Relative Survival of Subyearling Chinook Salmon

That Have Passed Through the Turbines or Bypass System of Bonneville Dam Second Powerhouse, 1990

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COASTAL ZONE AND ESTUARINE STUDIES

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INTRODUCTION

Research at the Bonneville Dam Second Powerhouse has shown that subyearling chinook salmon (Oncorhynchus tshawytscha) migrating in summer are not effectively guided into the juvenile bypass system from turbines equipped with submersible traveling screens (STS) (Gessel et al. 1990). Consequently, most summer-migrant fall chinook salmon pass downstream through the turbines. Pending resolution of this guidance problem, operation of the Second Powerhouse has been curtailed at night and restricted during daylight to minimize turbine passage losses. During these periods, downstream migrants pass Bonneville Dam via the turbines and bypass system of the First Powerhouse and, when flow conditions allow, over the spillway between the two powerhouses. While it is generally agreed that operation in this manner maximizes survival of migrants passing Bonneville Dam, it is costly in terms of lost power production.

The rationale for this operating procedure is based on results of passage mortality studies at the Bonneville Dam First Powerhouse (Holmes 1952) and at other hydroelectric projects with similar physical features and operating characteristics (Schoeneman et al. 1961). Hence, the adequacy of this procedure as the best means of protecting downstream migrant salmonids at the Second Powerhouse has not been directly tested. Moreover, the Kaplan turbines at the Second Powerhouse are more efficient (less cavitation) than those at the First Powerhouse, and passage mortality is thought to be inversely related to turbine efficiency (Cramer and Oligher 1964, Ruggles 1985). In addition, survival assessments at spillways with flow deflectors (installed in the 1970s to decrease air supersaturation of spilled water) have produced mixed results--estimates of relative survival have ranged from about 97% at Lower Monumental Dam spillway (Long et al. 1975) to 87% at Bonneville Dam spillway (Johnsen and Dawley 1974). Finally, substantive data are not available for survival of juvenile salmonids after passage through the bypass system and tailrace at other dams: Lower Granite, Little Goose, McNary, John Day, or Bonneville Dams.

Accordingly, in 1987, the National Marine Fisheries Service (NMFS), in cooperation with the U.S. Army Corps of Engineers (COE), began a multi-year study to evaluate relative survival of subyearling fall chinook salmon after passage through the spillway or Second Powerhouse turbines, bypass, or tailrace basin at Bonneville Dam (Fig. 1). Estimates of long- and short-term relative survival of marked chinook salmon using these passage routes are being developed by comparing recovery percentages of these groups. Long-term relative survival will be based on returns of tagged and branded adult fish to ocean fisheries, Columbia River fisheries, and Columbia River hatcheries. Short-term relative survival is based on recoveries of branded fish 157 km downstream from the dam near the upper boundary of the Columbia River estuary at Jones Beach, Oregon (Fig. 2).

During the 3 years of sampling at Jones Beach, 1987, 1988, and 1989, the short-term relative survival estimates indicated reduced survival of fish using the bypass system of the Second Powerhouse compared to that of fish passing through turbines or over the spillway (Ledgerwood et al. 1990). Visual examination of the bypass structure, as well as additional testing in which juvenile salmon were released at the bypass entrance and recovered near the outlet, provided little evidence that the passage conduit was causing gross injury or direct mortality (Ledgerwood et al. 1990). Noteworthy in this regard, however, are the observations from previous laboratory studies showing that juvenile salmon subjected to severe stress or severe turbulence can lose equilibrium and often exhibit abnormal avoidance behavior (Groves 1972, Sigismondi and Weber 1988). Hence, there is the possibility that fish exposed to turbulence in or near the bypass system are stressed to the extent that they become disoriented and unable to avoid predators. Consequently, the reduced estuarine recovery percentages of the groups that

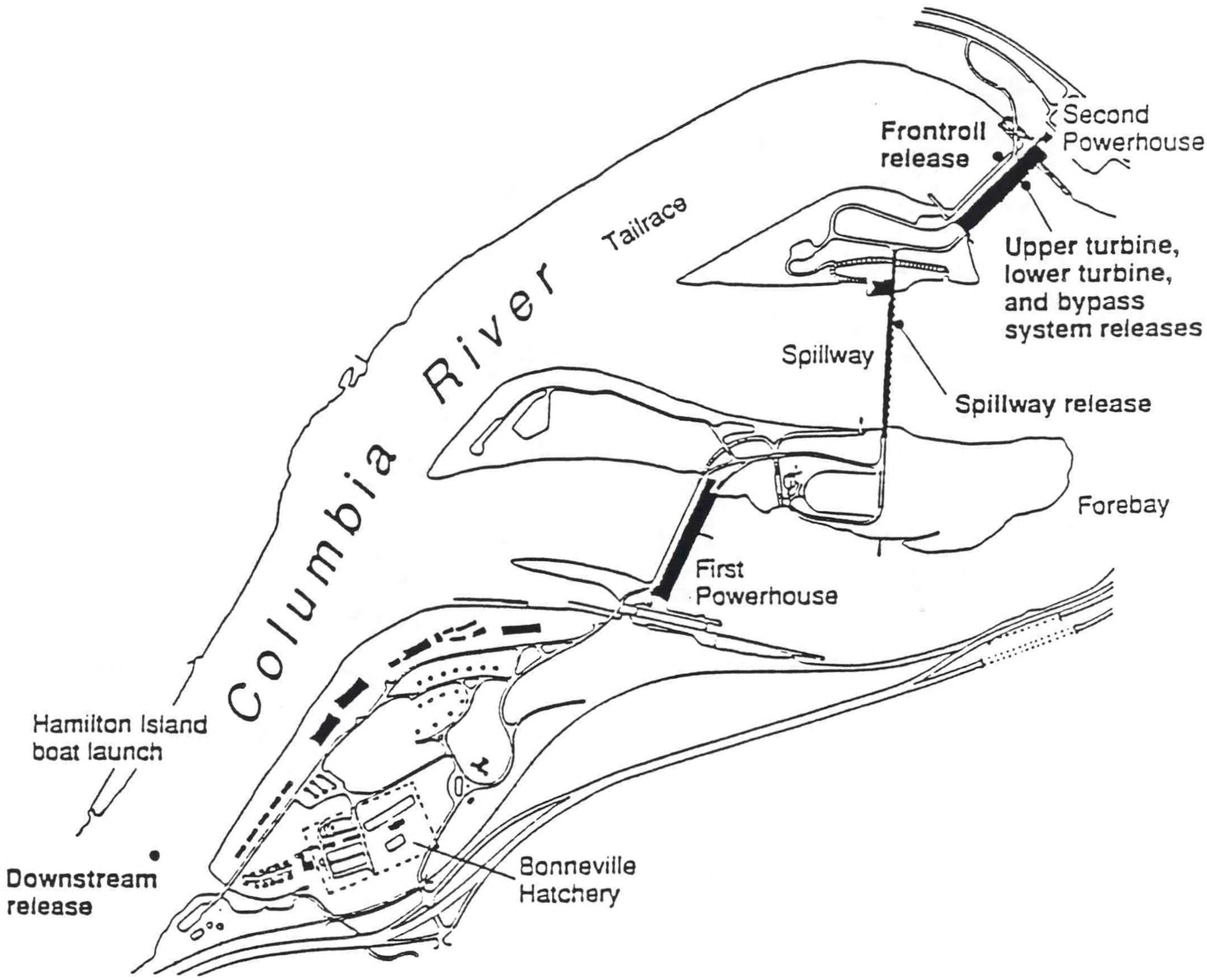

Figure 1.--Release locations for subyearling chinook salmon during the Bonneville Dam survival study, 1987-1990.

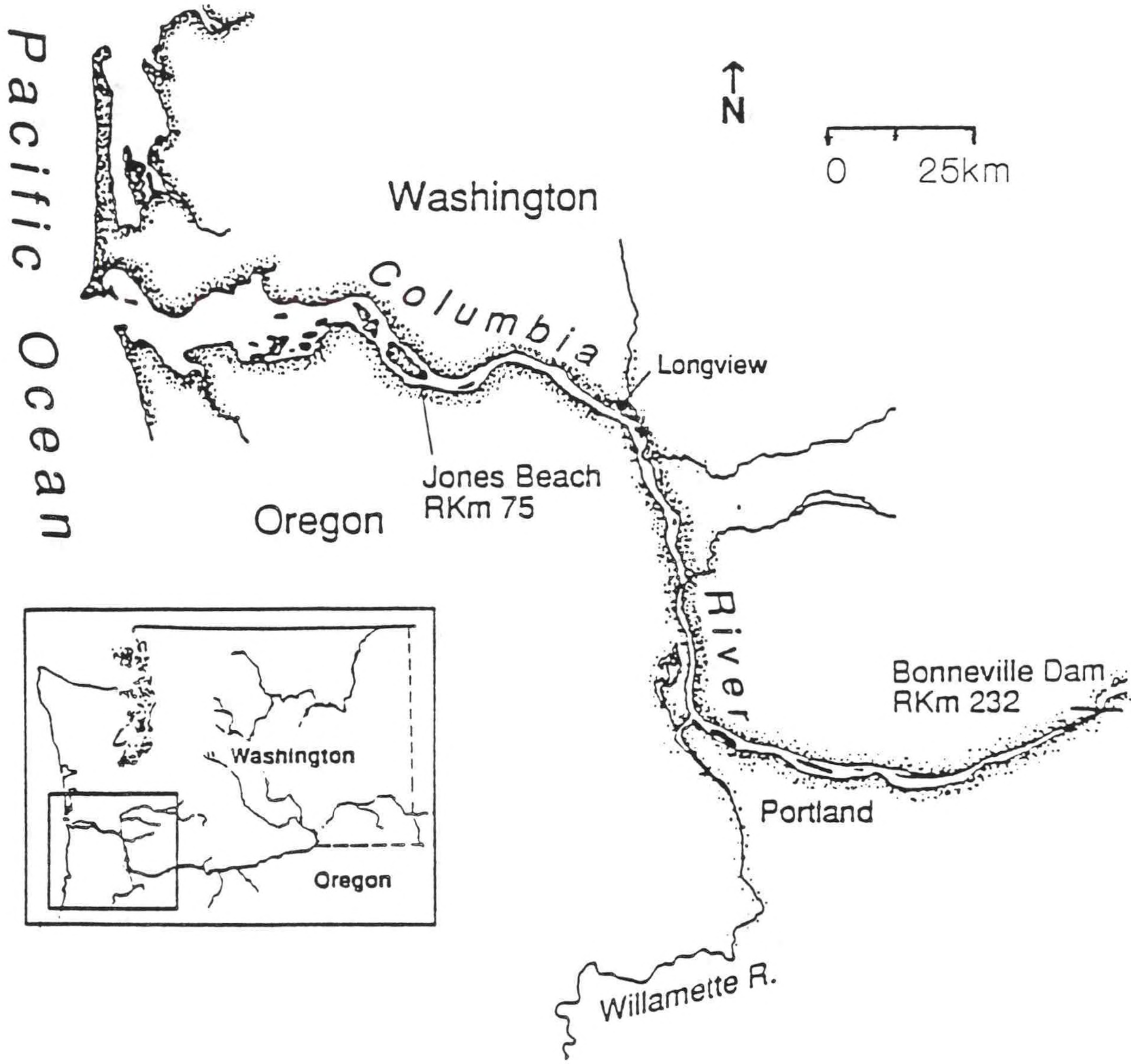

Figure 2.--The lower Columbia River showing locations of Bonneville Dam and the estuarine sampling site at Jones Beach, Oregon.

passed Bonneville Dam via the Second Powerhouse bypass system may be, at least in part, the result of high predation on fish emanating from a point source into the tailrace.

In 1990, the NMFS continued investigating the effects of bypass passage at Bonneville Dam Second Powerhouse on long- and short-term relative survival of subyearling fall chinook salmon. A fish release strategy was developed to determine whether previously observed decreases in survival occur as a result of passage through the bypass conduit, through the tailrace area of the dam, or a combination of both. A full powerhouse loading (eight-turbine discharge) was used to produce conditions that would minimize impacts from resident predators. However, the conditions tested did not necessarily relate to environmental conditions in the tailrace after long-term dam operation, but provided observations useful for evaluating the reasons for and the seriousness of decreased survival from bypass passage. Preliminary estimates of relative survival are based on comparisons of percentages of marked fish recovered in the estuary, whereas returns of tagged adults to ocean fisheries, Columbia River fisheries, and hatcheries will be used as the long-term and final indicator of relative survival. Secondary objectives of the estuarine sampling were 1) to evaluate the success of the release strategies (by assessing recovery percentages), and 2) to identify possible differences among treatment groups which might complement observations of recovery differences (by assessing descaling, injuries, fish size, feeding habits, and migration behavior).

METHODS

Experimental Design

In 1990, as in the previous 3 years of this study, test dates and dam operational criteria were chosen to represent conditions encountered by subyearling upriver bright fall chinook salmon migrating past Bonneville Dam. Test fish from Bonneville Hatchery were specifically chosen because of their similarity to summer migrants, availability, low probability of straying, and expected high percentage of adult returns. Release locations for the bypass and lower turbine release groups were those used in 1987, 1988, and 1989 (Ledgerwood et al. 1990) but there were no upper turbine, frontroll, spillway, or downstream release groups as in previous years. A new release location, the bypass egress, was added in 1990. For this release, fish passed through a hose extending from the deck of the dam to the outside of the bypass exit structure into the bypass excurrent plume.

Test Fish

In 1990, about 1.9 million subyearling chinook salmon were reared specifically for this experiment at Bonneville Hatchery, operated by the Oregon Department of Fish and Wildlife (ODFW). Test fish were the progeny of fall chinook salmon (upriver bright stock) collected by ODFW personnel at Bonneville Hatchery. Fish size at marking and release varied from 5.6 to 10.1 g (41-74 fish/lb), similar to the size of test fish used in the 1988 and 1989 studies.

Marking Procedures

Test fish were marked from 12 June to 28 July, Monday through Friday, using two marking crews; one crew worked from 0600 to 1400 h and the second from 1430 to 2230 h. About 60,000 fish were marked each day. The experimental design called for 21 release lots for each of three treatment groups, with each group consisting of about 30,000 fish. Each marked group had unique coded-wire tags (CWT) (Bergman et al. 1968). Cold brands (Mighell 1969) were used to visually identify fish from the different treatment groups.

Prior to marking, ODFW personnel at Bonneville Hatchery transported unmarked fish by truck from Batteries C and D to Battery A. A marking trailer was set up at the northwest end of Battery A, and fish were moved from Battery A to the holding tanks in the trailer using dip nets, apportioned to the marking stations, anesthetized with tricaine methane sulfonate (MS-222), and marked. Marked fish exited the trailer via 7.6-cm diameter PVC pipes that led to subdivided holding ponds in Battery A.

Three measures were taken to ensure that marked groups did not differ in fish size, fish condition, rearing history, or mark quality: 1) the three marked groups needed for one release lot (i.e., a single night's release) were marked simultaneously; 2) two marking stations were dedicated to each treatment group; and 3) differences in mark quality among groups were minimized by rotating fish markers between stations such that each marking team contributed equivalent numbers of marked fish to each treatment group.

Tag Loss

To maintain quality control in the tagging process, samples of about 100 fish from each marked group were collected periodically at the outfall pipe from the marking trailer and checked for CWTs (Appendix Table A1). In addition, samples of about 10 fish from each marked group were diverted into a separate holding pond at 2-hour intervals throughout the marking day and held for a minimum of 30 days to determine tag loss and brand retention. Due to space limitations at the hatchery, a single raceway was used to hold this sample. After the holding period, these fish were passed through a tag detector and brands used to assign detection results to particular treatment groups. Brand legibility for the first two release series was poor (less than 20%); therefore, tag loss for these series was estimated using a pooled sample of all sample fish having illegible brands. Estimates of tag loss, based on extended holding of samples of each marked release group, ranged from 3.4 to 16.8% ($\bar{x}$ = 8.2%, n = 12,040; Appendix Table A2). Tag loss estimates made immediately after marking were low (range 0 to 2.6%). This suggests that study fish continued to lose tags at a high rate for several days after tagging, possibly related to poor tag placement in the fish (Vreeland 1990). Release data for juvenile and adult recovery comparisons include an adjustment using estimated tag loss for marked fish held a minimum of 30 days.

Release Locations

The specific release locations and rationales for 1990 were as follows:

1) Lower Turbine: Test fish descended 29 m through a 30-m long by 7.6-cm diameter hose and were released 1 m below the STS water flow interception line in the Turbine 17 intake through Gatewell A (Fig. 3). The site was selected to allow comparisons of survival between bypassed fish and those passing through a turbine. Ambient water velocity at the release site was about 1.9 m/sec (Jensen 1987). This release was made with the STS in place to simulate conditions fish would encounter while passing into the middle of the intake, below the STS. Fish entering from this location pass through the turbine near the middle of the blade and presumably suffer greater injury than fish passing near the hub.

2) Bypass System: Test fish descended 10 m through a 30-m long by 7.6-cm diameter hose and were released at the water surface of the bypass gallery adjacent to Gatewell B of Turbine 17 (elevation +20.0 m; Fig. 4). Fish released at this point encounter an overfall weir, a downwell, and 5 elbows in passage through the 287-m long by 0.9-m diameter conduit. The conduit discharges fish into the tailrace about 76 m downstream from the powerhouse. Ambient water velocity of the channel at the release site is about 0.8 m/sec. The bypass system was automatically regulated to maintain flows at any combination of forebay and tailrace water elevations. These releases were made to simulate conditions encountered by fish after interception by an STS and shunting into the bypass channel.

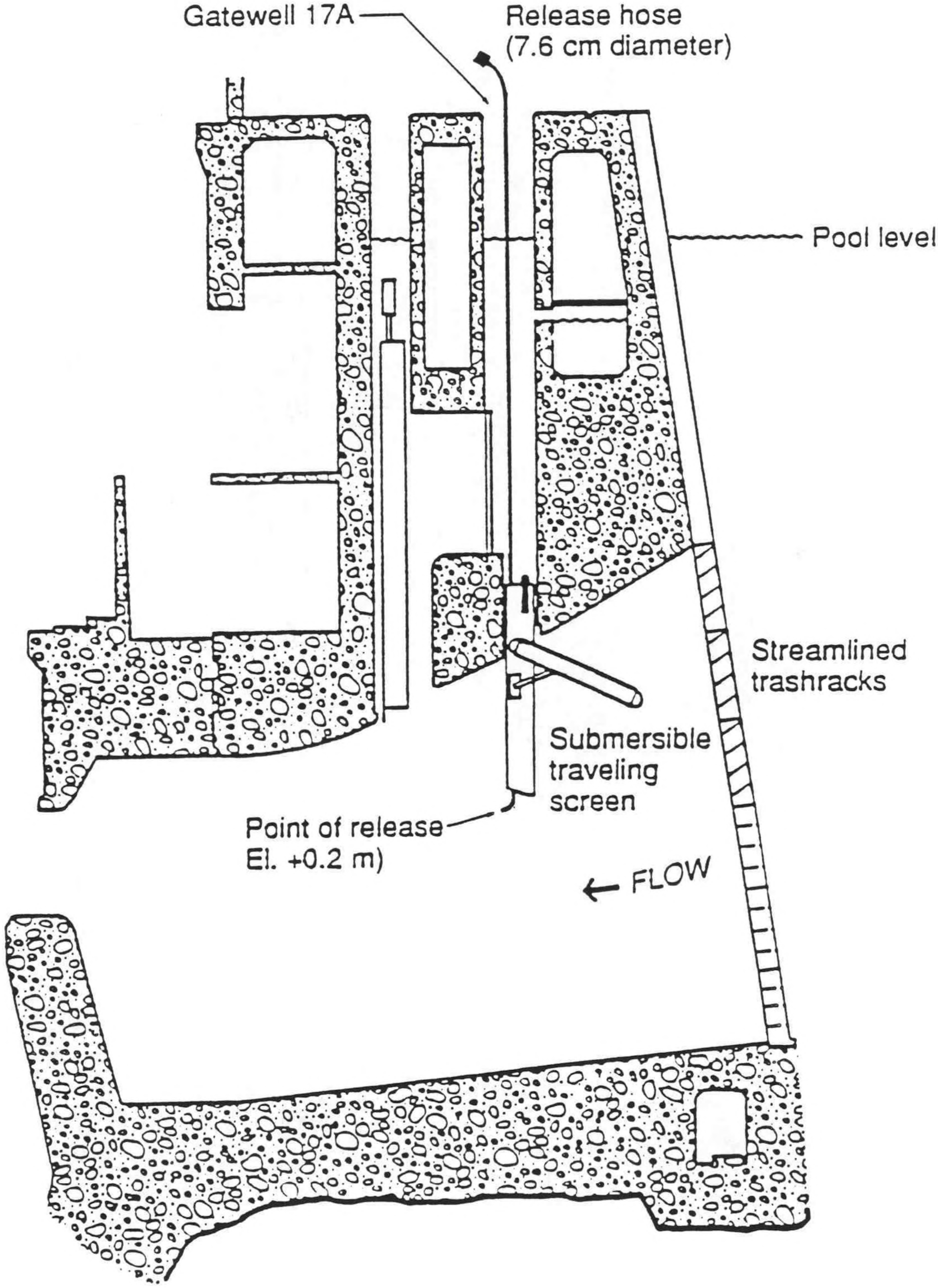

Figure 3.--Cross-section of Bonneville Dam Second Powerhouse depicting release location of lower turbine treatment group.

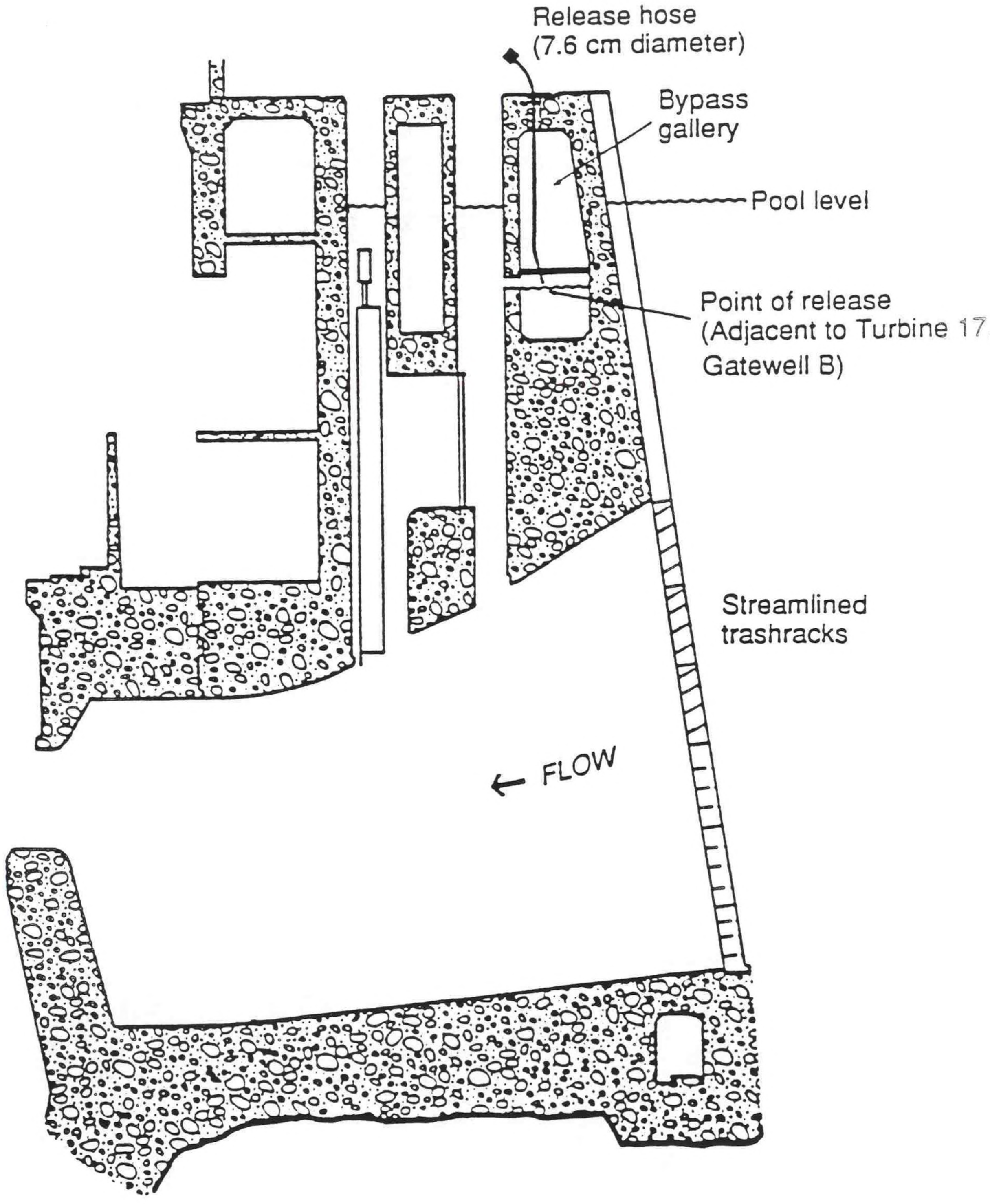

Figure 4.--Cross-section of Bonneville Dam Second Powerhouse depicting release location of bypass treatment group.

