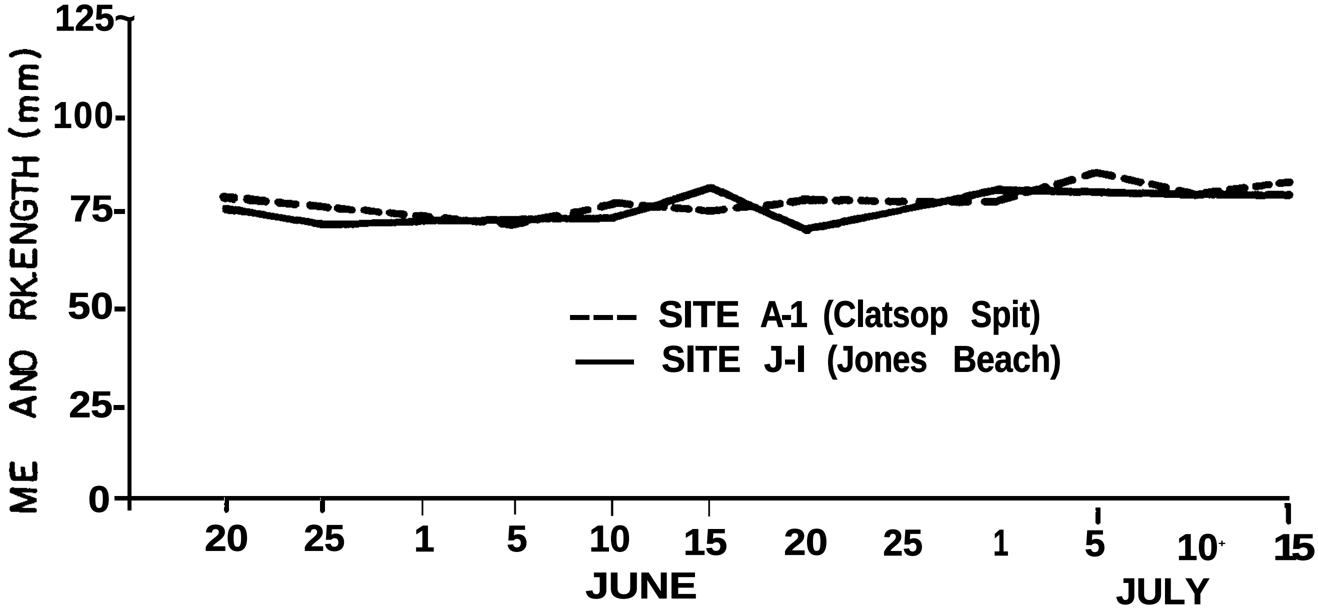



Figure 12.--Mean fork-length of juvenile fall chinook salmon in the upper (Site J-1) and lower (Site A-l) Columbia River estuary, 20 May-15 July 1970.

leave the estuary within 6 days or less after entering the estuary (Table 10). In addition, five branded fall chinook salmon fingerlings were taken by purse seine in the ocean several miles south of the river mouth in 1969. Two of these fish had been released 14 km above the Jones Beach site only 6 days earlier. The other three fish had been released at the same site from 9 to 15 days earlier. Although few in number, these ocean recoveries further suggest a rapid movement of juvenile fall chinook salmon through the estuary.

Additional mark recoveries indicate that when fall chinook salmon stay in the estuary for an extended period, their size increases rapidly. Recoveries from six groups of marked fall chinook salmon fingerlings transported from the Washougal Hatchery (WDF) and released at six separate locations in the lower river, 16-18 June 1969, showed that the behavior of these fish was different from that of any other groups of marked fish sampled during this study. These fish were small when released (approximately 200/lb) and obviously not ready to migrate. They began to enter the beach seine catches at Jones Beach on 21 June, and significant numbers were still being caught in mid-September. Recovery rates from the Washougal releases were 10 times greater than for any other groups of marked fish. Moreover, 10 times as many multiple mark recaptures were made. Many individual fish from these releases were caught four and five times during a l0-week period. Inasmuch as these fish remained in the estuary for a substantial period of time, their growth rate during this time is a valid indication of growth during residency in the estuary. Average size of these fish increased rapidly during their estuarine residence; whereas, the average size of all other groups of fish taken at Jones Beach during the same time period remained relatively constant (Fig. 13).

The evidence supports the conclusion that in the Columbia River, the majority of fall chinook salmon fingerlings remain in the estuary for a relatively short period and that they reside in the main river or tributaries upstream from the estuary until they reach a size range of about 7 to 8 cm. This would account for the similarity in size range of fall chinook salmon entering the estuary during the late spring and early summer. The rapid increase in the size of fish entering the estuary after mid-July is probably due to improved conditions (such as warmer water temperatures) for growth in the upriver rearing areas.

## Relative Survival of Hatchery Fall Chinook Salmon

Ebel (1970) reported a significant increase in survival of hatchery fall chinook salmon fingerlings transported from an upriver hatchery and released below Bonneville Dam over survivals from conventional releases at the hatchery.

Estimates of relative survival during passage to the estuary of hatchery fall chinook salmon released at various points in the river from 1968 to 1970 are shown in Tables 11, 12, and 13. In each instance, the relative survival was increased by transporting the fish to a point below Bonneville Dam for release. Relative survival rates of seven experimental groups of branded fall chinook salmon released below Bonneville Dam are compared to a duplicate

Table 10.-- Passage time of 16 groups of marked hatchery fall chinook salmon from Jones Beach to Clatsop Spit, Oregon (74 km) 1970.

| Hatchery of origin | Date of first arrival at Jones Beach | Date of first arrival at Clatsop Spit | Passage time (days) |
|---|---|---|---|
| Oxbow | 18 May | 22 May | 4 |
| Oxbow | 18 May | 22 May | 4 |
| Oxbow | 20 May | 26 May | 6 |
| Oxbow | 23 May | 27 May | 4 |
| Spring Creek | 25 June | 29 June | 4 |
| Spring Creek | 25 June | 29 June | 4 |
| Spring Creek | 25 June | 28 June | 3 |
| Spring Creek | 27 June | 30 June | 3 |
| Little White Salmon | 25 June | 29 June | 4 |
| Little White Salmon | 26 June | 28 June | 2 |
| Little White Salmon | 25 June | 28 June | 3 |
| Little White Salmon | 25 June | 1 July | 6 |
| Little White Salmon | 26 June | 2 July | 6 |
| Little White Salmon | 26 June | 30 June | 4 |
| Little White Salmon | 28 June | 29 June | 1 |
| Little White Salmon | 28 June | 30 June | 2 |

Table 11.-- Recovery rate and relative survival of branded groups of hatchery fall chinook salmon at Jones Beach, Oregon, 1968.

| Hatchery of origin and release point | Size at release | Release date | Recovery rate (%) | Relative survival' rate (%) |
|---|---|---|---|---|
| Little White Salmon [a] | | | | |
| Hatchery | 110/lb | 22 June | 0.27 | 45 |
| Below Bonneville Dam | 107/lb | 24 June | 0.56 | 93 |
| Beaver, Oregon | 103/lb | 27 June | 0.60 | 100 |
| Oxbow | | | | |
| Hatchery | 72/lb | 4 June | 0.05 | 45 |
| Below Bonneville Dam | 72/lb | 5 June | 0.11 | 100 |
| Ringold | | | | |
| Hatchery | 62/lb | 14 May | 0.01 | 6 |
| Below Bonnevil | 62/lb | 16 May | 0.16 | 100 |

[a] Data reported by Ebel (1970).

Table 12.-- Recovery rate and relative survival of branded groups of hatchery fall chinook salmon at Jones Beach, Oregon, 1969.

| Hatchery of origin and point of release | Size at release (no./lb) | Release date | Recovery rate(%) | Relative survival rate (%) |
|---|---|---|---|---|
| Little White Salmon | | | | |
| Hatchery | 109 | 24 June | 0.13 | 57 |
| Below Bonneville Dam | 109 | 25 June | 0.20 | 87 |
| Rainier, Oregon | 109 | 27 June | 0.23 | 100 |
| oxbow | | | | |
| Bonneville Spillway | 85 | 19 May' | 0.31 | 38 |
| Below Bonneville Dam | 85 | 19 May | 0.29 | 35 |
| Rainier, Oregon | 85 | 20 May | 0.82 | 100 |
| Ringold | | | | |
| Hatchery | 65 | 12 May | 0.02 | 18 |
| Below Bonneville Dam | 65 | 16 May | 0.11 | 100 |

Table 13.-- Recovery rate and relative survival of branded groups of hatchery fall chinook salmon at Jones Beach, Oregon, 1970.

| Hatchery of origin and release point | Size at release | Release date | Recovery rate (%) | Relative survival rate (%) |
|---|---|---|---|---|
| Little White Salmon | | | | |
| Group 1 | | | | |
| Hatchery | 65/lb | 22 June | 0.35 | 40 |
| Below Bonneville Dam | 69/lb | 23 June | 0.38 | 44 |
| Rainier, Oregon | 69/lb | 25 June | 0.87 | 100 |
| Group 2 | | | | |
| Hatchery | 110/lb | 22 June | 0.49 | 66 |
| Below Bonneville Dam | 126/lb | 23 June | 0.59 | 80 |
| Rainier, Oregon | 126/lb | 27 June | 0.74 | 100 |
| Spring Creek | | | | |
| Group 1 | | | | |
| Hatchery | 109/lb | 14 April | 0.94 | 91 |
| Rainier, Oregon | 92/lb | 20-21 April | 1.03 | 100 |
| Group 2 | | | | |
| Hatchery | 43/lb | 22 June | 0.09 | 31 |
| Rainier, Oregon | 39/lb | 24-26 June | 0.29 | 100 |
| Group 3 | | | | |
| Hatchery | 67/lb | 22 June | 0.19 | 86 |
| Rainier, Oregon | 68/lb | 24-26 June | 0.22 | 100 |

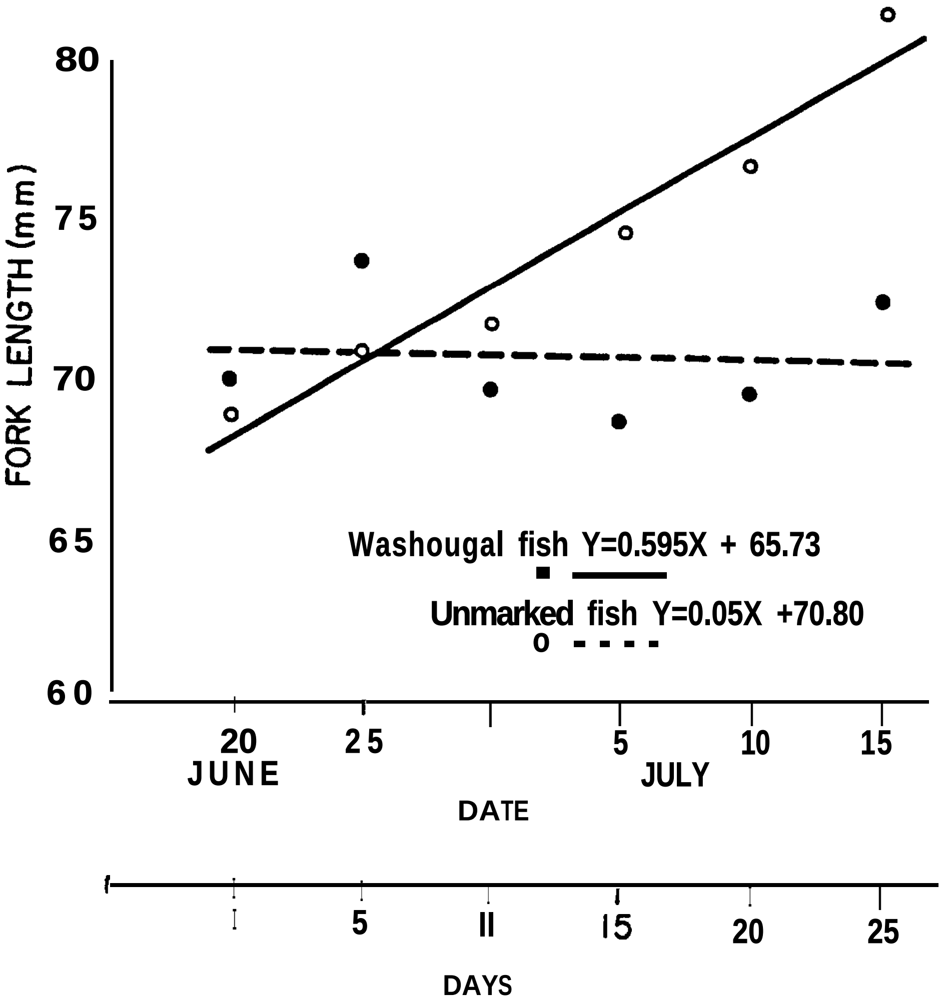



Figure 13.--Size comparison of branded Washougal Hatchery fall chinook salmon and the unmarked fall chinook salmon catch at Jones Beach, Oregon, 20 June-15 July 1969.

hatchery release in Table 14. The increase in survival of transported fish over those released at the hatchery ranged from 4 to 96%. Transporting fish from Ringold Ponds (490 km from river mouth) for release below Bonneville Dam resulted in survival increases of 96% in 1968 and 73% in 1969. Transporting fish below the dam from hatcheries located on the Bonneville pool (160 to 192 km from the river mouth) increased survival by 51% in 1968 and 30% in 1969.

## Conclusions

1. Juvenile fall chinook salmon concentrate in shallow near-shore areas of the estuary, and when in deep water areas are generally found within 3 m of the surface.

2. Most movement of juvenile fall chinook salmon through the estuary occurs during daytime.

3. Tidal conditions or direction of flow does not appear to influence die1 movement patterns of juvenile fall chinook salmon in the estuary.

4. Timing of the juvenile fall chinook salmon migration into the estuary is generally bimodal, characterized by an early peak in May and early June, followed by a general decline later in June and a second, usually'larger, peak in July or August.

5. A trend toward later entry of juvenile fall chinook salmon into the estuary was noted. During the period of this study, the percentage of fish entering the estuary in May and June declined, whereas portions entering in August increased significantly.

6. The early release of hatchery fall chinook salmon in 1971 had little affect on temporal distribution of the overall outmigration through the estuary.

7. Larger fall chinook salmon migrants generally move downstream at a faster rate than smaller fish.

8. Juvenile fall chinook salmon released from hatcheries near the estuary generally move downstream at a slower rate than those released from hatcheries more distant from the estuary.

9. Average sizes (7 to 8 cm) of juvenile fall chinook salmon entering the estuary remain relatively constant from mid-May to late July.

10. The majority of juvenile fall chinook salmon rear to smolting size in the river areas above the estuary.

11. Most juvenile fall chinook salmon migrate rapidly through the estuary.

Table 14.-- Increases in survival of juvenile hatchery reared fall chinook salmon resulting from transporting fish to release sites below Bonneville Dam, 1968-70.

| | 1968 | | 1969 | | 1970 | |
|---|---|---|---|---|---|---|
| Hatchery of origin | Size of fish | Increased survival (%) | Size of fish | Increased survival (%) | Size of fish | Increased survival (%) |
| Little White Salmon | 107/lb | 48 | 109/lb | 30 | 69/lb | 4 |
| | - | - | - | - | 126/lb | 14 |
| Oxbow | 72/lb | 55 | - | - | - | - |
| Ringold | 62/lb | 96 | 65/lb | 73 | - | - |

12. Transporting juvenile fall chinook salmon from hatcheries above Bonneville Dam to release sites below the dam increases fingerling survival to the estuary. Generally, fish transported from more distant rearing areas show greater survival benefits than those transported from hatcheries nearer the estuary.

# SECTION II--COHO SALMON, 1966-1971

## Introduction

The coho salmon is an important commercial and recreational species the Columbia River and its tributaries for spawning and presmolt rearing. Drawing from several sources, Pruter (1966) devised a table which showed the annual average coho salmon landings in terms of pounds from 1893 to 1963. The peak landings of coho salmon occurred between 1921 and 1930 with an average of 6,000,OOO pounds (2,722,OOO kg) taken annually. Landings decreased progressively until 1956-60, when an average of only 300,000 pounds (136,000 kg) were taken. Assuming an approximate average weight of 10 lb (4.5 kg) per fish, coho salmon landings were reduced from 600,000 to 30,000 fish.

Many factors together with the commercial harvest affected the Columbia River coho salmon stocks. Silt-choked gravel beds and log jams in streams from early forest harvesting reduced the spawning areas and limited food production during the rearing period. Low head hydroelectric dams impaired adult and juvenile migrations directly and indirectly, whereas some multipurpose high head storage dams completely blocked adult spawning migrations. Commercial trolling and recreational ocean fishing contributed to losses, since many immature, sublegal fish are caught and mortally injured before being released (Parker et al. 1959; Milne and Ball 1956). Additional causes for the decline in the number of coho salmon include municipal and industrial pollution, pesticide usage, nitrogen supersaturation, and hydrothermal conditions. Despite these negative factors, the decline in coho salmon numbers was reversed in the early 1960s. The run has subsequently averaged 265,000 fish landed from 1964 to 1974, with a high of 521,000 in 1970 and a low of 125,000 fish in 1968.

An improved hatchery diet which sustained the juvenile fish until their yearling migration is credited as the single most important factor in the improved coho salmon runs. Cleaver (1969b) determined the benefits from various coho hatcheries in the Columbia River system appeared to be well in excess of their costs. Haw and Mathews (1969) reported that the technological advances in the rearing of coho salmon resulted in returns far exceeding the rearing capacity of the hatcheries.

Since the early 1960s, the number of coho salmon returning to hatcheries has increased substantially, while their presence in selected natural spawning tributaries has decreased according to tables prepared by Gunsolus and Wendler (1975). Pollution control, restricted use of pesticides, improved forest harvesting techniques, updated designs for fish passage facilities at dams, and reduction in supersatuation of dissolved atmospheric gas in the water downstream from dams are all continuing improvements that should result in increased survival of coho salmon. However, while coho salmon have increased numerically from their Low point in the 1950s, they have not reached the magnitude of earlier runs. One possibility for the apparent leveling off of the coho resurgence might be attributed to problems encountered by smolts during their migration to the sea. This section presents data collected from 1966 through 1971 on juvenile coho salmon migrations.

## Methods

Beach seines were used to capture samples of juvenile coho salmon in the Columbia River. A detailed description of the net and technique used to make sets is given by Sims and Johnsen (1974).

Sampling sites for the study are shown in Figure 14. The locations varied during 1966 and 1967, but from 1968 through 1971, the primary site was at Jones Beach. Sites at nearby Puget Island and Cape Horn Beach on the Washington shore were sampled frequently during the first 3 years of the study (Table 15). Seining at those locations consistently resulted in a smaller catch per set than at Jones Beach. Size range, species composition, and other catch characteristics were similar at all sites.

Until April 1968, the seine crew examined and recorded their catch. Beginning in May 1968, a separate crew was used to process fish and record data. In both situations, all juvenile salmon and trout were anesthetized with MS-222 (tricaine methanesulfonate), identified, enumerated by species, and examined for marks; individuals from a subsample were measured for fork length. Fish were held until they completely recovered from the anesthetic and then were returned to the river. Use of a separate processing crew resulted in a greater number of sets being made at a site and reduced the time that the fish were held under stress.

Juvenile coho salmon were also taken by purse seining in the navigation channel of the river adjacent to Jones Beach (Johnsen and Sims 1973). Purse seining effort was consistent for only 2 years in the area and for that reason little information from that effort is included in this report. Coho salmon data from purse seine catches were in agreement with those from the beach seine catches.

## Results and Discussion

### Annual and Monthly Catches

Juvenile coho salmon are abundant in the Columbia River estuary from mid-April to early June and are present in small numbers through the remainder of the year. Beach seining captured 110,421 juvenile coho between 1966 and 1971. Monthly and annual catches are presented in Table 16. Our largest annual catch was in 1970 when 45,146 fish were caught and the least was in 1967 when we took only 5,792 coho salmon. Sampling effort, in seine sets per month, provides a basis for annual comparison, but caution is advised in interpreting these results. Catch alone should not be construed as an annual index of abundance. Major considerations in this study are the variation in seine sites in 1966 and 1967 and the frequency of seine sets during the period of maximum availability. Monthly averages show that most coho salmon were caught in May followed by April and June in that order. The large monthly catch in August 1969 was a

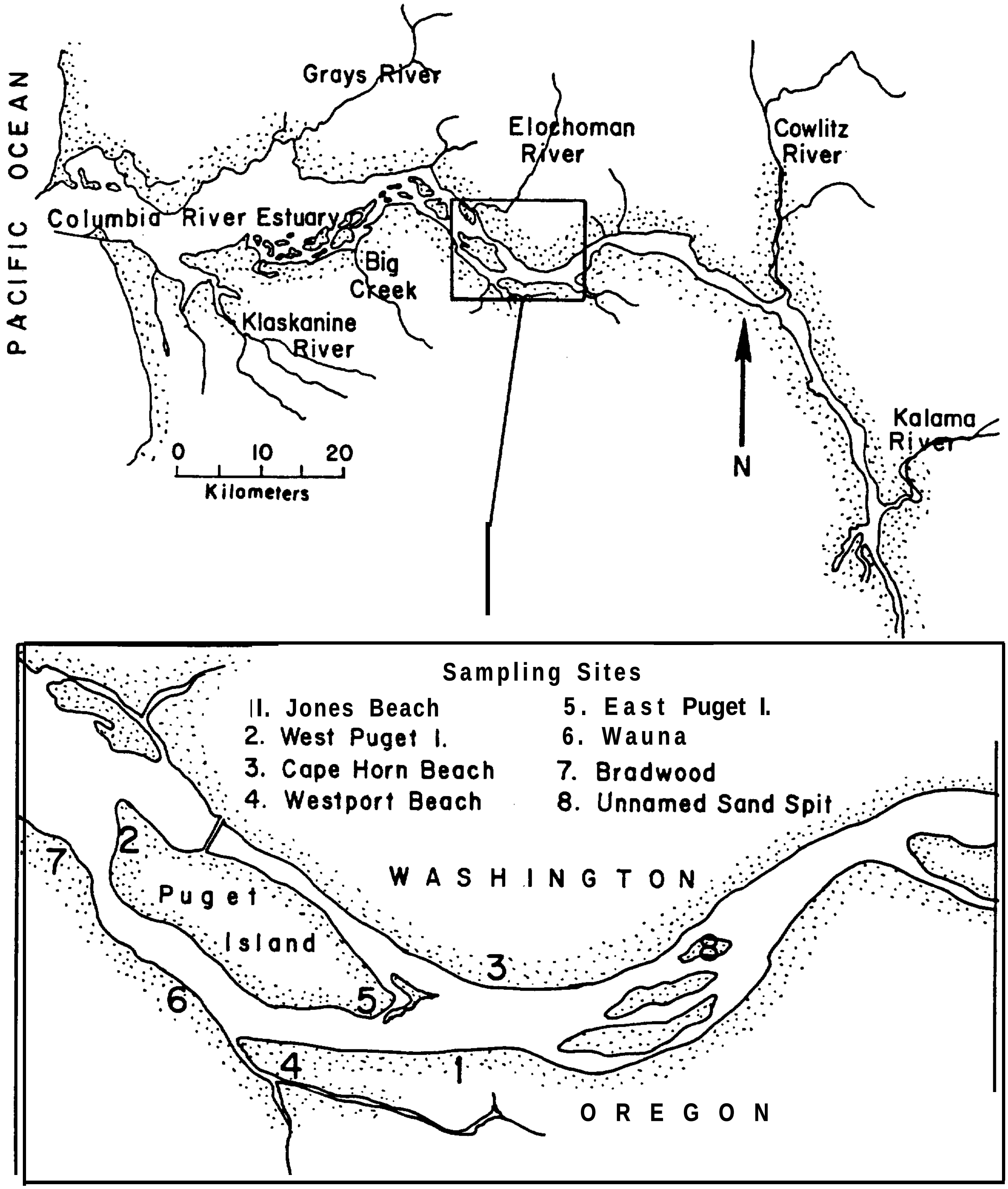



Figure 14 .--Map of lower Columbia River with inset showing location of sampling sites used in the upper estuary between 1966 and 1971.

Table 15.--Sampling effort in the upper Columbia River estuary, April through June, 1966-71.

| Year | Principal sampling sites | Secondary sampling sites | No. of work shifts | Daily sampling period | Sampling days per week | Sets per day |
|---|---|---|---|---|---|---|
| 1966 | West. Puget Is. | Westport Beach<br>Jones Beach<br>Unnamed Sand Spit | 2 | 0800-1600 | 5 | 3 to 10 |
| 1967 | West. Puget Is.<br>Jones Beach | East Puget Is.<br>Bradwood Beach<br>Westport Beach<br>Wuana<br>Cape Horn Beach | 2 | 0800-1600 | 5 | 3 to 10 |
| 1968 | Jones Beach<br>Cape Horn Beach | West. Puget Is.<br>East. Puget Is. | 2 | (0800-1600 until mid-May)<br>(0500-1100 after mid-May) | 5<br>7 | 9<br>9 |
| 1969 | Jones Beach | Cape Horn Beach | 1 | (0800-1600 until mid-May)<br>(0500-1100 after mid-May) | 5<br>7 | 12<br>12 |
| 1970 | Jones Beach | Cape Horn Beach | 2 | 0500-1200<br>1300-2000 | 7 | 24 |
| 1971 | Jones Beach | None | 1 | 0500-1200 | 5 | 12 |

Table 16.--Results of beach seine sampling for juvenile coho salmon in the Columbia River estuary, 1966.

| | 1966 | | | 1967 | | | 1968 | | | 1969 | | | 1970 | | | 1971 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | No. sets | No. coho | CPS[a/] | No. sets | No. coho | CPS | No. sets | No. coho | CPS | No. sets | No. coho | CPS | No. sets | No. coho | CPS | No. sets | No. coho | CPS |
| Jan | -- | -- | -- | -- | -- | -- | 4 | 0 | 0.0 | 19 | 0 | 0.0 | -- | -- | -- | -- | -- | -- |
| Feb | -- | -- | -- | 50 | 1 | 0.0 | 12 | 1 | 0.1 | 31 | 3 | 0.1 | -- | -- | -- | -- | -- | -- |
| Mar | 66 | 0 | 0.0 | 92 | 14 | 0.2 | 69 | 78 | 1.1 | 60 | 3 | 0.1 | -- | -- | -- | -- | -- | -- |
| Apr | 217 | 3,547 | 16.3 | 104 | 271 | 2.6 | 227 | 1,831 | 8.1 | 165 | 4,831 | 29.3 | 386 | 9,826 | 25.5 | 80 | 3,017 | 37.7 |
| May | 320 | 3,851 | 12.0 | 104 | 5,283 | 50.8 | 372 | 6,172 | 16.6 | 320 | 18,973 | 59.3 | 673 | 34,771 | 51.7 | 168 | 10,484 | 62.4 |
| Jun | 398 | 86 | 0.2 | 405 | 185 | 0.5 | 525 | 255 | 0.5 | 637 | 1,114 | 1.7 | 674 | 510 | 0.8 | 240 | 118 | 0.5 |
| Jul | 83 | 7 | 0.1 | 315 | 37 | 0.1 | 589 | 68 | 0.1 | 697 | 79 | 0.1 | 597 | 29 | 0.0 | 187 | 55 | 0.3 |
| Aug | -- | -- | -- | 17 | 1 | 0.1 | 214 | 1 | 0.0 | 406 | 4,745 | 11.6 | 178 | 10 | 0.1 | -- | -- | -- |
| Sep | -- | -- | -- | -- | -- | -- | -- | -- | -- | 163 | 67 | 0.4 | -- | -- | -- | -- | -- | -- |
| Oct | -- | -- | -- | -- | -- | -- | -- | -- | -- | 78 | 27 | 0.3 | -- | -- | -- | -- | -- | -- |
| Nov | 11 | 3 | 0.3 | -- | -- | -- | 48 | 25 | 0.5 | 33 | 0 | 0.0 | -- | -- | -- | -- | -- | -- |
| Dec | 9 | 38 | 4.2 | -- | -- | -- | 34 | 4 | 0.1 | 12 | 0 | 0.0 | -- | -- | -- | -- | -- | -- |
| Total | 1,104 | 7,532 | 6.8 | 1,087 | 5,792 | 5.3 | 2,094 | 8,435 | 4.0 | 2,621 | 29,842 | 11.4 | 2,508 | 45,146 | 18.0 | 675 | 13,674 | 20.3 |

a/ CPS = catch per set.

result of a large release of hatchery fish (subyearling coho salmon) in late July by the Washington Department of Fisheries into the Columbia River above our sampling site. With this exception, our catch records show consistently high captures relative to expended effort in the spring of each year, but relatively insignificant numbers during winter, summer, and fall.

## Timing of Annual Migration

The annual peak in the daily catch per set (CPS) of coho salmon (averages of all seine sets in that day) occurred within a 12-day period over the 6-year study (Fig. 15). Peak CPS occurred in the upper estuary of the Columbia River between 5 and 16 May of each year; 10 May most likely approximates the average, as all annual peaks occurred within 6 days before or after this date.

The date of peak migration may be determined on a basis other than CPS. Figure 16 shows daily total catches in percentages of the annual total catch. Less than 5% of the coho salmon reached the estuary before 17 April. Each year the midpoint of the migration was reached between 2 and 13 May. The yearling smolt migration was 95% complete between 19 and 31 May. Thus, both the daily percentage of the total CPS and the average daily catch indicated that the annual migration of coho salmon smolts in the Columbia River was compact, consistent, and comparable through the 6-year investigation.

The chronological similarity of annual peak catches in the upper estuary is particularly interesting since many widely separated hatcheries and tributaries contribute to the total migration. Fulton (1970) listed 39 Columbia River streams and 62 of their tributaries that now have or have had spawning runs of coho salmon. He also reported that 78 of these presently have spawning areas. More important numerically are coho salmon reared at as many as 19 different Columbia River hatcheries, though not all of these hatcheries produce coho salmon every year. Considering the number of diverse systems contributing to the migration, and differences in river discharge between years, it is remarkable that coho salmon smolt migrations into the estuary were so consistent in their timing.

The timing of migrations of juvenile coho salmon coincides with movement reported in other widely separate geographic areas. Shapovalov and Taft (1954) presented tables showing that the peak migration of juvenile coho salmon occurred from 6 to 12 May during a 9-year study of Waddell Creek, California. Chamberlain (1907) reported a heavy migration of yearling coho salmon into seawater in May of 1903 and 1904 in southeastern Alaska. Peck (1970) found that most coho salmon smolts left a Lake Superior tributary within a week of planting on 16 and 17 May. Salo (1955) reported the peak seaward migration of juvenile coho salmon in Minter Creek, a tributary of Puget Sound in Washington, occurred in early May.

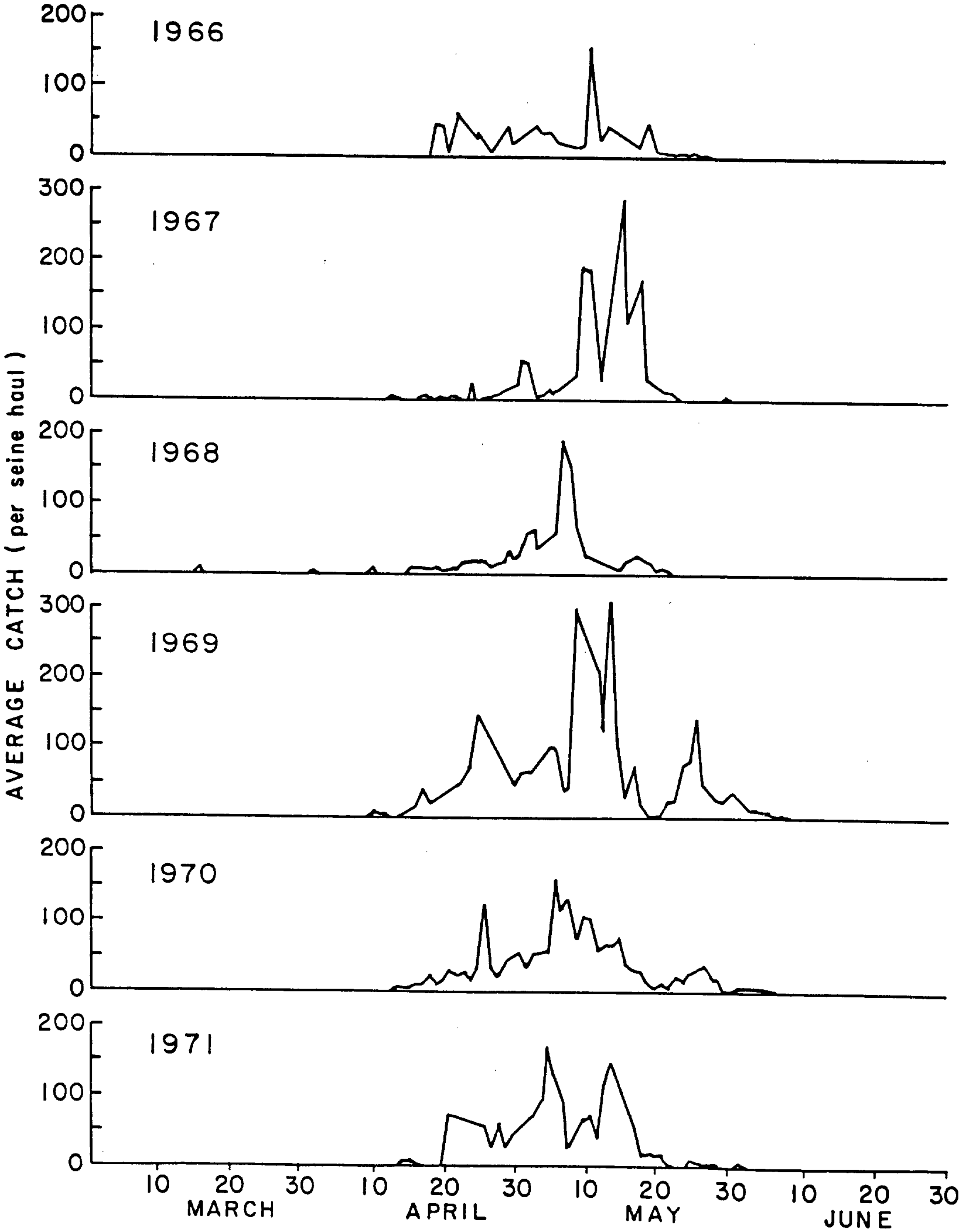



Figure 15.--Average daily beach seine catches of juvenile coho salmon at sites in the upper Columbia River estuary (1966-71).

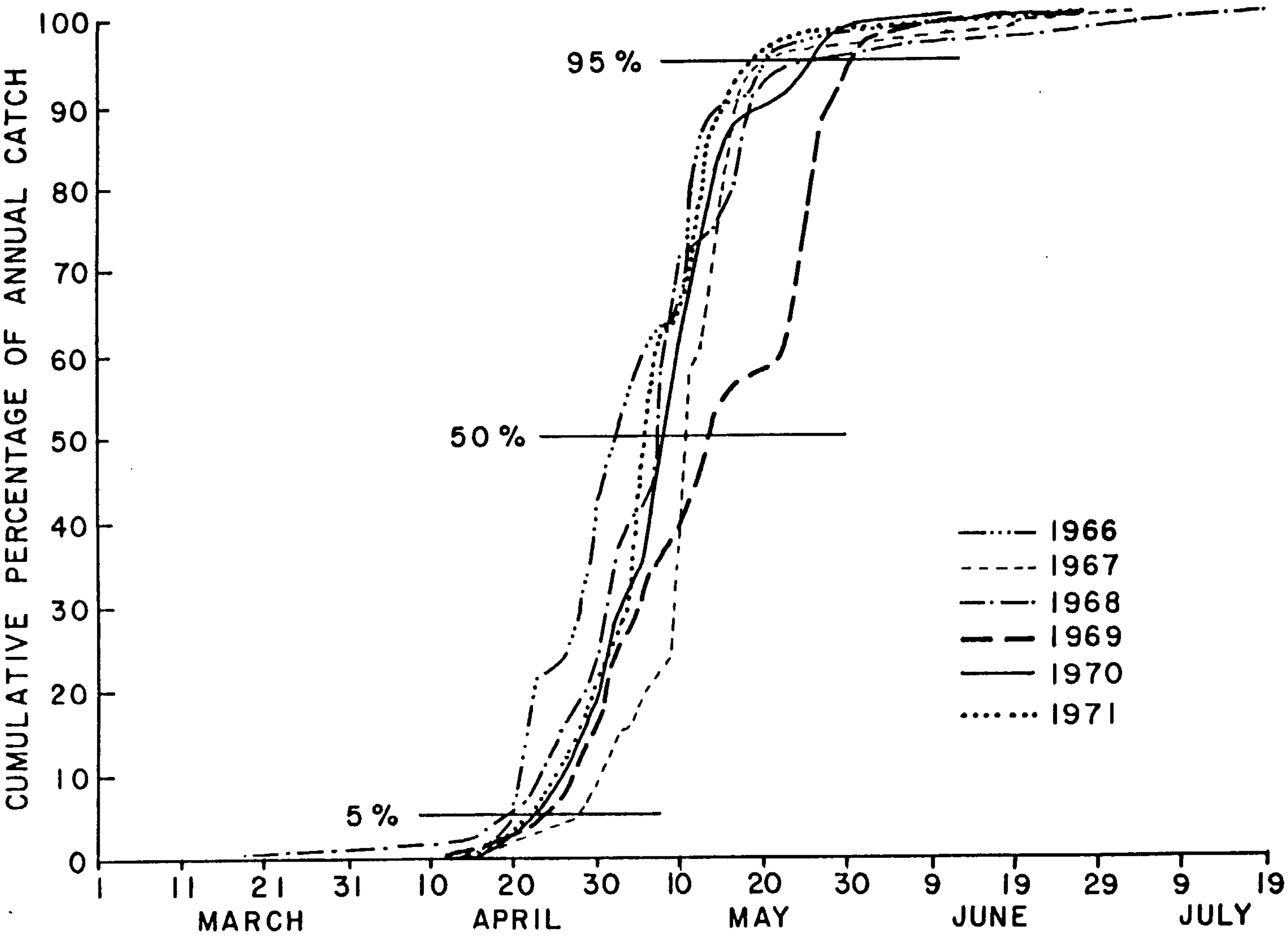



Figure 16 .--Daily total seine catch of juvenile coho salmon in the upper Columbia River estuary (expressed in percentage of the annual catch), 1966-71.

Hartman et al. (1967) compared timing of sockeye salmon, 0. *nerka,* smolts with the latitude of their nursery areas and determined photoperiodism to be an overriding stimulus for downstream migration. Such a relation for coho salmon smolts is not apparent because their migration seems to occur at a similar time irrespective of latitude.

Water temperature may be a factor that influences the timing and movement rate of coho smolts (Fig. 17). During the study, water temperatures would generally rise from approximately $10^{o}$ C in early April to $16^{o}$-$18^{o}$ C in late June. Temperatures at peak migrations ranged from $11.3^{o}$ C (1970) to $14.7^{o}$ C (1967). Water temperatures in 1969 generally lagged behind those in other study years; coincidently, progression of the smolt migration in that year was somewhat later than in other years of this study (Fig. 16). The relation of temperature to timing of migration, however, is not precise and can only be suggested.

No consistent relation was found between flow volume of the Columbia River and timing of juvenile coho salmon (Fig. 17). In 1966, 1969, and 1971, the period of peak arrival of coho generally corresponded with increasing river flows. In 1967, 1968, and 1970, however, increased river flows began after the migratory peak had passed. Recovery of marked coho salmon released from Cowlitz Hatchery in 1969, 1970, and 1971 indicated a variation in rate of movement of only 2 km per day for seven separate groups of coho salmon. It appears, therefore, that since the timing of the coho salmon migration was generally consistent over the study period and the volume of river flow was substantially different during the 6-year investigative period, timing of the migration is not dependent upon volume of river flow.

The possibility that the time of release of coho salmon from the various hatcheries influenced the time of peak migration into the estuary also was examined. Timing of releases from the 19 coho salmon hatcheries varied oonsiderably within and between years. Major releases ranged from January to May. March was the principal month for juvenile releases in 1966 and 1967, whereas the major releases from 1968 to 1971 were in April. Based on recoveries at Jones Beach, early release of coho salmon from the hatcheries failed to result in a correspondingly early seaward migration. For this reason, the March to May release time suggested by Wallis (1968) for hatchery coho salmon might be modified to a mid-April to May schedule if direct seaward migration is desired.

Zaugg (1970) discussed the migratory timing of juvenile coho salmon in several Pacific Northwest streams and found a corresponding seasonal change in gill $Na^{+}$-$K^{+}$ ATPase. He interpreted increases of $Na^{+}$-$K^{+}$ ATPase (in late March) as an indication of biological readiness for seawater and decreases (July) as indicative of a loss of urge to move seaward. The timing data from our catches of yearling coho salmon entering the Columbia River estuary are generally in agreement with this observation. However, subyearling coho salmon reared in a hatchery and released in late July also moved toward the estuary in large numbers. On 28 July 1969, the Washington

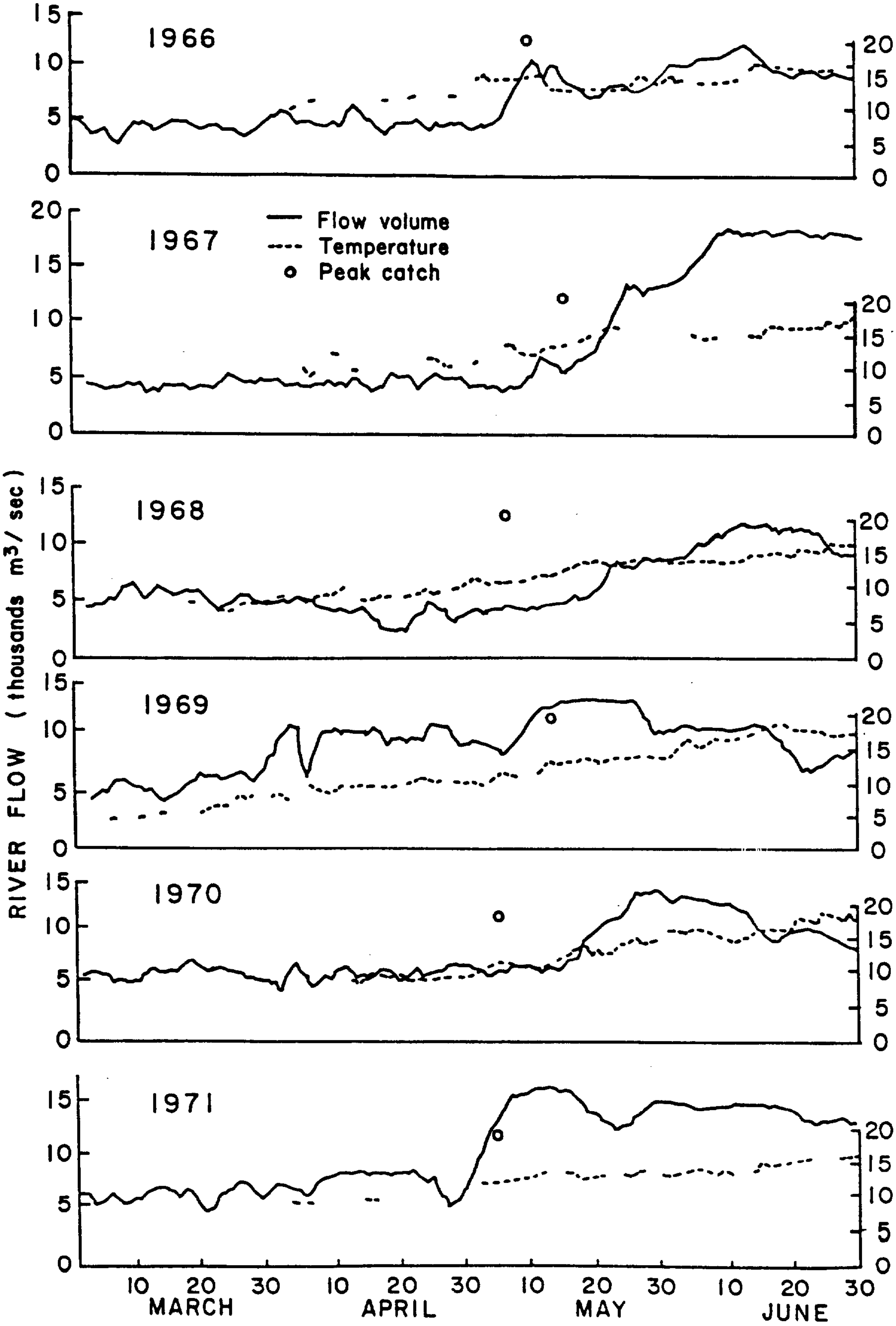



Figure 17.--Columbia River flows (U.S. Geological Survey 1965-1971), water temperatures at Jones Beach, and dates of peak catch for the spring migration, 1966-1971.

Department of Fisheries released 742,218 subyearling coho salmon at Rainier, Oregon, 28 km above Jones Beach. We captured 4,817 of these fish during the following few weeks (although they were not marked, individuals from this group were easily identified from size and dates of recovery). The fish averaged 80 mm in length and were from 50 to 100 mm long. Since these fish were not marked and were released directly into the Columbia River, evaluation of adult contribution to the fisheries was not possible.

Since many hatchery releases of yearling coho salmon made before mid-April apparently did not move directly and rapidly to the estuary, their behavior during the interim period is of interest. Chapman (1962) found that aggressive behavior caused some wild coho salmon (i.e., nonhatchery fish) in small streams to migrate downstream early. Chapman (1965) also noted that relatively large freshets in small streams caused downstream movement of wild coho salmon. Continuance of such movement to the estuary was not indicated at Jones Beach. We did learn that some hatchery reared coho salmon released before May in tributary streams downstream from Jones Beach moved upstream. Recovery of these marked fish at Jones Beach is shown in Table 17. Unfortunately, there were no distinctively marked fish released after 1 May below Jones Beach. Jones Beach is from 10 to 80 km upstream from the indicated release sites of the hatcheries. No marked coho salmon were released below our sampling sites in 1966, but from 1967 through 1970 marked fish were released in the lower area, and upstream movement was indicated each year. Although coho salmon were released in the lower estuary in 1971, no assessment was made since the only fin-clip release made below our site also coincided with similarly marked coho salmon released upstream.

## Rates of Movement

Many groups of juvenile coho salmon were marked and released at various state and federal hatcheries during this study. Average rates of movement to the estuary based on distance traveled and time of release have been determined from the analysis of recovery data at the Jones Beach sampling site (Table 18). Releases of identifiable fish ranged from about 63,000 to 742,000 fish. The largest release was the group of unmarked subyearling coho salmon from Lower Kalama Hatchery of the Washington Department of Fisheries. Their distinctive size and time of release in late July 1969 made it possible to readily identify these fish upon recovery. Recoveries of groups of marked fish ranged from 5 to 4,817 individuals. Average travel time to Jones Beach among the 24 specific groups ranged from 3 to 81 days. Average rate of travel ranged from 3 to 26 km per day. Rate of movement was associated with distance traveled. Generally, we found that coho salmon released above Bonneville Dam moved more rapidly than those released at sites below the dam. In an unusual example of travel rate over an extended distance, Witty (1966) found juvenile coho salmon moved from the Wallowa River to Bonneville Dam (about 700 km) at an average rate of 71.3 km per day.

Table 17.--Releases and recoveries of marked coho salmon yearlings moving upstream to Jones Beach.

| Hatchery and release point[a] | Km from Jones Beach (approx.) | Release date | No. marked fish Released | Recovered | Type of finclip mark[b] |
|---|---|---|---|---|---|
| Grays River-WDF | 75 | 23 April 1967 | 35,068 | 1 | D-LV |
| Grays River-WDF | 75 | 23 April 1967 | 36,344 | 1 | D-RV |
| Elochoman-WDF | 75 | 23 April 1967 | 107,227 | 18 | AD-RM |
| Grays River-WDF | 20 | 1 January 1967 | 118,365 | | |
| Big Creek-ODFW | 35 | 27 February 1968 | 123,343 | 69 | |
| Clatskanine-ODFW | 80 | 7 March 1968 | 113,316 | 69 | AD-RM |
| Grays River-WDF | 75 | 15 April 1968 | 63,150 | 69 | |
| Elochoman-WDF | 20 | 16 April 1968 | 88,515 | 69 | |
| Cathlamet-Trans. from Cowlitz-WDF | 10 | 14 April 1969 | 314,639 | 9 | AD-LP |
| Big Creek-ODFW | 35 | 15 April 1969 | 80,957 | 121 | AD and wire ta |
| Big Creek-ODFW | 35 | 15 March 1970 | 73,920 | 123 | AD |
| Grays River-WDF | 75 | 2 April 1970 | 232,081 | 123 | |
| Youngs Bay-Trans. from Little White Salmon-FWS | 60 | 23, 29 April 1970 | 100,662 | 13 | LV |

[a] WDF designates Washington Department of Fisheries, ODFW the Oregon Department of Fish and Wildlife, and FWS the U.S. Fish and Wildlife Service.

[b] AD designates that the adipose fin was removed, D the dorsal fin, RM the right maxillary bone, LP left pectoral fin, LV left ventral fin, RV the right ventral fin.

Table 18.--Rate of movement (from area of release to the Jones Beach sampling site) for various releases of marked hatchery-reared juvenile coho salmon, 1967-71.

| Origin of stock | Agency[a] | Km. to Jones Beach | Mark | Release date | No. released | No. recovered | Rate of recovery per 10,000 | Average no. days to Jones Beach | Movement rate km/day |
|---|---|---|---|---|---|---|---|---|---|
| Leavenworth | FWS | 730 | D-AD | 3/1/67 | 200,000 | 5 | 0.25 | 81 | 9.0 |
| Ringold Ponds | WDF | 490 | LV-LM | 3/24-27/70 | 80,215 | 6 | 0.75 | 22 | 20.0 |
| Ice Harbor | NMFS | 461 | BRAND | 3/24-5/15/67 | 643,123 | 90 | 1.40 | 26 | 17.7 |
| Ice Harbor | NMFS | 461 | BRAND | 3/28-5/1/68 | 505,840 | 152 | 3.00 | 29 | 15.7 |
| Little White | FWS | 190 | RV | 5/12/70 | 100,367 | 112 | 11.16 | 12 | 15.8 |
| Cascade | ODFW | 166 | 1/2 D-LP | 4/5/71 | 88,000 | 41 | 4.66 | 36 | 4.6 |
| Cascade | ODFW | 166 | 1/2 D-P | 4/5/71 | 81,000 | 36 | 4.44 | 34 | 4.7 |
| Leavenworth (Trans. to Bonn. Dam) | FWS | 162 | D-AD-LM | 3/10/68 | 97,000 | 41 | 4.23 | 53 | 3.1 |
| Cascade (Trans. To Tanner Cr.) | ODFW | 162 | RV-RM | 3/29/71 | 100,000 | 28 | 2.80 | 37 | 4.4 |
| Eagle Creek | FWS | 140 | AN | 4/1/68 | 87,000 | 39 | 4.48 | 46 | 3.0 |
| Sandy River | ODFW | 138 | D-LM | 2/20-24/67 | 171,435 | 19 | 1.11 | 40 | 3.5 |
| Ringold Ponds (Trans. to Washougal) | WDF | 132 | LV-RM | 4/14/70 | 63,293 | 93 | 14.69 | 5 | 26.4 |
| Washougal | WDF | 132 | RV | 4/9/71 | 87,876 | 65 | 7.40 | 26 | 5.1 |
| Washougal | WDF | 132 | LV | 4/9/71 | 87,824 | 47 | 5.35 | 26 | 5.1 |
| Cowlitz | WDF | 110 | AD-RV | 4/14/69 | 335,681 | 308 | 9.18 | 32 | 3.5 |
| Cowlitz | WDF | 110 | AD-LV | 4/15/69 | 348,754 | 422 | 12.10 | 22 | 5.0 |
| Cowlitz | WDF | 110 | AD-LV | 4/6/70 | 285,000 | 428 | 15.02 | 27 | 4.0 |
| Cowlitz | WDF | 110 | AD-RV | 4/6/70 | 326,000 | 527 | 16.17 | 31 | 3.5 |
| Cowlitz | WDF | 110 | AD-RP | 4/1/71 | 303,365 | 63 | 2.08 | 37 | 3.0 |
| Cowlitz | WDF | 110 | AD-LP | 4/1/71 | 266,695 | 117 | 4.39 | 34 | 3.2 |
| Cowlitz | WDF | 110 | D | 4/1/71 | 302,695 | 89 | 2.94 | 37 | 3.0 |
| Kalama (Trans. to Rainier, OR) | WDF | 36 | [b] | 7/28/69 | 742,218 | 4,817 | 64.90 | 7 | 5.1 |
| Abernathy | FWS | 28 | AD | 5/28/69 | 78,000 | 1,540 | 197.44 | 3 | 9.3 |

[a] FWS designates the U.S. Fish and Wildlife Service, WDF the Washington Department of Fisheries, NMFS the National Marine Fisheries Service, and ODFW the Oregon Department of Fish and Wildlife.

[b] Not marked but readily identifiable because of small size (0-age). All other releases were yearling fish.

Time of release was another factor influencing the movement rate. Releases of a single stock of marked juvenile coho salmon made in the spring over a 2-month period at Ice Harbor Dam in 1967 and 1968 provided examples of changing rates of movement in relation to time of release. Subsequent recovery of these fish at Jones Beach enabled determinations of travel time. Scientists studying the effects of turbines on salmon smolts released 643,123 marked juvenile coho salmon during an 8-week period in 1967. These coho salmon were released at various times (Table 19) at four sites near Ice Harbor Dam, 461 km above Jones Beach. Recoveries of marked fish indicate that the average number of days required to reach Jones Beach decreased by 30 days from late March to mid-May, resulting in an increase in rate of movement from 11.5 km/day to 46.1 km/day.[2/] Therefore, the average coho salmon released in late March at Ice Harbor Dam would have arrived at Jones Beach in early May; coho salmon released in mid-April would have arrived in mid-May; and those released in mid-May would have arrived in late May. The range of the recovery period was broad for early release groups and narrow for late releases.

An additional 505,840 marked coho salmon were released at Ice Harbor Dam in 1968 (Table 20). Though fewer fish were released, our beach seine effort doubled and, as a result, more marked fish were recovered than in 1967. The release schedule in 1968 began slightly later, was interrupted for 13 days in mid-April, and was completed 2 weeks earlier than in 1967. The average late-March releases appeared at Jones Beach in early May, whereas releases in late April and early May arrived in late May. The range of travel time for each group was again broad for early releases and narrow for late releases. Once again, the rate of movement to the estuary increased as the migratory season progressed, but in 1968 the change was more abrupt between early and late April. The overall average rate of movement decreased slightly in 1968 (15.7 km/day) compared with 1967 (17.7 km/day). Completion of the John Day Dam in spring 1968 impounded over 100 km of free-flowing river and perhaps accounted, in part, for the apparent slower movement of the migration in 1968. Raymond (1968) indicated that rate of movement of yearling chinook salmon through McNary Reservoir was about one-third the rate of movement in free-flowing reaches of the river.

Movement of the 1967 and 1968 releases at Ice Harbor Dam is compared in Figure 18. Plotting the time of release against the average number of days to reach Jones Beach for each of the groups of coho salmon indicates a close agreement between the 2 years of travel times that apparently are a function of time of release.

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2/ Krema, R. F., C. W. Long, and W. M. Marquette, Fishery Biologists, Northwest and Alaska Fisheries Center, Coastal Zone and Estuarine Studies Division, NMFS, NOAA, Seattle, WA 98112, pers. commun. and unpubl. data.

Table 15. Rate of movement and recovery of marked coho salmon fingerlings released at Ice Harbor Dam between 24 March and 15 May 1967 and subsequently recovered at Jones Beach.

| Release period | Number of coho released | Number recovered at Jones Beach | Recovery rate per 10,000 released | Range of days recovered | Days to Jones Beach | Standard deviation | Average km/day |
|---|---|---|---|---|---|---|---|
| 24-27 March | 37,790 | 5 | 1.3 | 31-54 | 40.2 | 8.4 | 11.5 |
| 30 March-3 April | 87,770 | 15 | 1.7 | 32-53 | 38.9 | 7.2 | 11.8 |
| 6-10 April | 97,051 | 21 | 2.2 | 20-46 | 32.3 | 7.5 | 14.9 |
| 14-17 April | 87,295 | 10 | 1.1 | 23-40 | 31.2 | 5.6 | 14.9 |
| 21-24 April | 91,304 | 12 | 1.3 | 17-41 | 23.4 | 6.9 | 20.0 |
| 28 April-May | 89,895 | 5 | 0.6 | 16-25 | 19.0 | 3.5 | 24.3 |
| 5-8 May | 84,574 | 7 | 0.8 | 12-17 | 13.9 | 1.9 | 32.9 |
| 12-15 May | 67,444 | 15 | 2.2 | 3-13 | 9.7 | 2.7 | 46.1 |
| Totals | 643,123 | 90 | | | | | |
| Grand avg. | | | 1.4 | | 26.1 | | 17.7 |

Table 20.--Rate of movement and recovery of marked coho salmon fingerlings released at Ice Harbor Dam between 28 March and 1 May 1968 and subsequently recovered at Jones Beach.

| Release period | Number of coho released | Number recovered at Jones Beach | Recovery rate per 10,000 released | Range of days recovered | Days to Jones Beach | Standard deviation | Average km/day |
|---|---|---|---|---|---|---|---|
| 28 March | 41,987 | 13 | 3.1 | 13 to 59 | 36.2 | 13.5 | 12.8 |
| 1 April | 34,744 | 8 | 2.3 | 32 to 53 | 39.9 | 7.9 | 11.2 |
| 2 April | 34,776 | 5 | 1.4 | 21 to 48 | 35.6 | 10.5 | 13.2 |
| 3 April | 34,786 | 4 | 1.1 | 30 to 51 | 39.0 | 9.2 | 11.8 |
| 4 April | 34,744 | 11 | 3.2 | 27 to 48 | 36.7 | 8.5 | 12.8 |
| 5 April | 34,779 | 7 | 2.0 | 31 to 45 | 35.9 | 5.5 | 12.8 |
| 9 April | 34,789 | 5 | 1.4 | 36 to 45 | 39.2 | 3.8 | 12.5 |
| 10 April | 33,966 | 5 | 1.5 | 34 to 44 | 40.8 | 4.2 | 11.8 |
| 23 April | 62,587 | 16 | 2.6 | 22 to 35 | 28.9 | 3.8 | 15.9 |
| 25 April | 35,971 | 17 | 4.7 | 19 to 33 | 26.0 | 3.9 | 17.7 |
| 26 April | 35,935 | 20 | 5.6 | 18 to 32 | 24.0 | 3.6 | 19.2 |
| 20 April | 32,344 | 11 | 3.4 | 21 to 25 | 22.7 | 1.6 | 20.0 |
| 30 April | 11,982 | 2 | 1.7 | 23 to 24 | 23.5 | 0.7 | 20.0 |
| 1 May | 42,450 | 28 | 6.6 | 19 to 28 | 21.9 | 1.9 | 21.0 |
| Total | 505,840 | 152 | | | | | |
| Grand avg. | | | 3.0 | | 29.4 | | 15.7 |

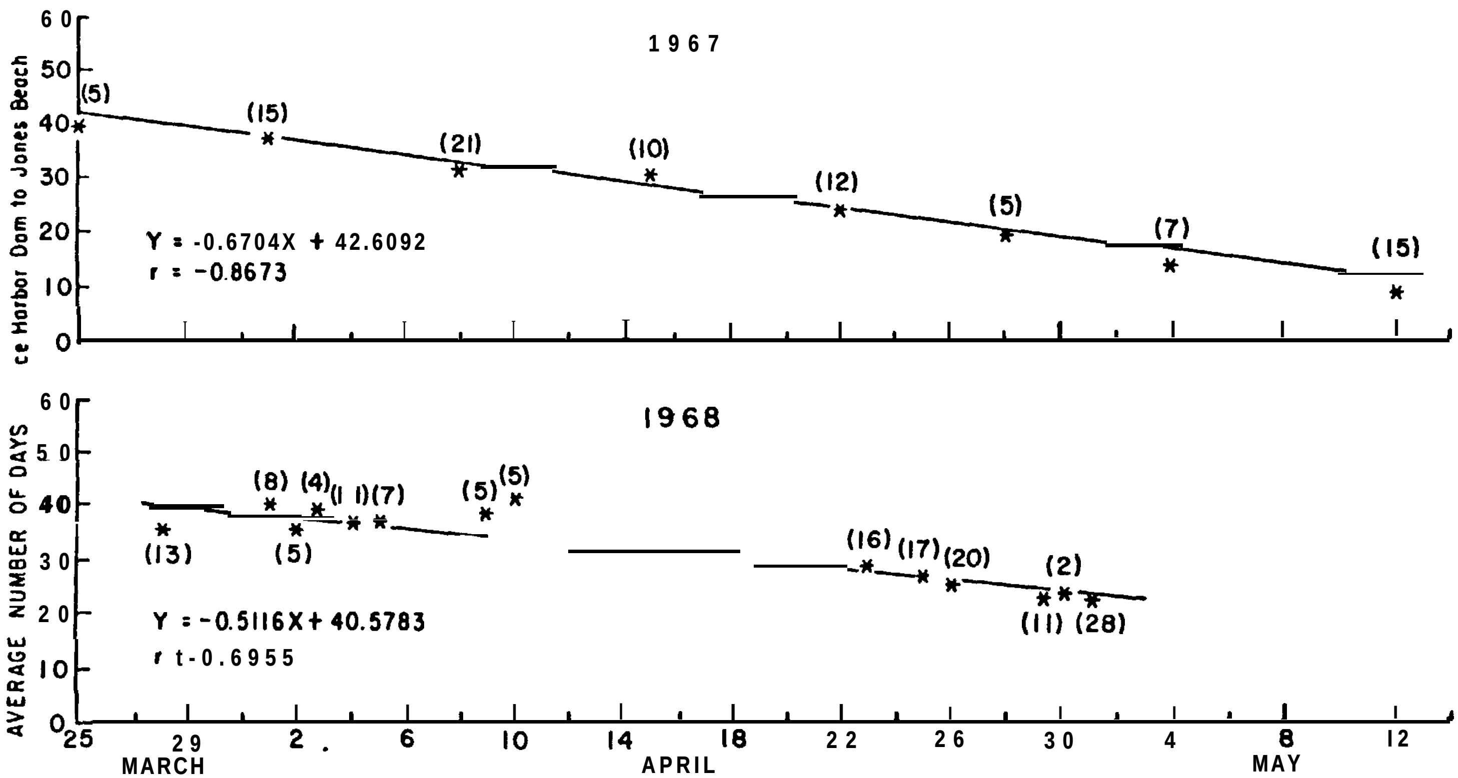



Figure 18--Relation between rate of migration (i.e., the average number of days from time of release at Ice Harbor Dam to time of recovery at Jones Beach) of juvenile coho salmon and the date of their release at Ice Harbor Dam, 1967-68. The number of coho salmon recovered from each release group is shown in parentheses; their average travel time is marked with an asterisk.

## Variation in Hourly Seine Catches

It was apparent from the sampling at Jones Beach that coho salmon smolts were present in greater numbers during midday than dawn or dusk--there was no sampling at night. In 1970, it was possible to assess hourly variations in the catch from 0600 to 1930 h each day throughout the coho salmon migration. The coho salmon were separated from other salmon and the total averaged for each 30-minute seine haul during the principal 3 weeks (26 April-16 May) of the outmigration (Fig. 19). During these 21 sampling days, 34,537 coho salmon were captured, which was 76.5% of the 1970 total catch of that species. Coho salmon were the dominant species of salmon taken in the 3-week period, comprising 65.2% of all salmon captured. Inspection of Figure 19 indicates that coho salmon smolts were captured most frequently between 0830 and 1430 h, and the largest catches occurred at midday. Samples of coho salmon were marked and released in the area with negligible recoveries. We assume, therefore, that coho salmon smolts are not milling in the area but are actively migrating seaward during midday.

## Fish Length in Relation to Seaward Migration

Fork length samples of coho salmon were taken daily and averaged for each year from 1966 through 1971 (Fig. 20). The trend of increasing smolt size is very likely a reflection of the changing rearing techniques at state and federal hatcheries.

Differences in the average length of early and late migrating coho salmon smolts were also apparent. Larger fish (>125 mm) consistently migrated earlier than the smaller migrants (Fig. 21). Shapovalov and Taft (1954), in a 9-year study of Waddell Creek, reported a similar gradual decrease in the average size of coho salmon migrants as the season progressed. Salo and Bayliff (1958), in a coho salmon life history study on Minter Creek, also found large individuals migrating earlier than small fish. Apparently this characteristic is not confined to one species since Shapovalov and Taft noted a similar phenomenon for juvenile steelhead of a given age class, and Hartman et al. (1967) reported that they and other investigators observed a tendency for larger juvenile sockeye salmon to migrate earlier in the season than smaller sockeye salmon.

The trend toward releasing larger coho salmon in recent years has resulted in earlier timing of the peak migrations as well (Fig. 21). For example, fish migrating in 1971 (mean annual fork length, 138 mm) peaked on 5 May, 10 days earlier than those migrating in 1967 (122 mm). Similar relations were also evident in the other years as shown in Figure 22. The strong relation (correlation coefficient, $r = 0.85$) suggests that the mean annual fork length of coho salmon is a factor in the time that they migrate seaward.

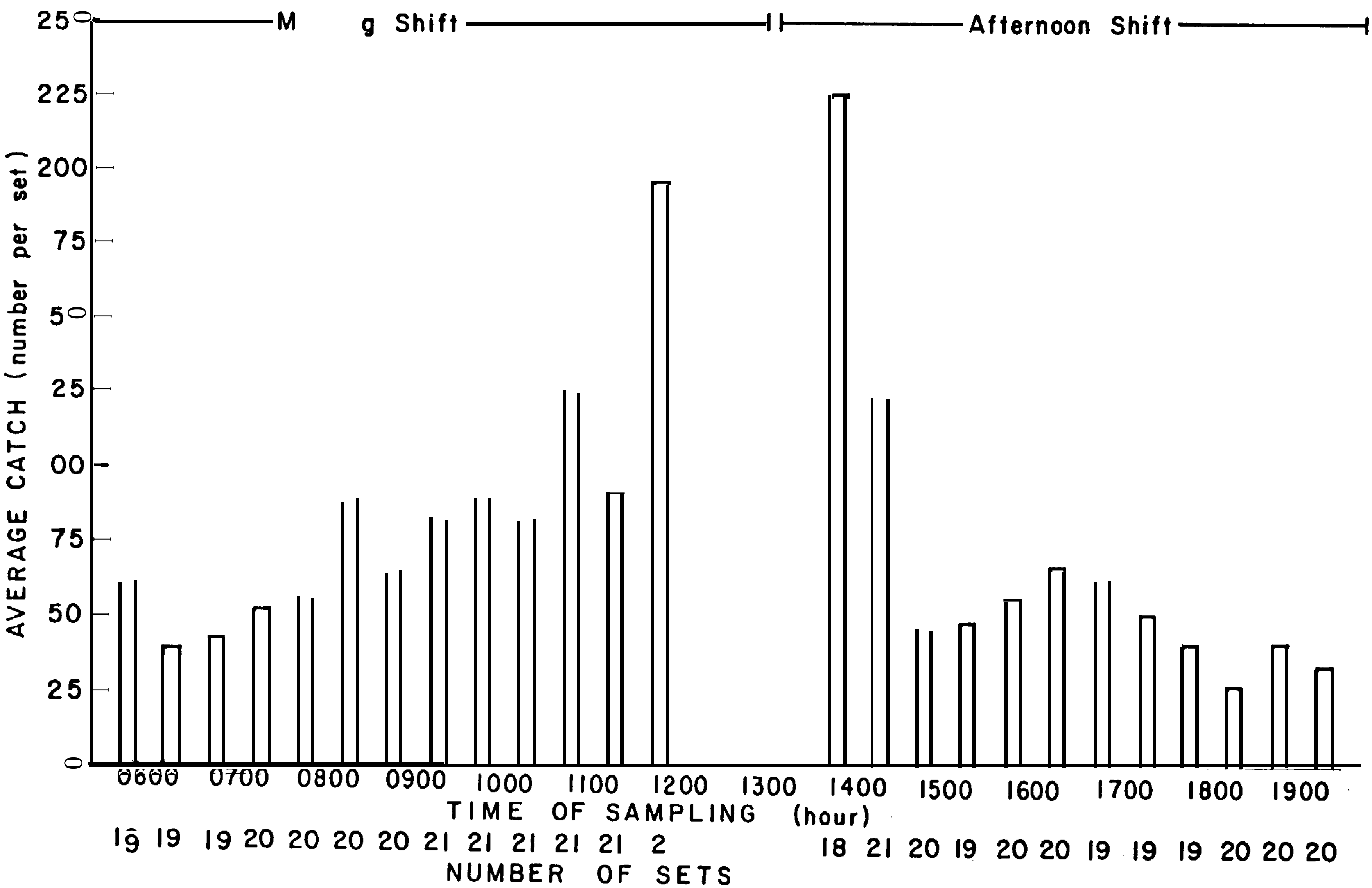



Figure 19.--Average seine catches of juvenile coho salmon per half hour for the 3-week period of maximum availability between 26 April and 16 May 1970.

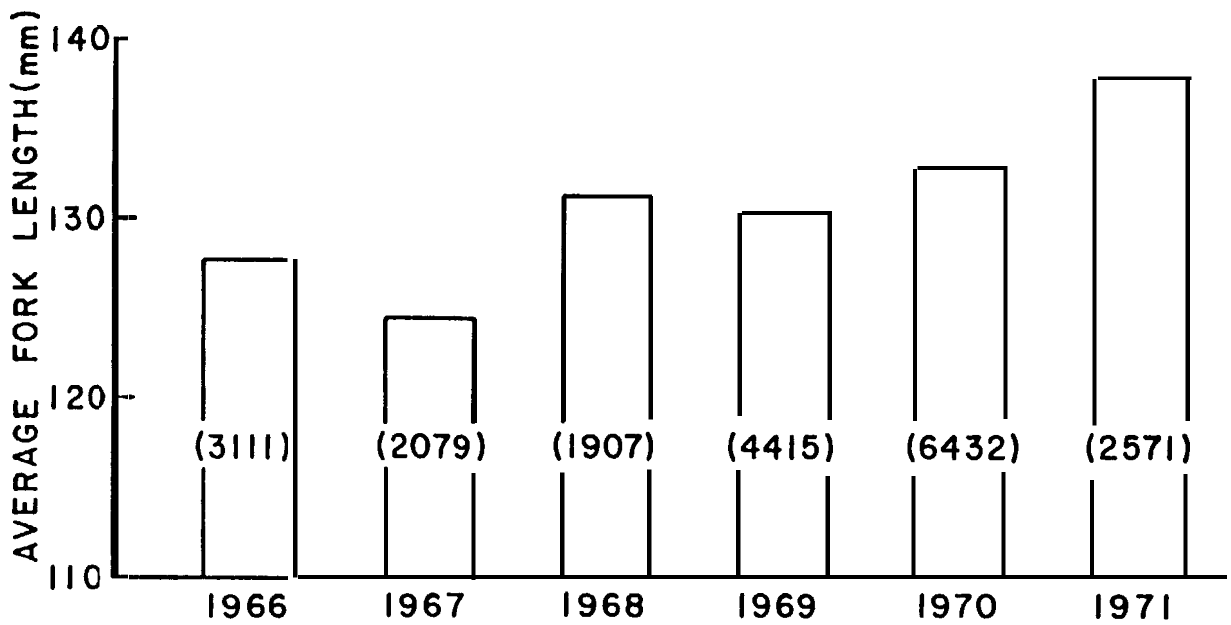



Figure 20 .--Average fork lengths of juvenile coho salmon at time of migration through the upper Columbia River estuary, 1966-71 (sample size in parentheses).

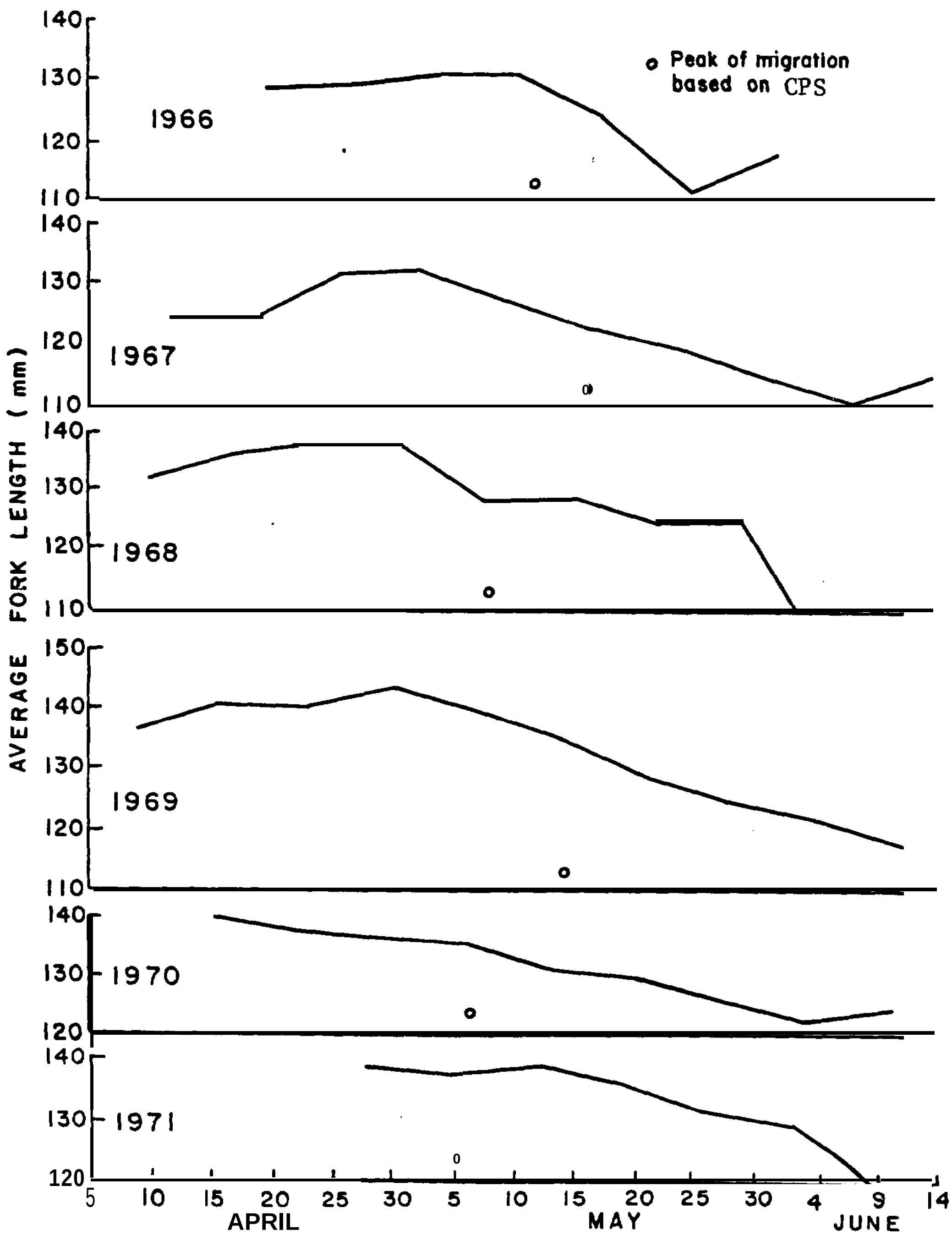



Figure 21 .--Average fork length of juvenile coho salmon captured in the upper Columbia River estuary for each weekly period of the annual smolt migration, 1966-71.

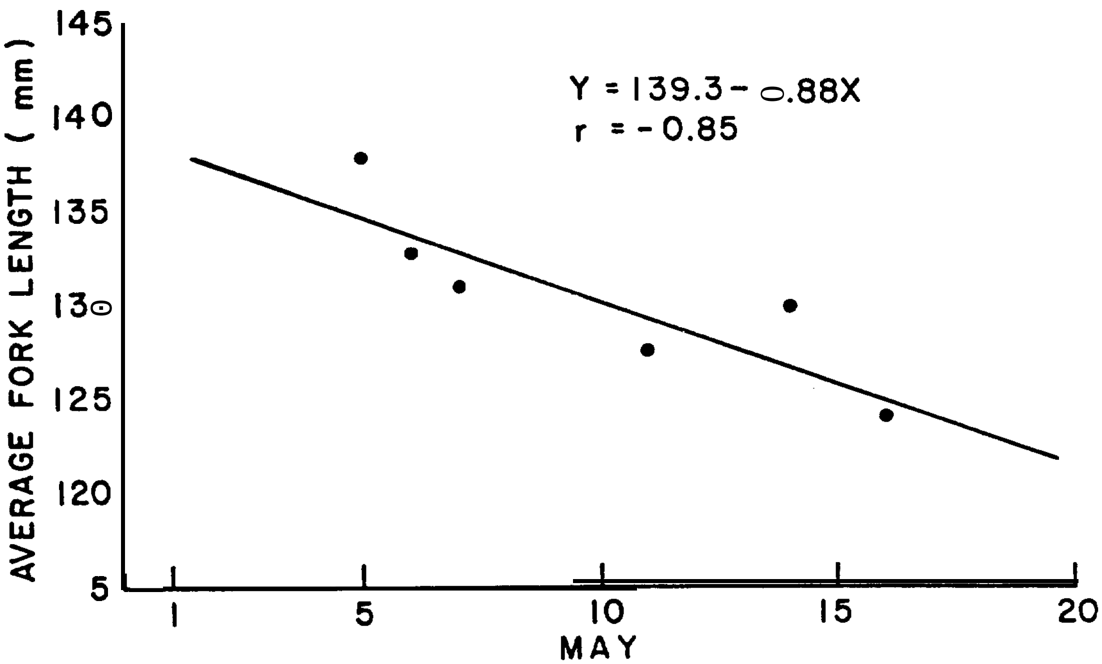



Figure 22 —Relation between annual average fork length of coho salmon smolts and date of annual peak catches at Jones Beach (1966-71).

## Conclusions

1. Juvenile coho salmon migrate into the upper estuary between mid-April and late May.

2. A relationship exists for yearling coho salmon between their rate of seaward movement and the time of their release and the distance migrated to the estuary. Generally, coho salmon released in upper reaches of the Columbia River system moved downstream more rapidly than those released near our sampling site. Also, fingerlings released before mid-April moved at a slower rate than those released in late April or May.

3. Maximum catch abundance occurs around midday (0600 to 2000 h).

4. Improvements in rearing technique and diet at Columbia River hatcheries during the study period appears to have caused an increase in average annual fork length of coho salmon smolts entering the upper estuary; about 10% during this study.

5. Average size of migrants characteristically increases through the migration period; larger coho salmon smolts (> 125 mm fork length) were the first to arrive in the upper estuary and were followed by smaller individuals (< 125 mm).

6. Timing of the annual peak of migration for coho salmon varied in association with annual mean fork length; overall average size for the migrating population increased through the 6 years of study, and the peak of migration came progressively earlier.

# SECTION III--SALMONIDS, 1977-1983

## Introduction

From 1977 through 1983, millions of juvenile salmonids were marked and released from sites throughout the Columbia River basin (Fig. 23 and Table 21). From 2.3 to 5.0% of the migrating juveniles were marked each year to evaluate cultural practices, bypass systems at dams, ocean distribution, contribution to the fisheries, and other factors. Marked fish also provided data to compare timing, movement rates, physical condition, and relative survival differences between stocks following migration to the estuary.

The objectives of Jones Beach sampling varied somewhat from year to year depending on fishery agency requirements and fish groups/stocks released. The general objectives of research from 1977 through 1983 were as follows: (1) define variables affecting timing and movement of juvenile salmonids to and through the estuary; (2) evaluate recovery rates in relation to river flow, release site, release date, cultural treatment, physical traits of migrants, and effects of the 18 May 1980 eruption of Mount St. Helens; (3) evaluate trends of relative survival and relate to survival of adults; and (4) compare wild and hatchery fish stocks.

## Methods

### Sampling

From 1977 through 1983, beach and purse seines were used to sample juvenile salmonids at Jones Beach, (RKm 75) near Woodson, Oregon, (Fig. 24). In some years, additional sites were sampled. In 1978, beach seines were used at Sand Island (RKm 9) and Clatsop Spit (RKm 7); from 1978 to 1980 purse seines were used at McGowan (RKm 16), at incidental sites throughout the estuary, and in the Columbia River ocean plume (24 km radius of the river mouth).

Each year sampling was intensive during spring and summer (7 h/day; 5-7 days/week); additional limited sampling was conducted during fall and winter. Sampling procedures, levels of effort, and catches of marked and unmarked fish are listed and summarized by Dawley et al. (1985a and b).

Beach and purse seine sampling and subsequent examination of juvenile salmonids caused mechanical injury and stress which resulted in immediate (0-20%) and delayed (0-5%) mortality. Delayed mortality was assessed by retaining a random sample of about 50 fish in a net-pen for 24 h, 3 days/week in May and June 1983 and occasionally during other years.

Weather, river, and tidal conditions during sampling affected catches of juvenile salmonids. At Jones Beach, our ability to sample was unimpaired; however, sampling efficiency changed with variations in river flow. Columbia River flow (measured at Bonneville Dam by the U.S. Army Corps of Engineers, 1977-1983) varied widely within and between years (Fig. 25). During the

Table 21.--Origins of marked juvenile salmonids captured during estuarine or ocean sampling, 1977-1983. Footnotes identify organizations responsible for marked fish groups.

| | | |
|---|---|---|
| Abernathy SCDC a/ | Klaskanine Hat. b/ | Rnd. Butte Hat. b/ |
| Alsea Hat. b/ | Klickitat Hat. f/ | Rnd. Butte Ladder b/ |
| Anadromous Inc. c/ | Kooskia Hat. a/ | Roaring River Hat. b/ |
| Aumsville Pd. b/ | Leavenworth Hat. a/ | Rocky Reach Dam k/ |
| Big Creek Hat. b/ | Lewis R. f/ | S. Santiam Hat. b/ |
| Bonneville Hat. b/ | Lewis R. Hat. f/ | S.Fk. Klaskanine Pd. l/ |
| Cascade Hat. b/ | Lit. Goose D. i/ | Sandy Hat. b/ |
| Casey Pd. a/ | Lit. Wh. Sal. Hat. a/ | Satus Cr. h/ |
| Carson Hat. a/ | Lo. Granite D. i/ | Sawtooth Hat. g/ |
| Chelan Hat. d/ | Lower Kalama Hat. f/ | Siletz R. b/ |
| Chinook R. Pd. e/ | Lyons Ferry Hat. a/ | Skamania Hat. d/ |
| Cowlitz Salmon Hat. f/ | Marion Fks. Hat. b/ | Speelyai Hat. f/ |
| Cowlitz Trout Hat. d/ | McCall Hat. g/ | Spring Cr. Hat. a/ |
| Decker Flats Pd. g/ | McKenzie Hat. b/ | Stayton Pds. b/ |
| Deschutes R. b/ | McNary D. i/ | The Dallas D. b/ & i/ |
| Dexter Pd. b/ | Naches Hat. d/ | Toutle Hat. f/ |
| Dry Cr. h/ | Nehalem Hat. b/ | Tucannon Hat. d/ |
| Dworshak Hat. a/ | Nelson Sp. Pd. h/ | Turtle Rock Pd. k/ |
| Eagle Cr. Hat. a/ | Niagara Springs Hat. g/ | Upper Kalama Hat. f/ |
| Elokomin Hat. f/ | Oakridge Hat. b/ | Vanderveldt Pd. l/ |
| Entiat Hat. d/ | Oak Springs Hat. b/ | Villiard Slough a/ |
| Gnat Cr. Hat. b/ | Oregon Aqua j/ | Wallowa Hat. a/ |
| Grays R. Hat. f/ | Oxbow Hat. b/ | Warm Spring R. @ Hat. a/ |
| Hagerman Hat. a/ | Pahsimeroi Rearing Pd.g/ | Warm Spring R. b/ |
| Hayden Pd. g/ | Patterson Slough a/ | Warm Spring Trap b/ |
| Ice Harbor D. i/ | Pr. Rapid Spaw. Ch. f/ | Washougal Hat. f/ |
| John Day D. i/ | Quinalt Hat. f/ | Wells Spaw. Ch. d/ & f/ |
| John Day R. b/ | Rapid R. Hat. g/ | Weyco Pd. f/ |
| John Day Reservoir i/ | Red R. Hat. g/ | Whitebird Trap i/ |
| Jones Beach i/ | Riggins Trap i/ | Willard Hat. a/ |
| Kalama Falls Hat. f/ | Ringold Rearing Pd. f/ | Winthrop Hat. a/ |

a/ U.S. Fish and Wildlife Service, Fisheries Assist. Office, 2625 Parkmont Lane, Bldg. A., Olympia, WA 98502.

b/ Oregon Dept. of Fish & Wildlife, P.O. Box 3503, Portland, OR 97208.

c/ Anadromous Incorporated, Rt. 2 Box 2013, Deer Island, OR 97054.

d/ Washington Dept. Game, 600 North Capital Way, Olympia WA 98504.

e/ Sea Resources, P.O. Box 187, Chinook, WA 98614.

f/ Washington Dept. Fisheries, 115 General Admin. Bldg., Olympia, WA 98504.

g/ Idaho Dept. Fish & Game, 1540 Warner Ave., Lewiston, ID 83501.

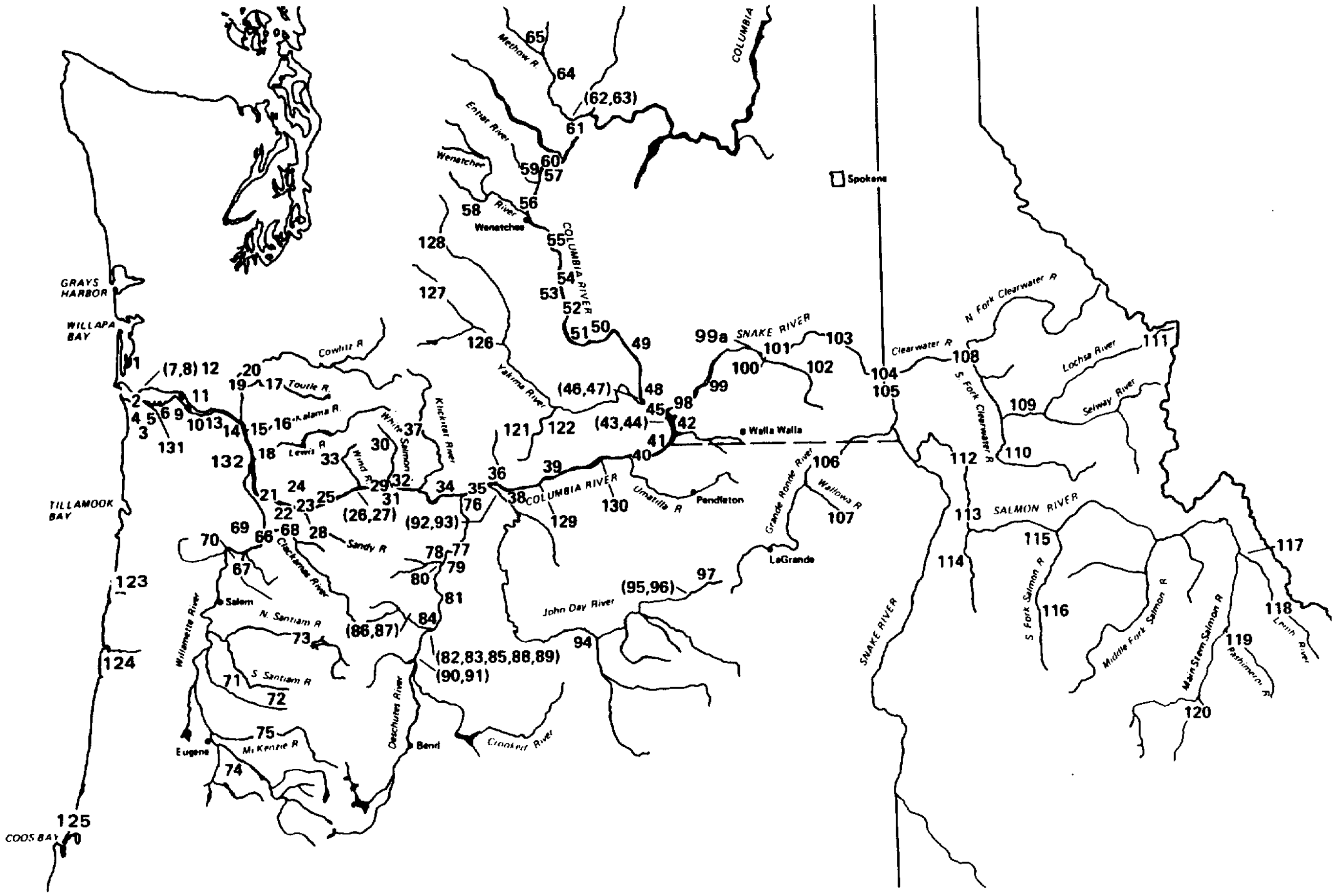
h/ Yakima Indian Nation, Fish Resources Management, P.O. Box 151, Toppenish, WA 98948.

i/ Natl. Mar. Fish. Serv., 2725 Montlake Blvd. E., Seattle, WA 98112.

j/ Oregon Aqua Foods Inc., 88700 Marcola Rd., Springfield, OR 97477

k/ Chelan County P.U.D., P.O. Box 1231, Wenatchee, WA 98801.

l/ Clatsop Economic Dev. Comm., O.S.U. Seafoods Lab., 250 36th., Astoria, OR 97103.