3) Egress: Test fish descended 21 m through one of two 76-m long by 10.2-cm diameter hoses from the tailrace driveway deck of the Second Powerhouse to 7.6-cm nozzles attached to each side of the bypass outlet structure located about 10 m below the river surface (Fig. 5). Test fish were expelled through the nozzles at a 10° angle into the bypass excurrent plume with a water velocity matching that of the bypass excurrent (about 7.6 m/sec; varies with tailwater surface elevation). These releases were designed to introduce fish into the tailrace at the location of the bypass exit, but without having passed through the bypass system. Hence, differences in recoveries of bypass- versus egress- released fish could be used to estimate impacts of bypass passage on survival.

The turbine release groups entered the tailrace from the turbine discharge boil which dispersed fish over a large area (ca. 700 m^2). These were termed broadcast releases. The bypass and egress groups entered the tailrace directly from a pipe or hose; these were termed point-source releases.

Project Operating Parameters

In 1990, turbines were operated at maximum efficiency for the available hydraulic head, power demands, and river conditions during the June-July test period. On release days, all Second Powerhouse turbines (11-18) were operated at 66-67 MW electrical load from 2400 h (2 hours before fish releases) until 0800 h. Second Powerhouse discharge during tests ranged from 3,119 to 3,720 m^3/sec (112.7 to 131.3 k·ft^3/sec), and operating head was 16.2 to 18.7 m. Effective head for Turbine 17 is about 0.4 m less than the operating head due to occlusion by trashracks, debris, and water resistance past the intake structure (personal communication, Brian Moentenich, COE, North Pacific Division, Portland, Oregon). Under these conditions, the plant sigma varied from 0.92 to 1.19 and the calculated efficiency of the turbine varied from 92 to 93% (from model

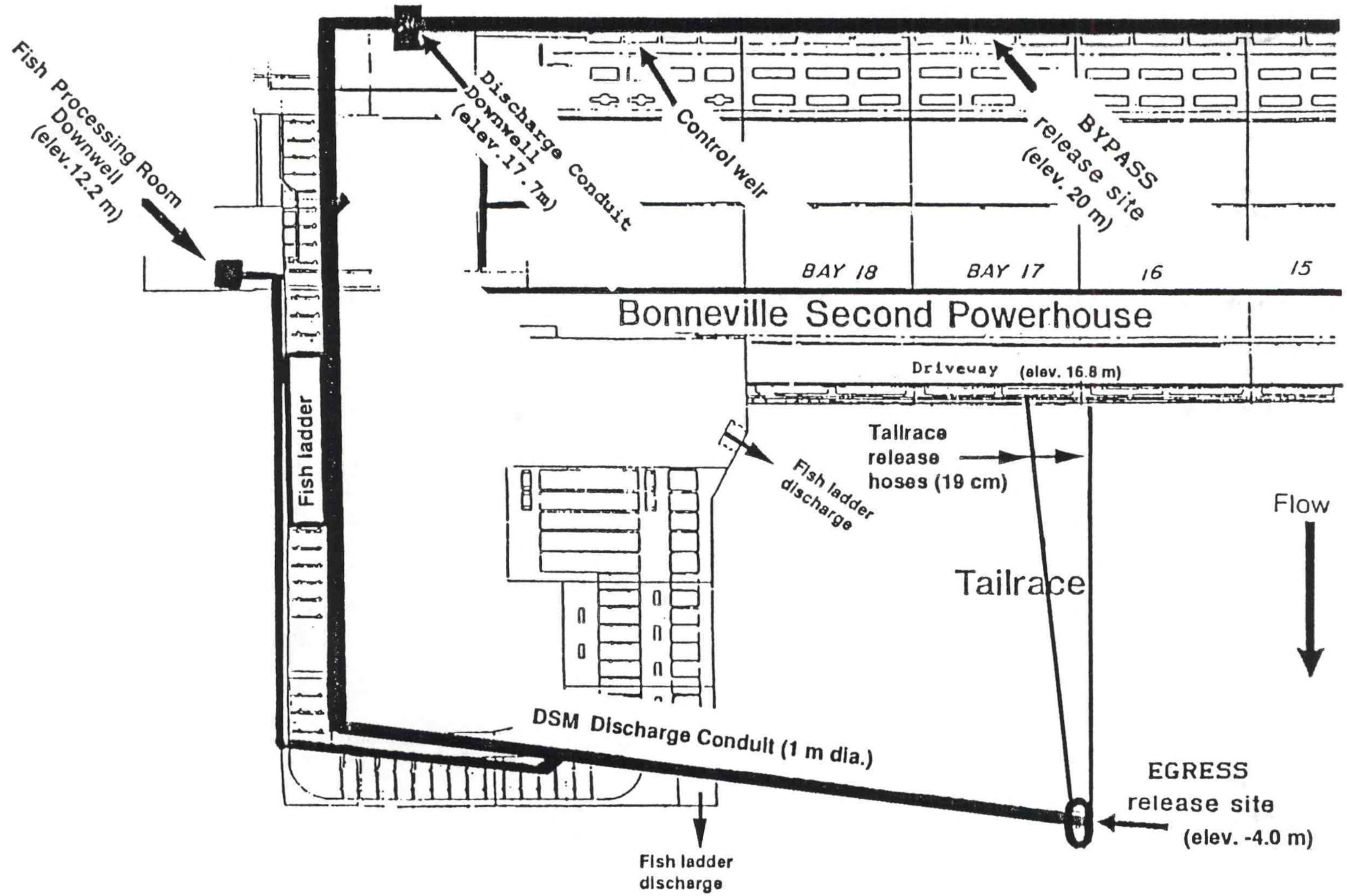

Figure 5 .--Schematic of the downstream migrant bypass system at Bonneville Dam Second Powerhouse, showing fish release sites, 1990.

studies data; Allis-Chalmers 1978).[1] Daily flows, operating conditions, and water temperatures are listed in Appendix Table B1. In past years of survival tests at the Second Powerhouse, Turbines 11, 12, 13, and 18 were operated in July for fish guidance efficiency studies. We speculated that these Second Powerhouse turbine flows attracted northern squawfish (*Ptychocheilus oregonensis*) into the tailrace basin which, in turn, impacted survival of study fish. In 1990, beginning 8 July, turbines were generally operated 2 days prior to testing to simulate conditions in previous tests. Units 11 and 18 were operated from 1600 to 2400 h and units 12 and 13 from 2000 to 2400 h.

Release Procedures

On 21 days during the period from 30 June to 3 August, simultaneous releases of about 30,000 marked fish were made at the three release sites during early morning darkness (0200 h). The release days were selected to coincide with the migration of juvenile upriver bright fall chinook salmon past Bonneville Dam, and provide sufficient time for marking yet not require more than 15 days holding prior to release. Uniquely branded fish groups were released at each site during six time series: 30 June-3 July (except 1 July); 5-6 July; 10-13 July; 17-21 July (except 19 July); 24-27 July; and 31 July-3 August.

On release days, loading of transport trucks began at 1800 h and was completed by about 2230 h. Fish were moved with dip nets from the holding pond to a sluiceway which carried them to a catch tank located near the transport trucks. Fish were loaded on the trucks by dip net and held at densities less than 60 g fish/L water (0.5 lb/gal). Two trucks (17,000- and 19,000-L capacities, subdivided into two compartments) were used to transport fish to the Second Powerhouse. Fish in loaded trucks were tempered to river water over a 3-hour period prior to release. All releases were made from the transport

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[1] Flow and efficiency data were derived from Figure 8-02.1 of Bonneville Second Powerhouse model test report (Allis-Chalmers 1978).

tanks using a smooth-bore plastic hose to carry the fish to the release point. Vertical distances from the transport trucks to the water surface were about 6, 9, and 12 m (20, 30, and 40 ft), respectively, for turbine, bypass, and egress releases. Hose discharge velocities were calculated to be 3.7, 7.0, and 7.6 m/sec, respectively, for lower turbine, bypass, and egress releases. Velocity differences between water exiting the release hoses and the surrounding water were calculated to be less than 6.3 m/sec. The lowest differential velocity shown to cause mortality of juvenile salmonids in laboratory tests was 15 m/sec (Groves 1972).

Sampling at Jones Beach

Assessment of short-term relative survival among release groups was made from comparisons of tagged fish recovered near the upper boundary of the Columbia River estuary at Jones Beach. Detailed description of the sampling site and the fishing gear may be found in Dawley et al. (1985, 1988).

Sampling was conducted by two to four crews, 7 days per week, 8 to 16 hours per day, beginning at sunrise (Appendix Table C1). Both purse seines (mid-river) and beach seines (Oregon shore) were used about every fourth day to determine whether study fish were captured in greater numbers in mid-river or near shore (Fig. 6). On other days, the gear type shown to catch the greatest number of study fish was used by all crews. Beach seining was limited to the Oregon shore.

All captured fish were processed aboard the purse seine vessels. The catch from each seine set was anesthetized using a 50 mg/L solution of ethyl-*p*-aminobenzoate. Subyearling chinook salmon were examined for excised adipose fins, brands, descaling, and injury.

Fish were classified as descaled when 25% or more of its scales are missing on one side. All juvenile salmonids captured were evaluated for descaling. Descaling was judged rapidly, generally aboard the sampling vessel, during the process of counting and

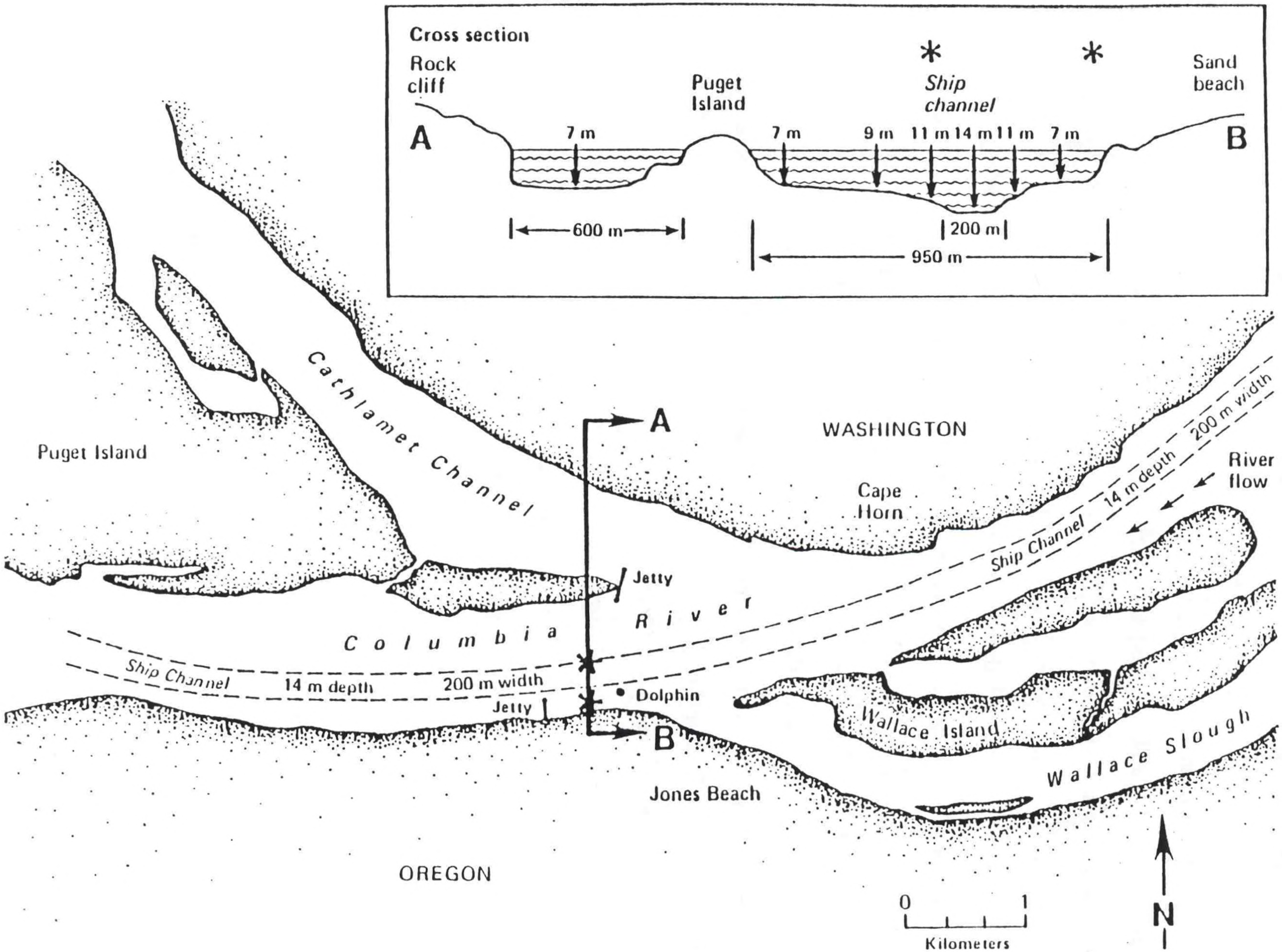


Figure 6.--Jones Beach, Columbia River, Oregon sampling sites. The beach- and purse-seining areas are denoted by asterisks.

separating target fish from non-target fish. Non-target fish were returned to the river immediately after counting and evaluation. If the percentage of descaled fish exceeded 5% for any consecutive three day period (which did not occur) various fisheries agencies were to be alerted and sampling could continue only with approval. Descaling of captured fish at Jones Beach was generally related to the rolling of fish in nets caused by wave action (waves created by wind or passing ships) but great care was taken to minimize descaling under adverse conditions. A subsample of fish evaluated for descaling at a specific time of the day will not necessarily represent fish throughout the sample day. Real-time evaluations of descaling are used to determine the appropriateness of continued sampling when wind conditions change. Fork lengths of marked fish were recorded to the nearest mm. Brand information, fork length, and associated sampling data (i.e., vessel code, gear type, date, set number, time of examination) were immediately entered into a computer database and printed.

Brands were used to identify study fish for collecting CWTs, obtaining biological samples, comparing fish size among treatment groups, and adjusting the daily sampling effort to attain the desired minimum sample of 0.5% of release. All branded fish (including those with illegible brands) were sacrificed to obtain CWTs which identified treatment group and day of release. Of the total number of adipose fin clipped fish captured, 83% were study fish.

The heads of branded fish containing CWTs were pooled by recovery day and site. All CWTs were decoded and later verified using a 45-X dissecting microscope. (Additional details of tag processing are presented in Appendix D of Ledgerwood et al. 1990).

Purse seine catch data from 6 July through 15 August were standardized to a 14 set per day effort using the following formula:

$A_i = N_i \times (S_i \div P_i)$

where: A_i = Standardized purse seine catch on day i.

N_i = Actual purse seine catch on day i.

A = 14 = Constant (weighted daily average number of purse seine sets during the sampling period).

P_i = Actual number of purse seine sets on day i.

Few fish were captured after 15 August and effort was reduced during the final week of sampling, thus those data were not included in the standardized data set. Dates of median fish recovery for each marked group were determined using the standardized data. Movement rates for each CWT group were calculated as the distance from the downstream release site used in previous years (RKm 232) to Jones Beach (RKm 75) divided by the travel time (in days) from release date to the date of median recovery.

Diel Sampling

Diel purse seine and bottom trawl sampling were conducted during a 24-hour period between 31 July and 1 August. The sampling dates were selected to correspond to the approximate date of the peak catches of fish released 17 to 27 July. Bottom trawling was conducted in conjunction with purse seining to investigate diel behavior of fish traveling too deep for capture by purse seine. The trawl was a 7.9-m semiballoon shrimp trawl of the type used to collect juvenile white sturgeon (Acipenser transmontanus) (McCabe and Hinton 1990).

Stomach Fullness and Diet Composition

Stomach fullness of selected CWT fish was examined to assess possible differences among treatments. Samples were collected primarily during the diel sampling. For this evaluation, stomachs were excised (esophagus to pyloric caeca), and cleaned of external fat. A stomach fullness value, based on the proportion of the total stomach length containing food, was estimated. A scale of 1 to 7 was used to quantify the fullness as follows: 1 = empty, 2 = trace of food, 3 = one-quarter full, 4 = half full, 5 = three-quarters full, 6 = full, and 7 = distended full (Terry 1977). All stomachs appearing empty were opened for examination, and a value of 2 was assigned if traces of food were observed. Subsamples of stomachs were preserved in 10% buffered formaldehyde solution for weight determination and content analyses. Holding time prior to fullness observations was about 35 minutes.

Diet was determined using preserved stomachs from the fullness evaluation. Stomachs were opened longitudinally, the contents scraped onto a screen, blotted from beneath, allowed to air dry for about 1 minute, weighed to the nearest 50 µg, and washed from the screen into a watch glass with a 70% solution of ethyl alcohol for examination. All stomachs from fish captured in the same purse seine set were pooled. Organisms were identified to the lowest practical taxa; insects were further separated by metamorphic stage. In samples containing large numbers of cladocerans (>1,000), total numbers were estimated using weight.

Statistical Analysis

Differences among recovery percentages for each tagged group at Jones Beach were evaluated by analysis of variance (ANOVA) using a randomized block design where each release day was considered a block (Sokal and Rohlf 1981). Transformations of percentages were not required. Differences among descaling percentages of branded groups were also evaluated using ANOVA. Fisher's protected least significance procedures were used to rank treatment means for significant F-tests (Petersen 1985). Chi-square goodness of fit was used to test the hypothesis that different marked groups released the same day had equal probability of capture through time (Zar 1974).

RESULTS

In 1990, a total of 1,876,669 fish were marked with freeze brands, CWTs, and excision of the adipose fin (Table 1). A total of 8,770 study fish were recovered in the estuary (ca. 0.5% of those released); most were mid-river migrants captured with purse seines (Appendix Table C2). Handling mortality of captured fish was less than 0.5%.

Migration Behavior and Fish Condition

Statistical analysis of migrational timing differences among treatment groups released on the same day showed no significant difference for any of the 21 release lots ($\alpha = 0.05$), and no difference when the results of the individual tests were pooled ($P = 0.6264$; Appendix D). Temporal catch distribution of treatment groups released each day are presented for visual comparison in Figures 7, 8, and 9; and in Appendix Figures C1-C4.

Movement rates of study fish from the release site at Bonneville Dam to Jones Beach ranged from 10 to 31 km/day (Table 2); these rates were similar to those observed in 1988 and 1989. Movement rates generally increased during the period of the study which was probably a function of increased size at release. River flow during the same period was variable (Appendix Fig. C5) and movement rates were apparently unrelated to river flow or treatment group.

Comparisons of fork length distributions of study fish at release to those at Jones Beach suggest that all groups grew during migration (Figs. 10-11). In contrast to the apparent loss of smaller-sized fish in 1988, there was little indication that smaller fish dropped out of the population during migration to Jones Beach in 1990. The exception may have been release series 5 (24-27 July; Fig. 11). There were no indications of temporal differences in size among treatment groups at recovery (Figs. 12-13); however, fish from the first four release series showed increasing mean lengths during the time of

Table 1.--Summary of releases of marked subyearling chinook salmon, Bonneville Dam survival study, 1990.

Marking dates	Release date	Brand[a]	Number released: Total[b]	Untagged[c]	Tagged[d]	Wire tag code (AG D1 D2)[e]
Lower turbine releases						
12 June	30 June	RD U1	1,806	139	1,667	23 24 51
12-13 "	30 "	RD Z1	27,887	2,147	25,740	23 24 51
13-14 "	02 July	RD Z1	29,689	2,286	27,403	23 24 54
14-16 "	03 "	RD Z1	29,794	2,294	27,500	23 24 57
18-19 "	05 "	RD Z2	29,705	2,287	27,418	23 24 60
02-03 July	06 "	RD Z2	29,784	2,293	27,491	23 24 63
03-05 "	10 "	LD U1	29,924	1,151	28,773	23 25 06
05-06 "	11 "	LD U1	29,764	1,145	28,619	23 25 12
06-07 "	12 "	LD U1	29,755	1,144	28,611	23 25 18
07-09 "	13 "	LD U1	29,659	1,141	28,518	23 25 24
09-10 "	17 "	LD U3	29,707	1,846	27,861	23 25 30
11-12 "	18 "	LD U3	29,804	1,852	27,952	23 25 36
12-13 "	20 "	LD U3	29,757	1,849	27,908	23 25 43
13-16 "	21 "	LD U3	29,839	1,854	27,985	23 25 48
17-18 "	24 "	RD>H1	29,846	5,022	24,824	23 25 54
18-19 "	25 "	RD>H1	29,879	5,027	24,852	23 25 60
20-21 "	26 "	RD>H1	29,868	5,025	24,843	23 26 05
21-23 "	27 "	RD>H1	29,849	5,022	24,827	23 26 10
23-25 "	31 "	RD>H3	29,821	4,157	25,664	23 26 17
25-26 "	01 Aug.	RD>H3	29,790	4,152	25,638	23 26 23
26-27 "	02 "	RD>H3	29,817	4,156	25,661	23 26 29
27-28 "	03 "	RD>H3	29,791	4,152	25,639	23 26 34
	Subtotals		625,535	60,141	565,394	

Table 1.--Continued.

Marking dates	Release date	Brand[a]	Number released: Total[b]	Untagged[c]	Tagged[d]	Wire tag code (AG D1 D2)
Bypass releases						
12 June	30 June	RD 21	2,103	162	1,941	23 24 52
12 "	30 "	RD 31	25,372	1,954	23,418	23 24 52
13-14 "	02 July	RD 31	29,866	2,300	27,566	23 24 55
14-16 "	03 "	RD 31	29,734	2,290	27,444	23 24 58
18-19 "	05 "	RD 33	31,163	2,400	28,763	23 24 61
02-03 July	06 "	RD 33	29,759	2,291	27,468	23 25 03
03-05 "	10 "	LD 21	29,920	2,240	27,680	23 25 09
05-06 "	11 "	LD 21	29,776	2,229	27,547	23 25 15
06-07 "	12 "	LD 21	29,761	2,228	27,533	23 25 20
07-09 "	13 "	LD 21	29,726	2,225	27,501	23 25 27
09-11 "	17 "	LD 23	29,517	1,672	27,845	23 25 33
11-12 "	18 "	LD 23	29,734	1,684	28,050	23 25 39
12-13 "	20 "	LD 23	29,702	1,682	28,020	23 25 45
13-16 "	21 "	LD 23	29,888	1,693	28,195	23 25 51
17-18 "	24 "	RD>K1	29,823	2,560	27,263	23 25 57
18-19 "	25 "	RD>K1	29,893	2,566	27,327	23 25 63
20-21 "	26 "	RD>K1	29,865	2,564	27,301	23 26 06
21-23 "	27 "	RD>K1	29,874	2,564	27,310	23 26 12
23-25 "	31 "	RD>K3	29,825	2,555	27,270	23 26 18
25-26 "	01 Aug.	RD>K3	29,831	2,555	27,276	23 26 24
26-27 "	02 "	RD>K3	29,862	2,558	27,304	23 26 30
27-28 "	03 "	RD>K3	29,885	2,560	27,325	23 26 36
	Subtotals		624,879	47,532	577,347	

Table 1.--Continued.