## LEGEND

| Release site | Rkm |
|---|---|
| **LOWER COLUMBIA R & 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 R@RM 13 | 57 |
| 8. Grays R@RM 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 R@RM 6 | 127 |
| 16. Kalama R@RM 15 | 141 |
| 17. Green R | 160 |
| 18. Lewis R | 163 |
| 19. Cowlitz R@RM 47 | 184 |
| 20. Cowlitz R@RM 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 Dalles D | 306 |
| 35. John Day D | 347 |
| 36. Towal Wash | 351 |
| 37. Klickitat R | 358 |
| 38. Blalock Shore | 375 |
| 39. Patterson Slough | 448 |
| 40. McNary D | 470 |
| 41. Port Kelly Wash | 501 |
| 42. Walla Walla R@Mo | 507 |
| 43. Casey Pd | 516 |
| 44. Villiard Slough | 521 |
| **MID COLUMBIA R & TRIBS.** | |
| 45. Pasco Wash | 522 |
| 46. Yakima R@Mo | 539 |
| 47. Richland Wash | 540 |
| 48. Ringold Pd | 568 |
| 49. Wh Bluffs | 596 |
| 50. Vernita Brid | 629 |
| 51. Pr Rapid Spaw Ch | 639 |
| 52. Crab Cr | 660 |
| 53. Wanapum 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 Spaw Ch | 828 |
| 62. Methow R@Mo | 838 |
| 63. Pateros Ferry | 839 |
| 64. Methow R@RM 28 | 893 |
| 65. Methow R@Hat | 919 |
| **WILLAMETTE R & 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 Ld | 411 |
| 72. S Santiam@Foster | 416 |
| 73. N Santiam@Minto | 452 |
| 74. M Fk William@Dexter | 491 |
| 75. McKenzie@Leaburg | 492 |
| **DESCHUTES R & TRIBS.** | |
| 76. Deschutes R@Mo | 330 |
| 77. Sherars Falls-Mo | 363 |
| 78. Deschutes@RM 43 | 395 |
| 79. Oak Springs Hat | 404 |
| 80. Maupin Trap RM 50 | 408 |
| 81. WmSp 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 R | 494 |
| 90. Rnd Butte Ladder | 503 |
| 91. Rnd Butte Hat | 506 |
| **JOHN DAY R** | |
| 92. John Day R@Mo | 349 |
| 93. John Day R@RM 16 | 374 |
| 94. John Day@Spray Ore | 623 |
| 95. N Fk John D@RM 60 | 744 |
| 96. M Fk John D@RM 32 | 749 |
| 97. John D@Granite Cr | 788 |
| **SNAKE R & TRIBS.** | |
| 98. Ice Harbor D | 537 |
| 99. Fishhook Park | 557 |
| 99a. Lyons Ferry | 600 |
| 100. Texas Rapids | 630 |
| 101. Lit Goose D | 634 |
| 102. Tucannon 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 & TRIBS.** | |
| 108. N Fk Clearwater R | 809 |
| 109. Clear Cr | 868 |
| 110. S Fk Clearwater R | 941 |
| 111. Lochsa R | 1026 |
| **SALMON R & TRIBS.** | |
| 112. Whitebird Trap | 908 |
| 113. Riggins Trap | 959 |
| 114. Rapid R 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. Satus 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 | 368 |
| 130. Biggs | 335 |
| 131. Tongue Pt | 28 |
| 132. Conf. E. Fork Lewis | 146 |

Figure 23.--Map and list of release sites for marked fish in the Columbia River system with index numbers for location.

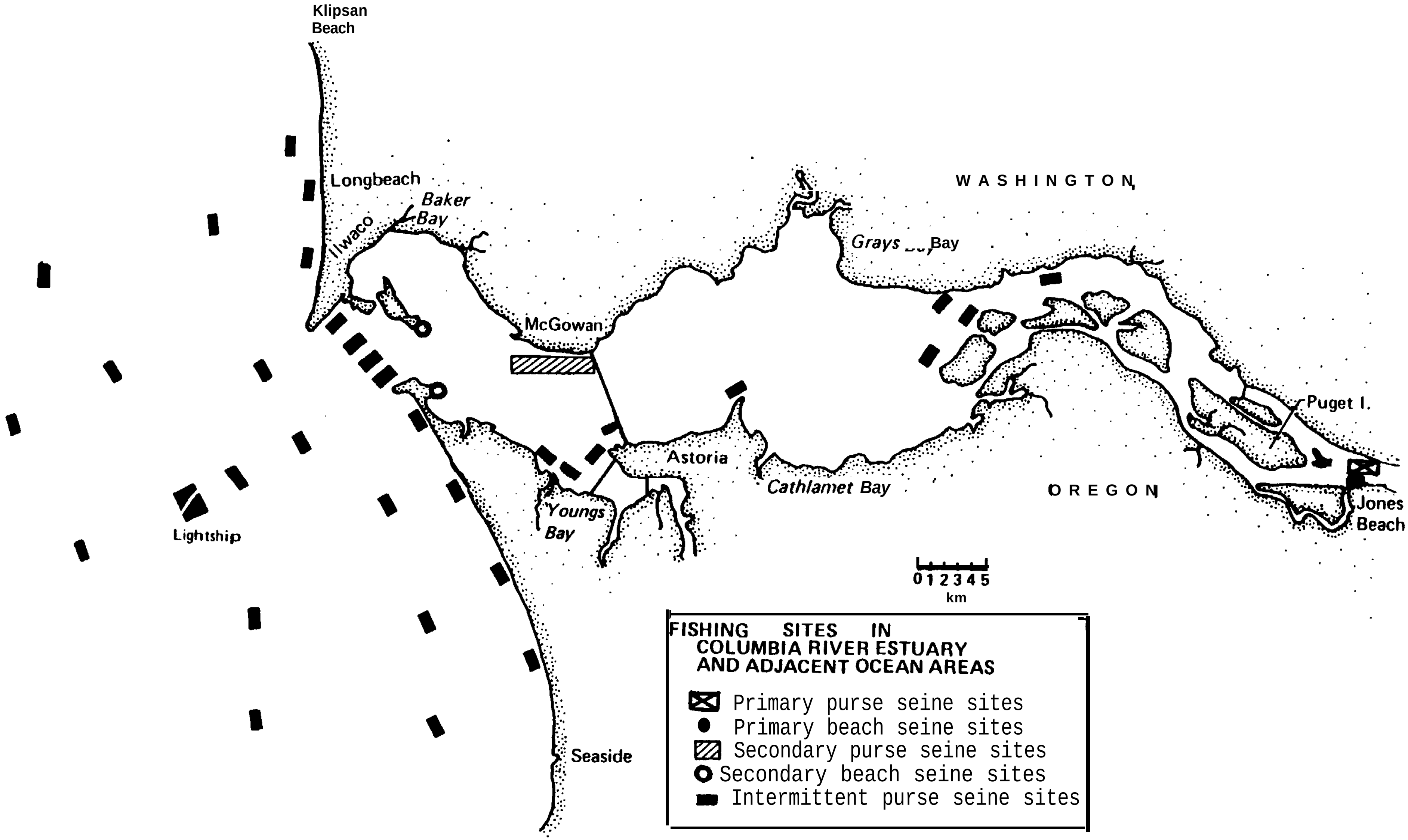



Figure 24.--The Columbia River estuary and adjacent Pacific Ocean showing sampling sites.

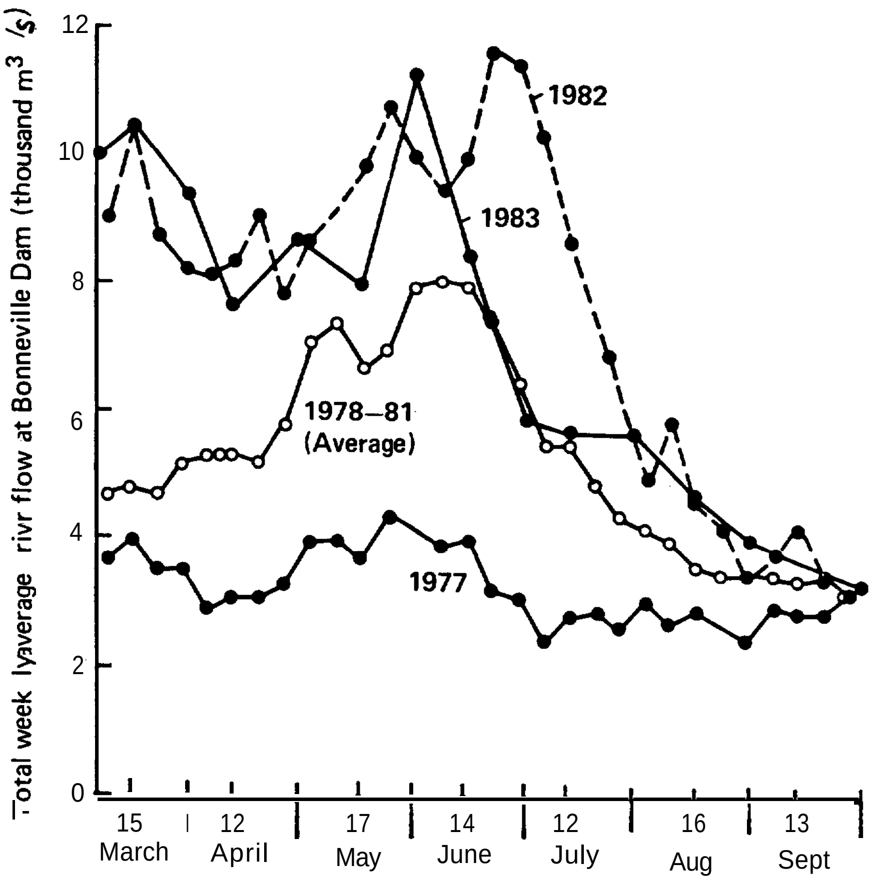



Figure 25.--Weekly average Columbia River flows for 1977, mean of 1978-1982, 1982, and 1983; collated from data supplied by U.S. Army Corps of Engineers, Portland, Oregon.

period of spring outmigrations, April-June, river flows in 1977 were extremely low (2,900 to 4,400 $m^3$/second); flows in 1978, 1979, 1980, and 1981 were moderate (averaging 4,700 to 8,900 $m^3$/second); and in 1982 and 1983 were high (8,100 to 11,700 and 5,900 to 11,300 $m^3$/second, respectively). We evaluated the change relative to river flow and for certain analyses adjusted catch data to compensate. Water temperatures at Jones Beach fluctuated in a fairly consistent pattern: during winter from 1° to 5°C, during spring from 6° to 17°C, and during summer from 18° to 21°C (Dawley et al. 1985a). In the lower estuary (RKm 1-16) and the ocean plume, conditions encountered affected catch efficiency and our ability to sample. Consequently, data pertaining to juveniles in the lower estuary and ocean were used primarily for timing and movement rate analyses and not for survival estimates.

## Analysis

Subyearling chinook salmon were predominantly fall and summer races, whereas yearling chinook salmon were predominantly a spring race (Van Hyning 1973) ; they were separated for analyses and presentation. Marked fish were classified from mark release information provided by the fishery organizations, whereas unmarked fish were classified on the basis of fork length [error rates varied from 0 to 4% (Dawley et al. 1985a)]. Jones Beach mark recovery data were expanded to represent a standard effort of 10 beach seine sets and 5 purse seine sets per day, 7 days per week. Details of expansion formula are in Dawley et al. (1985b). Sampling from other sites was not adjusted.

Marked fish movement rates were calculated using distance traveled and time between first date of release and the 10% fish recovery or the median fish recovery at Jones Beach.

Juvenile catch percentages were compared with adult recoveries from the fisheries, hatcheries, and spawning grounds. The adult recovery data include recoveries from the fisheries, spawning surveys, and hatcheries which were obtained from the Washington Department of Fisheries (WDF) , Oregon Department of Fish and Wildlife (ODFW), Idaho Department of Fish and Game (IDFG), U.S. Fish and Wildlife Service (FWS), and the Pacific Marine Fisheries Commission (PMFC). Comparisons between groups released at different times or locations may result in erroneous interpretations because of differences in ocean distribution, unequal fishing, or sampling effort,

## Relative Survival

To assess the statistical validity of estimated survival differences between treatment and control groups, catch differences were evaluated in relation to observed differences between replicate groups previously captured at Jones Beach (Appendix Table B1). To simplify the evaluation, an empirical power of the test curve was developed where catch ratios (no. caught/no. released) of replicate mark groups were averaged (U); the percent difference between this average and each individual catch ratio was then calculated (Y) and plotted versus the number of fish captured (X) . The curve in Figure 26 represents the 95% confidence level ($P<0.05$) for the hypothesis that no difference exists between groups.

The empirical method was used for detecting significant differences between catch ratios for treatment and control groups. Differences were plotted in Figure 26 to discern if they were greater than those observed between replicate groups with similar numbers of recoveries at Jones Beach. If any of the plotted points fell outside the range observed for replicate groups, significant differences existed between 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 use the following data:

| Stock | Size (no./lb) | No. released | No. captured Actual | No. captured Adjusted | U | X | Y |
|---|---|---|---|---|---|---|---|
| A | 2 | 38,800 | 84 | 109 | 0.00320 | 84 | 12 |
| A | 5 | 39,100 | 104 | 142 | | 104 | 13 |
| B | 4 | 37,600 | 102 | 119 | | 102 | 1 |

All data points for X and Y fall inside the range of replicate groups (Fig. 26); consequently, we conclude there was no detectable difference in survival to the estuary for Stocks A and B. 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 because no adjustment for sampling effort is included. The empirical evaluation accounts for variation (including random) that has affected previous sampling; consequently, it provides a more precise evaluation (Efron and Morris 1975).

Assessments of statistical differences among adult recoveries from mark groups were made using the G statistic at $P < 0.05$ rejection of the null hypothesis (no difference).

Relative survival estimates for mark groups given various treatments were made by comparing catch percentages of control and treatment groups by the following formula:

$$\left(\frac{\%\ \text{catch treatment} - \%\ \text{catch control}}{\%\ \text{catch control}}\right) \times 100 = \%\ \text{difference in survival}$$

## Results. and Discussion

Numbers of marked and unmarked fish captured during estuary sampling varied from a high of 370,000 in 1977 of to a low of 170,000 in 1980 (Fig. 27). The variation was related to numbers of juveniles released from culture facilities, sampling effort, and river flow which may have altered catch efficiency. In 1980, decreased catches also resulted from the effects of the 18 May eruption of Mount St. Helens.

Empirical Power of Test Curve

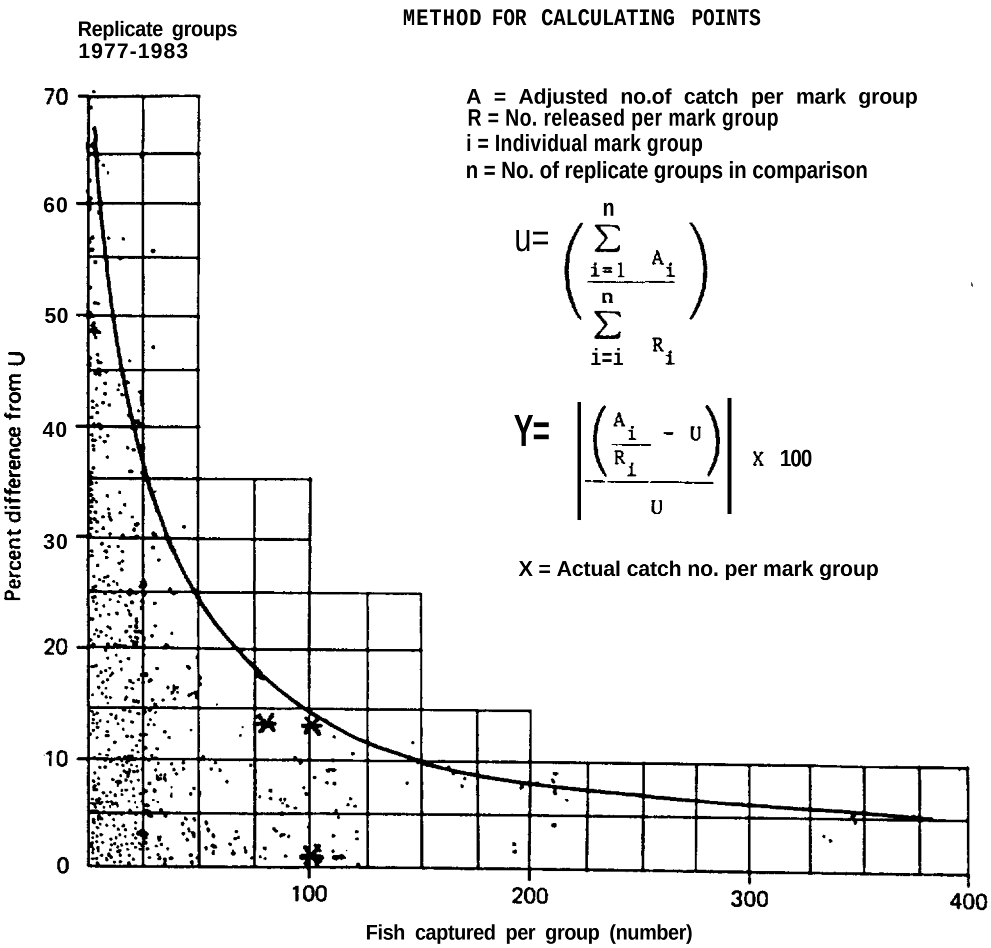
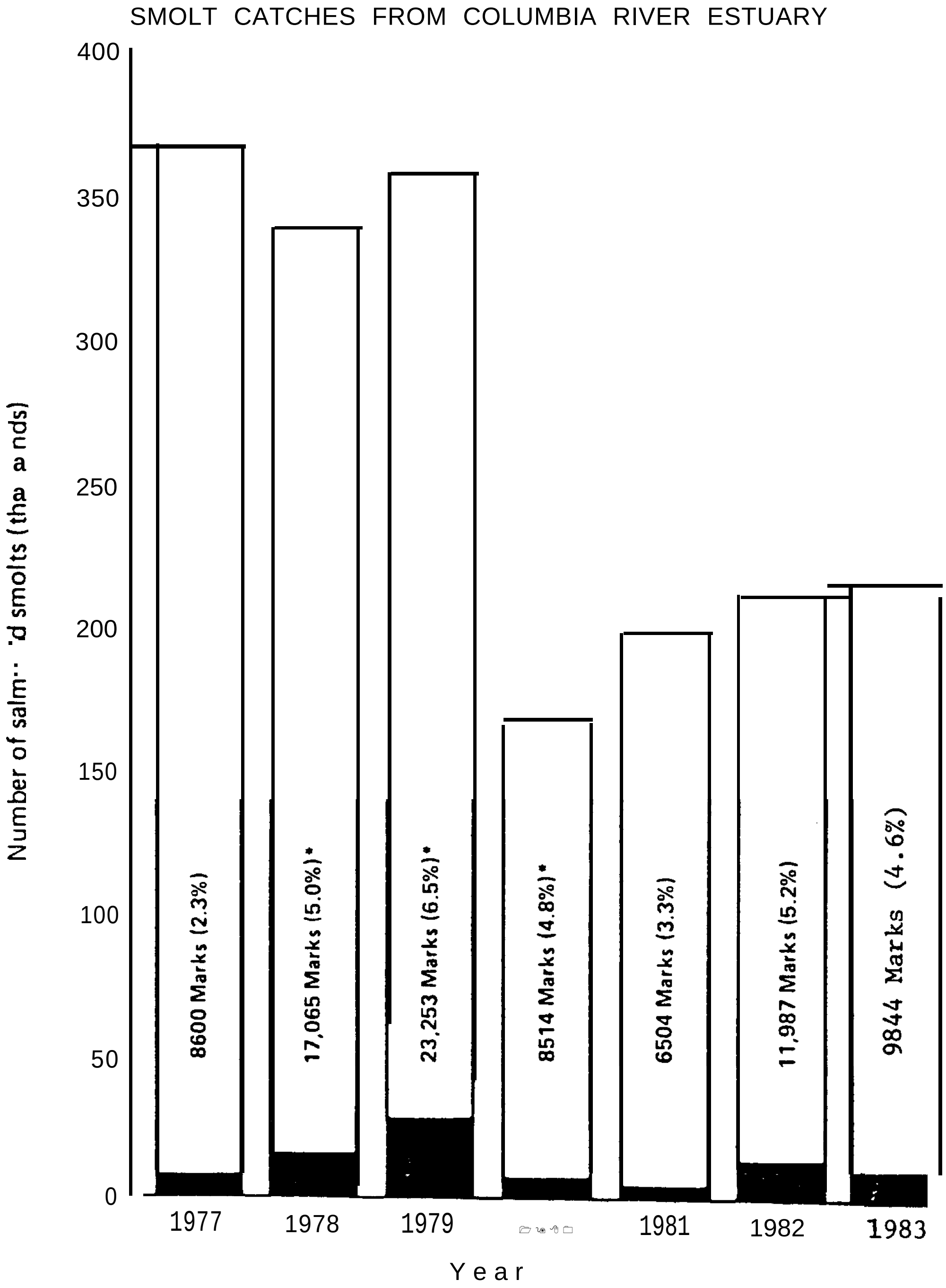



Figure 26.--Empirical power of the test curve developed by comparing differences between catch percentages for replicate mark groups to number caught. * = treatment groups from example in text.




***Includes off-shore and lower estuary**

Figure 27.--Numbers of marked (darkened area) and unmarked salmonids captured at Jones Beach, 1977-1983. Percentage of marked fish in total catch is shown in parenthesis.

## Migrational Timing

Migration patterns of juvenile salmonids into the estuary, depicted by catch per set (CPS) averages, were similar between years. Few fish were captured in January and February (less than 10 fish captured per set). A small CPS peak of yearling and subyearling chinook salmon (25 to 95) occurred in March followed by a decline in early to mid-April. Steadily increasing numbers of yearling and subyearling chinook salmon, coho salmon, and steelhead occurred after mid-April with peak catches in May and early June (100 to 200 CPS for yearlings and up to 1,000 CPS for subyearlings). Yearling fish catches declined rapidly during June to less than 10 CPS by early July and almost none were captured through the end of the year. Variable numbers of subyearling fish were captured in July and August (25 to 350 CPS), catches then declined in September (15 to 75 CPS). Small peaks of subyearling chinook salmon were recorded in November (10 to 40 CPS) and decreased in December (less than 5 CPS). The catch per set pattern of 1983 (Fig. 28) depicts a migration pattern similar to most years; catch patterns for other years are presented in Dawley et al. (1985a).

Spring and Summer Migrations.--In general, timing for upriver stocks migrating through reservoirs and past dams is characterized in reports by Sims et al. (1978-1983) and by the Water Budget Center.[3/] At Jones Beach, peaks of migration for yearling chinook salmon, coho salmon, and steelhead were generally in the latter part of May (Table 22); subyearling chinook salmon showed a wider variation of migration pattern than yearlings, but generally the peaks were directly related to release dates of major hatcheries and river flow.

Fall and Winter Migrations.--Attempts to decrease rearing costs and/or increase adult returns prompted renewed efforts in the 1970s and 1980s to determine the effects of releasing salmonids during fall (Smith 1979a; Hansen et al. 1979). Preliminary recoveries of adults indicated benefits in some instances (Smith and Zakel 1981) and none in others (Hansen 1982). Researchers were concerned that some of the fall released juveniles would overwinter in tributaries and compete with wild stocks. Observations demonstrating residualism were made at the Pelton Ladder on the Deschutes River (Hart et al. 1980) and at Jones Beach (Dawley et al. 1978).

At Jones Beach, sampling was extended into the fall, winter, and early spring of 1978-79, 1981-82, and 1982-83 to examine the timing and migration success of fall released fish. Most fish released in the fall migrated past Jones Beach before 15 December; the remainder passed primarily in late February, March, and April (Table 23). Large portions of a few groups, however, wintered upstream from Jones Beach and migrated during the spring. In 1982-83 when the effort at Jones Beach was substantial throughout most of

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3/ Water Budget Center, 2705 E. Burnside, Suite 213, Portland, OR 97214.

Table 22.--Dates of migrational peaks for juvenile salmonids at Jones Beach indicating migrational overlap, 1977-1983.

| Year | Week of peak migration [a/] Chinook salmon Subyearling | Chinook salmon Yearling[c/] | Coho salmon[c/] | Steelhead[c/] |
|---|---|---|---|---|
| 1977 | 21-27 May | - | -- | -- |
| 1978 | 11-17 June | 7-13 May | 14-20 May | 14-20 May |
| 1979 | 2-8 July | 14-20 May | 28 May-3 June | 14-20 May |
| 1980 | 11-17 June | 7-13 May | 14-20 May | 7-13 May |
| 1981 | 6-10 June | 7-13 May | 14-20 May | 7-13 May |
| 1982 | 11-17 June | 21-27 May | 21-27 May | 21-27 May |
| 1983 | 4-10 June | 14-20 May | 21-27 May | 21-27 May |

a/ From the date of median fish recovery; not adjusted for river flow.
b/ Timing based on beach seine catches.
c/ Timing based on purse seine catches.

Table 23.--Catches of marked juvenile chinook salmon at Jones Beach (RKm 75) released in fall and late summer 1977-1983.

| Release information a/ | | | | | | | Recovery information | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Fall | | | | Winter/Spring | | | |
| | | | | | | | | Catch | | | | Catch | | | |
| Tag (Ag,D1,D2) | Source | Site | Treatment stock | No. (thou) | Date b/ | Size (no./lb) | Gear c/ code | (no.) | Adj. (no.) | % | Date d/ range | (no.) | Adj. (no.) | % | Date d/ range |
| 1977 e/ | | | | | | | | | | | | | | | |
| 63/17/15 | Cowlitz | @ Hat. | | 84.4 | 28 Se 77 | 12 | B | 0 | 0 | 0 | --- | 1 | 1 | 0.002 | 03 Ap |
| | | | | | | | P | - | - | - | | 0 | 0 | 0 | |
| 09/16/27 | S.Santiam | @ Hat. | | 28.7 | 07 No 77 | 13 | B | 0 | 0 | 0 | --- | 1 | 2 | 0.008 | 11 Ap-02 My |
| | | | | | | | P | - | - | - | | 1 | 1 | 0.005 | |
| 09/16/28 | S.Santiam | @ Hat. | | 56.3 | 07 No 77 | 11 | B | 0 | 0 | 0 | --- | 0 | 0 | 0 | 28 Ap |
| & 29 | | | | | | | P | - | - | - | | 1 | 1 | 0.005 | |
| 09/16/30, | S.Santiam | @ Hat. | | 84.5 | 08 No 77 | 11 | B | 0 | 0 | 0 | --- | 7 | 13 | 0.015 | 27 Mr-28 Ap |
| 31-32 | | | | | | | P | - | - | - | | 8 | 12 | 0.014 | |
| 1978 | | | | | | | | | | | | | | | |
| 07/16/56 | Bonneville | @ Bonn. | Tule | 88.7 | 30 Oc 78 | 13 | B | 19 | 95 | 0.107 | 06 No-12 De | 10 | 28 | 0.032 | 20 Mr-12 Ap |
| & 59 | | | | | | | P | 1 | 7 | 0.008 | | 0 | 0 | 0 | |
| 07/16/58 | Bonneville | @ Bonn. | Bright | 89.2 | 30 Oc 78 | 22 | B | 22 | 79 | 0.089 | 06 No-17 No | 10 | 44 | 0.049 | 15 Fe-03 My |
| & 60 | | | | | | | P | 8 | 32 | 0.036 | | 0 | 0 | 0 | |
| 07/16/26, | Bonneville | @ Mill Cr. | | 150.8 | 8-9 No 78 | 23 | B | 0 | 0 | 0 | 13 De | 17 | 62 | 0.041 | 05 Mr-04 My |
| 19/17-18 | | | | | | | P | 1 | 8 | 0.015 | | 9 | 33 | 0.022 | |
| 07/17/37 | Dexter | @ Dexter | Tule | 23.0 | 07 No 78 | 7 | B | 0 | 0 | 0 | 27 No-05 De | 0 | 0 | 0 | 22 Mr-05 Ap |
| | | | | | | | P | 3 | 30 | 0.131 | | 2 | 15 | 0.067 | |
| 63/17/47 | K. Falls | @ Hat. | | 140.9 | 15 Se 78 | 34 | B | 101 | 368 | 0.261 | 20 Se-08 No | 8 | 16 | 0.012 | 02 Ap-21 Ap |
| | | | | | | | P | 0 | 0 | 0 | | 0 | 0 | 0 | |
| 05/03/52, | Lewis | @ Lewis | F.Chin. | 108.2 | 01 No 78 | 39 | B | 3 | 18 | 0.051 | 12 De | 4 | 35 | 0.032 | 15 Fe-04 Ap |
| 53-54 | | | | | | | P | 0 | 0 | 0 | | 0 | 0 | 0 | |
| 07/17/27 | Marion FKS | @ Minto | Carson | 92.9 | 06 No 78 | 23 | B | 0 | 0 | 0 | --- | 0 | 0 | 0 | 28 Mr-11 Jn |
| | | | | | | | P | 0 | 0 | 0 | | 18 | 34 | 0.037 | |
| 07/17/38 | Oakridge | @ Dexter | | 24.0 | 07 No 78 | 8 | B | 0 | 0 | 0 | 04-05 De | 1 | 3 | 0.011 | 29 Mr-30 Mr |
| | | | | | | | P | 2 | 15 | 0.063 | | 0 | 0 | 0 | |
| 07/17/39 | Oakridge | @ Dexter | | 28.9 | 07 No 78 | 15 | B | 0 | 0 | 0 | --- | 1 | 8 | 0.029 | 18 Mr-18 Ap |
| | | | | | | | P | 0 | 0 | 0 | | 1 | 3 | 0.004 | |
| 07/17/40 | Oakridge | @ Dexter | | 29.4 | 07 No 78 | 25 | B | 0 | 0 | 0 | --- | 1 | 3 | 0.010 | 06 Ap-01 My |
| | | | | | | | P | 0 | 0 | 0 | | 1 | 1 | 0.004 | |
| 10/03/28 | Red R. | SFK Clearwater | | 37.0 | 21 Se 78 | 34 | B | 0 | 0 | 0 | --- | 0 | 0 | 0 | 03 My-06 Jn |
| | | | | | | | P | 0 | 0 | 0 | | 6 | 7 | 0.019 | |
| 07/19/26, | S.Santiam | @ Hat. | William | 85.4 | 07 No 78 | 8 | B | 0 | 0 | 0 | 05 De | 3 | 30 | 0.035 | 27 Fe-02 My |
| 27-28 | | | | | | | P | 3 | 23 | 0.044 | | 2 | 2 | 0.002 | |
| 07/19/29 | S.Santiam | Blw.Willam | Fall | 65.4 | 07 No 78 | 8 | B | 1 | 15 | 0.046 | 10 No-05 De | 5 | 10 | 0.015 | 04 Ap-30 Ap |
| & 30 | | | | | | | P | 5 | 50 | 0.076 | | 5 | 7 | 0.011 | |
| 1979 f/ | | | | | | | | | | | | | | | |
| 07/17/35 | Bonneville | @ Hat. | Brights | 51.2 | 20 No 79 | 12 | B | - | - | - | --- | 4 | 7 | 0.013 | 23 My-17 My |
| | | | | | | | P | - | - | - | | 1 | 1 | 0.003 | |
| 07/19/14 | Bonneville | @ Hat. | Tule | 48.7 | 20 No 79 | 9 | B | - | - | - | --- | 3 | 15 | 0.031 | 09-30 Mr |
| | | | | | | | P | - | - | - | | 0 | 0 | | |
| 63/19/42 | Cowlitz | @ Hat. | | 23.4 | 16 Oc 79 | 85 | B | - | - | - | --- | 9 | 21 | 0.015 | 09 Mr-23 Ap |
| | | | | | | | P | - | - | - | | 0 | 0 | 0 | |
| 63/19/51 | Cowlitz | @ Hat. | | 7.8 | 16 Oc 79 | 85 | B | - | - | - | --- | 6 | 21 | 0.194 | 11 Mr-05 My |
| | | | | | | | P | - | - | - | | 2 | 5 | 0.048 | |
| 07/20/49 | McKenzie | @ Leaburg | | 31.6 | 09 No 79 | 6 | B | - | - | - | --- | 1 | 3 | 0.009 | 27 Mr |
| | | | | | | | P | - | - | - | | 0 | 0 | 0 | |
| 07/20/50 | McKenzie | @ Leaburg | | 28.4 | 09 NO 79 | 7 | B | - | - | - | --- | 1 | 4 | 0.014 | 11 Mr-15 Ap |
| | | | | | | | P | - | - | - | | 1 | 2 | 0.007 | |
| 07/20/52 | McKenzie | @ Leaburg | | 33.8 | 09 No 79 | 15 | B | - | - | - | --- | 3 | 8 | 0.022 | 19 Mr-30 Ap |
| | | | | | | | P | - | - | - | | 0 | 0 | 0 | |
| 63/19/20 | Lewis | Speelyai | | 51.7 | 05 Se 79 | 28 | B | 18 | 81 | 0.156 | 11-25 Se | 1 | 2 | 0.004 | 27 Ap |
| | | | | | | | P | - | - | - | | 0 | 0 | 0 | |
| 07/20/47 | Oakridge | @ Dexter | Large | 31.3 | 05 No 79 | 9 | B | - | - | - | --- | 2 | 3 | 0.011 | 24 Mr-02 Ap |
| | | | | | | | P | - | - | - | | 0 | 0 | 0 | |
| 07/20/45 | Oakridge | @ Dexter | Ungraded | 30.9 | 05 No 79 | 14 | B | - | - | - | --- | 3 | 7 | 0.022 | 24 Mr-23 Ap |
| | | | | | | | P | - | - | - | | 3 | 3 | 0.011 | |
| 07/20/43 | Oakridge | @ Dexter | Medium | 31.3 | 05 No 79 | 16 | B | - | - | - | --- | 4 | 11 | 0.036 | 12 Mr-09 Ap |
| | | | | | | | P | - | - | - | | 1 | 2 | 0.006 | |
| 07/20/41 | Oakridge | @ Dexter | Small | 30.8 | 05 No 79 | 29 | B | - | - | - | --- | 2 | 4 | 0.014 | 18 Mr-25 Mr |
| | | | | | | | P | - | - | - | | 0 | 0 | 0 | |

Table 23.--continued.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 07/19/43 | Oakridge | @ Foster | | 32.0 | 7-8 No 79 | 9 | B | - | - | - | --- | 4 | 9 | 0.028 | 26 Mr-29 My |
| | | | | | | | P | - | - | - | | 1 | 1 | 0.004 | |
| 07/19/44 | Oakridge | @ Blw.Will.Fall | | 34.8 | 08 No 79 | 10 | B | - | - | - | --- | 2 | 4 | 0.012 | 02 Ap-04 Ap |
| | | | | | | | P | - | - | - | | 2 | 7 | 0.020 | |
| 10/21/12 | Red Riv. | @ S.Fk.Clearwater | | 43.8 | 25-7 Se 79 | 27 | B | - | - | - | --- | 1 | 1 | 0.003 | 03 My-08 Jn |
| | | | | | | | P | - | - | - | | 5 | 9 | 0.022 | |
| 07/20/20- | S.Santiam | @ Foster | | 102.0 | 5-6 No 79 | 9 | B | - | - | - | --- | 0 | 0 | 0 | 14 Ap-22 Ap |
| 22 | | | | | | | P | - | - | - | | 4 | 8 | 0.008 | |
| 07/20/18& | S.Santiam | @ Blw.Will.Fall | | 69.8 | 5-6 No 79 | 9 | B | - | - | - | --- | 5 | 9 | 0.013 | 19 Mr-18 Ap |
| 19 | | | | | | | P | - | - | - | | 2 | 6 | 0.009 | |
| 1980 f/ | | | | | | | | | | | | | | | |
| 07/17/34 | Bonn. Hat. | @ Hat. | Brights | 51.3 | 05 No 80 | 14 | B | - | - | - | --- | 1 | 4 | 0.007 | 18 Mr |
| | | | | | | | P | - | - | - | | 0 | 0 | 0 | |
| 07/22/47& | Marion Fks | @ Minto | Carson | 100.0 | 05 No 80 | 20 | B | - | - | - | --- | 0 | 0 | 0 | 11 Ap-23 My |
| 48 | | | | | | | P | - | - | - | | 9 | 18 | 0.018 | |
| 07/22/18 | McKenzie | @ Leaburg | | 32.4 | 05 No 80 | 11 | B | - | - | - | --- | 0 | 0 | 0 | 31 Mr-01 Ap |
| | | | | | | | P | - | - | - | | 1 | 2 | 0.006 | |
| 07/22/21 | McKenzie | @ Leaburg | | 37.9 | 05 No 80 | 15 | B | - | - | - | --- | 0 | 0 | 0 | 06 Ap-21 Ap |
| | | | | | | | P | - | - | - | | 4 | 9 | 0.024 | |
| 07/23/06 | Oakridge H. | @ Dexter | | 30.1 | 5-6 No 80 | 28 | B | - | - | - | --- | 0 | 0 | 0 | 31 Mr |
| | | | | | | | P | - | - | - | | 1 | 2 | 0.006 | |
| 07/22/24 | Oakridge H. | @ Dexter | | 27.1 | 5-6 No 80 | 11 | B | - | - | - | --- | 0 | 0 | 0 | 31 Mr |
| | | | | | | | P | - | - | - | | 1 | 2 | 0.006 | |
| 10/21/27 | Red R. | @ S.FK.Clearwater | | 49.5 | 16 Se 80 | 25 | B | - | - | - | --- | 0 | 0 | 0 | 05 My-05 Jn |
| | | | | | | | P | - | - | - | | 6 | 9 | 0.017 | |
| 05/08/20& | Warm Spr. Hat. | @ Hat. | | 54.7 | 01 No 80 | 9 | B | - | - | - | --- | 0 | 0 | 0 | 13 Ap-01 My |
| 21 | | | | | | | P | - | - | - | | 2 | 4 | 0.007 | |
| 1981 g/ | | | | | | | | | | | | | | | |
| 07/21/38& | Bonn. Hat. | @ Hat. | Tule | 101.6 | 09 No 81 | 10 | B | - | - | - | 11 - 18 No | 0 | 0 | 0 | 07 Mr-07 Ap |
| 39 | | | | | | | P | 8 | 42 | 0.041 | | 9 | 41 | 0.040 | |
| 07/21/41& | Bonn. Hat. | @ Hat. | Brights | 100.5 | 09 No 81 | 10 | B | - | - | - | 11 - 13 No | 0 | 0 | 0 | 25 - 29 Mr |
| 42 | | | (McKen. Stk.) | | | | P | 6 | 33 | 0.033 | | 2 | 11 | 0.011 | |
| 07,22,37 | Dexter | @ Dexter | Ungraded | 29.4 | 05 No 81 | 4 | B | - | - | - | 16 No-03 De | 0 | 0 | 0 | 28 - 29 Mr |
| | | | | | | | P | 12 | 45 | 0.154 | | 1 | 3 | 0.011 | |
| 07/25/23, | Marion Fks. | @ Minto | | 92.3 | 03 No 81 | 24 | B | - | - | - | --- | 0 | 0 | 0 | 25 Ap-23 My |
| 24 | | | | | | | P | 0 | 0 | 0 | | 7 | 9 | 0.010 | |
| 07/22/23 | McKenzie | @ Leaburg | Ungraded | 31.1 | 05 No 81 | 8 | B | - | - | - | 16 - 30 No | 0 | 0 | 0 | --- |
| | | | | | | | P | 9 | 42 | 0.135 | | 0 | 0 | 0 | |
| 07/25/17 | McKenzie | @ Leaburg | Large | 31.1 | 05 No 81 | 5 | B | - | - | - | 16 - 19 No | 0 | 0 | 0 | --- |
| | | | | | | | P | 11 | 44 | 0.140 | | 0 | 0 | 0 | |
| 07/25/19 | McKenzie | @ Leaburg | Medium | | 05 No 81 | 18 | B | - | - | - | --- | 0 | 0 | 0 | 28 - 29 Mr |
| | | | (Oakridge Stk.) | | | | P | 0 | 0 | 0 | | 2 | 7 | 0.018 | |
| 07/24/18 | Oakridge | @ Dexter | Large | 31.7 | 05 No 81 | 6 | B | - | - | - | 25 - 27 No | 0 | 0 | 0 | --- |
| | | | | | | | P | 3 | 16 | 0.051 | | 0 | 0 | 0 | |
| 07/23/08 | Oakridge | @ Dexter | Ungraded | 29.7 | 05 No 81 | 9 | B | - | - | - | --- | 3 | 18 | 0.060 | 12 Mr-01 Ap |
| | | | | | | | P | 0 | 0 | 0 | | 2 | 5 | 0.017 | |
| 07/24/23 | Oakridge | @ Dexter | Medium | 31.7 | 05 No 81 | 19 | B | - | - | - | --- | 0 | 0 | 0 | 14 Mr-03 Ap |
| | | | | | | | P | 0 | 0 | 0 | | 3 | 13 | 0.041 | |
| 07/23/47 | Rd. Butte Hat. | @ Hat. | | 44.2 | 05 Oc 81 | 6 | B | - | - | - | 26 No-03 De | 0 | 0 | 0 | --- |
| | | | | | | | P | 2 | 13 | 0.028 | | 0 | 0 | 0 | |
| 07/23/49 | Rd. Butte Hat. | @ Hat. | | 26.9 | 05 Oc 81 | 11 | B | - | - | - | --- | 0 | 0 | 0 | 05 My |
| | | | | | | | P | 0 | 0 | 0 | | 1 | 1 | 0.004 | |
| 1982 | | | | | | | | | | | | | | | |
| 07/23/63 | Bonn. Hat. | @ Hat. | Tule/Well | 45.9 | 01 No 82 | 11 | B | 115 | 236 | 0.522 | --- | 4 | 8 | 0.018 | 13 - 29 Mr |
| | | | | | | | P | 4 | 9 | 0.020 | | 0 | 0 | 0 | |
| 07/25/46 | Bonn. Hat. | @ Hat. | Tule/Tanner | 51.6 | 01 No 82 | 12 | B | 100 | 207 | 0.401 | --- | 5 | 5 | 0.010 | 27 Ja-08 Mr |
| | | | | | | | P | 18 | 41 | 0.079 | | 0 | 0 | 0 | |
| 07/25/48 | Bonn. Hat. | @ Hat. | Bright/Well | 50.7 | 01 No 82 | 12 | B | 97 | 209 | 0.412 | --- | 2 | 2 | 0.004 | 17 Fe-03 Mr |
| | | | | | | | P | 8 | 19 | 0.037 | | 0 | 0 | 0 | |
| 07/25/45 | Bonn. Hat. | @ Hat. | Bright/Tanner | 48.6 | 01 No 82 | 12 | B | 94 | 228 | 0.445 | --- | 0 | 0 | 0 | --- |
| | | | | | | | P | 13 | 25 | 0.051 | | 0 | 0 | 0 | |
| 05/09/52& | Cowlitz Hat. | @ Big White | | 295.9 | 21 No 82 | 30 | B | 2 | | 0.001 | --- | 7 | 17 | 0.006 | 27 Ja-05 My |
| 53, RA PI 1,2,4 | | | | | | | P | 3 | | 0.002 | | 3 | 6 | 0.002 | |
| 63/24/50& | Cowlitz Hat. | @ Hat. | | 59.5 | 01 Se 82 | 30 | B | 8 | | 0.029 | 03 No-19 No | 7 | 12 | 0.020 | 26 Ja-22 Ap |
| 2603 | | | | | | | P | 0 | | 0 | | 1 | 3 | 0.005 | |
| LD SU 3 | Dworshak Hat. | @ Hat. | | 28.1 | 16 De 82 | 12 | B | 0 | | 0 | --- | 0 | 0 | 0 | 24 Mr-05 My |
| | | | | | | | P | 0 | | 0 | | 5 | 9 | 0.032 | |

Table 23.--continued.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 07/25/21 | McKenzie Hat. @ Leaburg | Ungraded | 32.3 | 08 No 82 | 11 | B | 0 | 0 | 0 | 26 No | 7 | 9 | 0.029 | 11 Mr |
| | | | | | | P | 2 | 5 | 0.014 | | 0 | 0 | 0 | |
| 07/27/19 | McKenzie Hat. @ Leaburg | Large | 32.0 | 08 No 82 | 7 | B | 2 | 5 | 0.014 | 30 No-10 De | 9 | 11 | 0.033 | 26 Ja-10 Mr |
| | | | | | | P | 2 | 5 | 0.014 | | 0 | 0 | 0 | |
| 07/17/21 | McKenzie Hat. @ Leaburg | Medium | 31.9 | 08 No 82 | 16 | B | 2 | 5 | 0.014 | 30 No-09 De | 7 | 15 | 0.045 | 12 - 28 Mr |
| | | | | | | P | 1 | 2 | 0.007 | | 1 | 1 | 0.003 | |
| 07/27/15 | Rnd. Butte Hat. @ Hat. | Norm.Incu. | 56.2 | 11 Oc 82 | 24 | B | 0 | 0 | 0 | --- | 0 | 0 | 0 | 25 - 30 Ap |
| | | | | | | P | 0 | 0 | 0 | | 2 | 2 | 0.004 | |
| 07/25/20 | Rnd. Butte Hat. @ Hat. | Fast.Incu. | 26.8 | 11 Oc 82 | 6 | B | 0 | 0 | 0 | 06 No-10 De | 0 | 0 | 0 | --- |
| | | | | | | P | 2 | 4 | 0.016 | | 0 | 0 | 0 | |
| 1983 h/ | | | | | | | | | | | | | | |
| 63/26/10 | Cowlitz Hat. @ Hat. | F. Chin. | 146.4 | 02 No 83 | 20 | B | 23 | 177 | 0.121 | 04 - 18 No | - | - | - | --- |
| | | | | | | P | 7 | 14 | 0.010 | | - | - | - | |
| 10/13/20 | Eagle Cr. Hat. @ Hat. | Stress | 36.4 | 17 Oc 83 | 9 | B | 2 | 3 | 0.008 | 02 No-22 No | - | - | - | --- |
| | | | | | | P | 3 | 16 | 0.044 | | - | - | - | |
| 10/13/21 | Eagle Cr. Hat. @ Hat. | Control | 36.6 | 17 Oc 83 | 8 | B | 1 | 2 | 0.004 | 10 No-11 No | - | - | - | --- |
| | | | | | | P | 0 | 0 | 0 | | - | - | - | |
| 10/13/22 | Eagle Cr. Hat. @ Hat. | Control | 35.8 | 17 Oc 83 | 8 | B | 1 | 2 | 0.006 | 08 No-22 No | - | - | - | --- |
| | | | | | | P | 2 | 11 | 0.031 | | - | - | - | |
| 10/13/23 | Eagle Cr. Hat. @ Hat. | Control | 38.5 | 17 Oc 83 | 9 | B | 0 | 0 | 0 | 02 No-22 No | - | - | - | --- |
| | | | | | | P | 2 | 10 | 0.025 | | - | - | - | |
| 07/28/43 | Rnd.Butte Hat. @ Hat. | Norm.Incub. | 53.6 | 06 Oc 83 | 14 | B | 1 | 2 | 0.003 | 10 No | - | - | - | --- |
| | | | | | | P | 0 | 0 | 0 | | - | - | - | |
| 07/28/37 | Rnd.Butte Hat. @ Hat. | Fast Incub. | 28.2 | 06 Oc 83 | 6 | B | 2 | 13 | 0.047 | 24 Oc-07 No | - | - | - | --- |
| | | | | | | P | 1 | 2 | 0.005 | | - | - | - | |
| 63/22/59 | Washougal Hat. @ Hat. | F. Chin. | 101.2 | 31 Au 83 | 28 | B | 101 | 280 | 0.276 | 06 Se-05 Oc | - | - | - | --- |
| | | | | | | P | 15 | 153 | 0.151 | | - | - | - | |
| 63/22/39 | Washougal Hat. @ Hat. | F. Chin. | 100.6 | 11 Oc 83 | 23 | B | 39 | 307 | 0.305 | 16 Oc-06 No | - | - | - | --- |
| | | | | | | P | 29 | 145 | 0.144 | | - | - | - | |
| 63/22/38 | Washougal Hat. @ Hat. | F. Chin. | 100.3 | 02 No 83 | 22 | B | 71 | 495 | 0.494 | 06 - 15 No | - | - | - | --- |
| | | | | | | P | 1 | 2 | 0.002 | | - | - | - | |

a/ Only groups with recoveries at Jones Beach are listed. More complete information available from Dawley et al. 1985b or releasing agency Table 1. Binary coded wire tags: Ag=Agency code, D1=Data 1 code, and D2=Data 2 code. Color coded wire tags begin with WH and each two digits thereafter represent a color. Brands are represented by the following: Loc=Location on fish, Sym=Brand symbol, and Rot=Rotation of symbol. For abbreviations, symbol, and descriptions see Dawley et al. 1985b. Abbreviations are listed: Blw=downstream of, Bonn=Bonneville, Bright=Stock of fall chinook salmon which changes color only after extended residence in fresh water, F. Chin=Fall chinook salmon, Fk=Forks, Hat=Hatchery, Incu=Incubation, K=Kalama, Large=Fish selected for largest size, McKen=McKenzie, Medium=Fish selected for medium size, Rd=Round, R=River, S=South, Small=Fish selected for smallest size, Spr=Springs, Stk=Stock, Tanner=Reared in Tanner Creek water, Tule=Lower river stock of fall chinook salmon, Ungraded=No selection for size, Well=Reared in well water, Willam=Willamette, and @=Released at.

b/ Two letter abbreviation for months Se, Oc, No, De, Ja, Fe, Mr, Ap, My, Jn represent September through June.

c/ B = beach seine and P = purse seine.

d/ Range of dates for beach and purse seine recoveries combined.

e/ No purse (low B effort).

f/ No fall and winter sampling.

g/ No fall and winter beach seine.

h/ No winter and spring sampling.

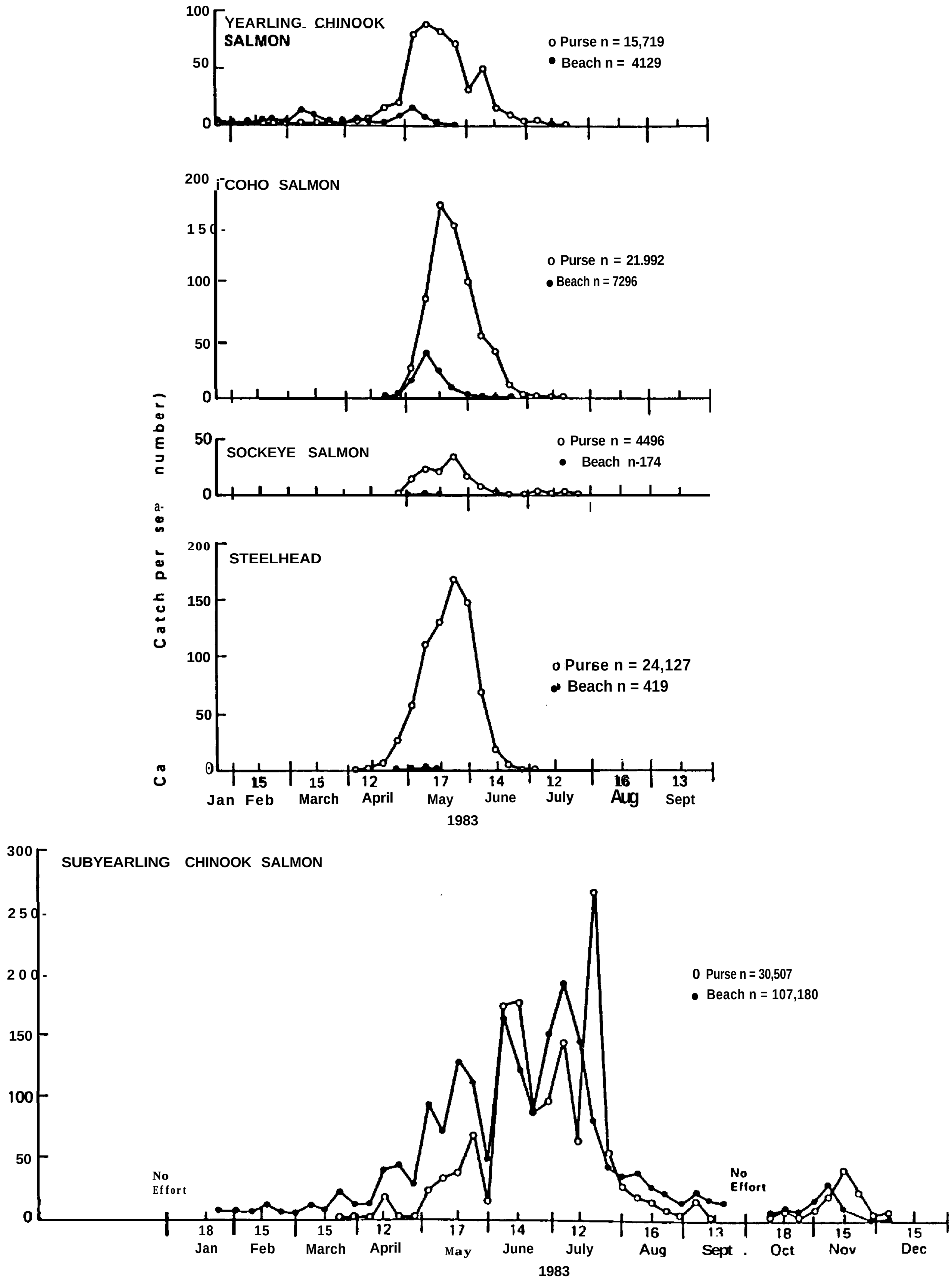


Figure 28.--Weekly catch per set averages for subyearling chinook, yearling chinook, coho, and sockeye salmon and steelhead caught by beach and purse seines at Jones Beach, 1983.

the year, catch data indicated that nearly 50% of the fall released spring chinook salmon from the Big White Rearing Facility[4/]; the Cowlitz, Round Butte, and McKenzie Hatcheries[5/]; and all fish from the Dworshak National Fish Hatchery [6/] overwintered in the river in 1982-83 then migrated in the spring of 1983. The smaller fish of most stocks showed the greatest tendency to residualize.

## Movement Rates

Raymond (1979) related increased river flow to faster movement rates and higher survival of juvenile salmonids migrating through the Snake and Columbia Rivers to The Dalles Dam. He also linked decreased river flows to slow movement rate and low survival.

At Jones Beach, observations of movement rates and dates of passage for individual mark groups indicate that movement rates of lower river hatchery-reared subyearling chinook salmon were strongly correlated with river flow, but movement rates of subyearling chinook salmon and yearling salmonids migrating downstream from McNary Dam were not well correlated with river flow. A relationship between movement rate and adult survival was not attainable because of the diversity of the fish groups examined.

Annual averages for movement rates of each species during migration from release sites to Jones Beach ranged from 7 to 36 km/day (Table 24). Movement rates of individual tag groups ranged from 1 to 80 km/day. The fastest movements from release site to Jones Beach were measured for groups of steelhead captured and tagged at Lower Granite, Little Goose, and McNary Dams and subsequently transported to various release sites downstream from Bonneville Dam (Park et al. 1984). The slowest movement rates resulted from: (1) individuals that resided in the Columbia River or its tributaries overwinter and migrated in the spring; (2) yearling chinook salmon released in March and April; and (3) groups of fall chinook salmon released at a small size (100/lb or greater) during May, June, and July.

Little or no cessation of migration was observed for juvenile salmonids in the Columbia River estuary which is substantially different from observations from estuaries of smaller northwest rivers (Reimers 1973; Bottom 1981; and Healey 1980). The average movement rates of subyearling chinook salmon decreased 30% between Jones Beach (RKm 75) and McGowan (RKm 16) compared to the average rate from upstream release sites to Jones Beach. Movement rates of yearling chinook salmon, coho salmon, and steelhead through the estuary compared to rates to the estuary showed no difference, a 40% increase, and a 50% increase, respectively (Table 24). The period of capture for individual mark groups at McGowan was generally equal to, or shorter than, the duration observed for the same groups at Jones Beach. Similar dates of recovery were noted for marked fish captured in the beach seine at Sand Island

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4/ Fisheries Assistance Office, USFWS, Vancouver, WA 98665; pers. commun.
5/ E. M. Smith, ODFW, 3150 E. Main St., Springfield, OR 97477; pers. commun.
6/ T. C. Bjomn, Co-op Fish Res. Unit, Moscow, ID 83843; pers. commun.

Table 24.--Annual average and range of movement rates for selected groups of marked juvenile salmon and steelhead from release site to Jones Beach, from Jones Beach to the lower estuary, from Jones Beach to the ocean plume, 1977-1983.

| | Release Site to Jones Beach (RKm 75)[a] | | | | | | | RKm 75 to RKm 16[b] | | | RKm 75 to Plume[c] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1978 | 1979 | 1980 | 1978 | 1979 | 1980 |
| **Subyearling chinook salnon** | | | | | | | | | | | | | |
| Average (km/day) | 7 | 16 | 21 | 19 | 18 | 16 | 22 | 4 | 11 | 25 | 6 | 10 | 21 |
| Range (km/day) | 2-27 | 5-39 | 2-48 | 2-48 | 4-32 | 2-41 | 4-31 | 2-59 | 1-59 | 2->59 | 1-20 | 1-50 | 1-99 |
| No. mark group | 10 | 13 | 14 | 10 | 12 | 12 | 3 | 14 | 9 | 33 | 23 | 31 | 26 |
| **Yearling chinook salmon** | | | | | | | | | | | | | |
| Average (km/day) | | 20 | 17 | 23 | 20 | 16 | 18 | 15 | 15 | 28 | 1 | 5 | 13 |
| Range (km/day) | | 6-35 | 5-37 | 7-44 | 9-46 | 8-25 | 10-24 | 8-59 | 6-59 | 5->59 | - | 1-13 | 1-68 |
| No mark group | | 11 | 13 | 10 | 7 | 9 | 5 | 8 | 5 | 38 | 1 | 10 | 18 |
| **Coho salmon** | | | | | | | | | | | | | |
| Average (km/day) | | 16 | 20 | 18 | 23 | 14 | 17 | 26 | 22 | 28 | | 25 | 11 |
| Range (km/day) | | 6-26 | 7-57 | 8-37 | 7-53 | 5-25 | 7-29 | 16-59 | 12-59 | 20-30 | | - | 2-44 |
| No, mark group | | 6 | 8 | 7 | 5 | 8 | 7 | 4 | 3 | 8 | 0 | 1 | 12 |
| **Steelhead** | | | | | | | | | | | | | |
| Average (km/day) | | 21 | 32 | 29 | 34 | 36 | 35 | 44 | - | 43 | | | 21 |
| Range (km/day) | | 3-39 | 10-61 | 12-43 | 18-52 | 26-45 | 27-53 | 31-59 | - | 20->59 | | - | 1-62 |
| No. mark group | | 7 | 6 | 4 | 3 | 3 | 5 | 3 | 0 | 24 | 0 | 0 | 10 |

a/ Marked groups representing large releases (>100,000) and released at similar sites 1977-1983, Not all groups used as indicies were represented all years; several groups are missing for steelhead in 1982 and yearling and subyearling chinook in 1983,

b/ Average from mark groups captured in substantial numbers in 1978 and 1979 but all groups weighted by catch for 1980; calculated using dates of median fish recapture excluding groups which passed in periods with low effort.

c/ Average for all groups recaptured in the ocean, calculated from date of 1st recapture in the ocean within 24 km of the river mouth.

(RKm 7) and Clatsop Spit (RKm 9) as were observed from the purse seine at McGowan. The dates of capture at McGowan closely represent the dates of migration through the es tuary into marine waters . Movement patterns for groups released directly into the estuary were not evaluated.

The grand average movement rate from Jones Beach to ocean sampling sites for all mark groups of subyearling chinook salmon observed from 1978 to 1980 was 7% slower than the grand average movement rate through the estuary, 1978-80. The estimated movement rates for individual mark groups from Jones Reach to seawater were of ten affected by low sampling effort and catch rates in the ocean. Marked fish from other salmonid groups were rarely captured in the plume area; consequently, movement rate calculations were not meaningfull. Data for mark groups are listed in Dawley et al. (1985b).

There is a large data base available describing movement rates for the various species migrating to Jones Beach. Intraspecies differences were better defined by separating stocks released upstream from John Day Dam from those released downstream from the dam (RKm 347).

Stocks Downstream from John Day Dam.--In 1977, below average flows apparently caused decreased movement rates which increased the duration of migrations be tween release site and Jones Beach. For example, the migration period (total days from date of release to date of median catch) for marked groups of subyearling chinook salmon captured in August 1977 averaged 170% greater than the longest migration period observed for each group from 1978 through 1983 (Table 25); average river flows during August 1977 were 21% less than the least flow during August 1978-1983 (Dawley et al. 1985b).

In 1982 and 1983, above average river flows produced significantly higher movement rates of subyearling chinook salmon ($P<0.01$, $t = 2.87$ at 74 df; Table 25) than near normal flows during 1978-1981.

During normal and high flow years from 1966 to 1972, we found that subyearling chinook salmon which migrated the greatest distance moved the fastest (Section I). Data from 1978 to 1983 confirm this; however, in 1977, when river flow was below average, the marked group that migrated the farthest (fall chinook salmon from Klickitat Hatchery-283 km) displayed the longest migration period and had a very slow movement rate (4 km/day)--apparently related to the exceptionally low river flow.

Four factors appear correlated with increased movement rate from release site to Jones Beach for marked subyearling chinook salmon released at sites downstream from John Day Dam: size, distance of migration, river flow, and $Na^+$-$K^+$ ATPase enzyme levels in the blood (Zaugg 1981). To eliminate effects on movement rate resul ting from variability in the stage of smoltifica tion, as indicated by blood $Na^+$-$K^+$ATPase, without using actual $Na^+$-$K^+$ATPase values (necessary because data were available for a few marked groups only), we calculated movement rates based on timing of the first 10% of the migrants captured, assuming that those rates represented highly smolted fish.

Mu1tiple 1inear regression of movement rates for the tenth percentile fish. recovery (Table 25), with size, distance traveled, and river flow for lower river subyearling chinook salmon provided the relationship:

Table 25.—Release information and Jones Beach recovery information for marked subyearling chinook salmon groups used in correlation analyses of movement rate, and catch percent to variables of fish size, recovery date, river flow, and spill volume, 1977-1983.

| Release information: Tag a/ (Ag,01,02) Brand (Loc Syn Rot) | Site b/ description | Site b/ (Rkm) | Size (no/lb) | Recovery dates c/: 10th percent (da,mo) | 10th percent (jul) | Recovery dates c/: 50th percent (da,mo,yr) | 50th percent (jul) | Movement Rate d/ (km/day) (10%) | Movement Rate d/ (km/day) (50%) | Recovery (no) | Recovery (%) | River flow @ Jones Beach (kcms) e/ | Flow adjust. recov. (%) f/ | Flow @ Bonneville Dam: Total @ 10% rec (kcms) | Flow @ Bonneville Dam: Total @ 50% rec (kcms) | Flow @ Bonneville Dam: Spill: total ratio g/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Abernathy Salmon Cultural Development Center h/ | | | | | | | | | | |
| 05/58/01 | Hatchery | 91 | 69 | | | 22APR78 | 112 | | | 101 | 0.105 | 7.2 | 0.107 | - | 6.5 | - |
| 05/59/01 | " | 91 | 44 | | | 18MAY78 | 138 | | | 30 | 0.028 | 9.2 | 0.033 | - | 6.8 | - |
| 05/04/51 | " | 91 | 43 | | | 6MAY79 | 126 | | | 35 | 0.090 | 9.7 | 0.111 | - | 6.2 | - |
| 05/04/50 | " | 91 | 18 | | | 7MAY79 | 127 | | | 60 | 0.119 | 9.7 | 0.146 | - | 7.6 | - |
| 05/04/44 | " | 91 | 27 | | | 16MAY80 | 137 | | | 18 | 0.091 | 7.6 | 0.096 | - | 6.8 | - |
| 05/06/46 | " | 91 | 70 | | | 16MAY80 | 137 | | | 42 | 0.060 | 7.6 | 0.063 | - | 6.8 | - |
| 05/07/44,45 | " | 91 | 69 | | | 1MAY81 | 121 | | | 59 | 0.085 | 7.9 | 0.092 | - | 6.9 | - |
| 05/10/58,59 | " | 91 | 55 | | | 3JUN82 | 154 | | | 1129 | 0.109 | 11.0 | 0.146 | - | 10.0 | - |
| | | | | | | Aumsville / Stayton Rearing Ponds | | | | | | | | | | |
| 09/16/12,13 | Will. Falls | 208 | 74 | 12MAY | 132 | 19MAY77 | 139 | 14 | 3 | 209 | 1.160i/ | 4.5 | 0.914 | 4.0 | 3.7 | - |
| 07/17/08,10 | " | 208 | 47 | 8JUN | 159 | 12JUN78 | 163 | 18 | 13 | 96 | 0.153 | 8.3 | 0.170 | 7.3 | 7.3 | - |
| 07/18/41 | Vari.sites Will.R. | 264 | 67 | | | 17MAY79 | 137 | | | 258 | 0.109 | 8.1 | 0.119 | - | 6.9 | - |
| 07/20/55 | " | 264 | 100 | | | 19MAY80 | 140 | | | 57 | 0.037 | 7.6 | 0.039 | - | 6.8 | - |
| 07/23/35 | " | 264 | 75 | | | 17MAY81 | 137 | | | 169 | 0.082 | 6.7 | 0.080 | - | 6.1 | - |
| 07/26/62 | " | 0 | 88 | | | 15MAY82 | 135 | | | 204 | 0.081 | 10.9 | 0.108 | - | 9.9 | - |
| 07/23/28,30-34 | " | 264 | 79 | | | 15MAY83 | 135 | | | 94 | 0.059 | 9.2 | 0.070 | - | 8.0 | - |
| | | | | | | Bonneville Hatchery—Early Release | | | | | | | | | | |
| 09/16/05 | Hatchery | 231 | 91 | 15MAY | 134 | 20MAY77 | 140 | 46 | 10 | 9 | 0.470i/ | 4.5 | 0.370 | 3.7 | 3.7 | - |
| 07/16/08 | " | 231 | 78 | 6MAY | 126 | 9MAY79 | 129 | 32 | 20 | 128 | 0.167 | 9.7 | 0.205 | 6.2 | 7.6 | - |
| 07/21/56 | " | 231 | 73 | 30APR | 120 | 1MAY81 | 121 | 27 | 22 | 140 | 0.121 | 7.9 | 0.130 | 6.9 | 6.9 | - |
| 07/24/07 | " | 231 | 80 | 28APR | 118 | 1MAY82 | 121 | 32 | 20 | 262 | 0.254 | 10.0 | 0.319 | 7.8 | 8.7 | - |
| LD&RD T 1,2 | ds Bonn. Dam | 233 | 80 | 28APR | 07 | 1MAY82 | 121 | 32 | 20 | 794 | 0.383 | 10.0 | 0.481 | 7.8 | 8.7 | - |
| 07/26/63 | Umatilla R. | 467 | 92 | | | 10MAY82 | 161 | | | 137 | 0.138 | 10.2 | 0.176 | - | 9.2 | - |
| 07/27/29,30 | Hatchery | 231 | 74 | 7MAY | 127 | 9MAY83 | 127 | 50 | 30 | 87 | 0.087 | 10.4 | 0.112 | 9.3 | 9.3 | - |
| | | | | | | Bonneville Hatchery--Late Release | | | | | | | | | | |
| 07/18/42 | Hatchery | 231 | 88 | | | 2JUN79 | 153 | | | 499 | 0.208 | 7.4 | 0.219 | - | 6.8 | - |
| 07/21/57 | " | 231 | 75 | 31MAY | | 1JUN80 | 153 | | | 56 | 0.085 | 9.0 | 0.099 | 8.2 | 8.2 | - |
| 07/23/29 | " | 231 | 68 | 10MAY | 130 | 21MAY81 | 141 | 27 | 19 | 57 | 0.092 | 7.7 | 0.097 | 6.1 | 6.6 | - |
| 07/24/08 | " | 231 | 80 | | | 3JUN82 | 154 | | | 182 | 0.192 | 11.0 | 0.257 | - | 10.0 | - |
| 07/28/26 | Vernita Br. | 629 | 100 | | | 13JUL83 | 194 | | | 47 | 0.070 | 6.5 | 0.075 | - | 5.7 | - |
| | | | | | | Cowlitz Salmon Hatchery | | | | | | | | | | |
| 63/18/02 | Hatchery | 109 | 133 | 30JUN | 181 | 11JUL78 | 192 | 13 | 5 | 311 | 0.417 | 6.8 | 0.410 | 6.4 | 6.4 | - |
| 63/19/42 | " | 109 | 85 | 15JUL | 196 | 2AUG79 | 214 | 7 | 3 | 278 | 0.373 | 3.6 | 0.265 | 3.6 | 3.3 | - |
| 63/22/55 | " | 109 | 77 | | | 5JUL81 | 186 | | | 195 | 0.248 | 7.8 | 0.265 | - | 7.2 | - |
| 63/21/56 | " | 109 | 86 | 1JUL | 182 | 5JUL81 | 186 | 33 | 15 | 494 | 0.493 | 7.8 | 0.527 | 8.2 | 7.2 | - |
| 63/24/62 | " | 109 | 90 | | | 14JUL82 | 195 | | | 525 | 0.353 | 9.7 | 0.434 | - | 8.7 | - |
| 63/20/32 | " | 109 | 98 | 8JUL | 189 | 26JUL82 | 207 | 9 | 4 | 136 | 0.526 | 6.6 | 0.508 | 10.4 | 6.2 | - |
| 63/25/03 | " | 109 | 72 | | | 6JUL83 | 187 | | | 522 | 0.493 | 7.2 | 0.501 | - | 6.3 | - |
| | | | | | | Hagerman Hatchery | | | | | | | | | | |
| 05/04/20 | ds Bonn. Dam | 230 | 84 | 28MAY | 148 | 31MAY79 | 151 | 22 | 15 | 74 | 0.177 | 3.6 | 0.126 | 3.4 | 6.8 | - |
| 05/04/21 | Asotin | 754 | 92 | | | 2JUL79 | 183 | | | 3 | 0.010 | 4.2 | 0.008 | - | 3.7 | - |
| 05/05/28 | ds Bonn. Dam | 230 | 59 | | | 15JUN80 | 166 | | | 34 | 0.084 | 3.7 | 0.060 | - | 8.4 | - |
| 05/05/27 | Asotin | 754 | 60 | | | 24JUN80 | 176 | | | 6 | 0.021 | 9.1 | 0.025 | - | 8.5 | - |
| 10/22/11 | ds Bonn. Dam | 230 | 51 | 5JUN | 156 | 7JUN81 | 158 | 20 | 16 | 67 | 0.132 | 12.4 | 0.193 | 11.1 | 11.1 | - |
| 10/22/10 | Lo. Granite Res. | 699 | 34 | | | 16JUN82 | 167 | | | 21 | 0.061 | 10.9 | 0.081 | - | 10.0 | - |
| 05/10/23 | " | 699 | 30 | | | 28JUN82 | 179 | | | 115 | 0.197 | 12.2 | 0.284 | - | 11.5 | - |
| 05/10/22 | Asotin | 754 | 37 | | | 29JUN82 | 180 | | | 84 | 0.156 | 12.2 | 0.225 | - | 11.5 | - |
| 10/25/15 | Clear Creek | 868 | 25 | | | 6JUL83 | 187 | | | 27 | 0.200 | 7.2 | 0.203 | - | 6.3 | - |

Table 25.—cont.

| Release information: Tag a/ (Ag,D1,D2) Brand (Loc Sym Rat) | Site b/ description | (Rkm) | Size (no/lb) | Recovery dates c/ 10th percent (da,mo) | (jul) | Recovery dates c/ 50th percent (da,mo,yr) | (jul) | Movement Rate d/ (km/day) (10%) | (50%) | Recovery (no) | (%) | River flow @ James Beach (kcms) e/ | Flow adjust. recov. (%) f/ | Flow @ Bonneville Dam: Total @ 10% rec (kcms) | Total @ 50% rec (kcms) | Spill: total ratio g/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | **Ringold Rearing Pond** | | | | | | | | |
| 63/17/45 | Hatchery | 568 | 35 | | | 14JUL78 | 195 | | | 24 | 0.065 | 6.8 | 0.064 | - | 6.4 | - |
| | | | | | | | | **Round Butte Hatchery** | | | | | | | | |
| 07/28/36 | Deschutes R. | 506 | 19 | | | 8JUN83 | 159 | | | 45 | 0.210 | 10.6 | 0.274 | - | 3.1 | - |
| | | | | | | | | **Speelyai Hatchery** | | | | | | | | |
| 63/21/60 | Lewis R. | 146 | 148 | 24JUL | 206 | 5AUG80 | 218 | 11 | 5 | 197 | 0.292 | 4.0 | 0.218 | - | 3.7 | - |
| | | | | | | | | **Spring Creek Hatchery--March Release** | | | | | | | | |
| 05/43/01 | Hatchery | 269 | 111 | 16APR | 106 | 5MAY77 | 125 | 7 | 4 | 169 | 0.191 i/ | 4.7 | 0.154 | 3.1 | 4.0 | 0.00 |
| 05/56/01 | " | 269 | 104 | 29MAR | 88 | 15APR78 | 105 | 25 | 8 | 174 | 0.153 | 7.7 | 0.162 | 6.5 | 7.1 | 0.30 |
| 05/04/46 | " | 269 | 125 | 28MAR | 87 | 7APR79 | 97 | 25 | 12 | 229 | 0.174 | 6.4 | 0.165 | 5.7 | 5.3 | 0.15 |
| 05/06/39 | " | 269 | 123 | 18MAR | 78 | 26MAR80 | 86 | 25 | 13 | 123 | 0.201 | 4.0 | 0.150 | - | 3.8 | 0.22 |
| 05/07/40,48,50,51 | " | 269 | 99 | 2APR | 92 | 4APR80 | 94 | 25 | 21 | 92 | 0.096 | 6.2 | 0.089 | 4.9 | 4.9 | 0.17 |
| 05/10/50 | " | 269 | 110 | 29MAR | 88 | 15APR82 | 105 | 49 | 10 | 106 | 0.099 | 10.4 | 0.128 | 8.2 | 8.3 | 0.57 |
| | | | | | | | | **Spring Creek Hatchery--April Release** | | | | | | | | |
| 05/44,45,49/01 | Hatchery | 269 | 86 | 17APR | 107 | 30APR77 | 120 | 22 | 8 | 638 | 0.416 i/ | 4.7 | 0.335 | 3.1 | 4.0 | 0.00 |
| 05/50/01,RD U 4 | ds Bonn.Dam | 230 | 83 | 17APR | 107 | 1MAY77 | 121 | 26 | 7 | 304 | 0.627 | 4.7 | 0.504 | 3.1 | 4.0 | - |
| 05/60/01,62/01 | Hatchery | 269 | 64 | 24APR | 114 | 1MAY78 | 121 | 33 | 16 | 328 | 0.213 | 8.8 | 0.246 | 6.7 | 7.8 | 0.40 |
| 05/54/01 | " | 230 | 79 | 25APR | 115 | 1MAY78 | 121 | 32 | 14 | 201 | 0.249 | 8.8 | 0.287 | 6.7 | 7.8 | - |
| 05/04/34,44 | " | 269 | 78 | 28APR | 118 | 3MAY79 | 123 | 25 | 16 | 477 | 0.258 | 8.8 | 0.297 | 6.7 | 6.2 | 0.10 |
| 05/06/40 | " | 269 | 83 | 17APR | 108 | 24APR80 | 115 | 28 | 17 | 108 | 0.299 | 7.3 | 0.307 | 4.8 | 5.9 | 0.00 |
| 05/07/41,49 | " | 269 | 71 | 23APR | 113 | 28APR81 | 118 | 25 | 17 | 113 | 0.126 | 6.5 | 0.121 | 5.4 | 5.4 | 0.04 |
| 05/10/51,53,54 | " | 269 | 72 | 20APR | 110 | 25APR82 | 115 | 39 | 21 | 223 | 0.196 | 9.4 | 0.236 | 9.1 | 7.8 | 0.34 |
| 05/08/51 | Umatilla R. | 467 | 79 | | | 4MAY82 | 124 | | | 48 | 0.103 | 10.0 | 0.129 | - | 8.7 | 0.00 |
| 05/10/57 | " | 467 | 79 | | | 7MAY82 | 127 | | | 106 | 0.105 | 10.2 | 0.134 | - | 9.2 | 0.00 |
| 05/11/42,43 | Hatchery | 269 | 54 | 3MAY | 123 | 5MAY83 | 125 | 39 | 31 | 109 | 0.108 | 9.6 | 0.132 | 8.7 | 8.7 | 0.16 |
| RD&LD U 1 | ds Bonn. Dam | 230 | 64 | 7MAY | 127 | 8MAY83 | 128 | 39 | 26 | 115 | 0.110 | 10.4 | 0.142 | 9.3 | 9.3 | - |
| | | | | | | | | **Spring Creek Hatchery--May Release** | | | | | | | | |
| 05/46/01 | Hatchery | 269 | 42 | 30MAY | 150 | 31MAY77 | 151 | 34 | 27 | 42 | 0.092 i/ | 5.1 | 0.077 | 4.2 | 4.2 | 0.21 |
| 05/57/01 | " | 269 | 56 | 22MAY | 142 | 24MAY78 | 144 | 52 | 31 | 106 | 0.088 | 8.7 | 0.101 | 7.9 | 7.9 | 0.41 |
| 05/04/33 | " | 269 | 50 | 21MAY | 141 | 22MAY79 | 142 | 61 | 47 | 98 | 0.087 | 8.4 | 0.097 | 7.3 | 7.3 | 0.40 |
| 05/06/41 | " | 269 | 51 | 11MAY | 132 | 13MAY80 | 134 | 86 | 55 | 55 | 0.129 | 8.8 | 0.149 | 8.0 | 8.0 | 0.45 |
| 56/48/09 | ds Bonn. Dam | 230 | 45 | 22MAY | 143 | 24MAY80 | 144 | 39 | 33 | 71 | 0.080 | 8.1 | 0.087 | 7.2 | 7.2 | - |
| 05/07/42 | Hatchery | 269 | 65 | 9MAY | 129 | 11MAY81 | 131 | 49 | 32 | 105 | 0.171 | 7.2 | 0.174 | 6.5 | 6.5 | 0.44 |
| 05/07/46 | Rock Creek | 368 | 75 | | | 18MAY81 | 138 | | | 56 | 0.046 | 6.7 | 0.045 | - | 6.1 | 0.00 |
| 05/07/43 | " | 368 | 75 | | | 23MAY81 | 143 | | | 10 | 0.050 | 7.7 | 0.053 | - | 6.6 | 0.00 |
| 05/10/52 | Hatchery | 269 | 49 | 23MAY | 143 | 25MAY82 | 237 | 65 | 41 | 73 | 0.128 | 11.9 | 0.181 | 10.8 | 10.8 | 0.44 |
| | | | | | | | | **Spring Creek Hatchery--August Release** | | | | | | | | |
| 05/03/39,40,41 | Hatchery | 269 | 16 | 22AUG | 234 | 25AUG78 | 237 | 49 | 32 | 19 | 0.043 | 3.9 | 0.032 | 3.5 | 3.5 | 0.00 |
| 05/04/45 | " | 269 | 19 | 17AUG | 229 | 19AUG79 | 230 | 49 | 33 | 33 | 0.181 | 3.2 | 0.123 | 2.9 | 2.9 | 0.00 |
| 05/06/42 | " | 269 | 19 | 10AUG | 223 | 13AUG80 | 226 | 65 | 32 | 9 | 0.144 | 3.7 | 0.104 | 3.6 | 3.4 | 0.12 |
| | | | | | | | | **Toutle Hatchery** | | | | | | | | |
| 63/16/40 | Hatchery | 160 | 117 | 17JUL | 198 | 5AUG77 | 217 | 5 | 3 | 606 | 0.658 | 3.4 | 0.457 | 2.9 | 3.1 | - |
| 63/17/63 | " | 160 | 98 | 27JUN | 178 | 5JUL78 | 186 | 11 | 7 | 457 | 0.559 | 6.1 | 0.516 | 6.4 | 5.7 | - |
| 63/18/01 | " | 160 | 72 | 16JUL | 197 | 30JUL78 | 211 | 10 | 4 | 164 | 0.267 | 4.5 | 0.210 | 5.3 | 4.2 | - |
| 63/18/54,19/41,54 | " | 160 | 160 | 2JUL | 183 | 12JUL79 | 193 | 6 | 3 | 866 | 0.822 | 4.0 | 0.612 | 3.7 | 3.6 | - |

Table 25.--cont.

| Tag a/ (Ag,D1,D2) Brand (Loc Sym Rot) | Release information: Site b/ description | Site b/ (Rkm) | Size (no/lb) | Recovery dates c/: 10th percent (da,mo) | 10th percent (jul) | 50th percent (da,mo,yr) | 50th percent (jul) | Movement Rate d/ (km/day) (10%) | Movement Rate d/ (km/day) (50%) | Recovery (no) | Recovery (%) | River flow @ Jones Beach (kcms) e/ | Flow adjust. recov. (%) f/ | Flow @ Bonneville Dam: Total @ 10% rec (kcms) | Total @ 50% rec (kcms) | Spill: total ratio g/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **Kalama Falls Hatchery** | | | | | | | |
| 63/16/55 | Hatchery | 141 | 76 | 2JUL | 183 | 14JUL77 | 195 | 8 | 3 | 131 | 0.207 | 3.1 | 0.138 | 2.4 | 2.8 | - |
| 63/16/39 | " | 141 | 113 | 5JUL | 186 | 26JUL77 | 207 | 6 | 2 | 697 | 0.718 | 2.9 | 0.468 | 2.4 | 2.6 | - |
| 63/17/46 | " | 141 | 108 | 19JUL | 199 | 3AUG78 | 215 | 10 | 3 | 541 | 0.631 | 4.5 | 0.497 | 5.3 | 4.2 | - |
| 63/19/57 | " | 141 | 180 | 8JUL | 189 | 27JUL79 | 208 | 4 | 2 | 2229 | 1.429 | 3.8 | 1.040 | 3.7 | 3.4 | - |
| 63/21/05 | " | 141 | 115 | 26JUN | 178 | 12JUL80 | 193 | 17 | 4 | 163 | 0.239 | 5.3 | 0.204 | 6.8 | 4.9 | - |
| 63/20/36 | " | 141 | 119 | 26MAY | 146 | 31MAY81 | 151 | 17 | 8 | 175 | 0.117 | 9.0 | 0.137 | 8.2 | 10.1 | - |
| 63/24/60 | " | 141 | 130 | 14JUN | 165 | 7JUL82 | 188 | 17 | 3 | 185 | 0.153 | 11.0 | 0.205 | 10.0 | 10.4 | - |
| | | | | | | | | | **Klickitat Hatchery** | | | | | | | |
| 63/16/05 | Hatchery | 358 | 92 | 4JUL | 185 | 19AUG77 | 23 | 10 | 4 | 38 | 0.059i/ | 3.2 | 0.040 | 2.4 | 2.9 | 0.00 |
| 63/16/63 | " | 358 | 87 | 21JUN | 172 | 7JUL78 | 188 | 21 | 12 | 97 | 0.169 | 6.1 | 0.156 | 7.4 | 5.7 | 0.42 |
| 63/19/49 | " | 358 | 80 | | | 7JUN79 | 158 | | | 224 | 0.127 | 4.2 | 0.097 | - | 5.6 | 0.35 |
| 63/19/47 | " | 358 | 85 | 3JUN | 154 | 9JUN80 | 161 | 42 | 24 | 64 | 0.066 | 9.0 | 0.077 | 8.2 | 8.3 | 0.50 |
| 63/20/08 | " | 358 | 78 | 12JUN | 163 | 18JUN81 | 169 | 47 | 30 | 30 | 0.032 | 11.2 | 0.043 | 10.8 | 9.9 | 0.59 |
| 63/21/57 | " | 358 | 83 | | | 13JUN82 | 164 | | | 214 | 0.111 | 10.9 | 0.148 | - | 10.0 | 0.31 |
| | | | | | | | | | **Kooskia Hatchery** | | | | | | | |
| 05/04/27 | ds Bonn. Dam | 230 | 40 | 16MAY | 136 | 21MAY79 | 141 | 14 | 9 | 38 | 0.117 | 8.4 | 0.131 | - | 7.3 | - |
| 05/04/26 | Clear Creek | 868 | 40 | | | 16JUN79 | 167 | | | 31 | 0.062 | 5.5 | 0.054 | - | 5.0 | - |
| 10/22/18 | " | 868 | 36 | | | 18JUN81 | 169 | | | 11 | 0.043 | 11.2 | 0.058 | - | 9.9 | - |
| | | | | | | | | | **Little White Salmon Hatchery** | | | | | | | |
| 05/47/01 | Hatchery | 261 | 122 | 11JUN | 162 | 21JUN77 | 172 | 7 | 6 | 267 | 0.127i/ | 3.6 | 0.090 | 4.0 | 3.2 | 0.00 |
| 05/03/46,47,48 | " | 261 | 115 | 31MAY | 151 | 7JUN78 | 158 | 32 | 14 | 330 | 0.358 | 7.9 | 0.385 | 6.7 | 7.3 | 0.45 |
| 05/03/43,44,45 | " | 261 | 135 | 1JUN | 152 | 8JUN78 | 159 | 27 | 13 | 334 | 0.348 | 7.9 | 0.375 | 6.7 | 7.3 | 0.45 |
| 05/03/55,56,57 | " | 261 | 100 | 24JUL | 205 | 31JUL78 | 212 | 17 | 10 | 61 | 0.109 | 4.5 | 0.086 | 4.7 | 4.7 | 0.21 |
| 05/04/48 | " | 261 | 105 | 29JUN | 180 | 3JUL79 | 184 | 28 | 17 | 254 | 0.210i/ | 4.2 | 0.160 | 4.4 | 3.7 | 0.02 |
| 05/04/49 | " | 261 | 123 | 1JUL | 182 | 4JUL79 | 185 | 22 | 16 | 412 | 0.223 | 4.2 | 0.170 | 4.4 | 3.7 | 0.02 |
| 05/06/43 | " | 261 | 101 | 16JUN | 168 | 19JUN80 | 171 | 32 | 22 | 94 | 0.073 | 9.1 | 0.086 | 8.4 | 8.5 | 0.51 |
| 05/07/47,49,50 | " | 261 | 94 | 9JUN | 157 | 11JUN81 | 162 | 38 | 28 | 164 | 0.072 | 12.4 | 0.105 | 11.1 | 10.8 | 0.57 |
| 05/04/35,36 | " | 261 | 93 | 7JUN | 158 | 10JUN82 | 161 | 38 | 21 | 267 | 0.136 | 10.2 | 0.173 | 9.5 | 9.5 | 0.38 |
| | | | | | | | | | **Lower Kalama Hatchery h/** | | | | | | | |
| 63/17/42 | Hatchery | 127 | 61 | 31MAY | 151 | 5JUN78 | 156 | | 18 | 136 | 0.136 | 7.9 | 0.146 | 6.7 | 7.3 | - |
| 63/20/06 | " | 127 | 150 | 7JUN | 158 | 13JUN80 | 166 | | 8 | 209 | 0.195 | 9.1 | 0.230 | 8.3 | 8.4 | - |
| 63/22/54 | " | 127 | 100 | 4JUN | 155 | 19JUN81 | 170 | | 4 | 175 | 0.133 | 11.2 | 0.180 | 11.1 | 9.9 | - |
| 63/24/63 | " | 127 | 117 | 15JUN | 166 | 25JUN82 | 176 | | 6 | 191 | 0.162 | 12.6 | 0.239 | 10.0 | 11.5 | - |
| | | | | | | | | | **Priest Rapids Spawing Channel** | | | | | | | |
| 63/17/41 | ds Priest Rap. Dam | 639 | 124 | | | 26JUL78 | 207 | | | 20 | 0.055 | 5.1 | 0.046 | - | 4.7 | - |
| 63/18/21 | " | 639 | 74 | | | 17JUL79 | 198 | | | 12 | 0.045 | 4.1 | 0.034 | - | 2.7 | - |
| 63/20/17 | " | 639 | 77 | | | 30JUL79 | 211 | | | 6 | 0.025 | 3.6 | 0.018 | - | 3.3 | - |
| 63/19/48 | " | 639 | 88 | | | 4JUL80 | 186 | | | 11 | 0.028 | 5.7 | 0.025 | - | 5.2 | - |
| 63/22/61 | " | 639 | 67 | | | 7JUL81 | 188 | | | 13 | 0.083 | 7.8 | 0.089 | - | 7.2 | - |
| 63/21/55 | " | 639 | 115 | | | 9AUG81 | 221 | | | 33 | 0.073 | 5.5 | 0.064 | - | 5.1 | - |
| 63/24/56 | " | 639 | 67 | | | 23JUN82 | 174 | | | 35 | 0.099 | 12.6 | 0.146 | - | 11.7 | - |
| 63/22/52 | " | 639 | 87 | | | 5JUL82 | 217 | | | 93 | 0.073 | 11.0 | 0.098 | - | 10.4 | - |
| 63/26/11 | " | 639 | 84 | | | 17JUN83 | 168 | | | 141 | 0.096 | 9.3 | 0.115 | - | 8.5 | - |
| 63/26/12 | " | 639 | 63 | | | 20JUL83 | 201 | | | 86 | 0.103 | 7.5 | 0.107 | - | 6.7 | - |

Table 25.--continued.

a/ More complete information available from Dawley et al. 1985b or releasing agency Table 21. Binary coded wire tags: Ag=Agency, Dl=Data 1 code, and D2=Data 2 code. Color coded wire tags begin with WH and each two digits thereafter represent a color. Brands are represented by the following: Loc=Location fish, Sym=Brand symbol, and Rot=Rotation of symbol. For abbreviations, symbols, and descriptions see Dawley et al. 1985b.

b/ Abbreviations are listed: Bonn=Bonneville, Br=Bridge, D=Dam, ds=downstream, Lo=Lower, R=River, Rap=Rapid, Res=Reservoir, Vari=Various, and Will=Willamette.

c/ Julian date that 10th percentile or 50th percentile (median) fish were captured at Jones Beach; calculated from adjusted daily recovery. Assessment limited to groups showing data.

d/ Movement rate from release site to Jones Beach for 10th percentile and 50th percentile fish captured at Jones Beach; calculated from adjusted daily recovery. Assessment limited to groups showing data.

e/ Flow at Bonneville Dam (from CofE) and Willamette, Lewis, and Cowlitz Rivers (from U.S. Geological Survey); average for week of median fish recovery.

f/ Adjusted to represent flows at 7,000 $m^3$/second (7.0 kcms); % flow adjusted catch = % catch x [1 + (kcms at Jones Beach - 7.0) x 0.0851. Assessment limited to groups showing data.

g/ Spillway flow at Bonneville Dam; total flow at Bonneville Dam; averages from week of median fish recovery at Jones Beach.

h/ Close proximity to the sampling site caused anomalous movement rate observations--data not used in correlation.

i/ 1977 catch data are beach seine expanded to represent beach seine plus purse seine by using the average ratios of purse seine to beach seine catch of that fish stock from years 1978-1983.

log (movement rate) = 1.034 - 0.0106(size--no/lb) + 0.00646(distance--RKm of release site) + 0.133 (flow-1,000 $m^3$/second) and $R_a^2 = 0.66$, $F = 77.03$ at 2, 74 df with $P < 0.001$.

The equation is given in the original data units but the statistics were calculated using normalized units. Movement rates for groups which migrated through Bonneville reservoir were poorly correlated with both date of recovery ($r = 0.06$) and with the proportion of spill volume to total discharge at Bonneville Dam ($r = 0.10$).

Though movement rates for subyearling chinook salmon generally increased with fish size, the largest fish within a mark group did not necessarily migrate more rapidly than smaller fish. Increasing and decreasing trends of daily mean length were observed within various mark groups; examples of each are presented in Figure 29; coho salmon data are presented in Figure 30. Previous observations of smolt behavior indicated that the larger fish within a population migrated faster than the smaller fish (Shapovalov and Taft 1954; Salo and Bayliff 1958; and earlier data on coho and subyearling chinook salmon in this report).

From 1977 to 1983, lower river stocks of yearling fish were not well represented by marked groups. Marked fish were released for specific tests of: culture treatment, structural bypass effects, and/or date and release sites. Therefore, trends in movement rates could not be examined for the general salmonid population.

Stocks Upstream from John Day Dam.--In 1977, many juvenile steelhead and chinook salmon (possibly 50% of the run) stopped their seaward migration upstream from Lower Granite Dam on the Snake River because of low river flows and no water spill at dams (Park et al. 1978). Recovery of marked fish during estuarine sampling in the fall, winter, and spring of 1977-1978 indicated that few individuals successfully migrated in the fall or endured overwintering to migrate the following year; only 13 marked fish released in the Snake River during 1977 were captured in late 1977 or 1978.

Evaluation of the influence of river flow on movement rates of the fish that migrated from the upper river in 1978-83 was limited to subyearling and yearling fish captured, marked, and released in the tailrace of McNary Dam (RKm 470). Other groups were not included because of: (1) extensive migration in tributaries or areas of the Columbia River where a single river flow would not accurately represent the conditions of migration or (2) effects of transportation from Lower Granite, Little Goose, or McNary Dams (Park et al. 1984). Flow measurements at Bonneville Dam generally represent conditions from McNary through Bonneville Dams, but have little relationship to flows in the Columbia River above McNary Dam or in the Snake River.

Movement rates of yearling fish from McNary Dam to Jones Beach were higher than those of subyearling fish (means - 62 and 32 km/day, respectively), therefore, the data could not be combined. Movement rates of steelhead and yearling chinook salmon were not statistically different ($P<0.05$) and were combined for analysis.

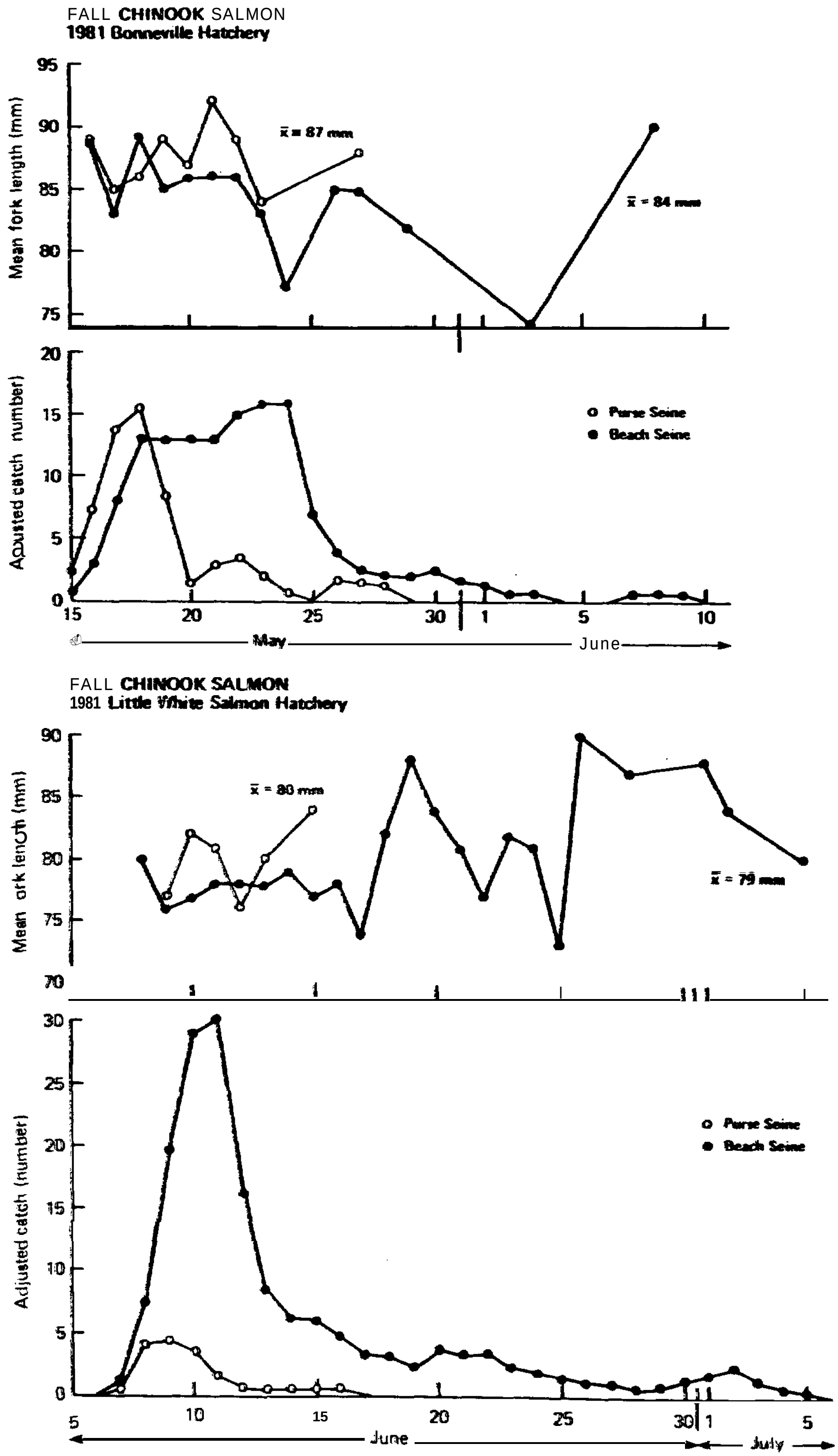


Figure 29.--Daily beach and purse seine catches and mean fork lengths for two marked groups of subyearling chinook salmon at Jones Beach; one showing decrease and the other increase in fork lengths with date.

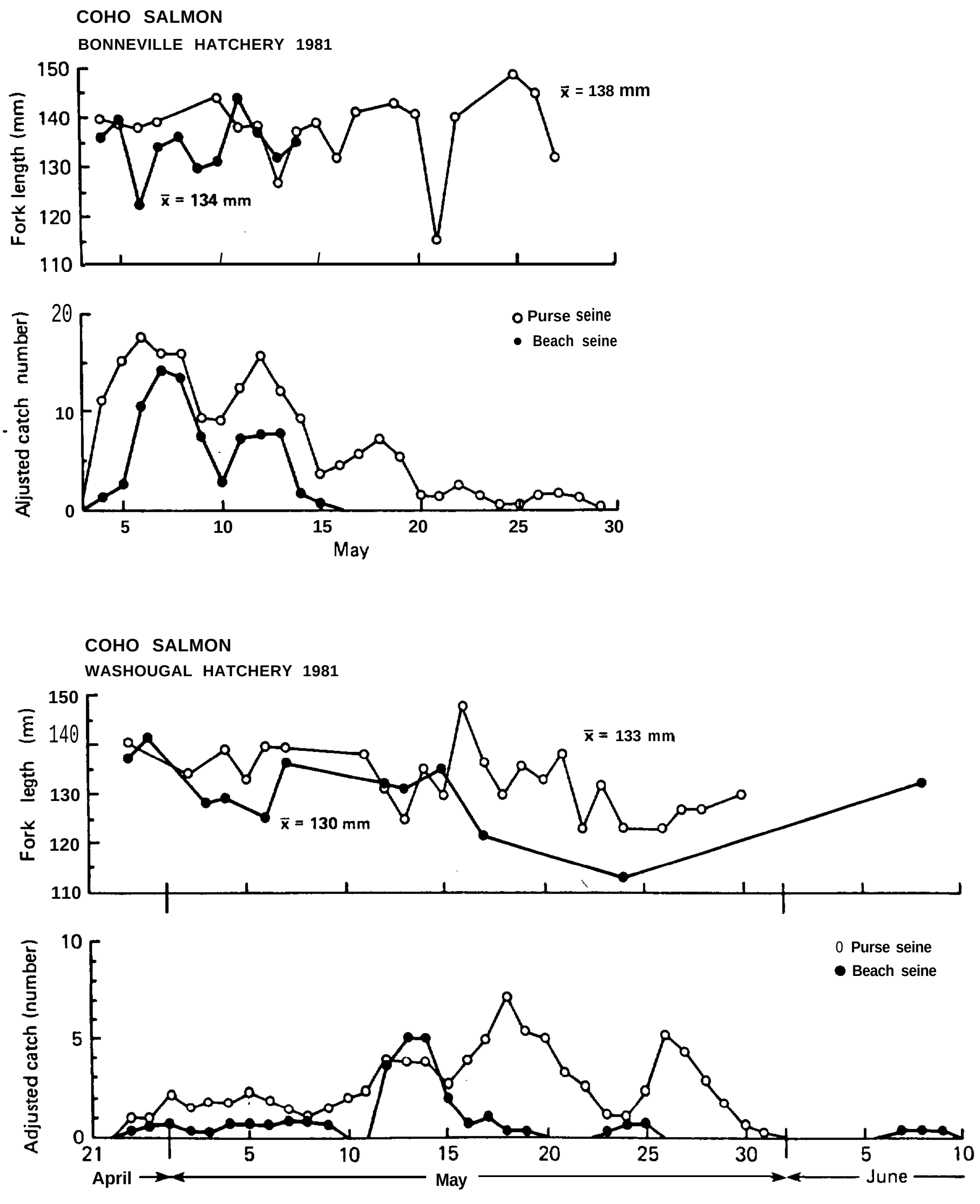


Figure 30.--Daily beach and purse seine catches and mean fork lengths for two marked groups of coho salmon at Jones Beach; one showing decrease and the other increase in fork lengths with date.

Movement rates of yearling and subyearling salmonids were not well correlated with river flow. A linear model was developed for data from yearling fish [movement rate (km/day) = 35.25 + 3.1 x flow (1,000 $m^3$/second) (Fig. 31); however, correlation was not high for the 27 groups evaluated, r = 0.45. Movement rates for subyearling chinook salmon (mostly summer chinook salmon from the mid-Columbia River which migrate during July-September) showed little correlation (r = 0.19) with flow (Fig. 31). Variability between the 20 marked groups examined was high, and the slope was not significantly different from zero ($P<0.05$). Likewise, no correlation of movement to flow was observed by Miller and Sims (1983) for subyearling fish migrating between McNary and John Day Dams.

## Variability of Catch

To make conclusions regarding differences in catch rate between time periods or between fish groups, it is necessary to understand the variables affecting each. Catches at Jones Beach were examined in relation to: time of day, river flow, and size of fish; also, catch percentages of replicate groups were compared to develop a base line of expected variation from sampling marked fish.

Die1 Patterns.--Diel movement patterns were examined to partially assess the consistency of catch data to determine if morning sampling (7 h beginning at sunrise) was representative of juvenile migrations throughout the day.

We evaluated catch per set in relation to hour and tidal fluctuation during five 24-h periods in 1978 and 1980. Catches indicated that movement patterns of juvenile salmonids were generally consistent (Fig. 32). However, patterns were different than reported for other river systems and different portions of the Columbia River (Thrower et al. 1985).

Die1 sampling indicated that the periods during the day and the lateral locations in the river which grossed the largest catches of migrating salmonids were as follows: sunrise to early afternoon near shore for subyearling chinook salmon, sunrise to early afternoon in mid-river for yearling chinook salmon (catches fluctuated in relation to the origin of the fish and other variables), mid-morning to late afternoon near shore and early morning to early afternoon in mid-river for coho salmon, noon to early evening in mid-river for steelhead, and daylight in mid-river for sockeye salmon (too few were captured to discriminate between hours of catch). Decreased movement during darkness was indicated for all salmonids. No relationship between tide cycle and catch was apparent for either beach or purse seine sampling; detailed analysis is presented by Thrower et al. (1985).

Catch patterns observed during the five 24-h sampling periods were compared with patterns from 7 h/day sampling from 1979 through 1983. Generally, the curves representing percent of total catch per day by set were similar in shape (Fig. 33). More fluctuation is apparent for die1 sampling than for morning sampling, primarily because of sample size. Initial beach seine sets during morning-only sampling captured a greater proportion of fish

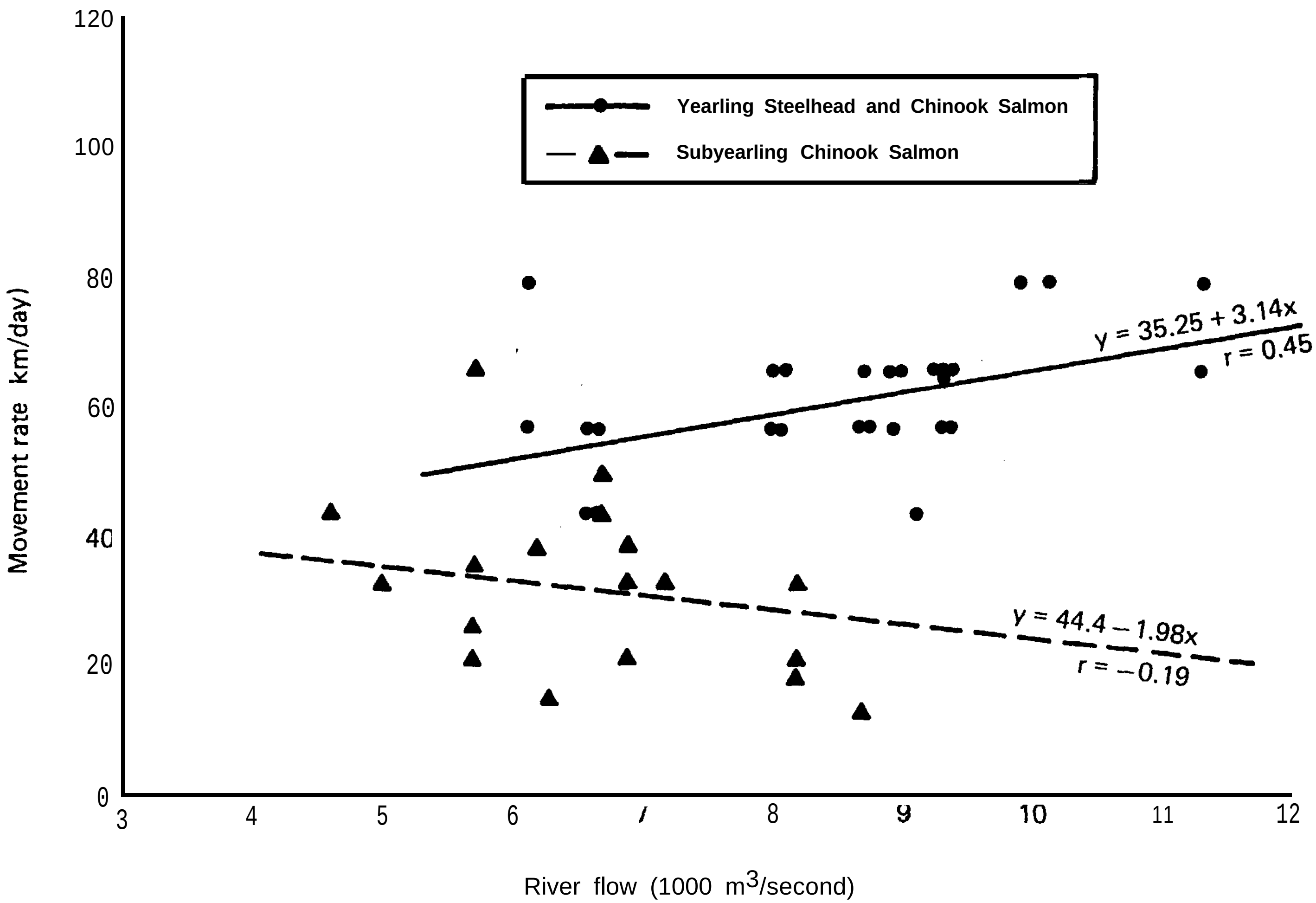


Figure 31.--Movement rates in relation to river flow for mark groups of yearling and subyearling salmonids released in the tailrace of McNary Dam and recovered at Jones Beach, 1978-1983.

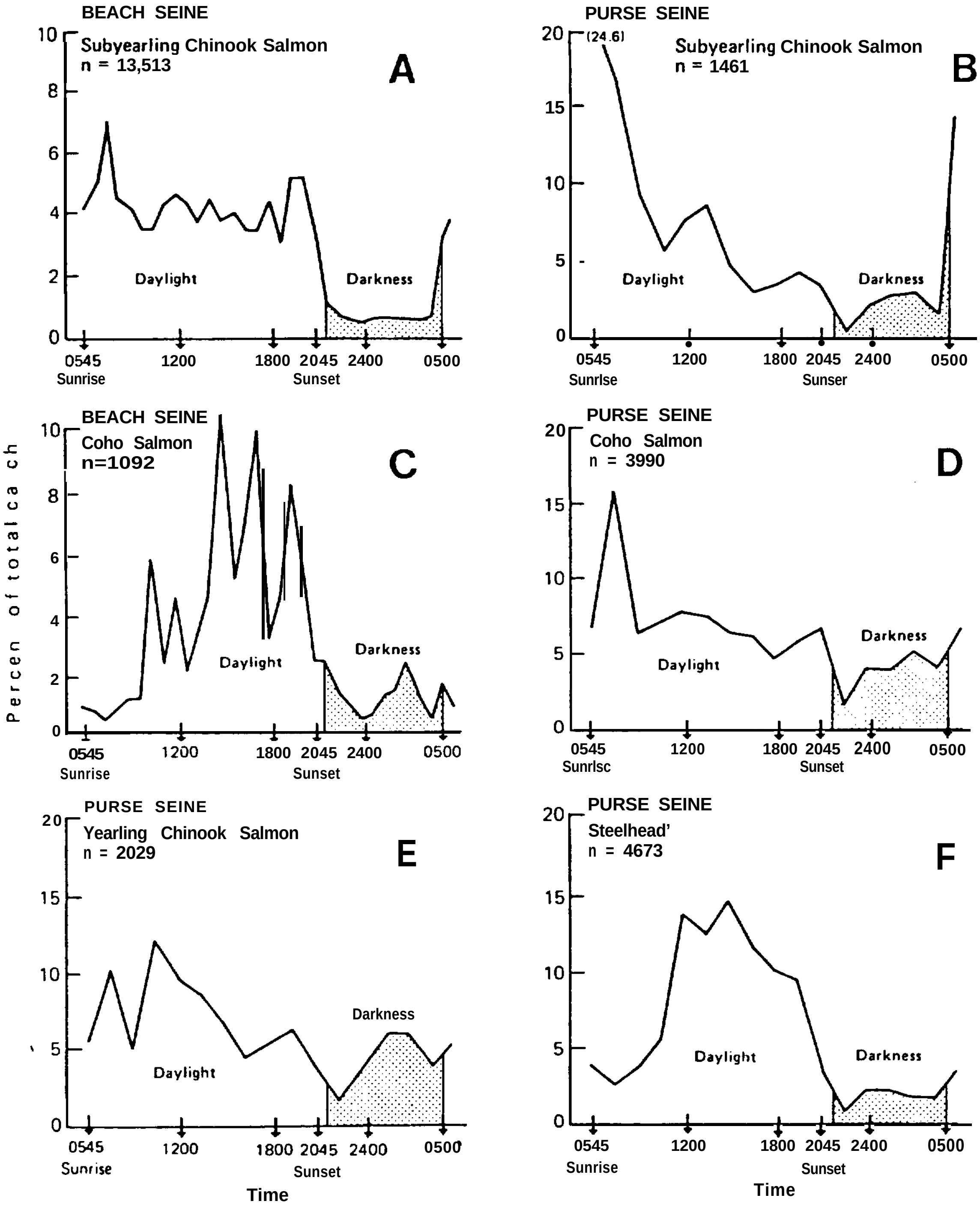


Figure 32.--Die1 catch patterns for chinook salmon, coho salmon, and steelhead from beach and purse seine sampling at Jones Beach, 1978-1980.

CUMULATIVE YEARS

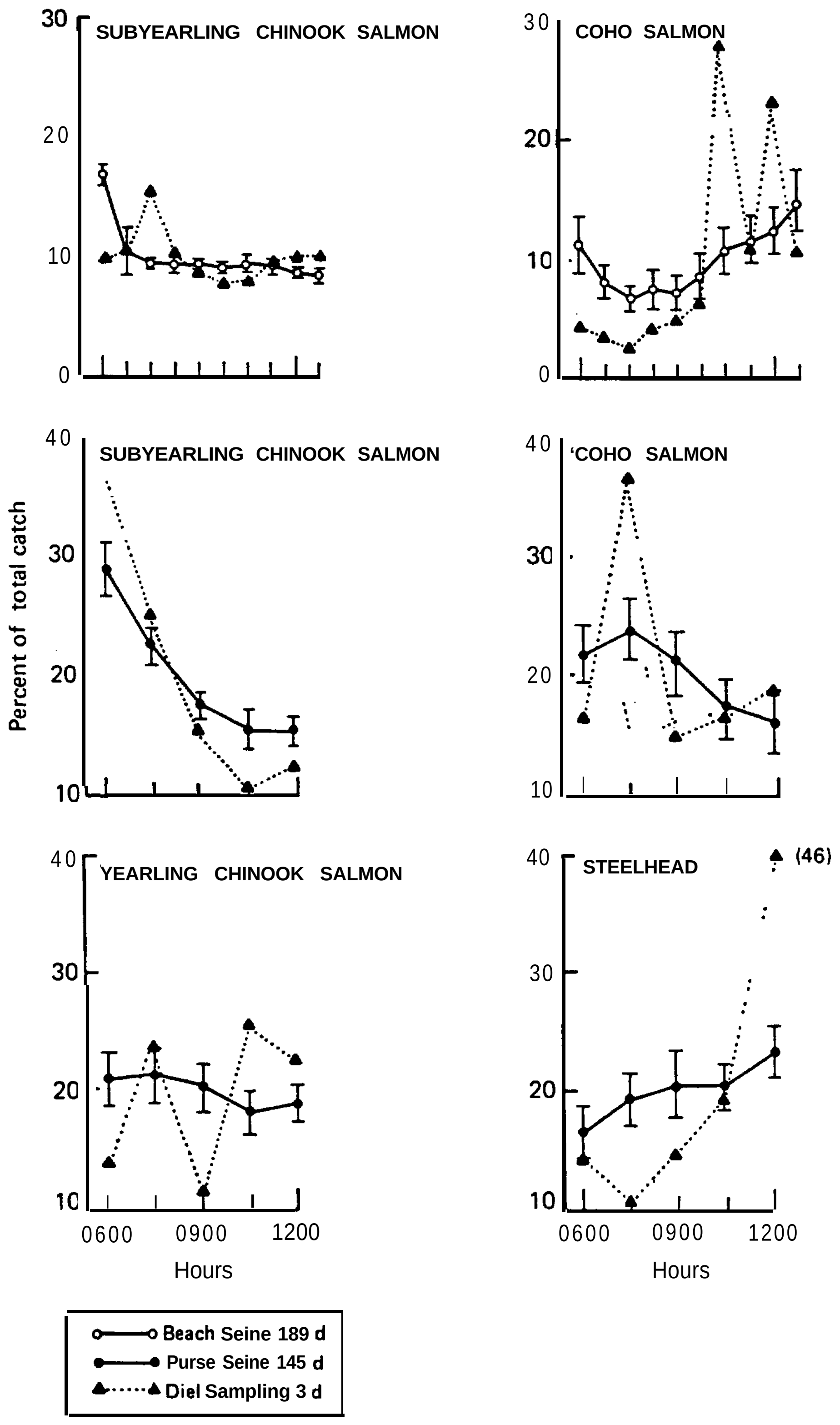


Figure 33.--Means and 95% confidence limits for percentage of total catch by 45- or 90-minute intervals from morning sampling, 1979-1983, compared to mean percentages from die1 sampling at the same time of day, 1978-1980; chinook and coho salmon and steelhead captured with beach and purse seines at Jones Beach.

(relative percent catch per time interval) than in die1 sampling because fish accumulated in the sampling area at night and increased morning-only catches, but were cleared out in earlier sets during die1 sampling. Only data from days with maximum effort (10 beach seine or 5 purse seine sets) during the peak of migration (May and June) were used for evaluation. Means and 95% confidence bands for percent of daily catch by time interval were computed for each year, 1979-1983. These catch patterns were then compared with a pattern developed from the aggregate of 1979-1983 data. Variations within years were not large, thus confidence bands of catch percentages for daily set intervals were small enough to show significant differences between sets for each species (Fig. 33).

It appears that die1 movement behavior of fish at Jones Beach was consistent, and that representative samples of most fish groups passing into the estuary were obtained during one 7-hour portion (morning) of the day. Exceptions that showed erratic patterns of migration were fish groups that passed the site in 3 days or less (discussed later).

River Flow.--Two indirect evaluations were made to assess effects of river flows on juvenile catch percentages from 1977 to 1983: (1) the ratio of subyearling chinook salmon captured to the number released from hatcheries each year was compared to seasonal average river flow and (2) catch percentages from mark groups of similar fish released at different dates were compared to differences of flow at recovery.

The first evaluation of effects from river flow indicated that 76% of the variability of catch percentage between groups was attributable to river flow (Table 26). The linear relationship (Fig. 34) from regression analysis was: Y (catch percent) = 0.622 - 0.039 (Flow--1,000 $m^3$/second) r = -0.87. using this model, an increase in flow from 6,000 to 7,000 $m^3$/second results in a 10.1% decrease in catch. Assumptions are: (1) survival for the subyearling chinook salmon population reared at hatcheries was the same for all years, (2) average river flow for the season appropriately represented the conditions encountered by most fish, and (3) wild subyearling chinook salmon populations immigrating from tributaries downstream from Bonneville Dam were a constant percentage of the catch during all years. River flow data were an average of the daily cumulative flow for the Columbia River at Bonneville Dam obtained from the U.S. Army Corps of Engineers (1977-1983), and the Willamette, Lewis, and Cowlitz Rivers[7/], 30 April-1 July.

The second evaluation involved comparisons between catch percentages of similar fish groups (same body size and stock) released at the same site on different dates. To limit variations from survival differences related to passage conditions at dams, only groups which did not pass through Snake River or Columbia River dams were selected for comparison. The aggregation of data

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7/ Data obtained from the U.S. Ceoglogical Survey, 847 N.E. 19th Ave., Suite 300, Portland, OR 97232.

Table 26.--Numbers of subyearling chinook salmon reared annually at hatcheries in the Columbia River basin, numbers and percent of total subyearling chinook salmon captured in the beach seine at Jones Beach, and seasonal average river flows, 1977-1983.

| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|---|---|---|
| No. released from[a/] hatcheries (millions) | 82.3 | 75.7 | 81.1 | 63.1 | 66.4 | 64.5 | 63.9 |
| No. captured at Jones[b/] Beach (thousands) | 381 | 263 | 303 | 131 | 139 | 154 | 122 |
| Percent capture[c/] | 0.46 | 0.36 | 0.39 | 0.23 | 0.22 | 0.25 | 0.19 |
| River flow thou. $m^3/s$[d/] | 4.0 | 8.0 | 7.0 | 8.5 | 9.5 | 11.1 | 9.8 |

a/ Data obtained from Idaho Department of Fish and Game, Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and Washington Department of Fisheries. Only fish released upstream from Jones Beach were included. Those from Priest Rapids spawning channel, Ringold, Wells spawning channel, and Hagerman Hatchery were omitted as these groups are almost exclusively purse seine captured.

b/ The following adjustment of catches was used to standardize effort levels between years; (weekly average catch per set x 70 cumulative for the period 9 April-30 September each year. Catch per set numbers are listed in Dawley et al. (1985a).

c/ A constant percentage of wild fish within the catch year was assumed, and the error from not including an estimated number was ignored.

d/ Average from daily measurements of the Columbia River at Bonneville Dam, Willamette River, Lewis River, and Cowlitz River, 30 April-l July (calculated from data provided by: U. S. Army Corps of Engineers, NPD, P.O. Box 2870, Portland, OR 97208, and U.S. Geological Survey, P.O. Box 3202, Portland, OR 97208.

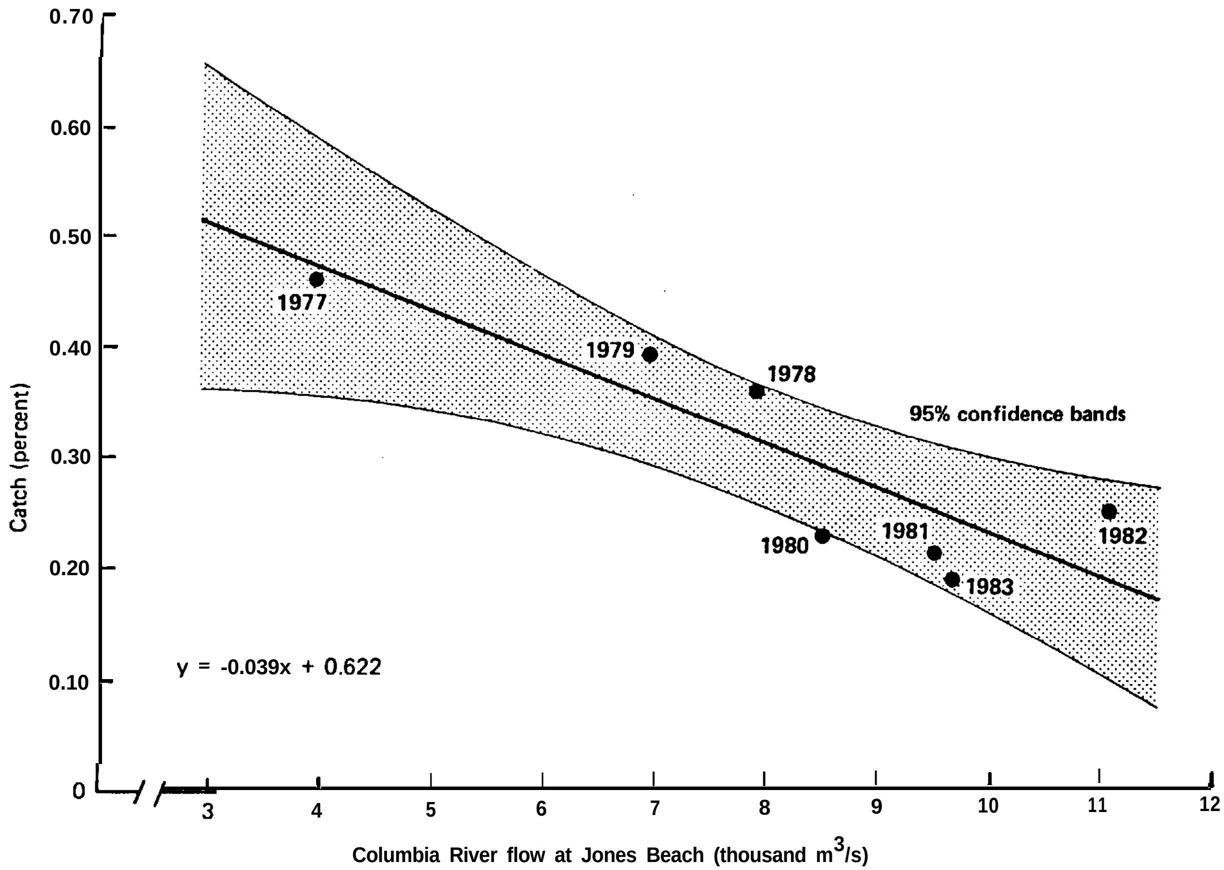


Figure 34.--Subyearling chinook salmon catch at Jones Beach as percent of total hatchery release number by year; plotted against seasonal average flow, 1977-1983.

(Table 27) shows an inverse correlation between river flow and catch percentage. Increased flow resulted in decreased catch percentages in 59% of marked groups (276). Groups which showed changes of catch percentage greater than 99% per 1,000 $m^3$/second were assumed to be erroneous and were deleted from the data base. The overall mean ($\bar{x}$) decrease of catch percentage for a 1,000 $m^3$/second increase of river flow was 2.3%. These data produced a relatively large standard deviation (SD) of 28%. Data were reexamined to determine if variance could be decreased by separating the data into categories of low, medium, and high flow or small, moderate, and large changes of flow and/or by species. Categorizing had little effect on variation, Means and standard deviation for decrease of percentage catch for a 1,000 $m^3$/second flow increase were almost identical for subyearling chinook, yearling chinook, and coho salmon ($\bar{x}$ = 1.6, 2.8, and 2.5%, and SD = 28.2, 28.7, and 26.8% respectively). A single linear relationship over the entire range of flow was used because change of catch percentage per incremental flow change was not correlated with range of flow volume.

Limiting the data set to include only catches from similar mark groups captured under conditions of large flow changes (> 3,000 $m^3$/second) produced a more consistent data set for evaluation of effects of flow on catch percentage; mean 6.8% decrease of catch percentage per 1,000 $m^3$/second flow increase with a SD of 13.7% from 70 comparisons (Table 28). Differences of means among species using the more limited data set were not statistically significant at $P < 0.05$.

At this time, adult recovery data available for these comparison groups (23 sets) show high variability (Table 28) and are insufficient to evaluate precision of flow relationship to juvenile catches.

The two evaluations indicate that increased river flow causes decreased catches of subyearling chinook salmon and yearling migrants in the beach and purse seines. No difference could be detected between species or between different flow ranges. We used a linear catch decrease of 8.5% per 1,000 $m^3$/second increase of flow (average of 10.1 and 6.8%) to standardize catch data for comparison of mark groups of fish captured under different flows.

Fish Size and Location of Sampling.--Most yearling salmonids were captured in mid-river during purse seine sampling, and the majority of subyearlings were captured near shore during beach seine sampling. However, there were exceptions: (1) through mid-April each year, yearling chinook salmon were captured primarily in the beach seine; (2) coho salmon released in early May at sites close to Jones Beach (<100 km) were of ten captured in the beach seine; and (3) large (< 50 fish/lb) subyearling chinook salmon and those which migrated long distance (> 250 km) were of ten captured in the purse seine. The ratios of beach seine to purse seine catch in May, June, and July at Jones Beach were 1:3 for yearling chinook salmon, 1:35 for coho salmon, 1:41 for steelhead, and 1.7:1 for subyearling chinook salmon. The average size of marked and unmarked fish recovered in the beach seine were smaller than those captured with the purse seine--5 to 10 mm for yearling fish and 10 to 20 mm for subyearling fish (Dawley et al. 1985a and b).

Table 27.-- Marked groups used to evaluate catch percentages of marked fish in relation to flow, 1977-1983.

| Release Information a/ | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tag b/ (Ag/D17D2) Brand (Loc Sym Rot) | Size no/lb. | Source/stock c/ (treatment) | Number (thou) | Date (da/mo/yr) | Jones Beach catch d/ (no.) | Jones Beach catch d/ (%) | Flow e/ (Kcms) |
| | | **Subyearling Chinook Salmon** | | | | | |
| 07/25/07 | 35 | Bonneville Hat/ | 102.2 | 30 Jul 81 | 58 | 0.16 | 5.5 |
| 07/24/26 | 40 | Late fall (Well W.35-44/lb.) | 105.0 | 03 Aug 82 | 91 | 0.20 | 6.3 |
| 07/28/28 | 44 | " | 99.0 | 01 Aug 83 | 39 | 0.13 | 5.2 |
| 09/16/05 | 78 | Bonneville Hat | 183.2 | 05 May 77 | 409 | 0.47 f/ | 4.5 |
| 07/16/08 | 78 | Tule (Well water production) | 96.6 | 01 May 79 | 128 | 0.17 | 9.7 |
| 07/21/56 | 76 | " | 130.0 | 24 Apr 81 | 148 | 0.12 | 7.9 |
| 07/24/07 | 80 | " | 105.9 | 23 Apr 82 | 262 | 0.25 | 10.0 |
| 07/27/29 | 74 | " | 52.6 | 04 May 83 | 40 | 0.09 | 10.4 |
| 07/27/30 | | | 47.4 | | 47 | | |
| 07/18/42 | 88 | Bonneville Hat g/ | 287.9 | 01-29 May 79 | 499 | 0.21 | 7.6 |
| 07/23/29 | 85 | Tule (Tanner Cr.) | 75.7 | 12 May 81 | 57 | 0.09 | 7.7 |
| 07/24/08 | 80 | " | 96.8 | 21May-04Jun 82 | 182 | 0.19 | 11.0 |
| 63/18/02 | 133 | Cowlitz Hat/ | 146.0 | 19 Jun 78 | 311 | 0.42 | 6.8 |
| 63/19/42 | 85 | (production) | 120.4 | 27 Jun 79 | 78 | 0.39 | 3.6 |
| 63/21/56 | 84 | " | 153.2 | 12-28 Jun 81 | 195 | 0.40 | 7.8 |
| 63/22/55 | | | 121.3 | | 494 | | |
| 63/20/32 | 94 | " | 41.3 | 24Jun-08Jul 82 | 136 | 0.37 | 7.3 |
| 63/24/62 | | | 199.2 | | 523 | | |
| 63/25/03 | 72 | " | 150.2 | 06-25 Jun 83 | 522 | 0.49 | 7.2 |
| 63/16/39 | 113 | Kalama Falls Hat | 145.7 | 22 Jun 77 | 697 | 0.72 f/ | 2.9 |
| 63/17/46 | 108 | (production) | 150.5 | 12 Jul 78 | 541 | 0.66 | 4.5 |
| 63/19/57 | 180 | " | 209.7 | 22Jun-13Jul79 | 2229 | 1.40 | 3.8 |
| 63/21/05 | 115 | " | 100.4 | 13-24 Jun 80 | 163 | 0.34 | 5.3 |
| 63/20/36 | 119 | " | 175.4 | 22-28 May 81 | 175 | 0.12 | 10.9 |
| 63/24/60 | 130 | " | 163.2 | 10Jun-17Jul 82 | 185 | 0.16 | 10.0 |
| 63/17/42 | 61 | Lo. Kalama Hat | 129.7 | 30 May 78 | 136 | 0.13 | 7.9 |
| 63/20/06 | 150 | (production) | 144.5 | 06 Jun 80 | 209 | 0.20 | 9.1 |
| 63/22/54 | 100 | " | 155.3 | 01-11 Jun 81 | 175 | 0.14 | 11.2 |
| 63/24/63 | 117 | " | 139.4 | 13-25 Jun 82 | 191 | 0.17 | 12.2 |
| 05/50/01ℓ RD U 4 | 83 | Spring Cr.Hat.@ ds Bonn.D. (79-83 lb.) | 76.1 | 11 Apr 77 | 304 | 0.63 f/ | 4.7 |
| 05/54/01 | 79 | " | 98.2 | 20 Apr 78 | 201 | 0.24 | 8.8 |
| 63/16/40 | 117 | Toutle Hat | 132.5 | 29 Jun 77 | 606 | 0.74 f/ | 3.4 |
| 63/17/63 | 98 | (production) | 142.8 | 19 Jun 78 | 457 | 0.57 | 6.1 |
| 63/19/41 | 160 | " | 132.1 | 17 Jun 79 | 794 | 0.82 | 4.0 |
| 63/16/41 | 64 | Washougal Hat | 128.6 | 28 Jun 77 | 188 | 0.23 f/ | 3.0 |
| 63/18/03 | 62 | (production) | 151.4 | 26 Jun 78 | 212 | 0.26 | 5.7 |
| 63/19/38 | 95 | " | 93.7 | 14 Jun 79 | 296 | 0.45 | 4.8 |
| 63/19/46 | | | 158.8 | | 589 | | |
| 63/21/53 | 80 | " | 319.2 | 30 Jun 80 | 609 | 0.34 | 4.8 |
| 63/22/51 | 71 | " | 277.3 | 26-30 Jun 81 | 417 | 0.25 | 7.8 |
| 63/24/61 | 90 | " | 167.9 | 28 Jun 82 | 427 | 0.41 | 9.7 |
| | | **Yearling Chinook Salmon** | | | | | |
| 07/16/57 | 7 | Bonneville Hat/ | 47.9 | 13 Mar 79 | 105 | 0.38 | 7.3 |
| 07/17/36 | 6 | Tule (Well water) | 48.1 | 13 Mar 80 | 52 | 0.22 | 4.9 |
| 07/21/40 | 7 | " | 51.9 | 17 Mar 82 | 52 | 0.43 | 9.3 |
| 07/27/01 | 7 | " | 37.5 | 08 Mar 83 | 44 | 0.23 | 13.9 |
| 07/16/61 | 8 | Bonneville Hat/ | 32.7 | 13 Mar 79 | 62 | 0.41 | 7.3 |
| 07/17/33 | 7 | Late fall (Well water) | 49.3 | 13 Mar 80 | 70 | 0.33 | 4.9 |
| 07/21/43 | 7 | " | 50.6 | 17 Mar 82 | 48 | 0.38 | 12.1 |
| 07/25/47 | 6 | " | 49.9 | 23 Mar 83 | 13 | 0.05 | 10.0 |

Table 27.--continued.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| WHLBGN 1 | 20 | Carson Hat | 41.0 | 03 May 79 | 28 | 0.08 | 9.7 |
| (LA AN 4) | | (homing) | | | | | |
| 05/04/37 | 19 | " | 82.1 | 28 Apr 80 | 38 | 0.07 | 8.8 |
| 63/17/11 | 5 | Cowlitz Hat | 58.3 | 08 Mar 78 | 77 | 0.45 | 7.2 |
| 63/17/12 | | (Density 6 lb/gal/min) | 57.0 | | 85 | | |
| 63/18/17 | 6 | " | 24.1 | 23 Apr 79 | 35 | 0.19 | 6.4 |
| 63/18/18 | | | 24.3 | | 34 | | |
| 63/21/34 | 8 | (Erythromyin control @ | 24.0 | 01 Apr 82 | 9 | 0.06 | 10.4 |
| 63/23/11 | | 5-6 lb/gal/min) | 24.4 | | 11 | | |
| 63/25/05 | 6 | (Adult arrival timing @ | 73.0 | 04 Apr 83 | 18 | 0.05 | 9.1 |
| 63/25/06 | | 5-6 lb/gal/min) | 77.5 | | 26 | | |
| 63/26/09 | | | 58.3 | | 11 | | |
| 09/16/58 | 15 | Eagle Creek Hat | 97.2 | 24 Apr 78 | 53 | 0.07 | 8.1 |
| 07/17/47 | 13 | (production) | 46.2 | 01 May 79 | 39 | 0.11 | 8.1 |
| 07/17/48 | | | 48.3 | | 51 | | |
| 09/16/61 | 16 | Marion FKs. Hat @ Minto/ | 48.6 | 13-15 Mar 78 | 17 | 0.07 | 7.2 |
| 09/16/62 | | Carson stock | 45.9 | | 22 | | |
| 09/16/63 | | | 50.2 | | 17 | | |
| 07/17/25 | 16 | " | 49.7 | 03-05 Apr 79 | 32 | 0.08 | 9.7 |
| 07/17/26 | | | 49.6 | | 21 | | |
| 07/17/29 | | | 45.0 | | 37 | | |
| 07/22/49 | 14 | " | 50.3 | 16-23 Mar 81 | 10 | 0.04 | 6.5 |
| 07/22/50 | | | 49.7 | | 7 | | |
| 07/22/51 | | | 47.1 | | 7 | | |
| 07/25/25 | 16 | " | 50.6 | 15-17 Mar 82 | 12 | 0.04 | 9.4 |
| 07/25/26 | | | 50.7 | | 13 | | |
| 07/25/27 | | | 49.5 | | 26 | | |
| 09/17/01 | 12 | Marion FKs. Hat @ Minto/ | 49.1 | 13-15 Mar 78 | 28 | 0.08 | 8.0 |
| 09/17/02 | | Santiam stock (12-17/lb) | 49.6 | | 22 | | |
| 09/17/03 | | | 50.1 | | 45 | | |
| 07/17/31 | 17 | " | 49.4 | 03-05 Apr 79 | 36 | 0.09 | 9.7 |
| 07/17/32 | | | 50.6 | | 38 | | |
| 07/22/52 | 14 | " | 39.7 | 16-24 Mar 81 | 10 | 0.05 | 6.5 |
| 07/22/53 | | | 42.2 | | 10 | | |
| 07/25/28 | 15 | " | 50.0 | 18-22 Mar 82 | 14 | 0.05 | 10.0 |
| 07/25/29 | | | 49.5 | | 22 | | |
| 07/25/30 | | | 49.2 | | 20 | | |
| 07/17/30 | 19 | Marion FKs. Hat @ Minto/ | 48.2 | 03-05 Apr 79 | 29 | 0.08 | 9.7 |
| 07/22/54 | 20 | Santiam stock (19-20/lb) | 48.3 | 16-18 Mar 81 | 7 | 0.03 | 7.9 |
| 07/20/53 | 11 | McKenzie Hat | 34.9 | 15 Mar 80 | 13 | 0.08 | 5.8 |
| 07/22/22 | 9 | (Graded-medium) | 36.0 | 16 Mar 81 | 11 | 0.08 | 6.2 |
| 07/25/18 | 11 | " | 34.2 | 15 Mar 82 | 2 | 0.01 | 9.4 |
| 07/27/20 | 10 | " | 30.0 | 14 Mar 83 | 15 | 0.10 | 7.7 |
| 07/20/48 | 3 | McKenzie Hat | 31.1 | 15 Mar 80 | 18 | 0.15 | 5.8 |
| 07/22/20 | 4 | (Graded-large) | 35.6 | 16 Mar 81 | 11 | 0.07 | 6.2 |
| 07/25/16 | 3 | " | 36.3 | 15 Mar 82 | 2 | 0.01 | 10.0 |
| 07/27/18 | 4 | " | 36.2 | 14 Mar 83 | 9 | 0.06 | 12.0 |
| 07/20/51 | 4 | McKenzie Hat | 29.4 | 15 Mar 80 | 13 | 0.11 | 5.8 |
| 07/22/17 | 6 | (Ungraded) | 30.2 | 16 Mar 81 | 4 | 0.03 | 6.2 |
| 07/20/54 | 4 | " | 32.5 | 15 Mar 82 | 4 | 0.03 | 9.6 |
| 07/25/22 | 6 | " | 32.1 | 14 Mar 83 | 4 | 0.02 | 9.1 |
| 07/17/41 | 14 | Oakridge Hat @ Dexter | 32.0 | 19-20 Mar 79 | 40 | 0.17 | 6.9 |
| 07/20/40 | 16 | (Graded-small) | 30.9 | 10-11 Mar 80 | 18 | 0.13 | 5.8 |
| 07/24/20 | 14 | " | 29.5 | 15 Mar 82 | 6 | 0.04 | 11.6 |
| 07/17/42 | 8 | Oakridge Hat @ Dexter | 29.5 | 20 Mar 79 | 50 | 0.26 | 6.9 |
| 07/20/42 | 9 | (Graded-medium) | 30.7 | 10-11 Mar 80 | 20 | 0.14 | 5.8 |
| 07/23/07 | 8 | " | 31.7 | 16 Mar 81 | 17 | 0.10 | 5.6 |
| 07/23/05 | | | 29.9 | | 14 | | |
| 07/24/22 | 9 | " | 30.9 | 15-16 Mar 82 | 5 | 0.03 | 11.6 |
| 07/17/44 | 6 | Oakridge Hat @ Dexter | 32.8 | 20 Mar 79 | 36 | 0.31 | 7.3 |
| 07/20/46 | 4 | (Graded-large) | 29.0 | 10 Mar 80 | 15 | 0.15 | 4.9 |
| 07/23/03 | 4 | " | 31.2 | 16 Mar 81 | 12 | 0.11 | 6.2 |
| 07/24/19 | 5 | " | 30.7 | 15 Mar 82 | 8 | 0.10 | 9.6 |

Table 27.--continued.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 07/17/43 | 12 | Oakridge Hat @ Dexter | 30.2 | 20 Mar 79 | 32 | 0.18 | 6.9 |
| 07/20/44 | 8 | (Ungraded) | 30.7 | 10 Mar 80 | 25 | 0.19 | 5.8 |
| 07/22/25 | 7 | " | 26.6 | 16 Mar 81 | 9 | 0.06 | 6.5 |
| 07/25/13 | 7 | " | 27.4 | 15 Mar 82 | 7 | 0.07 | 9.3 |
| 09/16/21 | 8 | S. Santiam Hat | 25.0 | 13-15 Mar 78 | 10 | 0.09 | 7.9 |
| 09/16/22 | | (production) | 29.5 | | 5 | | |
| 09/16/26 | | | 14.9 | | 11 | | |
| 07/19/45 | 5 | " | 29.4 | 14 Mar 80 | 23 | 0.19 | 4.9 |
| 07/19/46 | | | 29.9 | | 19 | | |
| 09/16/23 | 9 | S. Santiam Hat | 26.9 | 13-15 Mar 78 | 30 | 0.24 | 7.9 |
| 09/16/24 | | (Below Williams Falls) | 24.6 | | 25 | | |
| 09/16/25 | | | 13.4 | | 12 | | |
| 07/19/47 | 6 | " | 32.1 | 13-14 Mar 80 | 36 | 0.28 | 4.9 |
| 07/19/48 | | | 28.5 | | 30 | | |
| | | Coho Salmon | | | | | |
| 07/19/08 | 23 | Cascade Hat @ Tanner Cr. | 27.9 | 07 May 79 | 18 | 0.07 | 8.1 |
| 07/19/11 | | (May release) | 26.9 | | 18 | | |
| 07/19/63 | 24 | " | 29.2 | 28 Apr 80 | 13 | 0.08 | 7.6 |
| 07/21/27 | 17 | " | 24.9 | 06 May 81 | 24 | 0.11 | 6.7 |
| 07/21/30 | | | 26.7 | | 28 | | |
| 07/19/07 | 23 | Cascade Hat @ Tanner Cr. | 27.2 | 07 Jun 79 | 37 | 0.14 | 5.5 |
| 07/19/10 | | (Late May-June release) | 25.9 | | 36 | | |
| 07/21/28 | 17 | " | 27.9 | 08 Jun 81 | 21 | 0.10 | 12.4 |
| 07/21/31 | | | 26.1 | | 25 | | |
| 07/24/29 | 18 | " | 27.7 | 25 May 82 | 25 | 0.10 | 11.0 |
| 07/24/33 | | | 28.2 | | 30 | | |
| 07/27/47 | 18 | " | 43.1 | 24 May 83 | 21 | 0.06 | 12.2 |
| 07/19/09 | 23 | Cascade Hat @ Tanner Cr. | 24.6 | 06 Jul 79 | 50 | 0.44 | 4.0 |
| 07/19/12 | | (July release) | 25.2 | | 56 | | |
| 07/21/29 | 17 | " | 27.7 | 06 Jul 81 | 13 | 0.14 | 7.6 |
| 07/21/32 | | | 28.9 | | 19 | | |
| 63/24/30 | 20 | Cowlitz Hat | 10.6 | 03 May 82 | 17 | 0.16 | 11.9 |
| 63/24/31 | | (Density 11.6-11.7 lb/gal/min) | 10.6 | | 13 | | |
| 63/24/32 | | | 10.2 | | 16 | | |
| 63/24/33 | | | 10.4 | | 17 | | |
| 63/24/34 | | | 10.5 | | 18 | | |
| 63/26/28 | 20 | " | 10.2 | 03 May 83 | 19 | 0.18 | 9.9 |
| 63/26/29 | | | 10.3 | | 16 | | |
| 63/26/30 | | | 10.4 | | 17 | | |
| 63/26/31 | | | 10.2 | | 17 | | |
| 63/26/32 | | | 10.6 | | 17 | | |
| 09/16/57 | 15 | Eagle Creek Hat | 74.7 | 24 Apr 78 | 95 | 0.17 | 8.7 |
| 07/17/46 | 18 | (Density 0.45 lb/cu ft/in) | 69.3 | 22 May 79 | 128 | 0.22 | 6.2 |
| 05/08/26 | 14 | " | 126.8 | 22 Apr 81 | 180 | 0.18 | 6.7 |
| 05/10/39 | 16 | " | 68.3 | 06 May 82 | 114 | 0.18 | 11.0 |
| 05/10/40 | | | 66.6 | | 115 | | |
| 05/11/33 | 15 | " | 60.5 | 04 May 83 | 78 | 0.13 | 9.2 |
| 05/11/34 | | | 62.8 | | 76 | | |
| 63/23/03 | 17 | Lower Kalama Hat | 52.8 | 03 May 82 | 89 | 0.17 | 10.9 |
| 63/26/05 | 17 | (Density 11-11.5 lb/gal/min) | 52.0 | 04 May 83 | 53 | 0.10 | 9.2 |
| 09/16/49 | 15 | Sandy Hat | 34.0 | 04 May 78 | 21 | 0.08 | 8.1 |
| 09/16/50 | | (nutrition) | 33.3 | | 24 | | |
| 09/16/51 | | | 34.4 | | 19 | | |
| 09/16/52 | | | 33.0 | | 22 | | |
| 07/17/49 | 19 | " | 27.5 | 01 May 79 | 28 | 0.13 | 8.1 |
| 07/17/50 | | | 27.4 | | | | |
| 07/17/51 | | | 27.5 | | 32 | | |
| 07/17/52 | | | 27.9 | | 28 | | |

Table 27.--continued.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 07/20/31 | 18 | Sandy Hat. (nutrition) | 25.2 | 01 May 80 | 16 | 0.12 | 7.6 |
| 07/20/33 | | | 25.2 | | 15 | | |
| 07/20/32 | | | 25.4 | | 16 | | |
| 07/20/34 | | | 25.2 | | 21 | | |
| 07/20/35 | | | 25.9 | | 12 | | |
| 07/20/36 | | | 24.5 | | 20 | | |
| 07/20/37 | | | 26.0 | | 15 | | |
| 07/20/38 | | | 26.5 | | 20 | | |
| 07/22/59 | 18 | " | 29.9 | 01 May 81 | 34 | 0.09 | 7.2 |
| 07/22/62 | | | 27.8 | | 25 | | |
| 07/22/60 | | | 28.1 | | 17 | | |
| 07/22/63 | | | 29.7 | | 18 | | |
| 07/22/61 | | | 29.8 | | 20 | | |
| 07/23/01 | | | 28.9 | | 22 | | |
| 07/22/56 | | | 27.3 | | 20 | | |
| 07/22/58 | | | 28.0 | | 12 | | |
| 07/22/55 | | | 27.6 | | 21 | | |
| 07/22/57 | | | 28.9 | | 16 | | |
| 07/25/53 | 18 | " | 26.0 | 30 Apr 82 | 25 | 0.15 | 10.9 |
| 07/25/55 | | | 28.3 | | 33 | | |
| 07/25/50 | | | 26.4 | | 50 | | |
| 07/25/58 | | | 27.9 | | 36 | | |
| 07/25/51 | | | 27.3 | | 34 | | |
| 07/25/54 | | | 27.6 | | 46 | | |
| 07/25/49 | | | 24.0 | | 20 | | |
| 07/25/52 | | | 26.9 | | 36 | | |
| 07/25/56 | | | 27.6 | | 43 | | |
| 07/25/57 | | | 28.1 | | 53 | | |
| 07/27/31 | 17 | " | 54.7 | 29 Apr 83 | 32 | 0.07 | 9.2 |
| 07/27/32 | | | 54.9 | | 34 | | |
| 07/27/33 | | | 54.1 | | 36 | | |
| 07/27/34 | | | 54.7 | | 37 | | |
| 07/27/35 | | | 54.6 | | 33 | | |
| 07/27/36 | | | 54.9 | | 46 | | |
| 63/19/11 | 18 | Toutle Hat (May release) | 42.4 | 07 May 79 | 46 | 0.13 | 8.1 |
| 63/19/12 | | | 34.7 | | 40 | | |
| 63/19/31 | 19 | " | 38.6 | 07 May 80 | 43 | 0.28 | 7.6 |
| 63/20/58 | | | 39.5 | | 31 | | |
| 63/19/23 | 16 | Washougal Hat (Late April-Early May) | 74.4 | 07 May 79 | 81 | 0.13 | 8.4 |
| 63/19/24 | | | 80.7 | | 87 | | |
| 63/20/39 | 18 | " | 99.6 | 08 May 80 | 81 | 0.13 | 7.6 |
| 63/20/40 | | | 98.7 | | 68 | | |
| 63/21/50 | 18 | " | 51.8 | 30 Apr 81 | 45 | 0.11 | 6.7 |
| 63/22/02 | | | 52.0 | | 46 | | |
| 63/26/45 | 18 | " | 50.9 | 15-30 Apr 83 | 40 | 0.08 | 9.6 |
| 63/19/25 | 20 | Washougal Hat (Late May-Early June; Density 13.5-16 lb/gal/min) | ~~73.0~~ | 07 Jun 79 | ~~120~~ | ~~0.16~~h/ | 5.5 |
| 63/19/26 | | | ~~82.9~~ | | ~~119~~ | h/ | |
| 63/20/37 | 18 | | 97.3 | 09 Jun 80 | 53 | 0.10 | 9.1 |
| 63/20/38 | | | 97.8 | | 65 | | |
| 63/21/51 | 20 | " | ~~52.9~~ | 27 May 81 | 35 | ~~0.09~~i/ | 10.9 |
| 63/22/03 | | | 52.4 | | 35 | 0.10 | |
| 63/25/13 | 21 | " | 10.2 | 25 May 82 | 9 | 0.09 | 11.0 |
| 63/25/14 | | | 9.9 | | 9 | | |
| 63/25/15 | | | 10.3 | | 14 | | |
| 63/25/16 | | | 9.9 | | 6 | | |
| 63/25/17 | | | 9.8 | | 6 | | |
| 63/27/13 | 19 | " | 10.0 | 27 May 83 | 7 | 0.09 | 12.2 |
| 63/27/14 | | | 10.9 | | 8 | | |
| 63/27/15 | | | 10.3 | | 8 | | |
| 63/27/16 | | | 10.3 | | 3 | | |
| 63/27/17 | | | 10.6 | | 12 | | |
| 63/19/27 | 20 | Washougal Hat (July release) | 81.0 | 06 Jul 79 | 197 | 0.49 | 4.0 |
| 63/19/34 | | | 82.1 | | 191 | | |
| 63/19/54 | 18 | " | 106.7 | 07 Jul 80 | 126 | 0.25 | 5.3 |
| 63/19/55 | | | 107.0 | | 118 | | |

Table 27.--continued.

a/ Only groups released downstream from Bonneville Dam were used due to variation in survival associated with changing spill to turbine discharge rate at dams; only groups of the same stock released at similar size from the same site. Assumed no variation in affect from Willamette Falls on survival or catch percentage. Groups with rapid movement rates which were not dispursed and 50% past Jones Beach in 2 days or less were not used due to variable catch rates. Nutrition treatment groups with no statistical difference (trend over the years) were combined into one observation per year.

b/ More complete information available from Dawley et al. 1985b or releasing agency Table 21. Binary coded wire tags: Ag=Agency code, Dl=Data 1 code, and D2=Data 2 code. Color coded wire tags begin with WH and each two digits thereafter represent a color. Brands are represented by the following: Loc=Location on fish, Sym=Brand symbol, and Rot=Rotation of symbol. For abbreviations, symbol, and descriptions see Dawley et al. 1985b.

c/ Abbreviations are listed: Bonn=Bonneville, Cr=Creek, D-Dam, ds=downstream, Fks=Forks, Gal=Gallon, Graded=Fish mechanically selected by size, Hat=Hatchery, lb=pound, Lo=Lower, Min=Minute, S=South, Tule=Lower river stock of fall chinook salmon, Ungraded=No fish selection by size, W=Water, and @=Released at.

d/ Actual catch; catch percent adjusted for effort.

e/ Seven-day average of river flow at Jones Beach during the week of median fish recovery; including Columbia River above Bonneville Dam, Willamette River, Cowlitz River, and Lewis River; 1 kcms = 1,000 $m^3$/s.

f/ Inconsistent purse seine effort in 1977, consequently, yearling fish not used for evaluation. Catch adjustments were made for subyearling fish to equate with other years (8, 11, 8, and 15% increase, respectively, for Bonneville Dam, Kalama Falls, and Spring Creek fish released downstream from Bonneville, Toutle, and Washougal Hatchery fish); obtained from average purse seine contribution to those groups from 1978-1983.

g/ Did not use 1980 due to effects of Mount St. Helens.

h/ Diseased fish at release; not used in the analysis.

i/ Higher densitv: not used in the analvsis.

Table 28.--Adult recovery data plus differences of juvenile catch related to river flow difference during downstream migration for mark groups used in evaluating effects of flow on beach and purse seine sampling efficiency; biologically similar mark groups captured at Jones Beach during river flows which were different by 3,000 $m^3$/second or more.

| Group captured @ low flow tag code a/ (AgD1D2) | Group captured @ high flow tag code a/ (AgD1D2) | Low flow (Kcms) b/ | Δflow; c/ hi-low (Kcms) | Δcatch % d/ per 1 Kcms increase | Adult recov. e/ from low flow group (no.) | % | Adult recov. e/ from high flow group (no.) | % |
|---|---|---|---|---|---|---|---|---|
| | | | Subyearling chinook salmon | | | | | |
| 091605 | 071608 | 4.5 | 5.2 | -12.3 | 101 | 0.06 | 350 | 0.36 |
| 091605 | 072729 | 4.5 | 5.5 | -8.5 | 8 | 0.00 | 13 | 0.00 |
| 091605 | 072407 | 4.5 | 5.9 | -13.7 | 53 | 0.03 | 120 | 0.11 |
| 091605 | 072156 | 4.5 | 3.4 | -21.9 | 99 | 0.05 | 145 | 0.11 |
| 071842 | 072408 | 7.6 | 3.4 | 10.8 | 380 | 0.13 | 11 | 0.01 |
| 072329 | 072408 | 7.7 | 3.3 | -2.8 | 69 | 0.09 | 11 | 0.01 |
| 631942 | 631802 | 3.6 | 3.2 | 2.4 | 144 | 0.12 | 182 | 0.12 |
| 631942 | 632503 | 3.6 | 3.6 | 7.1 | | | | |
| 631942 | 632032,2462 | 3.6 | 3.7 | -1.4 | | | | |
| 631942 | 632156,2255 | 3.6 | 4.2 | 0.6 | 54 | 0.04 | 200 | 0.07 |
| 631639 | 632036 | 2.9 | 8.0 | -10.4 | 61 | 0.04 | 27 | 0.02 |
| 631639 | 632460 | 2.9 | 8.1 | -9.6 | 1 | 0.00 | 0 | 0.00 |
| 631746 | 632036 | 4.5 | 6.4 | -12.8 | 20 | 0.01 | 27 | 0.02 |
| 631746 | 632460 | 4.5 | 6.5 | -11.7 | 2 | 0.00 | 0 | 0.00 |
| 631957 | 632036 | 3.8 | 7.1 | -12.9 | 7 | 0.00 | 27 | 0.02 |
| 631957 | 632460 | 3.8 | 7.2 | -60.6 | 1 | 0.00 | 0 | 0.00 |
| 632105 | 632036 | 5.3 | 5.6 | 12.3 | 25 | 0.02 | 27 | 0.02 |
| 632105 | 632460 | 5.3 | 5.7 | -11.6 | 1 | 0.00 | 0 | 0.00 |
| 631742 | 632254 | 7.9 | 3.3 | 2.3 | 16 | 0.01 | 53 | 0.03 |
| 631742 | 632463 | 7.9 | 4.3 | 7.2 | 1 | 0.00 | 1 | 0.00 |
| 632006 | 632463 | 9.1 | 3.1 | -4.8 | 2 | 0.00 | 1 | 0.00 |
| 055001 | 055401 | 4.7 | 4.1 | -15.1 | 355 | 0.47 | 479 | 0.49 |
| 631641 | 632461 | 3.0 | 6.7 | 11.7 | 4 | 0.00 | 1 | 0.00 |
| 631641 | 632251 | 3.0 | 4.8 | 1.8 | 222 | 0.17 | 63 | 0.02 |
| 631803 | 632461 | 5.7 | 4.0 | 4.2 | 5 | 0.00 | 1 | 0.00 |
| 631938,46 | 632251 | 4.8 | 3.0 | -14.8 | 54 | 0.02 | 63 | 0.02 |
| 631938,46 | 632461 | 4.8 | 4.9 | -1.8 | 2 | 0.00 | 1 | 0.00 |
| 632153 | 632251 | 4.8 | 3.0 | -8.8 | 170 | 0.05 | 63 | 0.02 |
| 632153 | 632461 | 4.8 | 4.9 | 14.4 | 5 | 0.00 | 1 | 0.00 |
| | | | Yearling chinook salmon | | | | | |
| 071657 | 072701 | 7.3 | 6.6 | -6.0 | | | | |
| 071736 | 072701 | 4.9 | 9.0 | 0.5 | | | | |
| 071736 | 072140 | 4.9 | 4.4 | 21.7 | 58 | 0.12 | 38 | 0.07 |
| 072140 | 072701 | 9.3 | 4.6 | -10.1 | | | | |
| 071661 | 072143 | 7.3 | 4.7 | -1.5 | 98 | 1.30 | 20 | 0.04 |
| 071733 | 072143 | 4.9 | 7.1 | 2.1 | 27 | 0.06 | 20 | 0.04 |
| 071733 | 072547 | 4.9 | 5.1 | -16.6 | | | | |

Table 28.--continued.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 631711,12 | 632134,2311 | 7.2 | 3.2 | -27.1 | 1640 | 1.42 | 20 | 0.04 |
| 631817,18 | 632134,2311 | 6.4 | 4.0 | -17.1 | 344 | 0.71 | 20 | 0.04 |
| 072249-51 | 071725,2629 | 6.5 | 3.4 | 31.3 | 49 | 0.03 | 26 | 0.02 |
| 072252,53 | 071731,32 | 6.5 | 3.2 | 25.0 | 69 | 0.08 | 205 | 0.21 |
| 072252,53 | 072528,2930 | 6.5 | 3.5 | 0.0 | | | | |
| 072053 | 072518 | 5.8 | 3.6 | -24.3 | 0 | 0.00 | 0 | 0.00 |
| 072222 | 072518 | 6.2 | 3.2 | -27.3 | 2 | 0.01 | 0 | 0.00 |
| 072048 | 072516 | 5.8 | 4.2 | -22.2 | 3 | 0.01 | 0 | 0.00 |
| 072048 | 072718 | 5.8 | 6.2 | -9.7 | | | | |
| 072220 | 072516 | 6.2 | 3.8 | -22.2 | 4 | 0.01 | 0 | 0.00 |
| 072220 | 072718 | 6.2 | 5.8 | -2.5 | | | | |
| 072051 | 072054 | 5.8 | 3.8 | -19.1 | 0 | 0.00 | 2 | 0.01 |
| 072051 | 072522 | 5.8 | 3.3 | -24.8 | | | | |
| 072217 | 072054 | 6.2 | 3.4 | 0.0 | 2 | 0.01 | 2 | 0.01 |
| 071741 | 072420 | 6.9 | 4.7 | -16.3 | 2 | 0.01 | 2 | 0.01 |
| 072040 | 072420 | 5.8 | 5.8 | -11.9 | 9 | 0.03 | 2 | 0.01 |
| 071742 | 072422 | 6.9 | 4.7 | -18.8 | 25 | 0.08 | 2 | 0.01 |
| 072042 | 072420 | 5.8 | 5.8 | -13.5 | 22 | 0.07 | 2 | 0.01 |
| 072305 | 072422 | 5.6 | 6.0 | -11.7 | 11 | 0.04 | 2 | 0.01 |
| 072303 | 072419 | 6.2 | 3.4 | -2.7 | 13 | 0.04 | 7 | 0.02 |
| 072046 | 072419 | 4.9 | 4.7 | -7.1 | 20 | 0.07 | 7 | 0.02 |
| 072044 | 072513 | 5.8 | 3.5 | -18.0 | 17 | 0.06 | 3 | 0.01 |
| 071945,46 | 091622,26 | 4.9 | 3.0 | -17.5 | 77 | 0.13 | 276 | 0.62 |
| 071947,48 | 091623-25 | 4.9 | 3.0 | -4.8 | 54 | 0.09 | 493 | 1.22 |
| | | | Coho salmon | | | | | |
| 071907,10 | 072429,33 | 5.5 | 5.5 | -5.2 | 643 | 1.21 | 310 | 0.55 |
| 071907,10 | 072747 | 5.5 | 6.7 | -8.5 | | | | |
| 071907,10 | 072128,31 | 5.5 | 6.9 | -4.1 | 643 | 1.21 | 1771 | 3.28 |
| 071909,12 | 072129,32 | 4.0 | 3.6 | -18.9 | 440 | 0.88 | 1451 | 2.56 |
| 071746 | 051133,34 | 6.2 | 3.0 | -13.6 | | | | |
| 071746 | 051039,40 | 6.2 | 4.8 | -3.8 | 1053 | 1.52 | 766 | 0.57 |
| 050826 | 051039,40 | 6.7 | 4.3 | 0.0 | 1524 | 1.20 | 766 | 0.57 |
| 072031-38 | 072549-58 | 7.6 | 3.3 | 5.5 | 2128 | 1.04 | 3719 | 1.38 |
| 072255-2301 | 072549-58 | 7.2 | 3.8 | 7.5 | 811 | 1.44 | 3719 | 1.38 |
| 632037,38 | 632713-17 | 9.1 | 3.1 | -3.2 | | | | |

a/ Binary tag of groups captured at the lowest river flow or at the highest river flow of the comparison; Ag=agency code, D1=data 1 code, and D2=data 2 code. Separations by comma or hyphen indicate data are averaged for multiple tag groups. Two or four digits following a comma represent an additional tag number with the same agency and data 1 codes or the same agency code, respectively. Two or four digits following a hyphen represent a series of tags with the same agency code and data 1 code or agency code, respectively.

b/ One thousand $m^3$/second = 1 Kcms = 35,000 $ft^3$/second.

c/ Difference of river flow, in thousand $m^3$/second during the week of median fish recovery for groups in comparison.

d/ [(% catch hi flow - % catch low flow) ÷ % catch low flow] x 100 ÷ (Kcms hi flow - Kcms low flow).

e/ Observed recoveries, limited to age of youngest tag group returning in each comparison, and data which are available for both sets of groups.

Differences in sampling efficiency related to fish size were not apparent for groups captured exclusively in purse seine sampling. Fork length distributions of marked fish from purse seine samples of some groups showed close agreement with length distributions obtained prior to release (see examples in Fig. 35); we assume that survival for small and large fish within such groups was similar. Substantial numbers of fish as small as 60 mm in fork length were captured in the purse seine, thus we believe the purse seine was reasonably efficient at capturing smaller fish.

Sampling efficiency was affected by fish size for those groups which were captured in the beach seine. Catch rate of subyearlfng chinook salmon captured in the beach seine is inversely related to body size (Section I, Fig. 4); the same relationship may apply to yearling fish. Location of fish in the cross section of the river, not gear efficiency, seems to have created the size related alteration of catch rate. Catch rate comparison between mark groups of subyearlings that were not the same body size are therefore inappropriate . Catch rate comparisons between marked groups of yearling fish released at different sizes were only made when the ratio of beach seine to purse seine catch was the same for both groups.

Replicate Groups of Marked Fish.--From 1977 to 1983, juvenile and adult recovery data (fisheries and escapement) for 120 sets of replicate groups were examined for consistency (Appendix Table Bl) . We found the following : (1) juvenile catch variations among replicates were random in relation to adult recoveries--juvenile catch and adult recovery percentages varied in the same direction (positive or negative) among replicates 54% of the time; (2) juvenile recoveries for 14 (12%) of the 120 sets of replicates showed significant differences between replicates ($P < 0.10$, from G statistic analysis)--by definition 10% of the sets of true replicates should fall outside the boundaries of no difference between groups; (3) adult recoveries for 42 (35%) of the 120 sets of replicates showed significant differences between replicate groups at $P < 0.10$, and the direction of variation among groups within the sets was the same as observed for juvenile catches in 50% of the 42 sets--as expected of rep1icate groups; and (4) 82% of the replicates showing statistical difference as adults, which is 15% of the total sets of replicates, had differences greater than 20% between groups. Some sets of replicate groups provided very consistent adult recovery data, e.g., five sets of replicate groups of coho salmon released in 1981 at Sandy Hatchery (Westgate et al. 1983b) produced from 363 to 535 adult recoveries per group with from 0 to 4% difference between replicates. However, other sets of replicates had large deviations from theoretical catch probabilities, e.g., four sets of rep1 icate groups of coho salmon released from Sandy Hatchery in 1980 (Wes tgate et al. 1983b) produced from 152 to 377 adult recoveries per group with 8 to 34% difference between groups.

It appears that juvenile catch data are normally distributed with expected variation, however, adult recoveries show greater than expected deviation which we assume represents survival differences. Differences of survival to adulthood, among replicate groups, may have resulted from subtle differences of environmental conditions, culture methods, or migratory behavior that did not substantially affect survival during freshwater rearing

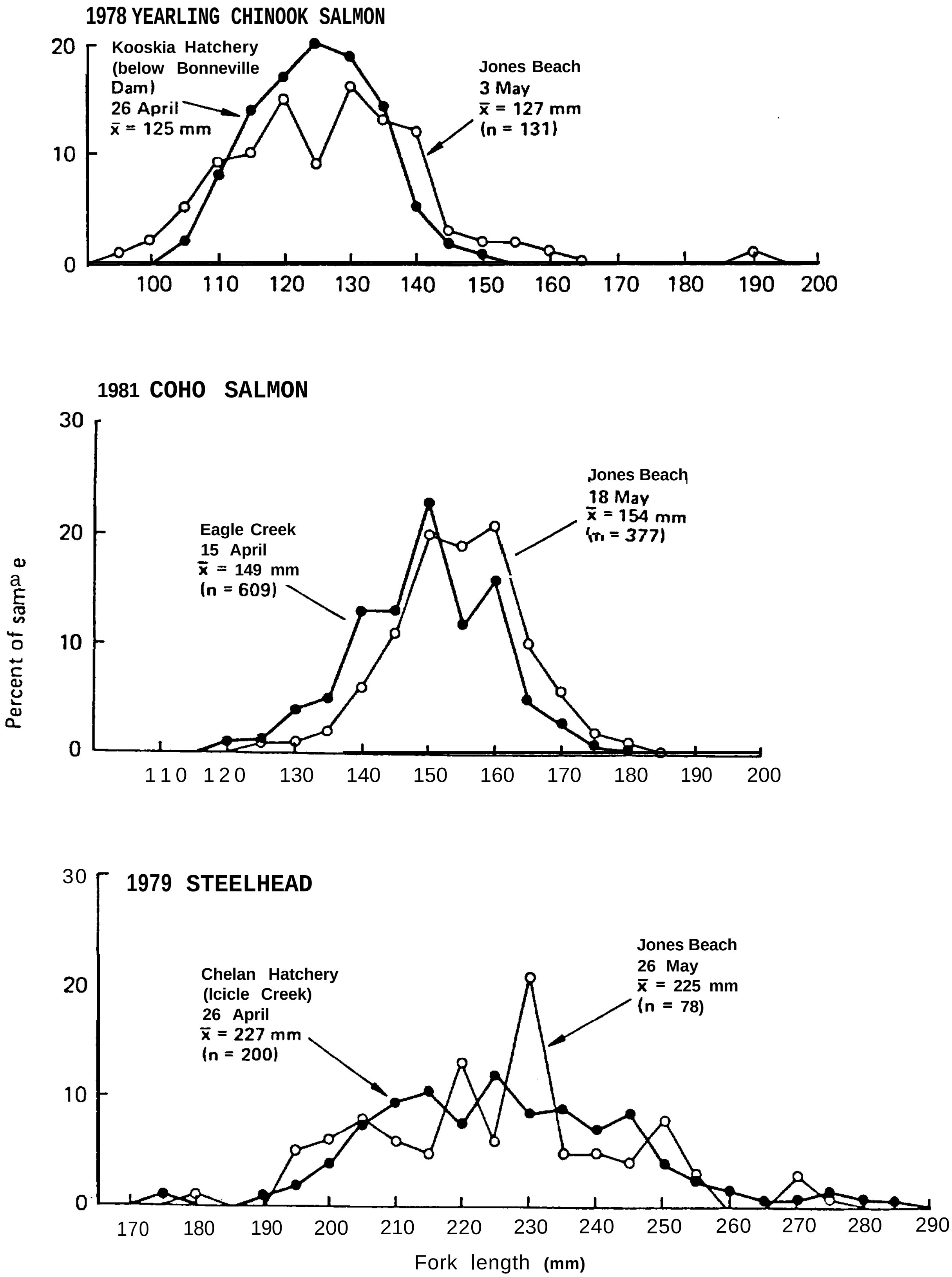


Figure 35.--Fork lengths of marked fish groups before and after migration showing little change in length frequencies within the population.

or mlgra tlon. Consequently, treatment versus control evaluations made from adult recovery data may be affected, and researchers comparing adult return data must consider the degree of error among replicates .

## Relative Survival in Relation to Controlled Treatments

Treatment and control groups used to evaluate effects of fish size, stock, transportation, rearing density, nutrition, and release date on adult survival were examined for inter- and intra-specific trends in relative survival to the estuary. We assume from the assessment of variability in catches that significant differences between catch percentages of treatment and control groups generally indicate relative survival differences if recovery data are adjusted for sampling effort and river flow. The conclusions reported herein are based on catches at Jones Beach only. Individual researchers may draw different conclusions based on knowledge of other factors relating to their research.

Estuarlne catch data for treatment and control groups were compared with adult recovery data to determine if relative survival trends were similar and to identify the types of treatment groups from which juvenile catch rates may provide erroneous inferences of survival.

Fish Size.--Increased body size at release for hatchery reared salmonids has been equated with greater survival in downstream migration and to adulthood (Conte et al. 1966; Salo 1955; Salo and Bayliff 1958; and Wallis 1968). Also, minimum-size thresholds for survival have been hypothesized (Relmers and Loeffel 1967; Buchanan et al. 1981; and Washington 1982). Fork length measurements of marked individuals from many groups captured at Jones Beach provided the opportunity to observe size-related survival differences during freshwater migration in the Columbia River.

Estuarine catch data indicate a positive relationship between survival during migration to the estuary and increased body size at the time of release for chinook and coho salmon and steelhead. The smaller individuals from particular release groups were missing from the migrant population captured at Jones Beach. Examples of length frequency distributions for mark groups representing each species comparing sizes of fish prior to release to sizes after migration show loss of smaller fish from the population prior to arrival at Jones Beach (Fig. 36). Not all groups of fish were measured prior to release. Consequently, we were unable to determine the extent of the loss of smaller individuals for the overall migratory population.

Comparisons were made among mark groups captured between 1977 and 1983 which were similar in stock, treatment, and release characteristics but showed differences in size at release (Table 29). The majority of comparisons were for spring chinook salmon graded and marked for size/survival research from a multiyear study at various hatcheries in the Wlllamette River system (Smith 1979a and b; Smith and Zakel 1980 and 1981; and Smith et al. 1982, 1983, and 1984).

The aggregate of groups showed a trend of higher catch percentages at Jones Beach for increased sizes (measured as no./lb) at release (Table 29); 20

Table 29.--Jones Beach catches and adult recoveries for marked fish from size at release studies, 1977-1983.

| Release information | | | | | | Juvenile catch c/ at Jones Beach | | | Adult recoveries d/ observed—cumulative | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tag a/ (Ag/D1/D2) Brand (Loc Sym Rot) | Source b/ | Treatment/ stock | Release number (thou) | Release date (da/mo/yr) | Size (no./lb) | fall (no.) | winter&spring (no.) | total (%) | total (no.) | 2 yr (%) | 3 yr (%) | 4 yr (%) | 5 yr (%) |
| | | | | | SUBYEARLING CHINOOK SALMON | | | | | | | | |
| 05/41/01 | Big White Rear. Pd | morpholene | 87.7 | 18 Apr 77 | 77 | | 358 | 0.555 | 202 | 0.02 | 0.17 | 0.23 | - |
| 05/42/01 | | control | 91.4 | | 82 | | 333 | 0.487 | 166 | 0.02 | 0.11 | 0.18 | - |
| | | | | | YEARLING CHINOOK SALMON | | | | | | | | |
| 63/18/50 | Cowlitz Hat. | | 23.0 | 25 Apr 79 | 5 | | 34 | 0.194 | 719 | - | 0.74 | 2.50 | 3.13 |
| 63/18/16 | | | 24.5 | | 7 | | 36 | 0.195 | 706 | - | 0.58 | 2.44 | 2.88 |
| 63/18/17 | Cowlitz Hat. | | 24.3 | 23 Apr 79 | 5 | | 35 | 0.200 | 829 | - | 0.85 | 2.75 | 3.44 |
| 63/18/18 | | | 24.1 | | 7 | | 34 | 0.191 | 632 | - | 0.57 | 2.18 | 2.60 |
| 05/06/59,RD IU 3 | Kooskia Hat. | | 49.5 | 16 Apr 82 | 9 | | 24 | 0.055 | 0 | - | 0.00 | - | - |
| 05/05/30,RD IU 1 | | | 54.2 | | 21 | | 17 | 0.031 | 0 | - | 0.00 | - | - |
| 07/22/52,53 | Marion Fks. Hat. | size&time | 81.9 | 16-24 Mar 81 | 14 | | 20 | 0.046 | 59 | - | 0.02 | 0.07 | - |
| 07/22/54 | | | 48.3 | | 20 | | 7 | 0.025 | 14 | - | 0.01 | 0.03 | - |
| 07/20/48 | McKenzie Hat. | size&time | 31.1 | 15 Mar 80 | 3 | | 18 | 0.153 | 48 | - | 0.03 | 0.12 | 0.15 |
| 07/20/51 | | | 29.4 | | 4 | | 13 | 0.112 | 21 | - | 0.01 | 0.05 | 0.07 |
| 07/20/53 | | | 34.9 | | 11 | | 13 | 0.079 | 6 | - | 0.00 | 0.01 | 0.02 |
| 07/22/20 | McKenzie Hat. | size&time | 35.6 | 16 Mar 81 | 4 | | 11 | 0.078 | 69 | - | 0.03 | 0.19 | - |
| 07/22/17 | | | 30.2 | | 6 | | 4 | 0.029 | 12 | - | 0.01 | 0.04 | - |
| 07/22/22 | | | 36.0 | | 9 | | 11 | 0.075 | 71 | - | 0.03 | 0.20 | - |
| 07/27/19 | McKenzie Hat. | size&time | 32.0 | 08-18 Nov 83 | 7 | 4 | 9 | 0.088 | - | - | - | - | - |
| 07/25/21 | | | 32.3 | 08 Nov 83 | 11 | 2 | 7 | 0.046 | - | - | - | - | - |
| 07/27/21 | | | 31.9 | | 16 | 3 | 8 | 0.072 | - | - | - | - | - |
| 07/27/18 | McKenzie Hat. | size&time | 36.2 | 14 Mar 83 | 4 | | 9 | 0.057 | - | - | - | - | - |
| 07/25/22 | | | 32.1 | | 6 | | 4 | 0.023 | - | - | - | - | - |
| 07/27/20 | | | 30.0 | | 10 | | 14 | 0.095 | - | - | - | - | - |
| 07/17/43 | Oakridge Hat. | size&time | 30.2 | 20 Mar 79 | 12 | | 32 | 0.173 | 292 | - | 0.07 | 0.73 | 0.97 |
| 07/17/41 | | | 32.0 | | 14 | | 40 | 0.178 | 229 | - | 0.01 | 0.40 | 0.72 |
| 07/17/44 | Oakridge Hat. | size&time | 32.8 | 20 Mar 79 | 6 | | 36 | 0.299 | 223 | - | 0.06 | 0.56 | 0.68 |
| 07/17/42 | | | 29.5 | | 8 | | 50 | 0.282 | 313 | - | 0.08 | 0.74 | 1.06 |
| 07/20/46 | Oakridge Hat. | size&time | 29.0 | 10 Mar 80 | 4 | | 15 | 0.145 | 246 | - | 0.07 | 0.67 | 0.85 |
| 07/20/44 | | | 30.7 | | 8 | | 25 | 0.202 | 272 | - | 0.06 | 0.54 | 0.89 |
| 07/20/42 | Oakridge Hat. | size&time | 30.7 | 10 Mar 80 | 9 | | 20 | 0.148 | 339 | - | 0.07 | 0.67 | 1.10 |
| 07/20/40 | | | 30.9 | | 16 | | 18 | 0.134 | 228 | - | 0.03 | 0.36 | 0.74 |
| 07/23/03 | Oakridge Hat. | size&time | 31.2 | 16 Mar 81 | 4 | | 12 | 0.096 | 139 | - | 0.04 | 0.45 | - |
| 07/22/25 | | | 26.6 | | 7 | | 9 | 0.063 | 91 | - | 0.02 | 0.34 | - |
| 07/23/05 | Oakridge Hat. | size&time | 29.9 | 16 Mar 81 | 7 | | 14 | 0.104 | 145 | - | 0.04 | 0.48 | - |
| 07/23/07 | | | 31.7 | | 9 | | 17 | 0.133 | 106 | - | 0.02 | 0.33 | - |
| 07/16/15 | Round Butte Hat. | lg. grade | 26.1 | 31 Mar 78 | 24 | | 31 | 0.183 | 0 | - | 0.00 | 0.00 | 0.00 |
| 07/16/11 | | vibrio vac. | 46.4 | | 28 | | 33 | 0.122 | 0 | - | 0.00 | 0.00 | 0.00 |
| 07/16/12 | | vac. control | 46.2 | | 32 | | 34 | 0.121 | 1 | - | 0.00 | 0.00 | 0.00 |
| | | | | | COHO SALMON | | | | | | | | |
| 63/17/58 | Toutle Hat. | | 39.8 | 07 Jun 79 | 18 | | 107 | 0.310 | 955 | 0.00 | 2.40 | - | - |
| 63/17/13 | | | 40.5 | | 20 | | 103 | 0.287 | 799 | 0.00 | 1.97 | - | - |
| 63/19/31 | Toutle Hat. | | 38.6 | 07 May 80 | 18 | | 43 | 0.219 | 204 | 0.00 | 0.53 | - | - |
| 63/20/58 | | | 39.5 | | 20 | | 31 | 0.165 | 133 | 0.00 | 0.34 | - | - |
| | | | | | STEELHEAD | | | | | | | | |
| 05/13/33 | Hagerman Hat. & | A stock | 38.8 | 18-20 Apr 83 | 2 | | 84 | 0.281 | - | - | - | - | - |
| 05/13/34 | Salmon River | size | 39.1 | | 5 | | 104 | 0.363 | - | - | - | - | - |

Table 29.--continued.

a/ More complete information available from Dawley et al. 1985b or releasing agency Table 21. Binary coded wire tags: Ag=Agency, Dl=Data 1 code, and D2=Data 2 code. Color coded wire tags begin with WH and each two digits thereafter represent a color. Brands are represented by the following: Loc=Location on fish, Sym=Brand symbol, and Rot=Rotation of symbol. For abbreviations, symbol, and descriptions see Dawley et al. 1985b.

b/ More complete information available from Dawley et al. 1985b or releasing agency Figure 21. Abbreviations used are listed: Fks=Forks, Hat=Hatchery, Lit=Little, Pd=Pond, Rear=Rearing, Sal-Salmon, Wh=White, and @=Released at.

c/ Actual number recovered and effort adjusted % catch--effort not consistent during fall and winter periods, thus total recovery percentages are not comparable between different studies.

d/ Observed recoveries; may provide erroneous comparisons between studies not migrating at the same time or between stocks because of possible difference associated with unequal fishing effort and sampling effort.