Marking dates	Release date	Brand[a]	Number released: Total[b]	Untagged[c]	Tagged[d]	Wire tag code (AG D1 D2)
Egress releases						
12-13 June	30 June	RD F1	30,275	2,331	27,944	23 24 53
13-14 "	02 July	RD F1	29,753	2,291	27,462	23 24 56
14-16 "	03 "	RD F1	29,727	2,289	27,438	23 24 59
18-19 "	05 "	RD F3	29,602	2,279	27,323	23 24 62
02-03 July	06 "	RD F3	29,814	2,296	27,518	23 25 05
03-05 "	10 "	LD F1	29,843	2,455	27,388	23 25 10
05-06 "	11 "	LD F1	29,851	2,456	27,395	23 25 17
06-07 "	12 "	LD F1	29,782	2,450	27,332	23 25 23
07-09 "	13 "	LD F1	29,799	2,452	27,347	23 25 29
09-10 "	17 "	LD F3	29,786	1,020	28,766	23 25 34
11-12 "	18 "	LD F3	29,779	1,019	28,760	23 25 40
12-13 "	20 "	LD F3	29,769	1,019	28,750	23 25 46
13-16 "	21 "	LD F3	29,941	1,025	28,916	23 25 53
17-18 "	24 "	RD>X1	29,817	3,368	26,449	23 25 58
18-19 "	25 "	RD>X1	29,889	3,376	26,513	23 26 03
20-21 "	26 "	RD>X1	29,905	3,378	26,527	23 26 09
21-23 "	27 "	RD>X1	29,776	3,363	26,413	23 26 15
23-25 "	31 "	RD>X3	29,779	1,320	28,459	23 26 20
25-26 "	01 Aug.	RD>X3	29,819	1,322	28,497	23 26 27
26-27 "	02 "	RD>X3	29,767	1,320	28,447	23 26 33
27-28 "	03 "	RD>X3	29,782	1,320	28,462	23 26 39
	Subtotals		626,255	44,149	582,106	
	Totals		1,876,669	151,822	1,724,847	

[a] Brand position (RD = right dorsal, LD = left dorsal), brand used (number, letter, or symbol/letter combination), and brand rotation (1, 2, or 3).
[b] Total fish marked; branded, tagged, and adipose fin clipped.
[c] Estimated number of fish released without coded-wire tags. See Appendix Table A2 for tag loss sample data.
[d] Estimated number of fish released with coded-wire tags.
[e] AG D1 D2 = Agency, Data 1, Data 2.

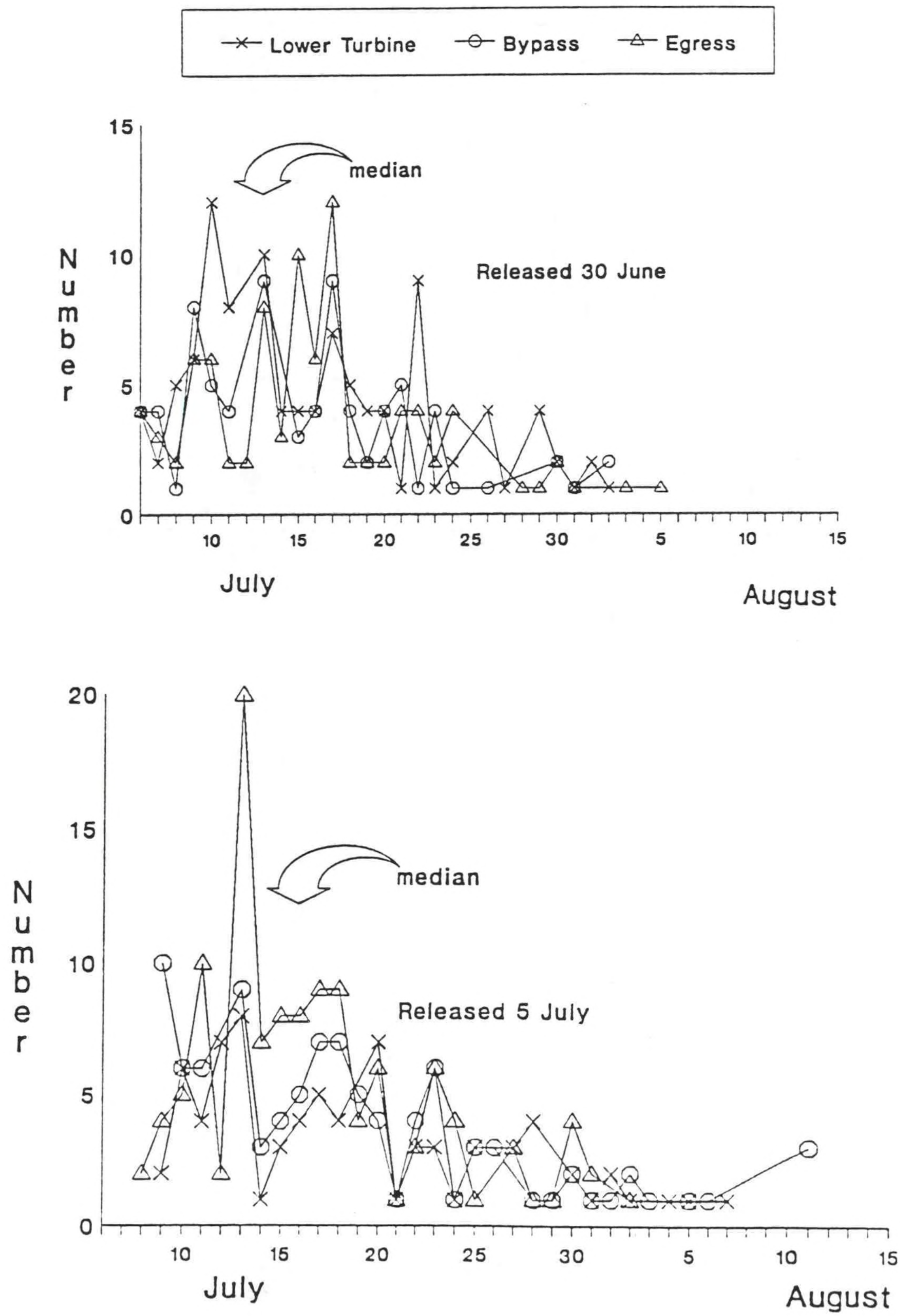


Figure 7.--Daily recoveries of test fish by treatment (standardized for effort) at Jones Beach, 1990. Data shown are from the first two release series.

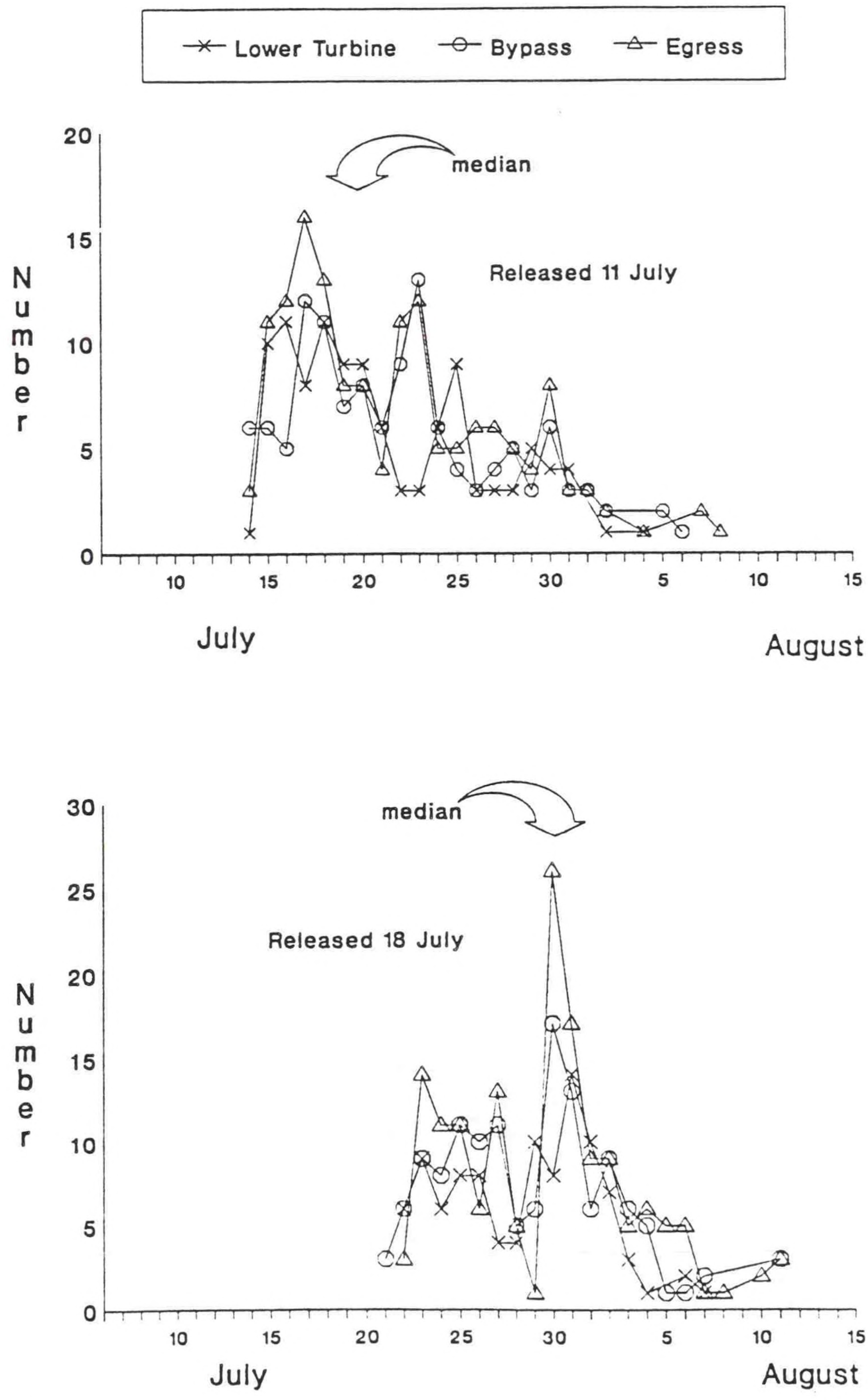


Figure 8.--Daily recoveries of test fish by treatment (standardized for effort) at Jones Beach, 1990. Data shown are from the third and fourth release series.

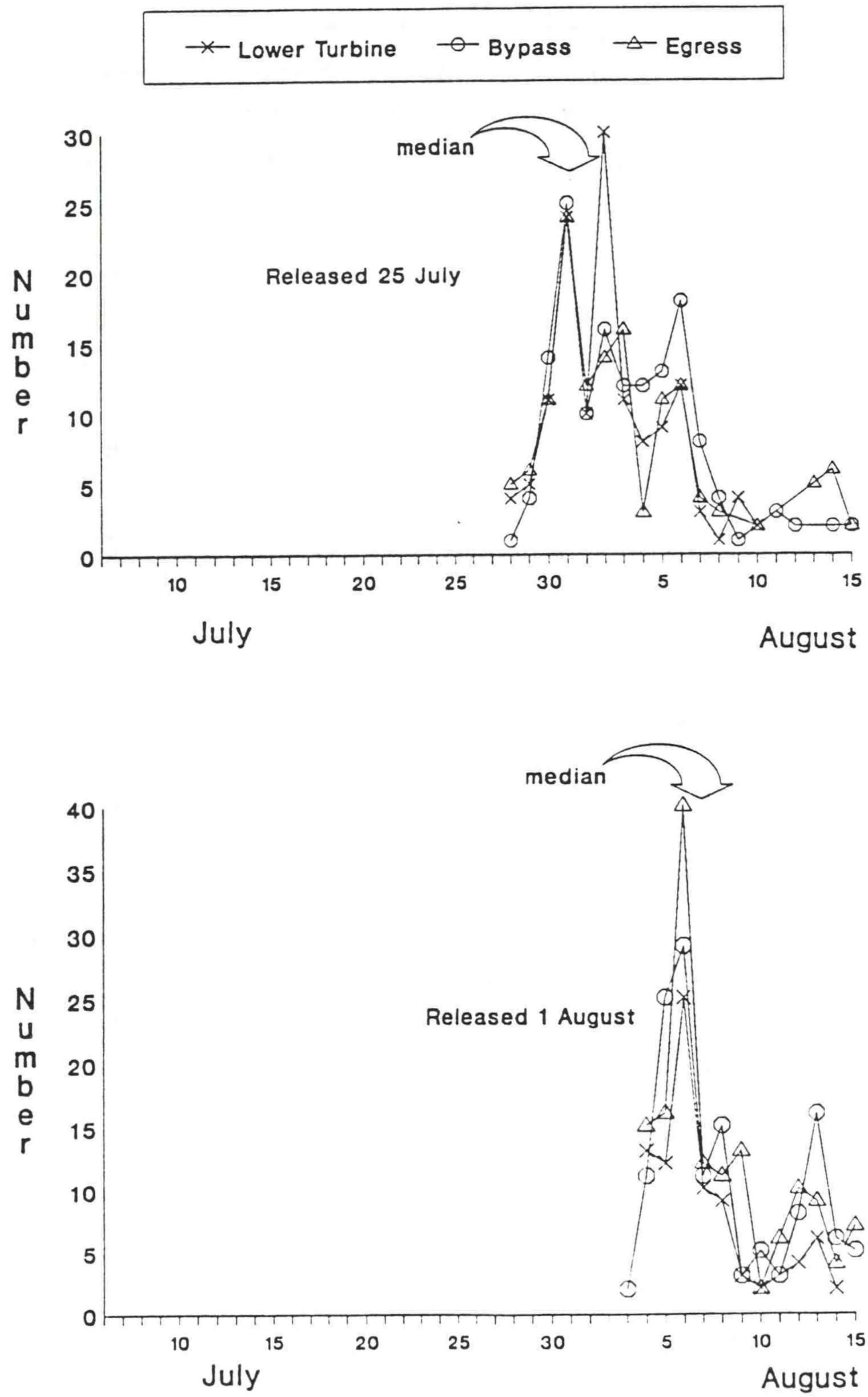


Figure 9.--Daily recoveries of test fish by treatment (standardized for effort) at Jones Beach, 1990. Data shown are from the fifth and sixth release series.

Table 2.--Movement rates from Bonneville Dam to Jones Beach for marked groups of subyearling chinook salmon, Bonneville Dam survival study, 1990.

Release date[b]	Movement rate (km/day)[a]			Flow (k•ft^3/sec)[c]
	Lower turbine	Bypass	Egress	
20 June	11	10	11	181.5
2 July	11	11	10	158.4
3 July	11	11	11	158.1
5 July	13	13	14	173.4
6 July	17	17	20	190.4
10 July	20	17	20	158.4
11 July	17	14	17	147.9
12 July	13	14	14	141.8
13 July	16	16	14	137.4
17 July	13	13	13	132.9
18 July	14	14	13	135.9
20 July	14	14	14	136.0
21 July	16	14	16	136.0
24 July	17	20	17	142.5
25 July	20	17	20	142.5
26 July	20	22	20	148.3
27 July	20	22	22	148.3
31 July	26	26	26	151.8
1 August	31	26	26	150.6
2 August	31	31	31	150.6
3 August	31	31	31	144.8

[a] Purse seine recoveries standardized to a 14 set per day effort (Appendix Table C2). Movement rate = distance from the downstream release site (RKm 232) to recovery site (RKm 75) ÷ travel time in days from release to median fish recovery.

[b] Fish released during early morning darkness.

[c] Average flow through Bonneville Dam within 4 days of the date that the median fish was captured; by convention, English units were used for river flow volumes (k•ft^3 / sec = 1,000 ft^3 / sec = 35.3 m^3 / sec).

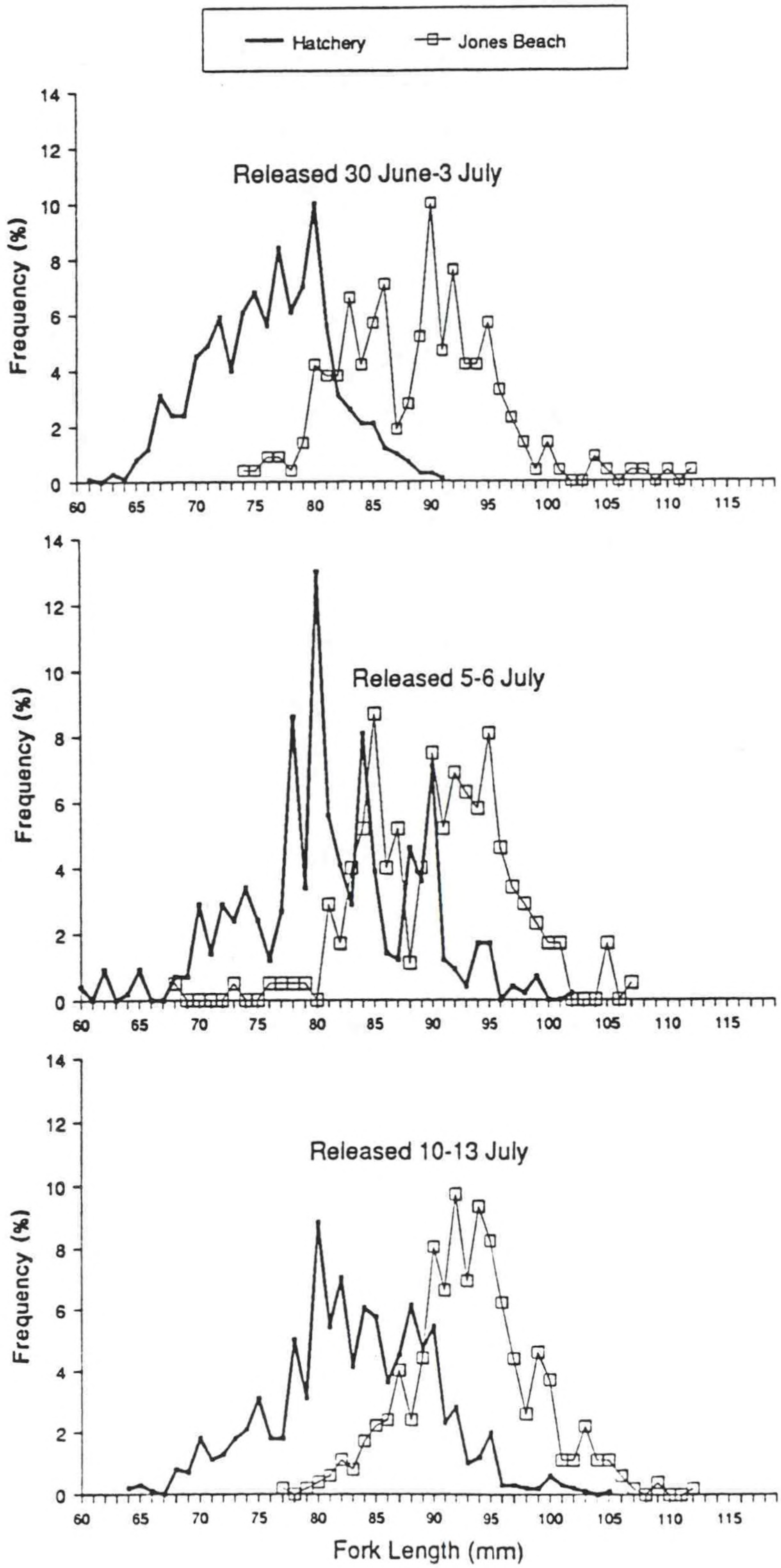


Figure 10.--Fork length distributions of fish at release and after recovery in the estuary, first three release series, Bonneville Dam survival study, 1990.

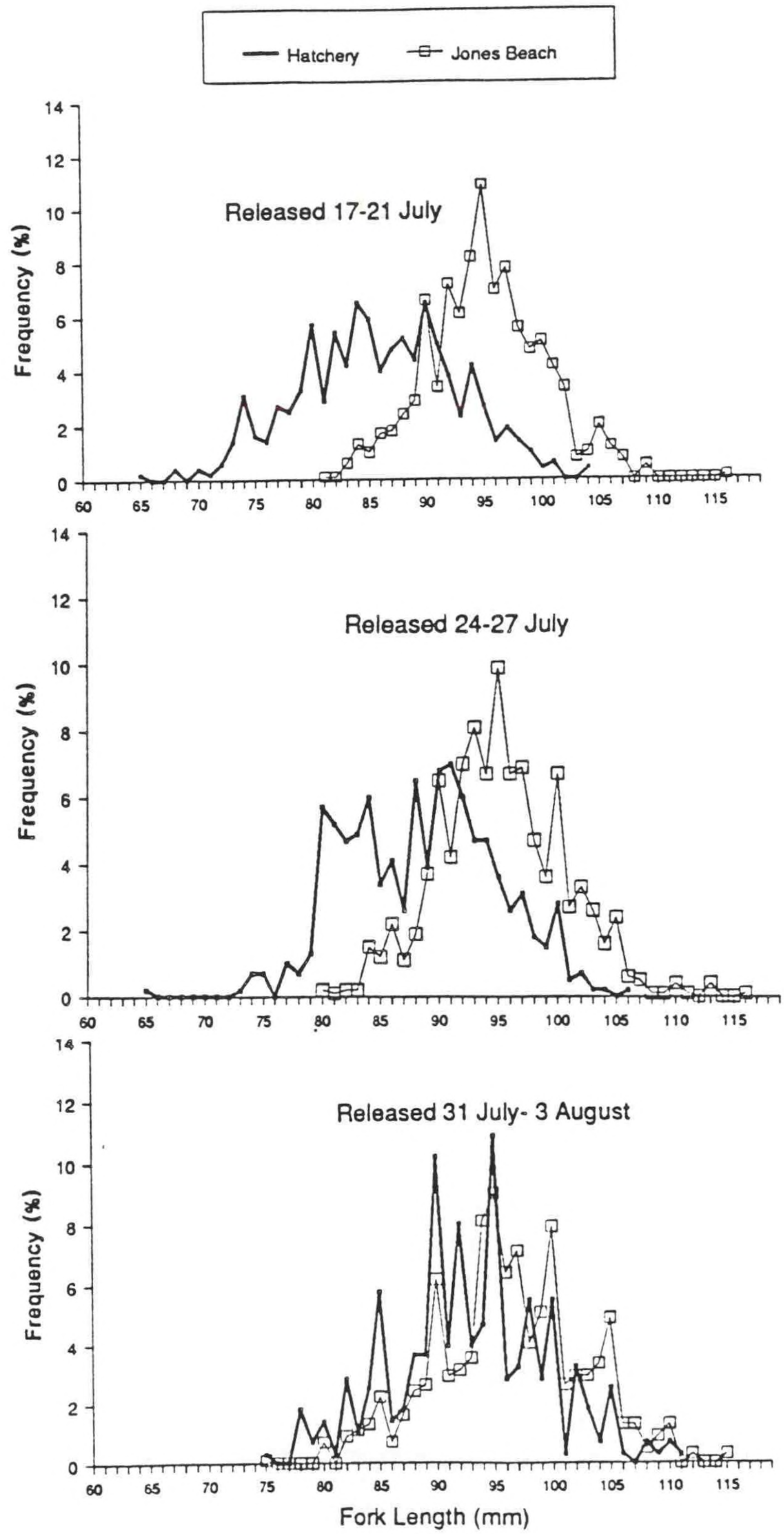


Figure 11.--Fork length distributions of fish at release and after recovery in the estuary, final three release series, Bonneville Dam survival study, 1990.

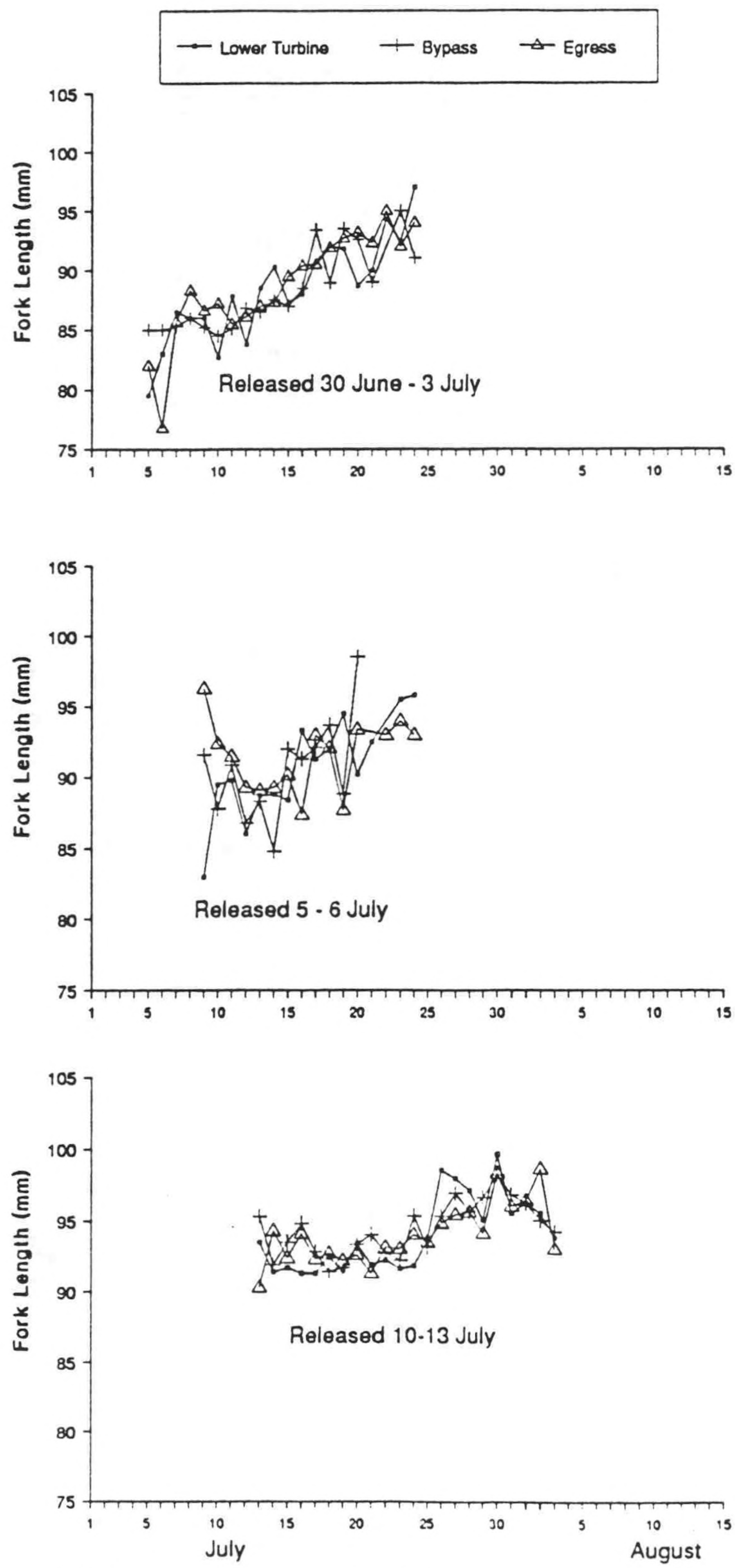


Figure 12.--Daily mean fork lengths of subyearling chinook salmon recovered at Jones Beach, comparing treatments from the first three release series, 1990.

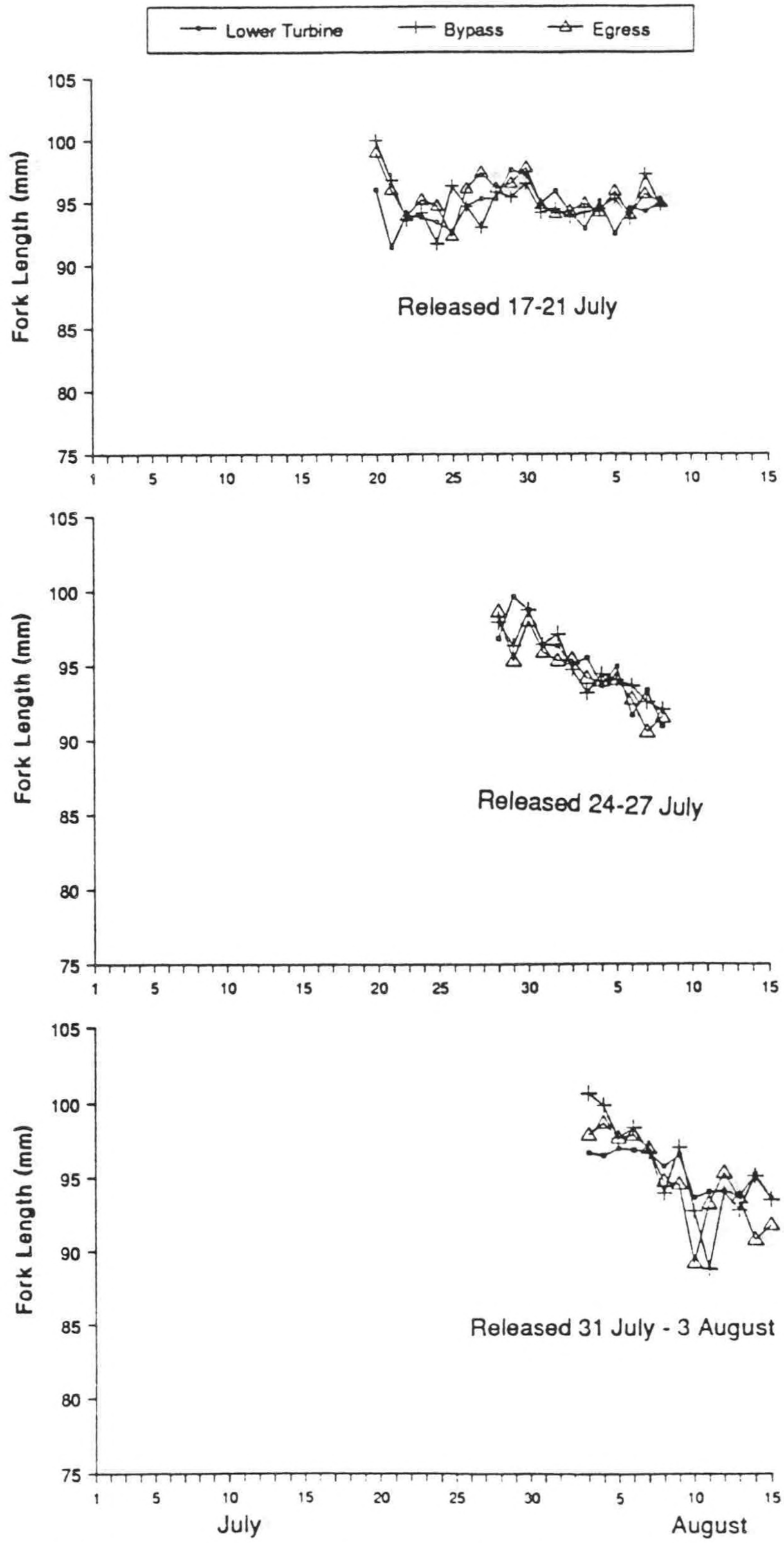


Figure 13.--Daily mean fork lengths of subyearling chinook salmon recovered at Jones Beach, comparing treatments from the final three release series, 1990.

recovery, and fish from the final two release series showed decreasing mean lengths. This may indicate that the larger individuals from the latter two groups were more highly smolted and traveled downstream faster than smaller individuals.

Descaled test fish recovered at Jones Beach ranged from 0 to 1.4%; there were no significant differences among treatments ($\alpha = 0.05$, Table 3; Appendix D). The somewhat higher descaling of lower turbine groups during the initial four release series may have been related to a torn release hose.

Diel Recovery Patterns

Purse Seine

During the diel sampling period, 314 study fish were captured by purse seine during daylight and 2 (0.6%) were captured at night (Appendix Table C3). Catches were highest at sunrise, generally decreased during the afternoon, increased again at dusk, and were lowest at night (Fig. 14). The decreased catch in the afternoon was typical of afternoon catches throughout the 1990 recovery period; however, this pattern was different from that observed in previous years. Diel patterns of recovery reported previously for subyearling chinook salmon at Jones Beach during May and June (Ledgerwood et al. 1991) and July (Ledgerwood et al. 1990) did not show a decrease in afternoon catch.

Bottom Trawl

During the diel sampling period, 15 bottom trawls were made and a total of five subyearling chinook salmon were captured (all at night; Appendix Table C4). Although numbers captured were low, recoveries of juvenile salmonids in the bottom trawl support the hypothesis that decreased purse seine catches at night reflect movement of fish to the river bottom. Similar trawl gear has captured juvenile salmon during daylight in other areas of the Columbia River (McCabe and Hinton 1990).

Table 3.--Numbers of descaled test fish among treatment groups of subyearling chinook salmon recovered at Jones Beach, Bonneville Dam survival study, 1990.

	Treatments					
	Lower turbine		Bypass system		Egress	
Release dates[a]	Number	%[b]	Number	%	Number	%
30 June-2,3 July	0[c]	0.00	2	0.00	2	0.00
5-6 July	2[c]	1.16	0	0.00	0	0.00
10-13 July	2[c]	0.45	0	0.00	0	0.00
17,18,20,21 July	8[c]	1.37	3	0.57	4	0.60
24-27 July	5	0.69	3	0.44	1	0.14
31 July-3 August	0	0.00	1	0.19	2	0.36
Total descaled	17		8		7	
Total recovered[d]	2672		2486		2841	
Mean(%)[e]	0.64		0.32		0.25	

[a] Fish released during early morning darkness.
[b] % = (number of descaled fish recovered ÷ total number recovered for that release period) X 100.
[c] A split in the release hose compromised the first 11 releases (through the 18 July release) and may have contributed to an increase in descaling.
[d] Total number of fish with legible brands.
[e] Mean descaled = (total descaled branded fish ÷ total branded fish recovered) X 100.

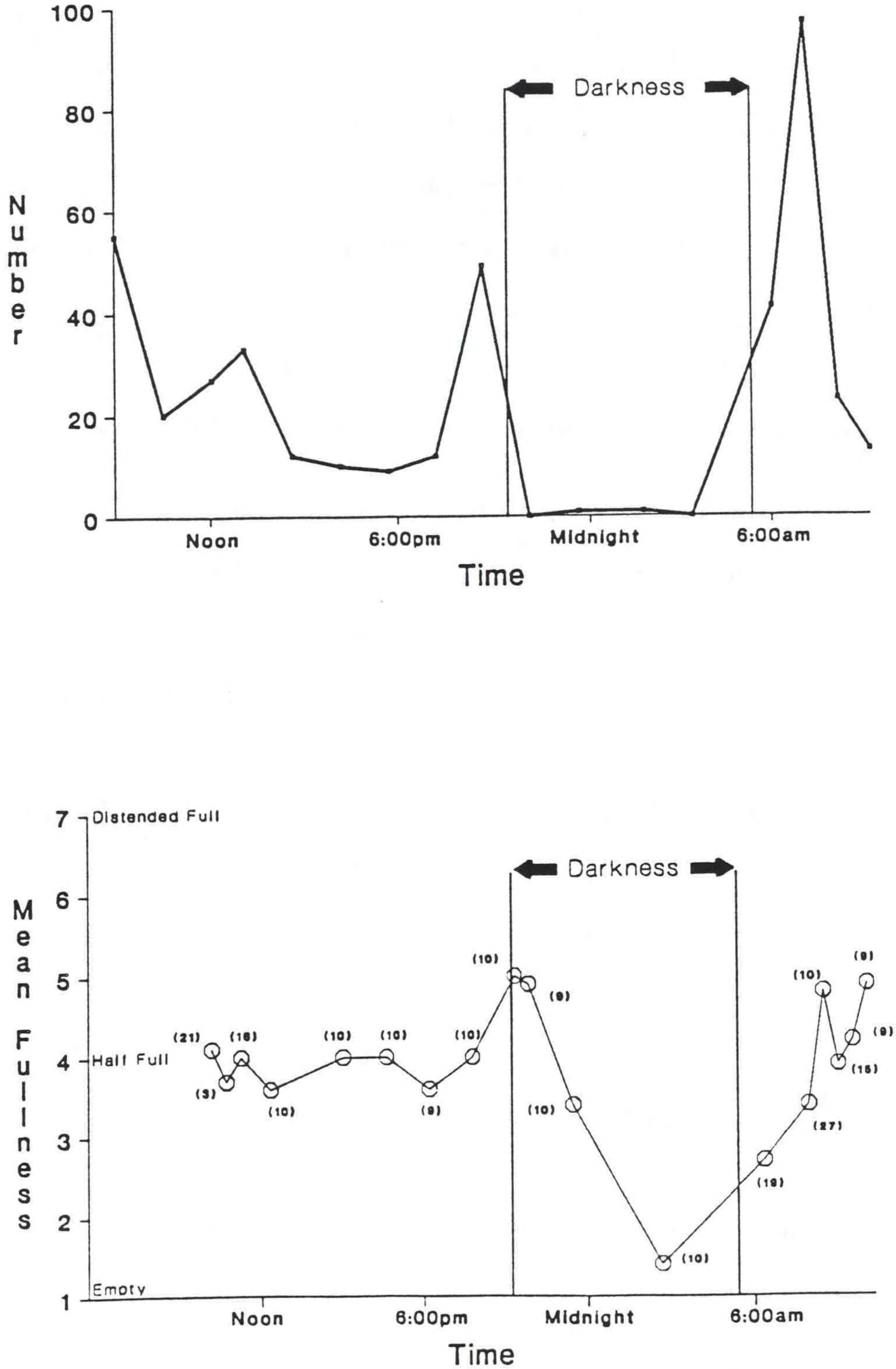


Figure 14.--Diel catch pattern and diel stomach fullness patterns of subyearling chinook salmon at Jones Beach, Bonneville Dam survival study, 1990. Sample size is in parentheses. See text for explanation of stomach fullness scale.

Stomach Fullness and Diet Composition

Based on examination of stomach fullness of selected marked fish, study fish were feeding by the time they arrived at Jones Beach. Stomachs were generally about half full in fish collected during daylight hours. As in 1990, feeding activity appeared to peak at sunset, then declined steadily throughout the night (Fig. 14).

Analysis of stomach contents showed Insecta and Crustacea were the dominant prey items in the diet of the test fish examined (Appendix Table C5). Of these two groups, Diptera and Cladocera were the most common taxa, similar to previous years (Ledgerwood et al. 1990, Kirn et al. 1986a). Although numbers of prey items fluctuated considerably, there were no apparent diel differences in diet composition.

Juvenile Recovery Differences

Statistical analyses of CWT-fish recoveries at Jones Beach (Appendix D) indicate no significant differences ($\alpha = 0.7892$) among mean recovery percentages of the treatment groups (first 11 releases omitted due to failure of the lower turbine release hose; Table 4). Rank order (from lowest to highest) was bypass, egress, and lower turbine with mean recovery percentages of 0.56, 0.57, and 0.57%, respectively. Statistical analysis of recoveries for bypass and egress groups using all 21 releases also indicated no significant differences ($\alpha = 0.1409$) in mean recovery percentages; means were 0.51 and 0.53%, respectively.

Purse seine recovery data, standardized to a 14-set per day effort (Appendix Table C2) were also analyzed (Appendix D). Conclusions regarding differences among mean recovery percentages derived from the standardized data were similar to those reached with the raw data--no significant differences (Fig. 15). Beach seine recoveries were too low for meaningful statistical conclusions (326 total, with the first 11 releases omitted; Appendix Table C2).

Table 4.--Recovery percentages of tagged subyearling chinook salmon at Jones Beach, Bonneville Dam survival study, 1990.

Release date[a]	Treatments: Lower turbine	Bypass system	Egress[b]
30 June	[c]	0.3273	0.3364
2 July	[c]	0.4498	0.4443
3 "	[c]	0.3425	0.4045
5 "	[c]	0.3442	0.4575
6 "	[c]	0.4260	0.3634
10 "	[c]	0.4588	0.5367
11 "	[c]	0.5046	0.5694
12 "	[c]	0.5521	0.5671
13 "	[c]	0.6479	0.6122
17 "	[c]	0.5746	0.5562
18 "	[c]	0.5169	0.5946
20 "	0.5590	0.5425	0.6330
21 "	0.6182	0.6278	0.6917
24 "	0.6848	0.6272	0.6049
25 "	0.6639	0.6550	0.6223
26 "	0.6440	0.6190	0.7012
27 "	0.5397	0.5456	0.4657
31 "	0.4676	0.4547	0.4357
1 August	0.3510	0.4839	0.4737
2 "	0.6508	0.5860	0.5414
3 "	0.5421	0.4355	0.5165
Mean recovery percentages[d]			
All 21 releases	------	0.5106	0.5299
Last 10 releases	0.5721	0.5577	0.5686
Total released[e]			
All 21 releases	565,545	575,777	582,200
Last 10 releases	257,841	274,591	277,433
Total recovered[f]			
All 21 releases	2,745	2,940	3,085
Last 10 releases	1,474	1,532	1,576

[a] Fish were released during early morning darkness.

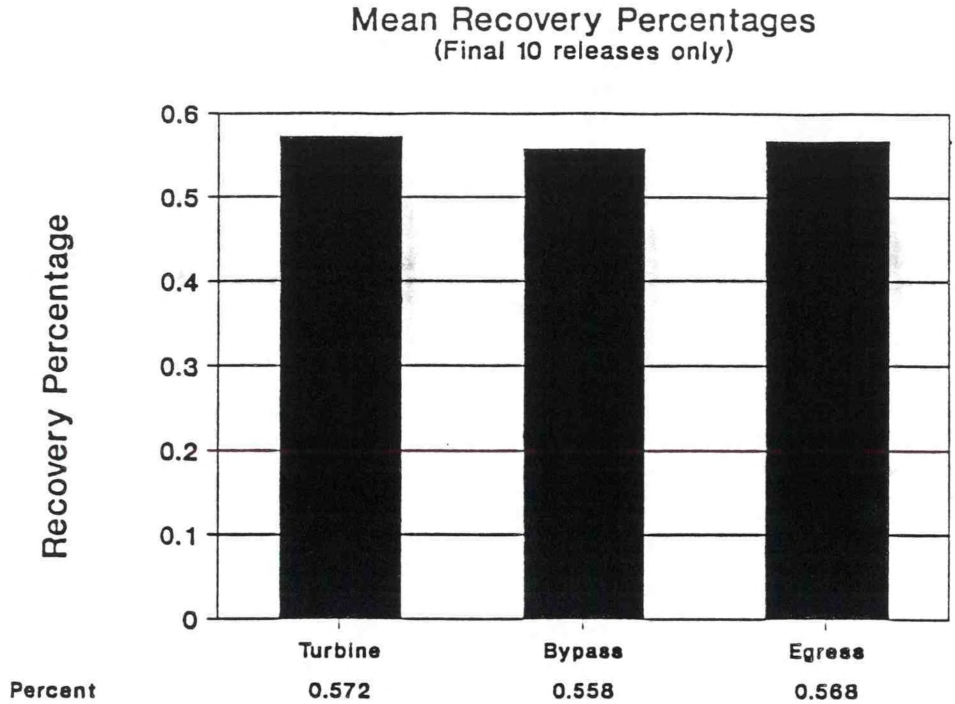
[b] Egress fish were released through a 76-m long, 10-cm diameter hose attached to the side of the submerged bypass outlet structure. There were two egress release hoses, one attached to the north side of the bypass structure and one attached to the south side; releases alternated daily between the two hoses.

[c] Release hose failure compromised the first 11 releases--data not used in analysis.

[d] Weighted equally by block (i.e., by release day).

[e] Adjusted for tag loss.

[f] Observed catch, purse seine plus beach seine.



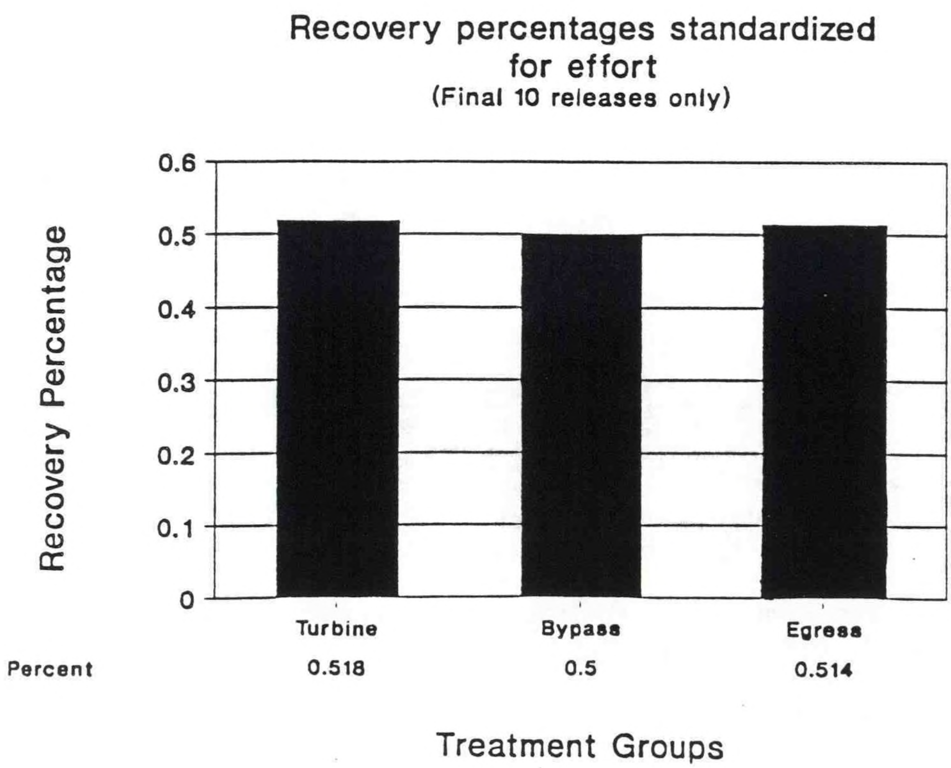


Figure 15.--Mean recovery percentages, both observed catch and catch standardized for sampling effort (first 11 releases deleted) for treatment groups of tagged subyearling chinook salmon following migration to Jones Beach, Bonneville Dam survival study, 1990. Differences in recovery percentages were not significant ($\alpha > 0.05$).

Tag Loss

For data analysis, final release numbers for each tag group were reduced by estimates of tag loss based on extended holding of marked fish (tag loss range, 3.4 to 16.8%; Appendix Table A2). Held fish were passed through a tag detector and brands used to assign detection results. Although tags were unique for each release day, brands were not; therefore, the individual estimates of tag loss were extrapolated from brand data. Although the estimates of tag loss were generally within the range reported from other tagging programs (5 to 10%; Vreeland 1990), they varied substantially between treatments tagged at the same time; maximum loss in release series ranged from 4.6 to 13.9%. This variability prompted an alternate analysis of recovery data where the recoveries were blocked according to brand assignment (the five blocks available for estimating tag loss); conclusions were unchanged--no differences between treatments (Appendix D).

Adult Recoveries

Tag recovery data from adult fish released as juveniles in 1987 is essentially complete (Table 5). Mean recovery percentages for bypass, lower turbine, upper turbine, and Hamilton Island release groups were 0.16, 0.16, 0.15, and 0.12, respectively. The differences were not significant except for the Hamilton Island release group ($P = 0.0056$, Appendix D). Both juvenile and the adult data indicated lower survival for Hamilton Island release groups. We hypothesized that the Hamilton Island fish, which were released on the shoreline, were subjected to more predation than were groups released in mid-river (Dawley et al. 1988). Based on juvenile data, the experimental design for subsequent years was changed to provide only mid-river releases.

Recovery of adult fish averaged 0.15%; this percentage is substantially lower than the expected 0.5%. The low recovery numbers limited the ability to statistically detect differences; differences had to exceed 15.5% to be significant (Appendix D). The low adult

Table 5.--Tag recovery data[a] from adult chinook salmon released as juveniles to evaluate passage survival in passage at Bonneville Dam Second Powerhouse, 1987.