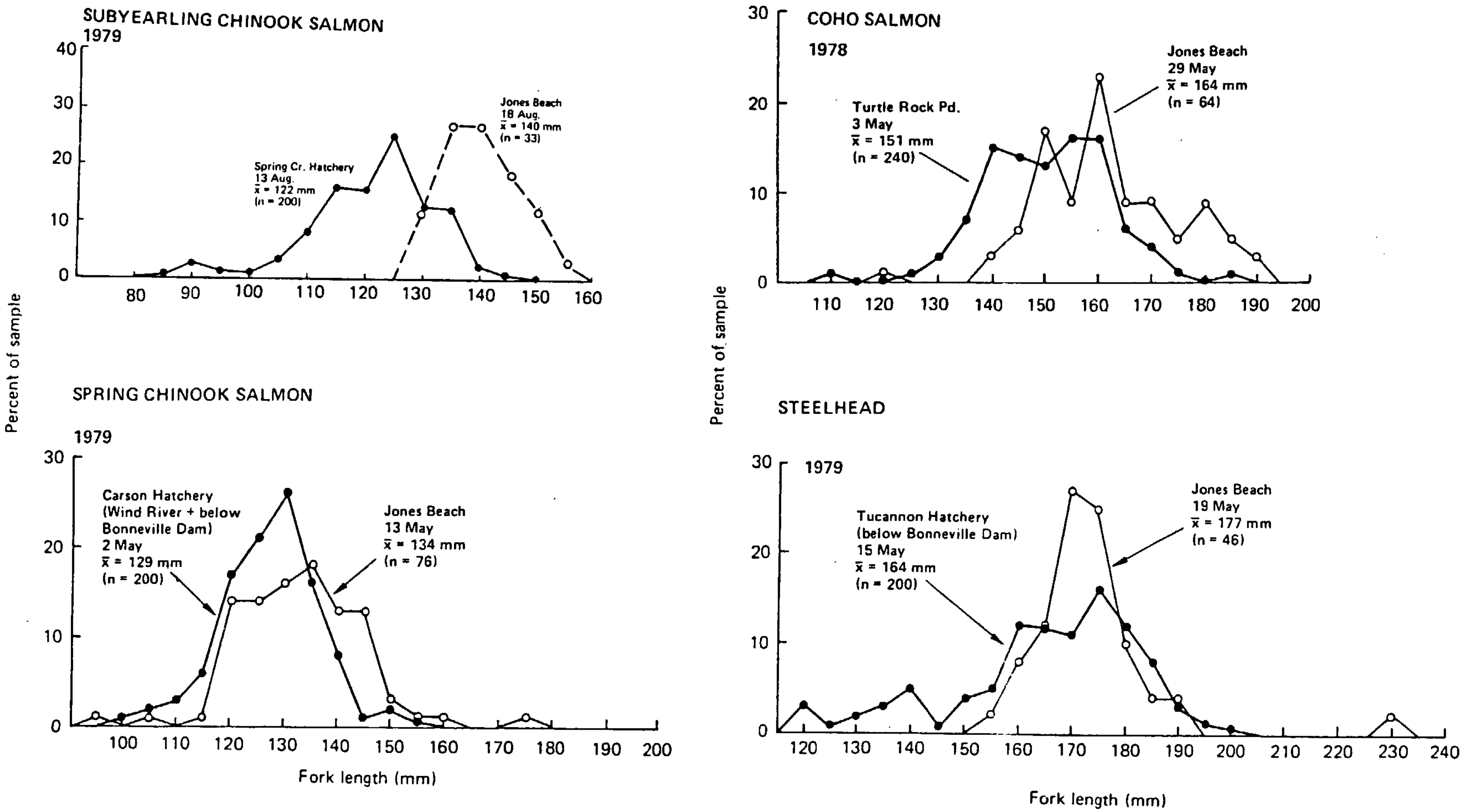


Figure 36.--Fork lengths of subyearling chinook, yearling chinook, and coho salmon and steelhead before and after migration, showing an upward shift in size of the population at Jones Beach.

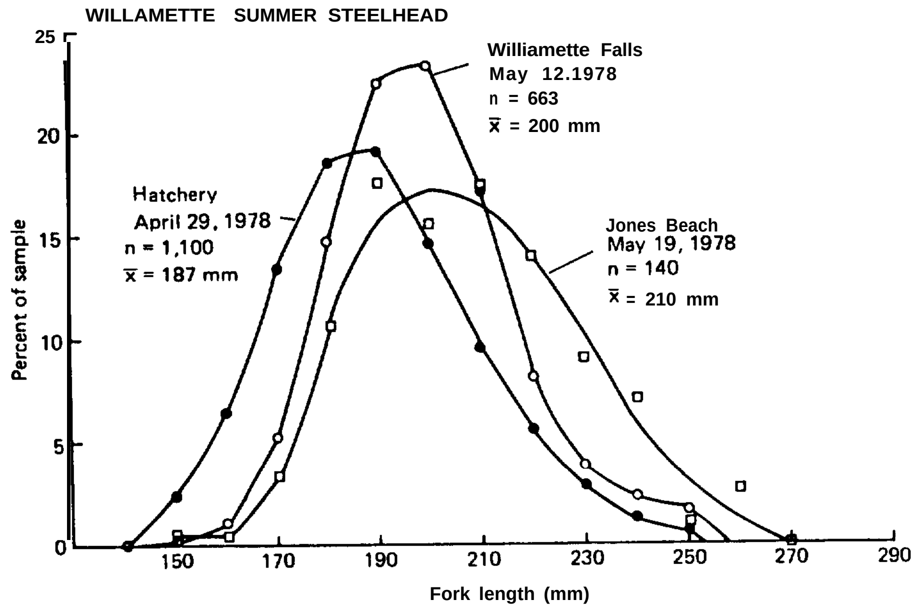


Figure 37.--Fork length measurements of Skamania summer steelhead smolts prior to hatchery release, from catches at Willamette Falls, and from catches at Jones Beach, 1978. Hatchery and Willamette Falls length frequencies from Buchanan et al. (1979).

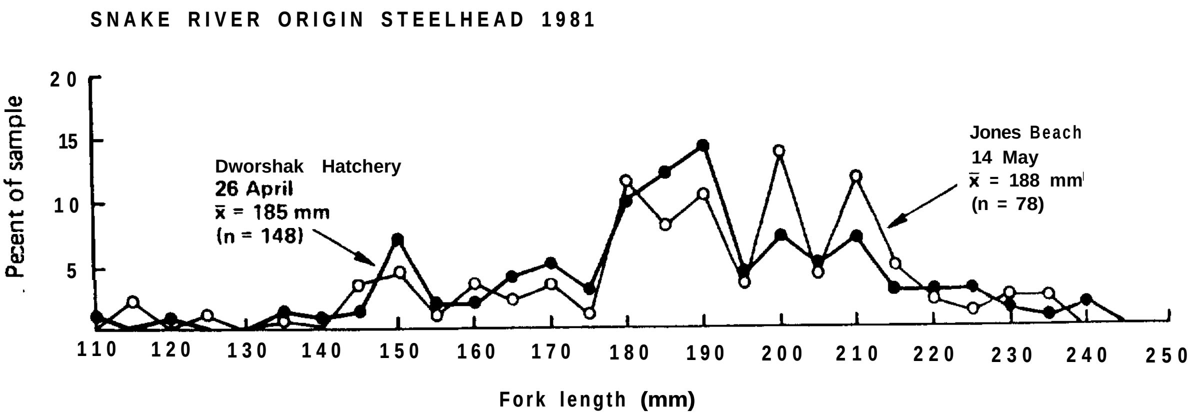


Figure 38.--Fork lengths of Snake River steelhead before and after migration showing little change in length frequencies for the portion of the population less than 180 mm.

of 28 comparisons showed a positive relationship. A two-way ANOVA was calculated to compare the catch percentages according to size at release (similar groups were paired according to difference in size at release). The ANOVA was conditioned on the marked groups, and the F-value for size at release was used to determine significance. The ANOVA table is:

| Source of variation | DF | SS | MS | F | Probability of F-value |
|---|---|---|---|---|---|
| Size at release | 1 | 0.002929 | 0.002929 | 3.972 | 0.0565 |
| Mark group | 27 | 0.573188 | 0.021229 | 28.791 | 0.0000 |
| Remainder | 27 | 0.019908 | 0.00073735 | | |

The probability value of 0.0565 for size at release indicates significance at the $\alpha = 0.06$ level. The only comparison available for effects of size on steelhead groups from the Snake River showed reversed recovery rate and was not included in the statistical analysis.

Adult recoveries (Table 29) showed greater survival for groups released at a larger size in 13 of 19 comparisons and were statistically greater in 11 comparisons.

Minimum-size thresholds for successful migration to the ocean have been suggested by several investigators. Buchanan (1981) hypothesized a minimum-size threshold of 180 mm for steelhead of Willamette River origin. Our observations of Willamette River steelhead support Buchanan's hypothesis (Fig. 37). Observations of steelhead from the Snake River, however, do not show this relationship; individuals as small as 110 mm migrated successfully from the Snake River to Jones Beach, e.g., Dworshak steelhead ranging from 100 mm to 240 mm (Fig. 38). Washington (1982) hypothesized a minimum-size threshold for survival of 130-140 mm for coho salmon from Columbia River Hatcheries--developed from fork length measurements of migrants at Jones Beach. Reimers (1967) hypothesized that the minimum-size threshold for wild subyearling chinook salmon in the Columbia River varies between tributaries.

Transportation Past Dams.--Relative survival differences for marked fish groups transported by truck or barge past dams in the Columbia River system (1977-1983) were calculated from catch percentages at Jones Beach. Comparisons between catch percentages of transported and control fish were limited to two data sets: (1) juveniles transported directly from hatcheries, upstream or downstream, were compared to controls released at the hatchery, and (2) juveniles captured at McNary Dam subsequently marked and transported downstream past three dams were compared to controls released in the tailrace of McNary Dam.

A large range of catch percentages was observed for transported groups which moved rapidly past Jones Beach (50% of the catch in 2 days or less), and marked groups behaving in this fashion were not used in the assessment of effects from transportation. We hypothesize that these particular transported fish migrated rapidly from release sites to Jones Beach and did not disperse widely in the river. Low catch percentages, unrepresentative of abundance, resulted when the majority of individuals within such a group passed during nonfishing hours, and high catch percentages, also unrepresentative of abundance, resulted when the majority passed during fishing hours. In either instance, the comparison to control groups was erroneous.

Calculated survival estimates generally increased with the number of dams bypassed (Fig. 39); the average increased survival estimate for one dam bypassed was 44% (12 transport groups) and for eight dams 236% (9 transport groups). Data (Table 30) were transformed to stabilize the variance of the dependent variable for linear regression. The hypothesis that the slope = 0 was rejected at $P<0.01$ ($t = 2.72$, 49 df). Average survival increase from bypassing dams was 50, 33, 20, and 11% per dam, respectively, for subyearling chinook salmon, yearling chinook salmon, coho salmon, and steelhead.

Adult recoveries for transport versus control groups were evaluated to determine if survival changes from transportation were similar to those observed from estuarine recovery estimates (Table 30). A positive correlation exists between change in adult survival and numbers of dams bypassed as juveniles (average no increase for one dam and 121% increase for eight dams) (Fig. 39); however, the slope of the linear regression (transformed data) was not significantly different from zero ($t = 0.4$, 35 df) . Comparison of adult survival increases to estuarine estimates of juvenile survival increases provided the following correlation coefficients (r): 0.42, 0.14, 0.72, and 0.77 for subyearling chinook salmon, yearling chinook salmon, coho salmon, and steelhead, respectively. In general, adult recoveries showed the same survival benefits from transportation as estuarine sampling, but as observed from evaluation of replicate groups, the variation was greater within adult data. Not all adult recoveries of mark groups are avaliable at this time, thus these conclusions regarding adult recoveries are preliminary.

Estuarine catch data for some species and/or stocks may provide a more accurate estimation of effects of transportation of juveniles past dams than adult data.

Serial Releases.--Delayed releases of coho salmon (June and July) from Cascade, Toutle, and Washougal Hatcheries, generally showed increased juvenile catch percentages that often were significantly greater than catch percentages of groups released at the normal release time in early May (Table 31). Adult recoveries showed increased returns from late May and June releases as expected on the basis of juvenile recoveries, but July releases displayed an erratic pattern (Westgate et al. 1981, 1982, and 1983a; Schneider and Foster 1981).

In July, high water temperatures in the river and the ocean may have affected the survival of coho salmon groups during transition to seawater.

Table 30.--Survival differences between fish groups transported past dams and those not transported; from catch percentages at Jones Beach, 1977-1983.

| RELEASE INFORMATION: Tag a/ (Ag/D17D2) Brands (Loc Sym Rot) | Site/source(treatment) b/ | Number (thou) | Date (da/mo/yr) | JONES BEACH RECOVERY INFORMATION: Fish catch (no.) | Median fish recov. date | Flow @ Jones Beach c/ (Kcms) | Adj. cat. d/ (%) | ADULT RECOV. INFORMATION: Observed e/ (no.) | Observed e/ (%) | Dams passed (no.) | Flow @ Bonn. Dam f/ (Kcms) | Estim. sur. change of transport g/ juv. (%) | Estim. sur. change of transport g/ adult (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **SUBYEARLING CHINOOK SALMON** | | | | | | | | | | | | |
| 09/16/12 | Upstream Willam. Falls/Aumsville Pd. | 44.6 | 04 Apr 77 | 209 | 19May | 4.5 | 0.434 | 35 | 0.04 | - | | | |
| 09/16/13 | (control) | 43.1 | | | | | | | | | | | |
| 09/16/11 | ds Willam. Falls (trans.) | 46.4 | 04 Apr 77 | 504 | 14May | 4.5 | 0.557 | 59 | 0.03 | 1 | 0.4 h/ | 28 | -23 |
| 09/16/06 | " | 92.0 | | | | | | | | | | | |
| 09/16/07 | " | 43.5 | | | | | | | | | | | |
| 07/24/07 | Bonneville Hat. (control) | 105.8 | 23 Apr 82 | 262 | 01May | 10.0 | 0.254 | - | - | - | | | |
| 07/26/63 | Umitilla R./Bonneville Hat. (upstream trans.) | 102.3 | 14-20 Apr 82 | 137 | 10May | 10.2 | 0.137 | - | - | -3 | 7.8 | -47 | - |
| 07/28/27 | Bonn. Hat. (Control) | 100.3 | 16 Jun 83 | 111 | 10May | 10.4 | 0.168 | - | - | - | | | |
| 07/28/26 | Vernita Br.(upstream trans./tule) | 100.2 | 02 Jun 83 | 47 | 16Jul | 7.5 | 0.078 | - | - | -4 | 7.2 | -42 | - |
| 05/04/26,RASU1 | Kooskia Hat. (control) | 55.7 | 29 May 79 | 31 | 17Jun | 5.5 | 0.058 | 5 | 0.01 | - | | | |
| 05/04/27 | ds Bonn. Dam (trans.) | 46.3 | 03-20 May 79 | 38 | 23May | 8.4 | 0.102 | 5 | 0.01 | 8 | 5.6 | 33 | 20 |
| 05/04/21 | Asotin, WA/Hagerman H. (control) | 44.0 | 21 May 79 | 3 | 03Jul | 4.2 | 0.012 | 18 | 0.04 | - | | | |
| 05/04/20 | DS Bonn. Dam (trans.) | 51.0 | 20 May 79 | 74 | 31May | 7.6 | 0.177 | 192 | 0.38 | 8 | 5.0 | 949 | 850 |
| 05/05/27 | Asotin, WA/Hagerman H. (control) | 58.1 | 03 May 80 | 6 | 24Jun | 9.1 | 0.023 | 279 | 0.48 | - | | | |
| 05/05/28 | ds Bonn. Dam (trans.) | 56.0 | 06 Jun 80 | 34 | 15Jun | 9.1 | 0.084 | 43 | 0.08 | 8 | 8.2 | 265 | -84 |
| 10/22/10 | Asotin, WA/Hagerman H. (control) | 55.4 | 26 May 81 | 21 | 18Jun | 11.2 | 0.066 | 196 | 0.35 | - | | | |
| 10/22/11 | ds Bonn. Dam (trans.) | 55.7 | 28 May 81 | 67 | 07Jun | 12.4 | 0.132 | 201 | 0.36 | 8 | 11.1 | 80 | 3 |
| WHPUGNBL,LAIF1 | McNary Dam (resevoir control) | 15.1 | 29Jun-14Jul 78 | 3 | 21Jul | 5.7 | 0.108 | | | | | | |
| WHYWXYGN | " | 23.0 | 17Jul-01Sep 78 | 0 | - | - | 0.000 | | | | | | |
| All Reservoir Control i/ | | 38.1 | 29Jun-01Sep 78 | 3 | 21Jul | 5.7 | 0.042 | 54 | 0.14 | | | | |
| WHORGNLG,RAIC1 | ds Bonn. Dam (truck trans.) | 17.0 | 28Jun-13Jul 78 | 7 | 16Jul | 6.8 | 0.156 | | | 3 | | | |
| WHLG,RAIC3 | " | 3.4 | 19Jul-30Aug 78 | 7 | 15Aug | 3.9 | 0.627 | | | 3 | | | |
| All Truck Transport i/ | | 20.4 | 28Jun-30Aug 78 | 14 | 16Jul | 5.7 | 0.191 | 298 | 1.46 | 3 | 5.7 | 355 | 942 |
| WHYWBLLB,LAUP1,3 | McNary Dam(reservoir control) | 19.8 | 05Jul-13Aug 79 | 4 | 10Aug | 3.7 | 0.101 | | | - | | | |
| WHRDYWPK/ | McNary Dam(tailrace control) | 54.7 | 12Jun-17Jul 79 | 16 | 15Jul | 4.0 | 0.077 | | | - | | | |
| WHRDPKOR,LAIM1,3 j/ | | | | | | | | | | | | | |
| WHLBYWLB,LAIM2 | " | 40.4 | 24Jul-06Aug 79 | 2 | 03Aug | 3.6 | 0.013 | | | - | | | |
| BLACK,LA51 | " | 0.3 | 11Apr-03Jul 79 | 2 | 01Jul | 4.8 | 0.948 | | | - | | | |
| WHRDLBPK,LAIM4 | " | 19.9 | 08-24 Aug 79 | 0 | - | - | 0.000 | | | - | | | |
| WHRDLGYW,LA52,3 | " | 0.6 | 14May-21Jun 79 | 0 | - | - | 0.000 | | | - | | | |
| All Tailrace and Reservoir Control i/ | | 135.7 | 11Apr-24Aug 79 | 24 | 23Jul | 3.8 | 0.052 | 83 | 0.06 | - | | | |
| WHRDLGPK,RA32,2 | ds Bonn. Dam (truck-trans.) | 3.4 | 14May-21Jun 79 | 7 | 22Jun | 7.0 | 0.245 | | | 3 | | | |
| WHRDPKLB,RAI+1 | " | 43.5 | 12-29 Jun 79 | 141 | 26Jun | 6.9 | 0.424 | | | 3 | | | |
| WHLBYWLG,RAI+2 | " | 41.2 | 24Jul-06Aug 79 | 29 | 04Aug | 4.5 | 0.234 | | | 3 | | | |
| WHRDLBYW,RAI+4 | " | 18.5 | 08-24 Aug 79 | 20 | 15Aug | 3.9 | 0.279 | | | 3 | | | |
| WHRDPKOR,RAI+3 | " | 22.5 | 02-17 Jul 79 | 24 | 18Jul | 5.7 | 0.234 | | | 3 | | | |
| WH:RA31 | " | 0.7 | 16Apr-02Jul 79 | 0 | - | - | 0.000 | | | 3 | | | |
| All Truck Transport Groups | | 132.9 | 16 Apr-24Aug 79 | 221 | 15Jul | 6.8 | 0.301 | 548 | 0.41 | 3 | 3.7 | 331 | 583 |
| CE,LAIF1 | McNary Dam (tailrace control) | 39.0 | 09Jun-14Jul 80 | 4 | 25Jul | 4.2 | 0.035 | | | - | | | |
| CEDY,LAIF3 | " | 45.6 | 16-31 Jul 80 | 2 | 04Aug | 4.0 | 0.020 | | | - | | | |
| All Tailrace Control i/ | | 84.6 | 09Jun-31Jul 80 | 6 | 29Jul | 4.2 | 0.027 | 111 | 0.13 | - | | | |
| HO,RAIC3 | ds Bonn. Dam (truck-trans.) | 40.7 | 18Jul-01Aug 80 | 34 | 21Jul | 4.8 | 0.268 | | | 3 | | | |
| LA,RAIC1 | " | 39.5 | 13Jun-17Jul 80 | 40 | 10JUl | 5.3 | 0.274 | | | 3 | | | |
| All Truck Transport Group i/ | | 80.2 | 13Jun-01Aug 80 | 74 | 15Jul | 5.3 | 0.271 | 331 | 0.41 | 3 | 5.7 | 810 | 215 |
| 03/17/32,LAIM1-4 | McNary Dam(tailrace control) | 42.6 | 09-29 Jul 81 | 10 | 05Aug | 5.8 | 0.087 | 15 | 0.04 | - | | | |
| 03/17/33 | ds Bonn. Dam (truck trans.) | 42.9 | 09-31 Jul 81 | 44 | 24Jul | 6.2 | 0.272 | 66 | 0.15 | 3 | 5.7 | 202 | 275 |

Table 30.--continued.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LAH1,2(23/16/09) | McNary Dam(tailrace control) | 5.6 | 24-26 Jun 82 | 1 | 26Jul | 6.0 | 0.071 | | | - | | | |
| LAIF1,3(23/16/09) | . | 3.0 | 29Jun-01Jul 82 | 0 | - | - | 0.000 | | | - | | | |
| LAIC1,3(23/16/11) | . | 3.5 | 06-13 Jul 82 | 2 | 26Jul | 6.6 | 0.228 | | | - | | | |
| LAIM1,3(23/16/11) | . | 8.3 | 15-17 Jul 82 | 1 | 26Jul | 6.6 | 0.048 | | | - | | | |
| LAIF2,4(23/16/11) | . | 7.0 | 20-22 Jul 82 | 1 | 02Aug | 5.4 | 0.057 | | | - | | | |
| LAIC2,4(23/16/13) | . | 7.8 | 27-29 Jul 82 | 2 | 09Aug | 6.3 | 0.103 | | | - | | | |
| LAIM2,4(23/16/11) | . | 3.4 | 03-05 Aug 82 | 0 | - | - | 0.000 | | | - | | | |
| All Tailrace Control Groups i/ | | 38.6 | 29Jun-05Aug 82 | 7 | 31Jul | 5.4 | 0.072 | 2 | 0.01 | - | | | |
| RAV1(23/16/10) | ds Bonn. Dam (truck trans.) | 5.4 | 25Jun-02Jul 82 | 7 | 01Jul | 12.2 | 0.185 | | | 3 | | | |
| RAV2(23/16/12) | . | 18.8 | 12-21 Jul 82 | 8 | 19Jul | 7.3 | 0.176 | | | 3 | | | |
| RAV3(23/16/14) | . | 15.5 | 26Jul-06Aug 82 | 8 | 06Aug | 6.3 | 0.181 | | | 3 | | | |
| All Truch Transport Groups i/ | | 39.7 | 25Jun-06Aug 82 | 23 | 24Jul | 6.6 | 0.179 | 5 | 0.01 | 3 | 6.9 | 123 | 143 |
| LA2L1,3&LS2L (23/16/27) | McNary Dam (tailrace control | 15.0 | 08-15 Jul 83 | 10 | 22Jul | 7.5 | 0.153 | | | - | | | |
| LA2T1,3&LS2T (23/16/30) | . | 14.7 | 20-27 Jul 83 | 0 | - | - | 0.000 | | | - | | | |
| LA2X1,3(23/16/33) | . | 10.6 | 29Jul-05Aug 83 | 0 | - | - | 0.000 | | | - | | | |
| All Tailrace Control i/ | | 69.3 | 16Jun-02Sep 83 | 10 | 22Jul | 7.5 | 0.057 | - | - | - | | | |
| RAIJ1(23/16/25) | ds Bonn. Dam (truck trans.) | 15.1 | 07-14 Jul 83 | 3 | 20Jul | 7.5 | 0.038 | | | 3 | | | |
| RAIJ3(23/16/28) | . | 14.0 | 19-25 Jul 83 | 5 | 21Jul | 7.5 | 0.066 | | | 3 | | | |
| RAIJ2(23/16/31) | . | 6.2 | 30Jul-02Aug 83 | 8 | 01Aug | 6.2 | 0.258 | | | 3 | | | |
| All Truck Transport Groups i/ | | 35.3 | 07Jul-02Aug 83 | 16 | 26Jul | 6.6 | 0.088 | - | - | 3 | 6.7 | 66 | - |
| RA31(23/16/26) | ds Bonn. Dam (barge trans.) | 15.0 | 10-15 Jul 83 | 7 | 13Jul | 6.5 | 0.073 | | | 3 | | | |
| RA33(23/16/29) | . | 15.2 | 18-26 Jul 83 | 3 | 24Jul | 6.6 | 0.039 | | | 3 | | | |
| RA32(23/16/32) | . | 8.6 | 28Jul-01Aug 83 | 3 | 04Aug | 6.7 | 0.116 | | | 3 | | | |
| All Barge Transport Groups i/ | | 38.8 | 10Jul-01Aug 83 | 13 | 19Jul | 7.5 | 0.069 | - | - | 3 | | 21 | - |
| 05/49/01,RDU1 | Spring Cr. Hat. (control) | 75.8 | 08 Apr 77 | 215 | 29Apr | 3.9 | 0.404 | 334 | 0.44 | - | | | |
| 05/50/01,RDU4 | ds Bonn. Dam (trans.) | 76.0 | 08 Apr 77 | 304 | 30Apr | 4.7 | 0.560 | 355 | 0.47 | 1 | 3.1 | 29 | 6 |
| 05/62/01 | Spring Cr. Hat. (control) | 92.3 | 18 Apr 78 | 175 | 02May | 8.8 | 0.232 | 500 | 0.54 | - | | | |
| 05/54/01 | ds Bonn. Dam (trans.) | 98.1 | 20 Apr 78 | 201 | 30Apr | 8.8 | 0.247 | 479 | 0.49 | 1 | 6.7 | 6 | -9 |
| 05/07/41 | Spring Cr. Hat. (control) | 76.7 | 15Apr-05May 81 | 228 | 25May | 7.9 | 0.126 | 126 | 0.07 | - | | | |
| 05/07/49 | . | 30.9 | | | | | | | | | | | |
| 05/07/42 | . | 63.4 | | | | | | | | | | | |
| 05/07/43 | Rock Cr. (upstream trans.) | 25.7 | 21 Apr 81 | 66 | 28May | 10.9 | 0.045 | 360 | 0.20 | -2 | 6.5 | -73 | -64 |
| 05/07/46 | . | 150.5 | 21 Apr 81 | | | | | | | | | | |
| 05/10/51 | Spring Cr. Hat.(control) | 38.8 | 15 Apr 82 | 84 | 25Apr | 9.4 | 0.247 | 5 | 0.01 | | | | |
| 05/10/57 | Umitilla R.(upstream trans.) | 102.3 | 08-13 Apr 82 | 153 | 06May | 10.0 | 0.103 | 18 | 0.01 | -2 | 9.1 | -60 | -6 |
| 05/08/51 | . | 46.7 | | | | | | | | | | | |
| 07/17/08 | Upstream Willam. Falls/Stayton Pd. | 50.9 | 31May-01Jun 78 | 96 | 12Jun | 8.3 | 0.154 | 102 | 0.10 | | | | |
| 07/17/10 | (control) | 51.2 | | | | | | | | | | | |
| 07/17/09 | ds Willam. Falls (trans.) | 51.2 | 31May-01Jun 78 | 100 | 11Jun | 8.3 | 0.157 | 63 | 0.12 | 1 | 0.3 h/ | 2 | 23 |

YEARLING CHINOOK SALMON

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 07/25/47 | Bonn. Hat.(control/late fall) | 49.9 | 23 Mar 83 | 13 | 05Apr | 12.1 | 0.052 | - | - | | | | |
| 07/27/41 | Umatilla R.(upstream trans.) | 99.6 | 24Mar-18Apr 83 | 19 | 14May | 10.4 | 0.019 | - | - | -3 | 8.5 | -58 | - |
| WHLBGN,LAAN4 | Carson Hat. (control) | 41.0 | 03 May 79 | 28 | 13May | 9.7 | 0.090 | 3 | 0.01 | | | | |
| WHLBGM,LAAN1 | Pasco (upstream trans.) | 39.1 | 23 Apr 79 | 33 | 14May | 8.1 | 0.107 | 1 | 0.00 | -4 | 6.2 | 35 > | -65 |
| WHLBWHLB,RAY1 | ds Bonn. Dam (trans.) | 38.3 | 21Apr-07May 79 | 126 | 09May | 9.7 | 0.102 | 3 | 0.00 | 1 | 7.6 | 13 | -91 |
| WHLBBL,RAY4 | . | 36.3 | | | | | | | | | | | |
| WHLBYWYW,RAT1 | . | 40.4 | | | | | | | | | | | |
| WHLBYWXY,RAT2 | . | 39.8 | | | | | | | | | | | |
| 63/17/25 | Entiat Hat. (control) | 87.8 | 25-26 Apr 78 | 43 | 20May | 9.2 | 0.049 | - | - | | | | |
| RDAN3 | . | 35.8 | | | | | | | | | | | |
| LDAN4 | Vernita Bridge(trans.) | 16.6 | 02 May 78 | 13 | 23May | 8.7 | 0.102 | - | - | 4 | 7.4 | 117 | - |
| 09/16/21 | S. Santiam H. (control) | 25.0 | 13 Mar 78 | 26 | 08Apr | 7.9 | 0.084 | 451 | 0.65 | | | | |
| 09/16/22 | . | 29.5 | | | | | | | | | | | |
| 09/16/26 | . | 14.9 | | | | | | | | | | | |
| 09/16/23 | ds Willam. Falls (trans.) | 26.9 | 13 Mar 78 | 67 | 07Apr | 7.9 | 0.237 | 786 | 1.21 | 1 | 0.4 h/ | 182 | 86 |
| 09/16/24 | . | 24.6 | | | | | | | | | | | |
| 09/16/25 | . | 13.4 | | | | | | | | | | | |

Table 30.--continued.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 07/19/26 | S. Santiam H. (control) | 31.5 | 07 Nov 78 | 8 | 07Mar | 5.7 | 0.009 | 170 | 0.18 | | | | |
| 07/29/27 | • | 32.7 | | | | | | | | | | | |
| 07/19/28 | • | 31.1 | | | | | | | | | | | |
| 07/19/29 | ds Willam. Falls (trans.) | 32.6 | 07 Nov 78 | 18 | 15Apr | 7.7 | 0.018 | 182 | 0.28 | 1 | NA | 66 | 56 |
| 07/19/30 | • | 32.8 | | | | | | | | | | | |
| 07/19/19 | S. Santiam H./Oakridge H.(control) | 31.6 | 21 Mar 78 | 94 | 13Apr | 7.7 | 0.168 | 127 | 0.13 | | | | |
| 07/19/20 | • | 32.8 | | | | | | | | | | | |
| 07/19/21 | • | 32.4 | | | | | | | | | | | |
| 07/19/22 | ds Willam. Falls (trans.) | 34.2 | 23 Mar 78 | 151 | 13Apr | 7.7 | 0.265 | 60 | 0.06 | 1 | 0.4 h/ | 58 | -54 |
| 07/19/23 | • | 34.5 | | | | | | | | | | | |
| 07/19/24 | • | 35.3 | | | | | | | | | | | |
| 07/19/45 | S. Santiam H. (control) | 29.4 | 14 Mar 80 | 42 | 05Apr | 4.9 | 0.184 | 84 | 0.14 | | | | |
| 07/19/46 | • | 29.9 | | | | | | | | | | | |
| 07/19/48 | ds Willam. Falls (trans.) | 28.5 | 14 Mar 80 | 66 | 30Mar | 4.9 | 0.271 | 63 | 0.10 | 1 | 0.9 h/ | 47 | -24 |
| 07/19/47 | • | 32.1 | | | | | | | | | | | |
| 10/03/30,LAPP2 | Kooskia Hat. (control) | 83.8 | 12 Apr 78 | 61 | 11May | 8.1 | 0.073 | 26 | 0.03 | | | | |
| WHRDXY,RAL4 | ds Bonn. Dam (trans.) | 37.1 | 26-28 Apr 78 | 79 | 05May | 8.8 | 0.064 | 8 | 0.00 | 8 | 6.7 | -18 | -82 |
| WHRDLB,RAL1 | • | 37.0 | | | | | | | | | | | |
| WHRDYW,RAL3 | • | 35.4 | | | | | | | | | | | |
| WHRDPK,RAL2 | • | 36.9 | | | | | | | | | | | |
| 05/05/32 | Kooskia Hat. (control) | 61.3 | 16 Apr 80 | 14 | 04May | 8.3 | 0.044 | 9 | 0.01 | | | | |
| 05/05/29 | ds Bonn. Dam (trans.) | 62.3 | 14 Apr 80 | 26 | 05May | 8.3 | 0.072 | 3 | 0.00 | 8 | 7.3 | 63 | -67 |
| 63/17/02 | Leavenworth Hat. (control) | 95.2 | 25 Apr 78 | 67 | 22May | 8.7 | 0.090 | 90 | 0.09 | | | | |
| 63/17/03 | Leavenworth Hat. (hauled 4 h) | 94.3 | | 47 | 23May | 8.7 | 0.070 | 8 | 0.01 | | | | |
| 63/17/04 | ds Priest Rap. (trans.) | 94.6 | 08 May 78 | 80 | 24May | 8.7 | 0.115 | 7 | 0.01 | 3 | 3.8 k/ | 28 | -92 |
| 63/18/09 | Leavenworth Hat. (control) | 97.5 | 26 Apr 79 | 104 | 29May | 7.6 | 0.142 | 55 | 0.06 | | | | |
| 63/18/10 | Leavenworth Hat. (hauled 4 h) | 100.3 | | 86 | 28May | 7.6 | 0.115 | 5 | 0.00 | | | | |
| 63/18/08 | ds Priest Rap. (trans.) | 94.8 | 15 May 79 | 164 | 30May | 7.6 | 0.209 | 2 | 0.00 | 3 | 2.8 k/ | 47 | -96 |
| 03/46/02,LAPI1 | Leavenworth Hat. (control) | 32.8 | 24Apr-01May 80 | 30 | 26May | 8.1 | 0.032 | 4 | 0.00 | | | | |
| 03/47/02,LAPI2 | • | 32.9 | | | | | | | | | | | |
| 03/51/02,LAPI4 | • | 33.1 | | | | | | | | | | | |
| 03/48/02,LAPI3 | White Bluffs (trans.) | 32.0 | 24Apr-01May 80 | 41 | 18May | 7.6 | 0.085 | 6 | 0.01 | 3 | 3.3 k/ | 177 | 48 |
| 03/49/02,LAPP1 | • | 32.6 | | | | | | | | | | | |
| 03/50/02,LAS1 | • | 35.4 | | | | | | | | | | | |
| 03/43/02,RA91 | Dalton Point (trans.) | 32.4 | 24Apr-01May 80 | 141 | 05May | 8.3 | 0.115 | 2 | 0.00 | 7 | 6.8 k/ | 253 | -75 |
| 03/44/02,RA92 | • | 32.7 | | | | | | | | | | | |
| 03/45/02,RA93 | • | 32.4 | | | | | | | | | | | |
| 03/52/02,RAIK1 | • | 32.9 | | | | | | | | | | | |
| 03/53/02,RAIK2 | • | 32.8 | | | | | | | | | | | |
| 03/54/02,RAIK3 | • | 32.6 | | | | | | | | | | | |
| RDF1 | Pasteros Ferry/Leavenworth H. | 15.3 | 05-13 May 80 | 23 | 07Jun | 9.0 | 0.041 | - | - | | | | |
| LDF1 | (upstream control) | 16.4 | | | | | | | | | | | |
| RDIY3 | • | 13.4 | | | | | | | | | | | |
| LDIY3 | • | 15.3 | | | | | | | | | | | |
| RDIL2 | • | 13.9 | | | | | | | | | | | |
| LDIL2 | • | 15.0 | | | | | | | | | | | |
| RDF2 | ds Priest Rapids D. (trans.) | 15.5 | 22-27 May 80 | 48 | 05Jun | 9.0 | 0.090 | - | - | 5 | 3.8 k/ | 120 | - |
| LDF2 | • | 16.2 | | | | | | | | | | | |
| RDIL3 | • | 14.8 | | | | | | | | | | | |
| LDIL3 | • | 15.2 | | | | | | | | | | | |
| RDIY2 | • | 13.2 | | | | | | | | | | | |
| LDIY2 | • | 15.3 | | | | | | | | | | | |
| RDF3 | Richland, WA (trans.) | 15.8 | 22-29 May 80 | 40 | 05Jun | 9.0 | 0.074 | - | - | 5 | 3.8 k/ | 80 | - |
| LDF3 | • | 16.3 | | | | | | | | | | | |
| RDIY1 | • | 13.9 | | | | | | | | | | | |
| LDIY1 | • | 15.4 | | | | | | | | | | | |
| RDIL1 | • | 13.7 | | | | | | | | | | | |
| LDIL1 | • | 15.9 | | | | | | | | | | | |
| 07/16/09 | Rnd. Butte Hat. (control) | 66.5 | 22 May 78 | 91 | 11Jun | 8.3 | 0.218 | 1 | 0.00 | | | | |
| 07/16/10 | ds Bonn. Dam (trans.) | 71.5 | 30 May 78 | 110 | 03Jun | 7.5 | 0.215 | 5 | 0.01 | 2 | 6.7 | 5 | 365 |

Table 30.--continued.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 07/18/26 | Rnd. Butte Hat. (control) | 48.8 | 23-31 May 79 | 240 | 05Jun | 6.2 | 0.282 | 0 | 0.00 | | | | |
| 07/18/25 | " | 50.1 | | | | | | | | | | | |
| 07/18/27 | ds Bonn. Dam (trans.) | 49.6 | 30 May 79 | 149 | 02Jun | 7.6 | 0.338 | 0 | 0.00 | 2 | 6.8 | 6 | - |
| 63/18/12 | Winthrop H. (control) | 67.3 | 20 Apr 79 | 16 | 30May | 7.6 | 0.033 | 16 | 0.02 | | | | |
| 63/18/11 | Methow R. (hauled 4 h) | 86.2 | 24 Apr 79 | 34 | 27May | 8.4 | 0.055 | 7 | 0.01 | | | | |
| 63/18/20 | ds Priest R. Dam (trans.) | 77.6 | 16 May 79 | 73 | 01Jun | 7.6 | 0.111 | 7 | 0.01 | 5 | 2.5 | 236 | -40 |
| | | | | | COHO SALMON | | | | | | | | |
| WHORLGOR,LAPP2 | Pasco, WA/Carson Hat.(control) | 44.0 | 03 May 78 | 47 | 19May | 9.2 | 0.139 | 89 | 0.20 | | | | |
| WHORORXY,RAL1 | ds Bonn. Dam (trans.) | 29.7 | 01-04 May 78 | 23 | 15May | 9.2 | 0.053 | 53 | 0.09 | 4 | 7.4 | -62 | -55 |
| WHORBLOR,RAL2 | " | 28.9 | | | | | | | | | | | |
| WHRDLB | Willard Hat. (control | 19.9 | 24May-08Jun 78 | 13 | 11Jun | 8.3 | 0.053 | 63 | 0.21 | | | | |
| WHORLBYW | " | 19.8 | | | | | | | | | | | |
| WHORYWOR | ds Bonn. Dam (trans.) | 19.7 | 08 Jun 78 | 21 | 14Jun | 8.3 | 0.084 | 60 | 0.20 | 1 | 6.7 | 58 | -5 |
| WHORYWGN | " | 19.8 | | | | | | | | | | | |
| 05/03/59 | Willard Hat. (control) | 42.4 | 14-23 May 80 | 21 | 30May | 9.0 | 0.033 | 618 | 0.45 | | 7.2 | | |
| 05/03/58 | " | 43.0 | | | | | | | | | | | |
| 05/06/54 | " | 51.4 | | | | | | | | | | | |
| 05/06/60 | ds Bonn. Dam (trans.) | 33.7 | 24-25 May 80 | 29 | 31May | 9.0 | 0.039 | 518 | 0.39 | 1 | 7.2 | 18 | -14 |
| 05/06/50 | " | 47.9 | | | | | | | | | | | |
| 05/06/55 | " | 51.4 | | | | | | | | | | | |
| | | | | | STEELHEAD | | | | | | | | |
| WHLBYW,LAAN1 | Icicle Cr./Chelan Hat.(control) | 24.1 | 26 Apr 79 | 55 | 24May | 8.4 | 0.106 | 356 | 0.53 | | | | |
| WHLBPK,LAAN2 | | 24.2 | | | | | | | | | | | |
| WHLBLG,LAAN3 | | 19.2 | | | | | | | | | | | |
| WHLBOR,RAY3 | ds Bonn. Dam (trans.) | 22.8 | 28 Apr 79 | 80 | 08May | 9.7 | 0.139 | 543 | 0.77 | 1 | 7.6 | 17 | 45 |
| WHLBRD,RAY2 | | 24.3 | | | | | | | | | | | |
| WHLBWH,RAY1 | | 23.3 | | | | | | | | | | | |
| 05/04/55 | Dworshak Hat. (control) 8/lb | 59.1 | 17-25 Apr 80 | 124 | 07May | 8.8 | 0.144 | 568 | 0.37 | | | | |
| 10/21/62 | " 6/lb | 46.9 | | | | | | | | | | | |
| 10/21/61 | " 9/lb | 49.2 | | | | | | | | | | | |
| 10/21/19,LD41 | ds Bonn. Dam (trans.) 6/lb | 40.0 | 29May-02May 80 | 95 | 05May | 8.8 | 0.510 | 453 | 1.13 | 8 | 5.9 | 269 | 205 |
| 23/06/06,LAIK3 | Dworshak Hat. (control) | 29.8 | 19 Apr 82 | 13 | 12May | 10.2 | 0.039 | - | - | | | | |
| 23/06/07,RAL3 | Skamania Light (trans.) | 32.2 | 22Apr-03May 82 | 37 | 25Apr | 9.4 | 0.067 | - | - | 8 | 8.7 | 83 | - |
| 23/06/08,RAL4 | " | 33.0 | | | | | | | | | | | |
| 23/16/05,RAL2 | " | 32.9 | | | | | | | | | | | |
| 23/16/04,LAK2 | Dworshak Hat. (control) | 31.0 | 30 Apr 82 | 21 | 20May | 10.9 | 0.064 | - | - | | | | |
| 23/16/03,RAPP1 | Skamania Light (trans.) | 29.5 | 22May-03Jun 82 | 195 | 29May | 11.0 | 0.319 | - | - | 8 | 9.2 | 399 | - |
| 23/16/01,RAL1 | " | 31.9 | | | | | | | | | | | |
| 63/28/38,LAS1 | Lyons Ferry (control) | 54.6 | 01-20 May 83 | 68 | 29May | 12.2 | 0.141 | - | - | | | | |
| 63/28/39,RAS1 | Wallowa Hat. (upstream trans.) | 33.0 | 09-13 May 83 | 96 | 28May | 12.2 | 0.305 | - | - | -2 | 2.9 1/ | 116 | - |
| 63/28/40,RAS2 | " | 32.0 | | 78 | | | | | | | | | |
| WHORORRD,RAL3 | Ringold Hat.(control) | 17.6 | 05 May 78 | 11 | 18May | 9.2 | 0.079 | 122 | 0.69 | | | | |
| WHORLGYW,RAL2 | Methow R./Wells channel | 19.9 | 27Apr-08May 78 | 17 | 26May | 8.7 | 0.058 | 207 | 0.51 | -5 | 4.0 k/ | -23 | -26 |
| WHORORXY,LAPP1 | (upstream trans.) | 20.3 | | | | | | | | | | | |
| WHLBPKLG,LAIJ3 | Methow R./Wells channel | 18.3 | 09-14 May 79 | 13 | 28May | 7.6 | 0.042 | 50 | 0.13 | | | | |
| WHLBPKYW,RAIJ1 | (control) | 20.1 | | | | | | | | | | | |
| WHLBLB,RAT1 | ds Bonn. Dam(trans.) | 9.7 | 12 May 79 | 12 | 15May | 8.1 | 0.155 | 60 | 0.62 | 9 | 6.9 | 253 | 377 |
| WHBLOR | ds Priest Rapids Dam/Wells channel (downstream control) | | 20-24 Apr 82 | 25 | 08May | 10.2 | 0.108 | - | - | | | | |
| WHBLWH | Methow R./Wells channel (upstream trans.) | | 19-23 Apr 82 | 23 | 20May | 10.9 | 0.096 | - | - | -5 | 4.0 k/ | -16 | - |
| RA 52 1 | ds Priest Rapids D./Wells channel (downstream control) | 22.4 | 19-27 Apr 83 | 49 | 12May | 10.4 | 0.224 | - | - | | | | |
| RA 17 1 | Methow R. (upstream trans.) | 20.0 | 19-27 Apr 83 | 23 | 15May | 9.2 | 0.122 | - | - | -5 | 5.0 k/ | -40 | - |

Table 30.--continued.

a/ More complete information available from Dawley et al. 1985b or releasing agency Table 21. Binary coded wire tags: Ag=Agency, Dl=Data 1 code, and D2=Data 2 code. Color coded wire tags begin with WH and each two digits thereafter represent a color. Brands are represented by the following: Loc=Location on fish, Sym=Brand symbol, and Rot=Rotation of symbol. For abbreviations, symbol, and descriptions see Dawley et al. 1985b.

b/ Transport groups with time period from first to median fish capture at Jones Beach in 2 days or less were not included in analysis. Abbreviations: Bonn=Bonneville, Br=Bridge, D=Dam, ds=downstream, Hat=Hatchery, N=North, NA=Nonapplicable, R=River, S=South, Trans=Transported, and Willam=Willamette.

c/ Combined weekly average flow volume of Columbia River at Bonneville Dam, Willamette, Lewis, and Cowlitz Rivers during week of median fish recovery at Jones Beach; kcms = 1,000 $m^3$/second.

d/ Beach plus purse seine data adjusted for effort and flow at Jones Beach (catch % of recovery at lowest flow increased by 8.5% per 1,000 $m^3$/second difference). Comparisons not made for actual catch less than 10 transport fish. Mark groups were combined where possible to exceed the minimum.

e/ Preliminary observed data; dashes represent no data available.

f/ Weekly average flow volume of Columbia River at Bonneville Dam during week of mean date between release and median fish recovery at Jones Beach--represents best flow during passage through dams.

g/ [(Percent recovery transport group ÷ percent recovery control)] x 100.

h/ Weekly average flow volume of Columbia River at Bonneville Dam during week of mean date between release and median fish recovery at Jones Beach.

i/ Combined data comparison.

j/ WHRDPKOR also used for test group (Brand = RA I + 3). Tag not included in adult recovery information.

k/ Weekly average flow volume of Columbia River at Priest Rapids Dam during the week following release.

l/ Weekly average flow volume of Snake River at Ice Harbor Dam during the week following release.

Table 31.--Jones Beach catches and adult recoveries for serial releases of coho salmon, 1977-1983.

| Release information | | | | | Recovery information at Jones Beach | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Juvenile catch | | Date of | Flow @ | Flow adj. | Adult recoveries g/ observed--cumulative | | | |
| Tag a/ (Ag/D1/D2) | Source b/ | Number (thou) | Date (da/mo/yr) | Size c/ (no./lb) | (no.) | effort adj. d/ (%) | median fish recovery | Jones Beach e/ (kcms) | catch @ 7 Kcms (%) f/ | total (no.) | 2 yr (%) | 3 yr (%) | 4 yr (%) |
| 07/26/06 | Bonneville Hat. | 26.9 | 02/May/83 | 15' | 22 | 0.081 | 14 May | 9.2 | 0.096 | - | - | - | - |
| 07/26/07 | | 27.3 | 31/May/83 | 16 | 28 | 0.112 | 3 Jun | 12.2 | 0.162 | - | - | - | - |
| 07/19/08,11 | Cascade Hat. | 54.8 | 07/May/79 | 23 | 36 | 0.082 | 18 May | 8.1 | 0.090 | 312 | 0.01 | 0.57 | - |
| 07/19/07,10 | | 53.1 | 07/Jun/79 | 23 | 69 | 0.147 | 14 Jun | 5.5 | 0.128 | 637 | 0.00 | 1.20 | - |
| 07/19/09,12 | | 49.8 | 06/Jul/79 | 23 | 106 | 0.444 | 13 Jul | 4.0 | 0.331 | 439 | 0.00 | 0.88 | - |
| 07/19/63 | Cascade Hat. (for reference) | 29.2 | 28/Apr/80 | 24 | 13 | 0.082 | 17 May | 7.6 | 0.086 | 12 | 0.00 | 0.04 | - |
| 07/21/27,30 | Cascade Hat. | 51.6 | 06/May/81 | 17 | 52 | 0.109 | 17 May | 6.7 | 0.106 | 987 | 0.00 | 1.91 | - |
| 07/21/28,31 | | 54.0 | 08/Jun/81 | 17 | 46 | 0.102 | 10 Jun | 10.2 | 0.130 | 1760 | 0.00 | 3.26 | - |
| 07/21/29,32 | | 56.6 | 06/Jul/81 | 17 | 32 | 0.131 | 10 Jul | 7.6 | 0.138 | 1447 | 0.00 | 2.56 | - |
| 07/24/29,33 | Cascade Hat. (for reference) | 55.9 | 25/May/82 | 18 | 55 | 0.106 | 31 May | 11.0 | 0.142 | 310 | 0.00 | 0.55 | - |
| 07/27/47 | Cascade Hat. (for reference) | 43.1 | 24/May/83 | 17 | 21 | 0.059 | 31 May | 12.2 | 0.085 | - | - | - | - |
| 63/19/11,12 | Toutle Hat. | 77.1 | 07/May/79 | 18 | 86 | 0.136 | 19 May | 8.1 | 0.149 | 1062 | 0.02 | 1.38 | - |
| 63/17/58,19/13 | | 80.3 | 07/Jun/79 | 19 | 210 | 0.296 | 13 Jun | 5.5 | 0.258 | 1754 | 0.00 | 2.18 | - |
| 63/19/28,29 | | 80.9 | 06/Jul/79 | 18 | 205 | 0.525 | 13 Jul | 4.0 | 0.391 | 836 | 0.00 | 1.03 | - |
| 63/19/31,20/58 | Toutle Hat. (for reference) | 78.1 | 07/May/80 | 19 | 74 | 0.192 | 17 May | 7.6 | 0.202 | 335 | 0.00 | 0.43 | - |
| 63/19/23,24 | Washougal Hat. | 155.1 | 07/May/79 | 17 | 168 | 0.139 | 20 May | 8.1 | 0.152 | 2340 | 0.02 | 1.50 | - |
| 63/19/25 h/ | | 73.0 | 07/Jun/79 | 20 | 120 | 0.187 | 16 Jun | 5.5 | 0.163 | 687 | 0.00 | 0.94 | - |
| 63/19/26 | | 82.9 | 07/Jun/79 | 20 | 119 | 0.162 | 14 Jun | 5.5 | 0.141 | 1430 | 0.00 | 1.72 | - |
| 63/19/27,34 | | 163.1 | 07/Jul/79 | 20 | 388 | 0.503 | 13 Jul | 4.0 | 0.375 | 2056 | 0.00 | 1.26 | - |
| 63/20/39,40 | Washougal Hat. | 198.3 | 08/May/80 | 18 | 150 | 0.135 | 17 May | 7.6 | 0.142 | 1368 | 0.01 | 0.79 | - |
| 63/20/37,38 i/ | | 195.1 | 09/Jun/80 | 18 | 118 | 0.104 | 15 Jun | 9.1 | 0.123 | 4692 | 0.00 | 2.40 | - |
| 63/19/54,55 | | 213.7 | 07/Jul/80 | 19 | 244 | 0.262 | 12 Jul | 5.3 | 0.224 | 8981 | 0.00 | 4.20 | - |
| 63/21/50,22/02 | Washougal Hat. | 103.8 | 30/Apr/81 | 18 | 91 | 0.110 | 15 May | 6.7 | 0.107 | 602 | 0.01 | 0.58 | - |
| 63/21/51,22/03 | | 105.3 | 27/May/81 | 20 | 70 | 0.089 | 2 Jun | 10.9 | 0.119 | 2485 | 0.01 | 2.36 | - |
| 63/25/13-17 | Washougal Hat. (for reference) | 50.1 | 25/May/82 | 21 | 91 | 0.182 | 2 Jun | 11.0 | 0.244 | 183 | 0.01 | 0.37 | - |
| 63/26/45 | Washougal Hat. | 50.9 | 15-30/Apr/83 | 18 | 40 | 0.081 | 6 May | 9.6 | 0.099 | - | - | - | - |
| 63/27/13-17 | | 52.1 | 27/May/83 | 19 | 38 | 0.086 | 1 Jun | 12.2 | 0.124 | - | - | - | - |

a/ Binary coded wire tag: Ag=Agency code, D1=Data 1 code, D2=Data 2 code.

b/ More complete information is available from Dawley et al. 1985b or the releasing agency Table 21. Hat=Hatchery.

c/ Comparisons limited to groups with less than 20% difference in mean weight at release.

d/ Number is actual; % represents catch for effort adjusted combined replicates.

e/ Average flow including Columbia River at Bonneville Dam, Willamette, Lewis, and Cowlitz Rivers on week of median fish recovery; kcms = 1,000 $m^3$/second.

f/ Catch % additionally adjusted for river flow to represent catch at 7 kcms.

g/ Percent of total release calculated from observed recovery. No data (-) means either adults have yet to return, were not collected, or were not obtained from fishery agencies prior to analysis. Comparisons between groups released at different times may be erroneous because of differences in ocean distribution, unequal fishing effort, or sampling effort.

h/ BKD and high pre-release mortality from low dissolved oxygen.

i/ Poor health.

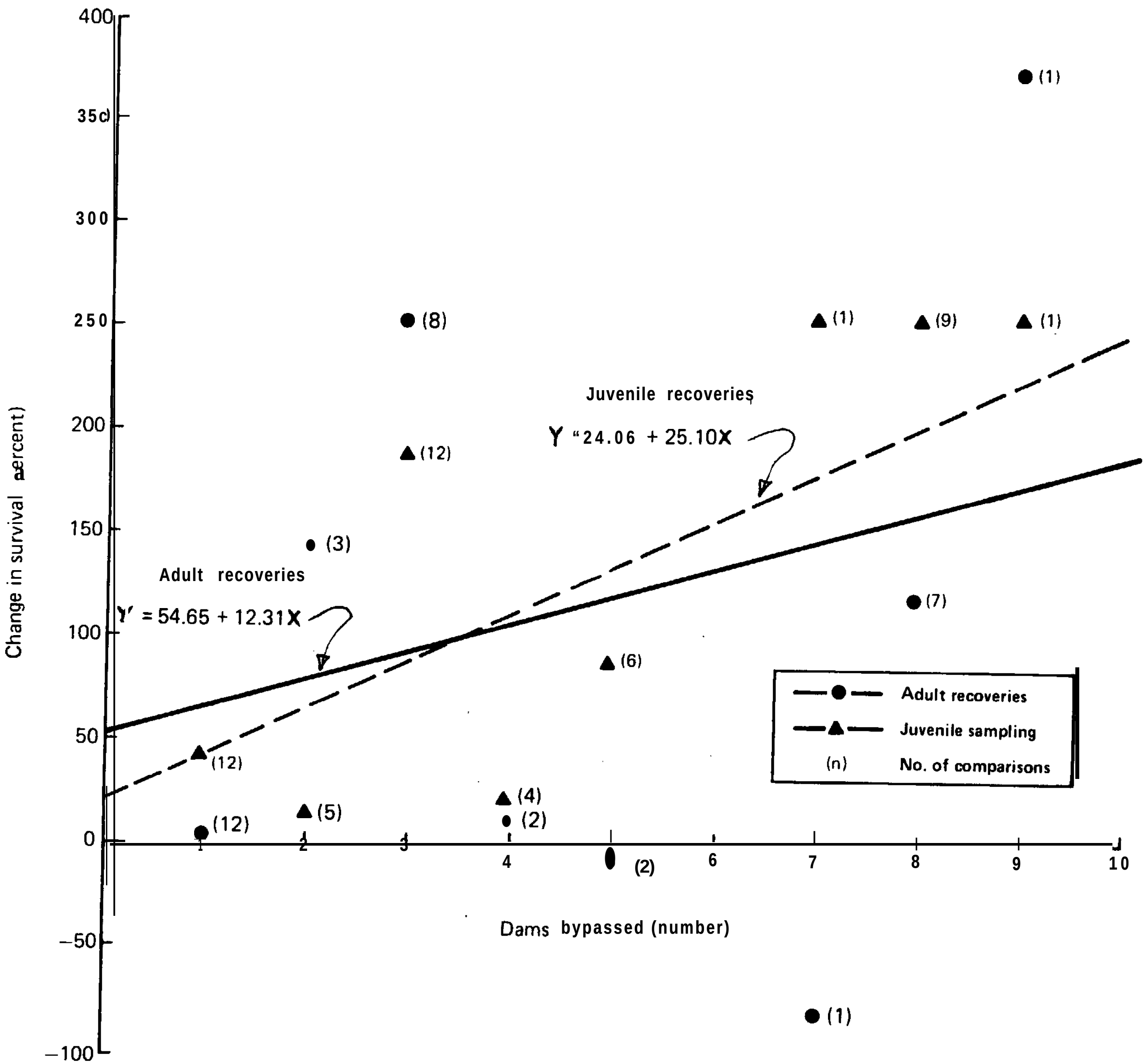


Figure 39.--Linear regression of mean survival increase with number of dams bypassed in downstream migration; from Jones Beach recoveries and adult recoveries.

Delayed releases of subyearling chinook salmon could not be compared because of effects of size differences.

Stocks.--Estuarine sampling showed some significant differences in catch between marked groups from studies evaluating the success of various fish stocks (Table 32). In 1 of 4 years, yearling chinook salmon of tule stock showed a significantly greater catch rate than late fall stock released from Bonneville Hatchery (Hansen 1982). Yearling chinook salmon releases from Klickitat Hatchery of wild stock and Wells stock were each different from the Klickitat stock but not different from one another. Wallowa stock steelhead showed greater catches than Wells stock released at Lyons Ferry. A few other stocks showed significant differences, but fish size was unequal, and in each instance a greater percentage of the larger fish were captured. Comparisons were limited to groups with less than 20% difference in body weight at release.

Juvenile catch percentages correlated well with adult recoveries. In 13 of 18 instances, juvenile catches varied in the same direction as adult recoveries, and in 9 of 12 instances where adult recoveries were significantly different (Table 32).

Nutrition.--Estuarine recovery data of fish from diet studies showed statistically significant differences which generally correlated with benefits of survival observed from adult recovery data. In 2 years of a 7-year study with coho salmon at Sandy Hatchery (Westgate et al. 1983b), estuarine recovery data showed statistically higher recoveries, from individual diet groups, which correlated with statistically higher adult survival (Table 33). One diet group showed statistically lower recoveries, but showed no decreased survival in adult recovery data. Recoveries of subyearling chinook salmon from a I-year study at Bonneville Hatchery (Westgate et al. 1983b) showed statistically higher benefits for one diet in 2 of the 3 years for which it was tested, and adult recoveries also showed survival benefits for both, however, only one was significant (Table 33). Recoveries of subyearling chinook salmon from a high salt concentration diet at Spring Creek Hatchery (Leek[8/]) showed statistical differences in 1983 and not in 1982.

Several diets showed statistically significant differences as adults which were not apparent from juvenile recovery data.

Rearing Density.--Differences in relative survival during migration to the estuary were examined for yearling chinook and coho salmon groups cultured

8/ S. Leek, USFWS, Little White NFH, Cook, WA 98605; pers. commun.

Table 32.--Catch percentages of marked fish from stock comparison studies.

| Release information: Tag a/ (Ag/D1/D2) Brand (Loc Sym Rot) | Source b/ | Stock | Number (thou) | Date (da/mo/yr) | Size c/ (no/lb) | Recovery information: Jones Beach d/ fall (no.) | Jones Beach d/ winter/spring (no.) | Jones Beach d/ (%) | Adult recoveries e/ observed--cumulative total (no.) | 2yr (%) | 3 yr (%) | 4 yr (%) | 5 yr (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SUBYEARLING CHINOOK SALMON | | | | | | | | | | | | | |
| 07/21/38 | Bonneville Hat. | Tule | 51.5 | 09 Nov 81 | 11 | 3 | 5 | 0.041 | 7 | - | 0.01 | - | - |
| 07/21/42 | | Late fall | 50.7 | | 11 | 3 | 1 | 0.024 | 4 | - | 0.01 | - | - |
| 07/21/39 | Bonneville Hat. | Tule | 50.0 | 09 Nov 81 | 9 | 5 | 4 | 0.085 | 8 | - | 0.02 | - | - |
| 07/21/41 | | Late fall | 49.8 | | 9 | 3 | 1 | 0.013 | 12 | - | 0.02 | - | - |
| 07/23/63 | Bonneville Hat. | Tule | 45.9 | 01 Nov 82 | 11 | 119 | 4 | 0.559 | - | - | - | - | - |
| 07/25/48 | | Late fall | 50.7 | | 12 | 105 | 2 | 0.445 | - | - | - | - | - |
| 05/61/01, 63/01,03/42 | Lit.Wh.Sal.Hat. | Spring Cr. | 151.2 | 24 May 78 | 119 | | 328 | 0.343 | 25 | 0.00 | 0.01 | 0.02 | 0.02 |
| 05/03/46-48 | | Lit.Wh.Sal. | 148.8 | 25 May 78 | 115 | | 334 | 0.358 | 10 | 0.00 | 0.01 | 0.01 | 0.01 |
| 63/26/11 | Pr Rap Spaw Ch./ | Production | 204.1 | 24 May 83 | 84 | | 141 | 0.096 | - | - | - | - | - |
| 63/26/12 | | Wild | 202.4 | 21 Jun 83 | 63 | | 86 | 0.103 | - | - | - | - | - |
| YEARLING CHINOOK SALMON | | | | | | | | | | | | | |
| 07/16/57 | Bonneville Hat. | Tule | 47.9 | 13 Mar 79 | 7 | | 105 | 0.393 | 471 | - | 0.31 | 0.97 | 0.98 |
| 07/16/61 | | Late fall | 32.7 | | 8 | | 62 | 0.403 | 514 | - | 0.39 | 1.29 | 1.57 |
| 07/17/36 | Bonneville Hat. | Tule | 48.1 | 13 Mar 80 | 6 | | 52 | 0.224 | 158 | - | 0.12 | 0.33 | 0.33 |
| 07/17/33 | | Late fall | 49.3 | | 9 | | 70 | 0.322 | 140 | - | 0.07 | 0.26 | 0.28 |
| 07/21/40 | Bonneville Hat. | Tule | 51.9 | 17 Mar 82 | 7 | | 52 | 0.435 | 38 | - | 0.07 | - | - |
| 07/21/43 | | Late fall | 50.6 | | 7 | | 48 | 0.377 | 20 | - | 0.04 | - | - |
| 07/27/01 | Bonneville Hat. | Tule | 37.5 | 08 Mar 83 | 7 | | 44 | 0.226 | - | - | - | - | - |
| 07/25/47 | | Late fall | 49.9 | 23 Mar 83 | 6 | | 13 | 0.052 | - | - | - | - | - |
| 63/17/32 | Klickitat Hat. | Klickitat | 94.6 | 30 Mar 79 | 10 | | 45 | 0.064 | 232 | - | 0.03 | 0.18 | 0.25 |
| 63/17/34 | | Wind River | 103.3 | | 10 | | 80 | 0.109 | 269 | - | 0.01 | 0.18 | 0.26 |
| 63/17/50 | | Wells | 94.2 | | 10 | | 87 | 0.131 | 361 | - | 0.15 | 0.35 | 0.38 |
| 09/16/63 | Marion Fks. Hat. | Carson | 50.2 | 13-15 Mar 78 | 15 | | 17 | 0.056 | 18 | - | 0.00 | 0.01 | 0.04 |
| 09/17/02 | @ Minto | Santiam | 49.6 | | 13 | | 22 | 0.089 | 3 | - | 0.00 | 0.01 | 0.01 |
| 07/17/25,26,29 | Marion Fks.Hat. | Carson | 144.3 | 03 Apr 79 | 16 | | 90 | 0.078 | 67 | - | 0.00 | 0.02 | 0.05 |
| 07/17/30-32 | @ Minto | Santiam | 148.2 | | 19 | | 101 | 0.088 | 524 | - | 0.01 | 0.19 | 0.35 |
| 07/22/49-51 | Marion Fks. Hat. | Carson | 147.1 | 16-24 Apr 81 | 14 | | 24 | 0.031 | 49 | - | 0.00 | 0.03 | - |
| 07/22/52,53 | @ Minto | Santiam | 81.9 | | 14 | | 27 | 0.036 | 59 | - | 0.02 | 0.07 | - |
| 07/25/25-27 | Marion Fks. Hat. | Carson | 150.8 | 15-17 Mar 82 | 16 | | 51 | 0.041 | 0 | - | 0.00 | - | - |
| 07/25/28-30 | @ Minto | Santiam | 148.7 | 18-20 Mar 82 | 14 | | 56 | 0.053 | 3 | - | 0.00 | - | - |
| 07/20/44 | Oakridge Hat. | Oakridge | 30.7 | 10 Mar 80 | 8 | | 25 | 0.202 | 272 | - | 0.06 | 0.54 | 0.89 |
| 07/20/42 | | Dexter | 30.7 | | 9 | | 20 | 0.148 | 339 | - | 0.07 | 0.67 | 1.10 |
| 07/22/25 | Oakridge Hat. | Oakridge | 26.6 | 16 Mar 81 | 7 | | 9 | 0.063 | 91 | - | 0.02 | 0.34 | - |
| 07/23/05 | | Dexter | 29.9 | | 7 | | 14 | 0.104 | 145 | - | 0.04 | 0.48 | - |
| 05/06/28 | Warm Springs Hat. | Early Sum. | 10.9 | 07-14 Apr 80 | 19 | | 5 | 0.086 | 126 | - | - | - | 1.15 |
| 05/06/27 | | Late Sum. | 168.0 | | 19 | | 51 | 0.059 | 1351 | - | - | - | 0.80 |
| 05/08/24 | Warm Springs Hat. | Early Sum. | 32.3 | 02 Apr 81 | 8 | | 4 | 0.027 | 0 | - | 0.00 | 0.00 | - |
| 05/08/22 | | Late Sum. | 66.7 | | 8 | | 20 | 0.062 | 2 | - | 0.00 | 0.00 | - |
| 05/08/25 | Warm Spring Hat. | Early Sum. | 186.0 | 09 Apr 81 | 20 | | 16 | 0.027 | 3 | - | 0.00 | 0.00 | - |
| 05/08/23 | | Late Sum. | 170.2 | 09-16 Apr 81 | 18 | | 48 | 0.042 | 10 | - | 0.00 | 0.01 | - |
| STEELHEAD | | | | | | | | | | | | | |
| 05/13/34 | Hagerman Hat. @ Upper Sal. R. | A stock | 39.1 | 18-20 Apr 83 | 5 | | 104 | 0.363 | - | - | - | - | - |
| 10/24/60 | Hagerman Hat. @ EFK Sal. R. | B stock | 37.6 | 12-13 Apr 83 | 4 | | 102 | 0.316 | - | - | - | - | - |
| LA S 1 | Lyons Ferry Hat. | Wallowa | 54.6 | 01-20 May 83 | 4 | | 68 | 0.104 | - | - | - | - | - |
| LD S 2 | | Wells | 51.6 | | 4 | | 7 | 0.016 | - | - | - | - | - |

Table 32.--continued.

a/ More complete information available from Dawley et al. 1985b or releasing agency Table 21. Binary coded wire tags: Ag=Agency code, Dl=Data 1 code, and D2=Data 2 code. Color coded wire tags begin with WH and each two digits thereafter represent a color. Brands are represented by the following: Loc=Location on fish, Sym=Brand symbol, and Rot=Rotation of symbol. For abbreviations, symbol, and descriptions see Dawley et al. 1985b.

b/ More complete information is available from Dawley et al. 1985b or the releasing agency Figure 21. Abbreviations used are listed: Ch=Channel, EFk=East Fork, Fks=Forks, Hat=Hatchery, Lit=Little, Pr=Priest, R=River, Rap=Rapids, Sal=Salmon, Spaw=Spawning, Wh=White, and @ = Released at.

c/ Only groups with average body weight < 20% difference were compared.

d/ Actual catch and adjusted percentage catch, purse seine plus beach seine; combined replicates.

e/ Percent of total release calculated from observed recovery. No data (-) means either adults have yet to return, were not collected, or were not obtained from fishery agencies prior to analysis. Comparisons between groups released at different times may be erroneous because of differences in ocean distribution, unequal fishing effort, or sampling effort.

Table 33.--Jones Beach catches and adult recoveries for marked fish from studies of nutrition, 1977-1983.

| Release information | | | | | Juvenile catches at Jones Beach b/ | | Adult recoveries c/ observed--cumulative | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Tag a/ (Ag/D1/D2) | Diet | Source | Number (thou) | Date (da/mo/yr) | (no.) | (%) | total (no.) | 2 yr (%) | 3 yr (%) | 4 yr (%) |
| | | | | COHO SALMON | | | | | | |
| 09/05/13 | Herring 8% | Sandy Hat. d/ | 60.6 | 06 May 77 | 23 | 0.076 | 1060 | 0.00 | 1.75 | - |
| 09/06/06 | Herring 4% soy 4% | | 57.2 | | 24 | 0.086 | 1330 | 0.00 | 2.33 | - |
| 09/06/07 | Herring 6% soy 2% | | 58.8 | | 26 | 0.091 | 1245 | 0.00 | 2.12 | - |
| 09/06/08 | Soy 8% | | 60.0 | | 25 | 0.085 | 1212 | 0.00 | 2.02 | - |
| 09/06/09 | Herring 2% soy 6% | | 60.2 | | 24 | 0.081 | 1238 | 0.00 | 2.06 | - |
| 09/16/44 | Soy 6% herring 2% | Sandy Hat. | 33.2 | 02 May 78 | 25 | 0.091 | 908 | 0.09 | 2.73 | - |
| 09/16/45 | Herring 8% | | 34.0 | | 14 | 0.051 | 848 | 0.05 | 2.49 | - |
| 09/16/46 | Soy 4% herring 4% | | 32.5 | | 16 | 0.063 | 832 | 0.07 | 2.56 | - |
| 09/16/47 | Soy 2% herring 6% | | 33.6 | | 26 | 0.102 | 865 | 0.09 | 2.57 | - |
| 09/16/48 | Soy 8% | | 33.7 | | 18 | 0.072 | 859 | 0.07 | 2.55 | - |
| 09/16/49 | Menhaden oil 6% | Sandy Hat. | 34.0 | 04 May 78 | 21 | 0.080 | 835 | 0.05 | 2.46 | - |
| 09/16/50 | Soy oil 6% | | 33.3 | | 24 | 0.096 | 759 | 0.06 | 2.28 | - |
| 09/16/51 | Herring oil 6% | | 34.4 | | 19 | 0.074 | 748 | 0.04 | 2.17 | - |
| 09/16/52 | Anchovy oil 6% | | 33.0 | | 22 | 0.085 | 771 | 0.03 | 2.34 | - |
| 07/17/49 | Anchovy oil 6% | Sandy Hat. | 27.5 | 01 May 79 | 28 | 0.133 | 343 | 0.06 | 1.25 | - |
| 07/17/50 | Menhaden oil 6% | | 27.4 | | 25 | 0.114 | 521 | 0.07 | 1.90 | - |
| 07/17/51 | Soy 6% | | 27.5 | | 32 | 0.151 | 622 | 0.07 | 2.26 | - |
| 07/17/52 | Herring 6% | | 27.9 | | 28 | 0.121 | 343 | 0.06 | 1.23 | - |
| 07/20/31,33 | OMP 4 | Sandy Hat. | 50.4 | 01 May 80 | 31 | 0.139 | 367 | 0.01 | 0.73 | - |
| 07/20/32,34 | OMP 2 Fresh & frozen | | 50.7 | | 33 | 0.140 | 531 | 0.01 | 1.05 | - |
| 07/20/35,36 | OMP 2 Acid | | 50.4 | | 32 | 0.131 | 446 | 0.01 | 0.88 | - |
| 07/20/37,38 | OMP 2 Frozen | | 52.5 | | 33 | 0.129 | 541 | 0.02 | 1.03 | - |
| 07/22/55,57 | OMP 2 Frozen | Sandy Hat. | 56.5 | 01 May 81 | 37 | 0.104 | 750 | 0.01 | 1.33 | - |
| 07/22/56,58 | OMP 2 Acid | | 55.3 | | 32 | 0.076 | 735 | 0.02 | 1.33 | - |
| 07/22/59,62 | Presscake | | 57.7 | | 59 | 0.144 | 1036 | 0.01 | 1.80 | - |
| 07/22/60,63 | OMP 4 | | 57.8 | | 35 | 0.077 | 927 | 0.01 | 1.60 | - |
| 07/22/61,23/01 | OMP 2 Frozen & fresh | | 58.7 | | 42 | 0.091 | 900 | 0.01 | 1.53 | - |
| 07/25/50,58 | OMP 2 | Sandy Hat. | 54.2 | 30 Apr 82 | 86 | 0.165 | 709 | 0.12 | 1.31 | - |
| 07/25/51,54 | OMP 4 | | 54.9 | | 80 | 0.151 | 642 | 0.13 | 1.17 | - |
| 07/25/49,57 | PC-6 | | 52.1 | | 84 | 0.170 | 759 | 0.20 | 1.46 | - |
| 07/25/53,55 | PC-4 | | 54.3 | | 58 | 0.110 | 726 | 0.14 | 1.34 | - |
| 07/25/52,56 | Abernathy | | 54.5 | | 79 | 0.147 | 743 | 0.09 | 1.36 | - |
| 07/27/31,36 | OMP 2 | Sandy Hat. | 109.6 | 29 Apr 83 | 78 | 0.071 | - | - | - | - |
| 07/27/32,35 | Sal. Meal | | 109.5 | | 67 | 0.062 | - | - | - | - |
| 07/27/33,34 | Abernathy | | 108.8 | | 73 | 0.068 | - | - | - | - |

Table 33.--continued.

SUBYEARLING CHINOOK SALMON

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 07/21/33,34 | OMP 2 | Bonneville Hat.d/ | 100.5 | 27 May 80 | 26 | 0.044 | 39 | 0.00 | 0.03 | 0.04 |
| 07/21/35,36 | OMP 4 | | 97.5 | | 50 | 0.090 | 31 | 0.00 | 0.03 | 0.03 |
| 07/23/41,42 | OMP 2 | Bonneville Hat. | 102.4 | 12 May 81 | 90 | 0.104 | 61 | 0.00 | 0.06 | - |
| 07/23/43,44 | OMP 4 | | 105.0 | | 114 | 0.132 | 95 | 0.01 | 0.09 | - |
| 07/23/45,46 | Presscake | | 101.9 | | 99 | 0.121 | 42 | 0.00 | 0.04 | - |
| 07/24/14,15 | OMP 2 | Bonneville Hat. | 104.1 | 04 Jun 82 | 84 | 0.081 | - | - | - | - |
| 07/24/16,17 | OMP 5 (presscake) | | 106.6 | | 91 | 0.090 | - | - | - | - |
| 07/27/29,30 | OMP 2 | Bonneville Hat. | 100.0 | 04 May 83 | 171 | 0.171 | - | - | - | - |
| 07/27/27,28 | OMP 4 | | 100.8 | | 172 | 0.171 | - | - | - | - |
| 05/10/55,56 | 7% Salt | Spring Creek Hat.e/ | 89.6 | 15 Apr 82 | 135 | 0.173 | - | - | - | - |
| 05/10/53,54 | Control | | 91.7 | | 139 | 0.174 | - | - | - | - |
| 05/11/42,43 | 7% Salt | Spring Creek Hat. | 100.0 | 28 Apr 83 | 136 | 0.136 | - | - | - | - |
| 05/11/44,45 | Control | | 104.0 | | 171 | 0.164 | - | - | - | - |

a/ Binary coded wire tag: Ag=Agency code, D1=Data 1 code, and D2=Data 2 code.
b/ Number is actual catch; % catch adjusted for effort; combined replicates.
c/ Percent of total release, calculated from observed recovery. No data (-) means either adults have yet to return, or were not collected or were not obtained from fishery agencies prior to analysis. Comparisons between groups released at different times may be erroneous because of differences in ocean distribution, unequal fishing effort or sampling effort.
d/ Jean Legasse, ODFW, Sandy Hatchery, 39800 SE Fish Hatchery Road, Sandy, Oregon 97055.
e/ Steve Leek, USFWS, Little White Salmon NFH, Cook, Washington 98605.

at various densities of fish per volume of water or per rate of water exchange (Table 34). Estuarine recovery data for coho salmon from Eagle Creek Hatchery over a 3-year test series 1981-1983 (Holway[9/]) showed statistically significant benefits related to lower rearing density which were also correlated to significantly increased survival to adulthood. However, estuarine recovery data of juveniles from single tests and series of tests from six other studies showed no correlation with density, even though adult recovery data showed strong positive correlation with decreased rearing density; statistically significant for three of five studies. One of the two groups which showed negative correlation was highly significant, whereas the other was poorly correlated.

Juvenile recoveries showed differences among study groups which varied in the same direction as adult recovery data less than 50% of the time which suggests that estuarine catch data are generally not sensitive in the prediction of adult survival trends for rearing density studies.

Catch Rate Models for Subyearling Chinook Salmon

Marked fish representing all the stocks of subyearling chinook salmon cultured in the Columbia River basin from 1978 to 1982 (Environmental and Technical Services Div. 1983) allowed a detailed assessment of variables affecting estuarine catch percentages and development of a catch rate model. Future catch data may be compared to model predictions for examining the relative success of survival during migration. Correlations with several variables were examined for upriver release groups (upstream from John Day Dam; > RKm 347), downriver release groups (downstream from John Day Dam), combined groups, and individual stocks. Variables examined were fish size (no./lb), movement rate (km/day), river flow ($m^3$/second), date of recovery (Julian date), and distance of migration [release site (RKm)- capture site (RKm)], Catch percentages were standardized to 7,000 $m^3$/second river flow for all data, 1977-1983 (Table 34). The equations are given in the original data units but the statistics were calculated using normalized units. Catch percentages of upriver released fish showed a significant linear relationship with distance of migration, fish size, and river flow. This relationship is: $Y = 0.1645 - 0.0001760X_1 - 0.0009868X_2 + 0.01569X_3$ (in normalized units the equation is: $Y = -0.2103X_1 - 0.3428X_2 + 0.5350X_3$; $R_a^2 = 0.53$, $F = 12.76$ at 2, 19 df with $P < 0.001$). Where Y is catch percentage, $X_1$ is distance of migration, $X_2$ is fish size, and $X_3$ is river flow.

In some cases, catch percentages for individual stocks showed a significant relationship to particular variables. Data from groups reared at Bonneville and Little White Salmon Hatcheries (primarily downstream releases), Priest Rapids Spawning Channel, and Hagerman Hatchery (primarily upstream releases) provided the following relationships:

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9/ J. Holway, USFWS, Eagle Creek NFH, Rt. 1, Box 610, Estacada, OR 97205; pers. commun.

Table 34.--Jones Beach catches and adult recoveries for marked fish from studies of rearing density, 1977-1983.

| Release information: Tag a/ (Ag/D17D2) Brand (Loc Sym Rot) | Source | Density | Number (thou) | Date (da/mo/yr) | Juvenile catches Jones Beach b/ (no.) | (%) | Adult recoveries c/ observed--cumulative Total (no.) | 2 yr (%) | 3 yr (%) | 4 yr (%) | 5 yr (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| YEARLING CHINOOK SALMON | | | | | | | | | | | |
| 13/09/11,12 | Cowlitz Hat. | High d/ | 176.8 | 08 Mar 77 | 80 | 0.132 | 2008 | - | 0.35 | 0.90 | 1.14 |
| 13/09/14,11/04 | | Med | 123.5 | | 55 | 0.107 | 2124 | - | 0.51 | 1.35 | 1.72 |
| 13/13/01,04 | | Low | 56.7 | | 24 | 0.111 | 896 | - | 0.74 | 1.09 | 1.58 |
| 63/17/09,10 | Cowlitz Hat. | 8.0 lbs/gal/min d/ | 177.4 | 08 Mar 78 | 233 | 0.418 | 5626 | - | 1.14 | 2.70 | 3.17 |
| 63/17/17,18 | | 6.5 lbs/gal/min | 140.7 | | 134 | 0.316 | 4418 | - | 1.32 | 3.23 | 3.83 |
| 63/17/11,12 | | 6.0 lbs/gal/min | 115.3 | | 162 | 0.448 | 4379 | - | 1.42 | 3.28 | 3.80 |
| 63/16/12,13 | | 3.0 lbs/gal/min | 56.0 | | 61 | 0.305 | 2280 | - | 1.51 | 3.49 | 4.07 |
| RA T 1 | Kooskia Hat. | 0.29 lbs/ft$^3$/in e/ | 14.7 | 04-12 Apr 83 | 11 | 0.075 | - | - | - | - | - |
| RA T 2 | | 0.08 lbs/ft$^3$/in | 8.2 | | 4 | 0.050 | - | - | - | - | - |
| COHO SALMON | | | | | | | | | | | |
| 63/24/20-24 | Cowlitz Hat. | 20.0 lbs/gal/min | 51.0 | 03 May 82 | 95 | 0.196 | 436 | 0.15 | 0.85 | - | - |
| 63/24/25-29 | | 19.8 lbs/gal/min | 52.9 | | 72 | 0.143 | 591 | 0.22 | 1.12 | - | - |
| 63/24/40-44 | | 12.7 lbs/gal/min | 53.2 | | 101 | 0.197 | 671 | 0.31 | 1.26 | - | - |
| 63/24/35-39 | | 12.6 lbs/gal/min | 51.2 | | 92 | 0.182 | 556 | 0.27 | 1.09 | - | - |
| 63/24/45-49 | | 12.2 lbs/gal/min | 51.7 | | 95 | 0.192 | 610 | 0.29 | 1.18 | - | - |
| 63/24/30-34 | | 11.6 lbs/gal/min | 52.3 | | 81 | 0.158 | 446 | 0.22 | 0.85 | - | - |
| 63/26/13-17 | Cowlitz Hat. | 22.9 lbs/gal/min | 52.4 | 03 May 83 | 84 | 0.174 | - | - | - | - | - |
| 63/26/18-22 | | 16.0 lbs/gal/min | 51.1 | | 72 | 0.145 | - | - | - | - | - |
| 63/26/38-42 | | 15.0 lbs/gal/min | 51.5 | | 80 | 0.159 | - | - | - | - | - |
| 63/26/23-27 | | 14.3 lbs/gal/min | 52.1 | | 71 | 0.152 | - | - | - | - | - |
| 63/26/28-32 | | 11.7 lbs/gal/min | 51.7 | | 86 | 0.176 | - | - | - | - | - |
| 63/26/33-37 | | 9.2 lbs/gal/min | 52.1 | | 80 | 0.161 | - | - | - | - | - |
| 05/08/26 | Eagle Cr. Hat. | 0.45 lbs/ft$^3$/in f/ | 127.8 | 22 Apr 81 | 180 | 0.185 | 1702 | 0.14 | 1.33 | - | - |
| 05/08/28 | | 0.30 lbs/ft$^3$/in | 83.7 | | 136 | 0.219 | 1106 | 0.16 | 1.32 | - | - |
| 05/08/27 | | 0.15 lbs/ft$^3$/in | 43.6 | | 62 | 0.186 | 678 | 0.21 | 1.56 | - | - |
| 05/10/39,40 | Eagle Cr. Hat. | 0.45 lbs/ft$^3$/in | 134.9 | 06 May 82 | 229 | 0.179 | 766 | 0.01 | 0.57 | - | - |
| 05/10/37,38 | | 0.30 lbs/ft$^3$/in | 85.0 | | 139 | 0.178 | 509 | 0.02 | 0.60 | - | - |
| 05/10/35,36 | | 0.15 lbs/ft$^3$/in | 39.1 | | 71 | 0.203 | 279 | 0.14 | 0.71 | - | - |
| 05/11/33,34 | Eagle Cr. Hat. | 0.45 lbs/ft$^3$/in | 123.3 | 04 May 83 | 154 | 0.135 | - | - | - | - | - |
| 05/11/35,36 | | 0.30 lbs/ft$^3$/in | 80.2 | | 110 | 0.155 | - | - | - | - | - |
| 05/11/37,38 | | 0.15 lbs/ft$^3$/in | 41.2 | | 68 | 0.187 | - | - | - | - | - |
| 09/06/02,04 | Sandy Hat. | High | 43.5 | 27 Apr 77 | 16 | 0.076 | 888 | 0.08 | 2.04 | - | - |
| 09/05/15,06/03 | | Med | 47.4 | | 14 | 0.057 | 814 | 0.08 | 1.71 | - | - |
| 09/05/14,06/01 | | Low g/ | 50.7 | | 15 | 0.063 | 808 | 0.06 | 1.59 | - | - |
| 63/25/13-17 | Washougal Hat. | 13.6 lbs/gal/min d/ | 50.1 | 25 May 82 | 44 | 0.101 | 183 | 0.01 | 0.35 | - | - |
| 63/25/18-22 | | 12.1 lbs/gal/min | 50.8 | | 34 | 0.084 | 194 | 0.00 | 0.38 | - | - |
| 63/25/23-27 | | 9.8 lbs/gal/min | 50.7 | | 32 | 0.072 | 254 | 0.01 | 0.49 | - | - |
| 63/25/28-32 | | 8.6 lbs/gal/min | 50.3 | | 38 | 0.094 | 268 | 0.01 | 0.52 | - | - |
| 63/25/33-37 | | 6.6 lbs/gal/min | 48.3 | | 40 | 0.094 | 163 | 0.01 | 0.33 | - | - |
| 63/25/38-42 | | 5.4 lbs/gal/min | 40.1 | | 29 | 0.093 | 167 | 0.01 | 0.32 | - | - |
| 63/27/13-17 | Washougal Hat. | 14.3 lbs/gal/min | 52.1 | 27 May 83 | 38 | 0.084 | - | - | - | - | - |
| 63/27/08-12 | | 12.5 lbs/gal/min | 52.0 | | 32 | 0.073 | - | - | - | - | - |
| 63/27/03-07 | | 10.6 lbs/gal/min | 51.3 | | 32 | 0.076 | - | - | - | - | - |
| 63/26/61-63,27/01,02 | | 8.8 lbs/gal/min | 49.4 | | 30 | 0.071 | - | - | - | - | - |
| 63/26/56-60 | | 6.8 lbs/gal/min | 48.5 | | 24 | 0.064 | - | - | - | - | - |
| 63/26/51-55 | | 6.0 lbs/gal/min | 39.8 | | 29 | 0.085 | - | - | - | - | - |
| 05/09/34-37,44,45 | Willard Hat. | 200 gpm/pd | 137.2 | 07 Jun 83 | 111 | 0.103 | - | - | - | - | - |
| 05/09/28-31,42,43 | | 400 gpm/pd h/ | 135.3 | | 112 | 0.099 | - | - | - | - | - |
| 05/09/32,33,38-41 | | 600 gpm/pd | 131.7 | | 123 | 0.089 | - | - | - | - | - |

Table 34.--continued.

a/ More complete information available from Dawley et al. 1985b or releasing agency Table 21. Binary coded wire tags: Ag=Agency, Dl=Data 1 code, and D2=Data 2 code. Color coded wire tags begin with WH and each two digits thereafter represent a color. Brands are represented by the following: Loc=Location on fish, Sym=Brand symbol, and Rot=Rotation of symbol. For abbreviations, symbol, and descriptions see Dawley et al. 1985b.

b/ Actual number captured, beach and purse seine, percent adjusted for effort; replicates combined.

c/ Cumulative percent of total release calculated from observed recovery. No data (-) means either adults have yet to return, were not collected, or were not obtained from fishery agencies prior to analysis. Comparisons between groups released at different times may be erroneous because of differences in ocean distribution, unequal fishing effort, or sampling effort.

d/ Robert Foster, WDF, 115 General Administration Building, Olympia, WA 98504. Production densities about 20 and 14-18 lb/gal/min for Cowlitz and Washougal Hatcheries, respectively.

e/ Ted Bjornn, University of Idaho, Idaho Co-op Fisheries Research, Moscow, ID 83843. Production density about 0.3 $lbs/ft^3/in.$

f/ Jamieson Holway, USFWS, Eagle Creek Hatchery, Route 1, Box 610, Estacada, OR 97203. Production density about 0.45 $lbs/ft^3/in.$

g/ Jean Legasse, ODFW, Sandy Hatchery, 39800 S.E. Fish Hatchery Road, Sandy, OR 97055.

h/ Joe Banks, USFWS, Abernathy SCDC, 1440 Abernathy Road, Longview, WA 98632. Production density about 400 gal/min per pond.

Bonneville Hatchery:

$$Y = 0.2311 + 0.02867X_1 - 0.0.01399X_2$$

$R_a^2 = 0.79$, $F = 24.17$ at 2, 5 df with $P < 0.005$.

Little White Salmon Hatchery:

$$Y = 0.2511 + 0.004045X_1 - 0.002958X_2$$

$R_a^2 = 0.44$, $F = 7.38$ at 2, 6 df with $P < 0.025$.

Priest Rapids Spawning Channel:

$$Y = 0.01163 + 0.01310X_3$$

$R^2 = 0.80$, $t = 5.69$ at 8 df with $P < 0.001$.

For the Priest Rapids Spawning Channel distance of migration and fish size did not contribute significantly to percent catch, although $R_a^2 = 0.77$ for the full model.

Hagerman Hatchery:

$$Y = 0.02554 + (2.36323\text{-}6) \log X_3$$

$R^2 = 0.96$, $t = 10.65$ at 5 df with $P < 0.001$.

The full model with a sample of nine observations did not yield a significant relationship ($R_a^2$ - 0.30, at 2, 6 df with $0.10 < P < 0.25$). A plot of percent catch versus river flow showed two outlying observations, and the above relationship was obtained when these were trimmed from the data set. Although this relationship is highly significant, the data set is too small to serve for anything but a general guide.

We hypothesize that cultural, biological, and environmental variables, independent of those examined, have great effects on estuarine catch percentage, and that sampling efficiencies are different for individual stocks, i.e., from different hatcheries. For that reason, compiled catch data from lower river released fish groups do not provide data which are consistent for representing numbers of individuals in the river. However, assessment of catch data from single stocks, in some instances, provided data consistent enough to develop a baseline of expected percentages in relation to those variables examined. Groups released upriver provided more consistency between stocks for a single variable examined.

## Survival of Subyearling Chinook Salmon to the Estuary

Measurement of survival from release site to the estuary was attemped for fall chinook salmon cultured at the largest hatcheries in the river system to examine variations in relation to river conditions and specifics of culture. Hatcheries more than 150 km from Jones Beach were used to provide a migration distance long enough for survival differences to become apparent. From 1978 to 1983, fish groups were branded at all hatcheries possible and transported by truck to release sites about 40 km upstream from Jones Beach. Catches of the branded fish were compared to those of tagged fish which migrated from the respective hatchery to Jones Beach. The branded group was assumed to have 100% survival due to the short distance of migration, and the difference of catch percentage between the tag and brand groups was assumed to represent survival difference.

Variation of survival estimates was high and seemed unrelated to known variables. Adult recovery data were not correlated with survival estimates and as a result those estimates provide no data which at present appear relevant for analysis.

## Decreased Catches Related to the Eruption of Mount St. Helens

Jones Beach catch data indicated a substantial loss of subyearling chinook salmon during the period immediately following the eruption when the river was highly turbid (34 to 2,800 Jackson Turbidity Units) and an increase in water temperature occurred. In 1980, purse and beach seine catches (145,650 fish) were 51% lower than the average catch for the previous 2 years--284,267 in 1978 and 309,267 in 1979. In both 1978 and 1979, subyearling fall chinook salmon released from Bonneville and Little White Salmon Hatcheries provided substantial peaks at Jones Beach during late May and June; catches were depressed even though 18.6 million fish were released from the two hatcheries (Fig. 40). The recovery rates of marked fish from releases in 1980 (0.083 and 0.072% for Bonneville and Little White Salmon fish, respectively) were less than half of the 1978 and 1979 averages (0.169 and 0.280%, respectively). Adult recovery rates for the marked groups from Bonneville Hatchery were confounded by a mix of fish rearing conditions (Tanner Creek vs well water) which has in the past caused different rates of survival to adulthood. Adult recoveries from groups of Little White Salmon Hatchery were exceptionally low for all years and no difference was detectable for groups which migrated in 1980.

While dead or moribund fish were not seen during sampling, observations indicated that 15 juvenile salmonids captured on 28 May 1980 had irritation of gill filaments, characterized by heavy mucus secretions laden with particulate matter. The particulate matter and mucus observed may have been indicative of mortality in other individuals which would have contributed to decreased catch. Fourteen fish were examined on 2 June and their gill filaments appeared normal. Other researchers performing bioassays found that suspended ash from Mount St. Helens affected salmonid gills and caused mortality (Stober et al. 1980; and Newcomb and Flagg 1983).

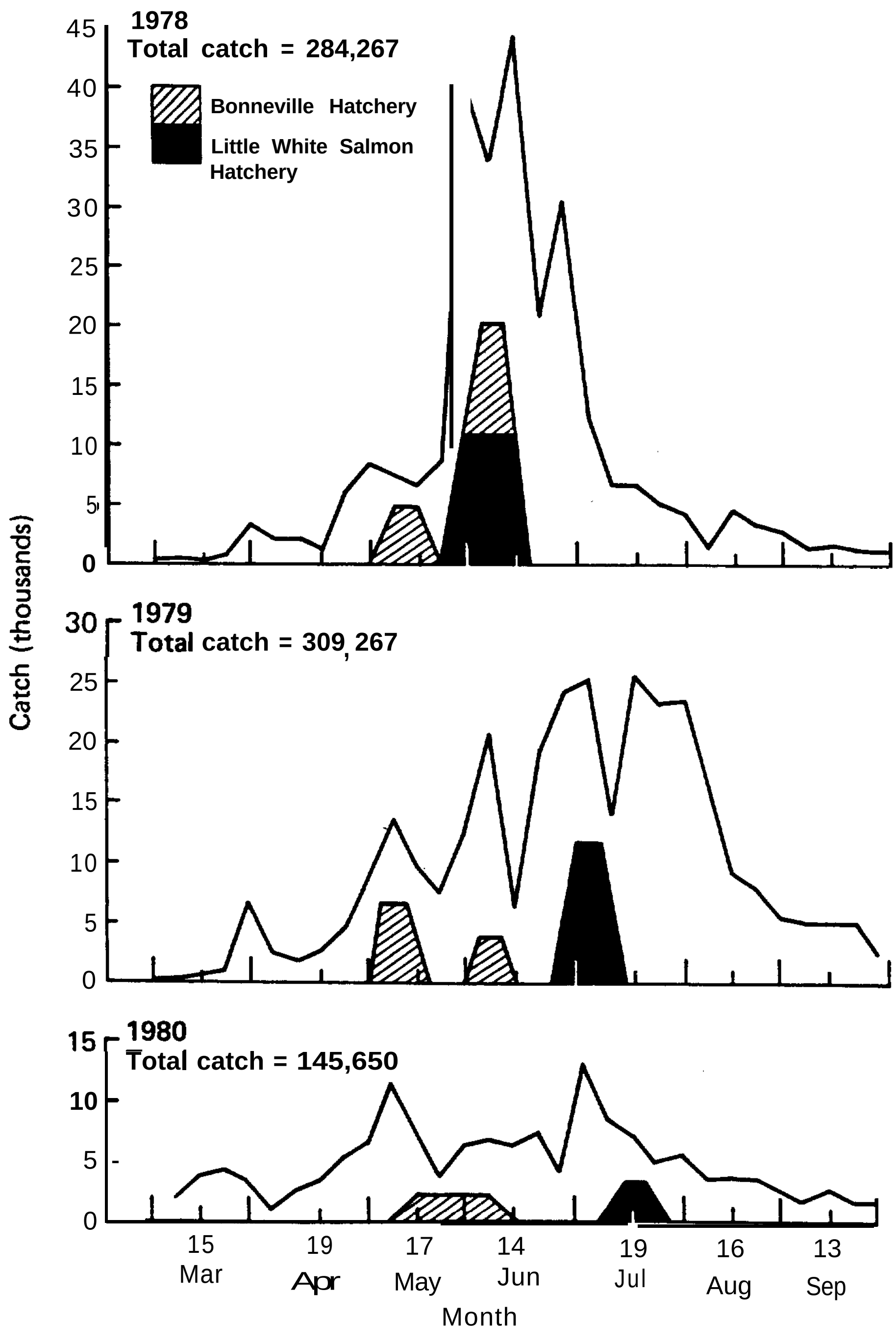


Figure 40.--Weekly beach seine catches of subyearling chinook salmon at Jones Beach, 1978-1980, with shaded area representing fish captured from Bonneville and Little White Salmon Hatcheries.

## Characteristics of Wild Stocks

Detection of the various stocks of wild fish was impossible because they could not be identified unless marked. Some wild fish, however, were tagged as part of various research projects; fish from the Lewis (Norman 1984), Deschutes (Lindsay et al. 1982), Warm Springs (Lindsay et al. 1982), and John Day Rivers (Knox et al. 1984) were seined, marked, and returned to their natal stream for rearing. Recoveries at Jones Beach (Table 35) provided for some assessment of timing, catch rates, and physical condition.

Timing, Size, and Catch Rates.--Migrational timing, size, and catch percentage data for marked wild migrants were comparable to data obtained from hatchery reared fish. Wild yearling migrants (35 total fish) had similar timing to hatchery stocks; March and April for Lewis River fish from the west side of the Cascade Mountains and May and June for John Day, Deschutes, and Warm Spring Rivers on the east side of the Cascades. Mean fork lengths ranged from 117 to 142 mm; catch rate averages for fish from each tributary ranged from 0.014 to 0.119%. Timing of wild subyearlings from the Lewis River (2,209 total fish; date range of median fish recovery = 22 July-23 August) was later than for migrants from the Deschutes River (84 fish; date range of median fish recovery = 1 June-12 July). Overall catch rates (0.069 to 0.353%) and mean fork lengths (91 mm to 106 mm) of wild subyearlings were similar to hatchery fish.

Timing observations of size-graded wild fish from the Lewis River in 1983 indicated that date of passage at Jones Beach was related to individual size. From 6 to 11 June, personnel of WDF seined, graded into two size groups (45-54 mm and > 54 mm), tagged, and returned to the Lewis River 96,444 wild fall chinook salmon (Norman 1984). Average fork lengths of the two mark groups at tagging were 49.3 and 58.4 mm. Recoveries of these fish at Jones Beach indicated a distinct timing difference (Table 36); the dates of median fish recovery were 20 July for the large fish and 9 August for the smaller fish. Mean fork lengths at recovery were nearly identical (84.6 and 84.3 mm, respectively). Reimers and Loeffel (1967) suggested that in the Columbia River tributaries, juvenile salmonids must reach a minimum size before migrating size varying in different streams. Our observation of the Lewis River fish seems consistent with this hypothesis.

Movement Rates.--Movement rates for wild fish were generally not representative of hatchery fish movement rates past Jones Beach because dates' for beginning of migration were unknown; comparisons were not made.

## Conclusions

1. Migration timing of juvenile salmonids entering the estuary was affected by dates of release from hatcheries and other factors which altered movement rates. In some instances, fall-released fish groups overwintered upstream from Jones Beach and migrated in the spring; size of fish and stock differences appear to influence the migration timing.

Table 35.--Summary of catches, migrational timing, and fork lengths of marked wild juvenile chinook salmon populations captured at Jones Beach, 1977-1983.

| River of origin | Age at capture | Marked groups: Total groups marked | Marked groups: Number of groups captured | Marked groups: Total fish marked | Recoveries adjusted a/ (no.) | Recoveries adjusted a/ (%) | Date range of median fish recoveries | Date range from 10% to 90% fish recovery | Mean fork length range by group (mm) | Overall mean fork length (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| John Day | subyearling | - | 0 | - | - | - | - | - | - | - |
| | yearling | 35 b/ | 5 c/ | 90,305 | 13 | 0.0144 | 4 May-17 Jun | 30 Apr-17 Jun | 115-129 | 118 |
| Deschutes | subyearling | 16 | 10 | 121,656 | 84 | 0.0690 | 1 Jun-12 Jul | 1 Jun-17 Aug | 97-115 | 106 |
| | yearling | 10 | 5 | 4,715 | 8 | 0.1186 | 4 May-16 May | 4 May-16 May | 130-150 | 142 |
| N.Fk. Lewis | subyearling | 23 | 23 | 625,803 | 2,209 | 0.3530 | 22 Jul-23 Aug | 25 May-18 Oct | 76-97 | 91 |
| | yearling | - | 4 d/ | - | 10 | - | 17 Mar-25 Apr | 17 Mar-30 May | 110-128 | 117 |
| Warm Springs | subyearling | - | 0 | - | - | - | - | - | - | - |
| | yearling | 12 b/ | 3 | 17,667 b/ | 4 | 0.0226 | 2 May-4 Jun | 2 May-5 Jun | 107-145 | 122 |

a/ Adjusted for standard effort (10 sets beach seine, 5 sets purse seine @ 7 days/week). Number of fish recovered (adjusted for effort) % total number of fish released (including those of groups which were not recovered).
b/ Includes fish groups marked as either yearlings or subyearlings.
c/ Three groups coded-wire tagged as subyearlings were captured as yearlings the following season at Jones Beach.
d/ Fish captured were from groups marked as subyearlings. Most fish from those groups were captured the previous year as subyearling.

Table 36.--Recoveries of wild subyearling chinook salmon at Jones Beach from groups which were seined, size graded, marked, and returned to the Lewis River by Washington Department of Fisheries personnel, 6-11 June 1983.

| Release Information | | | Recovery Information | | | | | |
|---|---|---|---|---|---|---|---|---|
| Size group/ (tag code) | No. (thous) | Mean fork length (mm) | (No.) | Adjusted (%) a/ | Recovery date (10%) | (50%) | (90%) | Mean fork length (mm) |
| ≤ 54mm (63/27/37) | 48.3 | 49.3 | 132 | 0.565 | 15Jul | 9Auq | 30Auq | 84.6 |
| ≥ 54mm (63/27/38) | 48.1 | 58.4 | 113 | 0.362 | 9Jul | 2OJul | 16Aug | 84.3 |

a/ Adjusted for sampling effort,

2. Movement rates of subyearling chinook salmon increase with increases of river flow, fish size, distance of migration, and $Na^{+}$-$K^{+}$ ATPase. Correlation to these variables was high for lower-river stocks, but low for upriver stocks. Increased river flow also increased movement rates of yearling fish, but other variables were not assessed because individual stocks were not consistently marked each year.

3. Cessation of movement in the estuary did not occur; yearling fish showed no slowing of movement during passage through the estuary and into the ocean plume, but subyearling chinook salmon did show a 30% decrease compared to rates from release site to Jones Beach. The Columbia River estuary is not used as a rearing area by subyearling chinook salmon released upstream from Jones Beach.

4. Variability among estuarine catches of replicate marked groups is consistent with normal sampling statistics. Consequently, catch rate differences among replicates were used to evaluate differences between treatment and control groups to provide the greatest statistical precision. Variability of adult recovery data from replicate groups appears higher than expected, which suggests that subtle differences in culture impact adult return rates but are not observable from estuarine catch data.

5. Die1 movement behavior showed a generally consistent pattern for each species, thus comparable percentages of fish passing for the 24-h period were sampled during the 7-h morning period.

6. River flow alters sampling efficiency; catch rates decreased an average of 8.5% per 1,000 $m^3$/second of increased flow.

7. Sampling date, fish size, and distance of migration sometimes affected the distribution of catch between the beach and purse seines; such catch-rate comparisons should only be made between dissimilar groups if the distributions of catch are nearly equivalent.

8. Estuarine sampling showed trends of significantly increased survival for migrants transported past dams, late releases of coho salmon (June and early July), and larger size at release for yearling chinook salmon. Smaller fish from some migrant populations disappeared prior to entering the estuary. Minimum-size thresholds for migration and survival of Columbia River coho salmon and wild fall chinook salmon and Willamette steelhead were supported with Jones Beach sampling data.

9. Particular groups from studies of fish stocks, rearing densities, and diets showed some survival differences, in estuarine catches, but generally differences among groups were not significant. Highly significant differences in adult recoveries observed in studies of density and nutrition were not predictable from juvenile catch data.

10. Catch rate models developed from the catch data for subyearling chinook salmon provided a reasonably good predictor for certain hatcheries, but a general model for lower-river fall chinook salmon was not possible due to differences between hatchery groups. Models were not developed for yearling fish because groups at individual hatcheries were not marked consistently through the years.

11. Survival of subyearling chinook salmon from release site to Jones Beach was evaluated for particular hatchery groups released in 1977-1983, but the precision of estimates was poor in relation to adult recoveries. Apparently, migration behavior of fish transported and then released close to the sampling site (controls) was inconsistent in relation to those that migrated downstream (test), which caused substantial catch-rate differences.

12. Losses of subyearling chinook salmon appeared to be substantial during the date range in 1980 when highly turbid water from Mount St. Helens was passing through the estuary.

13. Wild chinook salmon are diverse in their migration timing, size, and age structure--much the same as hatchery reared fish.

## SECTION IV ANCILLARY STUDIES

### Food Consumption of Juvenile Salmonids Captured at Jones Beach

#### Introduction

Quantity and/or quality of food consumed during the migration of juvenile salmonids is critical to their survival. Snyder (1980) found that inadequate nutrition reduced swimming stamina in juvenile coho salmon which could inhibit their ability to capture prey and avoid predators, thus affecting their survival.

Interspecific interaction between coho salmon and steelhead in small streams has resulted in agonistic behavior, influencing food consumption and growth (Stein et al. 1972); it may also influence stomach fullness values in Columbia River salmon smolts, especially during years with a high degree of migrational overlap of species (Table 37).

Reduced feeding rate may be an indicator of poor health or stress, which decreases survival to adulthood even when food is not limited. Nicholas et al. (1979) speculated that release trauma and unfamiliarity with the estuarine environment in the Siuslaw River (Oregon) resulted in a temporary inability of coho salmon to utilize available food (50-90% empty stomachs).

Reimers (1973) hypothesized that population density was a major cause of reduced growth rate for juvenile chinook salmon during a 3-month period of high population abundance in the Sixes River estuary (Oregon) during 1969. Bottom (1981) theorized a decline in carrying capacity of the Sixes River estuary for young salmon in mid-summer 1980 because of increased foraging pressure when population density was maximum.

To evaluate nutrition, interspecific interaction, and smolt quality, personnel of the the National Marine Fisheries Service examined the feeding habits of juvenile salmonids in the upper freshwater reach of the Columbia River estuary at Jones Beach (RKm 75) from 1979 to 1983.

Specific objectives were as follows: (1) document feeding rates (using stomach fullness as an index) and diet composition for juvenile chinook and coho salmon and steelhead, (2) identify those stocks with a large percentage of non-feeding individuals indicated by low stomach fullness values, (3) examine effects of interspecific interaction on feeding, (4) establish a relationship between visual quantifications of fullness and stomach content weights, and (5) compare stomach content weights for juvenile fish at Jones Beach to those in other locations.

Differences of stomach fullness between fish from various stocks captured at the same time (i.e., fish experiencing similar food availability and digestion rate) are directly related to differences in feeding rate. The amount of food in a fish's stomach at any point in time is related to food consumption and digestion rates (Elliott and Persson 1978; Dill 1983). Digestion rate is controlled primarily by temperature (Elliott 1972) and by the composition of the food organisms (Elliott and Persson 1978).

Table 37.--Dates of migrational peaks for juvenile salmonids at Jones Beach indicating migrational overlap, 1977-1983.

| | Week of peak migration [a] | | | |
|---|---|---|---|---|
| | Chinook salmon | | Coho | Steelhead [c] |
| Year | subyearling [b] | yearling [c] | salmon [c] | |
| 1977 | 21-27 May | -- | -- | -- |
| 1978 | ll-17June | 7-13May | 14-20May | 14-20May |
| 1979 | 2-8 July | 14-20May | 28May-3June | 14-20May |
| 1980 | 11-17June | 7-13May | 14-20May | 7-13May |
| 1981 | 6-10June | 7-13May | 14-20May | 7-13May |
| 1982 | ll-17June | 21-27May | 21-27May | 21-27May |
| 1983 | 4-10June | 14-20May | 21-27May | 21-27May |

a/ From the date of median fish recovery; not adjusted for river flow,

b/ Timing based on beach seine catches.

c/ Timing based on purse seine catches.

Methods

Salmonids sacrificed for CWT identification were used in feeding behavior evaluations. Mark release information was used to separate species and year classes of sampled fish. Subyearling chinook salmon are predominantly fall and summer races, whereas yearling chinook salmon are predominantly a spring race (Van Hyning 1973).

Stomach Fullness.--The subsamples of CWT fish were killed by immersion in a lethal concentration of ethyl p-aminobenzoate. Regurgitation during the killing process was not apparent. Stomachs were excised (esophagus to pyloric caeca) and cleaned of external fat (Appendix Tables B2-5). In 1979, stomach were classified as full, partial, and empty. A fullness value was assigned to represent the proportion of the total stomach length containing food (externally visible). A l-7 scale was used to quantify the fullness observations as described by Terry (1977): 1=empty, 2=trace of food, 3=one quarter full, 4=half full, 5=three quarters full, 6=full, and 7=distended full. Stomachs appearing empty were opened for examination, and the Value 2 assigned when traces of food were observed. For analysis, stomachs judged empty or trace (1 or 2) were termed non-feeding. Observations of stomach fullness were made from 3,500 to 6,000 juveniles annually, and subsamples of stomachs containing food were individually preserved in 10% buffered formaldehyde solution for weight measurements and content analyses (Appendix Table B6).

Records included: recovery date and location, net set time, fish weigh[10/] and fork length (± 0.5mm), fullness value, holding time (duration between capture and fullness observation), and tag identification information (Appendix Table B7). Holding time prior to fullness observation was approximately 90 minutes[11/].

Intraspecific comparisons of the proportions of non-feeding individuals within mark groups were made using the G-statistic--a log likelihood modification of Chi Square (Sokal and Rohlf 1981). Comparisons of stomach fullness means for fish groups with few non-feeding fish were made using analysis of variance. Generally, comparisons were not made for groups with more than 7 days between dates of median fish capture.[12/] Similar or replicate tag groups, showing no significant differences ($P<0.05$) of mean fullness, were combined for comparison to other groups. When significant differences were found among three or more groups, the Student's t-test was used to isolate differences and the significance level of t was adjusted to

10/ Weights of fish were obtained only for individuals collected in 1981, 1982 (± 0.5 g), and 1983 (± 0.005 g).

11/ Holding times were kept as low as possible by selecting only fish that were processed soon after capture. Times were recorded for individuals examined in 1981 (after April), 1982, and 1983.

12/ Median data for stomachs observed may not correspond to the recapture date of the median fish for the entire tag group due to non-representative subsampling required to minimize holding times of the fish selected for stomach observations.

$P \leq 0.05/K$; where K = number of means in the original F-test[13/] (Kleinbaum and Kupper 1978).

Frequency curves of fullness value were developed for all discrete marks with seven or more recoveries. Ninety-five percent confidence intervals of mean stomach fullness values were plotted for each species by 3-day intervals (all tag groups combined); however, the data are not necessarily representative of the total migrant population during the time period depicted.

Diet Composition and Overlap.--Organisms were identified to the lowest practical taxon; insects were further separated by metamorphic stage. When dismembered prey were present, parts were weighed together, and counts were based upon the number of head capsules present. Weight of unidentifiable material was not included in the total weight used for ranking relative importance in the diet. Frequencies of occurrence (FO), numbers, and weights were recorded for each prey taxon (Appendix Table B8). Non-feeding fish were omitted from analysis. The index of relative importance, IRI (Pinkas et al. 1971) was modified to rank each taxon (IRI'):

$$IRI' = \%W \times \%FO$$

where %W = percent of the total content weight from all stomachs

%FO = percent frequency of occurrence of all salmonids which contain the designated taxon.

The modified IRI' was used to decrease bias resulting from large numbers of small food items (MacDonald and Green 1983). Percent IRI' from the total IRI' is presented.

The degree of interspecific dietary overlap was assessed using biomass of food categories consumed using the formula developed by Morisita (1959) and modified by Horn (1966):

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13/ The adjustment of the significance level is required to stabilize the standard error without increasing the probability of a Type I error for aposteriori comparisons among individual means.

$$C\lambda = \frac{2 \sum_{i=1}^{s} X_i \cdot Y_i}{\sum_{i=1}^{s} X_i^2 + \sum_{i=1}^{s} Y_i^2}$$

Where: $C\lambda$ = overlap coefficient

i = individual food category

s = total number of food category

X and Y = proportion of the total diet, for fish species X or Y, contributed by food category i.

Only food categories making up more than 1% of the total weight consummed were used for overlap calculations (Myers 1979). Values of $C$ range from 0 to 1, with 0 indicating no overlap and 1 indicating complete diet overlap.

Proximate Analysis.--For each fish species, proximate analyses of stomach contents (percentage of protein, ash, and fat) were obtained from pooled subsamples collected in May and June 1982. Analyses were contracted to a private laboratory.

Stomach Content Weight.--In 1982, stomach contents from about half of all marked fish were removed, blotted dry, and weighed to the nearest 50 micrograms; 2,480 total. All weights were obtained within 4 months of capture.

Non-Feeding Juveniles 1979-1981 and Some Effects from the Eruption of Mount St. Helens

This portion of the report focuses on the definition of the range of stomach fullness in samples taken throughout the spring migration and identification of biological and environmental factors which appear related to high incidences of non-feeding. Fish groups used in the analysis were released in diverse areas of the Columbia River basin (Fig. 41).

In March-June 1979, 1980, and 1981, water temperatures at Jones Beach ranged from 8° to 16°C, and later in the summer increased to 21°C. In July-September, high water temperatures and long holding times possibly compromised the validity of stomach fullness observations (Elliott 1972). Presentation of fullness observations for groups captured after June of each year is limited to coho salmon captured in early July, which were processed more rapidly (about 60 minutes).

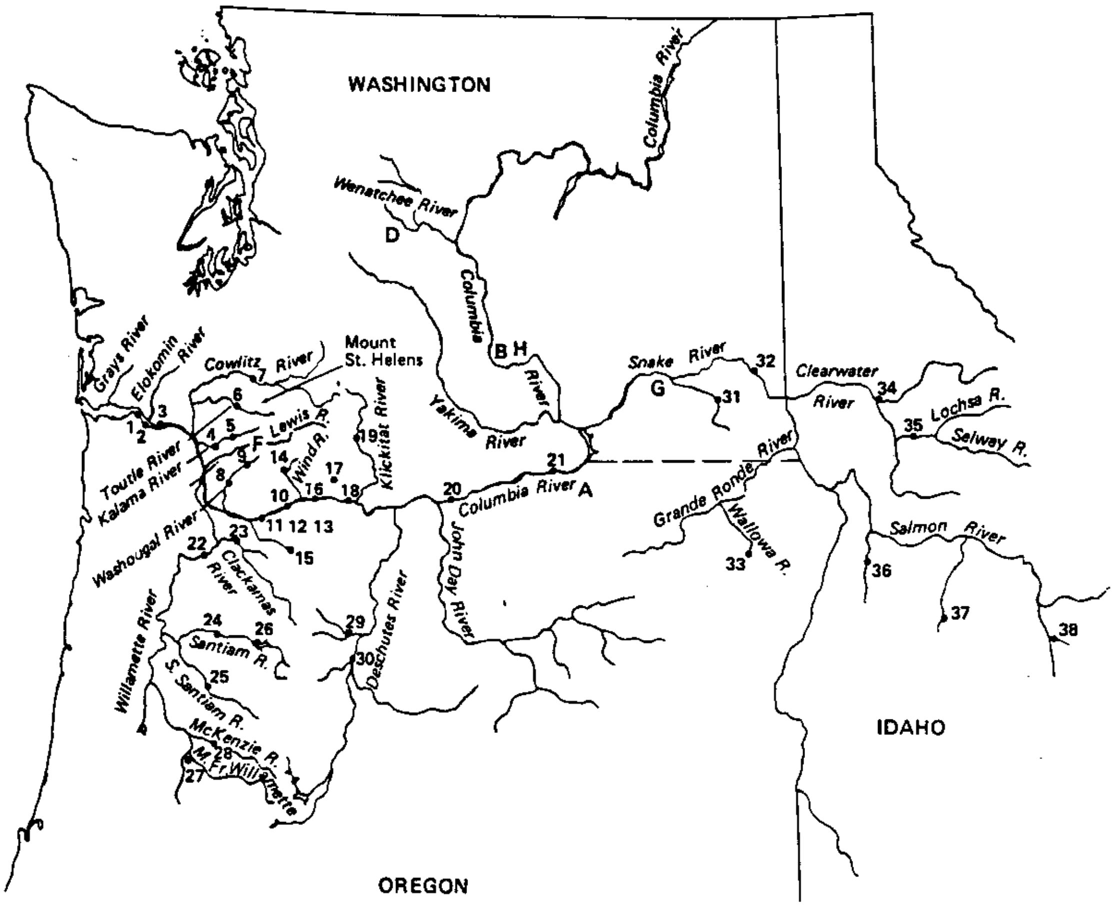
The majority of juvenile salmonids were feeding when they entered the estuary (Fig. 42). In both 1980 and 1981, steelhead had the lowest average fullness values (2.8 and 3.1) and coho salmon the highest (4.1 and 3.9).

The eruption of Mount St. Helens produced a deluge of debris that arrived in the river at Jones Beach after daily sampling was complete on 19 May 1980. Turbidity in the river rose to 3,000 Jackson Turbidity Units (JTU) which was 500 times normal turbidity.[14/] In attempting to determine the effect of this severe turbidity on feeding behavior of salmonids entering the estuary, species, stock, release location, and timing of releases had to be carefully considered because data from various release groups indicated all of these factors could have a bearing on indices of stomach fullness.

Subyearling Chinook Salmon.--Trends of changing stomach fullness during the migrations were not observed, however, the percentage of empty stomachs in subyearling salmon during late May and into June 1980 increased with the onset of the turbid water. A sudden increase in percentage of non-feeding fish was not observed in late May 1979 or 1981 (Fig. 43).

Observations from subyearling chinook salmon released at Abernathy Salmon Culture Development Center (SCDC) were omitted from computations of non-feeding fish shown in Figure 43 because Abernathy fish showed a non-feeding characteristic, unrelated to the eruption. In 1980 and 1981, Abernathy fish had significantly higher proportions of non-feeding individuals (51 and 44%) than other fish groups captured during similar periods--O and 9%, respectively, for Spring Creek Hatchery and Stayton Pond fish in 1980 and 10 and 5%, respectively, for Spring Creek and Bonneville Hatchery fish in 1981 (Figs. 44 and 45). We believe the high percentage of non-feeding individuals among fish from Abernathy SCDC was associated with

14/ Measurements adjacent to or 3 km downstream from the mouth of the Cowlitz River (RKm 106); collected by Robert McConnell, NMFS, P.O. Box 155, Hammond, OR 97121.




LEGEND

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a/ United States Fish and Wildlife Service.
b/ Washington Department of Fisheries.
c/ Washington Department of Game.
d/ Oregon Department of Fish and Wildlife.
e/ Idaho Department of Fish and Game.

Figure 41.--Columbia River basin showing the major tributaries, fish release sites, hatcheries, Jones Beach sampling site, and Mount St. Helens.

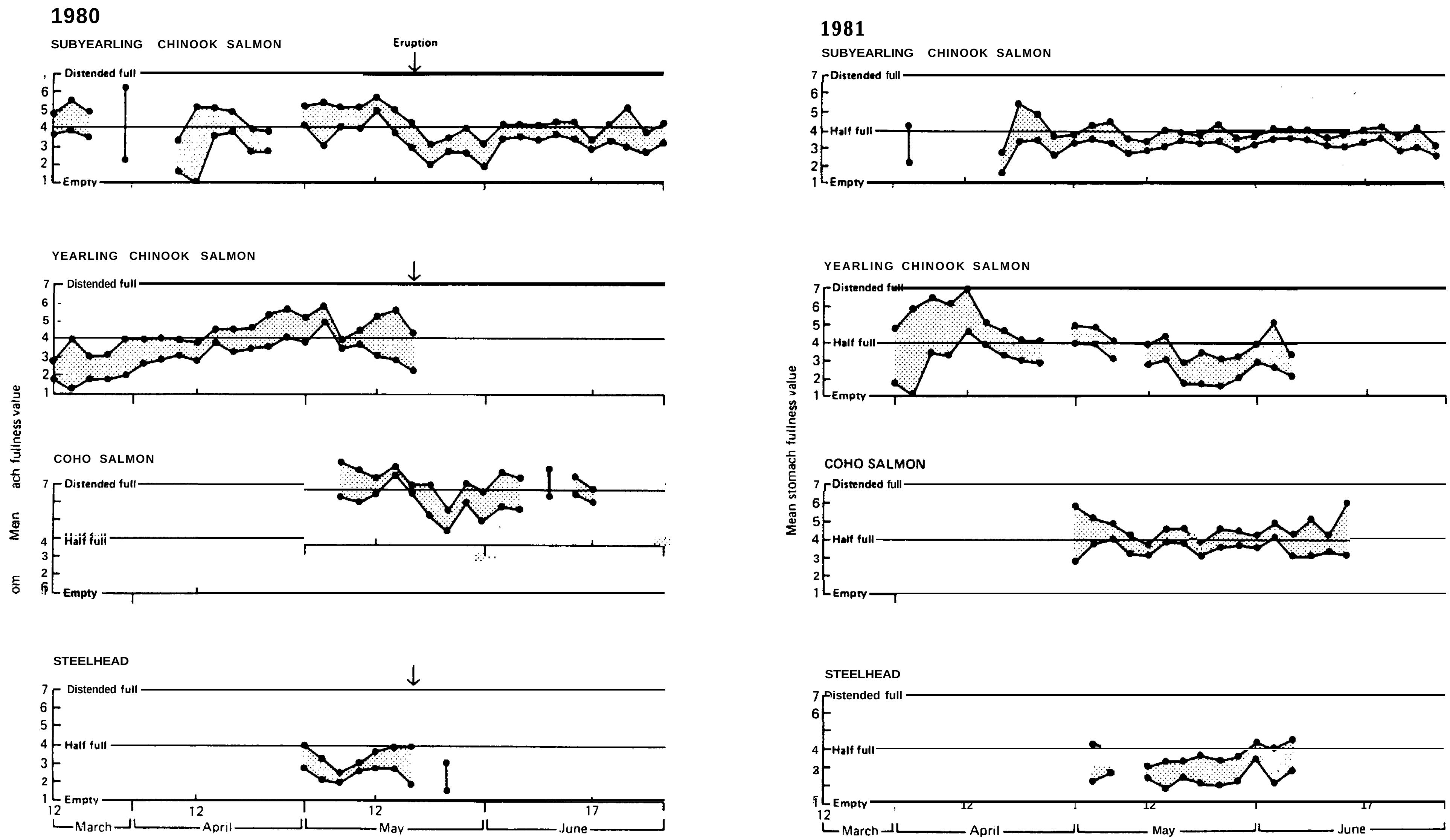


Figure 42.--Ninety-five percent confidence intervals of mean stomach fullness for salmonids captured at Jones Beach, plotted by 3-day intervals, March-June 1980 and 1981.

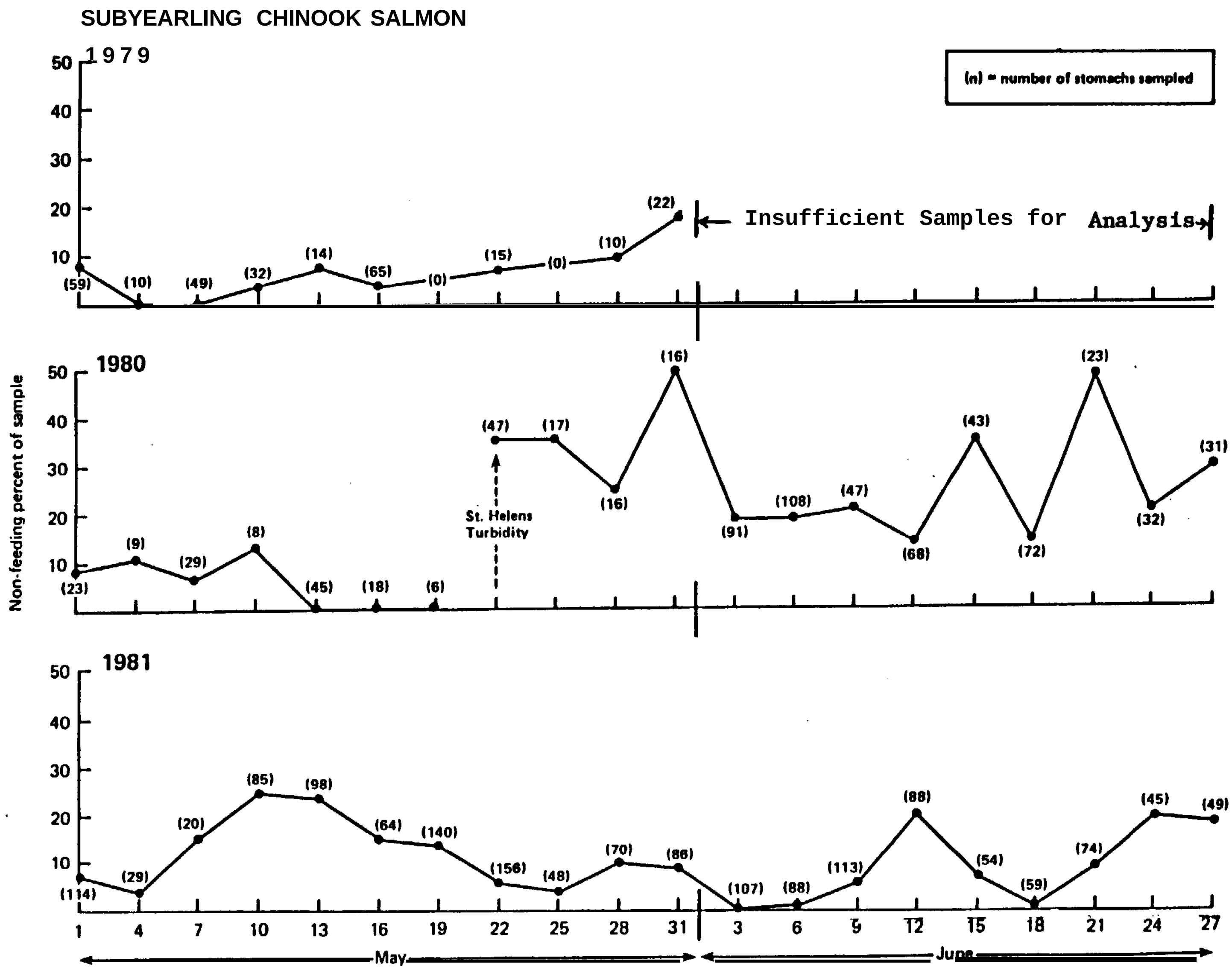


Figure 43.--Percentage of non-feeding subyearling chinook salmon captured at Jones Beach during May and June 1979, 1980, and 1981. Abernathy SCDC fish omitted.

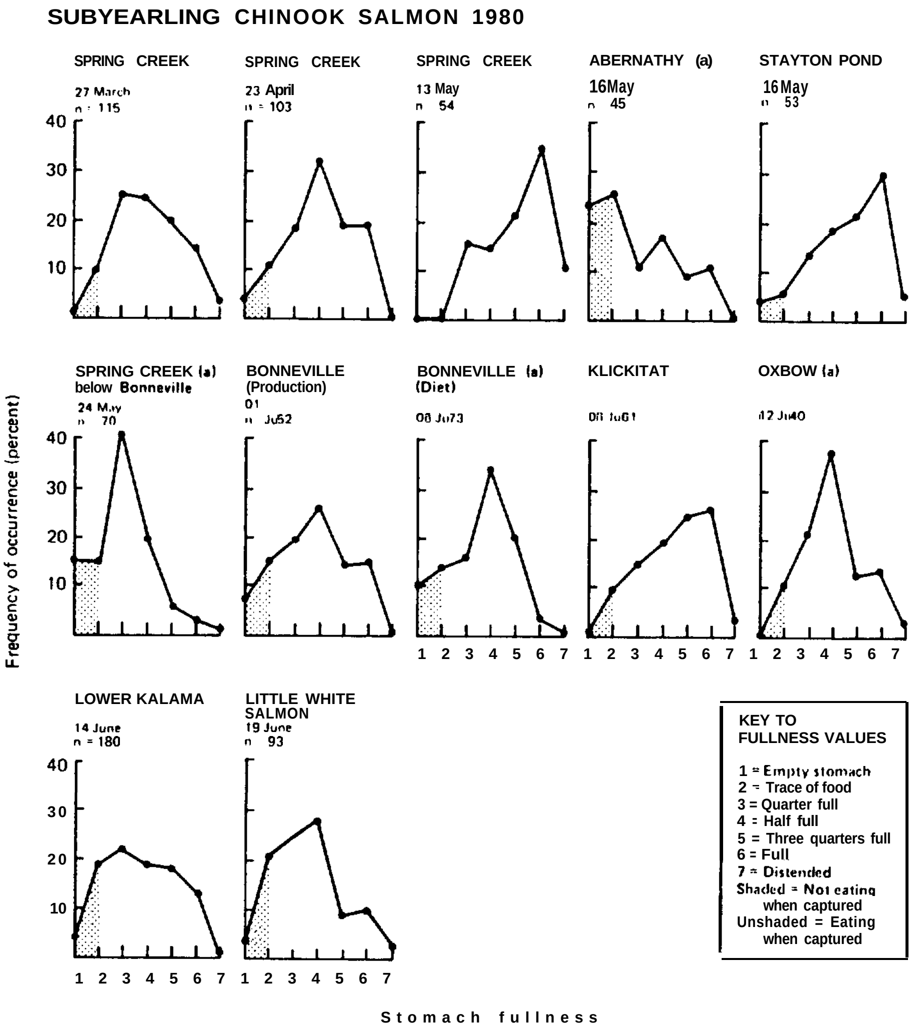


Figure 44.--Stomach fullness frequency curves for tag groups of subyearling chinook salmon captured at Jones Beach, March-June 1980. Source and release site, date of median fish recovery, and number observed are included.

the close proximity of the release site (RKm 91) to the recovery site (RKm 75).

Individual stocks of subyearling chinook salmon had high percentages of non-feeding individuals following the eruption. Prior to the increase in turbidity from the eruption, 3% of the Stayton Pond fish captured were not feeding (n = 34), compared to 21% after the eruption (n = 19)--median recovery date at Jones Beach was 19 May, 11% non-feeding (n = 54) (Fig. 44). No other group allowed direct before and after comparisons, but some groups passing Jones Beach following the eruption showed high proportions of non-feeding individuals. Spring Creek Hatchery fish released downstream from Bonneville Dam had 30% non-feeding individuals and Bonneville Hatchery fish (production and diet study) had 21 and 24% non-feeding individuals, respectively; similar groups in 1981 had 10% non-feeding individuals (Figs. 44 and 45).

By early June 1980, food consumption by subyearling chinook salmon increased toward average fullness levels observed in the pre-eruption period and in the following year (Fig. 42), even though water turbidity during June and July (35 to 130 JTU) remained substantially higher than normal. Fish captured during June and early July 1980 were primarily fish from Klickitat, Oxbow, Lower Kalama, and Little White Salmon Hatcheries. The non-feeding percentages for these groups were: 10, 11, 23, and 26%, respectively, compared to 9%, no marked group to compare, 24, and 8%, respectively, in 1981 (Figs. 44 and 45). Only fish from Little White Salmon Hatchery had significantly more non-feeding individuals in 1980 than in 1981.

The high percentage of empty stomachs in early May 1981 (Fig. 43) primarily resulted from an unexplained high percentage of non-feeding fish (27%) from Spring Creek Hatchery (0% for a similar release group observed in 1980).

Yearling Chinook Salmon.--Percentages of non-feeding individuals in marked groups of yearling chinook salmon varied between years, unrelated to proximity of the release site or effects from the eruption. In 1980, migrants which passed Jones Beach from March through mid-April had lower stomach fullness values than later migrants.

From mid-March to mid-April 1980, tagged yearling chinook salmon had significantly higher numbers of non-feeding fish than in 1981 (Fig. 42). In 1980, these fish originated from South Santiam (two groups), Bonneville, Oakridge, and McKenzie Hatcheries. The percentages of non-feeding fish in each group were 45, 33, 37, 24, and 40%, respectively. In 1981, although sample numbers were less, only the Cowlitz Hatchery group had comparable numbers of non-feeding fish (31%); McKenzie and Oakridge Hatchery groups had only 6 and 14% non-feeding fish, respectively (Fig. 46).

From late April to early May 1980, the aggregate fullness values of yearling chinook salmon increased (Fig. 42) and percentages of non-feeding fish for most groups decreased (Fig. 46). Yearling chinook salmon from Round Butte, Carson, and Warm Springs Hatcheries had 12, 11, and 18%

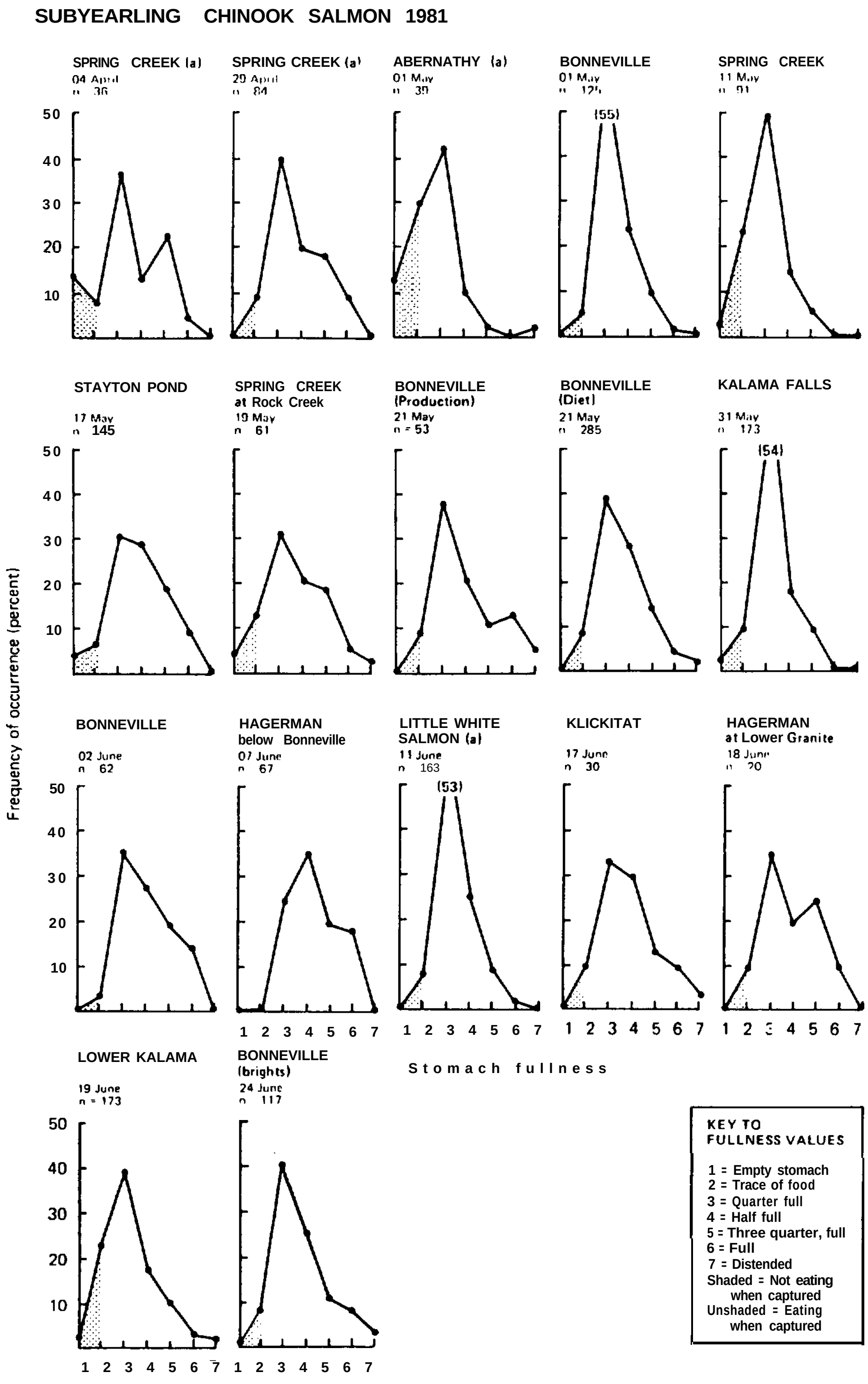


Figure 45.--Stomach fullness frequency curves for tag groups of subyearling chinook salmon captured at Jones Beach, March-June 1981. Source and release site, date of median fish recovery, and number observed are included.

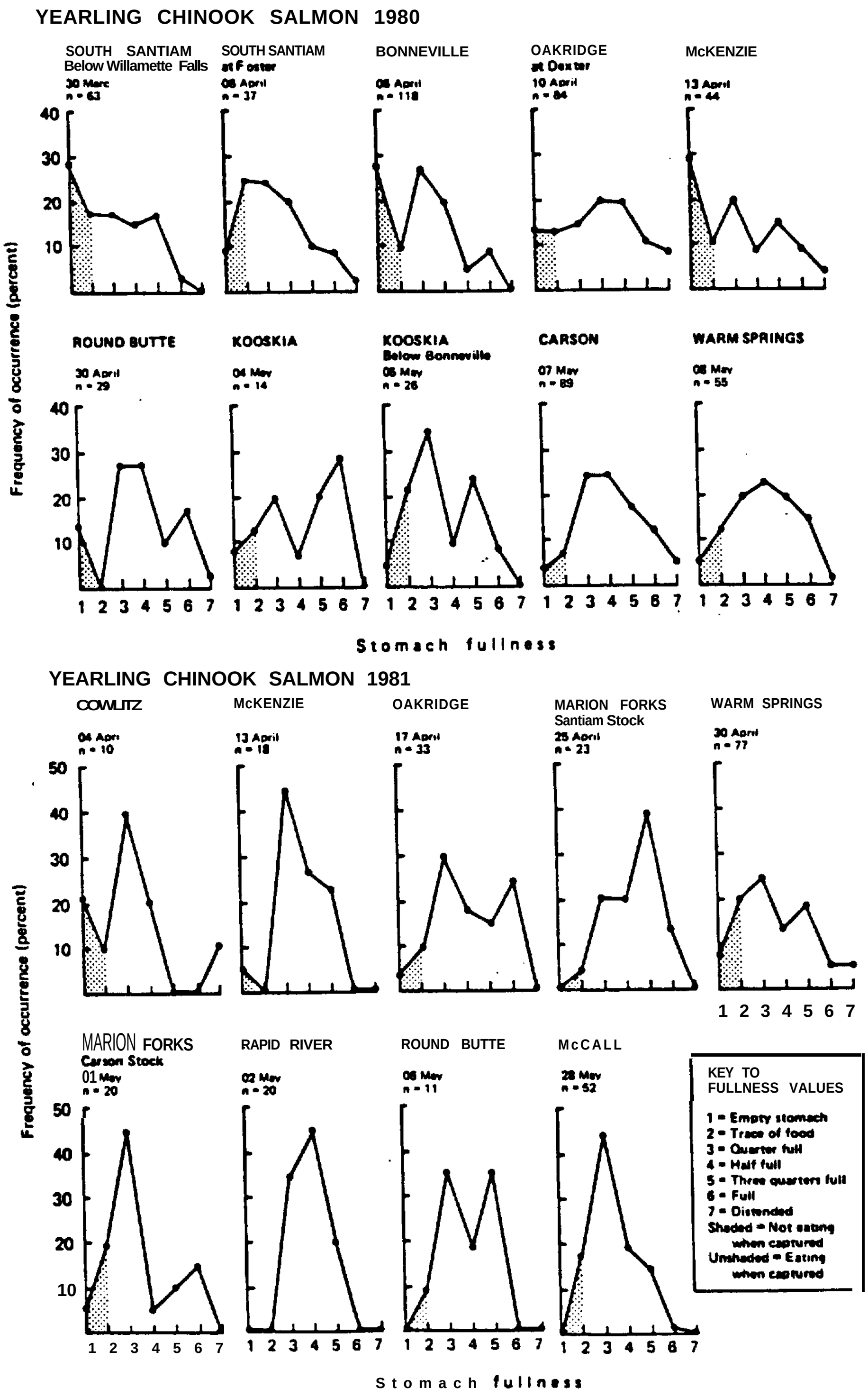


Figure 46.--Stomach fullness frequency curves for tag groups of yearling chinook salmon captured at Jones Beach, March-June 1980 and 1981. Source and release site, date of median fish recovery, and number observed are included.

non-feeding individuals, respectively. One exception was Kooskia Hatchery fish released below Bonneville Dam which had 27% non-feeding fish. During the same period in 1981, fish from Marion Forks (South Santiam stock), Rapid River, and Round Butte Hatcheries had 3, 0, and 10% non-feeding individuals, respectively. In 1981, two groups had a high percentage of non-feeding individuals: Marion Forks (Carson stock) and Warm Springs Hatcheries-- 26 and 28% non-feeding, respectively. During this period in both years, the high non-feeding rates could not be linked with environmental conditions (turbidity, water temperature, and water flow), biological, or migrational characteristics (fish health, stock differences, distance of migration, and release site).

From late May through June 1980, after the eruption of Mount St. Helens, too few tagged yearling chinook salmon(12) were captured to evaluate differences in food consumption [the migratory population normally decreases during that period (Dawley et al. 1982)]. In 1981, one group from McCall Hatchery was captured during late May/early June, and it had 18% non-feeding individuals (Fig. 46).

Coho Salmon.--Coho salmon generally had the fullest stomachs of the three salmonid species. It was unusual to observe greater than 10% non-feeding coho salmon within any population in 1980 or 1981 (Fig. 47). There were no significant differences in the percentages of non-feeding fish among groups recovered in mid-May 1980 or 1981.

Shortly after the eruption, three groups of coho salmon from Willard Hatchery showed significantly greater percentages of non-feeding fish than earlier migrants. Percentages of non-feeding fish were 95, 21, and 17%, respectively, for releases made at Beaver Terminal (RKm 84), downstream from Bonneville Dam (RKm 230), and at the hatchery (RKm 268). The close proximity of Beaver Terminal to Jones Beach undoubtedly allowed insufficient time for the fish to begin feeding prior to capture (all captured within 2 days). Excluding Beaver Terminal fish, the non-feeding percentages for these groups in 1980 were about double that of any other group in 1980 or 1981, which suggested that food consumption by these coho salmon was adversely affected by the eruption.

By mid-June 1980, food consumption by coho salmon returned to pre-eruption levels (Fig. 42).

Steelhead.--Steelhead had the lowest average fullness values of the juvenile salmonids (Fig. 42). Percentages of non-feeding fish within marked steelhead groups was almost always greater than 25% in 1980 and 1981 (Fig. 48). Dworshak Hatchery fish that were barged to a release site downstream from Bonneville Dam in 1980 had significantly higher numbers of non-feeding fish (73%) than controls which migrated from Dworshak Hatchery (34%). We suspect that the short time between release at Bonneville Dam and recovery at Jones Beach (88% captured within 3 days) was insufficient for fish to develop aggressive feeding behavior in the river environment.

No single group of steelhead was captured in large numbers following the eruption in 1980, but 59% of the 34 tagged fish observed were not feeding.

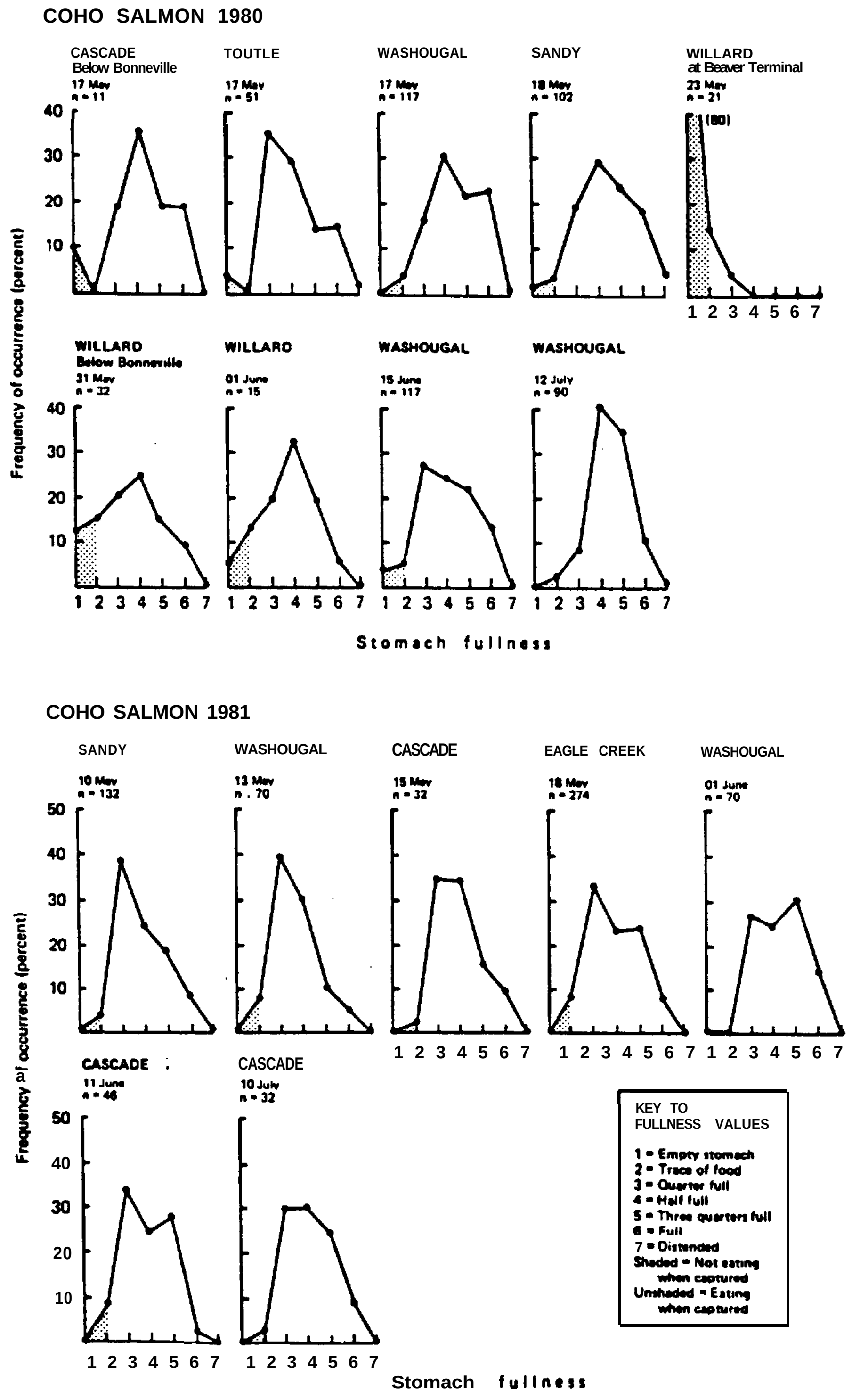


Figure 47.--Stomach fullness frequency curves for tag groups of coho salmon captured at Jones Beach, March-June 1980 and 1981. Source and release site, date of median fish recovery, and number observed are included.

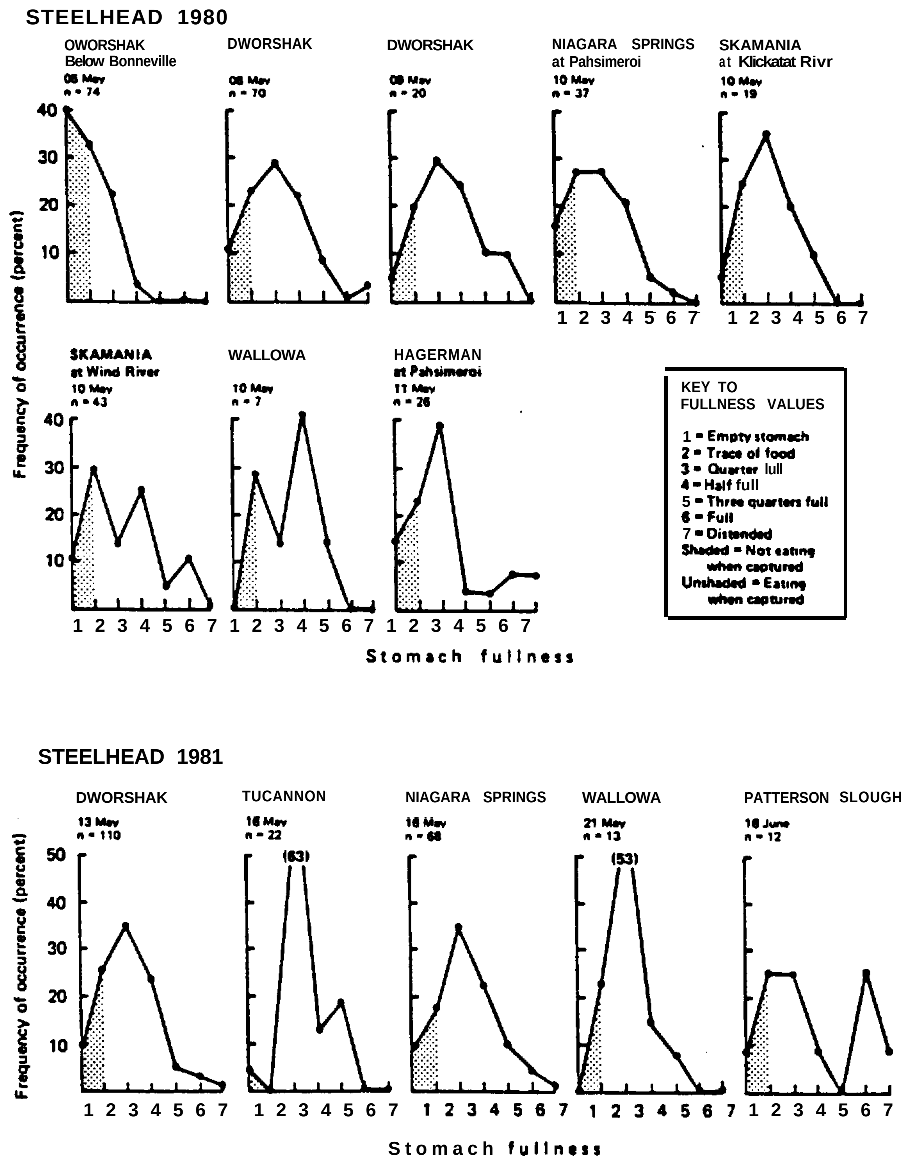


Figure 48.--Stomach fullness frequency curves for tag groups of steelhead captured at Jones Beach, March-June 1980 and 1981. Source and release site, date of median fish recovery, and number observed are included.

## Diet of Subyearling Chinook Salmon and Effects of the Eruption of Mount St. Helens

This portion of the report documents the diet of subyearling chinook salmon at the upstream extremity of the estuary (RKm 75) from 1979 through 1982 and discusses the impact of the eruption of Mount St. Helens on that diet.

The stomach contents from 492 subyearling chinook salmon collected from March through June of 1979-1982 and 74 collected from July through September 1980 were examined. Data from each year were grouped into 14-day intervals. The l4-day intervals were selected to separate pre-eruption from post-eruption (excessive turbidity) sampling periods at Jones Beach. Comparisons between years were limited to the March-June period.

During March-June, 1979-1982, Insecta and Crustacea comprised the major food items found in subyearling chinook salmon--54 and 41% IRI', respectively (Table 38). The most important order of insects was Diptera, 16% IRI'; however, unidentifiable Insecta represented 35% IRI'. The most important crustaceans were Amphipoda and Cladocera, which represented 19 and 13% IRI', respectively. Mysidacea were important only in 1982 (32% IRI'). In July 1980, insects were the most important source of food (62% IRI'), but during August and September of that year, Cladocera became the most important constituent of the diet, about 94% IRI' (Table 39).

Insecta.--Insecta were of major importance in the diet March-June in all years, particularly in 1981 (85% IRI'; Table 38) when the availability of amphipods appeared to be limited.

The types of insects found in the stomachs showed no apparent differences between years, consequently the data for all years were combined by 14-day periods (Table 40). Diptera were the most numerous insects identifiable to order--80.8%. There was no seasonal pattern of Diptera consumption for the various metamorphic stages; frequencies of larvae, pupae, and adults were similar. Homoptera and Hymenoptera (mostly adults) were the next most numerous insects--4.7 and 3.7% of the total insects, respectively. Insects representing 10 additional orders were identified; however, each represented less than 3% of the total insect count.

Crustacea --The consumption of amphipods varied from year to year. In 1979, peak consumption of amphipods occurred in late March-early April (71% IRI') and in June (85% IRI') (Fig. 49). In 1980, an early April peak at 39% IRI' was apparent; however, the June peak observed in 1979 was not repeated in 1980 after the eruption when the IRI' was only 6%. In 1981, minimal amphipod consumption was observed, averaging 3% IRI' March-June. In 1982, amphipods again increased in importance with peaks in early April (33% IRI') and in June (20% IRI'). Meyer et al. (1981) observed a similar bimodal peak of amphipod consumption by juvenile chinook salmon in the lower Duwamish River, Washington.

Table 38.--Percent modified index of relative importance (IRI')[a] of diet items identified in stomach contents from subyearling chinook salmon captured at Jones Beach, Oregon (RKm 75); March-June, 1979-1982.

| Diet item | 1979 | 1980 | 1981 | 1982 | Average |
|---|---|---|---|---|---|
| Insecta | | | | | |
| Unidentifiable | 38 | 33 | 54 | 14 | 35 |
| Diptera | 6 | 12 | 27 | 18 | 16 |
| Misc. Insecta | 2 | 3 | 4 | 5 | 3 |
| Total | 46 | 48 | 85 | 37 | 54 |
| Crustacea | | | | | |
| Amphipoda | 40 | 16 | 2 | 17 | 19 |
| Cladocera | 8 | 25 | 8 | 9 | 12 |
| Mysidacea | 2 | 1 | 1 | 32 | 9 |
| Misc. Crustacea | 0 | 2 | 1 | 0 | 1 |
| Total | 50 | 44 | 12 | 58 | 41 |
| Miscellaneous total | 4 | 8 | 3 | 5 | 5 |

[a] IRI' = weight x % frequency of occurrence.

Table 39.--Percent modified index of relative importance (IRI')[a/] of food items identified in stomach contents from subyearling chinook salmon captured at Jones Beach (RKm 75); 1 July to 8 September 1980.

| Diet | 1 Jul to 14 Jul | 15 Jul to 28 Jul | 29 Jul to 11 Aug | 12 Aug to 25 Aug | 25 Aug to 8 Sep |
|---|---|---|---|---|---|
| Total Insecta | 57 | 68 | 9 | 2 | 0 |
| Diptera | 24 | 24 | 5 | 0.8 | 0 |
| Total Crustacea | 41 | 32 | 91 | 98 | 100 |
| Cladocera | 35 | 18 | 87 | 96 | 99 |
| Miscellaneous prey | 2 | 0 | 0 | 0 | 0 |

a/ IRI' = % weight x % frequency of occurrence.

ble 40.--Insect orders and percent of total insects observed in stomach contents from subyearling chinook salmon during 14-day intervals, 25 March to 30 June 1979-1982.

| sect order | 25 Mar to 7 Apr | 8 Apr to 21 Apr | 22 Apr to 5 May | 6 May to 19 May | 20 May to 2 Jun | 3 Jun to 16 Jun | 17 Jun to 30 Jun | Average of intervals |
|---|---|---|---|---|---|---|---|---|
| | Percent[a] | | | | | | | |
| llembola | 4.1 | 4.8 | 1.5 | 0.3 | 1.2 | 0.9 | 1.1 | 2.0 |
| hemeroptera | 7.8 | 2.6 | 4.8 | 2.3 | 1.0 | 1.3 | 0.0 | 2.8 |
| onata | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| ecoptera | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.9 | 0.0 | 0.2 |
| ocoptera | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 3.6 | 8.1 | 1.7 |
| sanoptera | 0.0 | 0.0 | 0.1 | 0.0 | 0.2 | 0.0 | 0.1 | 0.1 |
| diptera | 3.8 | 1.1 | 0.3 | 0.0 | 0.1 | 0.0 | 0.1 | 0.8 |
| noptera | 0.0 | 0.6 | 15.4 | 2.3 | 4.1 | 7.0 | 3.2 | 4.7 |
| eoptera | 4.0 | 2.2 | 3.2 | 2.4 | 3.2 | 3.4 | 0.5 | 2.7 |
| choptera | 1.4 | 0.5 | 0.5 | 0.4 | 0.0 | 0.0 | 0.2 | 0.4 |
| idoptera | 1.3 | 0.0 | 0.2 | 0.2 | 0.0 | 0.4 | 0.2 | 0.3 |
| tera | 75.4 | 83.5 | 69.8 | 91.3 | 81.7 | 79.0 | 84.8 | 80.8 |
| enoptera | 2.6 | 4.2 | 3.2 | 1.3 | 8.1 | 3.9 | 2.3 | 3.7 |
| Total no. insects | 77 | 180 | 589 | 604 | 836 | 240 | 918 | 3,444 |
| Total no. stomachs | 44 | 58 | 102 | 78 | 71 | 65 | 74 | 492 |

Percent of total number of insects identified.

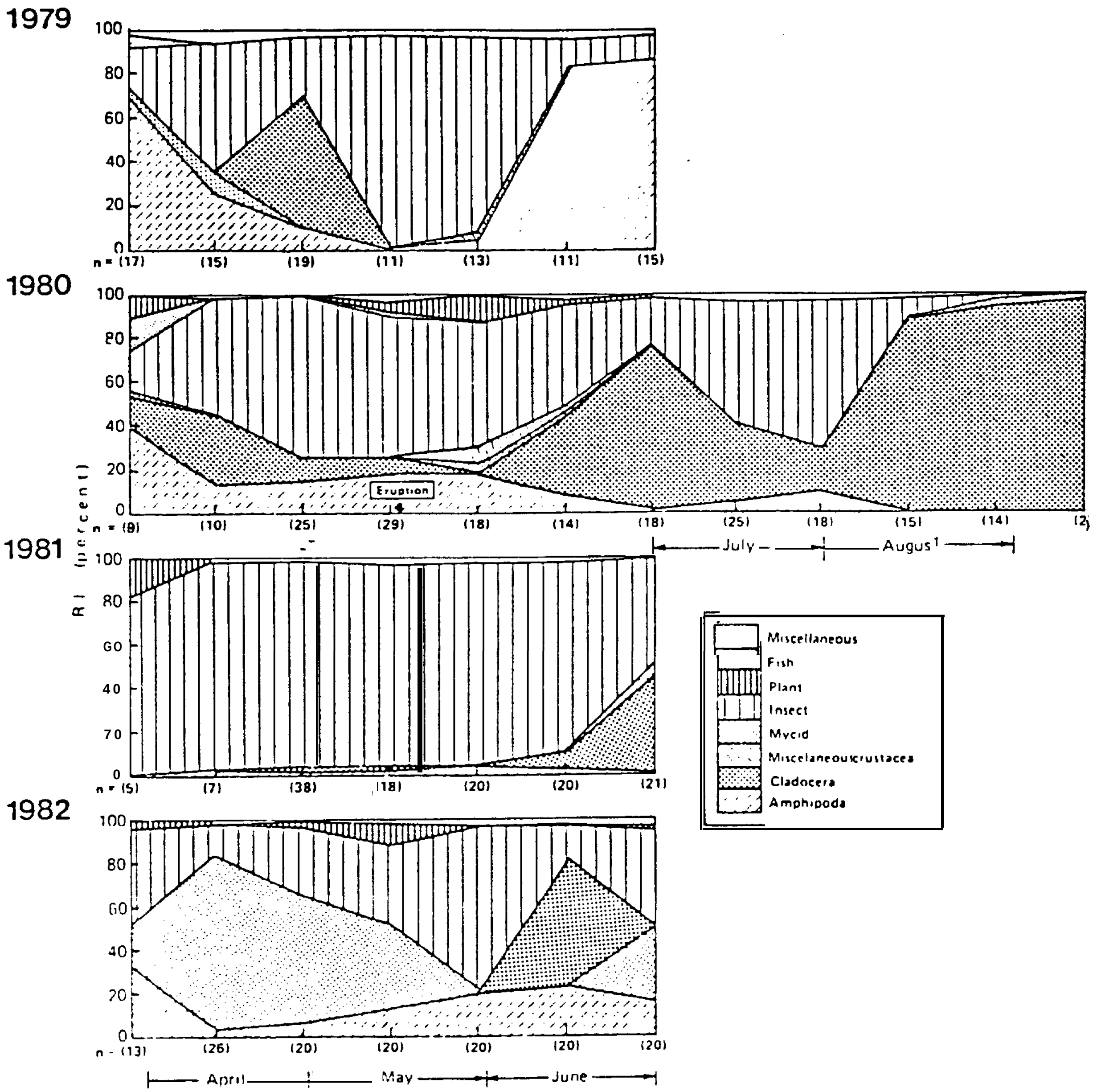


Figure 49.--Modified index of relative importance (IRI') for food items consumed by subyearling chinook salmon collected at Jones Beach, Oregon, 1979-1982.

Three species of Amphipoda were found in the stomachs: Corophium salmonis, C. spinicorne, and Eogammarus confervicolus. Diet composition after the eruption (Table 41) indicated that the population of C. salmonis was more severely reduced than that of the other two species. Before the eruption, C. salmonis comprised 74% of all amphipods identifiable to species, compared to 38% after the eruption. A substantial reduction of C. salmonis in the diet of juvenile salmonids following the eruption was also-observed in the lower Columbia River estuary by McCabe et al. (1981) and Emmett (1982). The greater reduction of C. salmonis could be a function of different substrate requirements (Hazel and Kelley 1966; Chang and Levings 1976; Brzezinski and Holton 1981; Turk et al. 1980; Turk and Risk 1981; Meyer et al. 1981; Albright 1982; Wilson 1983). Brzezinski and Holton (1981) found that amphipod abundance (primarily C. salmonis) was decreased after the eruption in areas of the estuary that had a benthic layer of ash.

In the Columbia River estuary, C. salmonis exhibit a bivoltine life cycle (Davis 1978; Wilson 1983). The previous fall generation produces a spring brood in May which matures throughout the summer and subsequently produces a fall brood. It appears that the 1980 spring brood, upstream from Jones Beach, was disrupted by the heavy deposition of sediment from the eruption. Substrate characteristics created upstream from Jones Beach appear to have inhibited the recovery of the amphipod population in 1981 as well, as indicated by their low percent IRI' in the diet of subyearling chinook salmon.

In March-June, Cladocera were of major importance in the diet only during 1980, averaging 25% IRI' (Table 38). Coincident with the decrease of amphipods (Fig. 49), the consumption of cladocerans increased sharply following the eruption. In other years, consumption of cladocerans in March-June was greater than 10% IRI' during only one 14-day interval each year: 56%, 22 April-5 May 1979; 51%, 17-30 June 1981; and 58% 3-16 June 1982. In August and September 1980, cladocerans were the major item in the diet (Table 38). Craddock et al. (1976) observed that cladocerans were an important portion of the diet for chinook salmon captured during August-October in the Columbia River at RKm 118.

Mysids (Neomysis mercedis) were rare except in 1982 when they were the dominant food from mid-April to mid-May.

Fluctuations in the abundance of cladocerans and mysids in the diet was apparently unrelated to effects from the eruption (Fig. 49). Cladoceran populations are known to exhibit extreme variability in their seasonal and annual abundance (Ward and Whipple 1918; Pennak 1978). N. mercedis abundance and distribution has been associated with a number of environmental factors including salinity, temperature, dissolved oxygen, light, and river flow (Hopkins 1958; Heubach 1969; Orsi and Knutson 1979; Siegfried et al. 1979, 1980). However, extreme variations in population abundance from one year to the next,unrelated to environmental changes, have been reported (Hopkins 1958; Turner and Heubach 1966; Heubach 1969). It is possible that increased mysid availability in 1982 masked the true extent of amphipod recovery.

Table 41.--Amphipod species and percent of total amphipods observed in stomach contents from subyearling chinook salmon before and after the eruption of Mount St. Helens--March-June, 1979-1982.

| Species | Before eruption[a/] (%) | After eruption[b/] (%) |
|---|---|---|
| *Corophium salmonis* | 74 | 38 |
| *Corophium spinicorne* | 22 | 45 |
| *Eogammarus confervicolus* | 4 | 17 |

a/ 25 March 1979 to 19 May 1980.

b/ 20 May 1980 to 30 June 1982 (excluding data from July to September 1980).

Miscellaneous Prey.--Fish larvae (Osmeridae) were of minor dietary importance in late March and early April 1979 and 1980, 6 and 15% IRI'. respectively; none were present in 1981 or 1982.

Immediately following the eruption (20 May-2 June 1980), consumption of plant material increased from 0 to 12% IRI'. Relatively high consumption of plant material also occurred from 25 March to 8 April in 1980 and 1981, 9 and 17% respectively, and from 6 to 19 May 1982, 10%.

Geographical Differences.--From March through June, during years prior to the eruption, subyearling chinook salmon captured at Jones Beach consumed similar proportions of insects and amphipods, whereas upstream from Jones Beach in the reservoir of McNary Dam (RKm 470-521), fish consumed insects and cladocerans (Fairly[15/]), and further upstream in the free flowing Hanford reach (RKm 591-629) fish consumed primarily insects (Becker 1973). Fish captured downstream from Jones Beach (RKm 4-40) consumed primarily amphipods (Durkin et al. 1977, 1981).

## Feeding Characteristics of Juveniles Entering the Estuary

This portion of the report focuses on the examination of feeding rate differences between stocks, species interaction, dietary overlap, and comparisons to other geographical areas. Proximate analysis of stomach contents are also presented.

Stomach Fullness Comparisons.--Differences in mean fullness for groups captured in 1982 and 1983 (Fig. 50) were evaluated statistically and some differences were related to biological or release characteristics. Researchers familiar with groups exhibiting increased or decreased rates of food consumption may be able to make additional correlations.

1. Subyearling chinook salmon: Subyearling chinook salmon were captured in all months of the year, and tagged fish showed great variability in mean fullness (Figs. 51-53). In 1982 and 1983, during peak migration (May and June), the majority of fish captured had higher fullness values than fish captured in 1980 and 1981 (Fig. 42).

Temporal trends in variation of stomach fullness between years (1980-83) are not apparent, but fish from three different culture stations and wild fish exhibited variations that were apparently related to rearing environment, release site, or pre-release disease incidence.

A higher feeding rate was observed for fish from Stayton Pond which may be a result of the earthen pond environment. In 1982, the mean fullness value

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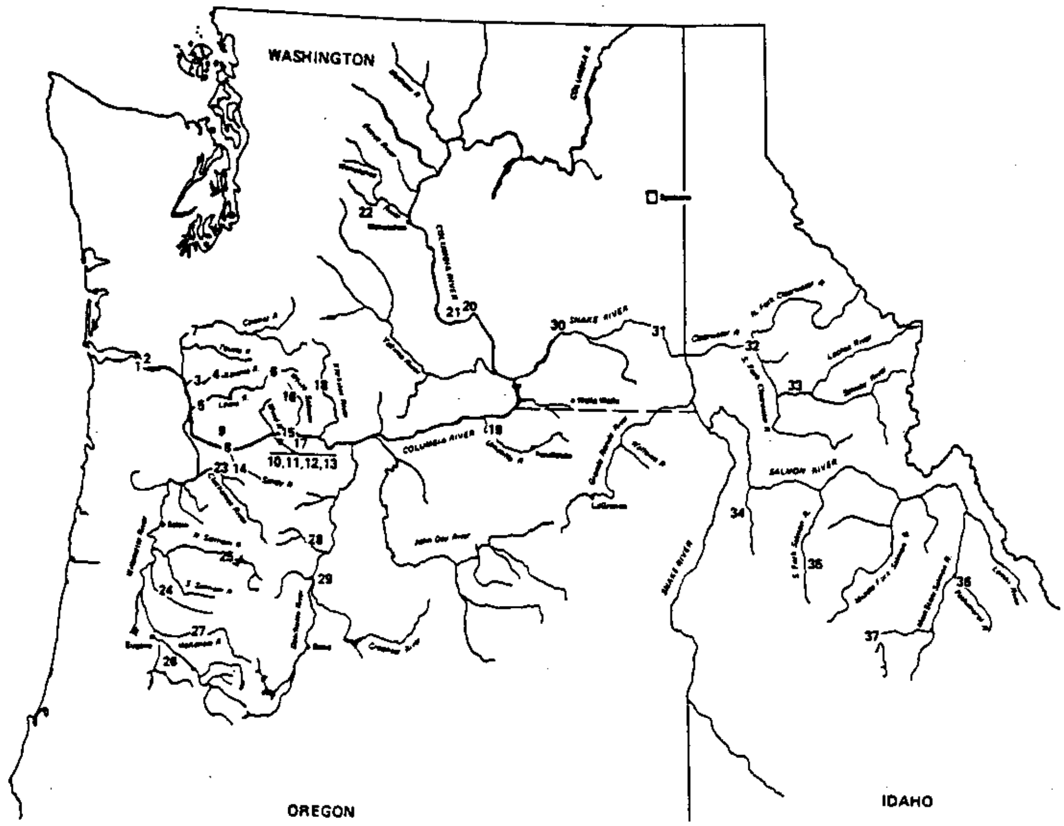
15/ R. Fairly, U.S. Fish and Wildlife Service, National Fishery Research Center, Willard Substation, Star Rt., Cook, WA 98605; pers. commun.




LEGEND

| Index | Site | RKm |
|---|---|---|
| | LOWER COLUMBIA R. & TRIBS. | |
| 1. | Jones Beach | 75 |
| 2. | Abernathy SCDC a/ | 91 |
| 3. | Lower Kalama Hat. b/ | 127 |
| 4. | Kalama Falls Hat. b/ | 141 |
| 5. | Lewis River Hat. b/ | 163 |
| 6. | Speelyai b/ | 196 |
| 7. | Cowlitz Hat. b/ | 189 |
| 8. | Skamania Hat. c/ | 213 |
| 9. | Washougal Hat. b/ | 221 |
| 10. | Bonneville Dam | 230 |
| 11. | Bonneville Hat. d/ | 231 |
| 12. | Oxbow Hat. d/ | 231 |
| 13. | Cascade Hat. d/ | 232 |
| 14. | Sandy Hat. d/ | 235 |
| 15. | Lit. Wht. Sal. Hat. a/ | 261 |
| 16. | Willard Hat. a/ | 268 |
| 17. | Spring Creek Hat. a/ | 269 |
| 18. | Klickitat Hat. b/ | 358 |
| 19. | Umatilla River | 472 |
| 20. | Vernita Bridge | 629 |
| 21. | Priest Rapids Dam | 639 |
| 22. | Leavenworth Hat. a/ | 789 |

| Index | Site | RKm |
|---|---|---|
| | WILLAMETTE R. & TRIBS. | |
| 23. | Eagle Creek Hat. a/ | 247 |
| 24. | Stayton Pond d/ | 412 |
| 25. | Minto (for Marion Fks. Hat.) d/ | 452 |
| 26. | Dexter (for Oakridge Hat.) d/ | 491 |
| 27. | McKenzie Hat. d/ | 492 |
| | DESCHUTES R. & TRIBS. | |
| 28. | Warm Springs Hat. a/ | 485 |
| 29. | Round Butte Hat. d/ | 506 |

| Index | Site | RKm |
|---|---|---|
| | SNAKE R. & TRIBS. | |
| 30. | Lyon's Ferry Hat. a/ | 600 |
| 31. | Lower Granite Dam (for Hagerman Hat.) e/ | 693 |
| | CLEARWATER R. & TRIBS. | |
| 32. | Dworshak Hat. a/ | 809 |
| 33. | Kooskia Hat. a/ | 868 |
| | SALMON RIVER & TRIBS. | |
| 34. | Rapid River Hat. e/ | 967 |
| 35. | S. Fork Salmon R. (for McCall Hat.) e/ | 1153 |
| 36. | Pahsimeroi R. (for Niagara Springs Hat.) e/ | 1311 |
| 37. | Sawtooth Hat. e/ | 1466 |

a/ United States Fish and Wildlife Service.
b/ Washington Department of Fisheries.
c/ Washington Department of Game.
d/ Oregon Department of Fish and Wildlife.
e/ Idaho Department of Fish and Game.

Figure 50.--Columbia River basin showing locations of release sites, hatcheries, and Jones Beach.