Release Date	Bypass system No.	Bypass system %[c]	Hamilton Island No.	Hamilton Island %	Lower turbine No.	Lower turbine %	Upper turbine No.	Upper turbine %	Daily totals[b] No.	Daily totals[b] %
24 June	13	0.0676	10	0.0895	6	0.0680	9	0.0910	38	0.0790
25 June	17	0.1046	17	0.1093	36	0.1136	10	0.0665	80	0.0985
26 June	25	0.1394	12	0.0748	22	0.1308	35	0.1225	94	0.1169
27 June	21	0.1191	33	0.0977	8	0.0472	17	0.1008	79	0.0912
28 June	52	0.1448	14	0.0818	31	0.1878	16	0.0849	113	0.1248
1 July	25	0.1798	16	0.1020	60	0.1707	17	0.1077	118	0.1401
2 July	24	0.1339	18	0.1009	19	0.1092	46	0.1309	107	0.1187
3 July	21	0.1149	33	0.0979	24	0.1300	29	0.1777	107	0.1301
4 July	40	0.1105	22	0.1219	35	0.1903	22	0.1237	119	0.1366
5 July	31	0.1698	18	0.0996	25	0.0675	32	0.1796	106	0.1291
8 July	26	0.1421	27	0.1492	26	0.1408	61	0.1712	140	0.1508
9 July	45	0.2395	56	0.1517	45	0.2405	29	0.1574	175	0.1973
10 July	63	0.1685	30	0.1658	43	0.2275	31	0.1694	167	0.1828
11 July	37	0.1973	27	0.1478	48	0.1263	36	0.2021	148	0.1684
12 July	49	0.2613	24	0.1328	27	0.1456	88	0.2411	188	0.1952
15 July	38	0.2035	67	0.1813	46	0.2590	30	0.1646	181	0.2021
16 July	58	0.1550	25	0.1388	36	0.1907	37	0.2049	156	0.1724
17 July	29	0.1547	37	0.1996	75	0.1973	32	0.1841	173	0.1839
18 July	46	0.2457	22	0.1187	52	0.2746	80	0.2197	200	0.2147
19 July	40	0.2244	47	0.1284	31	0.1694	22	0.1202	140	0.1606
Total/mean[de]	700	0.1638	555	0.1245	695	0.1593	679	0.1510	2,629	0.1512
No. released[f]	434,880		435,099		441,713		427,112		1,738,804	

[a] Preliminary tag recovery data through 15 February 1991.
[b] The daily total percentage is calculated as the unweighted average of the daily group percentages.
[c] % = (Number of recoveries ÷ number released with tags) X 100.
[d] Weighted by block (i.e., by release day).
[e] Empirical standard error = $\sqrt{MSE/n}$; MSE (mean square error) from randomized block ANOVA; n= number of blocks; SE = 0.0258, all treatments.
[f] Adjusted for tag loss.

returns may be related, in part, to the small size of fish at release (101 fish/lb). Lower survival to adulthood has been shown to correlate with small size of juveniles and shoreline recovery at Jones Beach (Zaugg and Mahnken 1991). Juveniles reared at Bonneville Hatchery during 1987 and released during May in the Umatilla River (60 fish/lb) and during September at the hatchery (20 fish\lb) had three-fold greater adult tag recoveries than did study fish (Appendix Table E1).

Additional catch and catch distribution data for adult fish released as juveniles in 1987, 1988, and 1989 are presented in Appendix Tables E2-E5.

DISCUSSION

In 1990, based on 10 releases, there were no significant differences in relative survival of subyearling chinook salmon released into the bypass system, the turbines, or at the bypass egress at Bonneville Dam Second Powerhouse. The failure of the turbine release hose severely compromised the study by reducing from 21 to 10 the number of data blocks available for analysis of turbine to bypass passage survival differences.

Compromised Lower Turbine Releases

On 18 July, immediately following the eleventh release of study fish, moribund fish were noted in the bypass channel. A sample of the moribund fish confirmed that they were study fish released through the lower turbine release hose. Further investigation revealed that during installation of the STS with attached turbine release hose, the orifice leading from the gate slot into the bypass channel was inadvertently left open. Evidently, the current flowing through the orifice was sufficient to force the hose against the opening, resulting in a kink and eventual tear which began leaking fish into the bypass channel. Subsequent assessment of marked fish data obtained from the 10% sample of bypass channel fish[2] following test releases through 18 July, indicated that the torn hose had compromised lower turbine releases beginning with the second release group. We suspect that the first turbine release group may have been compromised also due to a severe kink in the hose, though fish may not have escaped into the bypass channel. The release on 18 July had an estimated 4% mortality for fish which exited through the torn hose. Because the dates and percentages of fish from the turbine releases which escaped through the bypass system are unknown, and probably quite variable, those data were not used for assessing relative survival of turbine groups. The STS was retrieved and the turbine release hose replaced for releases beginning 20 July.

Tag Loss

Marking personnel were rotated between marking stations such that each marking team contributed similar numbers of fish to each treatment. To improve quality control in the future, treatment groups should also rotate between tagging stations. In addition, if an accurate count of each release day's fish held for tag loss were maintained, tag loss could be estimated by reading all tags, subtracting the number read from the total retained. This difference would be independent of brand data and provide an estimate for each tag code, further reducing error.

Effects of Tailwater Surface Elevation and Powerhouse Discharge

Annual average survival for bypass passage (relative to turbine passage) appears to be directly related to the tailwater surface elevation (Fig. 16). The apparent aberration of this general trend in 1990 may be related to diminished predator effectiveness from increased river flows and water velocities in the tailrace in association with the experimental design change to an eight-turbine operation test condition. Water velocity in

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[2] Bypass sampler data courtesy of Lynette Hawkes, NMFS, Environmental and Technical Services Division, Box 67, Rufus, Oregon 97050.

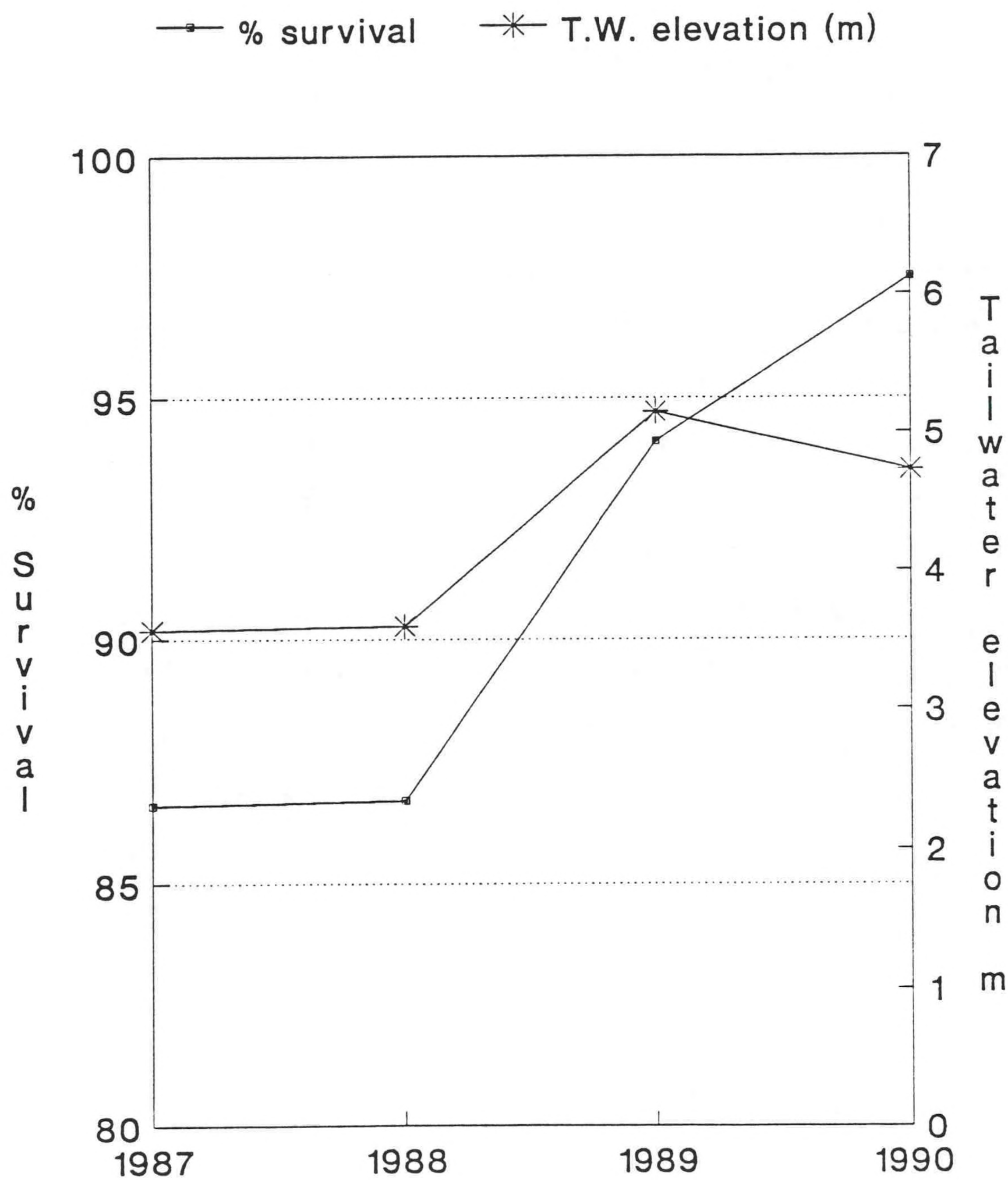

Figure 16.--Increased relative survival of bypass release groups associated with increased tail water surface elevation; where % survival = (Bypass recovery %) / (Lower turbine recovery %) X 100. Early release groups not included to provide 4 years of comparable data.

the bypass conduit decreases with increasing tailwater surface elevation (about 1.2 m/sec range for the tailwater surface elevations encountered during the 4 test years) which causes diminished turbulence in the conduit and diminished shear forces at the bypass/tailrace interface. During periods with low tailwater surface elevation, the high turbulence and shear forces in conjunction with decreased total river flow through a predator infested tailrace, may have generated increased predation mortality from synergistic effects of stress or injuries to the test fish. However, a series of three releases in 1988 tends to refute that premise. Tailwater surface elevations ranged from 4.3 to 4.6 m (substantially higher than other releases that year), yet juvenile recovery differences among test groups showed no increase in relative survival. Hence, the influence of tailwater surface elevation on these results is unknown.

During the first 3 years of study, fish releases were conducted with four of eight turbines in operation--beginning about 2 hours prior to release and continuing for 4 to 6 hours after release. In 1990, speculation that full powerhouse flow would decrease the abundance and predation efficiency of northern squawfish was the basis for an eight-turbine operation for fish releases. Although effects of this change cannot be isolated, one possible result could be decreased predation in general, which would help explain the observed decrease in percent difference between bypass and turbine groups as shown in Figure 16.

Impacts from Northern Squawfish

Increased abundance of northern squawfish in the lower Columbia River during recent years (Kirn et al. 1986b) may be severely impacting juvenile salmonids, especially near Bonneville Dam (Petersen et al. 1990). The impacts were documented by the U.S. Fish and Wildlife Service in survival study releases made on 24 and 25 July. They collected samples of northern squawfish for stomach content analysis at Bonneville Dam Second Powerhouse on two mornings after these releases. Electro-fishing produced a total of 43 and 15 northern squawfish respectively, on the two mornings following releases. Twenty of 30 northern squawfish examined had consumed food (all juvenile salmon). A total of 92 juvenile salmon were identified in the stomachs; of these, 55 were CWT fish released at 0200 h for the survival study (17, 29, and 9 CWTs each, for lower turbine, bypass, and egress releases, respectively). The researchers felt that this was a conservative indication of consumption of survival study fish because many of the juvenile salmonids consumed just after release would have been digested and evacuated from the gut by the time the northern squawfish were collected at 0500 h (24 July) and 0930 h (25 July) (personal communication, Thomas P. Poe, Willard, WA 98605).

CONCLUSIONS

The following conclusions are based on 4 years of estuarine recoveries of juvenile salmonids released at Bonneville Dam. It cannot be over-emphasized that these conclusions are valid only for the species and size of fish tested (subyearling chinook salmon) and the dam passage conditions and river environment during testing. Other fish species or other sizes of chinook salmon passing through the dam at other times of the year may have substantially different survival levels. Moreover, these conclusions are preliminary pending assessment of treatment group differences among adults recovered over the next 5 years.

1) In 1990, based on 10 releases and much reduced statistical power, there were no significant differences in relative survival of subyearling chinook salmon released into the bypass system, the turbines, or at the bypass egress at Bonneville Dam Second Powerhouse.
2) The failure of the turbine release hose compromised the study by reducing from 21 to 10 the number of data blocks available for analysis of turbine to bypass passage survival differences.

3) Estuarine sampling of juveniles provided recovery data to make statistical comparisons among treatment groups that are as sensitive as comparisons from expected adult recovery data; the lack of differences in catch distributions through time among treatment groups suggests uniform sampling of all treatment groups.

4) Analyses of differences in recoveries of bypass- and egress-released fish using 21 release blocks suggest that in past years of study (1988 and 1989) the frontroll release was not a good control for the bypass system. We speculate that predation by northern squawfish in the locality of the bypass outlet structure may have caused the diminished survival.

5) We speculate that increased turbine operation (from four to eight units) may have diminished abundance and predatory effectiveness of northern squawfish near the bypass outlet. The reduced statistical power compromised this assessment.

6) Tailwater elevation may be an important factor in explaining differences in turbine versus bypass passage survival; generally, the relative survival of bypass fish increased with increased tailwater surface elevation.

7) Few descaled fish (less than 1% of the total) were captured at Jones Beach, and, except for the lower turbine groups released through a torn hose early in the study, there was no apparent relationship with the treatments tested.

8) The conditions tested did not necessarily represent environmental conditions in the tailrace after long-term operation of the Second Powerhouse, but provided observations useful for evaluating the reasons for and the seriousness of decreased survival associated with bypass passage.

9) Adult recovery data for the 1987 releases are essentially complete, but detection power was low (15.5%) due to poor return rate. Except for the lower survival of Hamilton Island (shoreline) release groups, all differences were insignificant ($P = 0.05$).

RECOMMENDATIONS

1) Tag recovery data from adults should be compiled through 1995 to obtain the maximum amount of data for assessing passage survival differences.
2) Comparisons of juvenile recovery data to adult recovery data should be made.
3) Similar research at Bonneville First Powerhouse should be initiated immediately to determine which powerhouse provides the safest passage route for juvenile salmonids.

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APPENDIXES

Appendix A
Marking and Release Information: Tag Loss Estimates and Test Conditions

Appendix Table A1.--Short-term tag loss estimates among branded groups of subyearling chinook salmon, Bonneville Dam Survival Study, 1990.

Date marked	Time sampled	Release series	Egress Lines 1&2[a] NT[b]	T[c]	%	Bypass Lines 3&4 NT	T	%	Turbine Lines 5&6 NT	T	%
12 June	0515	1	0	100		0	100		3	100	
	2020	1	0	102		0	100		2	100	
13 June	0645	1	0	100		2	100		4	100	
	unk[d]	1	0	100		6	100		0	50	
	Subtotal	1	0	402	0.0	8	400	2.0	9	350	2.6
13 June	1715	2	0	100		2	100		4	100	
	2000	2				0	50				
14 June	0800	2	0	100		0	100		0	100	
	1535	2	0	100		4	100		0	100	
	Subtotal	2	0	300	0.0	6	350	1.7	4	300	1.3
15 June	1100	3	0	100		3	100		0	100	
	1530	3	1	100		0	100		0	100	
	Subtotal	3	1	200	0.5	3	200	1.5	0	200	0.0
18 June	1615	4	0	50		0	50		0	50	
19 June	0830	4	0	50		0	50		0	50	
	1515	4	0	50		0	50		0	50	
	Subtotal	4	0	150	0.0	0	150	0.0	0	150	0.0
2 July	unk	5	5	100		0	100		0	100	
	unk	5	2	100					0	50	
	1730	5	1	208		3	200		0	100	
	2040	5				0	100				
	Subtotal	5	8	308	2.6	3	400	0.8	0	250	0.0
3 July	0700	6	2	100		0	100		0	100	
	1030	6				0	100				
	unk	6	0	100		0	50				
	1800	6	2	205		4	200		0	200	
5 July	0645	6	0	203		0	201		0	202	
	unk	6	0	100							
	1500	6	0	200		0	200		1	200	
	Subtotal	6	4	908	0.4	4	851	0.5	1	702	0.1
6 July	0645	7	0	200							
	1130	7				0	200		1	200	
	1500	7	0	200		1	100				
	1645	7				0	115		0	200	
	Subtotal	7	0	400	0.0	1	415	0.2	1	400	0.3

Appendix Table A1.--Continued.

Date marked	Time sampled	Release series	Egress Lines 1&2[e] NT[f]	T[g]	%	Bypass Lines 3&4 NT	T	%	Turbine Lines 5&6 NT	T	%
7 July	0830	8	2	200		0	200		0	200	
	unk	8	2	200		3	200		1	200	
	Subtotal	8	4	400	1.0	3	400	0.8	1	400	0.3
9 July	1000	9	2	100		0	100		2	100	
	1300	9	0	50		0	40		0	60	
	1500	9	3	200		1	200		0	100	
	Subtotal	9	5	350	1.4	1	340	0.3	2	260	0.8
10 July	0900	10	0	100		2	100		0	100	
	1100	10	2	100		1	100		0	100	
	1245	10	0	50							
	1530	10	2	70							
	1550	10	0	200		1	200				
	1730	10							3	200	
	2100	10				0	100		0	100	
	Subtotal	10	4	520	0.8	4	500	0.8	3	500	0.6
11 July	0915	11	0	100		2	100		0	100	
	1435	11	4	200		0	200		0	200	
	2100	11	0	100							
	Subtotal	11	4	400	1.0	2	300	0.7	0	300	0.0
12 July	1100	12	0	200		2	200		1	200	
	unk	12				0	100				
	1715	12	2	200		0	200		0	200	
13 July	0700	12	1	206		6	203		2	200	
	0800	12				0	100		0	100	
	1115	12							0	100	
	1545	12	0	200		0	200		0	200	
	Subtotal	12	3	806	0.4	8	1003	0.8	3	1000	0.3
16 July	0830	13	0	200		0	200		3	200	
	unk	13	3	100							
	unk	13	1	100							
	unk	13	0	200		0	200		0	200	
	Subtotal	13	4	600	0.7	0	400	0.0	3	400	0.8
17 July	0615	14	0	200		1	200		1	200	
	1700	14	0	200		0	200		0	200	
18 July	0645	14	1	200		0	200		1	100	
	1700	14	0	200		1	200		0	200	
	Subtotal	14	1	800	0.1	2	800	0.3	2	700	0.3

Appendix Table A1.--Continued.

Date marked	Time sampled	Release series	Egress Lines 1&2[h] NT[i]	T[j]	%	Bypass Lines 3&4 NT	T	%	Turbine Lines 5&6 NT	T	%
19 July	0645	15	0	200		2	200		0	200	
	Subtotal	15	0	200	0.0	2	200	1.0	0	200	0.0
20 July	0645	16	5	141		0	207		2	203	
	unk	16	0	100					7	302	
	unk	16							1	100	
	1445	16	1	200		0	200		2	200	
	1930	16	1	200					0	100	
21 July	0830	16	0	200		1	200				
	1045	16							5	200	
	Subtotal	16	7	841	0.8	1	607	0.2	17	1105	1.5
23 July	unk	17	2	204		4	200		2	200	
	unk	17				5	207				
	unk	17				0	100				
	unk	17	0	200		1	200		0	100	
	Subtotal	17	2	404	0.5	10	707	1.4	2	300	0.7
24 July	0700	18	1	203		0	204		0	200	
	1100	18	0	100		0	200				
	1500	18	2	200		3	200		2	200	
	unk	18	3	200		0	200		1	200	
	Subtotal	18	6	703	0.9	3	804	0.4	3	600	0.5
26 July	1130	19	1	102		1	100				
	1530	19	0	200		2	200		0	100	
	Subtotal	19	1	302	0.3	3	300	1.0	0	100	0.0
27 July	0630	20	0	200		2	200		1	200	
	1500	20	0	200		1	200		0	200	
	unk	20							0	100	
	Subtotal	20	0	400	0.0	3	400	0.8	1	500	0.2
28 July	0645	21	0	200		2	200		1	200	
	1130	21				1	200				
	Subtotal	21	0	200	0.0	3	400	0.8	1	200	0.5
	Total	All	54	9594	0.6	70	9927	0.7	53	8917	0.6

[a] There were two marking stations (lines) for each treatment group.
[b] NT = Number of fish passed through the tag detector which tested negative for a tag.
[c] T = Number of fish passed through the tag detector which tested positive for a tag.
[d] UNK = Unknown time sample was obtained.
[e] There were two marking stations (lines) for each treatment group.
[f] NT = Number of fish passed through the tag detector which tested negative for a tag.
[g] T = Number of fish passed through the tag detector which tested positive for a tag.
[h] There were two marking stations (lines) for each treatment group.
[i] NT = Number of fish passed through the tag detector which tested negative for a tag.
[j] T = Number of fish passed through the tag detector which tested positive for a tag.

Appendix Table A2.--Tag loss estimates among branded groups of subyearling chinook salmon after a 30-day holding period; Bonneville Dam Survival Study, 1990.

Release dates	Brand[b]	CWT[a] AGD1D2	AGD1D2	AGD1D2	AGD1D2	NCWT[c]	Sample[d]
Lower turbine releases							
30 Jun, 2,3 Jul	RD Z1	232451	232454	232457		373	4,841[e]
5-6 Jul	RD Z2	232460	232463			373	4,841[e]
10-13 Jul	LD U1	232506	232512	232518	232524	23	598
17,18,20,21 Jul	LD U3	232530	232536	232543	232548	44	708
24-27 Jul	RD>H1	232554	232560	232605	232610	124	737
31 Jul-3 Aug	RD>H3	232617	232623	232629	232634	86	617
Bypass releases							
30 Jun, 2,3 Jul	RD 31	232452	232455	232458		373	4,841[e]
5-6 Jul	RD 33	232461	232503			373	4,841[e]
10-13 Jul	LD 21	232509	232515	232520	232527	28	374
17,18,20,21 Jul	LD 23	232533	232539	232545	232551	32	565
24-27 Jul	RD>K1	232557	232563	232606	232612	57	664
31 Jul-3 Aug	RD>K3	232618	232624	232630	232636	49	572
Egress releases							
30 Jun, 2,3 Jul	RD F1	232453	232456	232459		373	4,841[e]
5-6 Jul	RD F3	232462	232505			373	4,841[e]
10-13 Jul	LD F1	232510	232517	232523	232529	39	474
17,18,20,21 Jul	LD F3	232534	232540	232546	232553	19	555
24-27 Jul	RD>X1	232558	232603	232609	232615	82	726
31 Jul-3 Aug	RD>X3	232620	232627	232633	232639	28	609

[a] CWT = coded wire tag; where AG = agency code, D1 = data 1, D2 = data 2.
[b] Brand position RD (right dorsal) or LD (left dorsal) followed by the two-letter brand symbol; the numbers 1 or 3 indicate brand rotation.
[c] NCWT = Number of branded fish in the sample with no coded wire tag.
[d] Number of branded fish checked for the presence of coded wire tags.
[e] Brand legibility for fish held from the first week of release was poor (less than 20%); therefore, tag loss was estimated from the sample of all fish held having illegible brands.

Appendix B
Flow Data, Operating Conditions, and Water Temperatures, 1990

Appendix Table B1.--Flow data, operating conditions, and water temperatures at times of release on the 21 release dates of the Bonneville Dam survival study, 1990.

ENGLISH UNITS[a]

	Second powerhouse			Turbine 17							Bypass	
Date	Forebay elev. (ft)	Tailwater elev. (ft)	Flow[b] (kcfs)	Flow[c] (kcfs)	Load (MW)	Head (ft)	Wicket gate (%)	Blade angle (°)	Plant sigma[d] (σ)	Estim. effic.[c] (%)	Downwell elev. (ft)	River temp. (°F)
29 Jun	no release		0.0									
30 Jun	75.5	21.3	131.3	16.0	67.0	54.2	76.8	26.0	1.17	92.0	56.5	67
1 Jun	no release		0.0									
2 Jul	75.3	20.8	127.1	15.8	66.0	54.5	73.5	24.6	1.16	92.0	56.5	66
3 Jul	74.8	21.4	127.9	16.0	66.0	53.4	74.4	24.7	1.19	92.0	55.5	66
4 Jul	no release		0.0									
5 Jul	71.4	18.1	128.0	16.1	66.0	53.3	76.0	25.5	1.13	92.0	55.5	66
6 Jul	74.5	19.1	129.6	15.6	66.0	55.4	71.8	23.8	1.11	92.0	56.0	66
7 Jul	no release		0.0									
8 & 9 Jul	no release			64.0								
10 Jul	72.8	19.1	129.5	16.0	66.0	53.7	71.4	22.6	1.14	92.0	56.0	66
11 Jul	74.7	17.1	130.0	14.8	66.0	57.6	71.1	22.7	1.03	92.0	55.5	67
12 Jul	75.9	19.3	123.7	15.1	66.0	56.6	71.4	20.9	1.09	92.0	56.5	67
13 Jul	76.0	18.5	118.2	14.9	66.5	57.5	74.0	22.0	1.06	92.5	56.5	67
14 Jul	no release		0.0									
15 & 16 Jul	no release			67.0								
17 Jul	74.5	14.7	113.7	13.9	65.0	59.8	66.1	20.2	0.95	93.0	56.0	68
18 Jul	75.3	16.3	123.1	14.6	66.5	59.0	67.0	23.5	0.99	92.5	55.5	68
19 Jul	no release		0.0									
20 Jul	74.5	15.6	121.1	14.6	66.5	58.9	68.0	22.8	0.98	92.5	56.0	68
21 Jul	75.0	15.1	112.7	14.2	66.5	59.9	66.1	21.4	0.96	93.0	55.5	68
22 Jul	no release		0.0									
23 Jul	no release		61.5									
24 Jul	75.0	15.3	116.6	13.5	63.0	59.7	65.5	19.6	0.96	93.0	56.5	71
25 Jul	74.7	15.6	114.3	14.4	66.0	59.1	66.8	21.5	0.98	92.5	56.5	70
26 Jul	74.7	15.9	116.5	14.5	66.0	58.8	68.5	22.3	0.99	92.5	56.5	69
27 Jul	74.6	15.9	116.6	14.5	66.0	58.7	69.0	22.4	0.99	92.5	56.0	68
28 Jul	no release		0.0									
29 & 30 Jul	no release			58.0								
31 Jul	75.1	15.1	115.3	13.8	64.0	60.0	64.1	19.9	0.96	93.0	56.5	71
1 Aug	76.3	14.9	115.5	13.8	66.0	61.4	64.0	20.3	0.92	93.0	56.5	72
2 Aug	75.4	15.7	115.9	14.0	64.0	59.7	65.7	20.8	0.97	93.0	56.5	71
3 Aug	75.4	15.4	118.5	14.1	66.0	60.0	66.6	21.6	0.96	92.5	56.5	71

[a] English units are used by convention.