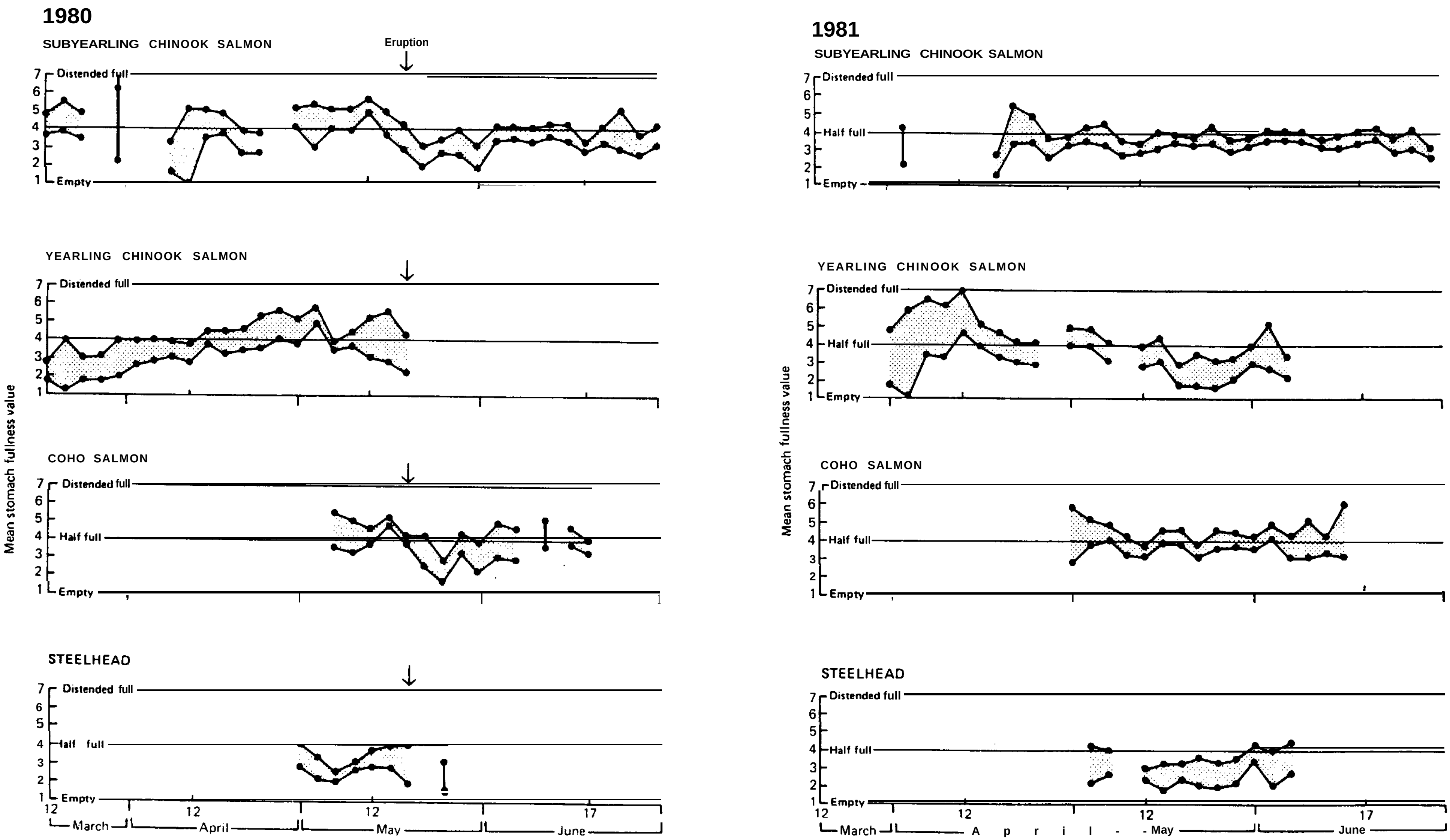



Figure 51.--Ninety-five percent confidence intervals of mean stomach fullness for salmonids captured at Jones Beach, plotted by 3-day intervals, March-June 1980 and 1981

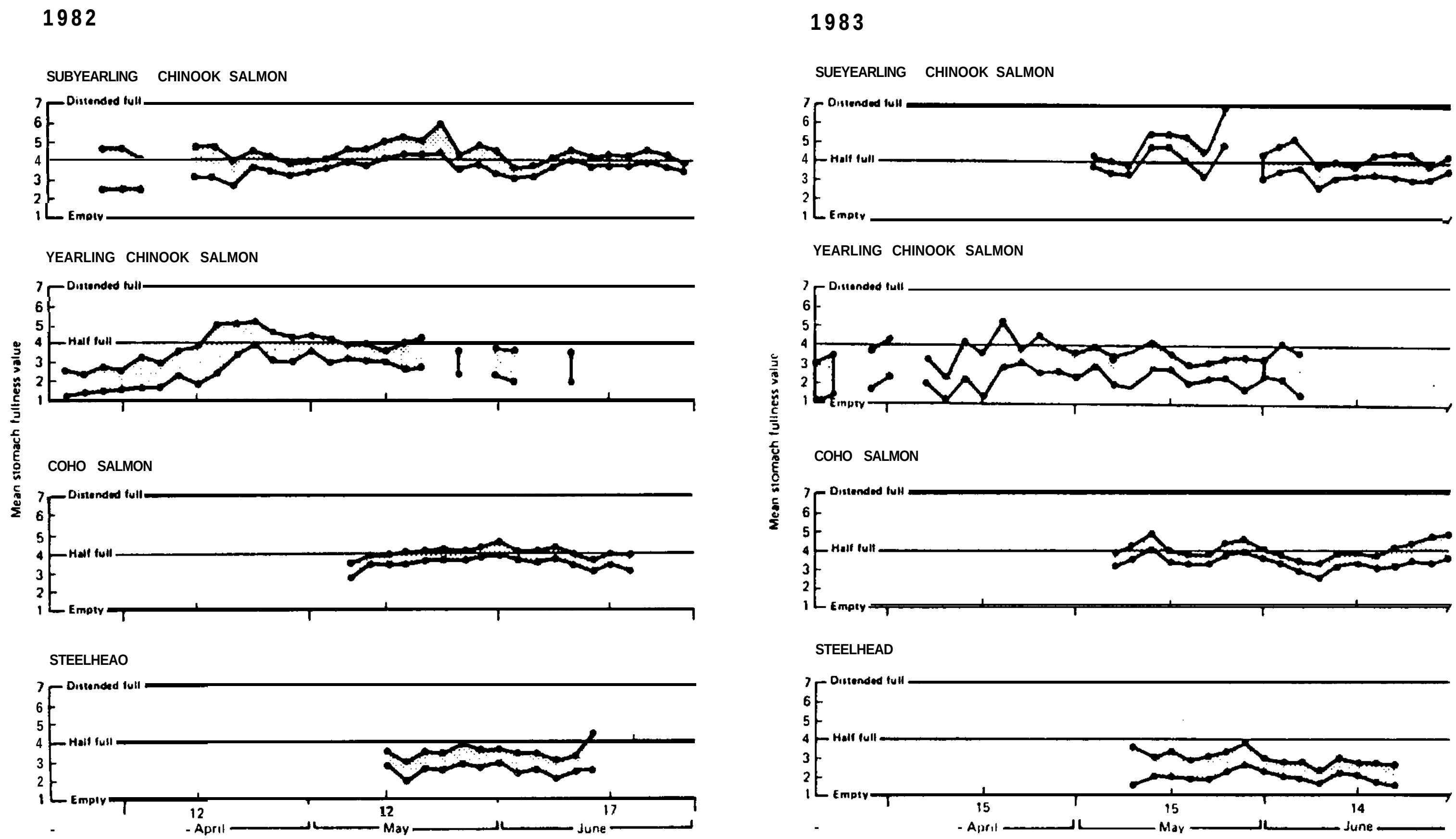



Figure 52. --Ninety-five percent confidence intervals of mean stomach fullness for juvenile salmonids captured in beach and purse seines at Jones Beach, plotted by 3-day intervals, March-June, 1982 and 1983.

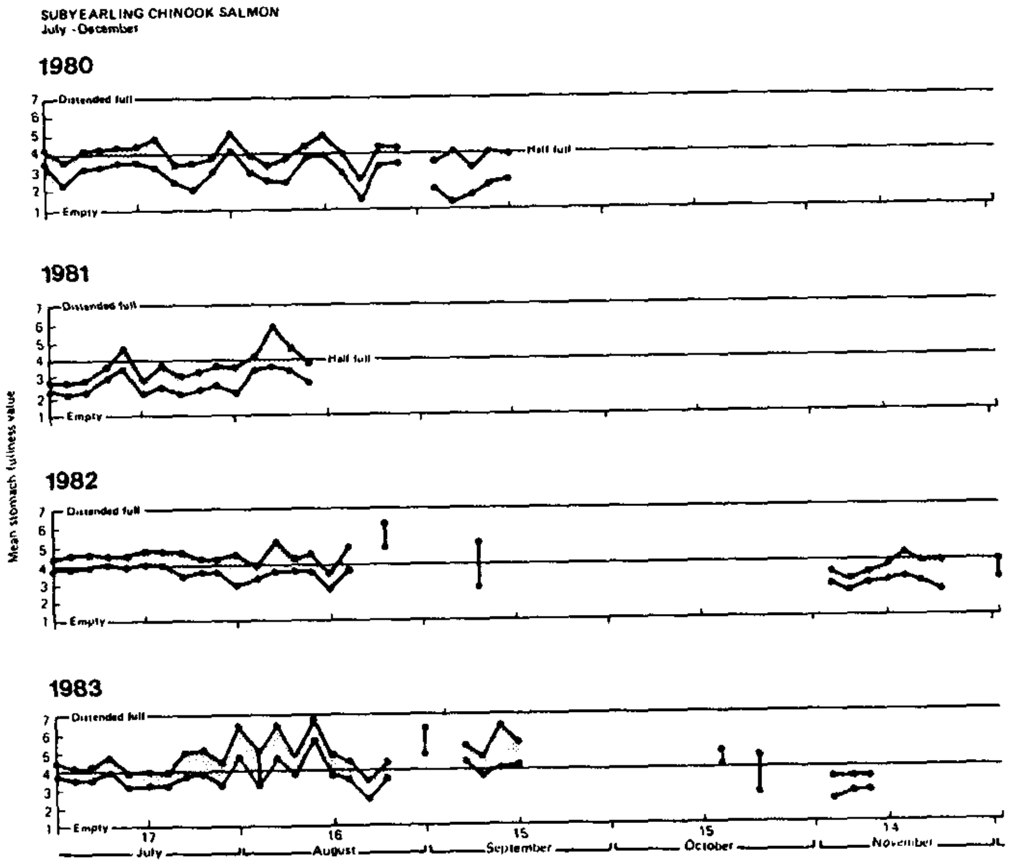



Figure 53.--Ninety-five percent confidence intervals of mean stomach fullness for subyearling chinook salmon captured in beach and purse seines at Jones Beach, plotted by 3-day intervals, July-December, 1980-1983.

for the Stayton Pond fish (5.0, early migrants) was significantly higher than that for fish from Spring Creek Hatchery (4.0) Fig. 54. In 1983, the mean fullness value for the Stayton Pond fish (4.8) was significantly higher than Bonneville Hatchery diet study fish (3.8) and higher (not significant) than Little White Salmon Hatchery fish (4.4) (Fig. 55). In 1980 and 1981, higher than average feeding rates were also observed from Stayton Pond fish. Estuarine recovery percentages for Stayton Pond fish (1980-1983) showed no **difference from other groups,** but adult return rates appear substantially **greater than average (Day[16/]).**

As mentioned previously, fish from the Abernathy Salmon Culture Development Center (SCDC) have a low feeding rate when captured at Jones Beach. We believe that the lower feeding rate for these fish is associated with the short time period between release and recapture at Jones Beach; release site is 16 km from Jones Beach[17/]. In May 1982, fish from Abernathy SCDC had significantly lower mean fullness value than fish from Spring Creek Hatchery and two groups from Bonneville Hatchery (2.9 versus 4.0, 3.7, and 3.8, respectively).

During November and December 1982, one of four tag groups released from Bonneville Hatchery had a significantly lower mean fullness value (Fig. 55) which probably resulted from factors affecting the fish during hatchery rearing. The lower river stock (tule) reared in well water (mean fullness 2.6) had a high pre-release mortality and were in poor health at release (Hansen[18/], whereas tule stock reared in Tanner Creek water, upriver late fall stock (bright) reared in Tanner Creek water, and bright stock reared in well water were unaffected by disease (mean fullness 3.1, 3.1, and 3.3, respectively).

In 1983, over 200 tagged wild fish from the Lewis River (seined, tagged, and released same day) were captured and their stomach fullness observed at Jones Beach (Fig. 55). The dates of median fish recovery for the two tag groups were outside of the 7-day range used for comparing mean fullness values with other groups; however, the wild fish appeared to feed at a similar rate as most cultured fish captured during the same months. An exception, however, was a comparison with fish reared at the Cowlitz Hatchery; where changes,

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16/ W. Day, Oregon Department of Fish and Wildlife, 17330 S.E. Evelyn St. Clackamas OR; pers. commun.

17/ In 1980 and 1981, fish from Abernathy Hatchery had 51 and 44% non-feeding fish compared to 24% in 1982. Non-feeding rates among these 3 years are significantly different ($P < 0.01$), but mean fullness values were not significantly different (range 2.90 to 3.10; $P < 0.05$). Diseases incurred during culture also may have increased the proportion of non-feeding fish observed in 1980 and 1981 (L. Fowler, U.S. Fish and Wildlife Service, Abernathy Salmon Cultural Development Center, 1440 Abernathy Road, Longview, 98632; pers. commun.

18/H. Hansen, Oregon Department of Fish and Wildlife, 17330 S. E. Evelyn St., Clackamas, OR, pers. commun.

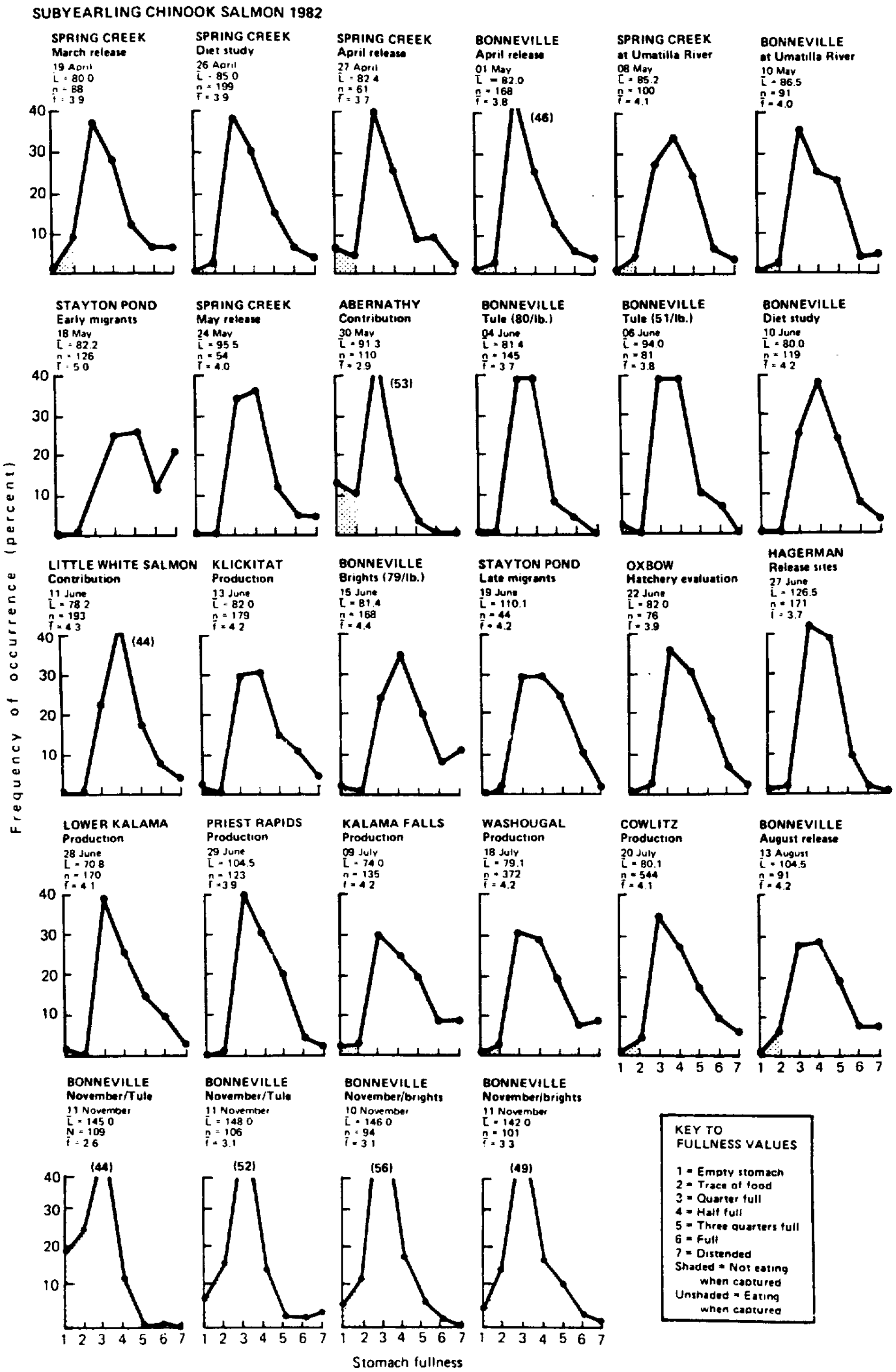


Figure 54.--Stomach fullness frequency curves for tag groups of subyearling chinook salmon captured at Jones Beach during 1982. Source, study descriptor, date of median fish recovery, mean length (mm), number observed, and mean fullness value are included.

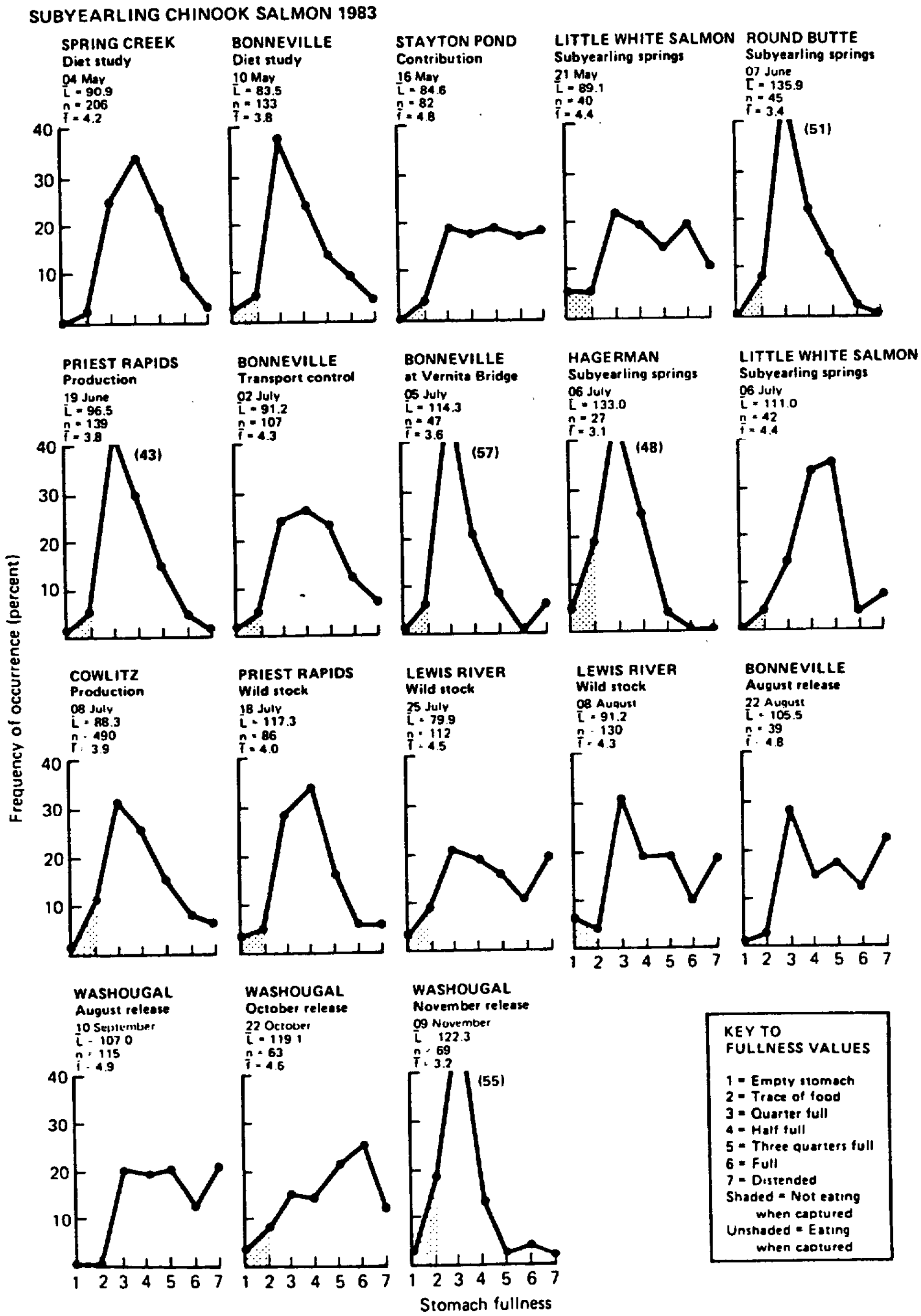


Figure 55.--Stomach fullness frequency curves for tag groups of subyearling chinook salmon captured at Jones Beach, 1983. Source, study descriptor, date of median fish recovery, mean length (mm), number observed, and mean stomach fullness value are included.

within the time period of migration, in condition factor, amounts of visible body fat, and fullness value indicated that the wild fish were better utilizing the available food resources.

Other fish groups showed significant differences in mean fullness values. In 1982, Bonneville Hatchery diet study fish (tule stock) had a significantly higher mean fullness value (4.2) than that for two tule stock production release groups (3.7 and 3.8, Fig. 54). In 1983, Bonneville Hatchery diet study fish had a significantly lower mean fullness value (3.8) than Spring Creek Hatchery diet study fish (4.2) and the Stayton Pond fish (Fig. 55). In 1982, Hagerman Hatchery fish had a significantly lower mean fullness (3.7) than fish from Lower Kalama Hatchery (4.1). In early July 1983, fish groups from Hagerman, Bonneville (transport and control groups), Cowlitz, and Little White Salmon Hatcheries had significant differences among mean stomach fullness values (range 3.1 to 4.4, Table 42). Differences of race and size affect this comparison, i.e., the fish from Hagerman and Little White Salmon Hatcheries were spring chinook salmon and the others were fall chinook salmon; mean fork lengths at recovery ranged from 88 to 133 mm.

2. Yearling chinook salmon: Fish captured from March through April generally had low fullness values (Figs. 51 and 52). To interpret the feeding behavior during January to early May, we divided the 1980 to 1983 fullness data into two groups: fish released from hatcheries in the fall that overwintered in the river system (residual), and those released during March (Fig. 56). Residual fish fed consistently throughout recovery, and mean fullness values (3-day averages) showed insignificant ($P<0.10$) correlation to recovery dates (correlation coefficient, $r = 0.37$). The overall mean fullness value for residual fish was 4.2 ($n = 149$; date of median fish recovery = 2 April). Fish released in the spring did not feed consistently throughout the recovery period and showed significant ($P<0.001$) positive correlation between mean fullness values (3-day averages) and dates of recovery ($r = 0.93$, non-linear power curve regression). Spring released fish had predominantly empty or trace full stomachs during March, with gradually increasing mean fullness thereafter; overall mean fullness was 2.8 ($n = 376$; date of median fish recovery = 1 April). High proportions of non-feeding yearling chinook salmon were recovered from releases in March 1982 at Oxbow Hatchery (41%) and Bonneville Hatchery in 1982 and 1983 (61 and 66%, respectively); Figure 57[19/] The proportion of non-feeding fish was highest for initial catches and decreased with time after release.

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19/ In 1983, a second mark group released from Bonneville Hatchery on 23 March had 31% non-feeding fish; although only 13 were examined and there was no significant difference from the earlier group. The two Bonneville releases were different stocks (tule and bright, respectively). In 1982, these two stocks were released on the same date (17 March) and had similar numbers of non-feeding fish (tule = 58%, bright = 64%). Time of release in the spring may affect feeding rate for yearling chinook salmon.

Table 42.--Comparison of mean stomach fullness for different marked groups of subyearling chinook salmon captured at Jones Beach in early July 1983.

| | Source/ / Description | | | | |
|---|---|---|---|---|---|
| | Hagerman/ subyearling spring chinook | Bonneville/ @ Vernita Br. fall chinook | Cowlitz/ fall chinook | Bonneville/ fall chinook | Little White Sul. subyearling spring chinook |
| Date a/ | 6 July | 5 July | 8 July | 2 July | 6 July |
| Mean length b/ | 133 | 114 | 88 | 91 | 111 |
| Number sampled | 27 | 47 | 490 | 107 | 42 |
| Mean fullness | 3.1 | 3.6 | 3.9 | 4.3 | 4.4 |
| Significance c/ | ---------- | ---------- | | ---------- | ---------- |
| | | ---------- | ---------- | | |

a/ Date of median fish recovery for individuals with fullness observations.

b/ Mean fork length (mm) for intire tag group; 7 day average about the date of median fish recovery.

c/ Underlined fullness means have no significant difference (P≥0.05).

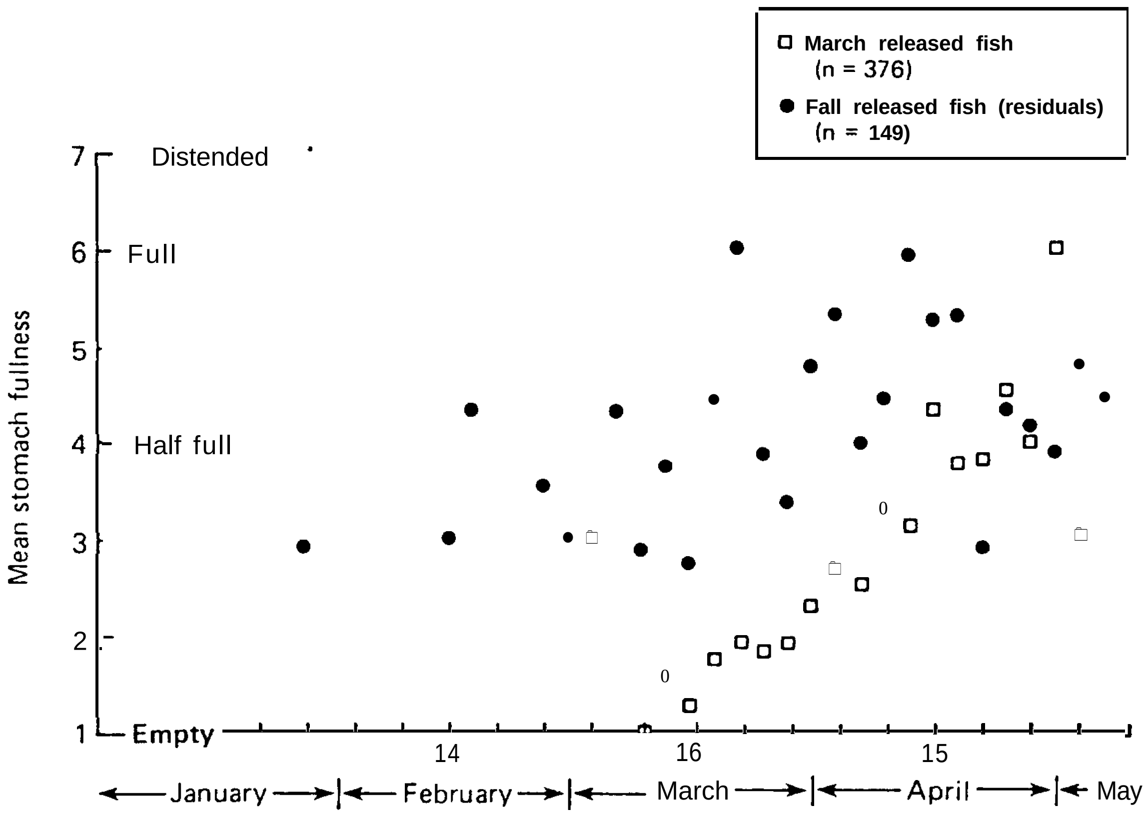


Figure 56.--Mean stomach fullness for yearling chinook salmon (residual and March released fish) captured at Jones Beach, 1980-1983, plotted by 3-day intervals.

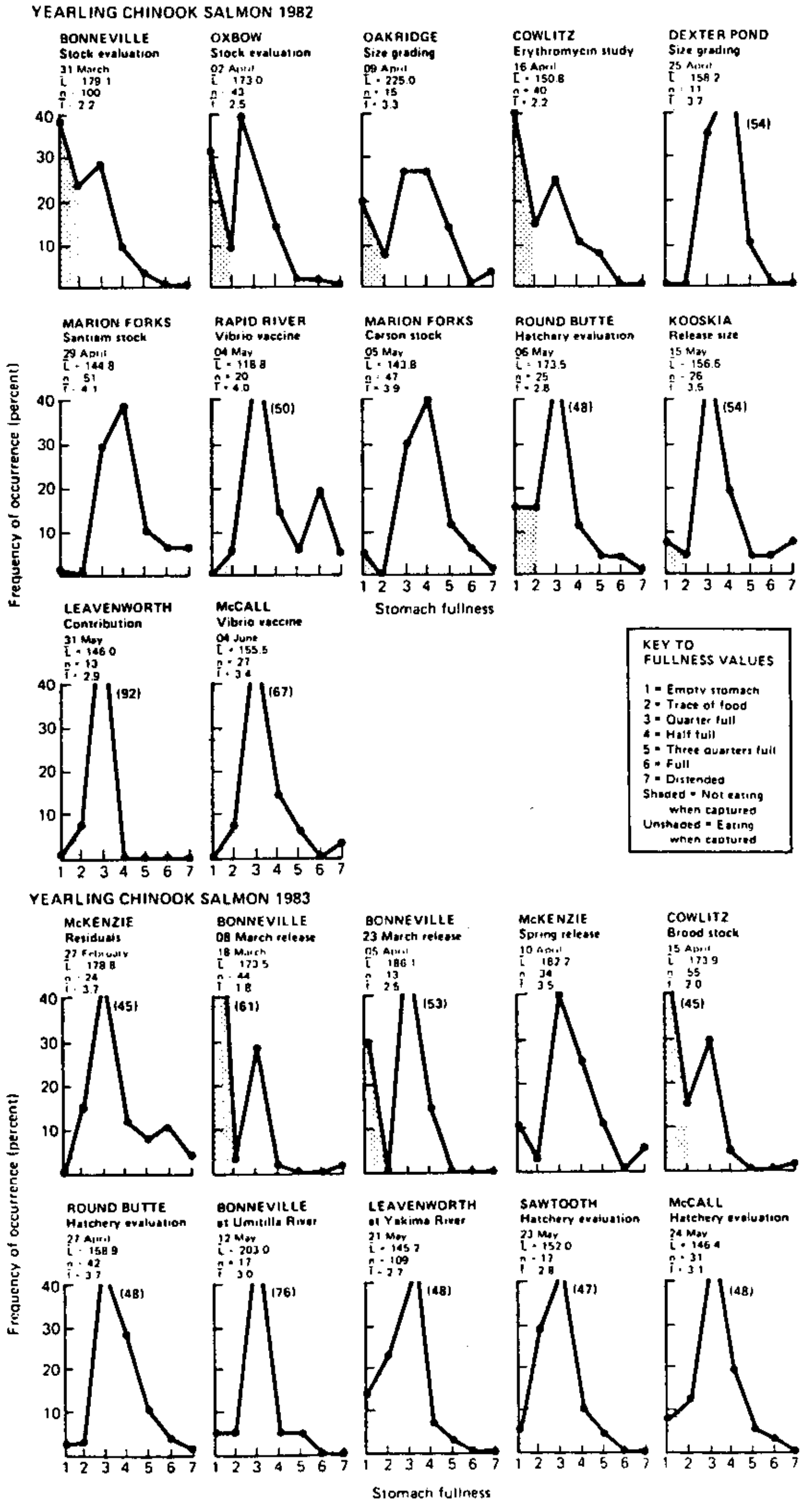


Figure 57.--Stomach fullness frequency curves for tag groups of yearling chinook salmon captured at Jones Beach, 1982 and 1983. Source, study descriptor, date of median fish recovery, mean length (mm), number observed, and mean stomach fullness value are included.

Fish captured in May and June generally elicited higher mean fullness values than those collected in March and early April, but each year there was a decrease in mean fullness during May (I: = -0.82, -0.69, -0.66, and -0.52, respectively, for 1980, 1981, 1982, and 1983) (Figs. 51 and 52). This decreasing fullness trend seemed to occur within mark groups as well as for the aggregate of all individuals. For example, Warm Springs Hatchery chinook salmon showed high food consumption in early May with progressively lower fullness through the month (Fig. 58).

Some fish groups passing Jones Beach in May and June showed significantly lower feeding rates than others passing during the same period (Fig. 57). In 1982, the mean fullness of fish from Round Butte Hatchery was significantly lower than that for fish from Marion Forks and Rapid River Hatcheries (2.8 versus 3.9, and 4.0, respectively). Mean fullness for Leavenworth Hatchery fish was significantly lower than for McCall Hatchery fish (2.9 versus 3.4). In 1983, mean fullness values of fish from Bonneville and Cowlitz Hatcheries were significantly lower than means for fish from McKenzie Hatchery (2.5 and 2.0 versus 3.5, respectively).

3. Coho salmon: Fullness values for coho salmon were lowest in 1983 (mean = 3.8) and highest in 1980 (mean = 4.1) (Figs. 51 and 52). In 1980 and 1981, proportions of non-feeding coho salmon did not exceed 10%. except for fish from Willard Hatchery released shortly after the eruption of Mount St. Helens.

In 1982, all groups of coho salmon had less than 5% non-feeding fish, but some groups captured during the same date range had significantly different fullness means (Fig. 59). Fullness mean for fish from Lower Kalama Hatchery was significantly lower than that for Cowlitz Hatchery fish, and both were significantly lower than the mean for Sandy Hatchery fish (3.3, 3.6, and 4.0, respectively). Fullness means for fish from Eagle Creek and Washougal Hatcheries were significantly lower than the mean for Cascade Hatchery fish (3.9, 4.1, and 4.4, respectively).

In 1983, all groups of coho salmon had less than 10% non-feeding fish except those from Lower Kalama and Cowlitz Hatcheries (14 and 15%, respectively); Figure 59. Although sample size was small (n = 29), the mean fullness value for fish from Lower Kalama Hatchery (3.7) was not significantly different than fish from Washougal (3.9) or Sandy Hatcheries (4.1); it was significantly lower than Bonneville Hatchery fish (4.7). Cowlitz Hatchery fish had a significantly lower mean fullness than fish from either Sandy or Eagle Creek Hatcheries (3.4 versus 4.1 and 3.8, respectively).

4. Steelhead: Fullness values were lowest in 1983 (mean = 2.6) and highest in 1982 (mean = 3.0; Figs. 51 and 52). In 1982, mark groups captured during similar time periods showed no significant differences between fullness means (range 2.7-3.1; Fig. 60). In 1983, Hagerman Hatchery B stock had a significantly lower fullness mean than fish from Lyons Ferry and Dworshak Hatcheries (2.1 versus 2.6 and 2.6), but 11 days later mean fullness for Hagennan A stock steelhead was not significantly different than that of a second group of Dworshak Hatchery fish (2.3 and 2.6, respectively). In 1982, Hagennan stock A and B steelhead were captured during similar date periods; both had fullness means of 3.1.

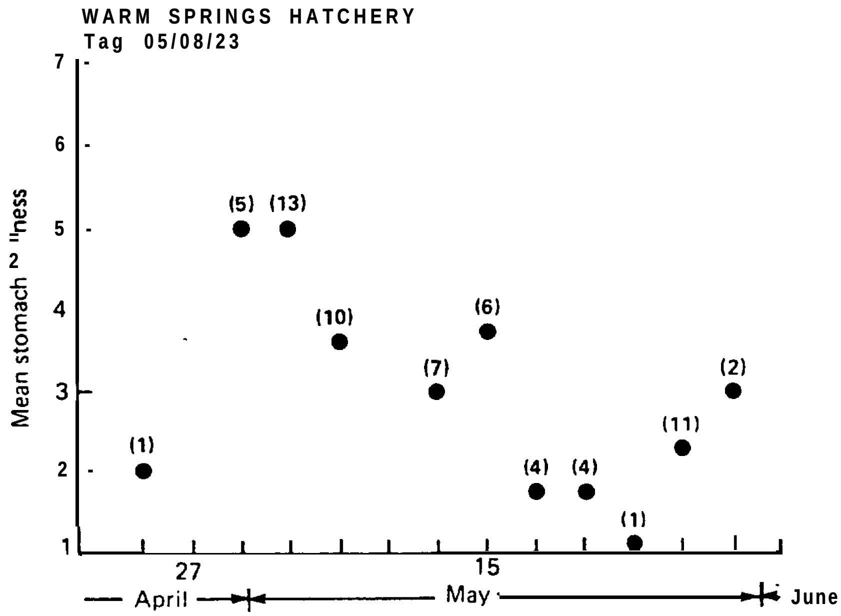


Figure 58.--Mean stomach fullness (3-day intervals) for yearling chinook salmon released at Warm Springs Hatchery and captured at Jones Beach, 1981. Sample number in parenthesis.

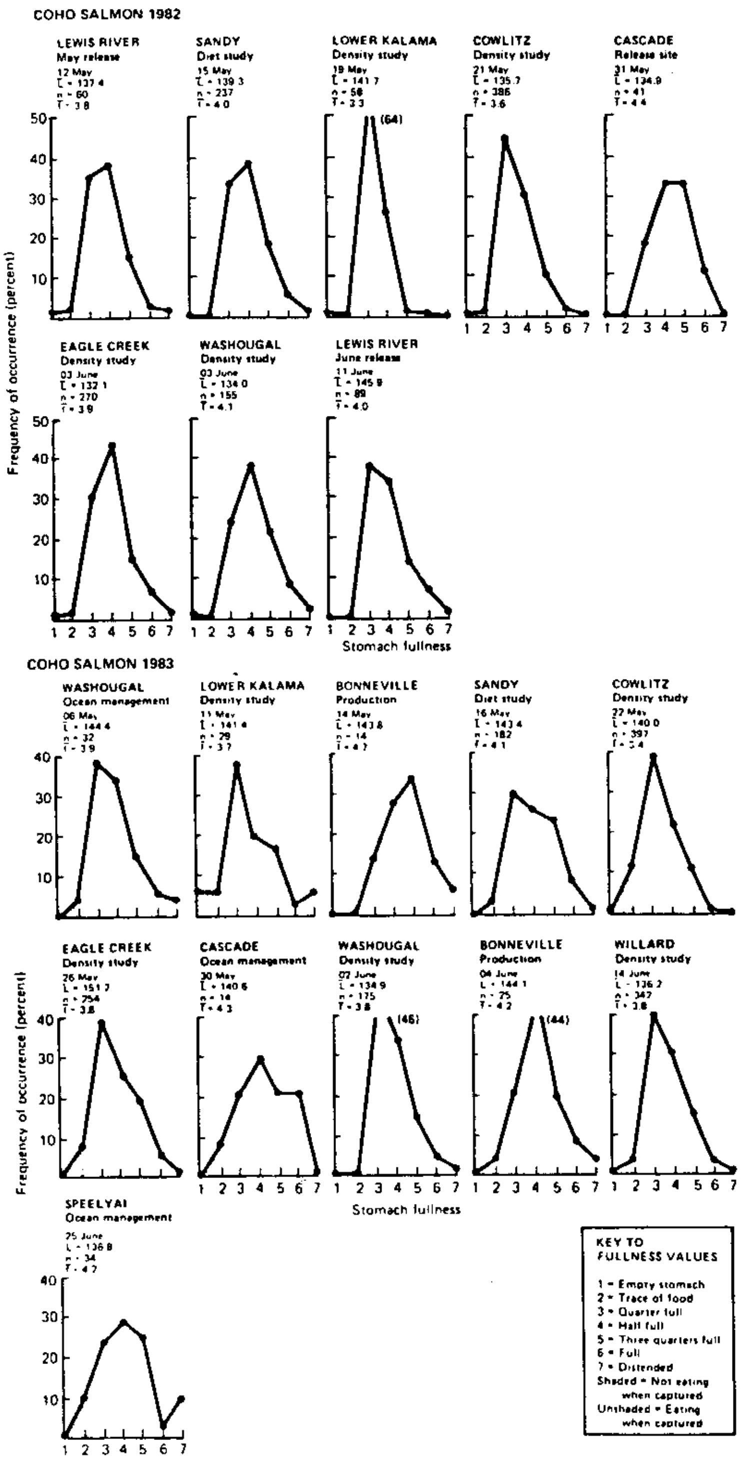


Figure 59.--Stomach fullness frequency curves for coho salmon captured at Jones Beach, 1982 and 1983. Source, study descriptor, date of median fish recovery, mean length (mm), number observed, and mean fullness value are included.

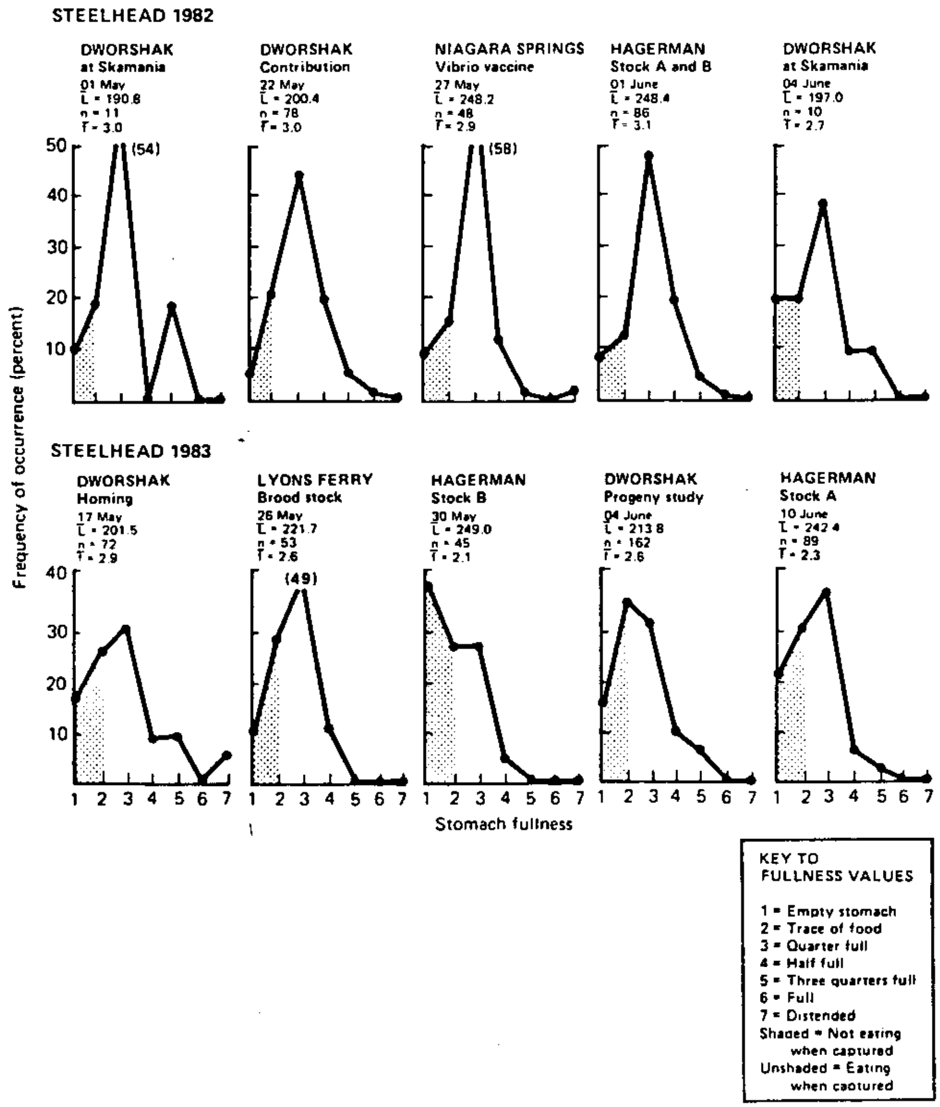


Figure 60.--Stomach fullness frequency curves for steelhead captured at Jones Beach, 1982 and 1983. Source, study descriptor, date of median fish recovery, mean length (mm), number observed, and mean fullness value are included.

5. Interspecific Comparisons: During May, the time period of peak out-migration, mean stomach fullness of yearling chinook salmon decreased coincidentally with increased migrants passing Jones Beach, No decrease was observed for subyearling chinook salmon or the other salmonid species. To determine if the decline in stomach fullness might show evidence of density dependence, we correlated daily mean stomach fullness of purse seine captured yearling chinook salmon to accumulated catch per set (ACPS) of all yearling salmonids captured in May and June 1980-1983. In all years there was inverse correlation (r = -0.70, -0.61, -0.60, and -0.37 for 1980, 1981, 1982, and 1983). Fullness values for yearling chinook salmon declined during increasing CPS in early May and continued to decline as CPS decreased in late May. Only in 1981 did fullness values increase in June, (Fig. 51); in 1980, few yearling fish were captured following the 18 May eruption of Mount St. Helens, and in 1982 and 1983 negative slopes for mean fullness values occurred during early June for all yearling salmonids. In 1983, sufficient numbers of tagged coho salmon were captured during mid-June to July for analysis. These fish showed increased feeding during months when migration of all yearling fish was minimal.

6. Effects of Time and Tide: We examined fullness data collected during May and June, 1980-1983 for relationships to hour of catch. There was high variability in the data and correlations were poor. To eliminate some of the variability, we selected for fish captured less than 2 h after sunrise (morning) and compared their mean stomach fullness to that of fish captured more than 6 h after sunrise (afternoon) (Table 43). Each year, coho and subyearling chinook salmon captured in the beach seine had higher mean fullness values in the afternoon than in the morning (7 out of 8 comparisons were significant, $P<0.05$). Fish captured in the purse seine showed differences between morning and afternoon mean fullness values in both directions and no trend was observed.

Little or no relationship was observed between fullness values and tide. Preliminary analyses comparing fullness value to time intervals from high or low slack tide were poorly correlated.

Diet Composition and Overlap.--Stomach contents from a sample of each species captured 6-19 May 1980 were identified to examine interspecific dietary overlap. Overlap calculations were performed at the ordinal level of identification using biomass to characterize the diets. Unidentified insects and fish were omitted from the analysis (only one fish was consumed--by a subyearling chinook salmon; we felt it was anomalous data). A $C_\lambda$ value of 0.6 is considered significant overlap (Zaret and Rand 1971).

The diet of subyearling chinook salmon was distinct from that of steelhead ($C_\lambda$ = 0.2) but had significant overlap with yearling chinook salmon ($C_\lambda$ = 0.6) and coho salmon ($C_\lambda$ = 0.8) (Table 44). Cladocera, was the most distinctive item in the diet of subyearling chinook salmon (7% IRI'). Amphipoda and Insecta (primarily Diptera), together with Cladocera accounted for over 90% of the IRI' (Fig. 61).

At the ordinal level of prey identification, yearling chinook salmon showed significant dietary overlap with coho salmon ($C_\lambda$ = 0.6) and steelhead ($C_\lambda$ = 0.6) (Table 44). All three species fed heavily on Amphipoda and Insecta

Table 43.--Comparison of morning and afternoon mean stomach fullness values for juvenile salmonids captured at Jones Beach during May and June 1980-1983.

| Year | Species | Location a/ | Morning b/ n | Morning b/ mean fullness | Afternoon c/ n | Afternoon c/ mean fullness | t-value |
|---|---|---|---|---|---|---|---|
| 1980 | Coho salmon | Shore | 47 | 2.9 | 19 | 3.9 | 2.3 d/ |
| 1981 | " | " | 18 | 3.5 | 23 | 4.1 | 1.5 |
| 1982 | " | " | 78 | 3.6 | 44 | 4.2 | 2.9 d/ |
| 1983 | " | " | 68 | 3.4 | 67 | 3.9 | 2.5 d/ |
| 1980 | " | Mid river | 138 | 4.4 | 30 | 4.2 | 0.7 |
| 1981 | " | " | 217 | 3.8 | 47 | 4.2 | 1.8 |
| 1982 | " | " | 403 | 3.9 | 46 | 3.9 | -0.1 |
| 1983 | " | " | 529 | 3.7 | 164 | 3.8 | 1.2 |
| 1980 | Yearling chinook salmon | " | 63 | 3.9 | 5 | 3.2 | -1.0 |
| 1981 | " | " | 77 | 3.1 | 41 | 3.9 | 3.7 d/ |
| 1982 | " | " | 47 | 3.4 | 10 | 3.2 | -0.9 |
| 1983 | " | " | 76 | 2.8 | 34 | 3.0 | 0.8 |
| 1980 | Steelhead | " | 96 | 2.7 | 15 | 3.7 | 2.3 d/ |
| 1981 | " | " | 86 | 2.9 | 41 | 3.8 | 4.1 d/ |
| 1982 | " | " | 50 | 3.0 | 27 | 3.2 | 0.7 |
| 1983 | " | " | 137 | 2.4 | 77 | 2.5 | 0.6 |
| 1980 | Subyearling chinook salmon | Shore | 187 | 3.5 | 124 | 4.0 | 3.3 d/ |
| 1981 | " | " | 450 | 3.2 | 175 | 3.9 | 6.2 d/ |
| 1982 | " | " | 584 | 3.9 | 127 | 4.8 | 7.0 d/ |
| 1933 | " | " | 227 | 3.9 | 127 | 4.3 | 2.5 d/ |
| 1980 | " | Mid river | 41 | 5.1 | 23 | 4.1 | -2.8 d/ |
| 1981 | " | " | 136 | 3.8 | 28 | 3.9 | 0.5 |
| 1982 | " | " | 1.96 | 4.1 | 54 | 4.4 | 1.8 |
| 1983 | " | " | 100 | 3.9 | 44 | 4.1 | 0.8 |

a/ Shoreline sampling with a beach seine, mid-river sampling with a purse seine. Insufficient yearling chinook salmon and steelhead were captured in the beach seine for evaluation.
b/ Morning defined as less than 2 hours after sunrise.
c/ Afternoon defined as greater than 6 hours after sunrise.
d/ Differences in morning mean fullnesssignificantly different than afternoon mean fullness ($P \leq 0.05$).

Table 44.--Diet overlap of juvenile salmonids[a] captured at Jones Beach, 6-19 May 1980.

| Fish species compared | | Overlap[b] |
|---|---|---|
| X | Y | |
| Subyr. chinook salmon[c] | Yr. chinook salmon | 0.6[d] |
| " " " | Coho salmon | 0.8[d] |
| " " " | Steelhead | 0.2 |
| Yr. chinook salmon | Coho salmon | 0.6[d] |
| " " " | Steelhead | 0.6[d] |
| Coho salmon | Steelhead | 0.3 |

a/ Classifications of food categories to order with unidentified insects and items which constitute less than 1% of the total biomass present omitted.
b/ Index of diet overlap from Morisita (1959) as modified by Horn (1966), based upon the proportional biomass of diet items present in two species.
c/ Biomass of one fish present in the stomach of a single subyearling chinook salmon omitted.
d/ An overlap value of 0.6 or greater is considered significant (Zaret and Rand 1971).

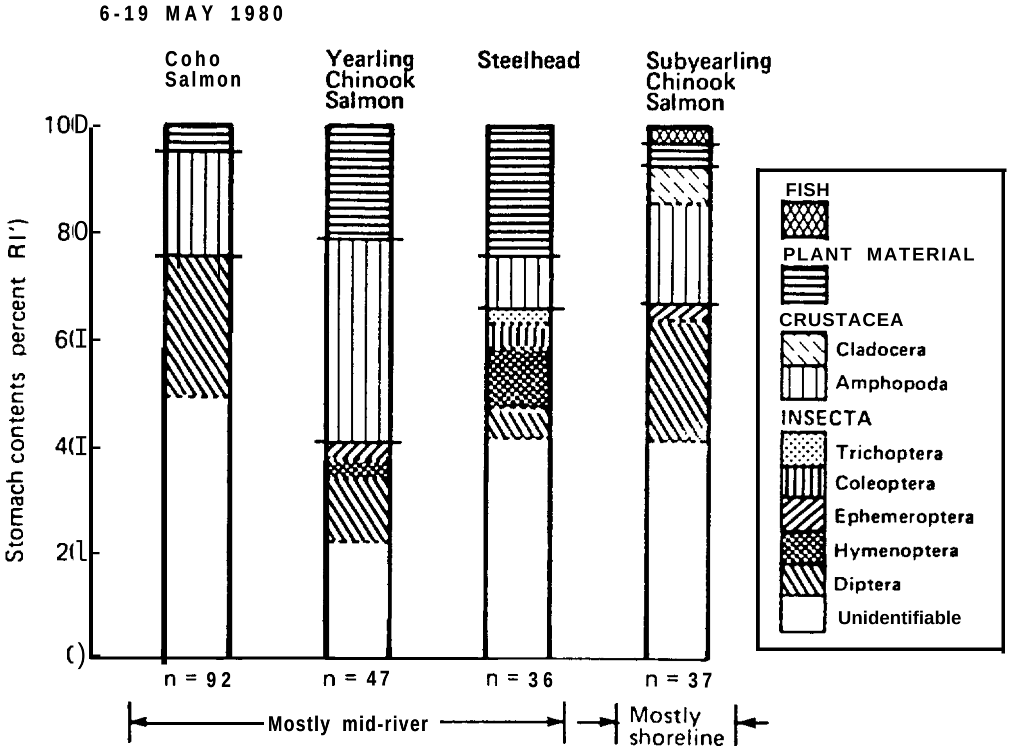


Figure 61.--Modified index of relative importance (IRI') for food items consumed by juvenile salmonids collected at Jones Beach, 6-19 May 1980.

(from 78 to 96% of the IRI′), with dip teran insects predominant in coho and chinook salmon and hymenopteran insects dominating the diet of steelhead (Fig. 61). Plant material accounted for more than 20% of the IRI′ for both yearling chinook salmon and steelhead.

Proximate Analysis.--Proximate analysis of stomach contents provided a cursory evaluation of food quality for the four salmonid species (Table 45). Compared to hatchery diets, contents of migrants appeared low in protein (26-36%), high in carbohydrates (28-39%) and ash (13-24%), a normal in fat (6-26%). The composition of Oregon Moist Pellet, OMP-2[20/], a standard hatchery diet, is: 52, 17, 13, and 19% protein, carbohydrate, ash, and fat, respectively (Westgate et al. 1983). The low protein percentage in the stomach contents of migrant fish may have resulted from more rapid absorption of protein relative to ash and carbohydrates.

Stomach Content Weight.--In 1982, the mean stomach content weights for subyearling and yearling chinook salmon, coho salmon, and steelhead collected throughout the May and June peak migration period were: 0.55, 0.16, 0.23, and 0.09% body weight (%BW), respectively (Table 46). The %BW of stomach contents decreased with increasing body size (Fig. 62) as previously observed for juvenile salmonids in culture situations (Buterbaugh and Willoughby 1967).

Statistical correlation of fullness value plus fork length or fish weight to weights of stomach contents was used to evaluate the consistency of the fullness data for 1982 (Table 47). Length produced slightly better correlation than body weight when used as the second independent variable. Correlation was highest for subyearling chinook salmon (I: = 0.78) and lowest for yearling chinook salmon (r = 0.70). By using fullness as an estimator of the actual contents weight (i.e., integer fullness values used to predict the continuously variable stomach content weight) about 50% of the observed variability in the stomach content weight data was not explained with this model. There were two main sources for the variation: (1) integer fullness values (previously discussed) and (2) estimating volume of food consumed by weighing. The first source of error is unavoidable because of the limitations inherent with visual indexes--even expanding the scale might not improve the resolution of the observations. The second source could be improved by using weights dried to constant weight (Congleton 1979). Blotted dry weights were used here to better allow for future prey identification.

## Discussion

Caloric content of food ingested plus metabolic activity are the determinants of adequate nutrition. A thorough evaluation of nutritional

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20/ Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Table 45.--Proximate analysis of stomach contents from juvenile salmonids captured at Jones Beach during May and June 1982.

| Species | Wet weight (g) | % $H_2O$ | Composition (% dry weight) Fat | Protein | Ash | Carbohydrate a_/ |
|---|---|---|---|---|---|---|
| Coho salmon b/ | 14.7 | 82.2 | 11.2 | 31.5 | 23.0 | 34.3 |
| Yr, chinooksalmon | 15.1 | 77.9 | 26.2 | 25.8 | 12.7 | 35.3 |
| Steelhead | 6.4 | 82.9 | 5.8 | 35.1 | 20.5 | 38.6 |
| Subyr.chinook salmon | 10.1 | 80.0 | 12.0 | 36.0 | 24.0 | 28.0 |

a_/ Carbohydrate calculated by the difference,

b_/ Eighty-four stomachs from May and June 1981 were added to the 1982 samples to obtain a minimum dry weight of 1.0g per sample.

Table 46.--Mean stomach content weight of juvenile salmonids captured at Jones Beach during May and June 1982.

| Sample [a] | Subyearling chinook salmon: Sample (n) | Mean weight (g) | Mean stomach content weight (g) | Stomach content (% BW) [b] | Yearling chinook salmon: Sample (n) | Mean weight (g) | Mean stomach content weight (g) | Stomach content (% BW) |
|---|---|---|---|---|---|---|---|---|
| All fish | 855 | 6.7 | 0.0371 | 0.55 | 96 | 39.1 | 0.0619 | 0.16 |
| Fish selected by size [c] | 244 | 5.1 | 0.0334 | 0.66 | 13 | 38.1 | 0.0571 | 0.15 |
| | **Coho salmon** | | | | **Steelhead** | | | |
| All fish | 612 | 24.0 | 0.0562 | 0.23 | 108 | 109.0 | 0.0970 | 0.09 |
| Fish selected by size | 186 | 24.4 | 0.0573 | 0.23 | 14 | 101.2 | 0.1087 | 0.11 |

a/ Only data for fish with stomach fullness values >2 (feeding fish) were used.
b/ Stomach content weight as a percent of body weight.
c/ Size selection; +/- 10% of the mean weight of fish captured except for subyearling chinook salmon for which 5g ± 10% was used for analysis to compare with fish from other areas.

Table 47.--Multi-linear relationships between stomach content weight, fullness value, and fork length or body weight for juvenile salmonids captured at Jones Beach during 1982.

MODEL A--FORK LENGTH

$$\hat{Y} = B_0 + B_1 X_1 + B_2 X_2$$

Where: $\hat{Y}$ = Stomach content weight ($g^{1/3}$ a/)

$X_1$ = Fullness 3-6 b/

$X_2$ = Fork length (mm)

| Species | n | B0 | B1 | B2 | Regression coefficient r |
|---|---|---|---|---|---|
| Coho salmon | 595 | -0.04762 | 0.073123 | 0.0008154 | 0.74 |
| Yr. chinook sal. | 191 | -0.11073 | 0.088765 | 0.0009689 | 0.70 |
| Steelhead | 100 | -0.23261 | 0.105870 | 0.0011684 | 0.71 |
| Subyr. chinook sal. | 1314 | -0.11986 | 0.057360 | 0.0020409 | 0.78 |

MODEL B--WEIGHT

$$\hat{Y} = B_0 + B_1 X_1 + B_2 X_2$$

Where: $\hat{Y}$ = Stomach content weight ($g^{1/3}$ a/)

$X_1$ = fullness 3-6 b/

$X_2$ = fish weight (g)

| Species | n | B0 | B1 | B2 | r |
|---|---|---|---|---|---|
| Coho salmon | 595 | 0.03373 | 0.073175 | 0.0012856 | 0.74 |
| Yr. chinook sal. | 191 | 0.00713 | 0.089054 | 0.0008066 | 0.70 |
| Steelhead | 100 | -0.05957 | 0.108370 | 0.0008304 | 0.71 |
| Subyr. chinook sal. | 1314 | 0.02353 | 0.057047 | 0.0047928 | 0.76 |

a/ The cube root transformation of the stomach content weight was used to produce normally distributed residual values of uniform variance.

b/ Fullness values 1, 2, and 7 omitted from the analysis because their relationship to stomach content weight is not linear.

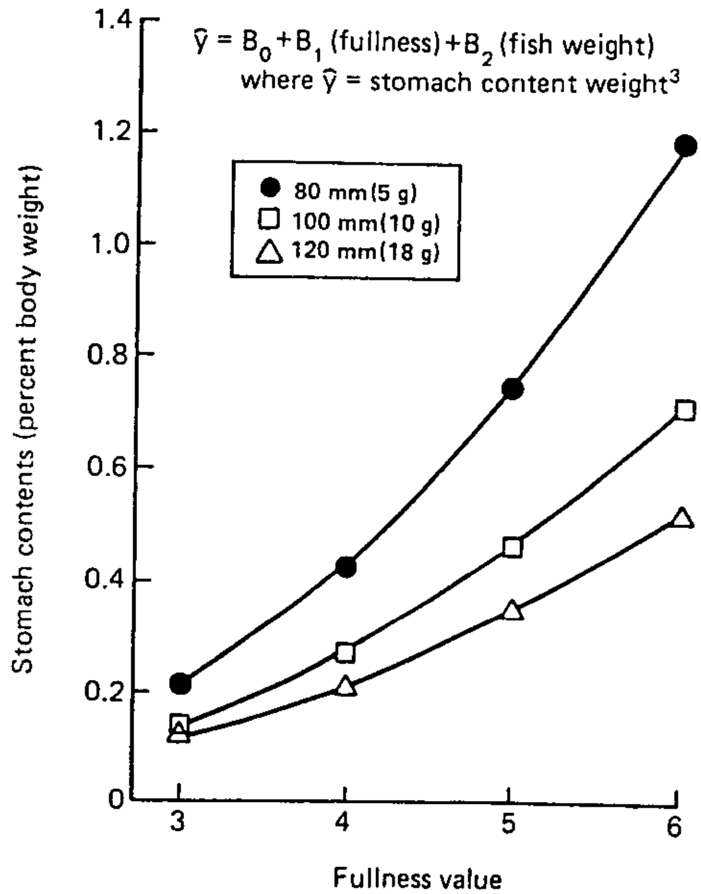


Figure 62. --Percent body weight of stomach contents for 5, 10, and 18 g subyearling chinook salmon as predicted from a regression model with stomach fullness and fish weight as predictor variables from Table 47.

sufficiency for even a few groups of migrants would be difficult and time consuming. With substantially less effort, evaluation of stomach fullness and content weights provided a preliminary evaluation of feeding behavior and relative food intake for thousands of individuals representing many groups. Visual observation of fullness takes about 1 minute per stomach compared with hours, in addition to the specialized equipment, required for a comprehensive analysis.

There are compromises associated with using estimates for fullness and stomach content weight to describe food consumption. Comparisons between dissimilar sized fish are affected by nonlinear variation of food requirements over the size range of juvenile migrants (Patrick 1974). Also, comparisons between similar sized fish captured at different times are affected by differences in metabolic activity associated with water temperature and differences of caloric intake from the prey items consumed. Therefore, statistical comparisons of fullness values were made only between mark groups passing Jones Beach within narrow date ranges. Significant differences in fullness means were not always directly correlated with fish size, but the mean lengths are presented for consideration (Figs. 54, 55, 57, 59, and 60).

Fish lose weight in response to low nutritional intake. To correctly identify fish groups that have lost weight from malnutrition, feeding indices (%BW) were calculated using length transformed to a corresponding body weight according to length/weight relationships observed for tagged fish at Jones Beach (Table 48).

Compensation Mechanism for Low Food Availability.--Foraging behavior of fish changes in response to food availability--Dill (1983) termed this adaptive flexibility. As hunger increases, search for food increases and diet includes less preferred prey. Consequently, a change in diet or a change in migration rate, as well as increased numbers of empty stomachs might be indicators of low food availability. A diet change for subyearling chinook salmon was observed at Jones Beach following the eruption of Mount St. Helens. Sediment deposition reduced the supply of a preferred food item, *Corophium salmonis*, which resulted in a diet shift to insects and mysids.

Food Consumption Compared with Juveniles in Other Locations.--Stomach content weights (%BW) of migrant chinook salmon captured at Jones Beach were compared to those of juveniles in other geographical areas, rivers, and estuaries and indirectly to traditional feeding rates at hatcheries.

1. Subyearling Chinook Salmon: Subyearling chinook salmon, 77-82 mm fork length, captured at Jones Beach during May and June (about 5 g; Table 46), averaged about half full stomachs and stomach content weights averaged about 0.7 %BW (wet weights, Table 46).[21/] Herrman (1971) found that stomach

21/ During May and June, the water temperatures at Jones Beach ranged between 10° and 19°C (mean 14°C). For this evaluation, non-feeding fish were considered atypical migrants and were not used, therefore, providing a liberal estimated food consumption for fish at Jones Beach.

Table 48.--Length/weight relationships of tagged juvenile salmonids captured at Jones Beach during 1982 and 1983.

| Species | n | Prediction Formula[a/] | Correlation coefficient (r) |
|---|---|---|---|
| Coho salmon | 3831 | $\hat{wt} = (1.24 \times 10^{-5})(lth^{2.94})$ | 0.96 |
| | | $\hat{lth} = (51.42)(wt^{0.313})$ | |
| Yearling chinook salmon | 893 | $\hat{wt} = (3.05 \times 10^{-6})(lth^{3.22})$ | 0.98 |
| | | $\hat{lth} = (52.98)(wt^{0.300})$ | |
| Steelhead | 1462 | $\hat{wt} = (1.37 \times 10^{-5})(lth^{2.91})$ | 0.98 |
| | | $\hat{lth} = (49.90)(wt^{0.332})$ | |
| Subyearling chinook salmon | 7215 | $\hat{wt} = (6.79 \times 10^{-6})(lth^{3.08})$ | 0.99 |
| | | $\hat{lth} = (47.47)(wt^{0.320})$ | |

a/ wt = weight of fish (g)

ltn = fork length of fish (mm)

^ = predicted value

content weights averaged 1.2 %BW (wet weights) for similar sized chinook salmon captured in the Chehalis River estuary, Washington. Healey (1980) reported that stomach content weights ranged from 0.1 %BW in May (during peak abundance) to 5 %BW in June for chinook salmon in the Nanaimo River estuary, British Columbia (wet weights in 1975, dry weights in 1976 and 1977). Becker (1973) found that dry stomach content weights averaged 0.4% dry food to wet body weight for 5-g chinook salmon collected in the Hanford reach of the Columbia River (RKm 591 to 629). Converting these percentages to represent %BW (dry weight), assuming preserved fish were 20% dry matter (Healey 1978), the average stomach content weight of Becker's fish was about 2 %BW.

These comparisons generally indicate that subyearling chinook salmon captured at Jones Beach had low food consumption. However, both of the aforementioned estuary studies characterize subyearling chinook salmon residing in the estuary (Healey calculated growth of fish in June to be 5.8 %BW/day). Likewise, fish examined by Becker in the Columbia River were residents of the sampling area. Subyearling chinook salmon captured at Jones Beach were actively migrating (average 16 to 18 km/day, Dawley et al. 1984) and such activity and physiological state (we assume that most are smolts) may affect foraging behavior. Loftus and Lenon (1977) observed heavy feeding by subyearling chinook salmon during downstream migration in the the Salcha River, Alaska. Over 99% of juvenile chinook salmon smolts (mean length 73 mm) had fed prior to capture, and most stomachs were full and distended. Fish were sampled 1,544 km upstream from the ocean, and those smolts may not be comparable to smolts collected only 75 km from the ocean at Jones Beach.

2. Yearling Chinook Salmon: Stomach content weights for yearling chinook salmon were available from two upstream sites in the Columbia River: the reservoir of Wanapum Dam (RKm 707) and the reservoir of John Day Dam (RKm 395) (Rondorf[22/]). The mean weight of fish captured at RKm 707 was 22.8 g and stomach contents averaged 0.6 %BW whereas at RKm 395, fish were smaller, mean weight of 16.0 g and stomach contents averaged 0.8 %BW (dry stomach content converted to wet weight, samples collected at 0900 h during May) l. At Jones Beach during May and June, stomach content weights for similar sized fish were less: 0.2 %BW (n = 27, weight range 20.0 - 26.0 g) and 0.6 %BW (n = 9, weight range 12.0 - 18.5 g).

3. Coho salmon and Steelhead: No data were found regarding food consumption of yearling coho salmon or steelhead in rivers or estuaries.

Food Consumption at Hatcheries.--Bardach et al. (1972) reported that salmon reared in hatcheries at 10°-15°C require daily rations of about 1 %BW/day for body maintenance, and upwards to 7 %BW/day for growth (weight of

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22/ D. Rondorf, U.S. Fish and Wildlife Service, National Fisheries Research Center, Willard Station, Star Rt., Cook, WA 98605; pers. commun.

food, about 20% water; and wet weight of fish). Fairgrave[23/] found that juvenile coho salmon ( 10-20 g fish) fed various hatchery diets at 0.6 %BW/day or less, exhibited negative, zero, or little growth.

Daily and morning hours rations were estimated for migrant fish captured at Jones Beach in May and June to compare with rations at hatcheries (Table 49). Die1 observations of food consumption by juvenile salmonids were not made, so we assumed that available daily feeding curves in published and unpublished literature (Johnson and Johnson 1981; Rondorf[22/] Table 49) properly represented diurnal feeding behavior of migrants captured at Jones Beach. The proportion of the total daily meal present in the gut in mid-morning (0800 to 0900 h) observed in those studies was about 22%. Assuming that proportion for average sized migrant fish at Jones Beach (Table 46), the total daily ration for each species was about 3.0, 0.7, 1.0, and 0.6 %BW/day, respectively for subyearling and yearling chinook salmon, coho salmon, and steelhead (wet weight of food). If these estimated daily rations are converted to 20% water for comparison to hatchery diets (0.03, 0.06, 0.13, and 0.05 %BW/day, respectively), all are substantially below the body maintenance requirements for hatchery feeds.

Interspecific Interaction.--Species interaction possibly caused lower feeding rates for yearling chinook salmon in May, when all salmonid species were present in the Columbia River in large numbers. Stein et al. (1972) observed that chinook salmon are less competitive than coho salmon, which impacts quantity and quality of food ingested. Interaction with steelhead elevated stress among yearling chinook salmon (Park et al. 1983, 1984), which may also affect their feeding success. Subyearling chinook salmon are more shore oriented than the yearling fish, thus may not be affected by the increased numbers of year1ing migrants. The observed decline in food consumption for all yearling fish during early June immediately following the peak migration period suggests one or more of the following: (1) the food resources were cropped by large numbers of migrant fish, (2) the food resources available to the migrants were reduced by increased water volume during June, or (3) yearling fish passing at the later portion of the migration period were poor foragers.

## Conclusions

1. Percentages of non-feeding fish within populations observed at Jones Beach were generally lower than 20, 10, and 30% for chinook and coho salmon and steelhead, respectively.

2. Relatively low mean fullness and high incidences of empty stomachs in particular fish groups were correlated with the following: close proximity of

23/ B. Fairgrave, Oregon Department Fish and Wildlife, 17330 S.E. Evelyn St., Clackamas, OR; pers . commun.

Table 49.--Published and unpublished data assessing daily and morning hours food consumption by juvenile salmonids.

| River | Species | Age | Total daily[a] meal (mg) | Observations at 0800 or 0900 h: stomach content (mg) | Observations at 0800 or 0900 h: Portion of daily meal (%) |
|---|---|---|---|---|---|
| Orwell Brook[b] New York State | Coho salmon | 0 | 10.6 | 1.83 | 17.3 |
| Orwell Brook[b] New York State | Steelhead | 0 | 7.8 | 1.40 | 17.9 |
| Columbia River[c] at RKm 395 | Chinook salmon | 1 | 158.2 | 31.1 | 19.7 |
| Columbia River[c] at RKm 707 | Chinook salmon | 1 | 69.4 | 23.9 | 34.4 |
| | | | | Average | 22.3 |

a/ Daily meal = amount of food consumed per day.
b/ Johnson and Johnson (1981).
c/D. Rondorf, U.S. Fish and Wildlife Service, National Fisheries Research Center, Willard Station, Star Rt., Cook, WA 98605; pers. commun.

release to recovery site and/or short migration period prior to recovery, early March release of yearling chinook salmon, high turbidity from the eruption of Mount St. Helens, and disease incidence prior to release at the hatchery. Some stocks of fish with high percentages of non-feeding individuals could not be correlated with known physical or biological factors likely to have affected feeding.

3. Relatively high mean fullness values were documented for Stayton Pond groups that were cultured in earthen ponds.

4. The turbid water resulting from the eruption of Mount St. Helens temporarily decreased food consumption by several stocks of subyearling chinook salmon and coho salmon.

5. The eruption of Mount St. Helens is not expected to have long term effects on the food resources of subyearling chinook salmon. Their decreased consumption of amphipods and increased consumption of insects, mysids, and cladocerans appears to be a temporary change. Partial restoration of amphipod consumption was observed in 1982, and continued improvement of benthic substrate should allow complete recovery to pre-eruption levels.

6. Jones Beach appears to be a geographical area of dietary transition for subyearling chinook salmon. Other researchers found that fish captured upstream consumed primarily insects, and fish captured downstream consumed primarily amphipods, whereas fish we captured at Jones Beach consumed both.

7. The decline in food consumption of yearling chinook salmon during the peak outmigration (May) may have been related to interspecific interaction and slow recovery of the food resources available. Significant dietary overlaps were indicated between the other salmonids. Decreased consumption was not apparent for subyearling chinook and coho salmon and steelhead.

8. Food items most important to juvenile salmonids near Jones Beach were insects including Diptera, Hymenoptera, Coleoptera, Ephemeroptera, and Trichoptera; and crustaceans including Amphipoda and Cladocera.

9. Stomach content weights from subyearling and yearling chinook salmon captured at Jones Beach were less than similar sized fish examined at other estuarine and riverine locations. Results of proximate analyses of stomach contents for fish captured at Jones Beach indicated that the food eaten was not of sufficient quality to compensate for low consumption rates.

10. Visual assessment of stomach fullness is a fast and economical method for examining the food consumption of large numbers of fish.

## Visceral Fat Content of Subyearling Chinook Salmon Captured at Jones Beach

### Introduction

The quantity of fat within the visceral cavity surrounding the pyloric caeca, stomach, intestine, and spleen of juvenile salmonids was used by Myers (1980) to differentiate between hatchery and wild fish in the Yaquina River estuary. In Myers' study, none of 28 wild coho or 87 wild chinook salmon had fat visible in the visceral cavity; whereas many of the hatchery fish had internal organs completely obscured by fat.

We examined tagged subyearling chinook salmon captured at Jones Beach to determine if differences in visceral fat could be used to differentiate between wild and hatchery fish in the Columbia River. If clear-cut differences were apparent for tagged hatchery fish, then the ratio of wild to hatchery juveniles could be. estimated for unmarked fish.

In 1983, comparisons of visceral fat between wild and hatchery stocks of subyearling chinook salmon were possible. Timing at Jones Beach of wild fish from the Lewis River (96,444 tagged fish, mentioned earlier--Table 36) was coincidental with tagged fish from several hatcheries including the Cowlitz. Comparison with Cowlitz stock was particularly appropriate because the Lewis and Cowlitz Rivers enter the lower Columbia River at RKm 140 and RKm 109, respectively, and the distance of migration was similar for both stocks.

### Methods

Generally, fish used for visceral fat observations were those selected for stomach fullness observations; the selection was based on holding time restrictions necessary for fullness observation and time available for additional processing.

The body cavities of selected fish were opened longitudinally, and the body organs were observed for surrounding fat. Observations were quantified numerically: 1 = no visible fat; 2 = some fat present; and 3 = extensive quantities of fat present.

Individual fish were weighed to $\pm$ 0.005 g (W) and measured to $\pm$ 0.5 mm fork length (L); condition factor (K) was calculated for each individual according to the formula $K = W/L^3$.

### Results

From June through August 1983, a total of 1,748 tagged subyearling chinook salmon were examined for quantities of visceral fat (1,522 hatchery fish and 226 wild fish). Some individuals within all marked groups examined had visceral fat. Twenty eight percent of the hatchery fish examined had no observable visceral fat, 38% had some fat, and 34% had extensive fat

(Table 50). Included in the hatchery group were 481 fish released from the Cowlitz Hatchery (31% no fat, 36% some fat, and 33% extensive fat), There were 226 wild fish from the Lewis River examined (47% no fat, 44% some fat, and 9% extensive fat).

There was a strong decrease through time for the proportion of Cowlitz Hatchery fish having visceral fat and an increase through time for the Lewis River wild fish (correlation coefficient, r = -0.9 and 0.6, respectively) (Fig. 63). The positive slope for the relationship of visceral fat to date of capture for the wild fish may be related to decreased competition for food during late July and August; large numbers of hatchery fish were migrating through the estuary in June; in comparison, few fish were passing Jones Beach in late July and August. More food may be available to later migrants which resulted in increased visceral fat of Lewis River wild fish.

Condition factors of fish from Cowlitz Hatchery were nea ly constant through the date range of recovery; overall mean = $10.4 \times 10^{-6}$ (Fig. 64). Conditio factors for Lewis River wild fish were higher (overall mean $10.7 \times 10^{-6}$) and showed strong positive correlation with date of capture (r = 0.8). By early August the condition factor of the wild fish reached 11.0x10-6.

Stomach fullness of the wild fish was consistently greater than that of Cowlitz Hatchery fish and of other hatchery fish passing during the period.

While examining wild subyearling chinook from the Lewis River, we observed a high incidence of nematodes in the visceral cavity (primarily in the air bladder). During the time period when we consistently recorded the incidence (1 July - 8 September 1983), 64% of the fish observed contained nematodes. These fish appeared outwardly healthy and showed no significant difference in relative stomach fullness from those of the same tag groups without nematodes ($P>0.4$).

## Conclusions

1. Observations of visceral fat content for subyearling chinook salmon captured in the Columbia River at Jones Beach are not useful for separating Lewis River wild stock from hatchery fish because a substantial portion of wild fish (53%) contained fat and 28% of the hatchery fish observed contained no fat.

2. Differences in natural food resources available to wild chinook salmon may exist between the Lewis and Yaquina Rivers which could explain the observed difference in the percentage of individuals containing visceral fat (53 and 0%, respectively).

Table 50.--Visceral fat observations from subyearling chinook salmon captured at Jones Beach, June through August 1983.

| | Fish observed | | | | | | |
|---|---|---|---|---|---|---|---|
| | No fat | | Some fat | | Extensive fat | | Total |
| | no. | % | no. | % | no. | % | no. |
| Total hatchery fish | 423 | 28 | 574 | 38 | 525 | 34 | 1,522 |
| Cowlitz Hatchery fish | 147 | 31 | 175 | 36 | 159 | 33 | 481 |
| Lewis River wild fish | 106 | 47 | 99 | 44 | 21 | 9 | 226 |

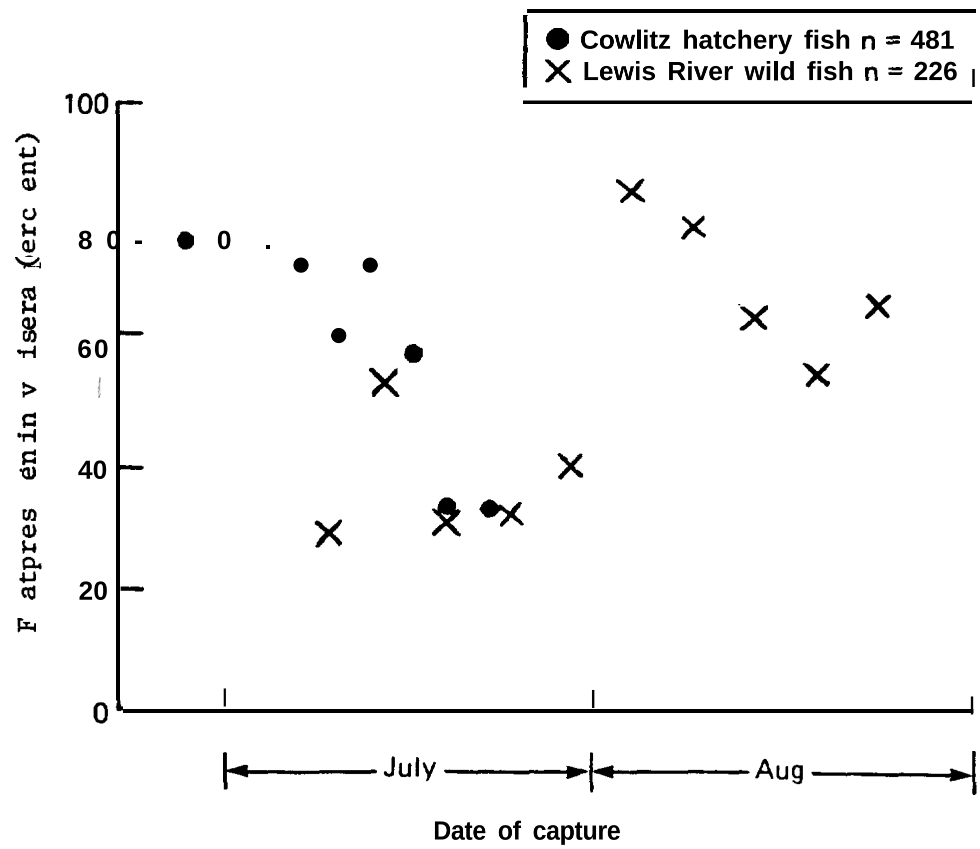


Figure 63.--Temporal plot of the proportion of subyearling chinook salmon of the Lewis River wild and the Cowlitz Hatchery stocks containing fat in the visceral cavity, from marked individuals captured at Jones Beach.

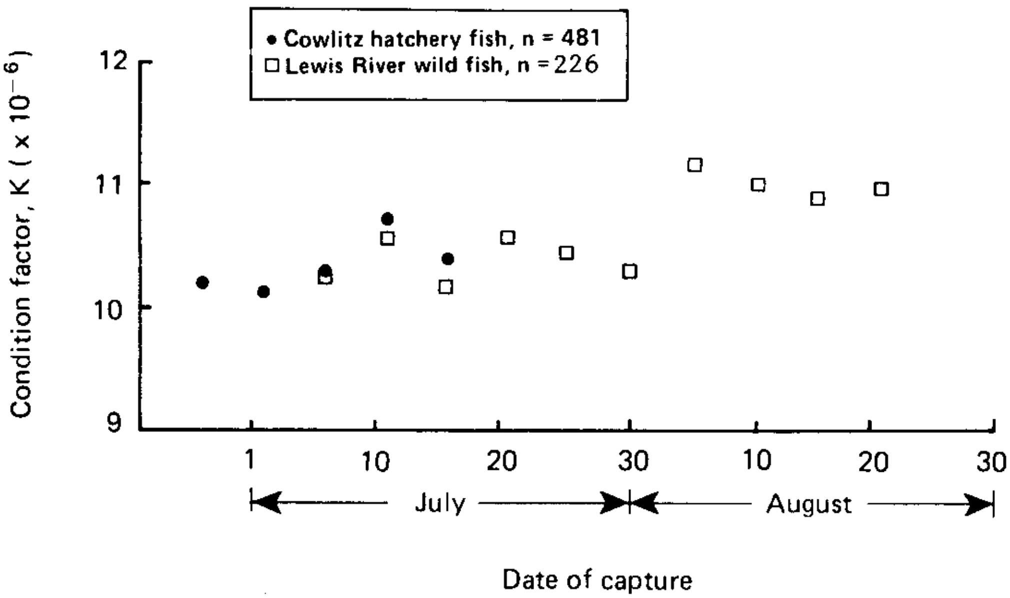


Figure 64.--Condition factor for Cowlitz Hatchery and Lewis River wild subyearling chinook salmon by 5-day intervals (intervals with less than nine fish measured were omitted).

3. Cowlitz Hatchery fish rapidly lost visceral fat following release from the hatchery, whereas wild Lewis River fish gained visceral fat during the period of capture at Jones Beach.

4. Wild fish from Lewis River generally had more food in their stomachs than hatchery fish.

## Catches of Non-Salmonids

### Introduction

Capturing fish of non-targeted species is inherent in sampling juvenile salmonid populations. Migrating and resident species were captured at all times of the year and in large numbers. The objective of this part of the report is to document catches of these fish.

### Results

Non-salmonids comprised nearly 40% of the total catch at Jones Beach (Dawley et al. 1985a). Adult and juvenile threespine stickleback, Gasterosteus aculeatus, and peamouth, Mylocheilus caurinus, were captured in large numbers year-round. Large catches of juvenile American shad, Alosa sapidissima, were obtained during their migration period (April through November). Two separate size groups were recovered each year. Large individuals were generally captured between April and August with a peak in May when they averaged about 105 mm fork length. More numerous smaller individuals were captured from July to December; peak catches occurred during the fall (undefined because of limited sampling in the fall) at an average fork length of about 70 mm. Eastern banded killifish, Fundulus diaphanus, were captured in the beach seine in 1971, 1981, and 1983 (Ledgerwood et al. 1985); the Columbia River is not described as part of the normal geographical range for this species (Scott and Crossman 1973).

In 1980, there was a significant increase in beach seine catches of several predator and scavenger fish species at Jones Beach, beginning with the heavy turbidity created by the eruption of Mount St. Helens. Catches of northern squawfish, Ptychocheilus oregonensis; prickly sculpin, Cottus asper; peamouth; and suckers, Catostomus sp., in late May and June were more than double those of previous years (Fig. 65). These fish were adults, not juveniles . It is possible that the increase in the catch resulted from fish being forced out of the Toutle and Cowlitz Rivers by high water temperature and turbidity.

Population changes of northern squawfish at Jones Beach were of particular interest due to their role as a predator in other areas (Ricker 1941; Jeppson and Platts 1959; Thompson 1959; Thompson and Tufts 1967; Steigenberger and Larkin 1974; Uremovich et al. 1980; Bentley and Dawley 1981). We observed an increase of squawfish during the sampling period. Catches escalated from none in 1966 to 1,754 in 1981. The trend of population increase was accelerated in 1980, as previously discussed. Stomach contents from a subsample of squawfish captured in 1983 were examined to determine the

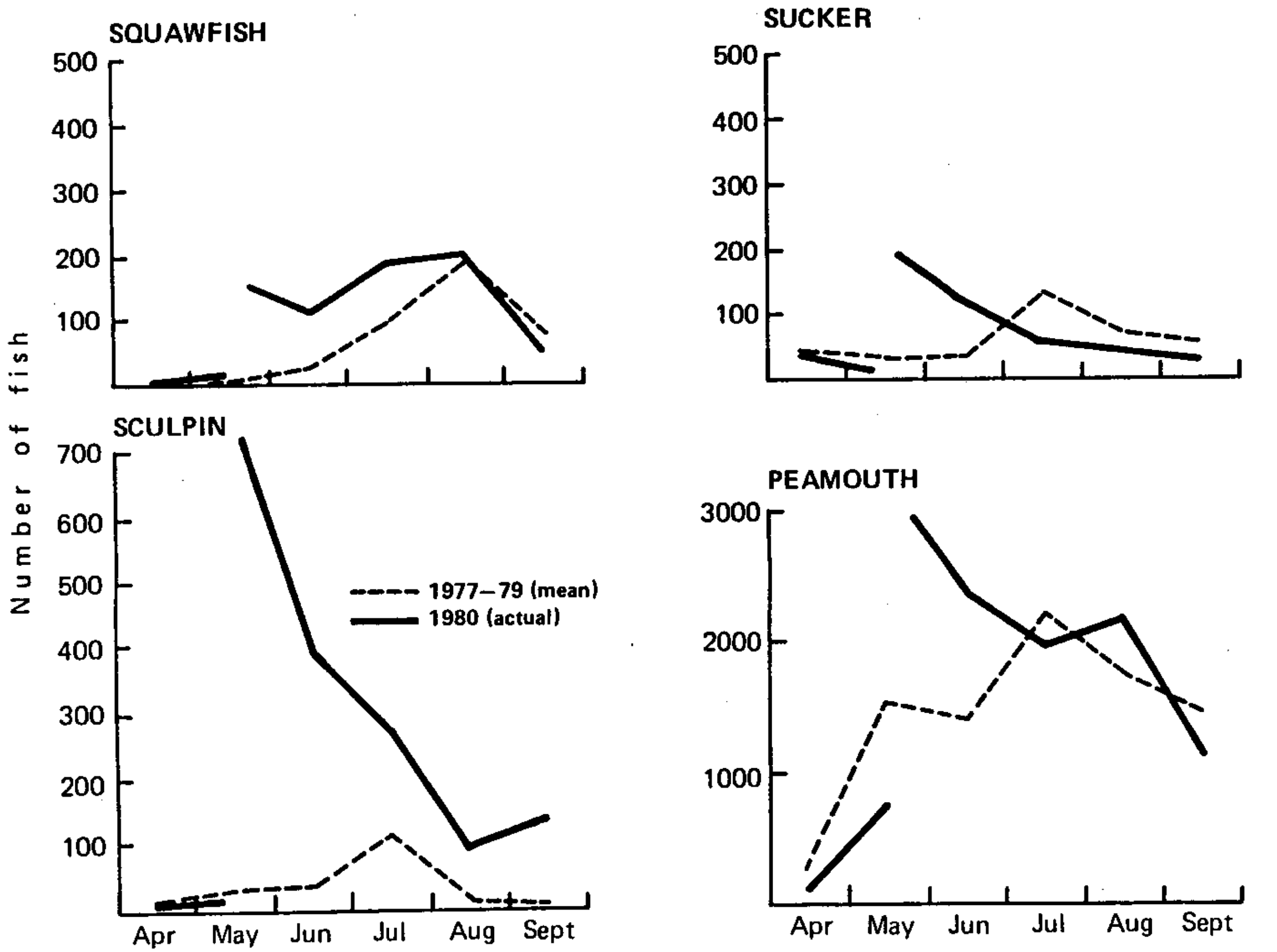


Figure 65. --Monthly beach seine catches of predator and scavenger species at Jones Beach for 1977-1979 (3-year means), compared to 1980. The month of May 1980 is divided into catches before and after arrival of highly turbid water.

extent of predation on juvenile salmonids. Ninty-five percent of the 197 squawfish examined contained food items, primarily crustaceans, insects, and fish. None of the squawfish examined had consumed salmonids. For details of the squawfish population change and stomach content analyses refer to Kirn et al. (1985).

## SUMMARY AND CONCLUSIONS

1. Generally, subyearling chinook salmon concentrate in shallow near-shore areas of the estuary, and when they are in deep water areas they are found within 3 m of the surface. However, large fish (< 50/lb) and those that migrate long distances (> 250 km) before entering the estuary do not concentrate in near-shore areas.

2. Yearling salmon and steelhead concentrate in mid-river areas except early in the year (March, April, and early May), presumably prior to smoltification.

3. Most movement of juvenile salmonids through the estuary occurs during daylight hours. Tidal conditions and direction of flow do not appear to substantially influence die1 movement patterns. Generally , die1 movement patterns appear consistent between years, and sampling 7 h/day in the morning provides samples which are representative of the overall migrant population.

4. Timing of the juvenile salmonid migrations into the estuary is primarily dependent on dates of release from hatcheries and river flow. Generally, high river flows cause faster migration through the river. In some instances , fall released fish groups overwintered upstream from Jones Beach and migrated in the spring; size of fish and stock differences appear to have influenced the migration timing.

5. Movement rates of marked groups of subyearling chinook salmon and coho salmon increase with size at release and distance of migration. From 1966 to 1972, larger individuals of marked groups migrated at a faster rate than smaller fish; however, within groups observed from 1977 to 1983, the larger individuals did not necessarily move at a faster rate. This change of migration behavior may have resulted from a general increase in size of fish at release, and, for coho salmon specifically, later dates of release. We speculate both factors increased the proportion of smolted fish among the smaller individuals of most groups and resulted in more uniform migration rates.