[b] Water flow volumes kcfs = thousand ft^3/sec.

[c] Data derived from Figure 8-02.1 of Bonneville Second Powerhouse model test report (Allis-Chalmers 1978).

[d]

$$\text{Plant Sigma}(\delta) = \frac{\underset{\text{(pressure)}}{\text{(Atmospheric)}} - \underset{\text{(pressure)}}{\text{(Water Vapor)}} - \underset{\text{(pressure differential)}}{\text{(CL runner elev.-TW elev.)}}}{\text{Head Pressure}}$$

Where CL = center line and TW = tailwater.

Appendix C
Recovery of Juveniles: Sampling Effort and River Conditions, Daily Recoveries (Raw Data and Data Standardized for Effort), Diel Patterns, and Diet Composition

Appendix Table C1.--Daily purse seine and beach seine fishing effort, water temperatures, and Secchi disk turbidity measurements at Jones Beach during the Bonneville Dam survival study, 1990.

Date	Number of sets Purse	Number of sets Beach	Temp. °C	Secchi (m)	Date	Number of sets Purse	Number of sets Beach	Temp. °C	Secchi (m)
13 Jun	2	0	15	---[a]	22 Jul	11	4	20	0.9
14 Jun	1	0	17	---	23 Jul	14	2	19	0.7
18 Jun	11	0	16	1.0	24 Jul	12	0	19	1.2
19 Jun	7	7	--	0.9	25 Jul	11	3	20	1.2
20 Jun	7	7	17	0.9	26 Jul	11	0	20	1.5
21 Jun	5	8	17	0.9	27 Jul	11	4	20	1.5
22 Jun	5	4	--	---	28 Jul	11	6	19	1.2
2 Jul	5	7	16	0.9	29 Jul	11	6	19	1.0
3 Jul	3	7	17	1.0	30 Jul	16	3	20	1.3
5 Jul[b]	7	5	19	0.9	31 Jul	22	0	19	1.5
6 Jul	4	9	17	1.0	1 Aug	14	2	20	0.9
7 Jul	14	2	19	1.2	2 Aug	17	3	21	1.0
8 Jul	12	0	19	1.0	3 Aug	14	5	21	1.2
9 Jul	7	10	19	1.0	4 Aug	13	4	22	1.0
10 Jul	9	10	19	1.0	5 Aug	14	3	21	0.9
11 Jul	7	6	19	0.9	6 Aug	17	1	20	1.2
12 Jul	6	8	18	0.9	7 Aug	16	2	21	1.2
13 Jul	11	9	18	1.2	8 Aug	14	2	20	1.5
14 Jul	10	5	20	1.2	9 Aug	10	0	21	1.5
15 Jul	13	6	20	1.0	10 Aug	6	4	21	1.2
16 Jul	12	0	20	1.2	11 Aug	5	6	20	1.0
17 Jul	19	2	20	1.0	12 Aug	7	0	20	---
18 Jul	16	0	20	1.0	13 Aug	9	0	21	1.2
19 Jul	12	4	19	1.0	14 Aug	7	0	21	1.2
20 Jul	12	0	20	0.7	15 Aug	6	2	--	1.2
21 Jul	11	4	19	0.9	16 Aug	5	1	--	1.2
					17 Aug	2	0	--	1.0

[a] --- = data not available.
[b] First recovery of study fish.

Appendix Table C2.--Daily recoveries, recoveries standardized for effort, dates of median fish recovery, and movement rates to Jones Beach of marked groups, Bonneville Dam survival study, 1990.

Date	Release date 30 June (Julian 181)						Release date 2 July (Julian 183)					
	Treatments Tag code (AG D1 D2)[a]						Treatments Tag code (AG D1 D2)					
	Turbine 23 24 51		Bypass 23 24 52		Egress 23 24 53		Turbine 23 24 54		Bypass 23 24 55		Egress 23 24 56	
of recovery[b]	N[c]	A[d]	N	A	N	A	N	A	N	A	N	A
186 (5 July)	1(1)		1		1						1	
187	1(6)	4	1(1)	4	1(5)	4	1(1)	4	1(1)	4		
188	2(1)	2	4	4	3	3	4	4	3(1)	3		
189	4	5	1	1	2	2	2	2	2	2		
190	3	6	4(4)	8	3(1)	6	4(3)	8	2(4)	4	2(3)	4
191 (10 July)	8	12	3(1)	5	4(4)	6	4(1)	6	5(3)	8	3(2)	5
192	4(2)	8	2(3)	4	1	2	2(1)	4	4(4)	8	2(4)	4
193	(5)		(2)		1	2	(4)		(2)		(4)	
194	8	10	7(2)	9	6(1)	8	6(4)	8	7	9	10(2)	13
195	3	4	(1)		2	3	2(2)	3	8	11	2(4)	3
196 (15 July)	4(1)	4[e]	3	3	9	10[e]	8(1)	9	6(4)	6	9(1)	10
197	3	4	3	4[e]	5	6	3	4	7	8[e]	6	7
198	10(1)	7	12	9	16(1)	12	11	8[e]	10	7	10	7
199	6	5	5	4	2	2	12	11	6	5	12	11[e]
200	3(1)	4	2(1)	2	2(1)	2	4(3)	5	2(3)	2	3(4)	4
201 (20 July)	3	4	3	4	2	2	5	6	4	5	3	4
202	1	1	4	5	3	4	2(1)	3	1	1	6(1)	8
203	7(1)	9	1	1	3	4	4(1)	5	4	5	3	4
204	1	1	4	4	2	2	3	3	3	3	2	2
205	2	2	1	1	3	4			1	1	5	6
206 (25 July)									1(1)	1	2	3
207	3	4	1	1			2	3	5	6	3	4
208	1	1					2	3	3(1)	4	2	3
209	(1)				1(1)	1					1(1)	1
210	3(2)	4			1(1)	1	(1)		2	3	1	1
211 (30 July)	2	2	2	2	2	2	2	2	3	3	2	2
212	2	1	1	1	2	1	1	1	2	1	4	3
213 (1 Aug.)	2	2					1	1	1	1	1	1
214	1	1	2	2			1	1	2	2		
215					1	1	(1)					
216									2	2		
217 (5 Aug.)					1	1	1	1				
218									2	2		
219									1	1		
220												
221												
222 (10 Aug.)												
223												
224												
225												
226												
227 (15 Aug.)												
NA[f]			1				2				1	
Total[g]	110	107	83	78	94	91	113	105	124	118	122	110
Mvmt rate[h]	11		10		11		11		11		10	

Appendix Table C2.--Continued

Date of recovery	Release date 3 July (Julian 184) Treatments Tag code (AG D1 D2) Turbine 23 24 57 N	A	Bypass 23 24 58 N	A	Egress 23 24 59 N	A	Release date 5 July (Julian 186) Treatments Tag code (AG D1 D2) Turbine 23 24 60 N	A	Bypass 23 24 61 N	A	Egress 23 24 62 N	A
187					1	4						
188	3	3	1	1	1	1						
189	1	1	1	1							2	2
190	3(2)	6	4(2)	8	5(1)	10	1(3)	2	5	10	2(1)	4
191 (10 July)	2(4)	3	4(1)	6	4(3)	6	4(2)	6	4(3)	6	3	5
192	3(2)	6	2(2)	4	2(2)	4	2(1)	4	3(2)	6	5(1)	10
193	2(5)	5	(6)		1(4)	2	3(2)	7	(1)		1(1)	2
194	9(1)	11	2(2)	3	4(3)	5	6(7)	8	7(3)	9	16(9)	20
195	3	4	4(1)	6	5(1)	7	1	1	2(1)	3	5(2)	7
196 (15 July)	8(3)	9	3(1)	3	3(1)	3	3(2)	3	4(2)	4	7(2)	8
197	6	7	4	5	2	2	3	4	4	5	7	8•
198	13(1)	10•	4	3	7	5	7	5•	10	7•	12(1)	9
199	12	11	10	9•	13	11•	4	4	8	7	10	9
200	(3)		2(2)	2	4(1)	5	(4)		4(2)	5	3(2)	4
201 (20 July)	3	4	2	2	4	5	6	7	3	4	5	6
202	4	5	1	1	2(1)	3	1(1)	1	1(1)	1	1	1
203	4(1)	5	4	5	4	5	2(1)	3	3	4	2	3
204	4	4	6	6	2	2	3	3	6	6	6	6
205	5	6	4	5	2	2	1	1	1	1	3	4
206 (25 July)	2	3	1	1	2	3	2	3	2	3	1	1
207			2	3					2	3		
208	2(2)	3	1	1	2	3	2	3			2	3
209			1(1)	1	2(2)	3	3(1)	4	1(1)	1	1(1)	1
210	3(1)	4	3	4	2	3	(1)		1(1)	1	1	1
211 (30 July)	7	6	3	3	9	8	2	2	2	2	5	4
212	9	6	2	1	4	3	2	1	1	1	3	2
213 (1 Aug.)	(1)				1	1	2	2	1	1		
214	1	1	1	1	1	1	1	1	2	2	1	1
215					1	1	(1)		1	1		
216			2	2			1	1				
217 (5 Aug.)							1	1	1	1		
218			1	1					1	1		
219							1	1				
220												
221												
222 (10 Aug.)												
223									1	3		
224												
225												
226												
227 (15 Aug.)												
NA	3		1		2				1		1	
Total	138	123	94	88	111	108	90	78	99	98	125	121
Mvmt rate	11		11		11		13		13		14	

Appendix Table C2.--Continued

Date of recovery	Release date 6 July (Julian 187)						Release date 10 July (Julian 191)					
	Treatments Tag code (AG D1 D2)						Treatments Tag code (AG D1 D2)					
	Turbine 23 24 63		Bypass 23 25 03		Egress 23 25 05		Turbine 23 25 06		Bypass 23 25 09		Egress 23 25 10	
	N	A	N	A	N	A	N	A	N	A	N	A
187												
188												
189												
190	2(1)	4	4	8	1(1)	2						
191 (10 July)	10(2)	16	6(2)	9	4(2)	6						
192	6(2)	12	3(1)	6	7(1)	14						
193	1(3)	2	(3)		1(6)	2						
194	11(7)	14	12(4)	15	11(5)	14	7(1)	9	6(1)	8	5(2)	6
195	3	4	6(4)	8	10(1)	14•	5	7	8(1)	11	7	10
196 (15 July)	8(2)	9•	10(1)	11•	6	6	10(2)	11	11	12	11(2)	12
197	5	6	5	6	2	2	10	12	5	6	11	13
198	12(2)	9	12	9	9	7	13(2)	10	10(1)	7	23	17
199	11	10	7	6	6	5	4	4•	14	12	17	15•
200	7	8	3(6)	4	2	2	2(4)	2	13(2)	15•	7(1)	8
201 (20 July)	6	7	3	4	6	7	3	4	4	5	4	5
202	4	5	2(1)	3			3	4	5	6	2	3
203			2	3	3	4	4	5	8	10	7(2)	9
204	2	2	3(1)	3	2	2	5	5	13	13	9	9
205	3	4	2	2	3	4	2	2			4	5
206 (25 July)	1	1			1	1			4	5	6	8
207			2	3	1	1	3	4	2	3		
208	2	3	1	1	1	1	1	1	1	1	(1)	
209	(1)		2	3	1(1)	1	3	4	1(1)	1	4	5
210			1	1	1	1	1	1	2(1)	3	2	3
211 (30 July)	1	1	3	3			8	7	3	3	11	10
212			3	2	3	2	4	3	5	3	3	2
213 (1 Aug.)	3	3	1	1			4	4	2	2	1	1
214			1	1			1	1				
215					1	1			1	1		
216							(1)				1	1
217 (5 Aug.)									1	1		
218											2	2
219												
220												
221									1	1		
222 (10 Aug.)												
223												
224												
225												
226												
227 (15 Aug.)												
NA	2				1						2	
Total	120	120	117	112	100	99	103	100	127	129	147	144
Mvmt rate	17		17		20		20		17		20	

Appendix Table C2.--Continued

Date of recovery	Release date 11 July (Julian 192) Treatments Tag code (AG D1 D2) Turbine 23 25 12 N	A	Bypass 23 25 15 N	A	Egress 23 25 17 N	A	Release date 12 July (Julian 193) Treatments Tag code (AG D1 D2) Turbine 23 25 18 N	A	Bypass 23 25 20 N	A	Egress 23 25 23 N	A
194												
195	1	1	4(1)	6	2	3						
196 (15 July)	9(4)	10	6(2)	6	10	11	8(1)	9	5	5	3	3
197	9	11	4	5	10	12	3	4	3	4	3	4
198	11(1)	8	16(2)	12	22	16	7(2)	5	12(2)	9	14	10
199	13	11	12	11	15	13	6	5	10	9	11	10
200	8(4)	9	6(2)	7	7(2)	8	4(4)	5	5(3)	6	10(6)	12
201 (20 July)	8	9•	7	8	7	8•	4	5	8	9	8	9
202	5	6	5(2)	6	3(1)	4	6(1)	8	6(1)	8	1(2)	1
203	2	3	7	9•	9(1)	11	5(1)	6	8(2)	10	8(3)	10
204	3(1)	3	13	13	12	12	4	4	13	13•	19	19•
205	5	6	5	6	4	5	1	1•	4	5	11	13
206 (25 July)	7(1)	9	3(1)	4	4(4)	5	9(1)	11	2(2)	3	6	8
207	2	3	2	3	5	6	2	3	4	5	5	6
208	2(1)	3	3(2)	4	5	6	2(1)	3	2(3)	3	1	1
209	2	3	4(2)	5	4(2)	5	4(1)	5	4(1)	5	3(5)	4
210	4	5	2(1)	3	3	4	(3)		3(8)	4	5	6
211 (30 July)	4	4	7	6	9	8	10	9	9	8	9	8
212	7	4	5	3	4	3	10	6	17	11	11	7
213 (1 Aug.)			3	3	3(1)	3	2	2	5(1)	5	3	3
214	1	1	2	2	2	2	7(1)	6	2	2	3	2
215	(1)						3	3	2	2	3(1)	3
216	1	1			1	1	1	1	2	2	1	1
217 (5 Aug.)			2	2								
218			1	1			2	2				
219					2	2						
220					1	1			1	1		
221												
222 (10 Aug.)												
223												
224												
225												
226												
227 (15 Aug.)												
NA	2		5		1		1		2			
Total	119	110	139	125	156	149	117	103	152	129	155	140
Mvmt rate	17		14		17		13		14		14	

Appendix Table C2.--Continued

Date of recovery	Release date 13 July (Julian 194)						Release date 17 July (Julian 198)					
	Treatments						Treatments					
	Tag code (AG D1 D2)						Tag code (AG D1 D2)					
	Turbine		Bypass		Egress		Turbine		Bypass		Egress	
	23 25 24		23 25 27		23 25 29		23 25 30		23 25 33		23 25 34	
	N	A	N	A	N	A	N	A	N	A	N	A
196 (15 July)												
197	4	5	1	1	5	6						
198	12	9	9	7	15	11						
199	13	11	13	11	14	12						
200	7(4)	8	6(5)	7	8(5)	9						
201 (20 July)	4	5	8	9	8	9	1	1	2	2	1	1
202	10(1)	13	7(1)	9	7(1)	9	4	5	4	5	1	1
203	2(1)	3	14(2)	18	7	9	5	6	9(1)	11	10	13
204	11(2)	11[e]	11(1)	11	11(1)	11	6	6	10	10	18	18
205	6	7	8	9[e]	7	8[e]	7	8	8	9	8	9
206 (25 July)	5(1)	6	6(1)	8	2	3	6(1)	8	4(2)	5	6(3)	8
207	5	6	4	5	3	4	4	5	12	15	5	6
208	4(1)	5	7	9	5(3)	6	4(1)	5	3(2)	4	6	8
209	1	1	6(2)	8	7(1)	9	3(3)	4	7(3)	9	2(5)	3
210	3(3)	4	3	4	8(2)	10	7(3)	9[e]	11(4)	14[e]	8(4)	10[e]
211 (30 July)	3	3	8	7	13	11	11	10	16	14	24(2)	21
212	14	9	22	14	12	8	15	10	29	18	24	15
213 (1 Aug.)	6(1)	6	8	8	9	9	10(1)	10	13	13	12	12
214	4	3	5	4	5	4	8	7	4(2)	3	14	12
215	3	3	2(1)	2	2	2			2(2)	2	2	2
216	3	3	2	2			4(1)	4			1	1
217 (5 Aug.)			1	1					3	3	2	2
218			1	1	1	1	4	3	3	2	1	1
219			1	1	1	1	1	1	2	2		
220					1	1					1	1
221												
222 (10 Aug.)					1	2						
223												
224												
225	1	2										
226												
227 (15 Aug.)					1	2						
NA	1		2		2		1		2			
Total	136	123	168	156	168	157	111	102	160	141	160	144
Mvmt rate	16		14		14		13		13		13	

Appendix Table C2.--Continued

Date of recovery	Release date 18 July (Julian 199) — Treatments — Tag code (AG D1 D2) — Turbine 23 25 36		Bypass 23 25 39		Egress 23 25 40		Release date 20 July (Julian 201) — Treatments — Tag code (AG D1 D2) — Turbine 23 25 43		Bypass 23 25 45		Egress 23 25 46	
	N	A	N	A	N	A	N	A	N	A	N	A
202			2	3								
203	5	6	5	6	2	3						
204	9	9	9	9	14(1)	14					2	2
205	5	6	7	8	9	11	9	11	2	2	1	1
206 (25 July)	6	8	9	11	9(1)	11	3	4	5(1)	6	7	9
207	6	8	8	10	5	6	2	3	1	1	4	5
208	3(1)	4	9(3)	11	10(2)	13	3(2)	4	7(2)	9	8(1)	10
209	3(3)	4	4(2)	5	4(5)	5	8(2)	10	7(4)	9	13(4)	17
210	8(4)	10*	5(7)	6*	1(1)	1	4(3)	5	7(3)	9	6(4)	8
211 (30 July)	9	8	19	17	30(1)	26*	19	17	30	26	18	16
212	22	14	20	13	27	17	36	23*	28	18*	46	29*
213 (1 Aug.)	10	10	6(1)	6	9(1)	9	16	16	12	12	11(1)	11
214	8(1)	7	11(2)	9	11	9	16(2)	13	17(1)	14	13(3)	11
215	3(3)	3	6	6	5(2)	5	5(3)	5	3	3	12(2)	12
216	1(1)	1	5	5	6	6	6(1)	6	7	8	7	8
217 (5 Aug.)			1	1	5	5	1	1	4	4	7	7
218	2	2	1	1	6	5	9	7	7	6	6	5
219	1	1	2	2	1	1	3	3			3	3
220					1	1			2	2		
221												
222 (10 Aug.)					1	2			1	2		
223			1	3	1	3					(1)	
224									1	2	1	2
225												
226							1	2				
227 (15 Aug.)												
NA							2				1	
Total	114	101	145	132	171	153	156	130	152	133	182	156
Mvmt rate	14		14		13		14		14		14	

Appendix Table C2.--Continued

Date of recovery	Release date 21 July (Julian 202) Treatments Tag code (AG D1 D2) Turbine 23 25 48 N	A	Bypass 23 25 51 N	A	Egress 23 25 53 N	A
204	1	1	1	1		
205					1	1
206 (25 July)	(1)		2	3	3	4
207	8	10	4	5	2	3
208	6	8	3(1)	4	12(1)	15
209	3(5)	4	3(4)	4	8(4)	10
210	12(6)	15	7	9	14(6)	18
211 (30 July)	19	17	12(1)	11	29(1)	25
212	40	25*	46	29	35	22*
213 (1 Aug.)	18	18	9	9*	11	11
214	16	13	27(1)	22	21(2)	17
215	7(1)	7	12(4)	12	16(6)	16
216	7(1)	8	9(1)	10	5(1)	5
217 (5 Aug.)	2	2	4	4	5(1)	5
218	10	8	12	10	9	7
219	2	2	3	3	2	2
220	2	2	2	2	1	1
221	1	1	2	3	1	1
222 (10 Aug.)	1	2				
223	1	3	1	3	(1)	
224						
225	1	2	1	2		
226	1	2	2	4		
227 (15 Aug.)					1	2
228			1			
229			1			
NA	1		1		1	
Total	173	150	177	150	200	165
Mvmt rate	16		14		16	

Date of recovery	Release date 24 July (Julian 205) Treatments Tag code (AG D1 D2) Turbine 23 25 54 N	A	Bypass 23 25 57 N	A	Egress 23 25 58 N	A
204						
205						
206 (25 July)						
207						
208	(1)		2	3	1	1
209	3(1)	4	7(2)	9	2(1)	3
210	5(2)	6	6(5)	8	3(2)	4
211 (30 July)	17(1)	15	16(2)	14	18	16
212	32	20	42	27	37	24
213 (1 Aug.)	14(2)	14	10	10*	13(1)	13
214	22	18*	19(8)	16	21(2)	17*
215	15(1)	15	10(5)	10	15(2)	15
216	14(1)	15	6	6	16(2)	17
217 (5 Aug.)	10	10	1	1	4	4
218	16	13	18	15	10	8
219	3	3	4	4	2	2
220			3	3	2	2
221	4	6			1	1
222 (10 Aug.)	1	2				
223					1	3
224			2	4		
225	2	3	2	3	1	2
226						
227 (15 Aug.)						
228					1	
229						
NA	3		1		2	
Total	170	144	171	133	160	132
Mvmt rate	17		20		17	

Date of recovery	Release date 25 July (Julian 206) Treatments Tag code (AG D1 D2) Turbine 23 25 60 N	A	Bypass 23 25 63 N	A	Egress 23 26 03 N	A
206 (25 July)						
207						
208						
209	3	4	1(2)	1	4	5
210	4	5	3(1)	4	5(2)	6
211 (30 July)	13	11	16	14	13	11
212	38	24	39	25	37	24
213 (1 Aug.)	10(1)	10	10	10	12	12
214	37(2)	30*	20(2)	16	17(4)	14*
215	11(1)	11	12(4)	12*	16(3)	16
216	7(3)	8	11	12	3(4)	3
217 (5 Aug.)	9	9	13	13	11	11
218	14(1)	12	22	18	14	12
219	3(2)	3	9	8	4	4
220	1	1	4	4	3	3
221	3	4	1	1		
222 (10 Aug.)	1	2			1	2
223			1	3		
224			1	2		
225					3	5
226			1	2	3	6
227 (15 Aug.)			1	2	1	2
228			1			
229					1	
NA	1		4		4	
Total	165	134	179	147	165	136
Mvmt rate	20		17		20	

Date of recovery	Release date 26 July (Julian 207) Treatments Tag code (AG D1 D2) Turbine 23 26 05 N	A	Bypass 23 26 06 N	A	Egress 23 26 09 N	A
206 (25 July)						
207						
208						
209						
210	1	1	2	3	1(2)	1
211 (30 July)	8	7	8	7	14	12
212	31	20	31	20	31	20
213 (1 Aug.)	15	15	26	26	17	17
214	26(4)	21	25(4)	21*	27	22
215	16(4)	16*	20(6)	20	17(7)	17*
216	13	14	15	16	11(3)	12
217 (5 Aug.)	6	6	5	5	11(1)	11
218	17	14	19	16	25	21
219	8	7	3(1)	3	10	9
220	(1)				1	1
221	1	1			1	1
222 (10 Aug.)	1	2			1	2
223	1	3			1	3
224	1	2				
225	1	2	2	3		
226	1	2	1	2	1	2
227 (15 Aug.)	1	2	(1)			
228						
229						
NA	3				4	
Total	160	135	169	142	186	151
Mvmt rate	20		22		20	

Appendix Table C2.--Continued

Date	Release date 27 July (Julian 208)						Release date 31 July (Julian 212)					
	Treatments						Treatments					
	Tag code (AG D1 D2)						Tag code (AG D1 D2)					
	Turbine		Bypass		Egress		Turbine		Bypass		Egress	
of	23 26 10		23 26 12		23 26 15		23 26 17		23 26 18		23 26 20	
recovery	N	A	N	A	N	A	N	A	N	A	N	A
210												
211 (30 July)	1	1	1	1	1	1						
212	21	13	23	15	13	8						
213 (1 Aug.)	12(1)	12	18	18	16	16						
214	23	19	23(2)	19	24(1)	20			2	2	1	1
215	9(1)	9	19(2)	19*	15(4)	15*	7(1)	7	10	10	8	8
216	13(1)	14*	16(4)	17	9(1)	10	17(2)	18	16(2)	17	16(5)	17
217 (5 Aug.)	15	15	8(2)	8	11	11	13	13	10	10	19	19
218	22	18	16(1)	13	12	10	41(1)	34*	37(1)	30*	32(1)	26*
219	4(1)	4	8	7	8(1)	7	11	10	19	17	14	12
220	6	6	3	3	1	1	8	8	6(1)	6	5(1)	5
221			1	1	1	1	1	1	4	6	1	1
222 (10 Aug.)	1	2			2	5	2	5	1(3)	2	1(2)	2
223					1	3	(1)		1	3	2(1)	6
224					1	2	6	12	1	2	1	2
225	2	3					5	8	3	5	6	9
226							2	4	2	4	5	10
227 (15 Aug.)	1	2					1	2	3(1)	7	1	2
228			1								1	
NA			1		1		1		1		1	
Total	134	118	149	121	123	110	120	122	124	121	124	120
Mvmt rate	20		22		22		26		26		26	

Date	Release date 1 August (Julian 213)						Release date 2 August (Julian 214)					
	Treatments						Treatments					
	Tag code (AG D1 D2)						Tag code (AG D1 D2)					
	Turbine		Bypass		Egress		Turbine		Bypass		Egress	
of	23 26 23		23 26 24		23 26 27		23 26 29		23 26 30		23 26 33	
recovery	N	A	N	A	N	A	N	A	N	A	N	A
213 (1 Aug.)												
214												
215			2	2			(1)					
216	12(1)	13	10	11	14	15	1	1	1	1	1	1
217 (5 Aug.)	12	12	25	25	16	16	8	8	14	14	6	6
218	30(1)	25*	35	29	48(1)	40	79	65	66	54	69(1)	57
219	11(1)	10	12(1)	11*	14(1)	12*	34	30*	35	31*	34	30*
220	9	9	15	15	11	11	7	7	8	8	10	10
221	2	3	2	3	9	13	9	13	3	4	6	8
222 (10 Aug.)	1(1)	2	2	5	1(1)	2	2(1)	5	3	7	1(2)	2
223			1(5)	3	2(1)	6	1(3)	3	(2)		(1)	
224	2	4	4	8	5	10	1	2	5	10	4	8
225	4	6	10	16	6	9	10	16	16	25	7	11
226	1	2	3	6	2	4	3	6	3	6	4	8
227 (15 Aug.)			2	5	3	7	3	7	1	2	5(1)	12
228							2					
229			1						1			
NA	2		2				2		2		2	
Total	90	86	132	139	135	145	167	163	160	162	154	153
Mvmt rate	31		26		26		31		31		31	

Appendix Table C2.--Continued

Date of recovery	Release date 3 August (Julian 215) Treatments Tag code (AG D1 D2) Turbine 23 26 34 N	A	Bypass 23 26 36 N	A	Egress 23 26 39 N	A
213 (1 Aug.)						
214						
215						
216					1	1
217 (5 Aug.)	1	1			1	1
218	32	26	31	26	34	28
219	36	32	29	25	48	42
220	24	24[e]	22(1)	22[e]	20(2)	20[e]
221	12	17	10	14	11	15
222 (10 Aug.)	4(1)	9	2(1)	5	3(2)	7
223	(2)		1(2)	3	(2)	
224	7	14	2	4	3	6
225	13	20	10	16	10	16
226	3	6	3	6	4	8
227 (15 Aug.)	2(1)	5	2	5	6	14
228			1			
229			1			
NA	1		1			
Total	139	154	119	126	147	158
Mvmt rate	31		31		31	

Grand Totals Turbine N	A	Bypass N	A	Egress N	A
2,745	2,508	2,940	2,680	3,085	2,842

[a] AG D1 D2 = Agency, Data 1, Data 2 codes.

[b] Julian date; equivalent day and month provided in parentheses.

[c] N = Actual daily purse seine and beach seine (in parentheses) catch of the particular mark group. Sampling was conducted on all dates and blanks represent 0 recoveries.

[d] A = Adjusted daily purse seine catch obtained by standardizing the daily purse seine effort to 14 sets from 6 July -15 August (Julian dates 187 to 227). Few fish were captured subsequent to 15 August and purse seine effort was much reduced during the final week of sampling.

[e] Day that the median fish was captured (adjusted effort).

[f] Date of recovery unavailable. Not used in data standardization.

[g] Actual totals include all purse seine and beach seine data; adjusted totals include only purse seine standardized data.

[h] Mvmt. rate = Movement rate (km/day) = distance traveled (RKm 232, control release site minus RKm 75, Jones Beach sampling site) ÷ travel time (in days, from release date to date of median fish recovery at Jones Beach).

Appendix Table C3.--Diel distribution of treatment groups from the Bonneville Dam Survival Study at Jones Beach, 1990.

	Lower turbine		Bypass system		Egress release	
	Number	%	Number	%	Number	%
	DIEL SAMPLING 31 JULY-01 AUGUST					
	Fish released 17-21 July					
Daylight	48	100.0	40	100.0	38	100.0
Darkness	0	0.0	0	0.0	0	0.0
	Fish released 24-27 July					
Daylight	65	100.0	56	98.2	67	98.5
Darkness	0	0.0	1	1.8	1	1.5
	TOTALS					
Daylight	113	100.0	96	99.0	105	99.1
Darkness	0	0.0	1	1.0	1	0.9

Appendix Table C4.--Numbers of fishes captured in the bottom trawl at Jones Beach during diel sampling 31 July to 1 August 1991.

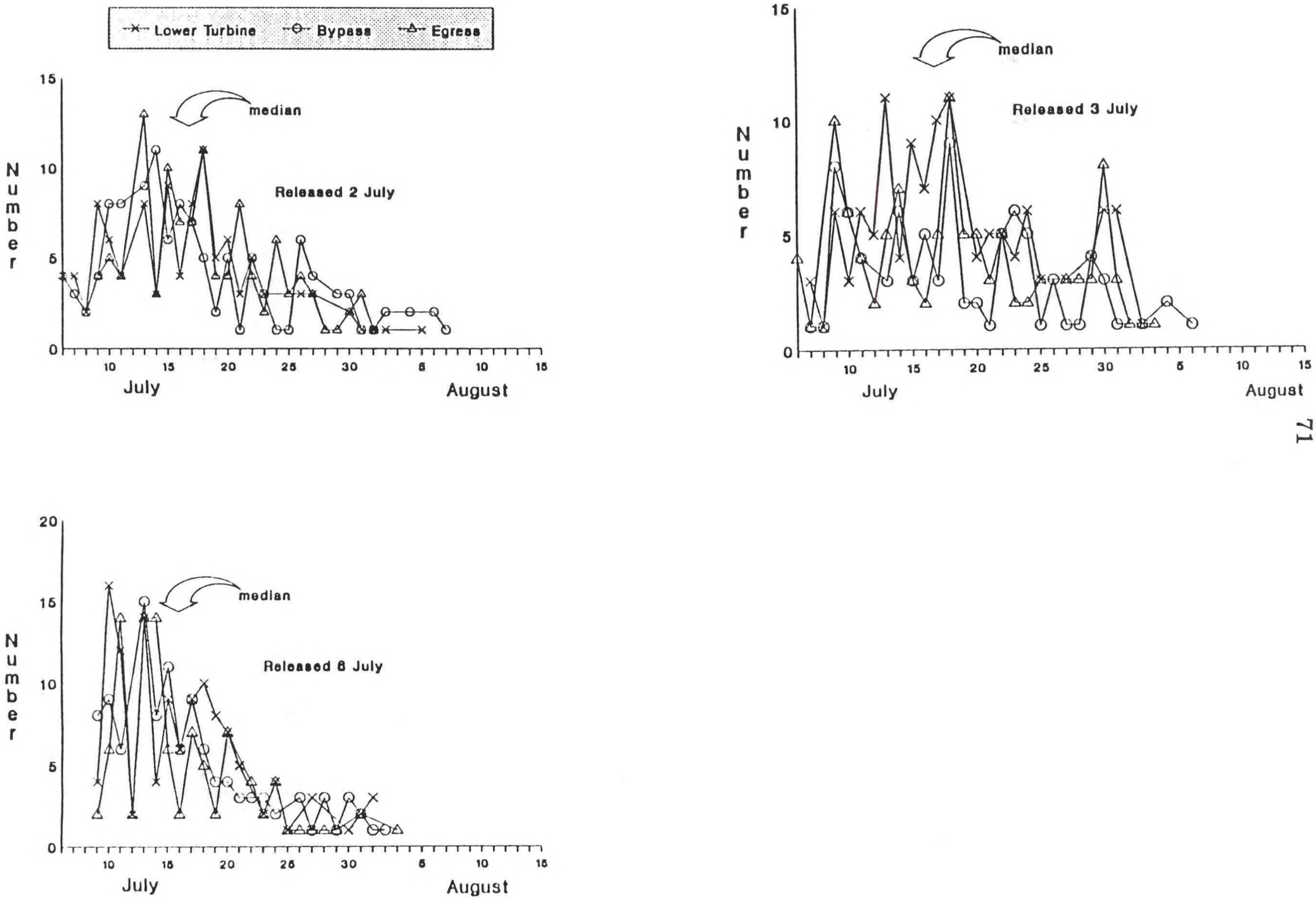
Set no.	Time (24 hr. clock)	Subyearling chinook salmon	White sturgeon	Threespine stickleback	Peamouth	Sculpin	Starry flounder	American shad	Sucker
1	1158	0	10	1	3	1	0	0	5
2	1255	0	0	0	4	5	1	0	1
3	1357	0	3	1	2	3	1	1	1
4	1533	0	0	0	0	12	0	0	1
5	1702	0	3	0	0	3	0	0	0
6	1830	0	2	0	2	12	0	0	3
7	1930	0	6	0	2	50[a]	2	0	2
8[b]	2029	0	4	0	3	30[a]	1	0	7
9[b]	2130	2	12	0	0	50[a]	4	0	5
10[b]	2230	1	15	2	0	20[a]	4	0	6
11[b]	0028	1	15	6	0	30[a]	2	0	1
12[b]	0218	0	2	10	0	10	2	0	0
13	0524	1	0	10	0	0	0	0	0
14	0646	0	3	8	0	10	0	0	0
15	0800	0	3	0	1	5	0	0	1
	Totals	5	78[c]	38	17	241	17	1	33

[a] Estimated counts.
[b] Sets made during darkness.
[c] Fifty-two were subyearling sturgeon.

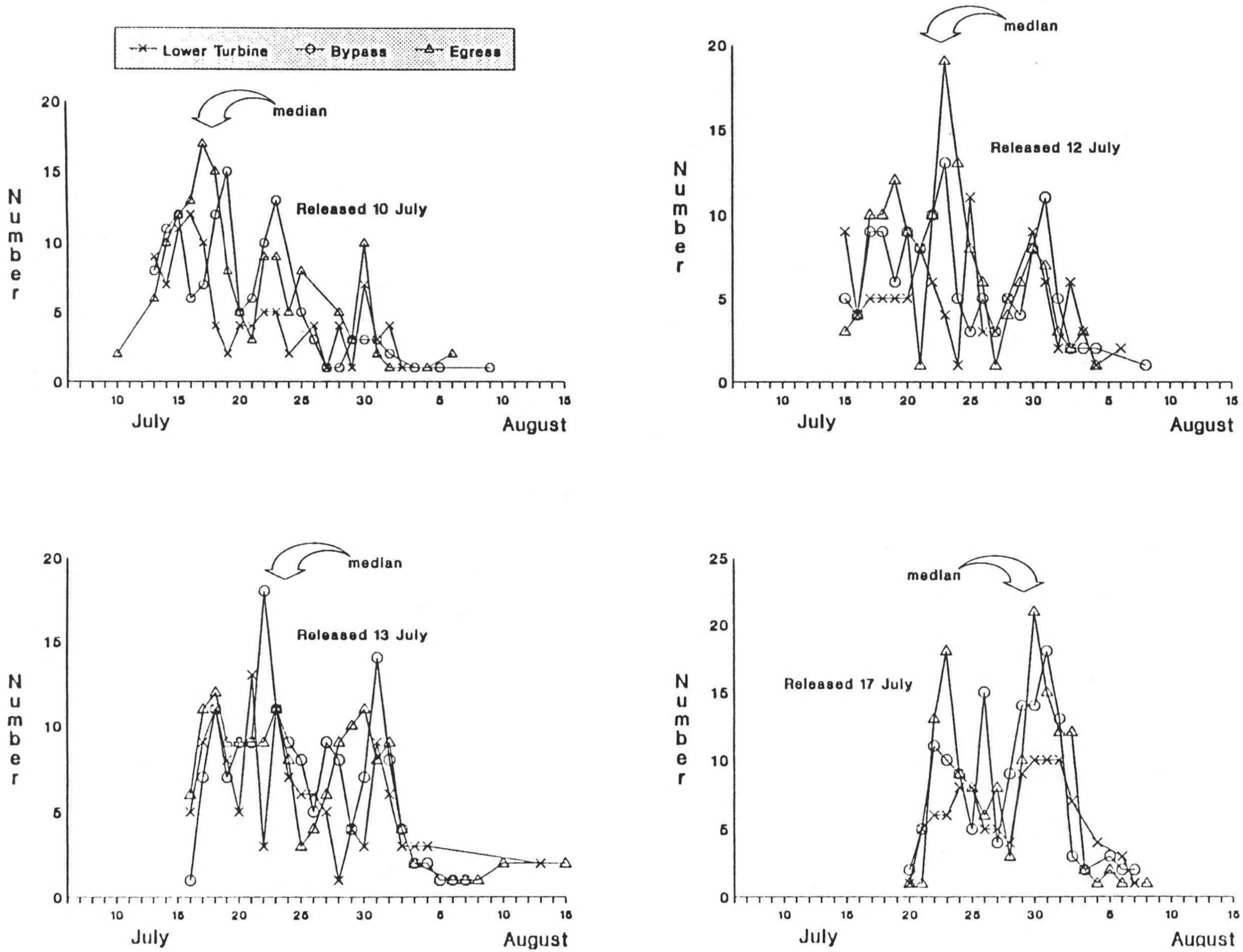
Appendix Table C5.--Diet (prey counts) of study fish recovered at Jones Beach, Bonneville Dam survival study, 1990.

Sample date:	July 16			July 31									August 1			
Sample time (24 hr. clock):	0511	0751	1013	1039	1152	1255	1433	1601	1729	1900	2033	2341	0125	0515	0622	0730
Stomachs pooled:	11	9	3	10	9	9	10	9	9	9	10	10	10	8	10	9
	Average Counts of Prey Items*															
Insecta																
Diptera	<1	7	3	1	3	1	3	3	5	4	4	1	<1		1	1
Unidentifiable	1	2	<1	1	1	<1	<1	<1	1	<1	2	2	<1	<1	1	<1
Other	<1	1		2	<1	1	1	<1	1	<1	<1	<1	<1	1		
Total	2	10	3	4	4	2	4	4	7	5	6	3	1	1	2	1
Crustacea																
Cladocera	<1	3	6	80	184	216	183	281	108	267	272	10	2		19	96
Amphipoda		3	1	1	1	<1	1	1	1	1	<1	<1		<1	1	1
Other		<1		1			1	<1	1	1	<1	<1	<1		<1	
Total	<1	6	7	82	185	216	185	282	110	269	273	11	2	<1	20	97
Other items		<1						<1	<1	<1		<1			<1	
Total content weight (g):	0.051	0.331	0.036	0.183	0.329	0.296	0.334	0.401	0.263	0.561	0.526	0.235	0.016	0.033	0.148	0.230

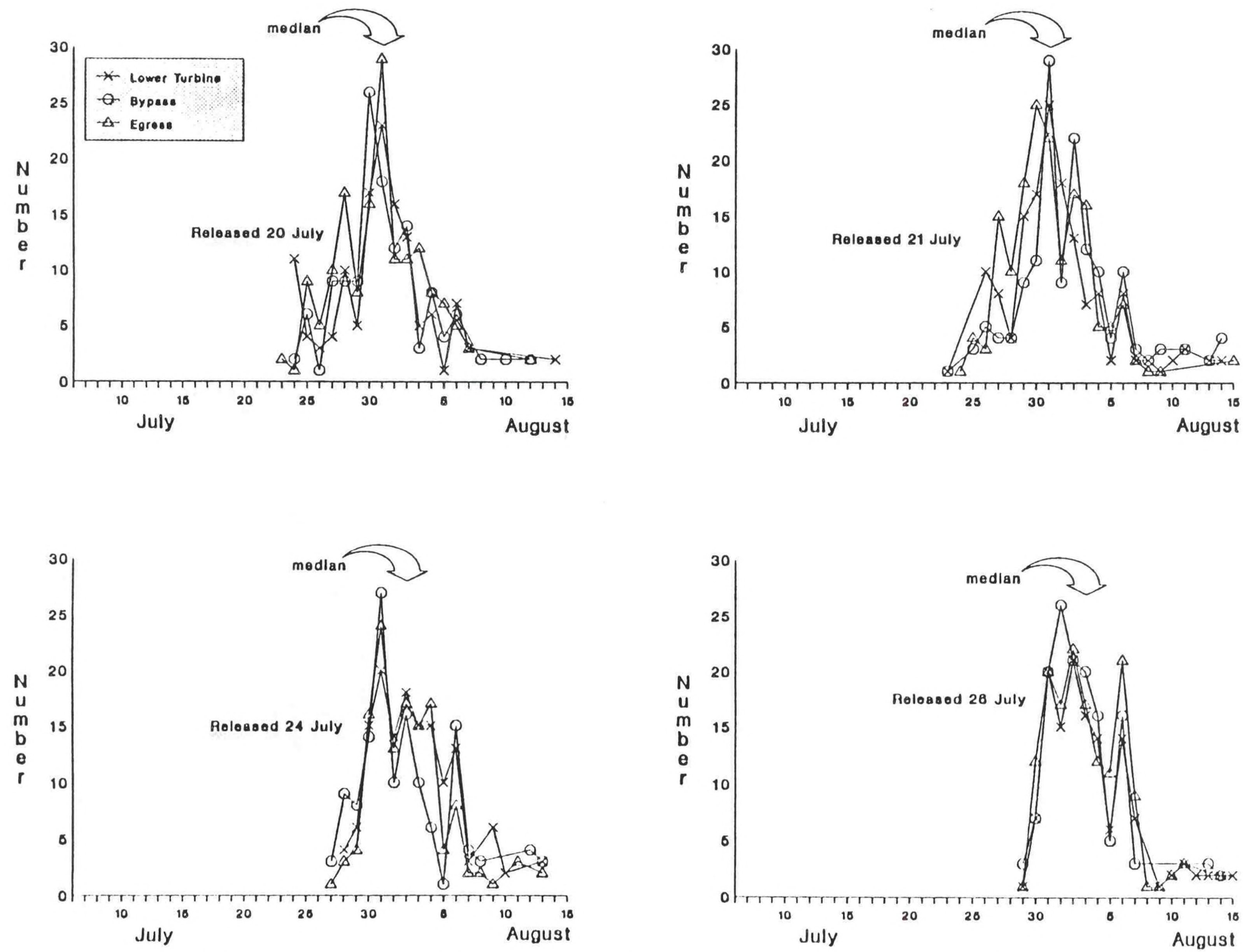
* Average count = (number of prey items in pooled stomachs) ÷ (number of stomachs).



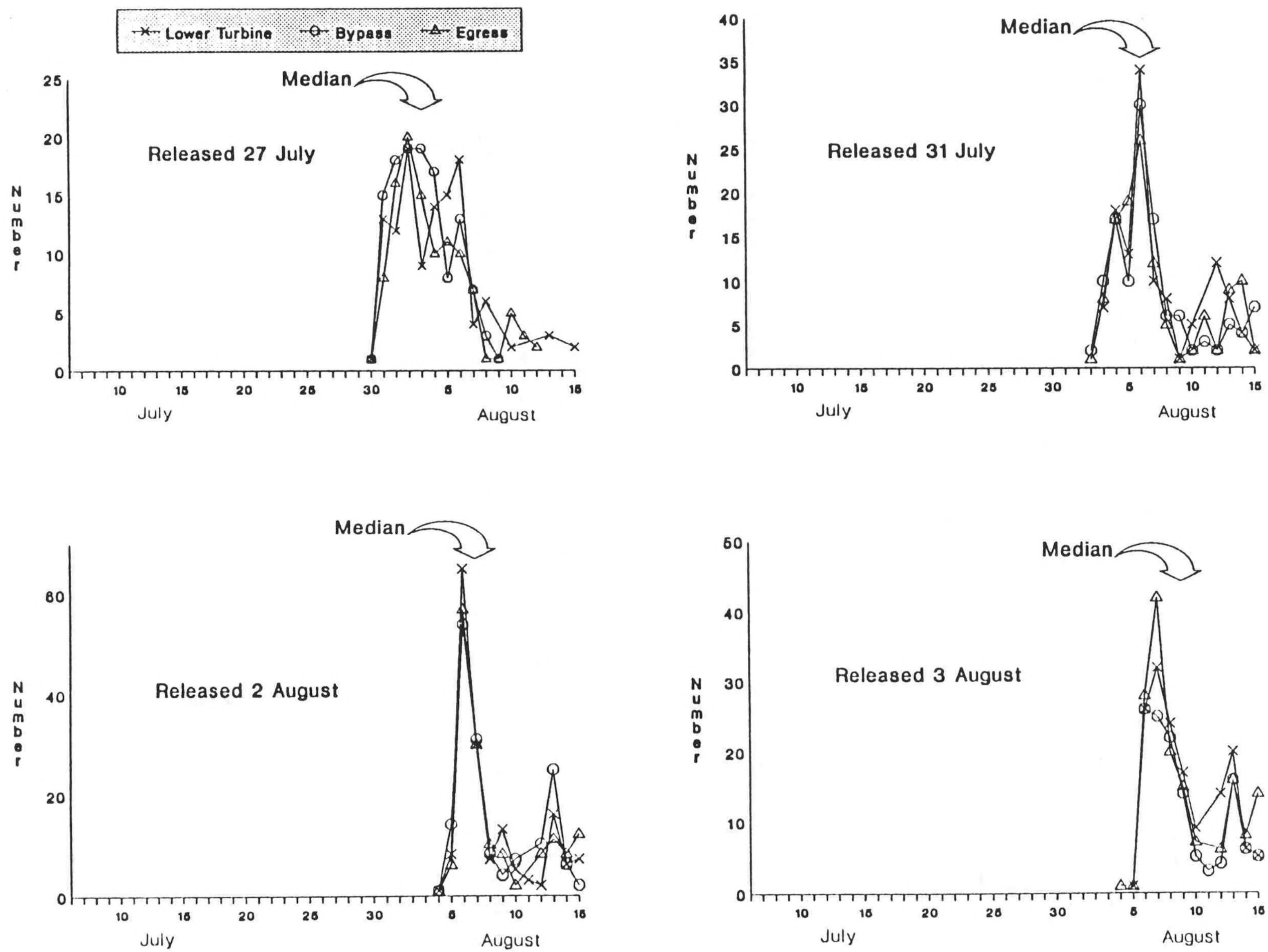
Appendix Figure C1.--Daily recoveries of test fish at Jones Beach (standardized for effort) from releases made at Bonneville Dam on 30 June, 2 July, 3 July, and 6 July.