6. Movement rates through the estuary and into the ocean are similar to rates from release site to the estuary, indicating that the use of the Columbia River estuary by juvenile salmonids originating upstream from Jones Beach is rather limited compared to documented use of other estuaries.

7. Increased river flow causes decreased catch rates of all species, which decreases precision of comparisons between time periods. An adjustment factor was computed to standardize catch percentages of groups recovered at different flow conditions.

8. Total numbers of subyearling chinook salmon, yearling chinook salmon, coho salmon, or steelhead sampled in the estuary do not relate to numbers of returning adults be cau se overal 1 survival rates are different between stocks . However,estuarine catch data are useful for within stock examination of survival differences among treatments. Generally , estuarine samples which show statistically significant differences among groups , show similar

differences in adult recoveries. However, many groups which showed differences in returns of adults did not show differences in juvenile sampling data. Trends of survival differences between treatment and control groups were attainable from estuarine sampling in evaluations of size at release; release date; release site; and from particular studies with density, nutrition, and fish stocks.

9. Minimum-size thresholds for migration and survival of Columbia River coho and wild fall chinook salmon and Willamette steelhead were supported with Jones Beach data.

10. Baseline data for catch rates for marked groups can be used for identifying groups which have substantially decreased survival during river migration.

11. Food consumption of migrants examined at Jones Beach appears to be substantially less than in other reaches of the river and in other river systems. Interspecific interaction or competition for food may be decreasing the overall food consumption rates for yearling chinook salmon. Adverse environmental conditions from the eruption of Mount St. Helens caused decreased feeding, alteration of available food resources, and decreased survival of juvenile migrants. Cultural practices, poor health, and release timing also affect food consumption of migrants. Although insufficient data are available for evaluation, we suspect that decreased feeding rate may impact survival to adulthood.

12. Absence of fat within the viscera of migrants captured at Jones Beach was not usable as an indicator for wild subyearling chinook salmon.

13. Resident populations of squawfish have increased dramatically at Jones Beach during the period of sampling, however, there are no signs of their predation on salmonids.

14. Researchers and culturists made extensive use of the estuarine sampling data to evaluate migration timing and relative success of marked groups. Additionally, marked fish from specific groups were utilized to: compare various physiological changes which occurred during migration, to evaluate transmission of disease between stocks originating from different tributary streams that mingled during migration, and to evaluate changes of sex ratio within populations of coho salmon following migration. We conclude that observation of marked fish groups at the terminus of freshwater migration is important to salmonid enhancement activities.

# ACKNOWLEDGMENTS

The success of this evaluation of estuarine catch data depended upon the cooperation and assistance from personnel of state and federal fishery agencies. Of primary importance in the study of subyearling chinook salmon survival were personnel of the U.S. Fish and Wildlife Service (USFWS) Elmo Barney and his staff, Jack Bode1 and his staff; personnel of the Oregon Department of Fish and Wildlife (ODFW) Ken Johnson, Art Oakley, Ed Weiss, Brunell Boho, Vern Knowles, and Ray Sheldon and his staff; personnel of the Washington Department of Fisheries (WDF) Dick Noble, Harry Senn, Bob Haggan, Bill Hopley, Dick Johnson and his staff, and Carl Ross and his staff. Mark release information and adult recovery data were expedited for our needs; we relied heavily on assistance from Steve Leek and Steve Olhausen of USFWS; Dennis Issac, Harold Hansen, Eugene Smith, Jeff Zakel, Jean Legasse, and Lynn Roberts of ODFW; Dick O'Conner, Gary Sherman, Bob Foster, Guy Norman, and Rich Schneider of WDF; and Rodney Duke of the Idaho Deparment of Fish and Game. Our thanks to these individuals for helping produce these data and observations.

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# APPENDIX A

## Uses of Estuarine Catch Data and Biological Samples or Observations Collected for Related Research

## INTRODUCTION

Upon request biological observations were made and tissue samples collected for other research programs. Tissues and internal organ observations were only made from fish sacrificed for tag identification. The objective of this section of the report is to provide examples showing how data obtained at Jones Beach are being used by managers and other researchers.

## BIOLOGICAL SAMPLES

1. Gas bubble disease incidence for water regulation and smolt release timing by the Columbia River Fish and Wildlife Commission[1/] (1977-83).

2. Gill tissue samples for adenosine triphosphatase ($Na^{+}$-$K^{+}$ ATPase) analysis by researchers from NMFS[2/] (1978-83) and ODFW[3/] (1978-79).

3. Scales for comparison with adult scales by ODFW[4/] (1979-83) Washington Department of Game[5/] (WDG) (1980-81), University of Washington (U of W)[6/] (1982-83), and Oregon State University (OSU)[7/] (1982-83).

4. Stomach samples for basic research by USFW[8/] (1979) and WDG[5/] (1980).

1/ Columbia River Fish and Wildlife Commission, Lloyd Bldg., Suite 1240, NE Multnomah St., Portland, Oregon 97232.
2/ W. S. Zaugg, NMFS, Star Rt., Cook, WA 98605.
3/ Ron Williams, ODFW, 303 Extension Hall, OSU, Corvallis, OR 97331.
4/ Concannon, G., ODFW, P.O. Box 182, Maupin, OR 97037; Hansen, H., ODFW, 1733 Evelyn Street, Clackamas, OR 97015; and Murphy, S., ODFW, Oregon State University, Corvallis, OR 97331.
5/ Loch, J.,WDG, 1351 Kalama River Rd., Kalama, WA 98625.
6/ Mathews, S., U of W, School of Fisheries, Seattle, WA 98195.
7/ Fisher, J.,School of Oceanography, OSU, Corvallis, OR 97331.
8/ Washington, P.,USFWS, Naval Support Activity, Bldg. 204, Seattle, WA 98115.

5. Incidence of enteric red-mouth in marked fall chinook salmon from Bonneville Hatchery for survival comparison by ODFW[9/] (1979).

6. Incidence of sunburn in marked coho salmon from Willard NFH for survival comparison by USFWS (1979).[10/]

7. Sex determinations for survival comparisons of coho by USFWS[9/] (1981-82).

8. Smolt carcasses for a salmon predation study of marine mammals by WDG[11/] (1982).

9. Branded fish for bioenergetics study by USFWS[12/] (1982-83).

10. Live unmarked fish for disease study by OSU[13/] (1982-83).

11. Incidence of nematode infestation in wild fish from the Lewis River for researchers from Washington Department of Fisheries (WDF)[14/] (1983).

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10/ Leek, S., USFWS, Little White Salmon NFS, Cook, WA 98605.
11/ Beach, R. J., WDG, 35 Portway, Astoria, OR 97103.
12/ Rondorf, D., USFWS, Cook, WA 98605.
13/ Fryer, J. L., OSU, Corvallis, OR 97331.
14/ Guy Norman, WDF, 16118 NE 219th St., P.O. Box 999, Battle Ground, WA 98604.

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## APPENDIX B

### Miscellaneous Tables Relating to Migration of Juvenile Salmonids

Appendix Table B1.--Number and percent recovery of juveniles at Jones Beach and adults from mark groups which were identified as replicates or near replicates and used to empirically define sampling variability.

REPLICATE GROUPS 1983

| Mark a/ (Loc Br Rot) (Ag/D1/D2) | Release Information: Site (source) b/ | Number | Date (da/mo/yr) | Juvenile catch at Jones Beach c/ (no.) | (%) | Adult Recoveries d/ (no.) | (%) |
|---|---|---|---|---|---|---|---|
| | | | *Subyearling chinook salmon* | | | | |
| 07/27/27 | Bonn. Hat. | 50,000 | 04/May/83 | 82 | 0.164 | - | - |
| 07/27/28 | | 50,800 | | 90 | 0.177 | - | - |
| 07/27/29 | " " | 52,600 | " | 85 | 0.162 | - | - |
| 07/27/30 | | 47,400 | | 86 | 0.181 | - | - |
| 05/11/42 | Spring Cr. Hat. | 49,700 | 28/Apr/83 | 65 | 0.131 | - | - |
| 05/11/43 | | 51,300 | | 71 | 0.138 | - | - |
| 05/11/44 | " " | 51,700 | | 82 | 0.159 | - | - |
| 05/11/45 | | 52,100 | | 89 | 0.171 | - | - |
| RD U 3 | Bonn. Dam | 51,400 | 02-03/May/83 | 89 | 0.173 | - | - |
| RD U 1 | (Sp. Cr. Hat.) | 53,200 | | 100 | 0.188 | - | - |
| LD U 3 | " " | 53,900 | | 107 | 0.198 | - | - |
| LD U 1 | | 52,800 | | 107 | 0.203 | - | - |
| 07/23/28 | Willam. River | 28,900 | 26/Apr-19/May/83 | 17 | 0.059 | - | - |
| 07/28/30 | (Stayton Pd.) | 24,000 | | 24 | 0.100 | - | - |
| 07/28/31 | | 26,000 | | 19 | 0.074 | - | - |
| 07/28/32 | | 26,200 | | 15 | 0.057 | - | - |
| 07/28/33 | | 24,800 | | 36 | 0.150 | - | - |
| 07/28/34 | | 26,800 | | 16 | 0.060 | - | - |
| | | | *Yearling chinook salmon* | | | | |
| 07/23/63 | Bonn. Hat. | 45,900 | 01/Nov/82 | 123 | 0.268e/ | - | - |
| 07/25/46 | | 51,600 | | 123 | 0.238e/ | - | - |
| 07/25/48 | " " | 50,700 | | 107 | 0.211e/ | - | - |
| 07/25/45 | | 48,600 | | 107 | 0.220e/ | - | - |
| 63/24/50 | Cowlitz Hat. | 8,300 | 01/Sep/82 | 1 | 0.012e/ | - | - |
| 63/26/03 | | 51,200 | | 15 | 0.029e/ | - | - |
| 63/25/05 | " " | 73,000 | 04/Apr/83 | 18 | 0.025 | - | - |
| 63/25/06 | | 77,500 | | 26 | 0.034 | - | - |
| | | | *Coho salmon* | | | | |
| 63/26/13 | Cowlitz Hat. | 10,900 | 03/May/83 | 19 | 0.174 | - | - |
| 63/26/14 | | 10,400 | | 11 | 0.106 | - | - |
| 63/26/15 | | 10,400 | | 26 | 0.250 | - | - |
| 63/26/16 | | 10,700 | | 16 | 0.150 | - | - |
| 63/26/17 | | 10,000 | | 12 | 0.120 | - | - |
| 63/26/18 | " " | 10,000 | " | 8 | 0.080 | - | - |
| 63/26/19 | | 10,200 | | 8 | 0.078 | - | - |
| 63/26/20 | | 10,100 | | 19 | 0.188 | - | - |
| 63/26/21 | | 10,300 | | 16 | 0.155 | - | - |
| 63/26/22 | | 10,500 | | 21 | 0.200 | - | - |
| 63/26/23 | " " | 10,600 | " | 24 | 0.226 | - | - |
| 63/26/24 | | 10,200 | | 11 | 0.108 | - | - |
| 63/26/25 | | 10,300 | | 14 | 0.136 | - | - |
| 63/26/26 | | 10,600 | | 7 | 0.066 | - | - |
| 63/26/27 | | 10,400 | | 15 | 0.144 | - | - |

Appendix Table B1.--continued.

Coho salmon

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 63/26/28 | Cowlitz Hat. | 10,200 | 03/May/83 | 19 | 0.186 | - | - |
| 63/26/29 | | 10,300 | | 16 | 0.155 | - | - |
| 63/26/30 | | 10,400 | | 17 | 0.163 | - | - |
| 63/26/31 | | 10,200 | | 17 | 0.167 | - | - |
| 63/26/32 | | 10,600 | | 17 | 0.160 | - | - |
| 63/26/33 | " " | 10,500 | " | 21 | 0.200 | - | - |
| 63/26/34 | | 10,100 | | 22 | 0.218 | - | - |
| 63/26/35 | | 10,600 | | 11 | 0.104 | - | - |
| 63/26/36 | | 10,400 | | 16 | 0.154 | - | - |
| 63/26/37 | | 10,500 | | 10 | 0.095 | - | - |
| 63/26/38 | " " | 10,500 | " | 17 | 0.162 | - | - |
| 63/26/39 | | 10,100 | | 16 | 0.158 | - | - |
| 63/26/40 | | 10,200 | | 15 | 0.147 | - | - |
| 63/26/41 | | 10,000 | | 13 | 0.130 | - | - |
| 63/26/42 | | 10,700 | | 19 | 0.178 | - | - |
| 05/11/33 | Eagle Cr. Hat. | 60,500 | 04/May/83 | 78 | 0.129 | - | - |
| 05/11/34 | | 62,800 | | 76 | 0.121 | - | - |
| 05/11/35 | | 40,900 | | 45 | 0.110 | - | - |
| 05/11/36 | | 39,300 | | 65 | 0.165 | - | - |
| 05/11/37 | " " | 20,900 | " | 32 | 0.153 | - | - |
| 05/11/38 | | 20,300 | | 36 | 0.177 | - | - |
| 07/27/31 | Sandy Hat. | 54,700 | 29/Apr/83 | 32 | 0.059 | - | - |
| 07/27/36 | | 54,900 | | 46 | 0.084 | - | - |
| 07/27/32 | " " | 54,900 | " | 34 | 0.062 | - | - |
| 07/27/35 | | 54,600 | | 33 | 0.060 | - | - |
| 07/27/33 | " " | 54,100 | " | 36 | 0.066 | - | - |
| 07/27/34 | | 54,700 | | 37 | 0.068 | - | - |
| 63/26/51 | Washougal Hat. | 8,000 | 27/May/83 | 7 | 0.087 | - | - |
| 63/26/52 | | 7,900 | | 3 | 0.038 | - | - |
| 63/26/53 | | 8,000 | | 4 | 0.050 | - | - |
| 63/26/54 | | 8,000 | | 7 | 0.087 | - | - |
| 63/26/55 | | 7,900 | | 8 | 0.101 | - | - |
| 63/26/57 | " " | 9,700 | " | 7 | 0.072 | - | - |
| 63/26/58 | | 9,900 | | 6 | 0.061 | - | - |
| 63/26/59 | | 9,800 | | 4 | 0.041 | - | - |
| 63/26/60 | | 9,700 | | 7 | 0.072 | - | - |
| 63/26/61 | " " | 9,900 | " | 5 | 0.050 | - | - |
| 63/26/62 | | 9,900 | | 5 | 0.050 | - | - |
| 63/26/63 | | 9,900 | | 10 | 0.101 | - | - |
| 63/27/01 | | 9,700 | | 3 | 0.031 | - | - |
| 63/27/02 | | 10,000 | | 7 | 0.070 | - | - |
| 63/27/03 | " " | 10,100 | " | 7 | 0.069 | - | - |
| 63/27/04 | | 10,400 | | 7 | 0.067 | - | - |
| 63/27/05 | | 10,100 | | 10 | 0.099 | - | - |
| 63/27/06 | | 10,600 | | 5 | 0.047 | - | - |
| 63/27/07 | | 10,100 | | 3 | 0.030 | - | - |
| 63/27/08 | " " | 10,400 | " | 3 | 0.029 | - | - |
| 63/27/09 | | 10,300 | | 9 | 0.087 | - | - |
| 63/27/10 | | 10,400 | | 8 | 0.077 | - | - |
| 63/27/11 | | 10,400 | | 5 | 0.048 | - | - |
| 63/27/12 | | 10,500 | | 7 | 0.067 | - | - |
| 63/27/13 | " " | 10,000 | " | 7 | 0.070 | - | - |
| 63/27/14 | | 10,900 | | 8 | 0.073 | - | - |
| 63/27/15 | | 10,300 | | 8 | 0.078 | - | - |
| 63/27/16 | | 10,300 | | 3 | 0.029 | - | - |
| 63/27/17 | | 10,600 | | 12 | 0.113 | - | - |

Appendix Table B1.--continued.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Coho salmon | | | | |
| 05/09/28 | Willard Hat. | 22,600 | 07/Jun/83 | 22 | 0.097 | - | - |
| 05/09/29 | | 22,200 | | 20 | 0.090 | - | - |
| 05/09/30 | | 21,900 | | 18 | 0.082 | - | - |
| 05/09/31 | | 22,500 | | 14 | 0.062 | - | - |
| 05/09/42 | | 23,300 | | 21 | 0.090 | - | - |
| 05/09/43 | | 22,800 | | 17 | 0.075 | - | - |
| 05/09/32 | " " | 23,300 | " | 16 | 0.069 | - | - |
| 05/09/33 | | 20,800 | | 16 | 0.077 | - | - |
| 05/09/38 | | 22,200 | | 19 | 0.085 | - | - |
| 05/09/39 | | 21,900 | | 23 | 0.105 | - | - |
| 05/09/40 | | 20,500 | | 17 | 0.083 | - | - |
| 05/09/41 | | 23,000 | | 32 | 0.139 | - | - |
| 05/09/34 | " " | 23,700 | " | 19 | 0.080 | - | - |
| 05/09/35 | | 22,100 | | 13 | 0.059 | - | - |
| 05/09/36 | | 22,700 | | 23 | 0.101 | - | - |
| 05/09/37 | | 22,200 | | 15 | 0.067 | - | - |
| 05/09/44 | | 23,200 | | 23 | 0.099 | - | - |
| 05/09/45 | | 23,300 | | 18 | 0.077 | - | - |
| | | | Steelhead | | | | |
| 63/28/39& RA S 1 | Lyons Ferry Hat. | 33,000 | 09-13/May/83 | 96 | 0.291 | - | - |
| 63/28/40& RA S 2 | | 32,000 | | 78 | 0.244 | - | - |
| RD KE 2 | Wh.R Falls/Rnd.Butte | 1,000 | 01/Jun/83 | 1 | 0.100 | - | - |
| RD KE 3 | | 1,000 | 06/Jun/83 | 1 | 0.100 | - | - |

Appendix Table B1.--continued.

REPLICATE GROUPS 1982

| Release Information: Mark a/ (Loc Br Rot) (Ag/D1/D2) | Site (source) b/ | Number | Date (da/mo/yr) | Juvenile catch at Jones Beach c/ (no.) | Juvenile catch at Jones Beach c/ (%) | Adult Recoveries d/ (no.) | Adult Recoveries d/ (%) |
|---|---|---|---|---|---|---|---|
| | | | **Subyearling chinook salmon** | | | | |
| 05/10/58 | Abernathy SCDC | 90,600 | 20/Apr-01/Jun/82 | 93 | 0.103 | 7 | 0.008 |
| 05/10/59 | | 29,700 | | 34 | 0.114 | 2 | 0.007 |
| 07/24/14 | Bonn. Hat. | 51,600 | 04/Jun/82 | 34 | 0.066 | 0 | 0.000 |
| 07/24/15 | | 52,400 | | 50 | 0.095 | 0 | 0.000 |
| 07/24/16 | " " | 52,500 | " | 45 | 0.086 | 0 | 0.000 |
| 07/24/17 | | 54,100 | | 46 | 0.085 | 0 | 0.000 |
| LD T 1 | Bonn. Dam Hat. | 51,800 | " | 221 | 0.427 | - | - |
| RD T 1 | (Bonn. Hat.) | 54,400 | | 199 | 0.366 | - | - |
| LD T 2 | " " | 52,900 | " | 215 | 0.406 | - | - |
| RD T 2 | | 49,800 | | 159 | 0.319 | - | - |
| 05/04/35 | Lit.Wh.Sal.Hat. | 101,300 | 02-03/Jun/82 | 121 | 0.119 | 0 | 0.000 |
| 05/04/36 | | 98,400 | | 146 | 0.148 | 0 | 0.000 |
| 07/23/30 | Oxbow Hat. | 52,300 | 04-25/Jun/82 | 45 | 0.086 | 0 | 0.000 |
| 07/24/11 | | 52,500 | | 46 | 0.088 | 0 | 0.000 |
| 05/08/51 | Spring Cr. Hat. | 46,700 | 08-13/Apr/82 | 48 | 0.103 | 8 | 0.017 |
| 05/10/57 | | 102,300 | | 105 | 0.103 | 10 | 0.010 |
| 05/10/53 | Spring Cr. Hat. | 43,100 | 15/Apr/82 | 68 | 0.157 | 3 | 0.007 |
| 05/10/54 | | 48,500 | | 71 | 0.146 | 12 | 0.025 |
| 05/10/55 | " " | 41,200 | " | 71 | 0.172 | 8 | 0.019 |
| 05/10/56 | | 48,200 | | 64 | 0.133 | 7 | 0.014 |
| | | | **Yearling chinook salmon** | | | | |
| 63/23/09 | Cowlitz Hat. | 23,900 | 01/Apr/82 | 16 | 0.067 | 18 | 0.075 |
| 63/23/10 | | 23,200 | | 6 | 0.026 | 30 | 0.129 |
| 63/23/11 | " " | 24,300 | " | 10 | 0.045 | 11 | 0.045 |
| 63/21/34 | | 24,000 | | 9 | 0.038 | 20 | 0.083 |
| 07/25/25 | N. Santiam R. | 50,600 | 17/Mar/82 | 12 | 0.024 | 0 | 0.000 |
| 07/25/26 | (Marion Fks Hat.) | 50,600 | | 13 | 0.026 | 0 | 0.000 |
| 07/25/27 | | 49,500 | | 26 | 0.053 | 0 | 0.000 |
| 07/25/28 | " " | 50,000 | 18-22/Mar/82 | 14 | 0.028 | 1 | 0.002 |
| 07/25/29 | | 49,400 | | 22 | 0.044 | 0 | 0.000 |
| 07/25/30 | | 49,200 | | 20 | 0.041 | 2 | 0.004 |
| 10/24/12& RD SU 4 | S.FK. Salmon R. (McCall Hat.) | 40,700 | 08-10/Apr/82 | 16 | 0.039 | f/ | |
| 10/24/13& RD SU 2 | | 40,500 | | 25 | 0.062 | f/ | |
| | | | **Coho salmon** | | | | |
| 07/24/29 | Cascade Hat. | 27,700 | 25/May/82 | 25 | 0.090 | 111 | 0.401 |
| 07/24/33 | | 28,200 | | 30 | 0.106 | 121 | 0.429 |
| 63/24/20 | Cowlitz Hat. | 9,700 | 03/May/82 | 18 | 0.184 | 89 | 0.908 |
| 63/24/21 | | 9,800 | | 15 | 0.154 | 77 | 0.778 |
| 63/24/22 | | 10,300 | | 25 | 0.240 | 93 | 0.894 |
| 63/24/23 | | 10,200 | | 18 | 0.175 | 85 | 0.825 |
| 63/24/24 | | 10,100 | | 19 | 0.188 | 103 | 1.020 |
| 63/24/25 | " " | 10,500 | " | 13 | 0.124 | 145 | 1.381 |
| 63/24/26 | | 10,400 | | 15 | 0.143 | 110 | 1.048 |
| 63/24/27 | | 10,400 | | 15 | 0.144 | 114 | 1.096 |
| 63/24/28 | | 10,500 | | 18 | 0.171 | 106 | 1.010 |
| 63/24/29 | | 10,400 | | 11 | 0.106 | 116 | 1.115 |

Appendix Table B1.--continued.

Coho salmon

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 63/24/30 | Cowlitz Hat. | 10,500 | 03/May/82 | 17 | 0.160 | 97 | 0.915 |
| 63/24/31 | | 10,500 | | 13 | 0.123 | 102 | 0.962 |
| 63/24/32 | | 10,100 | | 16 | 0.157 | 92 | 0.902 |
| 63/24/33 | | 10,400 | | 17 | 0.163 | 100 | 0.962 |
| 63/24/34 | | 10,400 | | 18 | 0.171 | 83 | 0.790 |
| 63/24/35 | " " | 10,300 | " | 18 | 0.175 | 98 | 0.951 |
| 63/24/36 | | 10,300 | | 20 | 0.194 | 122 | 1.184 |
| 63/24/37 | | 10,100 | | 17 | 0.168 | 101 | 1.000 |
| 63/24/38 | | 10,200 | | 20 | 0.196 | 119 | 1.167 |
| 63/24/39 | | 10,300 | | 17 | 0.165 | 115 | 1.117 |
| 63/24/40 | " " | 10,500 | " | 24 | 0.226 | 138 | 1.302 |
| 63/24/41 | | 10,600 | | 16 | 0.150 | 133 | 1.243 |
| 63/24/42 | | 10,600 | | 17 | 0.159 | 133 | 1.243 |
| 63/24/43 | | 10,400 | | 22 | 0.210 | 145 | 1.381 |
| 63/24/44 | | 10,700 | | 22 | 0.206 | 122 | 1.140 |
| 63/24/45 | " " | 10,200 | " | 16 | 0.155 | 140 | 1.359 |
| 63/24/46 | | 10,300 | | 21 | 0.202 | 136 | 1.308 |
| 63/24/47 | | 10,500 | | 24 | 0.226 | 122 | 1.151 |
| 63/24/48 | | 10,200 | | 15 | 0.146 | 113 | 1.097 |
| 63/24/49 | | 10,000 | | 19 | 0.188 | 105 | 1.040 |
| 05/10/35 | Eagle Cr. Hat. | 20,000 | 06/May/82 | 29 | 0.145 | 159 | 0.795 |
| 05/10/36 | | 19,100 | | 42 | 0.220 | 119 | 0.623 |
| 05/10/37 | " " | 42,600 | " | 68 | 0.160 | 250 | 0.587 |
| 05/10/38 | | 42,400 | | 77 | 0.182 | 257 | 0.606 |
| 05/10/39 | " " | 68,200 | " | 114 | 0.167 | 387 | 0.567 |
| 05/10/40 | | 66,600 | | 115 | 0.173 | 379 | 0.569 |
| 07/25/49 | Sandy Hat. | 23,900 | 30/Apr/82 | 31 | 0.129 | 361 | 1.504 |
| 07/25/57 | | 28,100 | | 43 | 0.153 | 398 | 1.416 |
| 07/25/50 | " ", | 26,400 | " | 50 | 0.189 | 396 | 1.500 |
| 07/25/58 | | 27,800 | | 36 | 0.129 | 378 | 1.355 |
| 07/25/54 | " " | 27,600 | " | 46 | 0.167 | 345 | 1.250 |
| 07/25/51 | | 27,200 | | 34 | 0.125 | 372 | 1.363 |
| 07/25/55 | " " | 28,200 | " | 33 | 0.117 | 411 | 1.452 |
| 07/25/53 | | 25,900 | | 25 | 0.096 | 315 | 1.212 |
| 07/25/56 | " " | 27,600 | " | 43 | 0.156 | 336 | 1.217 |
| 07/25/52 | | 26,800 | | 36 | 0.134 | 407 | 1.513 |
| 63/25/13 | Washougal Hat. | 10,100 | 25/May/82 | 9 | 0.088 | 42 | 0.412 |
| 63/25/14 | | 9,800 | | 9 | 0.091 | 33 | 0.333 |
| 63/25/15 | | 10,200 | | 14 | 0.136 | 29 | 0.282 |
| 63/25/16 | | 9,900 | | 6 | 0.061 | 35 | 0.354 |
| 63/25/17 | | 9,800 | | 6 | 0.061 | 44 | 0.449 |
| 63/25/18 | " " | 10,100 | " | 6 | 0.059 | 38 | 0.376 |
| 63/25/19 | | 10,100 | | 8 | 0.079 | 39 | 0.386 |
| 63/25/20 | | 10,000 | | 4 | 0.040 | 37 | 0.366 |
| 63/25/21 | | 10,200 | | 4 | 0.039 | 43 | 0.422 |
| 63/25/22 | | 10,200 | | 12 | 0.117 | 37 | 0.359 |
| 63/25/23 | " " | 10,100 | " | 7 | 0.069 | 59 | 0.578 |
| 63/25/24 | | 10,000 | | 4 | 0.040 | 38 | 0.376 |
| 63/25/25 | | 10,100 | | 5 | 0.050 | 66 | 0.653 |
| 63/25/26 | | 10,100 | | 7 | 0.069 | 30 | 0.294 |
| 63/25/27 | | 10,000 | | 9 | 0.089 | 51 | 0.505 |

Appendix Table B1.--continued.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Coho salmon | | | | |
| 63/25/28 | Washougal Hat. | 10,100 | 25/May/82 | 9 | 0.089 | 61 | 0.604 |
| 63/25/29 | | 10,100 | | 12 | 0.118 | 42 | 0.412 |
| 63/25/30 | | 10,100 | | 10 | 0.099 | 60 | 0.594 |
| 63/25/31 | | 10,000 | | 4 | 0.040 | 47 | 0.470 |
| 63/25/32 | | 9,900 | | 3 | 0.030 | 58 | 0.586 |
| 63/25/33 | " " | 9,600 | " | 8 | 0.082 | 26 | 0.268 |
| 63/25/34 | | 9,600 | | 9 | 0.094 | 39 | 0.406 |
| 63/25/35 | | 9,600 | | 5 | 0.052 | 40 | 0.412 |
| 63/25/36 | | 9,500 | | 7 | 0.073 | 30 | 0.313 |
| 63/25/37 | | 9,600 | | 11 | 0.113 | 35 | 0.361 |
| 63/25/38 | " " | 8,000 | " | 8 | 0.100 | 22 | 0.275 |
| 63/25/39 | | 7,900 | | 8 | 0.101 | 47 | 0.595 |
| 63/25/40 | | 8,100 | | 2 | 0.025 | 30 | 0.370 |
| 63/25/41 | | 8,100 | | 4 | 0.049 | 37 | 0.457 |
| 63/25/42 | | 7,900 | | 7 | 0.088 | 31 | 0.388 |
| | | | Steelhead | | | | |
| 10/24/04 | Pahsimeroi R. | 40,100 | 09/Apr/82 | 56 | 0.139 | 160 | 0.398 |
| 10/24/50 | (Niagara Spr.Hat.) | 40,500 | | 47 | 0.116 | 144 | 0.356 |

Appendix Table B1.--continued.

REPLICATE GROUPS 1981

| Release Information: Mark a/ (Loc Br Rot) (Ag/D1/D2) | Site (source) b/ | Number | Date (da/mo/yr) | Juvenile catch at Jones Beach c/ (no.) | (%) | Adult Recoveries d/ (no.) | (%) |
|---|---|---|---|---|---|---|---|
| **Subyearling chinook salmon** | | | | | | | |
| 05/07/44 | Abernathy SCDC | 22,300 | 15-26/Apr/81 | 11 | 0.049 | 87 | 0.389 |
| 05/07/45 | | 74,100 | | 48 | 0.065 | 260 | 0.351 |
| 07/23/41 | Bonn. Hat. | 50,800 | 12/May/81 | 45 | 0.089 | 37 | 0.073 |
| 07/23/42 | | 51,600 | | 45 | 0.087 | 24 | 0.047 |
| 07/23/43 | " " | 53,200 | " | 59 | 0.111 | 30 | 0.056 |
| 07/23/44 | | 51,800 | | 55 | 0.106 | 59 | 0.114 |
| 07/23/45 | " " | 51,000 | " | 41 | 0.080 | 10 | 0.020 |
| 07/23/46 | | 50,800 | | 58 | 0.114 | 32 | 0.063 |
| 05/07/47 | Lit.Wh.Sal.Hat. | 183,400 | 04-05/Jun/81 | 117 | 0.064 | 12 | 0.007 |
| 05/08/49 | | 52,400 | | 43 | 0.082 | 1 | 0.002 |
| 05/08/50 | | 13,300 | | 4 | 0.030 | 1 | 0.007 |
| 05/07/43 | Rock Creek | 25,700 | 21-22/Apr/81 | 10 | 0.039 | 50 | 0.194 |
| 05/07/46 | (Spring Cr. Hat.) | 150,500 | | 56 | 0.037 | 311 | 0.207 |
| 05/07/40 | Spring Cr. Hat. | 104,600 | 25/Mar/81 | 63 | 0.060 | 42 | 0.040 |
| 05/07/48 | | 28,800 | | 12 | 0.042 | 8 | 0.028 |
| 05/07/50 | " " | 13,700 | " | 9 | 0.065 | 1 | 0.007 |
| 05/07/51 | | 15,300 | | 8 | 0.052 | 6 | 0.039 |
| 05/07/41 | " " | 76,700 | 15/Apr/81 | 78 | 0.102 | 54 | 0.070 |
| 05/07/49 | | 30,900 | | 35 | 0.113 | 25 | 0.081 |
| **Yearling chinook salmon** | | | | | | | |
| 10/22/21 | Lemhi R. | 50,000 | 08/Apr/81 | 7 | 0.014 | 10 | 0.020 |
| 10/22/22 | (Hayden Pd.) | 51,000 | | 7 | 0.014 | 4 | 0.008 |
| 10/05/19 | Kooskia Hat. | 17,900 | 07/Apr/81 | 2 | 0.011 | 0 | 0.000 |
| 10/22/19 | | 37,700 | | 3 | 0.008 | 2 | 0.005 |
| 10/22/20 | | 38,600 | 08/Apr/81 | 4 | 0.010 | 1 | 0.003 |
| 07/22/47 | N. Santiam R. | 49,900 | 05/Nov/80 | 4 | 0.008 | 8 | 0.016 |
| 07/22/48 | (Marion Fks. Hat.) | 49,900 | 06-07/Nov/80 | 5 | 0.010 | 11 | 0.022 |
| 07/22/51 | " " | 47,100 | 16-23/Mar/81 | 7 | 0.015 | 22 | 0.047 |
| 07/22/50 | | 49,600 | 17-20/Mar/81 | 7 | 0.014 | 20 | 0.040 |
| 07/22/49 | | 50,200 | 18-20/Mar/81 | 10 | 0.020 | 24 | 0.048 |
| 07/22/53 | " " | 42,200 | 16-24/Mar/81 | 10 | 0.024 | 27 | 0.064 |
| 07/22/52 | | 39,600 | 23-24/Mar/81 | 10 | 0.025 | 34 | 0.086 |
| 07/22/18 | McKenzie@Leaburg | 32,300 | 05/Nov/81 | 1 | 0.003 | 23 | 0.071 |
| 07/22/21 | (McKenzie Hat.) | 37,900 | | 4 | 0.011 | 17 | 0.045 |
| 10/22/36 | Rapid R. Hat. | 49,000 | 12/Apr/81 | 3 | 0.007 | f/ | |
| 10/22/37 | | 44,200 | | 7 | 0.016 | 2 | 0.005 |
| 10/22/38 | | 51,900 | | 10 | 0.019 | 1 | 0.002 |
| **Coho salmon** | | | | | | | |
| 07/22/55 | Sandy Hat. | 27,600 | 01/May/81 | 21 | 0.076 | 363 | 1.313 |
| 07/22/57 | | 28,900 | | 16 | 0.055 | 387 | 1.337 |
| 07/22/56 | " " | 27,300 | " | 20 | 0.073 | 371 | 1.358 |
| 07/22/58 | | 28,000 | | 12 | 0.043 | 364 | 1.298 |
| 07/22/59 | " " | 29,800 | " | 34 | 0.114 | 535 | 1.792 |
| 07/22/62 | | 27,700 | | 25 | 0.090 | 501 | 1.803 |
| 07/22/60 | " " | 28,100 | " | 17 | 0.061 | 442 | 1.573 |
| 07/22/63 | | 29,600 | | 18 | 0.061 | 485 | 1.636 |

Appendix Table B1.--continued.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Coho salmon | | | | |
| 07/22/61 | Sandy Hat. | 29,700 | 01/May/81 | 20 | 0.067 | 451 | 1.515 |
| 07/23/01 | | 28,800 | | 22 | 0.076 | 454 | 1.571 |
| 07/21/27 | Tanner Creek | 24,900 | 06/May/81 | 24 | 0.096 | 510 | 2.047 |
| 07/21/30 | (Cascade Hat.) | 26,600 | | 28 | 0.105 | 488 | 1.828 |
| 07/21/28 | " " | 27,900 | 08/Jun/81 | 21 | 0.075 | 1017 | 3.644 |
| 07/21/31 | | 26,000 | | 25 | 0.096 | 752 | 2.883 |
| 07/21/29 | " " | 27,700 | 06/Jul/81 | 13 | 0.047 | 811 | 2.925 |
| 07/21/32 | | 28,900 | | 19 | 0.066 | 644 | 2.225 |
| RA IY 1 | Rock Island | 5,000 | 24/May/81 | 2 | 0.041 | | |
| RA IY 2 | (Turtle Rock Pd) | 4,900 | 25/May/81 | 1 | 0.021 | | |
| LA IY 1 | " " | 5,000 | 27/May/81 | 2 | 0.040 | | |
| LA IY 2 | | 4,900 | 28/MAy/81 | 1 | 0.021 | | |
| LA IN 2 | " " | 1,000 | 01/Jun/81 | 1 | 0.101 | | |
| LA IN 4 | | 1,000 | | 1 | 0.101 | | |
| 63/21/50 | Washougal Hat. | 51,700 | 30/Apr/81 | 45 | 0.087 | 366 | 0.707 |
| 63/22/02 | | 51,900 | | 46 | 0.089 | 226 | 0.435 |
| | | | Steelhead | | | | |
| LA P 2 | Clarkston | 1,700 | 01/May/81 | 3 | 0.175 | | |
| LA S 1 | (Lo. Granite DAM) | 2,200 | | 3 | 0.137 | | |
| LA P 3 | " " | 5,500 | 05-09/May/81 | 10 | 0.181 | | |
| LA S 2 | | 6,800 | | 13 | 0.191 | | |

Appendix Table B1.--continued.

REPLICATE GROUPS 1980

| Mark a/ (Loc Br Rot) (Ag/D1/D2) | Release Information: Site (source) b/ | Number | Date (da/mo/yr) | Juvenile catch at Jones Beach c/ (no.) | (%) | Adult Recoveries d/ (no.) | (%) |
|---|---|---|---|---|---|---|---|
| | | | Subyearling chinook salmon | | | | |
| 07/21/33 | Bonn. Hat. | 50,400 | 27/May/80 | 12 | 0.024 | 17 | 0.034 |
| 07/21/34 | | 49,900 | | 14 | 0.028 | 24 | 0.048 |
| 07/21/35 | " " | 48,000 | " | 24 | 0.050 | 10 | 0.021 |
| 07/21/36 | | 49,400 | | 26 | 0.053 | 21 | 0.043 |
| 07/21/62 | Skamania Lt. | 50,100 | 27-28/May/80 | 21 | 0.042 | 21 | 0.042 |
| 07/21/63 | (Oxbow Hat.) | 53,000 | | 20 | 0.038 | 32 | 0.060 |
| 05/06/48 | DS Bonn. Dam | 99,500 | 19/May/80 | 40 | 0.040 | 1091 | 1.096 |
| 05/06/49 | (Spring Cr. Hat.) | 99,700 | | 31 | 0.031 | 1021 | 1.024 |
| | | | Yearling chinook salmon | | | | |
| 10/21/25 | Lemhi R. | 40,100 | 01-03/Apr/80 | 2 | 0.005 | 18 | 0.045 |
| 10/21/26 | (Hayden Cr. Pd.) | 41,100 | 03-04/Apr/80 | 4 | 0.010 | 11 | 0.027 |
| LD IL 2 | Methow R.@Mo. | 15,000 | 05/May/80 | 5 | 0.034 | | |
| RD IL 2 | (Leavenworth Hat.) | 13,800 | | 2 | 0.015 | | |
| LD F 1 | " " | 16,400 | 10/May/80 | 6 | 0.037 | | |
| RD F 1 | | 15,200 | | 2 | 0.014 | | |
| LD IY 1 | " " | 15,200 | 13/May/80 | 7 | 0.046 | | |
| RD IY 1 | | 13,300 | | 1 | 0.008 | | |
| LA PI 2 | Icicle Creek | 32,900 | 27/May/80 | 6 | 0.019 | | |
| LA PI 4 | (Leavenworht Hat.) | 33,000 | 01/May/80 | 4 | 0.013 | | |
| LA PI 1 | | 32,700 | 24/Apr/80 | 4 | 0.013 | | |
| LD IL 3 | Pr. Rapid | 15,200 | 20/May/80 | 5 | 0.033 | | |
| RD IL 3 | (Leavenworth Hat.) | 14,700 | | 4 | 0.028 | | |
| LD F 2 | " " | 16,200 | 22/May/80 | 3 | 0.019 | | |
| RD F 2 | | 15,400 | | 13 | 0.084 | | |
| LD IY 2 | " " | 15,200 | 27/May/80 | 16 | 0.105 | | |
| RD IY 2 | | 13,200 | | 7 | 0.053 | | |
| LA PP 1& | Wh. Bluffs | 32,600 | 24/Apr/80 | 13 | 0.040 | | |
| LA S 1 & | (Leavenworth Hat.) | 35,400 | | 16 | 0.046 | | |
| LD IL 1 | Richland | 15,900 | 22/May/80 | 4 | 0.026 | | |
| RD IL 1 | (Leavenworth Hat.) | 13,600 | | 6 | 0.044 | | |
| LD F 3 | " " | 16,200 | 26/May/80 | 6 | 0.037 | | |
| RD F 3 | | 15,800 | | 8 | 0.051 | | |
| LD IY 3 | " " | 15,400 | 29/May/80 | 10 | 0.065 | | |
| RD IY 3 | | 13,900 | | 6 | 0.044 | | |
| RA 9 1 | Dalton Pt. | 32,400 | 24/Apr/80 | 14 | 0.044 | | |
| RA IK 1 | (Leavenworth Hat.) | 32,900 | | 22 | 0.068 | | |
| RA 9 2 | " " | 32,700 | 27/Apr/80 | 15 | 0.047 | | |
| RA IK 2 | | 32,800 | | 29 | 0.090 | | |
| RA IK 3 & | " " | 32,600 | 01/May/80 | 34 | 0.101 | | |
| 03/54/02 | | 32,600 | | 34 | 0.101 | | |
| RA 9 3 | | 32,400 | | 27 | 0.084 | | |
| 07/20/43 | Dexter | 31,300 | 05/Nov/79 | 5 | 0.016 | 34 | 0.109 |
| 07/20/45 | (Oakridge Hat.) | 30,800 | | 6 | 0.019 | 41 | 0.133 |
| 07/20/42 | " | 30,700 | 10-11/Mar/80 | 20 | 0.065 | 294 | 0.957 |
| 07/20/44 | | 30,700 | 10/Mar/80 | 25 | 0.081 | 265 | 0.862 |

Appendix Table B1.--continued.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | **Yearling chinook salmon** | | | | |
| 07/19/49 | Deschutes R. | 28,100 | 14/Apr/80 | 15 | 0.053 | 0 | 0.000 |
| 07/19/50 | (Rnd. Butte Hat.) | 29,900 | | 8 | 0.027 | 2 | 0.007 |
| 07/19/51 | | 29,100 | 14-15/Apr/80 | 7 | 0.024 | 5 | 0.017 |
| 07/20/18 | DS Willam. Falls | 34,700 | 05-06/Nov/79 | 3 | 0.009 | 5 | 0.014 |
| 07/20/19 | (S. Santiam Hat.) | 35,000 | | 4 | 0.011 | 6 | 0.017 |
| 07/20/20 | Foster | 33,000 | " | 2 | 0.006 | 10 | 0.030 |
| 07/20/21 | (S. Santiam Hat.) | 34,800 | | 1 | 0.003 | 28 | 0.080 |
| | | | **Coho salmon** | | | | |
| 07/20/31 | Sandy Hat. | 25,100 | 01/May/80 | 16 | 0.064 | 216 | 0.858 |
| 07/20/33 | | 25,100 | | 15 | 0.060 | 152 | 0.604 |
| 07/20/32 | " " | 25,500 | " | 16 | 0.063 | 259 | 1.014 |
| 07/20/34 | | 25,200 | | 17 | 0.067 | 276 | 1.095 |
| 07/20/35 | " " | 25,700 | " | 12 | 0.046 | 264 | 1.019 |
| 07/20/36 | | 24,400 | | 20 | 0.082 | 285 | 1.163 |
| 07/20/37 | " " | 26,000 | " | 13 | 0.050 | 377 | 1.448 |
| 07/20/38 | | 26,400 | | 20 | 0.076 | 298 | 1.126 |
| LD 52 1 | Rocky Reach Res. | 24,100 | 13/May/80 | 7 | 0.029 | | |
| RD 52 1 | (Turtle R. Pd.) | 24,100 | | 5 | 0.021 | | |
| LD 52 2 | Rocky Reach Tail | 25,400 | " | 10 | 0.040 | | |
| RD 52 2 | (Turtle R. Pd.) | 22,400 | | 5 | 0.023 | | |
| LD IX 2 | Rocky Reach Res. | 27,100 | 16/May/80 | 5 | 0.019 | | |
| RD IX 2 | (Turtle R. Pd.) | 24,800 | | 2 | 0.009 | | |
| LD IH 2 | " " | 24,900 | 19/May/80 | 8 | 0.033 | | |
| RD IH 2 | | 27,200 | | 3 | 0.012 | | |
| LD IH 3 | Rocky Reach Tail | 27,900 | " | 4 | 0.015 | | |
| RD IH 3 | (Turtle R. Pd.) | 25,400 | | 6 | 0.024 | | |
| 63/20/39 | Washougal Hat. | 99,600 | 08/May/80 | 82 | 0.082 | 683 | 0.686 |
| 63/20/40 | | 98,600 | | 68 | 0.069 | 686 | 0.696 |
| 63/20/37 | " " | 97,200 | 09/Jun/80 | 53 | 0.054 | 2393 | 2.462 |
| 63/20/38 | | 97,800 | | 65 | 0.066 | 2267 | 2.318 |
| 63/19/54 | " " | 106,700 | 07/Jul/80 | 126 | 0.118 | 4556 | 4.270 |
| 63/19/55 | | 106,900 | | 118 | 0.110 | 4430 | 4.144 |
| 05/03/59 | Lit. Wh. Sal. R. | 42,300 | 23/May/80 | 12 | 0.028 | 137 | 0.323 |
| 05/06/54 | (Willard Hat.) | 51,500 | | 6 | 0.012 | 158 | 0.307 |
| 05/06/60 | DS Bonn. Dam | 33,700 | 24/May/80 | 3 | 0.009 | 74 | 0.219 |
| 05/06/50 | (Willard Hat.) | 47,900 | 25/May/80 | 8 | 0.017 | 119 | 0.248 |
| 05/06/55 | | 51,400 | | 18 | 0.035 | 123 | 0.239 |
| | | | **Steelhead** | | | | |
| RD X3 1 | Pahsimeroi R. | 5,400 | 04/Feb-27/Apr/80 | 1 | 0.019 | | |
| LA SU 1 | (Dworshak Hat.) | 5,000 | 23-27/Apr/80 | 1 | 0.020 | | |
| RD IU 2 | Lemhi R. | 10,500 | 22/Apr/80 | 2 | 0.019 | | |
| LA SU 4 | (Dworshak Hat.) | 10,100 | 24/Apr/80 | 2 | 0.020 | | |
| LA X3 3 | Dworshak Hat. | 10,100 | 29/Apr/80 | 2 | 0.020 | | |
| RA DT 3 | | 9,900 | | 2 | 0.021 | | |
| 10/21/56 | Pahsimeroi | 49,900 | 06-16/Apr/80 | 26 | 0.052 | 241 | 0.483 |
| 10/21/57 | (Niagra Sp. Hat.) | 50,300 | 07-17/Apr/80 | 31 | 0.062 | 207 | 0.411 |
| LD Y 1 | Wells D. Res. | 13,400 | 01/May/80 | 1 | 0.008 | | |
| RD Y 1 | (Wells Spw. Ch.) | 13,000 | | 1 | 0.008 | | |

Appendix Table B1.--continued.

| | | | | | |
|---|---|---|---|---|---|
| | | | Steelhead | | |
| LD Y 3 | Wells D. Tail. | 13,000 | " | 2 | 0.016 |
| RD Y 3 | (Wells Spw. Ch.) | 12,200 | | 1 | 0.009 |
| LD K 3 | Wells D. Res. | 14,300 | 03/May/80 | 1 | 0.007 |
| RK K 3 | (Wells Spw. Ch.) | 13,600 | | 1 | 0.008 |
| LD K 2 | Wells D. Tail. | 13,100 | " | 2 | 0.016 |
| RD K 2 | (Wells Spw. Ch.) | 13,800 | | 1 | 0.008 |
| LD IJ 3 | Wells D. Res. | 13,100 | 05/May/80 | 1 | 0.008 |
| RD IJ 3 | (Wells Spw. Ch.) | 11,200 | | 1 | 0.009 |

Appendix Table B1.--continued.

REPLICATE GROUPS 1979

| Mark a/ (Loc Br Rot) (Ag/D1/D2) | Site (source) b/ | Number | Date (da/mo/yr) | Juvenile catch at Jones Beach c/ (no.) | Juvenile catch at Jones Beach c/ (%) | Adult Recoveries d/ (no.) | Adult Recoveries d/ (%) |
|---|---|---|---|---|---|---|---|
| | | | Subyearling chinook salmon | | | | |
| LD IC 1 | John Day D. | 20,000 | 06/Jun/79 | 29 | 0.146 | | |
| LD IC 2 | (Spring Cr. Hat.) | 20,400 | | 21 | 0.103 | | |
| LD IC 3 | | 19,800 | | 20 | 0.101 | | |
| LD IF 1 | " " | 19,600 | 05/Jun/79 | 19 | 0.097 | | |
| LD IF 2 | | 20,100 | | 6 | 0.030 | | |
| LD IF 3 | | 20,200 | | 15 | 0.074 | | |
| LD IK 1 | " " | 19,500 | " | 17 | 0.087 | | |
| LD IK 2 | | 19,500 | | 10 | 0.052 | | |
| LD IK 3 | | 19,500 | | 19 | 0.098 | | |
| LD PI 1 | " " | 21,200 | 06/Jun/79 | 17 | 0.081 | | |
| LD PI 2 | | 20,200 | | 24 | 0.119 | | |
| LD PI 3 | | 19,600 | | 22 | 0.113 | | |
| RD IC 1 | " " | 24,800 | " | 26 | 0.106 | | |
| RD IC 2 | | 20,000 | | 19 | 0.095 | | |
| RD IC 3 | | 20,200 | | 21 | 0.105 | | |
| RD PI 1 | " " | 20,100 | " | 30 | 0.150 | | |
| RD PI 2 | | 20,300 | | 23 | 0.114 | | |
| RD PI 3 | | 20,100 | | 21 | 0.105 | | |
| RD IF 1 | " " | 20,100 | 05/Jun/79 | 16 | 0.080 | | |
| RD IF 2 | | 20,100 | | 18 | 0.090 | | |
| RD IF 3 | | 19,700 | | 23 | 0.117 | | |
| RD IK 1 | " " | 21,500 | " | 30 | 0.140 | | |
| RD IK 2 | | 20,700 | | 33 | 0.160 | | |
| RD IK 3 | | 19,000 | | 28 | 0.148 | | |
| 03/55/01 | Big Wh. Pd. | 28,500 | 26/Jun/79 | 25 | 0.088 | 1 | 0.004 |
| 03/56/01 | (Spring Cr. Hat.) | 34,700 | | 17 | 0.049 | 2 | 0.006 |
| 03/57/01 | | 36,300 | | 11 | 0.030 | 0 | 0.000 |
| 05/04/34 | Spring Cr. Hat. | 95,500 | 20/Apr/79 | 196 | 0.206 | f/ | |
| 05/04/44 | | 135,500 | | 281 | 0.208 | f/ | |
| | | | Yearling chinook salmon | | | | |
| 07/16/26 | Mill Creek | 51,500 | 08-09/Nov/78 | 9 | 0.017e/ | 23 | 0.045 |
| 07/19/17 | (Bonn. Hat.) | 48,200 | | 10 | 0.021 | 20 | 0.041 |
| 07/19/18 | | 51,100 | | 8 | 0.016 | 27 | 0.053 |
| 63/18/17 | Cowlitz Sal. Hat. | 24,000 | 23/Apr/79 | 35 | 0.146 | 833 | 3.471 |
| 63/18/18 | | 24,300 | | 34 | 0.140 | 636 | 2.617 |
| 10/04/15 | Rapid R. | 127,000 | 15/Mar-15/Apr/79 | 30 | 0.024 | 115 | 0.091 |
| 10/04/24 | (Dworshak Hat.) | 122,000 | | 48 | 0.039 | 107 | 0.088 |
| 07/17/47 | Eagle Creek Hat. | 46,200 | 01/Mar/79 | 39 | 0.084 | 29 | 0.063 |
| 07/17/48 | | 48,200 | | 50 | 0.104 | 51 | 0.106 |
| LD IH 1 | Vantage Bridge | 49,800 | 11/May/79 | 85 | 0.172 | | |
| RD IZ 4 | (Leavenworth Hat.) | 55,900 | | 94 | 0.168 | | |
| LD IZ 1 | " " | 62,600 | 12/May/79 | 95 | 0.152 | | |
| RK IZ 2 | | 50,000 | | 94 | 0.189 | | |
| RD IH 1 | Wanapum D. | 38,400 | 13/May/79 | 92 | 0.240 | | |
| RD IZ 1 | (Leavenworth Hat.) | 49,000 | | 101 | 0.208 | | |
| LD IZ 2 | " " | 52,400 | 14/May/79 | 83 | 0.159 | | |
| RK IZ 3 | | 62,500 | | 100 | 0.160 | | |

Appendix Table B1.--continued.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Yearling chinook salmon | | | | |
| 07/17/25 | N. Santiam | 49,600 | 03-05/Apr/79 | 32 | 0.064 | 17 | 0.034 |
| 07/17/26 | (Marion Fks. Hat.) | 49,600 | | 21 | 0.042 | 18 | 0.036 |
| 07/17/29 | | 44,900 | | 37 | 0.082 | 22 | 0.049 |
| 07/19/26 | S. Santiam Hat. | 31,500 | 07/Nov/78 | 4 | 0.013e/ | 64 | 0.203 |
| 07/19/27 | | 32,700 | | 1 | 0.003 | 43 | 0.131 |
| 07/19/29 | DS Willam. Falls | 32,600 | " | 6 | 0.018e/ | 68 | 0.208 |
| 07/19/30 | (S. Santiam Hat.) | 32,800 | | 12 | 0.036e/ | 114 | 0.341 |
| 05/03/52 | Willard Hat. | 35,500 | 01/Nov/78 | 5 | 0.014e/ | 0 | 0.000 |
| 05/03/53 | | 35,700 | | 1 | 0.003 | 1 | 0.003 |
| 05/03/54 | | 36,900 | | 1 | 0.003 | 1 | 0.003 |
| 05/03/49 | Lit. Wh. Hat. | 31,100 | 19/Apr/79 | 20 | 0.064 | 20 | 0.064 |
| 05/03/50 | (Willard Hat.) | 31,200 | | 12 | 0.038 | 24 | 0.077 |
| 05/03/51 | | 32,900 | | 10 | 0.030 | 30 | 0.091 |
| | | | Coho salmon | | | | |
| 07/19/08 | Tanner Creek | 27,900 | 07/May/79 | 18 | 0.064 | 144 | 0.515 |
| 07/19/11 | (Cascade Hat.) | 26,900 | | 18 | 0.067 | 169 | 0.627 |
| 07/19/07 | " " | 27,100 | 07/Jun/79 | 37 | 0.136 | 299 | 1.101 |
| 07/19/10 | | 25,900 | | 32 | 0.123 | 344 | 1.327 |
| 07/19/09 | " " | 24,500 | 06/Jul/79 | 50 | 0.203 | 192 | 0.781 |
| 07/19/12 | | 25,100 | | 56 | 0.223 | 248 | 0.986 |
| 63/19/11 | Toutle Hat. | 42,400 | 07/May/79 | 46 | 0.108 | 482 | 1.137 |
| 63/19/12 | | 34,600 | | 40 | 0.115 | 476 | 1.372 |
| 63/19/28 | " " | 39,700 | 06/Jul/79 | 109 | 0.274 | 400 | 1.008 |
| 63/19/29 | | 41,100 | | 96 | 0.233 | 436 | 1.061 |
| 63/19/23 | Washougal Hat. | 74,300 | 07/May/79 | 81 | 0.109 | 1022 | 1.374 |
| 63/19/24 | | 80,600 | | 87 | 0.108 | 1333 | 1.654 |
| 63/19/27 | " " | 81,000 | 06/Jul/79 | 197 | 0.243 | 1078 | 1.331 |
| 63/19/34 | | 82,000 | | 191 | 0.233 | 980 | 1.195 |
| | | | Steelhead | | | | |
| LA AN 1& WHLBYW | Icicle Creek (Chelan Hat.) | 23,900 | 26/Apr/79 | 22 | 0.092 | 108 | 0.451 |
| LA AN 2& WHLBPK | | 19,100 | | 14 | 0.073 | 76 | 0.396 |
| LA AN 3& WHLBLG | | 24,100 | | 19 | 0.079 | 92 | 0.381 |
| RA Y 1 & WHLBWH | DS Bonn. Dam (Chelan Hat.) | 23,300 | 28/Apr/79 | 38 | 0.163 | 92 | 0.394 |
| RA Y 2 & WHLBRD | | 24,300 | | 21 | 0.086 | 97 | 0.399 |
| RA T 4 | DS Bonn. Dam | 20,700 | 17/May/79 | 90 | 0.434 | | |
| RA Y 4 | (Tucannon Hat.) | 22,000 | | 68 | 0.308 | | |
| LD P 1 | Wells Dam | 10,000 | 04/May/79 | 2 | 0.021 | | |
| LD P 3 | (Wells Spaw. Ch.) | 10,000 | | 1 | 0.010 | | |
| RD P 1 | " " | 10,000 | " | 4 | 0.041 | | |
| RD P 3 | | 9,600 | | 2 | 0.021 | | |

Appendix Table B1.--continued.

REPLICATE GROUPS 1978

| Mark a/ (Loc Br Rot) (Ag/D1/D2) | Release Information: Site (source) b/ | Number | Date (da/mo/yr) | Juvenile catch at Jones Beach c/ (no.) | (%) | Adult Recoveries d/ (no.) | (%) |
|---|---|---|---|---|---|---|---|
| | | | Subyearling chinook salmon | | | | |
| 05/03/43 | Lit. Wh. Hat. | 49,500 | 25/May/78 | 96 | 0.194 | 5 | 0.010 |
| 05/03/44 | | 51,300 | | 107 | 0.209 | 3 | 0.006 |
| 05/03/45 | | 52,100 | | 127 | 0.243 | 1 | 0.002 |
| 05/03/46 | " " | 49,800 | " | 114 | 0.229 | 5 | 0.010 |
| 05/03/47 | | 49,400 | | 99 | 0.200 | 4 | 0.008 |
| 05/03/48 | " " | 49,500 | " | 121 | 0.244 | 1 | 0.002 |
| 05/03/55 | " " | 39,300 | 12/Jul/78 | 15 | 0.038 | 15 | 0.038 |
| 05/03/56 | | 40,100 | | 18 | 0.045 | 11 | 0.027 |
| 05/03/57 | | 39,100 | | 28 | 0.071 | 17 | 0.043 |
| 05/03/42 | " " | 50,500 | 24/May/78 | 106 | 0.210 | 3 | 0.006 |
| 05/61/01 | | 48,400 | | 117 | 0.242 | 8 | 0.017 |
| 05/63/01 | | 52,200 | | 105 | 0.201 | 6 | 0.011 |
| 05/03/39 | Spring Creek Hat. | 49,900 | 18/Aug/78 | 6 | .012 | 172 | 0.345 |
| 05/03/40 | | 52,000 | | 7 | .013 | 231 | 0.444 |
| 05/03/41 | | 50,500 | | 6 | .012 | 182 | 0.360 |
| 05/60/01 | " " | 98,100 | 18/Apr/78 | 153 | .157 | e/ | |
| 05/62/01 | | 92,300 | | 175 | .191 | e/ | |
| 07/17/08 | Upstr. Willam. Falls | 50,900 | 31/May/78 | 44 | 0.086 | 43 | 0.084 |
| 07/17/10 | (Stayton Pd.) | 51,100 | 01/Jun/78 | 52 | 0.102 | 56 | 0.109 |
| | | | Yearling Chinook Salmon | | | | |
| 63/16/12 | Cowlitz Hat. | 28,200 | 08/Mar/78 | 34 | 0.122 | 1100 | 3.901 |
| 63/16/13 | | 27,700 | | 27 | 0.097 | 1245 | 4.495 |
| 63/17/09 | " " | 89,400 | " | 124 | 0.139 | 2836 | 3.172 |
| 63/17/10 | | 87,900 | | 109 | 0.125 | 2790 | 3.174 |
| 63/17/11 | " " | 58,200 | " | 77 | 0.132 | 2161 | 3.713 |
| 63/17/12 | | 56,900 | | 85 | 0.149 | 2218 | 3.898 |
| 63/17/17 | " " | 71,300 | " | 70 | 0.098 | 2181 | 3.059 |
| 63/17/18 | | 69,400 | | 64 | 0.092 | 2240 | 3.228 |
| 63/16/01 | Klickitat Hat. | 144,800 | 31/Mar/78 | 73 | 0.051 | f/ | |
| 63/16/02 | | 146,300 | | 76 | 0.053 | f/ | |
| WHRDLB RAL1 | DS Bonn. Dam | 37,000 | 09/May/78 | 22 | 0.059 | 1 | 0.002 |
| WHRDPK RAL2 | (Kooskia Hat.) | 36,900 | | 22 | 0.060 | 4 | 0.010 |
| WHRDYW RAL3 | | 35,400 | | 20 | 0.056 | 3 | 0.008 |
| WHRDXY RAL4 | | 37100 | | 15 | 0.040 | 3 | 0.000 |
| 09/16/61 | N. Santiam R. | 48,600 | 13-14/Mar/78 | 17 | 0.035 | 17 | 0.035 |
| 09/16/62 | (Marion FKs. Hat.) | 45,900 | | 22 | 0.048 | 18 | 0.039 |
| 09/16/63 | | 50,200 | | 17 | 0.034 | 18 | 0.036 |
| 09/17/01 | " " | 49,100 | " | 28 | 0.058 | e/ | |
| 09/17/02 | | 49,600 | | 22 | 0.046 | e/ | |
| 09/17/03 | | 50,000 | | 22 | 0.044 | e/ | |
| 07/16/11 | Rnd. Butte Hat. | 46,400 | 31/May/78 | 33 | 0.072 | f/ | |
| 07/16/12 | | 46,200 | | 34 | 0.074 | f/ | |
| 09/16/27 | S. Santiam Hat. | 28,700 | 07/Nov/77 | 2 | 0.007 | 158 | 0.550 |
| 09/16/29 | | 28,700 | | 1 | 0.003 | 164 | 0.571 |
| 09/16/30 | DS Willam. Falls | 25,900 | 08/Nov/77 | 4 | 0.015 | 72 | 0.277 |
| 09/16/31 | (S. Santiam Hat.) | 29,000 | | 3 | 0.010 | 95 | 0.327 |

Appendix Table B1.--continued.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Yearling chiniook salmon | | | | |
| 09/16/23 | DS Willam. Falls | 26,900 | 13-14/Mar/78 | 30 | 0.111 | 355 | 1.319 |
| 09/16/24 | (S. Santiam Hat.) | 24,600 | | 25 | 0.102 | 288 | 1.170 |
| | | | Coho salmon | | | | |
| LA ID 1 | John Day Dam | 31,400 | 09/May/78 | 33 | 0.105 | | |
| LA ID 2 | (Carson Hat.) | 31,500 | | 37 | 0.119 | | |
| LA ID 3 | | 32,300 | | 22 | 0.069 | | |
| RA ID 1 | " " | 33,000 | 22/May/78 | 28 | 0.085 | | |
| RA ID 2 | | 33,000 | | 17 | 0.053 | | |
| RA ID 3 | | 33,000 | | 12 | 0.037 | | |
| LD IJ 1 | DS Bonn. Dam | 31,500 | 18/May/78 | 13 | 0.042 | | |
| LD IJ 2 | (Carson Hat.) | 33,100 | | 17 | 0.053 | | |
| LD IJ 3 | | 32,300 | | 27 | 0.085 | | |

Appendix Table B1.--continued.

REPLICATE GROUPS 1977

| Release Information | | | | Juvenile catch at Jones Beach c/ | | Adult Recoveries d/ | |
|---|---|---|---|---|---|---|---|
| Mark a/ (Loc Br Rot) (Ag/D1/D2) | Site (source) b/ | Number | Date (da/mo/yr) | (no.) | (%) | (no.) | (%) |
| | | | Subyearling chinook salmon | | | | |
| 09/16/12 | Upstr. Willam. Falls | 44,600 | 02-04/Apr/77 | 106 | 0.238 | 16 | 0.036 |
| 09/16/13 | (Aumsville Pd.) | 43,100 | | 103 | 0.239 | 19 | 0.044 |
| 09/16/06 | DS Willam. Falls | 92,000 | | 238 | 0.259 | 26 | 0.028 |
| 09/16/11 | (Aumsville Pd.) | 46,400 | | 143 | 0.308 | 17 | 0.037 |
| 09/16/07 | | 43,500 | | 123 | 0.282 | 17 | 0.039 |
| 05/44/01 | Spring Creek Hat. | 96,700 | 08/Apr/77 | 216 | 0.223 | f/ | |
| 05/45/01 | | 95,800 | | 207 | 0.216 | f/ | |
| 05/49/01&RD U 1 | | 75,800 | | 215 | 0.284 | f/ | |
| | | | Yearling chinook salmon | | | | |
| 13/09/11 | Cowlitz Hat. | 88,000 | 08/Mar/77 | 44 | 0.050 | 904 | 1.027 |
| 13/09/12 | | 88,600 | | 36 | 0.041 | 1104 | 1.246 |
| 13/09/14 | " " | 61,700 | " | 31 | 0.050 | 1078 | 1.747 |
| 13/11/04 | | 61,600 | | 24 | 0.039 | 1052 | 1.708 |
| 13/13/01 | " " | 28,700 | " | 12 | 0.042 | 612 | 2.132 |
| 13/13/04 | | 27,900 | | 12 | 0.043 | 717 | 2.570 |
| 09/16/02 | Rnd. Butte Hat. | 29,400 | 02/May/77 | 2 | 0.007 | 0 | 0.000 |
| 09/16/01 | | 31,700 | | 2 | 0.006 | 2 | 0.006 |
| | | | Coho salmon | | | | |
| 06/05/14 | Sandy Hat. | 24,800 | 27/Apr/77 | 8 | 0.032 | 421 | 1.691 |
| 06/06/01 | | 25,800 | | 7 | 0.027 | 341 | 1.321 |
| 06/05/15 | Sandy Hat. | 24,400 | 27/Apr/77 | 8 | 0.033 | 418 | 1.708 |
| 06/06/03 | | 22,800 | | 6 | 0.026 | 339 | 1.483 |
| 06/06/02 | " " | 20,100 | " | 6 | 0.030 | 382 | 1.897 |
| 06/06/04 | | 23,400 | | 10 | 0.043 | 459 | 1.960 |
| LA X3 1 | Pasco | 16,600 | 01/May/77 | 3 | 0.019 | | |
| RA X3 1 | (Turtle Rock Pd.) | 16,600 | | 1 | 0.007 | | |
| 05/20/04 | Willard Hat. | 88,300 | 02-04/May/77 | 20 | 0.023 | e/ | |
| 05/21/04 | | 93,800 | | 21 | 0.024 | e/ | |
| | | | Steelhead | | | | |
| 10/13/07 | DS Bonn. Dam | 17,000 | 21/May/77 | 4 | 0.024 | 10 | 0.059 |
| 10/13/09 | (Dworshak Hat.) | 17,300 | | 3 | 0.017 | 20 | 0.116 |
| 10/13/11 | Clearwater R. | 57,200 | 20-21/Apr/77 | 7 | 0.017 | 52 | 0.124 |
| 10/13/13 | (Dworshak Hat.) | 31,100 | | 5 | 0.016 | 38 | 0.122 |
| 10/02/36 | Pahsimeroi R. | 55,400 | 05-10/Apr/77 | 2 | 0.004 | 9 | 0.016 |
| 10/02/35 | (Niagra Sp. Hat.) | 59,300 | | 5 | 0.008 | 9 | 0.015 |

a/ Percent of total release calculated from observed recovery. No data (-) means either adults have yet to return, were not collected, or were not obtained from fishery agencies prior to analysis. Comparisons between groups released at different times may be erroneous because of differences in ocean distribution, unequal fishing effort, or sampling effort.

b/ More complete release information is available in Dawley et al. 1985b and from the releasing agency Figure 1. Abbreviations: Bonn=Bonneville, Cr=Creek, D=Dam, DS=Downstream, Fk=Fork, Hat=Hatchery, Lit=Little, Lt=Light, Lo=Lower, N=North, Pd=Pond, Pr=Priest, R=River, Res=Reservoir, Rnd=Round, S=South, Sal=Salmon, Spr=Spring, Str=Stream, SCDC=Salmon Culture Developmental Center, Tail=Tailrace, and Wh=White.

c/ Actual catch and percent of number released for beach seine and purse seine combined.

d/ Observed recoveries from ocean and river fisheries plus escapement; preliminary data.

e/ Includes fall catch as well as spring catch.

f/ Not used for adult recovery comparison due to probable survival difference in seawater due to treatment.

Appendix Table B2.--Mean stomach fullness and standard deviation for juvenile salmonids captured in purse and beach seines at Jones Beach by 3-day intervals, 1980.

| 1980 | Purse Seine n | Purse Seine Mean | Purse Seine SD | Beach Seine n | Beach Seine Mean | Beach Seine SD | Purse & Beach Seine n | Purse & Beach Seine Mean | Purse & Beach Seine SD |
|---|---|---|---|---|---|---|---|---|---|
| **COHO SALMON** | | | | | | | | | |
| MAY 5-MAY 7 | 1 | 3.0 | 0.00 | 8 | 4.9 | 1.13 | 9 | 4.7 | 1.22 |
| MAY 8-MAY 10 | 11 | 4.1 | 1.58 | 7 | 4.6 | 1.40 | 18 | 4.3 | 1.49 |
| MAY 11-MAY 13 | 27 | 4.3 | 1.30 | 4 | 4.5 | 1.91 | 31 | 4.3 | 1.35 |
| MAY 14-MAY 16 | 66 | 5.1 | 1.00 | 16 | 5.0 | 1.10 | 82 | 5.1 | 1.01 |
| MAY 17-MAY 19 | 79 | 4.0 | 1.12 | 33 | 4.1 | 1.11 | 112 | 4.1 | 1.11 |
| MAY 20-MAY 22 | 13 | 3.5 | 1.27 | 0 | 0.0 | 0.00 | 13 | 3.5 | 1.27 |
| MAY 23-MAY 25 | 12 | 3.6 | 1.31 | 24 | 1.8 | 1.51 | 36 | 2.4 | 1.68 |
| MAY 26-MAY 28 | 20 | 4.3 | 1.34 | 11 | 3.3 | 1.19 | 31 | 3.9 | 1.36 |
| MAY 29-MAY 31 | 6 | 4.3 | 1.37 | 11 | 2.6 | 1.21 | 17 | 3.2 | 1.48 |
| JUN 1-JUN 3 | 9 | 4.4 | 1.13 | 1 | 2.0 | 0.00 | 10 | 4.2 | 1.32 |
| JUN 4-JUN 6 | 8 | 3.8 | 1.28 | 2 | 4.5 | 0.71 | 10 | 3.9 | 1.20 |
| JUN 7-JUN 9 | 2 | 5.0 | 1.41 | 0 | 0.0 | 0.00 | 2 | 5.0 | 1.41 |
| JUN 10-JUN 12 | 1 | 4.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 4.0 | 0.00 |
| JUN 13-JUN 15 | 48 | 4.3 | 1.45 | 6 | 4.5 | 1.52 | 54 | 4.3 | 1.45 |
| JUN 16-JUN 18 | 39 | 3.8 | 1.20 | 23 | 3.7 | 1.21 | 62 | 3.8 | 1.20 |
| JUN 19-JUN 21 | 2 | 5.5 | 0.71 | 1 | 3.0 | 0.00 | 3 | 4.7 | 1.53 |
| JUN 22-JUN 24 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 25-JUN 27 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 28-JUN 30 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 1-JUL 3 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 4-JUL 6 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 7-JUL 9 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 10-JUL 12 | 74 | 4.5 | 0.89 | 11 | 4.8 | 0.75 | 85 | 4.5 | 0.88 |
| JUL 13-JUL 15 | 0 | 0.0 | 0.00 | 3 | 3.7 | 1.53 | 3 | 3.7 | 1.53 |
| JUL 16-JUL 18 | 0 | 0.0 | 0.00 | 2 | 5.5 | 0.71 | 2 | 5.5 | 0.71 |
| JUL 19-JUL 21 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 22-JUL 24 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 25-JUL 27 | 1 | 3.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 |
| JUL 28-JUL 30 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| **YEARLING CHINOOK SALMON** | | | | | | | | | |
| MAR 9-MAR 11 | 0 | 0.0 | 0.00 | 5 | 2.8 | 0.84 | 5 | 2.8 | 0.84 |
| MAR 12-MAR 14 | 0 | 0.0 | 0.00 | 5 | 3.6 | 1.52 | 5 | 3.6 | 1.52 |
| MAR 15-MAR 17 | 1 | 1.0 | 0.00 | 3 | 1.7 | 1.15 | 4 | 1.5 | 1.00 |
| MAR 18-MAR 20 | 2 | 1.0 | 0.00 | 39 | 2.5 | 1.55 | 41 | 2.4 | 1.55 |
| MAR 21-MAR 23 | 0 | 0.0 | 0.00 | 10 | 2.7 | 1.89 | 10 | 2.7 | 1.89 |
| MAR 24-MAR 26 | 3 | 2.0 | 1.00 | 31 | 2.5 | 1.57 | 34 | 2.5 | 1.52 |
| MAR 27-MAR 29 | 1 | 2.0 | 0.00 | 25 | 2.6 | 1.58 | 26 | 2.6 | 1.55 |
| MAR 30-APR 1 | 2 | 2.5 | 0.71 | 20 | 3.0 | 2.14 | 22 | 2.9 | 2.04 |
| APR 2-APR 4 | 9 | 3.4 | 1.67 | 19 | 3.4 | 1.54 | 28 | 3.4 | 1.55 |
| APR 5-APR 7 | 8 | 3.6 | 1.06 | 5 | 3.4 | 1.14 | 13 | 3.5 | 1.05 |
| APR 8-APR 10 | 21 | 3.8 | 1.83 | 31 | 3.4 | 1.33 | 52 | 3.6 | 1.55 |
| APR 11-APR 13 | 9 | 3.4 | 0.73 | 6 | 3.3 | 1.03 | 15 | 3.4 | 0.83 |
| APR 14-APR 16 | 44 | 4.3 | 1.56 | 20 | 4.1 | 1.28 | 64 | 4.2 | 1.47 |
| APR 17-APR 19 | 28 | 4.2 | 1.25 | 3 | 2.0 | 1.73 | 31 | 4.0 | 1.43 |
| APR 20-APR 22 | 18 | 4.3 | 1.27 | 8 | 3.6 | 1.19 | 26 | 4.1 | 1.26 |
| APR 23-APR 25 | 17 | 4.9 | 2.03 | 8 | 4.1 | 1.89 | 25 | 4.6 | 1.98 |
| APR 26-APR 28 | 8 | 5.0 | 1.20 | 2 | 4.5 | 0.71 | 10 | 4.9 | 1.10 |
| APR 29-MAY 1 | 19 | 5.0 | 1.15 | 5 | 3.0 | 1.41 | 24 | 4.6 | 1.44 |
| MAY 2-MAY 4 | 11 | 5.5 | 0.69 | 0 | 0.0 | 0.00 | 11 | 5.5 | 0.69 |
| MAY 5-MAY 7 | 63 | 3.8 | 1.40 | 31 | 3.8 | 1.19 | 94 | 3.8 | 1.33 |
| MAY 8-MAY 10 | 38 | 4.4 | 1.41 | 29 | 3.9 | 1.29 | 67 | 4.2 | 1.37 |
| MAY 11-MAY 13 | 6 | 4.3 | 1.21 | 1 | 4.0 | 0.00 | 7 | 4.3 | 1.11 |
| MAY 14-MAY 16 | 3 | 4.3 | 0.58 | 0 | 0.0 | 0.00 | 3 | 4.3 | 0.58 |
| MAY 17-MAY 19 | 9 | 3.6 | 1.33 | 1 | 1.0 | 0.00 | 10 | 3.3 | 1.49 |
| MAY 20-MAY 22 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| MAY 23-MAY 25 | 4 | 2.0 | 0.00 | 0 | 0.0 | 0.00 | 4 | 2.0 | 0.00 |
| MAY 26-MAY 28 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| MAY 29-MAY 31 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 1-JUN 3 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 4-JUN 6 | 1 | 1.0 | 0.00 | 1 | 2.0 | 0.00 | 2 | 1.5 | 0.71 |
| JUN 7-JUN 9 | 1 | 4.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 4.0 | 0.00 |
| JUN 10-JUN 12 | 3 | 1.0 | 0.00 | 0 | 0.0 | 0.00 | 3 | 1.0 | 0.00 |
| JUN 13-JUN 15 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 16-JUN 18 | 1 | 4.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 4.0 | 0.00 |
| JUN 19-JUN 21 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |

Appendix Table B2.--continued.

| 1980 | Purse Seine n | Purse Seine Mean | Purse Seine SD | Beach Seine n | Beach Seine Mean | Beach Seine SD | Purse & Beach Seine n | Purse & Beach Seine Mean | Purse & Beach Seine SD |
|---|---|---|---|---|---|---|---|---|---|
| **STEELHEAD** | | | | | | | | | |
| APR 20-APR 22 | 1 | 7.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 7.0 | 0.00 |
| APR 23-APR 25 | 1 | 5.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 5.0 | 0.00 |
| APR 26-APR 28 | 1 | 5.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 5.0 | 0.00 |
| APR 29-MAY 1 | 40 | 3.5 | 1.69 | 0 | 0.0 | 0.00 | 40 | 3.5 | 1.69 |
| MAY 2-MAY 4 | 23 | 2.8 | 1.54 | 0 | 0.0 | 0.00 | 23 | 2.8 | 1.54 |
| MAY 5-MAY 7 | 111 | 2.4 | 1.32 | 6 | 1.5 | 0.84 | 117 | 2.4 | 1.31 |
| MAY 8-MAY 10 | 53 | 3.0 | 1.07 | 2 | 2.0 | 1.41 | 55 | 3.0 | 1.09 |
| MAY 11-MAY 13 | 25 | 3.5 | 1.19 | 0 | 0.0 | 0.00 | 25 | 3.5 | 1.19 |
| MAY 14-MAY 16 | 32 | 3.8 | 1.60 | 0 | 0.0 | 0.00 | 32 | 3.8 | 1.60 |
| MAY 17-MAY 19 | 8 | 2.9 | 1.13 | 0 | 0.0 | 0.00 | 8 | 2.9 | 1.13 |
| MAY 20-MAY 22 | 2 | 4.0 | 0.00 | 0 | 0.0 | 0.00 | 2 | 4.0 | 0.00 |
| MAY 23-MAY 25 | 17 | 2.4 | 1.41 | 0 | 0.0 | 0.00 | 17 | 2.4 | 1.41 |
| MAY 26-MAY 28 | 1 | 4.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 4.0 | 0.00 |
| MAY 29-MAY 31 | 2 | 2.0 | 0.00 | 0 | 0.0 | 0.00 | 2 | 2.0 | 0.00 |
| JUN 1-JUN 3 | 2 | 1.5 | 0.71 | 0 | 0.0 | 0.00 | 2 | 1.5 | 0.71 |
| JUN 4-JUN 6 | 1 | 7.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 7.0 | 0.00 |
| JUN 7-JUN 9 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 10-JUN 12 | 4 | 2.8 | 1.50 | 0 | 0.0 | 0.00 | 4 | 2.8 | 1.50 |
| JUN 13-JUN 15 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 16-JUN 18 | 2 | 2.5 | 0.71 | 0 | 0.0 | 0.00 | 2 | 2.5 | 0.71 |
| JUN 19-JUN 21 | 1 | 2.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 2.0 | 0.00 |
| JUN 22-JUN 24 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 25-JUN 27 | 2 | 3.0 | 1.41 | 0 | 0.0 | 0.00 | 2 | 3.0 | 1.41 |
| JUN 28-JUN 30 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| **SUBYEARLING CHINOOK SALMON** | | | | | | | | | |
| MAR 12-MAR 14 | 0 | 0.0 | 0.00 | 2 | 4.0 | 1.41 | 2 | 4.0 | 1.41 |
| MAR 15-MAR 17 | 0 | 0.0 | 0.00 | 6 | 4.0 | 1.55 | 6 | 4.0 | 1.55 |
| MAR 18-MAR 20 | 0 | 0.0 | 0.00 | 21 | 4.3 | 1.24 | 21 | 4.3 | 1.24 |
| MAR 21-MAR 23 | 0 | 0.0 | 0.00 | 7 | 4.7 | 0.76 | 7 | 4.7 | 0.76 |
| MAR 24-MAR 26 | 0 | 0.0 | 0.00 | 16 | 4.0 | 1.51 | 16 | 4.0 | 1.51 |
| MAR 27-MAR 2[illegible] | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| MAR 30-APR 1 | 0 | 0.0 | 0.00 | 4 | 4.3 | 1.26 | 4 | 4.3 | 1.26 |
| APR 2-APR 4 | 0 | 0.0 | 0.00 | 4 | 4.3 | 2.22 | 4 | 4.3 | 2.22 |
| APR 5-APR 7 | 0 | 0.0 | 0.00 | 1 | 7.0 | 0.00 | 1 | 7.0 | 0.00 |
| APR 8-APR 10 | 4 | 3.0 | 1.63 | 7 | 2.1 | 1.07 | 11 | 2.5 | 1.29 |
| APR 11-APR 13 | 0 | 0.0 | 0.00 | 4 | 3.0 | 1.41 | 4 | 3.0 | 1.41 |
| APR 14-APR 16 | 6 | 4.3 | 1.37 | 6 | 4.5 | 1.05 | 12 | 4.4 | 1.16 |
| APR 17-APR 19 | 3 | 5.3 | 0.58 | 12 | 4.2 | 1.03 | 15 | 4.4 | 1.06 |
| APR 20-APR 22 | 0 | 0.0 | 0.00 | 26 | 3.3 | 1.29 | 26 | 3.3 | 1.29 |
| APR 23-APR 25 | 0 | 0.0 | 0.00 | 32 | 3.3 | 1.47 | 32 | 3.3 | 1.47 |
| APR 26-APR 28 | 0 | 0.0 | 0.00 | 2 | 4.5 | 2.12 | 2 | 4.5 | 2.12 |
| APR 29-MAY 1 | 0 | 0.0 | 0.00 | 23 | 4.7 | 1.30 | 23 | 4.7 | 1.30 |
| MAY 2-MAY 4 | 0 | 0.0 | 0.00 | 12 | 4.4 | 1.68 | 12 | 4.4 | 1.68 |
| MAY 5-MAY 7 | 2 | 6.0 | 0.00 | 25 | 4.5 | 1.26 | 27 | 4.6 | 1.28 |
| MAY 8-MAY 10 | 2 | 4.0 | 2.83 | 18 | 4.6 | 0.92 | 20 | 4.6 | 1.10 |
| MAY 11-MAY 13 | 31 | 5.3 | 1.16 | 11 | 5.6 | 1.36 | 42 | 5.4 | 1.21 |
| MAY 14-MAY 16 | 15 | 5.1 | 1.30 | 20 | 3.8 | 1.96 | 35 | 4.4 | 1.82 |
| MAY 17-MAY 19 | 4 | 5.0 | 0.82 | 27 | 3.4 | 1.42 | 31 | 3.6 | 1.46 |
| MAY 20-MAY 22 | 26 | 2.7 | 1.52 | 1 | 2.0 | 0.00 | 27 | 2.6 | 1.50 |
| MAY 23-MAY 25 | 26 | 3.5 | 1.24 | 16 | 2.8 | 1.11 | 42 | 3.2 | 1.22 |
| MAY 26-MAY 28 | 2 | 3.5 | 0.71 | 11 | 3.4 | 1.12 | 13 | 3.4 | 1.04 |
| MAY 29-MAY 31 | 1 | 1.0 | 0.00 | 21 | 2.7 | 1.71 | 22 | 2.6 | 1.71 |
| JUN 1-JUN 3 | 9 | 5.4 | 1.13 | 57 | 3.6 | 1.37 | 66 | 3.9 | 1.47 |
| JUN 4-JUN 6 | 3 | 4.0 | 1.00 | 81 | 3.8 | 1.38 | 84 | 3.8 | 1.37 |
| JUN 7-JUN 9 | 12 | 5.1 | 1.31 | 50 | 3.5 | 1.36 | 62 | 3.8 | 1.47 |
| JUN 10-JUN 12 | 8 | 4.0 | 1.20 | 73 | 4.1 | 1.39 | 81 | 4.1 | 1.37 |
| JUN 13-JUN 15 | 2 | 3.5 | 3.54 | 37 | 4.0 | 1.38 | 39 | 4.0 | 1.47 |
| JUN 16-JUN 18 | 12 | 3.2 | 1.27 | 64 | 3.2 | 1.13 | 76 | 3.2 | 1.14 |
| JUN 19-JUN 21 | 7 | 5.4 | 1.51 | 41 | 3.5 | 1.45 | 48 | 3.8 | 1.60 |
| JUN 22-JUN 24 | 5 | 4.6 | 1.34 | 18 | 4.8 | 1.90 | 23 | 4.7 | 1.76 |
| JUN 25-JUN 27 | 2 | 4.0 | 1.41 | 27 | 3.3 | 1.56 | 29 | 3.3 | 1.54 |
| JUN 28-JUN 30 | 4 | 4.8 | 0.96 | 22 | 3.6 | 1.26 | 26 | 3.8 | 1.27 |
| JUL 1-JUL 3 | 7 | 4.6 | 1.13 | 76 | 3.8 | 1.40 | 83 | 3.9 | 1.39 |
| JUL 4-JUL 6 | 3 | 3.7 | 1.53 | 35 | 3.1 | 1.61 | 38 | 3.1 | 1.59 |
| JUL 7-JUL 9 | 16 | 3.9 | 1.12 | 71 | 3.7 | 1.72 | 87 | 3.8 | 1.62 |
| JUL 10-JUL 12 | 4 | 4.0 | 0.82 | 67 | 3.8 | 1.25 | 71 | 3.8 | 1.23 |
| JUL 13-JUL 15 | 13 | 4.8 | 1.68 | 40 | 3.9 | 1.18 | 53 | 4.1 | 1.37 |
| JUL 16-JUL 18 | 8 | 4.1 | 1.55 | 59 | 4.0 | 1.35 | 67 | 4.0 | 1.36 |
| JUL 19-JUL 21 | 1 | 7.0 | 0.00 | 20 | 4.0 | 1.43 | 21 | 4.1 | 1.55 |
| JUL 22-JUL 24 | 11 | 4.5 | 1.81 | 58 | 2.8 | 1.34 | 69 | 3.0 | 1.54 |
| JUL 25-JUL 27 | 3 | 3.0 | 1.00 | 18 | 3.1 | 1.37 | 21 | 3.1 | 1.30 |
| JUL 28-JUL 30 | 6 | 4.5 | 0.84 | 61 | 3.4 | 1.27 | 67 | 3.5 | 1.27 |
| JUL 31-AUG 2 | 10 | 5.1 | 1.52 | 38 | 4.7 | 1.40 | 48 | 4.8 | 1.42 |
| AUG 3-AUG 5 | 4 | 4.8 | 0.50 | 44 | 3.4 | 1.73 | 48 | 3.5 | 1.70 |
| AUG 6-AUG 8 | 2 | 5.5 | 0.71 | 58 | 3.0 | 1.46 | 60 | 3.1 | 1.51 |
| AUG 9-AUG 11 | 4 | 3.8 | 1.71 | 23 | 3.1 | 1.53 | 27 | 3.2 | 1.55 |
| AUG 12-AUG 14 | 3 | 4.3 | 1.53 | 60 | 4.1 | 1.37 | 63 | 4.1 | 1.36 |
| AUG 15-AUG 17 | 3 | 4.3 | 1.53 | 22 | 4.6 | 1.14 | 25 | 4.6 | 1.16 |
| AUG 18-AUG 20 | 9 | 4.3 | 1.73 | 48 | 3.4 | 1.66 | 57 | 3.5 | 1.69 |
| AUG 21-AUG 23 | 0 | 0.0 | 0.00 | 40 | 2.1 | 1.34 | 40 | 2.1 | 1.34 |
| AUG 24-AUG 26 | 0 | 0.0 | 0.00 | 40 | 3.2 | 1.69 | 40 | 3.2 | 1.69 |
| AUG 27-AUG 29 | 0 | 0.0 | 0.00 | 53 | 3.9 | 1.77 | 53 | 3.9 | 1.77 |
| AUG 30-SEP 1 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| SEP 2-SEP 4 | 2 | 6.0 | 0.00 | 23 | 2.5 | 1.59 | 25 | 2.8 | 1.80 |
| SEP 5-SEP 7 | 0 | 0.0 | 0.00 | 10 | 2.7 | 2.00 | 10 | 2.7 | 2.00 |
| SEP 8-SEP 10 | 0 | 0.0 | 0.00 | 10 | 2.5 | 0.97 | 10 | 2.5 | 0.97 |
| SEP 11-SEP 13 | 0 | 0.0 | 0.00 | 12 | 3.2 | 1.34 | 12 | 3.2 | 1.34 |
| SEP 14-SEP 16 | 0 | 0.0 | 0.00 | 12 | 3.3 | 1.23 | 12 | 3.3 | 1.23 |
| SEP 17-SEP 19 | 0 | 0.0 | 0.00 | 5 | 3.4 | 1.14 | 5 | 3.4 | 1.14 |
| SEP 20-SEP 22 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| SEP 23-SEP 25 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |

Appendix Table B3.--Mean stomach fullness and standard deviation for juvenile salmonids captured in purse and beach seines at Jones Beach by 3-day intervals, 1981.

| 1981 | Purse Seine n | Purse Seine Mean | Purse Seine SD | Beach Seine n | Beach Seine Mean | Beach Seine SD | Purse & Beach Seine n | Purse & Beach Seine Mean | Purse & Beach Seine SD |
|---|---|---|---|---|---|---|---|---|---|
| | | | | COHO SALMON | | | | | |
| APR 29-MAY 1 | 1 | 4.0 | 0.00 | 2 | 4.5 | 0.71 | 3 | 4.3 | 0.58 |
| MAY 2-MAY 4 | 6 | 4.3 | 0.52 | 3 | 4.7 | 1.53 | 9 | 4.4 | 0.88 |
| MAY 5-MAY 7 | 40 | 4.4 | 1.08 | 10 | 4.2 | 0.92 | 50 | 4.4 | 1.05 |
| MAY 8-MAY 10 | 3 | 2.7 | 0.58 | 21 | 4.0 | 1.34 | 24 | 3.8 | 1.34 |
| MAY 11-MAY 13 | 86 | 3.3 | 0.97 | 27 | 3.1 | 0.92 | 113 | 3.3 | 0.96 |
| MAY 14-MAY 16 | 63 | 4.3 | 1.07 | 4 | 3.5 | 1.73 | 67 | 4.2 | 1.11 |
| MAY 17-MAY 19 | 61 | 4.1 | 1.24 | 3 | 4.7 | 1.15 | 64 | 4.2 | 1.24 |
| MAY 20-MAY 22 | 100 | 3.4 | 0.94 | 1 | 2.0 | 0.00 | 101 | 3.4 | 0.95 |
| MAY 23-MAY 25 | 35 | 4.1 | 1.42 | 1 | 4.0 | 0.00 | 36 | 4.1 | 1.40 |
| MAY 26-MAY 28 | 43 | 4.1 | 1.18 | 0 | 0.0 | 0.00 | 43 | 4.1 | 1.18 |
| MAY 29-MAY 31 | 25 | 4.0 | 0.84 | 6 | 3.8 | 0.75 | 31 | 3.9 | 0.81 |
| JUN 1-JUN 3 | 37 | 4.6 | 0.92 | 10 | 4.4 | 1.07 | 47 | 4.6 | 0.95 |
| JUN 4-JUN 6 | 14 | 3.6 | 1.02 | 1 | 6.0 | 0.00 | 15 | 3.7 | 1.16 |
| JUN 7-JUN 9 | 3 | 4.0 | 1.00 | 2 | 4.5 | 0.71 | 5 | 4.2 | 0.84 |
| JUN 10-JUN 12 | 19 | 3.9 | 0.99 | 22 | 3.6 | 1.00 | 41 | 3.8 | 0.99 |
| JUN 13-JUN 15 | 2 | 5.0 | 0.00 | 1 | 4.0 | 0.00 | 3 | 4.7 | 0.58 |
| JUN 16-JUN 18 | 0 | 0.0 | 0.00 | 1 | 2.0 | 0.00 | 1 | 2.0 | 0.00 |
| JUN 19-JUN 21 | 1 | 5.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 5.0 | 0.00 |
| JUN 22-JUN 24 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 25-JUN 27 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 28-JUN 30 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 1-JUL 3 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 4-JUL 6 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 7-JUL 9 | 14 | 4.4 | 1.08 | 3 | 3.0 | 1.00 | 17 | 4.1 | 1.17 |
| JUL 10-JUL 12 | 12 | 3.8 | 0.75 | 1 | 4.0 | 0.00 | 13 | 3.8 | 0.73 |
| JUL 13-JUL 15 | 2 | 5.5 | 0.71 | 0 | 0.0 | 0.00 | 2 | 5.5 | 0.71 |
| JUL 16-JUL 18 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| | | | | YEARLING CHINOOK SALMON | | | | | |
| MAR 18-MAR 20 | 0 | 0.0 | 0.00 | 1 | 5.0 | 0.00 | 1 | 5.0 | 0.00 |
| MAR 21-MAR 23 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| MAR 24-MAR 26 | 0 | 0.0 | 0.00 | 1 | 4.0 | 0.00 | 1 | 4.0 | 0.00 |
| MAR 27-MAR 29 | 0 | 0.0 | 0.00 | 1 | 1.0 | 0.00 | 1 | 1.0 | 0.00 |
| MAR 30-APR 1 | 5 | 4.0 | 1.22 | 2 | 1.5 | 0.71 | 7 | 3.3 | 1.60 |
| APR 2-APR 4 | 5 | 3.2 | 2.28 | 0 | 0.0 | 0.00 | 5 | 3.2 | 2.28 |
| APR 5-APR 7 | 6 | 5.0 | 1.41 | 0 | 0.0 | 0.00 | 6 | 5.0 | 1.41 |
| APR 8-APR 10 | 2 | 4.5 | 0.71 | 1 | 5.0 | 0.00 | 3 | 4.7 | 0.58 |
| APR 11-APR 13 | 6 | 6.2 | 0.98 | 1 | 4.0 | 0.00 | 7 | 5.9 | 1.21 |
| APR 14-APR 16 | 31 | 4.5 | 1.36 | 1 | 3.0 | 0.00 | 32 | 4.4 | 1.36 |
| APR 17-APR 19 | 11 | 4.0 | 1.00 | 0 | 0.0 | 0.00 | 11 | 4.0 | 1.00 |
| APR 20-APR 22 | 17 | 3.5 | 1.12 | 3 | 4.0 | 1.73 | 20 | 3.6 | 1.19 |
| APR 23-APR 25 | 14 | 3.4 | 1.09 | 2 | 4.5 | 2.12 | 16 | 3.6 | 1.21 |
| APR 26-APR 28 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| APR 29-MAY 1 | 31 | 4.5 | 0.99 | 0 | 0.0 | 0.00 | 31 | 4.5 | 0.99 |
| MAY 2-MAY 4 | 34 | 4.5 | 1.11 | 2 | 4.0 | 1.41 | 36 | 4.4 | 1.11 |
| MAY 5-MAY 7 | 22 | 3.7 | 1.17 | 0 | 0.0 | 0.00 | 22 | 3.7 | 1.17 |
| MAY 8-MAY 10 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 | 1 | 3.0 | 0.00 |
| MAY 11-MAY 13 | 16 | 3.3 | 0.86 | 0 | 0.0 | 0.00 | 16 | 3.3 | 0.86 |
| MAY 14-MAY 16 | 17 | 3.8 | 1.25 | 0 | 0.0 | 0.00 | 17 | 3.8 | 1.25 |
| MAY 17-MAY 19 | 9 | 2.3 | 0.71 | 0 | 0.0 | 0.00 | 9 | 2.3 | 0.71 |
| MAY 20-MAY 22 | 9 | 2.6 | 1.13 | 0 | 0.0 | 0.00 | 9 | 2.6 | 1.13 |
| MAY 23-MAY 25 | 13 | 2.4 | 1.19 | 0 | 0.0 | 0.00 | 13 | 2.4 | 1.19 |
| MAY 26-MAY 28 | 24 | 2.8 | 1.29 | 0 | 0.0 | 0.00 | 24 | 2.8 | 1.29 |
| MAY 29-MAY 31 | 18 | 3.5 | 0.86 | 0 | 0.0 | 0.00 | 18 | 3.5 | 0.86 |
| JUN 1-JUN 3 | 4 | 4.0 | 1.15 | 1 | 4.0 | 0.00 | 5 | 4.0 | 1.00 |
| JUN 4-JUN 6 | 8 | 3.0 | 0.53 | 2 | 2.0 | 1.41 | 10 | 2.8 | 0.79 |
| JUN 7-JUN 9 | 1 | 3.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 |
| JUN 10-JUN 12 | 1 | 2.0 | 0.00 | 1 | 3.0 | 0.00 | 2 | 2.5 | 0.71 |
| JUN 13-JUN 15 | 2 | 5.5 | 0.71 | 1 | 1.0 | 0.00 | 3 | 4.0 | 2.65 |
| JUN 16-JUN 18 | 2 | 4.5 | 2.12 | 0 | 0.0 | 0.00 | 2 | 4.5 | 2.12 |
| JUN 19-JUN 21 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 22-JUN 24 | 2 | 3.5 | 2.12 | 0 | 0.0 | 0.00 | 2 | 3.5 | 2.12 |
| JUN 25-JUN 27 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 28-JUN 30 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 1-JUL 3 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 4-JUL 6 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 7-JUL 9 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 10-JUL 12 | 2 | 3.0 | 0.00 | 0 | 0.0 | 0.00 | 2 | 3.0 | 0.00 |
| JUL 13-JUL 15 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |

Appendix Table B3.--continued.

| 1981 | Purse Seine n | Purse Seine Mean | Purse Seine SD | Beach Seine n | Beach Seine Mean | Beach Seine SD | Purse & Beach Seine n | Purse & Beach Seine Mean | Purse & Beach Seine SD |
|---|---|---|---|---|---|---|---|---|---|
| | | | | STEELHEAD | | | | | |
| APR 29-MAY 1 | 2 | 5.0 | 0.00 | 0 | 0.0 | 0.00 | 2 | 5.0 | 0.00 |
| MAY 2-MAY 4 | 8 | 3.3 | 1.16 | 0 | 0.0 | 0.00 | 8 | 3.3 | 1.16 |
| MAY 5-MAY 7 | 5 | 3.4 | 0.55 | 0 | 0.0 | 0.00 | 5 | 3.4 | 0.55 |
| MAY 8-MAY 10 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| MAY 11-MAY 13 | 111 | 2.7 | 1.06 | 0 | 0.0 | 0.00 | 111 | 2.7 | 1.06 |
| MAY 14-MAY 16 | 14 | 2.6 | 1.28 | 0 | 0.0 | 0.00 | 14 | 2.6 | 1.28 |
| MAY 17-MAY 19 | 27 | 2.9 | 1.04 | 0 | 0.0 | 0.00 | 27 | 2.9 | 1.04 |
| MAY 20-MAY 22 | 15 | 2.9 | 1.28 | 0 | 0.0 | 0.00 | 15 | 2.9 | 1.28 |
| MAY 23-MAY 25 | 14 | 2.7 | 1.07 | 0 | 0.0 | 0.00 | 14 | 2.7 | 1.07 |
| MAY 26-MAY 28 | 10 | 3.0 | 0.94 | 0 | 0.0 | 0.00 | 10 | 3.0 | 0.94 |
| MAY 29-MAY 31 | 52 | 3.9 | 1.18 | 1 | 5.0 | 0.00 | 53 | 3.9 | 1.18 |
| JUN 1-JUN 3 | 1 | 3.0 | 0.00 | 1 | 3.0 | 0.00 | 2 | 3.0 | 0.00 |
| JUN 4-JUN 6 | 14 | 3.6 | 1.45 | 0 | 0.0 | 0.00 | 14 | 3.6 | 1.45 |
| JUN 7-JUN 9 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 10-JUN 12 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 13-JUN 15 | 2 | 5.0 | 2.83 | 0 | 0.0 | 0.00 | 2 | 5.0 | 2.83 |
| JUN 16-JUN 18 | 1 | 6.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 6.0 | 0.00 |
| JUN 19-JUN 21 | 2 | 2.5 | 0.71 | 0 | 0.0 | 0.00 | 2 | 2.5 | 0.71 |
| JUN 22-JUN 24 | 2 | 2.0 | 0.00 | 0 | 0.0 | 0.00 | 2 | 2.0 | 0.00 |
| JUN 25-JUN 27 | 1 | 3.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 |
| JUN 28-JUN 30 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| | | | | SUBYEARLING CHINOOK SALMON | | | | | |
| MAR 18-MAR 20 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 | 1 | 3.0 | 0.00 |
| MAR 21-MAR 23 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| MAR 24-MAR 26 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| MAR 27-MAR 29 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| MAR 30-APR 1 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 | 1 | 3.0 | 0.00 |
| APR 2-APR 4 | 1 | 4.0 | 0.00 | 13 | 3.2 | 1.64 | 14 | 3.3 | 1.59 |
| APR 5-APR 7 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| APR 8-APR 10 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| APR 11-APR 13 | 0 | 0.0 | 0.00 | 2 | 6.0 | 1.41 | 2 | 6.0 | 1.41 |
| APR 14-APR 16 | 1 | 4.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 4.0 | 0.00 |
| APR 17-APR 19 | 0 | 0.0 | 0.00 | 5 | 2.2 | 0.45 | 5 | 2.2 | 0.45 |
| APR 20-APR 22 | 6 | 4.7 | 1.37 | 5 | 4.2 | 1.79 | 11 | 4.5 | 1.51 |
| APR 23-APR 25 | 1 | 3.0 | 0.00 | 10 | 4.3 | 1.16 | 11 | 4.2 | 1.17 |
| APR 26-APR 28 | 0 | 0.0 | 0.00 | 16 | 3.3 | 1.01 | 16 | 3.3 | 1.01 |
| APR 29-MAY 1 | 9 | 3.9 | 1.27 | 125 | 3.5 | 0.96 | 134 | 3.6 | 0.98 |
| MAY 2-MAY 4 | 6 | 4.2 | 0.75 | 40 | 3.9 | 1.31 | 46 | 4.0 | 1.25 |
| MAY 5-MAY 7 | 7 | 4.1 | 1.07 | 9 | 3.9 | 1.36 | 16 | 4.0 | 1.21 |
| MAY 8-MAY 10 | 0 | 0.0 | 0.00 | 81 | 3.1 | 1.10 | 81 | 3.1 | 1.10 |
| MAY 11-MAY 13 | 20 | 3.1 | 1.02 | 81 | 3.2 | 0.84 | 101 | 3.2 | 0.88 |
| MAY 14-MAY 16 | 19 | 4.4 | 1.43 | 36 | 3.2 | 1.59 | 55 | 3.6 | 1.64 |
| MAY 17-MAY 19 | 55 | 3.7 | 1.22 | 92 | 3.6 | 1.13 | 147 | 3.7 | 1.16 |
| MAY 20-MAY 22 | 32 | 3.9 | 1.06 | 131 | 3.6 | 1.04 | 163 | 3.6 | 1.05 |
| MAY 23-MAY 25 | 8 | 3.6 | 1.30 | 42 | 4.1 | 1.54 | 50 | 4.0 | 1.50 |
| MAY 26-MAY 28 | 38 | 3.7 | 1.36 | 68 | 3.1 | 1.20 | 106 | 3.3 | 1.28 |
| MAY 29-MAY 31 | 15 | 3.8 | 1.01 | 69 | 3.6 | 1.08 | 84 | 3.6 | 1.06 |
| JUN 1-JUN 3 | 23 | 4.7 | 1.10 | 72 | 3.7 | 0.98 | 95 | 4.0 | 1.10 |
| JUN 4-JUN 6 | 19 | 4.2 | 1.27 | 78 | 3.8 | 0.92 | 97 | 3.9 | 1.01 |
| JUN 7-JUN 9 | 12 | 3.8 | 0.83 | 82 | 3.9 | 1.12 | 94 | 3.9 | 1.09 |
| JUN 10-JUN 12 | 27 | 3.8 | 1.08 | 108 | 3.4 | 0.94 | 135 | 3.5 | 0.98 |
| JUN 13-JUN 15 | 15 | 4.3 | 1.10 | 38 | 3.4 | 1.10 | 53 | 3.6 | 1.16 |
| JUN 16-JUN 18 | 14 | 4.4 | 1.28 | 38 | 3.5 | 0.95 | 52 | 3.8 | 1.12 |
| JUN 19-JUN 21 | 12 | 3.8 | 0.97 | 66 | 4.0 | 1.26 | 78 | 4.0 | 1.22 |
| JUN 22-JUN 24 | 5 | 4.2 | 1.30 | 54 | 3.4 | 1.20 | 59 | 3.4 | 1.22 |
| JUN 25-JUN 27 | 5 | 2.6 | 0.89 | 27 | 4.0 | 1.30 | 32 | 3.8 | 1.34 |
| JUN 28-JUN 30 | 4 | 3.3 | 0.50 | 110 | 2.9 | 1.31 | 114 | 3.0 | 1.29 |
| JUL 1-JUL 3 | 19 | 3.0 | 0.67 | 404 | 2.6 | 0.89 | 423 | 2.6 | 0.88 |
| JUL 4-JUL 6 | 5 | 2.8 | 1.30 | 129 | 2.5 | 0.93 | 134 | 2.5 | 0.94 |
| JUL 7-JUL 9 | 14 | 3.4 | 1.22 | 202 | 2.9 | 1.11 | 216 | 2.9 | 1.13 |
| JUL 10-JUL 12 | 4 | 4.5 | 1.73 | 53 | 3.3 | 1.05 | 57 | 3.4 | 1.13 |
| JUL 13-JUL 15 | 4 | 4.0 | 1.41 | 44 | 4.4 | 1.53 | 48 | 4.4 | 1.51 |
| JUL 16-JUL 18 | 1 | 4.0 | 0.00 | 24 | 2.5 | 0.93 | 25 | 2.6 | 0.96 |
| JUL 19-JUL 21 | 2 | 2.5 | 0.71 | 22 | 3.5 | 1.34 | 24 | 3.4 | 1.31 |
| JUL 22-JUL 24 | 0 | 0.0 | 0.00 | 48 | 2.8 | 1.38 | 48 | 2.8 | 1.38 |
| JUL 25-JUL 27 | 0 | 0.0 | 0.00 | 7 | 2.9 | 0.90 | 7 | 2.9 | 0.90 |
| JUL 28-JUL 30 | 3 | 4.7 | 1.15 | 27 | 3.2 | 1.30 | 30 | 3.3 | 1.35 |
| JUL 31-AUG 2 | 9 | 3.2 | 0.44 | 6 | 2.8 | 1.83 | 15 | 3.1 | 1.16 |
| AUG 3-AUG 5 | 13 | 4.3 | 0.85 | 27 | 3.6 | 1.15 | 40 | 3.9 | 1.10 |
| AUG 6-AUG 8 | 4 | 6.0 | 2.00 | 13 | 4.6 | 1.94 | 17 | 4.9 | 1.98 |
| AUG 9-AUG 11 | 27 | 4.2 | 1.50 | 5 | 3.8 | 1.48 | 32 | 4.2 | 1.48 |
| AUG 12-AUG 14 | 10 | 3.5 | 0.85 | 9 | 3.2 | 0.97 | 19 | 3.4 | 0.90 |
| AUG 15-AUG 17 | 0 | 0.0 | 0.00 | 3 | 2.7 | 1.53 | 3 | 2.7 | 1.53 |
| AUG 18-AUG 20 | 0 | 0.0 | 0.00 | 7 | 4.4 | 1.90 | 7 | 4.4 | 1.90 |
| AUG 21-AUG 23 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 | 1 | 3.0 | 0.00 |
| AUG 24-AUG 26 | 0 | 0.0 | 0.00 | 4 | 2.3 | 0.96 | 4 | 2.3 | 0.96 |
| AUG 27-AUG 29 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| AUG 30-SEP 1 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 | 1 | 3.0 | 0.00 |
| SEP 2-SEP 4 | 0 | 0.0 | 0.00 | 2 | 5.0 | 2.83 | 2 | 5.0 | 2.83 |
| SEP 5-SEP 7 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| SEP 8-SEP 10 | 3 | 6.0 | 1.00 | 2 | 3.5 | 2.12 | 5 | 5.0 | 1.87 |
| SEP 11-SEP 13 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| SEP 14-SEP 16 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| SEP 17-SEP 19 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| SEP 20-SEP 22 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| SEP 23-SEP 25 | 0 | 0.0 | 0.00 | 5 | 3.8 | 1.30 | 5 | 3.8 | 1.30 |
| SEP 26-SEP 28 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| SEP 29-OCT 1 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |

Appendix Table B4.--Mean stomach fullness and standard deviation for juvenile salmonids captured in purse and beach seines at Jones Beach by 3-day intervals, 1982.

| 1982 | Purse Seine | | | Beach Seine | | | Purse & Beach Seine | | |
|---|---|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | n | Mean | SD |
| **COHO SALMON** | | | | | | | | | |
| APR 29-MAY 1 | 1 | 7.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 7.0 | 0.00 |
| MAY 2-MAY 4 | 1 | 7.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 7.0 | 0.00 |
| MAY 5-MAY 7 | 5 | 3.6 | 0.89 | 37 | 3.1 | 0.81 | 42 | 3.2 | 0.82 |
| MAY 8-MAY 10 | 13 | 3.6 | 1.19 | 92 | 3.7 | 0.97 | 105 | 3.7 | 1.00 |
| MAY 11-MAY 13 | 35 | 3.8 | 0.99 | 85 | 3.7 | 0.78 | 120 | 3.7 | 0.84 |
| MAY 14-MAY 16 | 77 | 3.7 | 0.94 | 33 | 4.1 | 1.23 | 110 | 3.8 | 1.04 |
| MAY 17-MAY 19 | 83 | 3.9 | 1.01 | 20 | 3.9 | 1.21 | 103 | 3.9 | 1.04 |
| MAY 20-MAY 22 | 60 | 3.9 | 1.09 | 17 | 4.2 | 1.19 | 77 | 4.0 | 1.11 |
| MAY 23-MAY 25 | 61 | 4.0 | 1.07 | 14 | 3.9 | 0.95 | 75 | 3.9 | 1.04 |
| MAY 26-MAY 28 | 102 | 4.0 | 0.97 | 9 | 3.9 | 1.45 | 111 | 4.0 | 1.01 |
| MAY 29-MAY 31 | 60 | 4.5 | 1.21 | 35 | 4.3 | 1.43 | 95 | 4.4 | 1.29 |
| JUN 1-JUN 3 | 108 | 3.9 | 0.81 | 21 | 3.9 | 0.83 | 129 | 3.9 | 0.81 |
| JUN 4-JUN 6 | 95 | 3.9 | 0.87 | 2 | 5.0 | 0.00 | 97 | 3.9 | 0.87 |
| JUN 7-JUN 9 | 60 | 4.0 | 1.07 | 0 | 0.0 | 0.00 | 60 | 4.0 | 1.07 |
| JUN 10-JUN 12 | 79 | 3.7 | 1.00 | 1 | 5.0 | 0.00 | 80 | 3.8 | 1.00 |
| JUN 13-JUN 15 | 45 | 3.4 | 0.77 | 3 | 4.3 | 1.53 | 48 | 3.4 | 0.85 |
| JUN 16-JUN 18 | 34 | 3.8 | 0.82 | 1 | 4.0 | 0.00 | 35 | 3.8 | 0.81 |
| JUN 19-JUN 21 | 27 | 3.5 | 1.09 | 1 | 4.0 | 0.00 | 28 | 3.5 | 1.07 |
| JUN 22-JUN 24 | 2 | 3.0 | 0.00 | 2 | 4.0 | 2.83 | 4 | 3.5 | 1.73 |
| JUN 25-JUN 27 | 1 | 3.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 |
| JUN 28-JUN 30 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 1-JUL 3 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 4-JUL 6 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 7-JUL 9 | 1 | 4.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 4.0 | 0.00 |
| JUL 10-JUL 12 | 1 | 3.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 |
| **YEARLING CHINOOK SALMON** | | | | | | | | | |
| MAR 6-MAR 8 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 | 1 | 3.0 | 0.00 |
| MAR 9-MAR 11 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| MAR 12-MAR 14 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 | 1 | 3.0 | 0.00 |
| MAR 15-MAR 17 | 0 | 0.0 | 0.00 | 3 | 3.3 | 0.58 | 3 | 3.3 | 0.58 |
| MAR 18-MAR 20 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 | 1 | 3.0 | 0.00 |
| MAR 21-MAR 23 | 0 | 0.0 | 0.00 | 11 | 1.7 | 0.65 | 11 | 1.7 | 0.65 |
| MAR 24-MAR 26 | 0 | 0.0 | 0.00 | 49 | 1.9 | 1.24 | 49 | 1.9 | 1.24 |
| MAR 27-MAR 29 | 5 | 3.0 | 1.58 | 13 | 1.7 | 0.75 | 18 | 2.1 | 1.16 |
| MAR 30-APR 1 | 3 | 2.7 | 2.08 | 19 | 2.1 | 1.03 | 22 | 2.1 | 1.17 |
| APR 2-APR 4 | 0 | 0.0 | 0.00 | 23 | 2.5 | 1.78 | 23 | 2.5 | 1.78 |
| APR 5-APR 7 | 3 | 3.3 | 3.21 | 21 | 2.2 | 1.18 | 24 | 2.4 | 1.50 |
| APR 8-APR 10 | 3 | 4.3 | 2.31 | 21 | 2.8 | 1.26 | 24 | 3.0 | 1.46 |
| APR 11-APR 13 | 0 | 0.0 | 0.00 | 25 | 2.4 | 1.19 | 25 | 2.4 | 1.19 |
| APR 14-APR 16 | 1 | 4.0 | 0.00 | 10 | 3.8 | 2.10 | 11 | 3.8 | 1.99 |
| APR 17-APR 19 | 4 | 5.0 | 1.15 | 5 | 3.8 | 0.84 | 9 | 4.3 | 1.12 |
| APR 20-APR 22 | 7 | 4.9 | 1.21 | 13 | 4.5 | 1.33 | 20 | 4.6 | 1.27 |
| APR 23-APR 25 | 4 | 3.8 | 0.96 | 2 | 3.5 | 0.71 | 6 | 3.7 | 0.82 |
| APR 26-APR 28 | 14 | 3.8 | 1.12 | 8 | 3.8 | 1.83 | 22 | 3.8 | 1.38 |
| APR 29-MAY 1 | 38 | 4.1 | 1.35 | 5 | 4.6 | 1.34 | 43 | 4.1 | 1.35 |
| MAY 2-MAY 4 | 19 | 3.8 | 1.42 | 3 | 3.0 | 1.00 | 22 | 3.7 | 1.39 |
| MAY 5-MAY 7 | 19 | 3.6 | 0.69 | 2 | 3.0 | 0.00 | 21 | 3.5 | 0.68 |
| MAY 8-MAY 10 | 12 | 3.8 | 0.62 | 5 | 3.2 | 1.30 | 17 | 3.6 | 0.87 |
| MAY 11-MAY 13 | 21 | 3.3 | 0.48 | 1 | 3.0 | 0.00 | 22 | 3.3 | 0.48 |
| MAY 14-MAY 16 | 9 | 3.2 | 0.97 | 1 | 5.0 | 0.00 | 10 | 3.4 | 1.07 |
| MAY 17-MAY 19 | 8 | 3.9 | 1.46 | 1 | 3.0 | 0.00 | 9 | 3.8 | 1.39 |
| MAY 20-MAY 22 | 3 | 3.0 | 0.00 | 3 | 4.3 | 2.31 | 6 | 3.7 | 1.63 |
| MAY 23-MAY 25 | 3 | 3.3 | 0.58 | 0 | 0.0 | 0.00 | 3 | 3.3 | 0.58 |
| MAY 26-MAY 28 | 6 | 3.2 | 0.98 | 1 | 3.0 | 0.00 | 7 | 3.1 | 0.90 |
| MAY 29-MAY 31 | 3 | 3.7 | 0.58 | 1 | 2.0 | 0.00 | 4 | 3.3 | 0.96 |
| JUN 1-JUN 3 | 7 | 3.1 | 0.38 | 2 | 2.5 | 0.71 | 9 | 3.0 | 0.50 |
| JUN 4-JUN 6 | 7 | 3.0 | 0.00 | 3 | 1.7 | 1.15 | 10 | 2.6 | 0.84 |
| JUN 7-JUN 9 | 3 | 3.0 | 0.00 | 0 | 0.0 | 0.00 | 3 | 3.0 | 0.00 |
| JUN 10-JUN 12 | 3 | 3.0 | 0.00 | 0 | 0.0 | 0.00 | 3 | 3.0 | 0.00 |
| JUN 13-JUN 15 | 10 | 2.9 | 0.32 | 0 | 0.0 | 0.00 | 10 | 2.9 | 0.32 |
| JUN 16-JUN 18 | 2 | 2.0 | 1.41 | 0 | 0.0 | 0.00 | 2 | 2.0 | 1.41 |
| JUN 19-JUN 21 | 4 | 3.0 | 0.82 | 0 | 0.0 | 0.00 | 4 | 3.0 | 0.82 |
| JUN 22-JUN 24 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 25-JUN 27 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 28-JUN 30 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |

Appendix Table B4.--continued.

| 1982 | Purse Seine n | Purse Seine Mean | Purse Seine SD | Beach Seine n | Beach Seine Mean | Beach Seine SD | Purse & Beach Seine n | Purse & Beach Seine Mean | Purse & Beach Seine SD |
|---|---|---|---|---|---|---|---|---|---|
| | | | | STEELHEAD | | | | | |
| APR 23-APR 25 | 2 | 1.5 | 0.71 | 0 | 0.0 | 0.00 | 2 | 1.5 | 0.71 |
| APR 26-APR 28 | 0 | 0.0 | 0.00 | 2 | 2.0 | 0.00 | 2 | 2.0 | 0.00 |
| APR 29-MAY 1 | 1 | 3.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 |
| MAY 2-MAY 4 | 1 | 2.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 2.0 | 0.00 |
| MAY 5-MAY 7 | 7 | 3.7 | 0.95 | 1 | 3.0 | 0.00 | 8 | 3.6 | 0.92 |
| MAY 8-MAY 10 | 5 | 2.6 | 0.55 | 0 | 0.0 | 0.00 | 5 | 2.6 | 0.55 |
| MAY 11-MAY 13 | 16 | 3.2 | 0.66 | 1 | 3.0 | 0.00 | 17 | 3.2 | 0.64 |
| MAY 14-MAY 16 | 19 | 2.4 | 0.96 | 0 | 0.0 | 0.00 | 19 | 2.4 | 0.96 |
| MAY 17-MAY 19 | 36 | 3.1 | 0.97 | 0 | 0.0 | 0.00 | 36 | 3.1 | 0.97 |
| MAY 20-MAY 22 | 30 | 2.9 | 1.04 | 0 | 0.0 | 0.00 | 30 | 2.9 | 1.04 |
| MAY 23-MAY 25 | 13 | 3.4 | 0.87 | 0 | 0.0 | 0.00 | 13 | 3.4 | 0.87 |
| MAY 26-MAY 28 | 20 | 3.2 | 0.81 | 0 | 0.0 | 0.00 | 20 | 3.2 | 0.81 |
| MAY 29-MAY 31 | 26 | 3.3 | 0.68 | 0 | 0.0 | 0.00 | 26 | 3.3 | 0.68 |
| JUN 1-JUN 3 | 18 | 2.9 | 0.96 | 0 | 0.0 | 0.00 | 18 | 2.9 | 0.96 |
| JUN 4-JUN 6 | 30 | 3.1 | 1.06 | 1 | 1.0 | 0.00 | 31 | 3.0 | 1.11 |
| JUN 7-JUN 9 | 12 | 2.6 | 0.67 | 0 | 0.0 | 0.00 | 12 | 2.6 | 0.67 |
| JUN 10-JUN 12 | 14 | 2.9 | 0.62 | 0 | 0.0 | 0.00 | 14 | 2.9 | 0.62 |
| JUN 13-JUN 15 | 15 | 3.5 | 1.81 | 0 | 0.0 | 0.00 | 15 | 3.5 | 1.81 |
| JUN 16-JUN 18 | 3 | 3.3 | 2.31 | 0 | 0.0 | 0.00 | 3 | 3.3 | 2.31 |
| JUN 19-JUN 21 | 3 | 3.7 | 2.52 | 0 | 0.0 | 0.00 | 3 | 3.7 | 2.52 |
| JUN 22-JUN 24 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 25-JUN 27 | 1 | 2.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 2.0 | 0.00 |
| JUN 28-JUN 30 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 1-JUL 3 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 4-JUL 6 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 7-JUL 9 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 10-JUL 12 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 13-JUL 15 | 1 | 3.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 |
| JUL 16-JUL 18 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |

Appendix Table B4.--continued.

| 1982 | Purse Seine n | Purse Seine Mean | Purse Seine SD | Beach Seine n | Beach Seine Mean | Beach Seine SD | Purse & Beach Seine n | Purse & Beach Seine Mean | Purse & Beach Seine SD |
|---|---|---|---|---|---|---|---|---|---|
| SUBYEARLING CHINOOK SALMON | | | | | | | | | |
| MAR 27-MAR 29 | 0 | 0.0 | 0.00 | 9 | 3.6 | 1.42 | 9 | 3.6 | 1.42 |
| MAR 30-APR 1 | 0 | 0.0 | 0.00 | 12 | 3.7 | 1.72 | 12 | 3.7 | 1.72 |
| APR 2-APR 4 | 0 | 0.0 | 0.00 | 10 | 3.4 | 1.07 | 10 | 3.4 | 1.07 |
| APR 5-APR 7 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 | 1 | 3.0 | 0.00 |
| APR 8-APR 10 | 0 | 0.0 | 0.00 | 3 | 3.3 | 0.58 | 3 | 3.3 | 0.58 |
| APR 11-APR 13 | 0 | 0.0 | 0.00 | 5 | 4.0 | 1.22 | 5 | 4.0 | 1.22 |
| APR 14-APR 16 | 0 | 0.0 | 0.00 | 5 | 4.2 | 1.10 | 5 | 4.2 | 1.10 |
| APR 17-APR 19 | 0 | 0.0 | 0.00 | 18 | 3.4 | 1.25 | 18 | 3.4 | 1.25 |
| APR 20-APR 22 | 1 | 7.0 | 0.00 | 86 | 4.0 | 1.25 | 87 | 4.1 | 1.28 |
| APR 23-APR 25 | 1 | 4.0 | 0.00 | 50 | 3.9 | 1.56 | 51 | 3.9 | 1.54 |
| APR 26-APR 28 | 3 | 3.3 | 2.52 | 105 | 3.7 | 1.39 | 108 | 3.6 | 1.42 |
| APR 29-MAY 1 | 3 | 4.3 | 0.58 | 112 | 3.6 | 1.11 | 115 | 3.7 | 1.11 |
| MAY 2-MAY 4 | 3 | 4.3 | 0.58 | 90 | 3.9 | 1.13 | 93 | 3.9 | 1.12 |
| MAY 5-MAY 7 | 4 | 4.5 | 1.73 | 82 | 4.3 | 1.22 | 86 | 4.3 | 1.23 |
| MAY 8-MAY 10 | 0 | 0.0 | 0.00 | 50 | 4.3 | 1.23 | 50 | 4.3 | 1.23 |
| MAY 11-MAY 13 | 13 | 5.2 | 1.34 | 46 | 4.3 | 1.57 | 59 | 4.5 | 1.55 |
| MAY 14-MAY 16 | 10 | 5.1 | 1.60 | 33 | 4.8 | 1.48 | 43 | 4.9 | 1.49 |
| MAY 17-MAY 19 | 8 | 4.9 | 1.36 | 32 | 4.7 | 1.41 | 40 | 4.7 | 1.38 |
| MAY 20-MAY 22 | 2 | 4.5 | 0.71 | 13 | 5.4 | 1.50 | 15 | 5.3 | 1.44 |
| MAY 23-MAY 25 | 18 | 3.8 | 0.88 | 43 | 4.0 | 1.22 | 61 | 4.0 | 1.13 |
| MAY 26-MAY 28 | 7 | 3.6 | 0.98 | 18 | 4.7 | 1.23 | 25 | 4.4 | 1.26 |
| MAY 29-MAY 31 | 5 | 3.8 | 1.30 | 11 | 4.3 | 0.90 | 16 | 4.1 | 1.02 |
| JUN 1-JUN 3 | 20 | 3.6 | 1.10 | 99 | 3.4 | 1.09 | 119 | 3.4 | 1.09 |
| JUN 4-JUN 6 | 33 | 3.9 | 1.05 | 124 | 3.4 | 1.00 | 157 | 3.5 | 1.03 |
| JUN 7-JUN 9 | 72 | 3.8 | 0.94 | 151 | 4.1 | 0.92 | 223 | 4.0 | 0.94 |
| JUN 10-JUN 12 | 23 | 4.2 | 0.90 | 196 | 4.4 | 1.26 | 219 | 4.4 | 1.23 |
| JUN 13-JUN 15 | 69 | 3.7 | 1.12 | 155 | 4.1 | 1.24 | 224 | 4.0 | 1.22 |
| JUN 16-JUN 18 | 50 | 4.3 | 1.14 | 112 | 4.0 | 1.27 | 162 | 4.1 | 1.23 |
| JUN 19-JUN 21 | 51 | 4.2 | 1.45 | 64 | 4.0 | 1.21 | 115 | 4.0 | 1.32 |
| JUN 22-JUN 24 | 29 | 4.2 | 1.08 | 27 | 4.3 | 1.27 | 56 | 4.3 | 1.17 |
| JUN 25-JUN 27 | 38 | 3.6 | 0.86 | 56 | 4.3 | 1.44 | 94 | 4.0 | 1.29 |
| JUN 28-JUN 30 | 94 | 3.6 | 0.82 | 78 | 3.9 | 1.08 | 172 | 3.7 | 0.96 |
| JUL 1-JUL 3 | 74 | 4.0 | 0.99 | 58 | 4.0 | 0.98 | 132 | 4.0 | 0.98 |
| JUL 4-JUL 6 | 9 | 4.4 | 1.01 | 36 | 4.1 | 1.17 | 45 | 4.2 | 1.14 |
| JUL 7-JUL 9 | 28 | 4.2 | 0.77 | 107 | 4.4 | 1.36 | 135 | 4.3 | 1.26 |
| JUL 10-JUL 12 | 23 | 3.8 | 0.90 | 161 | 4.3 | 1.28 | 184 | 4.2 | 1.25 |
| JUL 13-JUL 15 | 9 | 5.2 | 1.09 | 91 | 4.1 | 1.14 | 100 | 4.2 | 1.18 |
| JUL 16-JUL 18 | 4 | 6.0 | 1.41 | 72 | 4.4 | 1.49 | 76 | 4.5 | 1.52 |
| JUL 19-JUL 21 | 5 | 4.8 | 0.45 | 83 | 4.3 | 1.53 | 88 | 4.4 | 1.50 |
| JUL 22-JUL 24 | 2 | 4.0 | 0.00 | 24 | 4.1 | 1.74 | 26 | 4.1 | 1.67 |
| JUL 25-JUL 27 | 13 | 3.0 | 0.58 | 40 | 4.3 | 1.38 | 53 | 4.0 | 1.36 |
| JUL 28-JUL 30 | 4 | 4.0 | 0.82 | 47 | 3.9 | 1.41 | 51 | 3.9 | 1.37 |
| JUL 31-AUG 2 | 3 | 3.7 | 2.08 | 8 | 3.8 | 1.04 | 11 | 3.7 | 1.27 |
| AUG 3-AUG 5 | 2 | 3.0 | 0.00 | 40 | 3.4 | 0.98 | 42 | 3.4 | 0.96 |
| AUG 6-AUG 8 | 4 | 5.3 | 1.50 | 15 | 4.5 | 1.41 | 19 | 4.6 | 1.42 |
| AUG 9-AUG 11 | 9 | 3.9 | 1.05 | 78 | 4.1 | 1.24 | 87 | 4.0 | 1.22 |
| AUG 12-AUG 14 | 2 | 5.5 | 2.12 | 37 | 4.0 | 1.20 | 39 | 4.1 | 1.26 |
| AUG 15-AUG 17 | 2 | 3.5 | 0.71 | 25 | 3.1 | 0.91 | 27 | 3.1 | 0.89 |
| AUG 18-AUG 20 | 2 | 3.0 | 0.00 | 32 | 4.5 | 1.46 | 34 | 4.4 | 1.46 |
| AUG 21-AUG 23 | 0 | 0.0 | 0.00 | 3 | 5.3 | 0.58 | 3 | 5.3 | 0.58 |
| AUG 24-AUG 26 | 3 | 6.3 | 0.58 | 10 | 5.7 | 1.49 | 13 | 5.8 | 1.34 |
| AUG 27-AUG 29 | 0 | 0.0 | 0.00 | 2 | 5.5 | 2.12 | 2 | 5.5 | 2.12 |
| AUG 30-SEP 1 | 1 | 7.0 | 0.00 | 3 | 2.7 | 0.58 | 4 | 3.8 | 2.22 |
| SEP 2-SEP 4 | 0 | 0.0 | 0.00 | 2 | 5.0 | 0.00 | 2 | 5.0 | 0.00 |
| SEP 5-SEP 7 | 0 | 0.0 | 0.00 | 4 | 4.5 | 1.73 | 4 | 4.5 | 1.73 |
| SEP 8-SEP 10 | 1 | 3.0 | 0.00 | 12 | 4.1 | 1.88 | 13 | 4.0 | 1.83 |
| SEP 11-SEP 13 | 1 | 5.0 | 0.00 | 2 | 4.0 | 0.00 | 3 | 4.3 | 0.58 |
| SEP 14-SEP 16 | 0 | 0.0 | 0.00 | 5 | 4.6 | 0.89 | 5 | 4.6 | 0.89 |
| SEP 17-SEP 19 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| SEP 20-SEP 22 | 0 | 0.0 | 0.00 | 1 | 2.0 | 0.00 | 1 | 2.0 | 0.00 |
| SEP 23-SEP 25 | 0 | 0.0 | 0.00 | 1 | 5.0 | 0.00 | 1 | 5.0 | 0.00 |
| SEP 26-SEP 28 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| SEP 29-OCT 1 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| OCT 2-OCT 4 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| OCT 5-OCT 7 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| OCT 8-OCT 10 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| OCT 11-OCT 13 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| OCT 14-OCT 16 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| OCT 17-OCT 19 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| OCT 20-OCT 22 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| OCT 23-OCT 25 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| OCT 26-OCT 28 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| OCT 29-OCT 31 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| NOV 1-NOV 3 | 2 | 4.0 | 4.24 | 3 | 5.7 | 0.58 | 5 | 5.0 | 2.35 |
| NOV 4-NOV 6 | 24 | 3.1 | 1.08 | 139 | 3.0 | 1.14 | 163 | 3.0 | 1.13 |
| NOV 7-NOV 9 | 1 | 3.0 | 0.00 | 62 | 2.6 | 0.91 | 63 | 2.6 | 0.91 |
| NOV 10-NOV 12 | 2 | 3.0 | 0.00 | 66 | 3.1 | 1.09 | 68 | 3.1 | 1.07 |
| NOV 13-NOV 15 | 4 | 4.3 | 0.96 | 48 | 3.2 | 1.27 | 52 | 3.3 | 1.27 |
| NOV 16-NOV 18 | 0 | 0.0 | 0.00 | 28 | 3.7 | 1.61 | 28 | 3.7 | 1.61 |
| NOV 19-NOV 21 | 0 | 0.0 | 0.00 | 21 | 3.4 | 1.25 | 21 | 3.4 | 1.25 |
| NOV 22-NOV 24 | 2 | 3.0 | 1.41 | 10 | 3.2 | 1.48 | 12 | 3.2 | 1.40 |
| NOV 25-NOV 27 | 3 | 3.3 | 1.15 | 6 | 4.2 | 1.60 | 9 | 3.9 | 1.45 |
| NOV 28-NOV 30 | 1 | 3.0 | 0.00 | 8 | 2.9 | 1.81 | 9 | 2.9 | 1.69 |
| DEC 1-DEC 3 | 1 | 2.0 | 0.00 | 11 | 3.5 | 0.93 | 12 | 3.4 | 1.00 |
| DEC 4-DEC 6 | 0 | 0.0 | 0.00 | 3 | 2.3 | 0.58 | 3 | 2.3 | 0.58 |
| DEC 7-DEC 9 | 0 | 0.0 | 0.00 | 8 | 3.1 | 0.99 | 8 | 3.1 | 0.99 |
| DEC 10-DEC 12 | 1 | 1.0 | 0.00 | 3 | 4.3 | 2.31 | 4 | 3.5 | 2.52 |
| DEC 13-DEC 15 | 0 | 0.0 | 0.00 | 2 | 2.5 | 2.12 | 2 | 2.5 | 2.12 |

Appendix Table B5.--Mean stomach fullness and standard deviation for juvenile salmonids captured in purse and beach seines at Jones Beach by 3-day intervals, 1983.

| 1983 | Purse Seine | | | Beach Seine | | | Purse & Beach Seine | | |
|---|---|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | n | Mean | SD |
| **COHO SALMON** | | | | | | | | | |
| APR 23-APR 25 | 0 | 0.0 | 0.00 | 1 | 4.0 | 0.00 | 1 | 4.0 | 0.00 |
| APR 26-APR 28 | 1 | 5.0 | 0.00 | 1 | 3.0 | 0.00 | 2 | 4.0 | 1.41 |
| APR 29-MAY 1 | 4 | 4.3 | 1.50 | 3 | 4.7 | 2.08 | 7 | 4.4 | 1.62 |
| MAY 2-MAY 4 | 2 | 5.0 | 1.41 | 2 | 3.0 | 0.00 | 4 | 4.0 | 1.41 |
| MAY 5-MAY 7 | 31 | 3.3 | 1.27 | 33 | 3.6 | 1.17 | 64 | 3.5 | 1.22 |
| MAY 8-MAY 10 | 34 | 3.8 | 1.26 | 24 | 4.0 | 1.29 | 58 | 3.9 | 1.26 |
| MAY 11-MAY 13 | 50 | 4.4 | 1.22 | 20 | 4.8 | 1.32 | 70 | 4.5 | 1.26 |
| MAY 14-MAY 16 | 100 | 3.7 | 1.12 | 12 | 3.7 | 1.44 | 112 | 3.7 | 1.15 |
| MAY 17-MAY 19 | 119 | 3.8 | 1.06 | 57 | 3.6 | 1.12 | 176 | 3.7 | 1.08 |
| MAY 20-MAY 22 | 85 | 3.6 | 1.12 | 17 | 3.6 | 1.17 | 102 | 3.6 | 1.12 |
| MAY 23-MAY 25 | 79 | 4.3 | 1.27 | 2 | 1.5 | 0.71 | 81 | 4.2 | 1.32 |
| MAY 26-MAY 28 | 91 | 4.3 | 1.09 | 2 | 3.5 | 0.71 | 93 | 4.3 | 1.08 |
| MAY 29-MAY 31 | 116 | 3.9 | 1.02 | 11 | 4.0 | 1.41 | 127 | 3.9 | 1.06 |
| JUN 1-JUN 3 | 176 | 3.5 | 1.03 | 22 | 3.8 | 0.66 | 198 | 3.6 | 0.99 |
| JUN 4-JUN 6 | 60 | 3.3 | 0.93 | 8 | 3.3 | 0.46 | 68 | 3.3 | 0.89 |
| JUN 7-JUN 9 | 23 | 3.1 | 0.79 | 4 | 2.5 | 0.58 | 27 | 3.0 | 0.78 |
| JUN 10-JUN 12 | 54 | 3.6 | 0.98 | 1 | 5.0 | 0.00 | 55 | 3.6 | 0.99 |
| JUN 13-JUN 15 | 231 | 3.7 | 1.02 | 20 | 3.8 | 1.41 | 251 | 3.7 | 1.05 |
| JUN 16-JUN 18 | 66 | 3.5 | 0.86 | 17 | 3.8 | 1.24 | 83 | 3.5 | 0.95 |
| JUN 19-JUN 21 | 15 | 3.5 | 0.83 | 3 | 4.3 | 1.53 | 18 | 3.7 | 0.97 |
| JUN 22-JUN 24 | 16 | 3.7 | 1.30 | 14 | 4.4 | 1.28 | 30 | 4.0 | 1.31 |
| JUN 25-JUN 27 | 5 | 3.8 | 0.84 | 2 | 5.0 | 2.83 | 7 | 4.1 | 1.46 |
| JUN 28-JUN 30 | 8 | 4.0 | 1.07 | 0 | 0.0 | 0.00 | 8 | 4.0 | 1.07 |
| JUL 1-JUL 3 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 4-JUL 6 | 6 | 4.2 | 1.72 | 0 | 0.0 | 0.00 | 6 | 4.2 | 1.72 |
| JUL 7-JUL 9 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| **YEARLING CHINOOK SALMON** | | | | | | | | | |
| JAN 26-JAN 28 | 0 | 0.0 | 0.00 | 6 | 3.0 | 0.00 | 6 | 3.0 | 0.00 |
| JAN 29-JAN 31 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| FEB 1-FEB 3 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| FEB 4-FEB 6 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| FEB 7-FEB 9 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 | 1 | 3.0 | 0.00 |
| FEB 10-FEB 12 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| FEB 13-FEB 15 | 0 | 0.0 | 0.00 | 2 | 2.5 | 0.71 | 2 | 2.5 | 0.71 |
| FEB 16-FEB 18 | 0 | 0.0 | 0.00 | 3 | 4.3 | 1.53 | 3 | 4.3 | 1.53 |
| FEB 19-FEB 21 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| FEB 22-FEB 24 | 0 | 0.0 | 0.00 | 2 | 6.0 | 1.41 | 2 | 6.0 | 1.41 |
| FEB 25-FEB 27 | 0 | 0.0 | 0.00 | 5 | 3.4 | 1.34 | 5 | 3.4 | 1.34 |
| FEB 28-MAR 2 | 0 | 0.0 | 0.00 | 3 | 4.0 | 1.73 | 3 | 4.0 | 1.73 |
| MAR 3-MAR 5 | 0 | 0.0 | 0.00 | 2 | 3.0 | 0.00 | 2 | 3.0 | 0.00 |
| MAR 6-MAR 8 | 0 | 0.0 | 0.00 | 3 | 4.7 | 1.53 | 3 | 4.7 | 1.53 |
| MAR 9-MAR 11 | 1 | 1.0 | 0.00 | 8 | 3.4 | 1.41 | 9 | 3.1 | 1.54 |
| MAR 12-MAR 14 | 0 | 0.0 | 0.00 | 11 | 1.8 | 1.17 | 11 | 1.8 | 1.17 |
| MAR 15-MAR 17 | 0 | 0.0 | 0.00 | 18 | 1.3 | 0.77 | 18 | 1.3 | 0.77 |
| MAR 18-MAR 20 | 2 | 1.0 | 0.00 | 5 | 2.6 | 2.61 | 7 | 2.1 | 2.27 |
| MAR 21-MAR 23 | 1 | 5.0 | 0.00 | 12 | 2.4 | 1.56 | 13 | 2.6 | 1.66 |
| MAR 24-MAR 26 | 0 | 0.0 | 0.00 | 3 | 2.7 | 0.58 | 3 | 2.7 | 0.58 |
| MAR 27-MAR 29 | 1 | 4.0 | 0.00 | 5 | 2.6 | 1.14 | 6 | 2.8 | 1.17 |
| MAR 30-APR 1 | 1 | 7.0 | 0.00 | 8 | 3.0 | 1.85 | 9 | 3.4 | 2.19 |
| APR 2-APR 4 | 1 | 4.0 | 0.00 | 2 | 2.0 | 1.41 | 3 | 2.7 | 1.53 |
| APR 5-APR 7 | 9 | 3.9 | 1.90 | 24 | 2.3 | 1.54 | 33 | 2.7 | 1.78 |
| APR 8-APR 10 | 0 | 0.0 | 0.00 | 13 | 1.7 | 1.03 | 13 | 1.7 | 1.03 |
| APR 11-APR 13 | 1 | 4.0 | 0.00 | 6 | 3.0 | 1.26 | 7 | 3.1 | 1.21 |
| APR 14-APR 16 | 4 | 2.8 | 0.96 | 2 | 1.0 | 0.00 | 6 | 2.2 | 1.17 |
| APR 17-APR 19 | 6 | 4.5 | 1.05 | 5 | 3.8 | 2.59 | 11 | 4.2 | 1.83 |
| APR 20-APR 22 | 16 | 3.6 | 0.62 | 2 | 2.5 | 0.71 | 18 | 3.5 | 0.71 |
| APR 23-APR 25 | 9 | 3.3 | 0.71 | 0 | 0.0 | 0.00 | 9 | 3.3 | 0.71 |
| APR 26-APR 28 | 11 | 3.3 | 1.01 | 1 | 5.0 | 0.00 | 12 | 3.4 | 1.08 |
| APR 29-MAY 1 | 12 | 3.1 | 0.90 | 1 | 3.0 | 0.00 | 13 | 3.1 | 0.86 |
| MAY 2-MAY 4 | 10 | 3.5 | 0.71 | 2 | 3.5 | 0.71 | 12 | 3.5 | 0.67 |
| MAY 5-MAY 7 | 10 | 2.7 | 1.06 | 0 | 0.0 | 0.00 | 10 | 2.7 | 1.06 |
| MAY 8-MAY 10 | 7 | 2.7 | 1.25 | 0 | 0.0 | 0.00 | 7 | 2.7 | 1.25 |
| MAY 11-MAY 13 | 20 | 3.5 | 1.43 | 0 | 0.0 | 0.00 | 20 | 3.5 | 1.43 |
| MAY 14-MAY 16 | 22 | 3.1 | 1.06 | 1 | 5.0 | 0.00 | 23 | 3.2 | 1.11 |
| MAY 17-MAY 19 | 33 | 2.5 | 1.25 | 0 | 0.0 | 0.00 | 33 | 2.5 | 1.25 |
| MAY 20-MAY 22 | 20 | 2.8 | 0.85 | 1 | 2.0 | 0.00 | 21 | 2.7 | 0.85 |
| MAY 23-MAY 25 | 31 | 2.9 | 1.18 | 1 | 2.0 | 0.00 | 32 | 2.9 | 1.17 |
| MAY 26-MAY 28 | 6 | 2.5 | 0.84 | 0 | 0.0 | 0.00 | 6 | 2.5 | 0.84 |
| MAY 29-MAY 31 | 21 | 2.7 | 0.91 | 0 | 0.0 | 0.00 | 21 | 2.7 | 0.91 |
| JUN 1-JUN 3 | 9 | 3.1 | 0.78 | 0 | 0.0 | 0.00 | 9 | 3.1 | 0.78 |
| JUN 4-JUN 6 | 8 | 2.1 | 1.13 | 0 | 0.0 | 0.00 | 8 | 2.1 | 1.13 |
| JUN 7-JUN 9 | 3 | 3.0 | 0.00 | 0 | 0.0 | 0.00 | 3 | 3.0 | 0.00 |
| JUN 10-JUN 12 | 1 | 3.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 |
| JUN 13-JUN 15 | 2 | 3.5 | 0.71 | 0 | 0.0 | 0.00 | 2 | 3.5 | 0.71 |
| JUN 16-JUN 18 | 2 | 3.0 | 0.00 | 0 | 0.0 | 0.00 | 2 | 3.0 | 0.00 |
| JUN 19-JUN 21 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 22-JUN 24 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 25-JUN 27 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUN 28-JUN 30 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 1-JUL 3 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 4-JUL 6 | 2 | 2.5 | 0.71 | 0 | 0.0 | 0.00 | 2 | 2.5 | 0.71 |
| JUL 7-JUL 9 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 10-JUL 12 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |

Appendix Table B5.--continued.

| 1983 | Purse Seine n | Purse Seine Mean | Purse Seine SD | Beach Seine n | Beach Seine Mean | Beach Seine SD | Purse & Beach Seine n | Purse & Beach Seine Mean | Purse & Beach Seine SD |
|---|---|---|---|---|---|---|---|---|---|
| | | | | STEELHEAD | | | | | |
| APR 29-MAY 1 | 1 | 4.0 | 0.00 | 1 | 3.0 | 0.00 | 2 | 3.5 | 0.71 |
| MAY 2-MAY 4 | 2 | 2.0 | 1.41 | 0 | 0.0 | 0.00 | 2 | 2.0 | 1.41 |
| MAY 5-MAY 7 | 2 | 1.5 | 0.71 | 1 | 7.0 | 0.00 | 3 | 3.3 | 3.21 |
| MAY 8-MAY 10 | 6 | 2.7 | 0.52 | 0 | 0.0 | 0.00 | 6 | 2.7 | 0.52 |
| MAY 11-MAY 13 | 22 | 2.6 | 0.95 | 0 | 0.0 | 0.00 | 22 | 2.6 | 0.95 |
| MAY 14-MAY 16 | 30 | 2.8 | 1.81 | 0 | 0.0 | 0.00 | 30 | 2.8 | 1.81 |
| MAY 17-MAY 19 | 43 | 2.5 | 1.30 | 0 | 0.0 | 0.00 | 43 | 2.5 | 1.30 |
| MAY 20-MAY 22 | 12 | 2.7 | 0.98 | 0 | 0.0 | 0.00 | 12 | 2.7 | 0.98 |
| MAY 23-MAY 25 | 30 | 3.0 | 1.43 | 2 | 2.0 | 0.00 | 32 | 2.9 | 1.40 |
| MAY 26-MAY 28 | 29 | 3.4 | 1.53 | 0 | 0.0 | 0.00 | 29 | 3.4 | 1.53 |
| MAY 29-MAY 31 | 93 | 2.6 | 0.94 | 0 | 0.0 | 0.00 | 93 | 2.6 | 0.94 |
| JUN 1-JUN 3 | 79 | 2.5 | 1.14 | 0 | 0.0 | 0.00 | 79 | 2.5 | 1.14 |
| JUN 4-JUN 6 | 20 | 2.5 | 1.05 | 0 | 0.0 | 0.00 | 20 | 2.5 | 1.05 |
| JUN 7-JUN 9 | 63 | 2.0 | 1.01 | 0 | 0.0 | 0.00 | 63 | 2.0 | 1.01 |
| JUN 10-JUN 12 | 24 | 2.7 | 0.82 | 0 | 0.0 | 0.00 | 24 | 2.7 | 0.82 |
| JUN 13-JUN 15 | 45 | 2.5 | 1.20 | 0 | 0.0 | 0.00 | 45 | 2.5 | 1.20 |
| JUN 16-JUN 18 | 16 | 2.4 | 0.89 | 0 | 0.0 | 0.00 | 16 | 2.4 | 0.89 |
| JUN 19-JUN 21 | 11 | 2.2 | 0.75 | 0 | 0.0 | 0.00 | 11 | 2.2 | 0.75 |
| JUN 22-JUN 24 | 3 | 2.3 | 0.58 | 0 | 0.0 | 0.00 | 3 | 2.3 | 0.58 |
| JUN 25-JUN 27 | 1 | 1.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 1.0 | 0.00 |
| JUN 28-JUN 30 | 3 | 4.0 | 0.00 | 0 | 0.0 | 0.00 | 3 | 4.0 | 0.00 |
| JUL 1-JUL 3 | 1 | 2.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 2.0 | 0.00 |
| JUL 4-JUL 6 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 7-JUL 9 | 1 | 2.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 2.0 | 0.00 |
| JUL 10-JUL 12 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 13-JUL 15 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| JUL 16-JUL 18 | 1 | 2.0 | 0.00 | 0 | 0.0 | 0.00 | 1 | 2.0 | 0.00 |
| JUL 19-JUL 21 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |

Appendix Table B5.--continued.

| 1983 | Purse Seine n | Mean | SD | Beach Seine n | Mean | SD | Purse & Beach Seine n | Mean | SD |
|---|---|---|---|---|---|---|---|---|---|
| SUBYEARLING CHINOOK SALMON | | | | | | | | | |
| MAR 24-MAR 26 | 0 | 0.0 | 0.00 | 1 | 7.0 | 0.00 | 1 | 7.0 | 0.00 |
| MAR 27-MAR 29 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| MAR 30-APR 1 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| APR 2-APR 4 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| APR 5-APR 7 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| APR 8-APR 10 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| APR 11-APR 13 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| APR 14-APR 16 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| APR 17-APR 19 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| APR 20-APR 22 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| APR 23-APR 25 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| APR 26-APR 28 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| APR 29-MAY 1 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 | 1 | 3.0 | 0.00 |
| MAY 2-MAY 4 | 24 | 3.8 | 0.96 | 106 | 4.3 | 1.11 | 130 | 4.2 | 1.09 |
| MAY 5-MAY 7 | 14 | 3.5 | 1.02 | 74 | 3.9 | 1.15 | 88 | 3.8 | 1.13 |
| MAY 8-MAY 10 | 12 | 3.8 | 1.11 | 81 | 3.7 | 1.04 | 93 | 3.7 | 1.04 |
| MAY 11-MAY 13 | 9 | 5.7 | 1.12 | 34 | 5.0 | 1.55 | 43 | 5.2 | 1.48 |
| MAY 14-MAY 16 | 8 | 5.9 | 0.99 | 22 | 5.0 | 0.98 | 30 | 5.2 | 1.04 |
| MAY 17-MAY 19 | 1 | 6.0 | 0.00 | 36 | 4.3 | 1.62 | 37 | 4.8 | 1.61 |
| MAY 20-MAY 22 | 2 | 4.0 | 4.24 | 26 | 3.9 | 1.60 | 28 | 3.9 | 1.74 |
| MAY 23-MAY 25 | 0 | 0.0 | 0.00 | 6 | 6.0 | 1.26 | 6 | 6.0 | 1.26 |
| MAY 26-MAY 28 | 0 | 0.0 | 0.00 | 4 | 4.5 | 1.29 | 4 | 4.5 | 1.29 |
| MAY 29-MAY 31 | 14 | 3.9 | 1.14 | 1 | 3.0 | 0.00 | 15 | 3.9 | 1.13 |
| JUN 1-JUN 3 | 8 | 4.3 | 0.89 | 1 | 4.0 | 0.00 | 9 | 4.2 | 0.83 |
| JUN 4-JUN 6 | 4 | 4.3 | 1.26 | 1 | 5.0 | 0.00 | 5 | 4.4 | 1.14 |
| JUN 7-JUN 9 | 15 | 3.1 | 0.64 | 2 | 4.5 | 3.54 | 17 | 3.3 | 1.16 |
| JUN 10-JUN 12 | 33 | 3.7 | 0.85 | 1 | 5.0 | 0.00 | 34 | 3.7 | 0.86 |
| JUN 13-JUN 15 | 59 | 3.6 | 0.85 | 3 | 2.7 | 0.58 | 62 | 3.6 | 0.86 |
| JUN 16-JUN 18 | 29 | 3.9 | 1.41 | 17 | 4.0 | 1.46 | 46 | 4.0 | 1.41 |
| JUN 19-JUN 21 | 9 | 3.8 | 1.30 | 9 | 4.2 | 1.48 | 18 | 4.0 | 1.37 |
| JUN 22-JUN 24 | 5 | 4.2 | 1.79 | 16 | 3.8 | 1.52 | 21 | 3.9 | 1.55 |
| JUN 25-JUN 27 | 12 | 4.1 | 1.88 | 69 | 3.5 | 1.13 | 81 | 3.6 | 1.27 |
| JUN 28-JUN 30 | 23 | 4.1 | 1.35 | 85 | 4.1 | 1.18 | 108 | 4.1 | 1.21 |
| JUL 1-JUL 3 | 11 | 3.9 | 0.54 | 54 | 4.3 | 1.46 | 65 | 4.2 | 1.35 |
| JUL 4-JUL 6 | 44 | 4.0 | 1.30 | 81 | 3.9 | 1.21 | 125 | 3.9 | 1.24 |
| JUL 7-JUL 9 | 55 | 4.2 | 1.30 | 55 | 3.8 | 1.33 | 110 | 4.0 | 1.33 |
| JUL 10-JUL 12 | 13 | 4.6 | 1.89 | 69 | 4.6 | 1.49 | 82 | 4.6 | 1.55 |
| JUL 13-JUL 15 | 14 | 4.9 | 1.64 | 87 | 3.4 | 1.50 | 101 | 3.6 | 1.60 |
| JUL 16-JUL 18 | 22 | 3.3 | 1.25 | 45 | 3.9 | 1.47 | 67 | 3.7 | 1.42 |
| JUL 19-JUL 21 | 60 | 3.3 | 0.97 | 35 | 4.3 | 1.75 | 95 | 3.7 | 1.39 |
| JUL 22-JUL 24 | 15 | 4.2 | 1.37 | 5 | 5.6 | 1.34 | 20 | 4.6 | 1.47 |
| JUL 25-JUL 27 | 5 | 5.4 | 1.52 | 30 | 4.6 | 1.81 | 35 | 4.7 | 1.78 |
| JUL 28-JUL 30 | 4 | 4.5 | 1.73 | 12 | 3.8 | 1.03 | 16 | 4.0 | 1.21 |
| JUL 31-AUG 2 | 2 | 6.0 | 0.00 | 3 | 5.0 | 2.65 | 5 | 5.4 | 1.95 |
| AUG 3-AUG 5 | 1 | 3.0 | 0.00 | 24 | 4.3 | 1.99 | 25 | 4.3 | 1.97 |
| AUG 6-AUG 8 | 4 | 5.5 | 1.73 | 4 | 5.5 | 1.29 | 8 | 5.5 | 1.41 |
| AUG 9-AUG 11 | 2 | 5.0 | 1.41 | 27 | 4.3 | 1.71 | 29 | 4.4 | 1.68 |
| AUG 12-AUG 14 | 4 | 5.5 | 1.73 | 13 | 6.6 | 0.65 | 17 | 6.4 | 1.06 |
| AUG 15-AUG 17 | 9 | 4.7 | 1.32 | 22 | 4.1 | 1.60 | 31 | 4.3 | 1.53 |
| AUG 18-AUG 20 | 0 | 0.0 | 0.00 | 8 | 4.0 | 1.60 | 8 | 4.0 | 1.60 |
| AUG 21-AUG 23 | 1 | 3.0 | 0.00 | 7 | 2.7 | 0.76 | 8 | 2.8 | 0.71 |
| AUG 24-AUG 26 | 0 | 0.0 | 0.00 | 8 | 4.0 | 1.07 | 8 | 4.0 | 1.07 |
| AUG 27-AUG 29 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 | 1 | 3.0 | 0.00 |
| AUG 30-SEP 1 | 0 | 0.0 | 0.00 | 6 | 5.8 | 1.60 | 6 | 5.8 | 1.60 |
| SEP 2-SEP 4 | 0 | 0.0 | 0.00 | 1 | 3.0 | 0.00 | 1 | 3.0 | 0.00 |
| SEP 5-SEP 7 | 11 | 4.9 | 0.70 | 48 | 5.1 | 1.34 | 59 | 5.1 | 1.24 |
| SEP 8-SEP 10 | 5 | 5.4 | 1.67 | 36 | 4.3 | 1.34 | 41 | 4.4 | 1.41 |
| SEP 11-SEP 13 | 1 | 7.0 | 0.00 | 9 | 5.2 | 1.72 | 10 | 5.4 | 1.71 |
| SEP 14-SEP 16 | 0 | 0.0 | 0.00 | 29 | 5.0 | 1.72 | 29 | 5.0 | 1.72 |
| SEP 17-SEP 19 | 0 | 0.0 | 0.00 | 4 | 4.0 | 1.15 | 4 | 4.0 | 1.15 |
| SEP 20-SEP 22 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| SEP 23-SEP 25 | 0 | 0.0 | 0.00 | 2 | 3.5 | 0.71 | 2 | 3.5 | 0.71 |
| SEP 26-SEP 28 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| SEP 29-OCT 1 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| OCT 2-OCT 4 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| OCT 5-OCT 7 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| OCT 8-OCT 10 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| OCT 11-OCT 13 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| OCT 14-OCT 16 | 0 | 0.0 | 0.00 | 1 | 2.0 | 0.00 | 1 | 2.0 | 0.00 |
| OCT 17-OCT 19 | 27 | 5.1 | 0.96 | 10 | 4.1 | 2.02 | 37 | 4.8 | 1.37 |
| OCT 20-OCT 22 | 0 | 0.0 | 0.00 | 8 | 6.1 | 0.64 | 8 | 6.1 | 0.64 |
| OCT 23-OCT 25 | 3 | 4.3 | 0.58 | 12 | 3.7 | 2.19 | 15 | 3.8 | 1.97 |
| OCT 26-OCT 28 | 0 | 0.0 | 0.00 | 2 | 5.5 | 2.12 | 2 | 5.5 | 2.12 |
| OCT 29-OCT 31 | 0 | 0.0 | 0.00 | 1 | 2.0 | 0.00 | 1 | 2.0 | 0.00 |
| NOV 1-NOV 3 | 2 | 3.5 | 2.12 | 3 | 3.3 | 2.52 | 5 | 3.4 | 2.07 |
| NOV 4-NOV 6 | 7 | 3.0 | 1.15 | 14 | 3.1 | 1.69 | 21 | 3.0 | 1.50 |
| NOV 7-NOV 9 | 0 | 0.0 | 0.00 | 57 | 3.2 | 1.19 | 57 | 3.2 | 1.19 |
| NOV 10-NOV 12 | 0 | 0.0 | 0.00 | 17 | 3.1 | 0.99 | 17 | 3.1 | 0.99 |
| NOV 13-NOV 15 | 0 | 0.0 | 0.00 | 9 | 2.1 | 0.33 | 9 | 2.1 | 0.33 |
| NOV 16-NOV 18 | 0 | 0.0 | 0.00 | 3 | 2.3 | 0.58 | 3 | 2.3 | 0.58 |
| NOV 19-NOV 21 | 4 | 2.3 | 0.50 | 1 | 4.0 | 0.00 | 5 | 2.6 | 0.89 |
| NOV 22-NOV 24 | 0 | 0.0 | 0.00 | 2 | 4.5 | 2.12 | 2 | 4.5 | 2.12 |
| NOV 25-NOV 27 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 | 0 | 0.0 | 0.00 |

Appendix Table B6.--Status of juvenile salmonid stomachs collected at Jones Beach (RKm 75), 1979-1983.

| Year: | 1979 | | 1980 | | 1981 | | 1982 | | 1983 | | 1979 | | 1980 | | 1981 | | 1982 | | 1983 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dates | P a/ | C b/ | P | C | P | C | P | C | P | C | P | C | P | C | P | C | P | C | P | C |
| | Subyearling chinook salmon | | | | | | | | | | Yearling chinook salmon | | | | | | | | | |
| 01 Jan - 13 Jan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 Jan - 27 Jan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| 28 Jan - 10 Feb | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 11 Feb - 24 Feb | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 |
| 25 Feb - 10 Mar | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 19 | 0 |
| 11 Mar - 24 Mar | 0 | 0 | 50 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 30 | 0 | 1 | 0 | 43 | 0 | 20 | 0 |
| 25 Mar - 07 Apr | 22 | 17 | 16 | 9 | 6 | 5 | 32 | 13 | 1 | 0 | 29 | 22 | 129 | 19 | 14 | 0 | 85 | 0 | 34 | 0 |
| 08 Apr - 21 Apr | 22 | 15 | 68 | 10 | 11 | 7 | 82 | 26 | 0 | 0 | 32 | 27 | 174 | 50 | 46 | 0 | 63 | 0 | 31 | 0 |
| 22 Apr - 05 May | 25 | 19 | 86 | 25 | 103 | 38 | 414c/ | 20 | 27 | 0 | 26 | 22 | 114 | 44 | 59d/ | 0 | 112d/ | 0 | 43 | 0 |
| 06 May - 19 May | 13 | 11 | 153 | 37 | 162 | 18 | 247c/ | 20 | 50 | 0 | 10 | 10 | 119 | 47 | 19d/ | 0 | 66d/ | 0 | 12 | 0 |
| 20 May - 02 Jun | 15 | 13 | 168 | 18 | 185 | 20 | 160c/ | 20 | 16 | 0 | 10 | 10 | 4 | 0 | 12d/ | 0 | 25d/ | 0 | 38 | 0 |
| 03 Jun - 16 Jun | 8 | 11 | 309 | 15 | 187 | 20 | 882c/ | 20 | 44 | 0 | 11 | 9 | 7 | 0 | 4d/ | 0 | 28d/ | 0 | 3 | 0 |
| 17 Jun - 30 Jun | 16 | 15 | 167 | 18 | 106 | 21 | 358c/ | 20 | 95 | 0 | 4 | 3 | 0 | 0 | 2d/ | 0 | 3d/ | 0 | 0 | 0 |
| 01 Jul - 14 Jul | 6 | 0 | 315 | 25 | 26 | 0 | 302 | 0 | 61 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 15 Jul - 28 Jul | 3 | 0 | 216 | 18 | 0 | 0 | 147 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29 Jul - 11 Aug | 5 | 0 | 229 | 15 | 14 | 0 | 82 | 0 | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 Aug - 25 Aug | 8 | 0 | 204 | 14 | 1 | 0 | 46 | 0 | 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 Aug - 08 Sep | 0 | 0 | 98 | 2 | 0 | 0 | 18 | 0 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 09 Sep - 22 Sep | 0 | 0 | 29 | 0 | 3 | 0 | 13 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 Sep - 06 Oct | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 07 Oct - 20 Oct | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 Oct - 03 Nov | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 04 Nov - 17 Nov | 0 | 0 | 0 | 0 | 0 | 0 | 103 | 0 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 Nov - 01 Dec | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 02 Dec - 15 Dec | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 Dec - 31 Dec | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Totals: | | 101 | | 206 | | 129 | | 139 | | 0 | | 103 | | 160 | | 0 | | 0 | | 0 |
| Totals: | 143 | | 2108 | | 805 | | 2928 | | 535 | | 131 | | 577 | | 157 | | 426 | | 212 | |

| Dates | 1979 P | 1979 C | 1980 P | 1980 C | 1981 P | 1981 C | 1982 P | 1982 C | 1983 P | 1983 C | 1979 P | 1979 C | 1980 P | 1980 C | 1981 P | 1981 C | 1982 P | 1982 C | 1983 P | 1983 C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coho salmon | | | | | | | | | | Steelhead | | | | | | | | | |
| 01 Jan - 13 Jan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 Jan - 27 Jan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 Jan - 10 Feb | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 Feb - 24 Feb | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 Feb - 10 Mar | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 Mar - 24 Mar | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 Mar - 07 Apr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 08 Apr - 21 Apr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 Apr - 05 May | 3 | 0 | 3 | 0 | 30 | 0 | 13c/ | 0 | 21 | 0 | 12 | 9 | 161 | 39 | 8 | 0 | 10c/ | 0 | 3 | 0 |
| 06 May - 19 May | 13 | 10 | 260 | 92 | 155 | 0 | 463c/ | 0 | 55 | 0 | 10 | 10 | 136 | 36 | 37 | 0 | 72c/ | 0 | 26 | 0 |
| 20 May - 02 Jun | 12 | 10 | 107 | 14 | 118 | 0 | 424c/ | 0 | 64 | 0 | 13 | 11 | 24 | 7 | 24 | 0 | 95c/ | 0 | 46 | 0 |
| 03 Jun - 16 Jun | 18 | 17 | 124 | 20 | 41 | 0 | 329c/ | 0 | 52 | 0 | 12 | 10 | 7 | 0 | 8 | 0 | 62c/ | 0 | 31 | 0 |
| 17 Jun - 30 Jun | 10 | 10 | 8 | 3 | 1 | 0 | 40c/ | 0 | 27 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 5c/ | 0 | 4 | 0 |
| 01 Jul - 14 Jul | 8 | 0 | 86 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 15 Jul - 28 Jul | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29 Jul - 11 Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 Aug - 25 Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 Aug - 08 Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 09 Sep - 22 Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 Sep - 06 Oct | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 07 Oct - 20 Oct | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 Oct - 03 Nov | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 04 Nov - 17 Nov | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 Nov - 01 Dec | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 02 Dec - 15 Dec | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 Dec - 31 Dec | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Totals (P) | 67 | | 591 | | 347 | | 1271 | | 221 | | 49 | | 332 | | 77 | | 245 | | 110 | |
| Totals (C) | | 47 | | 129 | | 0 | | 0 | | 0 | | 41 | | 82 | | 0 | | 0 | | 0 |

a/ P = Number stomachs preserved. Some stomachs may be missing from the collection due to storage problems.
b/ C = Number of stomachs with contents identified as of December 1984.
c/ Approximately 25% used for proximate analyses.
d/ Approximately 50% used for proximate analyses.

Appendix Table B7.--Source, date of median recovery, and tag codes for fish groups used in graphic comparison of stomach fullness (Figures 54, 55, 57, 59, and 60). Subyearling and yearling chinook salmon, coho salmon, and steelhead groups captured at Jones Beach in 1982 and 1983.

| Source | Date of median fish | CWT |
|---|---|---|
| Subyearling chinook salmon | | |
| Spring Creek a/ | 19 April 82 | 05/10/50 |
| " " | 26 April 82 | 05/10/53-56 |
| " " | 27 April 82 | 05/10/51 |
| Bonneville b/ | 01 May 82 | 07/24/07 |
| Spring Creek | 08 May 82 | 05/08/51,10/57 |
| Bonneville | 10 May 82 | 07/26/63 |
| Stayton Pond b/ | 18 May 82 | 07/26/62 |
| Spring Creek | 24 May 82 | 05/10/52 |
| Abernathy a/ | 30 May 82 | 05/10/58,59 |
| Bonneville | 04 June 82 | 07/24/08 |
| " | 06 June 82 | 07/24/25 |
| " | 10 June 82 | 07/24/14-17 |
| Little White Salmon a/ | 11 June 82 | 05/04/35,36 |
| Klickitat c/ | 13 June 82 | 63/21/57 |
| Bonneville | 15 June 82 | 07/24/24 |
| Stayton Pond | 19 June 82 | 07/26/62 |
| Oxbow b/ | 22 June 82 | 07/23/30,24/11 |
| Hagerman a/ | 27 June 82 | 05/10/22,23 |
| Lower Kalama c/ | 28 June 82 | 63/24/63 |
| Priest Rapids c/ | 29 June 82 | 63/22/52,24/56 |
| Kalama Falls c/ | 09 July 82 | 63/24/60 |
| Washougal c/ | 18 July 82 | 63/24/61 |
| Cowlitz c/ | 20 July 82 | 63/20/32,24/62 |
| Bonneville | 13 August 82 | 07/24/26 |
| " | 10 November 82 | 07/25/48 |
| " | 11 November 82 | 07/25/45 |
| " | 11 November 82 | 07/23/63 |
| " | 11 November 82 | 07/25/46 |
| Spring Creek | 04 May 83 | 05/11/42-45 |
| Bonneville | 10 May 83 | 07/27/27-30 |
| Stayton Pond | 16 May 83 | 07/23/28,28/30-34 |
| Little White Salmon | 21 May 83 | 05/11/41 |
| Round Butte b/ | 07 June 83 | 07/28/36 |
| Priest Rapids | 17 June 83 | 63/26/11 |
| Bonneville | 02 July 83 | 07/28/27 |
| " | 05 July 83 | 07/28/26 |
| Little White Salmon | 06 July 83 | 05/11/39 |
| Hagerman | 06 July 83 | 10/25/15 |
| Cowlitz | 08 July 83 | 63/25/03 |
| Priest Rapids | 18 July 83 | 63/26/12 |

Appendix Table B7.--continued.

| Source | Date of median fish | CWT |
|---|---|---|
| Lewis River c/ | 25 July 83 | 63/27/38 |
| " " | 08 August 83 | 63/27/37 |
| Bonneville | 22 August 83 | 07/28/28 |
| Washougal | 10 September 83 | 63/22/59 |
| " | 22 October 83 | 63/22/39 |
| " | 09 November 83 | 63/22/38 |
| | Yearling chinook salmon | |
| Bonneville | 31 March 82 | 07/21/40,43 |
| Oxbow | 02 April 82 | 07/21/37 |
| Oakridgde b/ | 09 April 82 | 07/24/19,25/13 |
| Cowlitz | 16 April 82 | 63/21/34,23/09-11 |
| Dexter Pond b/ | 25 April 82 | 07/24/20,22 |
| Marion Forks b/ | 29 April 82 | 07/25/28-30 |
| Rapid River d/ | 04 May 82 | 10/24/14-15 |
| Marion Forks | 05 May 82 | 07/25/25-27 |
| Round Butte | 06 May 82 | 07/24/48,50 |
| Kooskia d/ | 15 May 82 | 05/05/30,06/59 |
| Leavenworth a/ | 31 May 82 | 05/10/61 |
| McCall d/ | 04 June 82 | 10/24/12-13 |
| McKenzie b/ | 27 Feburary 83 | 07/25/21,27/19,21 |
| Bonneville | 18 March 83 | 07/27/01 |
| " | 05 April 83 | 07/25/47 |
| McKenzie | 10 April 83 | 07/25/22,27/18,20,24 |
| Cowlitz | 15 April 83 | 63/25/05-06,26/09 |
| Round Butte | 27 April 83 | 07/27/14,16-17 |
| Bonneville | 12 May 83 | 07/27/41 |
| Leavenworth | 21 May 83 | 05/13/38-39 |
| Sawtooth d/ | 23 May 83 | 10/24/08,25/35 |
| McCall | 24 May 83 | 10/24/58 |
| | Coho salmon | |
| Lewis River | 12 May 82 | 63/23/04 |
| Sandy b/ | 15 May 82 | 07/25/49-58 |
| Lower Kalama | 19 May 82 | 63/23/03 |
| Cowlitz | 21 May 82 | 63/24/20-49 |
| Cascade b/ | 31 May 82 | 07/24/29,33 |
| Eagle Creek a/ | 03 June 82 | 05/10/35-40 |
| Washougal | 03 June 82 | 63/25/13-42 |
| Lewis River | 11 June 82 | 63/23/05 |
| Washougal | 06 May 83 | 63/26/45 |
| Lower Kalama | 11 May 83 | 63/26/05 |
| Bonneville | 14 May 83 | 07/26/06 |
| Sandy | 16 May 83 | 07/27/31-36 |
| Cowlitz | 22 May 83 | 63/26/13-42 |
| Eagle Creek | 26 May 83 | 05/11/33-38 |

Appendix Table B7.--continued.

| Source | Date of median fish | CWT |
|---|---|---|
| Cascade | 30 May 83 | 07/27/47 |
| Washougal | 02 June 83 | 63/26/61-63,27/01-17 |
| Bonneville | 04 June 83 | 07/26/07 |
| Willard a/ | 14 June 83 | 05/09/28-45 |
| Speelyai c/ | 25 June 83 | 63/27/35 |
| | Steelhead | |
| Dworshak a/ | 01 May 82 | 23/06/07-08,16/05 |
| " | 22 May 82 | 05/10/24-27,23/16/02,04 |
| Niagara Springs d/ | 27 May 82 | 10/24/04,50 |
| Hagerman | 01 June 82 | 05/10/20-21 |
| Dworshak | 04 June 82 | 23/16/01,03 |
| " | 17 May 83 | 23/16/16,19,38 |
| Lyons Ferry e/ | 26 May 83 | 63/28/38-40 |
| Hagerman | 30 may 83 | 10/24/60 |
| Dworshak | 04 June 83 | 05/13/49-52,23/16/20 |
| Hagerman | 10 June 83 | 05/13/33-34 |

a/ United States Fish and Wildlife Service.
b/ Oregon Department of Fish and Wildlife.
c/ Washington Department of Fisheries.
d/ Idaho Department of Fish and Game.
e/ Washington Department of Game.

Appendix Table B8.--Taxonomic classifications and codes for food items found in juvenile salmonids from the lower Columbia River and near-shore marine waters.

| Prey Item | NODC Code[a/] | Prey Item | NODC Code |
|---|---|---|---|
| Diatomaceae | 070301 | Decapoda | 6175 |
| Chlorophyta | 08 | D. caridea | 6179 |
| Protozoa | 34 | Crangonidae | 617922 |
| H. hydroida | 3702 | C. franciscorum | 6179220107 |
| Turbellaria | 3901 | Astacidae | 6181 |
| Digenea | 3935 | Galatheidae | 618310 |
| Nemertea | 43 | Cancridae | 618803 |
| Nematoda | 47 | C. magister | 6188030104 |
| Annelida | 50 | C. oregonensis | 6188030106 |
| Polychaeta | 5001 | | |
| Oligochaeta | 5004 | Insecta I | 62 |
| Naididae | 500903 | Apterygota | 6201 |
| Hirudinea | 5012 | Protura | 6202 |
| Gastropoda | 51 | Thysanura | 6204 |
| Bivalvia | 55 | Diplura | 6206 |
| Corbiculidae | 551545 | Collembola | 6208 |
| Arachnida | 59 | Pterygota | 6213 |
| Araneae | 5911 | Ephemeroptera | 6215 |
| Acarina | 5922 | Ephemeridae | 621501 |
| Hydracarina | 5930 | Hexagenia | 62150101 |
| Halacaridae | 593001 | Baetidae | 621602 |
| Crustacea | 61 | Prosopistomatoidea | 6219 |
| Cladocera | 6108 | Odonata | 6223 |
| Ostracoda | 6110 | O. anisoptera | 6224 |
| Copepoda | 6117 | O. zygoptera | 6229 |
| C. calanoida | 6118 | Orthoptera | 6231 |
| E. affinis | 6118200201 | Isoptera | 6246 |
| C. harpacticoida | 6119 | Dermaptera | 6248 |
| C. cyclopoida | 6120 | Plecoptera | 6251 |
| C. caligoida | 6123 | Psocoptera | 6256 |
| Cirripedia | 6130 | Anoplura | 6267 |
| Mysidacea | 6151 | Thysanoptera | 6269 |
| Mysidacea mysida | 6153 | Hemiptera | 6271 |
| Neomysis mercedis | 6153011505 | H. hydrocorizae | 6272 |
| Isopoda | 6158 | Corixidae | 627201 |
| I. valvifera | 6162 | Homoptera | 6282 |
| Amphipoda | 6168 | Cicadellidae | 628403 |
| A. gammaridea | 6169 | Psylloidea | 6289 |
| Corophiidae | 616915 | Aphidoidea | 6291 |
| C. salmonis | 6169150209 | | |
| C. spinicorne | 6169150215 | Insecta II | 63 |
| Gammaridae | 616921 | Coleoptera | 6302 |
| A. subcarinatus | 6169210101 | Dytiscidae | 630506 |
| A. confervicolus | 6169210109 | Staphylinoidea | 6310 |
| Caprellidae | 6171 | Curculionoidea | 6325 |

Appendix Table B8.--continued.

| Prey | NODC Code |
|---|---|
| Insecta III | 64 |
| Neuroptera | 6405 |
| Trichoptera | 6418 |
| Hydropsychidae | 641804 |
| Lepidoptera | 6420 |
| Insecta IV | 65 |
| Diptera | 6501 |
| Tipuloidea | 6503 |
| Tipulidae | 650301 |
| Psychodoidea | 6504 |
| Culicoidea | 6505 |
| Culicidae | 650503 |
| Chaoborus | 65050301 |
| Heleidae | 650504 |
| Dixidae | 650505 |
| Simuliidae | 650506 |
| Chironomidae | 650508 |
| Symbiocladius | 65050821 |
| Pentanura | 65050834 |
| D. brachycera | 6515 |
| Muscoidea | 6540 |
| Hymenoptera | 6550 |
| Scolioidea | 6573 |
| Apoidea | 6576 |
| **Miscellaneous** | |
| Diplopoda | 68 |
| Bryozoa | 78 |
| Lamprey | 860301 |
| Gnathostomata | 87 |
| O. teleostei | 8735 |
| E. mordax | 8747020101 |
| O. tshawytscha | 8755010206 |
| A. hexapterus | 8845010101 |
| Aves | 91 |
| Inorganic matter | 95 |
| Unidentified organism | 96 |
| Unidentified Egg | 97 |
| Plant material | 98 |
| Digested Material | 99 |

METAMORPHIC STAGE b/

Blank-no information
0-indeterminable
1-egg
2-nauplius
3-zoea
4-megalops
5-veliger
6-larva
7-juvenile (juv.)
8-adult
9-larvae, juv., and adults
10-juv. and adults
11-larvae and juv.
12-maturity unknown
13-polyp
14-cypris
15-copepodid
16-pupa
17-nymph

STOMACH CONTENT DIGESTION STATE b/

0-no information
1-all contents unidentifiable
2-traces of prey organisms identifiable
3-less than 50% identifiable
4-50% - 75% identifiable
5-75% - 100% identifiable
6-all contents identifiable

PREY ITEMS b/

| | |
|---|---|
| Blank-no information | |
| 0-whole organism | 9-bones |
| 1-parts (misc.) | 10-head |
| 2-siphons | 11-eye |
| 3-inorganic parts | 12-jaws |
| 4-legs | 13-tail |
| 5-setae | 14-seeds |
| 6-chelae | 15-leaves |
| 7-zooecia | 16-wings |
| 8-scales | 17-antennae |

a/ National Oceanographic Data Center, 2001 Wisconsin Ave., N.W.; taxonomic codes, 2nd edition, 1978. Each two digits of code represents a descrete taxon. Each code may contain up to five taxonomic levels, with a provision for two additional digits to represent subspecies or a variety in some taxonomic group. The code system enables an animal to be classified to any systematic aggregation of data.

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