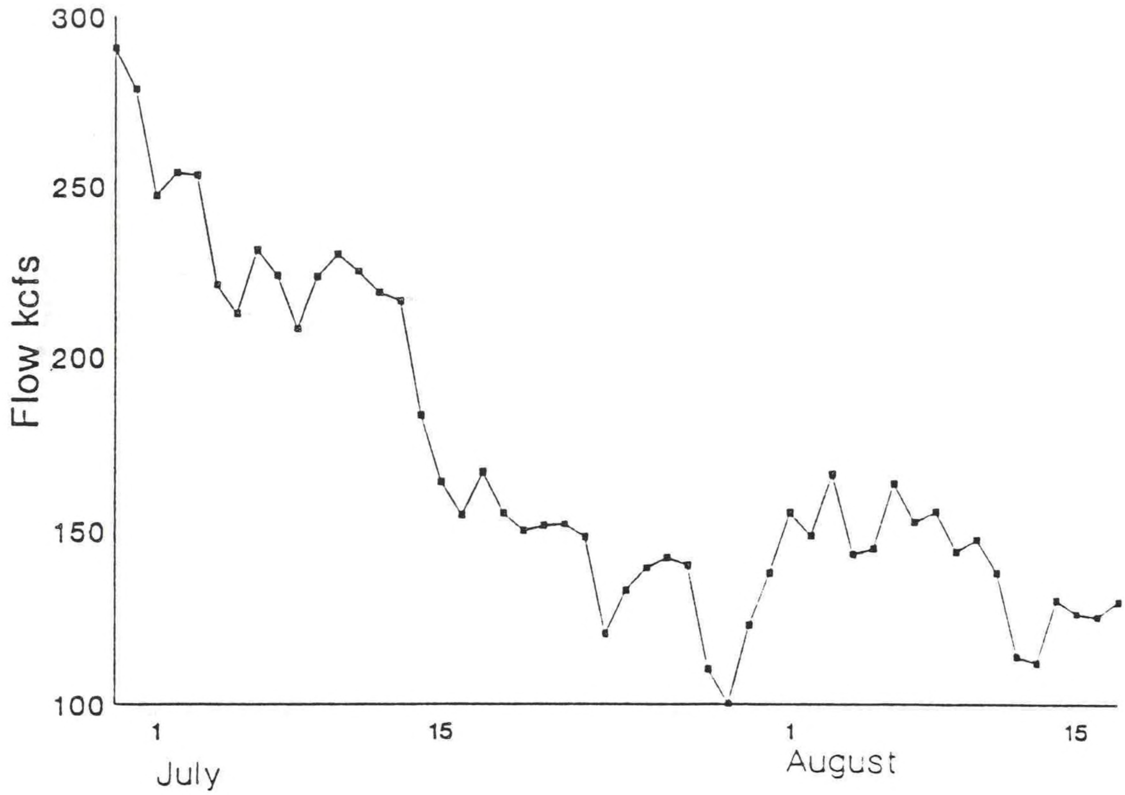
Appendix Figure C2.--Daily recoveries of test fish at Jones Beach (standardized for effort) from releases made at Bonneville Dam on 10, 12, 13, and 17 July.



Appendix Figure C3.--Daily recoveries of test fish at Jones Beach (standardized for effort) from releases made at Bonneville Dam on 20, 21, 24, and 26 July.



Appendix Figure C4.--Daily recoveries of test fish at Jones Beach (standardized for effort) from releases made at Bonneville Dam on 27 and 31 July, and 2 and 3 August.



Appendix Figure C5.--Daily mean river flow during the estuarine sampling period, 1990; measured at Bonneville Dam by the U.S. Army Corps of Engineers, Portland, Oregon.

Appendix D
Statistical Analysis of Juvenile Catch Data and Adult Tag Recovery Data

APPENDIX D

Statistical Analysis of Juvenile and Adult Catch Results

CONTENTS

Appendix D.--Continued.

I. Juvenile recovery differences, 1990.

A. Chi-square goodness of fit analysis was used to evaluate differences among observed purse seine recoveries (Appendix Table C2) through time for different treatment groups released on the same day (Sokal and Rohlf 1981). A non-significant result indicates that there was equal probability of capture at Jones Beach for each treatment group (i.e., that the groups were adequately mixed). For additional discussion of this procedure see Appendix D in Dawley et al. (1989). The compromised turbine groups (first 11 release groups) were included since migrational timing for these groups should be unaffected by the torn release hose.

H_o: There was homogeneity between recovery distributions of treatments in 1990.

Block	Date	Chi-sq.	df	p-value	Result
1	30 June	16.238	20	0.7082	non-significant
2	2 July	23.391	26	0.6107	"
3	3 July	18.144	24	0.7960	"
4	5 July	16.935	22	0.7669	"
5	6 July	18.559	22	0.6724	"
6	10 July	35.853	28	0.1464	"
7	11 July	29.251	32	0.6064	"
8	12 July	39.871	32	0.1599	"
9	13 July	33.952	36	0.5663	"
10	17 July	24.400	26	0.5531	"
11	18 July	30.041	26	0.2659	"
12	20 July	33.580	26	0.1459	"
13	21 July	36.257	24	0.0518	"
14	24 July	25.016	20	0.2008	"
15	25 July	27.893	24	0.2646	"
16	26 July	15.924	20	0.7213	"
17	27 July	19.480	18	0.3628	"
18	31 July	12.203	16	0.7299	"
19	1 August	14.164	16	0.5865	"
20	2 August	14.651	16	0.5503	"
21	3 August	8.570	14	0.8576	"

The 21 tests independently examined the same hypothesis, therefore their results can be combined to obtain an overall test (Fisher 1944). The overall test is:

Block	Date	p-value	-2Ln(p)	df
1	30 June	0.7018	0.7082	2
2	2 July	0.6107	0.9863	2
3	3 July	0.7960	0.4563	2
4	5 July	0.7669	0.5308	2
5	6 July	0.6724	0.7938	2
6	10 July	0.1464	3.8428	2
7	11 July	0.6064	1.0004	2
8	12 July	0.1599	3.6664	2
9	13 July	0.5663	1.1373	2

Appendix D.--Continued.

10	17 July	0.5531	1.1844	2
11	18 July	0.2659	2.6493	2
12	20 July	0.1459	3.8497	2
13	21 July	0.0518	5.9207	2
14	24 July	0.2008	3.2109	2
15	25 July	0.2646	2.6591	2
16	26 July	0.7213	0.6534	2
17	27 July	0.3628	2.0278	2
18	31 July	0.7299	0.6297	2
19	1 August	0.5865	1.0672	2
20	2 August	0.5503	1.1946	2
21	3 August	0.8576	0.3072	2
Overall Chi-square =			38.476324	42

P= 0.6264, non-significant

B. Analysis of treatment descaling rates of brand recoveries at Jones Beach using a randomized block Analysis of Variance (ANOVA) design where each release series (unique brand group) was considered a block.

1. Full data set using all brand release series (see Table 3). Lower turbine groups released during the first four series were compromised by a torn hose.

ANOVA Table

Source	Sum of squares	D.F.	Mean square	F	Significance level
Blocks	1.3250	5	0.2650		
Treatments	0.7064	2	0.3532	3.70	0.0625
Error	0.9534	10	0.0953		
Total	2.9849	17			

No multiple comparisons since the F-test for treatments was not significant.

Treatment	Count	Mean
Lower turbine	6	0.6117
Bypass	6	0.2000
Egress	6	0.1833

Appendix D.--Continued.

2. Modified data set using only the last 2 brand release series (see Table 3).

ANOVA Table

Source	Sum of squares	D.F.	Mean square	F	Significance level
Blocks	0.0864	1	0.0864		
Treatments	0.0094	2	0.0047	0.05	0.9564
Error	0.2071	2	0.1036		
Total	0.3029	5			

No multiple comparisons since the F-test for treatments was not significant.

Treatment	Count	Mean
Lower turbine	2	0.3450
Bypass	2	0.1250
Egress	2	0.1100

C. Analysis of treatment effects using a randomized block ANOVA design where each day was considered a block (Sokal and Rohlf 1981).

1. Estuarine recovery percentages. Modified data set using only the last 10 release days, and all release groups, purse seine and beach seine observed catch (Appendix Table C2).

Source	Sum of squares	D.F.	Mean square	F	Significance level
Blocks	0.1912	9	0.0212		
Treatments	0.0011	2	0.0006	0.24	0.7892
Error	0.0423	18	0.0024		
Total	0.2346	29			

No multiple comparisons since the F-test for treatments was not significant.

Treatment	Count	Mean
Lower turbine	10	0.5721
Bypass	10	0.5586
Egress	10	0.5577

Appendix D.--Continued.

2. Estuarine recovery percentages. Modified data set using all 21 release days comparing Bypass to Egress release groups, purse seine and beach seine observed catch (Appendix Table C2).

Source	Sum of squares	D.F.	Mean square	F	Significance level
Blocks	0.3766	20	0.0188		
Treatments	0.0039	1	0.0039	2.29	0.1409
Error	0.0335	20	0.0017		
Total	0.4140	41			

No multiple comparisons since the F-test for treatments was not significant.

Treatment	Count	Mean
Bypass	21	0.5106
Egress	21	0.5299

3. Estuarine recovery percentages. Modified data set using only the last 10 release days, and all release groups, purse seine standardized catch (Appendix Table C2).

Source	Sum of squares	D.F.	Mean square	F	Significance level
Blocks	0.0659	9	0.0073		
Treatments	0.0018	2	0.0009	0.34	0.7186
Error	0.0476	18	0.0026		
Total	0.1153	29			

No multiple comparisons since the F-test for treatments was not significant.

Treatment	Count	Mean
Lower turbine	10	0.5186
Bypass	10	0.5003
Egress	10	0.5134

Appendix D.--Continued.

4. Estuarine recovery percentages. Modified data set using all 21 release days, comparing Bypass to Egress release groups, purse seine standardized catch (Appendix Table C2).

Source	Sum of squares	D.F.	Mean square	F	Significance level
Blocks	0.2042	20	0.0102		
Treatments	0.0052	1	0.0052	4.24	0.0529
Error	0.0247	20	0.0012		
Total	0.2341	41			

No multiple comparisons since the F-test for treatments was not significant.

Treatment	Count	Mean
Bypass	21	0.4655
Egress	21	0.4878

D. Analysis of estuarine recovery percentages for possible differences between north and south Egress release hoses.

H_0: Mean recovery percentage of north and south egress release hoses are equal. Note: Release group for 30 June (south hose) was omitted to have equal sample sizes.

South Hose		North Hose		% Difference
Day	%	Day	%	(South-North)
3 July	0.4045	2 July	0.4443	-0.0398
6 July	0.3634	5 July	0.4575	-0.0941
10 July	0.5367	11 July	0.5694	-0.0327
12 July	0.5671	13 July	0.6122	-0.0451
18 July	0.5946	17 July	0.5562	+0.0384
21 July	0.6917	20 July	0.6330	+0.0587
24 July	0.6049	25 July	0.6223	-0.0174
26 July	0.7012	27 July	0.4657	+0.2355
1 August	0.4737	31 July	0.4357	+0.0380
3 August	0.5165	2 August	0.5414	-0.0249
Means	0.5454		0.5338	+0.0117

t=0.40, SE =0.0289, p=0.70.

Appendix D.--Continued.

E. Analysis of estuarine tag recovery percentages pooled into five blocks based upon brand assignment as required for estimating tag loss.

Source	Sum of squares	D.F.	Mean square	F	Significance level
Blocks	0.0778	4	0.0194		
Treatments	0.0048	2	0.0024	1.07	0.3871
Error	0.0181	8	0.0023		
Total	0.1007	14			

II. Adult tag recovery data from juveniles released in 1987.

A. Analysis of full data set using all release days, all release groups (ANOVA).

ANOVA Table

Source	Sum of squares	D.F.	Mean square	F	Significance level
Blocks	0.1173	19	0.0062		
Treatments	0.0186	3	0.0062	4.65	0.0056
Error	0.0760	57	0.0013		
Total	0.2119	79			

Multiple Comparisons
Method: 95 Percent FPLSD Intervals

Treatment	Count	Mean	Homogeneous[a] groups
Bypass	20	0.1638	1
Lower turbine	20	0.1593	1
Upper Turbine	20	0.1510	1
Downstream	20	0.1245	2

Fisher's Protected Least Significant Difference (FPLSD) =
$t_{(\alpha=0.05)(df=57)}$ * SQRT (2*MSE/r) = 0.0231

[a] Homogeneous groups are identified by a common number.

Appendix D.--Continued.

B. Analysis of modified data set with data from 5 July release groups deleted; on that day a mortality problem was observed in the transport truck for lower and upper turbine groups prior to release.

ANOVA Table

Source	Sum of squares	D.F.	Mean square	F	Significance level
Blocks	0.1154	18	0.0064		
Treatments	0.0184	3	0.0061	4.92	0.0043
Error	0.0673	54	0.0012		
Total	0.2012	75			

Multiple Comparisons
Method: 95 Percent FPLSD Intervals

Treatment	Count	Mean	Homogeneous[a] groups
Lower Turbine	19	0.1642	1
Bypass	19	0.1635	1
Upper Turbine	19	0.1495	1
Downstream	19	0.1258	2

Fisher's Protected Least Significant Difference (FPLSD) =
$t_{(\alpha=0.05)(df=54)}$ * SQRT (2*MSE/r) = 0.0230

[a] Homogeneous groups are identified by a common number.

Appendix E
Adult Tag Recovery Data

Appendix Table E1.--Tag recovery and distribution data of adult chinook salmon released as juveniles in 1987 to evaluate passage survival through the Bonneville Dam Second Powerhouse.

Recovery location[a]	Number of recaptures per year class 2 (1988)	3 (1989)	4 (1990)	5 (1991)	6 (1992)	Total Number	%
Ocean sport fishery, Alaska	1	3	[b]			4	0.2
Ocean net fishery, Alaska	16	5	[b]			21	0.8
Ocean troll fishery, Alaska	0	14	[b]			14	0.5
Ocean sport fishery, British Columbia	0	6	0			6	0.2
Ocean net fishery, British Columbia	37	28	14			79	3.0
Ocean troll fishery, British Columbia	2	85	196			283	10.8
Ocean sport fishery, Washington	3	21	5			29	1.1
Ocean net fishery, Washington	0	14	0			14	0.5
Ocean troll fishery, Washington	1	13	0			14	0.5
Ocean sport fishery, Oregon	1	0	3			4	0.2
Ocean troll fishery, Oregon	1	7	2			10	0.4
Columbia R. sport fishery, Oregon	0	6	0			6	0.2
Columbia R. sport fishery, Washington	0	0	1			1	-
Columbia R. net fishery, Youngs Bay	0	5	5			10	0.4
Columbia R. net fishery, Zones 1-5	3	144	239			386	14.7
Columbia R. net fishery, Zone 6 (fall)	5	114	624			743	28.3
Stream survey, Big White Salmon River, CRM 168.3	0	2	[b]			2	0.1
Stream survey, Umatilla River, CRM 288.8	0	2	[b]			2	0.1
Columbia R., Bonneville hatchery, CRM 144.5	102	267	305			674	25.6
Columbia R., Cascade hatchery, CRM 146.0	65	46	0			111	4.2
Columbia R., Little White Salmon NFH, CRM 161.1	23	61	104			188	7.1
Columbia R., Spring Creek NFH, CRM 166.5	1	0	4			5	0.2
Columbia R., Priest Rapids Hatchery, CRM 397.1	4	0	[b]			4	0.2
Snake R., Lyons Ferry Hatchery, SRM 58.0	1	16	[b]			17	0.6
Umatilla R., 3-Mile Trap	0	2	[b]			2	0.1
Totals	266	861	1502			2629[c]	100.0

[a] Complete descriptions of recovery locations available from Pacific States Marine Fisheries Commission, 2501 S.W. First Ave., Suite 200, Portland, OR 97201.

[b] Wire tag recoveries not yet available (15 February 1991).

[c] A total of 1,738,804 juveniles were released in 1987.

Appendix Table E2.--Tag recovery and distribution data of adult chinook salmon released as juveniles in 1988 to evaluate passage survival through the Bonneville Dam Second Powerhouse.

Recovery location[a]	Number of recaptures per year class 2 (1989)	3 (1990)	4 (1991)	5 (1992)	6 (1993)	Total Number	%
Ocean sport fishery, Alaska	0	[b]				0	0.0
Ocean net fishery, Alaska	2	[b]				2	1.5
Ocean troll fishery, Alaska	0	[b]				0	0.0
Ocean sport fishery, British Columbia	0	0				0	0.0
Ocean net fishery, British Columbia	4	3				7	5.3
Ocean troll fishery, British Columbia	0	12				12	9.1
Ocean sport fishery, Washington	0	1				1	0.7
Ocean net fishery, Washington	0	0				0	0.0
Ocean troll fishery, Washington	0	0				0	0.0
Ocean sport fishery, Oregon	0	1				1	0.7
Ocean troll fishery, Oregon	0	3				3	2.3
Columbia R. sport fishery, Oregon	0	0				0	0.0
Columbia R. sport fishery, Washington	0	0				0	0.0
Columbia R. net fishery, Youngs Bay	0	0				0	0.0
Columbia R. net fishery, Zones 1-5	2	6				8	6.1
Columbia R. net fishery, Zone 6 (fall)	0	29				29	22.0
Stream survey, Big White Salmon River, CRM 168.3	0	[b]				0	0.0
Stream survey, Umatilla River, CRM 288.8	0	[b]				0	0.0
Columbia R., Bonneville hatchery, CRM 144.5	11	30				41	31.1
Columbia R., Cascade hatchery, CRM 146.0	9	0				9	6.8
Columbia R., Little White Salmon NFH, CRM 161.1	7	10				17	12.9
Columbia R., Spring Creek NFH, CRM 166.5	0	0				0	0.0
Columbia R., Priest Rapids Hatchery, CRM 397.1	0	[b]				0	0.0
Snake R., Lyons Ferry Hatchery, SRM 58.0	2	[b]				2	1.5
Umatilla R., 3-Mile Trap	0	[b]				0	0.0
Totals	37	95				132[c]	100.0

[a] Complete descriptions of recovery locations available from Pacific States Marine Fisheries Commission, 2501 S.W. First Ave., Suite 200, Portland, OR 97201.
[b] Wire tag recoveries not yet available (15 February 1991).
[c] A total of 1,777,396 juveniles were released in 1988.

Appendix Table E3.--Tag recovery and distribution data of adult chinook salmon released as juveniles in 1989 to evaluate passage survival through the Bonneville Dam Second Powerhouse.

Recovery location[a]	Number of recaptures per year class					Total	
	2 (1990)	3 (1991)	4 (1992)	5 (1993)	6 (1994)	Number	%
Ocean sport fishery, Alaska	[b]					0	0.0
Ocean net fishery, Alaska	[b]					0	0.0
Ocean troll fishery, Alaska	[b]					0	0.0
Ocean sport fishery, British Columbia	0					0	0.0
Ocean net fishery, British Columbia	20					20	6.7
Ocean troll fishery, British Columbia	0					0	0.0
Ocean sport fishery, Washington	0					0	0.0
Ocean net fishery, Washington	0					0	0.0
Ocean troll fishery, Washington	0					0	0.0
Ocean sport fishery, Oregon	0					0	0.0
Ocean troll fishery, Oregon	0					0	0.0
Columbia R. sport fishery, Oregon	0					0	0.0
Columbia R. sport fishery, Washington	0					0	0.0
Columbia R. net fishery, Youngs Bay	0					0	0.0
Columbia R. net fishery, Zones 1-5	12					12	4.0
Columbia R. net fishery, Zone 6 (fall)	56					56	18.8
Stream survey, Big White Salmon River, CRM 168.3	[b]					0	0.0
Stream survey, Umatilla River, CRM 288.8	[b]					0	0.0
Columbia R., Bonneville hatchery, CRM 144.5	177					177	59.4
Columbia R., Cascade hatchery, CRM 146.0	0					0	0.0
Columbia R., Little White Salmon NFH, CRM 161.1	33					33	11.1
Columbia R., Spring Creek NFH, CRM 166.5	0					0	0.0
Columbia R., Priest Rapids Hatchery, CRM 397.1	[b]					0	0.0
Snake R., Lyons Ferry Hatchery, SRM 58.0	[b]					0	0.0
Umatilla R., 3-Mile Trap	[b]					0	0.0
Totals	298					298[c]	100.0

[a] Complete descriptions of recovery locations available from Pacific States Marine Fisheries Commission, 2501 S.W. First Ave., Suite 200, Portland, OR 97201.

[b] Wire tag recoveries not yet available (15 February 1991).

[c] A total of 2,123,383 juveniles were released in 1988.

Appendix Table E4.--Adult tag recoveries of survival study fish compared to other studies using upriver bright stock fall chinook salmon which had been reared at Bonneville Hatchery during 1987.

CWT (AG D1 D2 R)[a]	Study type	Release Information: Size (fish/lb)	Number	Location	Date	Observed recoveries (Age 2 & 3)	Percent of release
Agency 23[b]	Survival	101.0	1,738,804	Col. R.	6-7/87	1,127	0.065[c]
07 39 12-14[d]	Umatilla Eval.	60.4	121,076	Umatilla R.	5/87	272	0.225
07 43 15-18	IHN Eval.[e]	11.9	110,468	Tanner Cr.	11/87	147	0.133
07 41 29	IHN Eval.[f]	13.2	26,012	Tanner Cr.	11/87	7	0.027
07 43 09	IHN Eval.[e]	12.4	27,983	Tanner Cr.	11/87	18	0.064
07 43 19-20	IHN Eval.[e]	11.6	53,520	Tanner Cr.	11/87	64	0.120
07 47 19 R2[g]	Diet, OP-2	20.7	31,944	Tanner Cr.	9/87	94	0.294
07 47 21 R2	Diet, OP-2	21.2	32,196	Tanner Cr.	9/87	128	0.398
07 47 37 R2	Diet, OP-2	22.1	38,842	Tanner Cr.	9/87	117	0.301
07 47 38 R2	Diet, OP-2	24.3	40,060	Tanner Cr.	9/87	133	0.332
07 47 22 R2	Diet, Salmon meal	21.2	32,283	Tanner Cr.	9/87	80	0.248
07 47 25 R2	Diet, Salmon meal	20.3	31,823	Tanner Cr.	9/87	113	0.355
07 47 32 R2	Diet, Biomoist	23.2	40,542	Tanner Cr.	9/87	120	0.296
07 47 35 R2	Diet, Biomoist	21.8	40,470	Tanner Cr.	9/87	163	0.403
07 47 41 R2	Diet, Biomoist	22.3	39,452	Tanner Cr.	9/87	119	0.302
07 47 42 R2	Diet, Biomoist	22.4	36,847	Tanner Cr.	9/87	126	0.342

[a] CWT = coded wire tag; AG D1 D2 = Agency code, Data 1 code, Data 2 code, and R, if present, signifies embedded replicate style tag.
[b] Agency 23 codes used in the survival study are listed in Dawley et al. 1988 (Appendix Table A1).
[c] Recovery data of survival study groups from other age groups not included to allow comparison to other studies with as yet incomplete tag data.
[d] CWT codes with a '-' include a range of consecutive tag codes.
[e] IHN = Infectious Hematopoietic Necrosis; this group tested positive for the virus.
[f] Group tested negative for IHN.
[g] R2 = two embedded replicate sub-codes.

Appendix Table E5.--Adult tag recoveries of survival study fish compared to other studies using upriver bright stock fall chinook salmon which had been reared at Bonneville Hatchery during 1988.

CWT (AG D1 D2)[a]	Study type	Release Information: Size (fish/lb)	Number	Location	Date	Observed recoveries (Age 2)	Percent of release
Agency 23[b]	Survival	58.9	1,777,396	Col. R.	6-7/88	37	0.002
07 35 55	Hatchery eval.	8.9	24,352	Tanner Cr.	3/89	23	0.094
07 42 54	Hatchery eval.	86.8	53,333	Tanner Cr.	6/88	12	0.023
07 43 03	Hatchery eval.	39.6	53,014	Tanner Cr.	8/88	13	0.025
07 43 04	Hatchery eval.	13.1	52,809	Tanner Cr.	10-11/88	8	0.015

[a] CWT = coded wire tag; AG D1 D2 = Agency code, Data 1 code, and Data 2 code.
[b] Agency 23 codes used in the survival study 1988 are listed in Dawley et al. 1989 (Table 2).