Survival of Subyearling Chinook Salmon Which Have Passed through the Turbines, Bypass System, and Tailrace Basin of Bonneville Dam Second Powerhouse, 1988

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COASTAL ZONE AND ESTUARINE STUDIES

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INTRODUCTION

Research at the Columbia River's Bonneville Dam Second Powerhouse has shown that subyearling chinook salmon (Oncorhynchus tshawytscha) migrating in summer, mostly fall chinook salmon, are not effectively guided into the bypass system from turbines equipped with submersible traveling screens (STS) (Gessel et al. 1988). Consequently, most pass downstream through the turbines. To minimize turbine passage losses pending resolution of this guidance problem, operation of the Second Powerhouse has been curtailed at night; daytime operation has been restricted to periods necessary to limit spill to less than 2,124 m^3/sec (75,000 ft^3/sec) or meet firm energy demands if energy is unavailable elsewhere in the power system. As a result downstream migrants usually 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.

The rationale for this operating procedure is based on studies of passage mortality at the Bonneville Dam First Powerhouse (Holmes 1952) and at other hydroelectric projects (Schoeneman et al. 1961) with different physical features and turbine operating characteristics (elevation of blade in relation to tailwater, dimension of blades, and hydraulic head; Table 1). Hence, the adequacy of this procedure as the best means of protecting downstream migrant salmonids at the Second Powerhouse has not been rigorously documented. Moreover, the Kaplan turbines installed at the Second Powerhouse are of a more efficient design (less cavitation) than those previously studied at Bonneville First Powerhouse, and passage mortality is thought to be inversely related to turbine efficiency (Bell et al. 1981). Highly sensitive survival studies have not been conducted at Bonneville Dam since construction of spillway flow deflectors or the Second Powerhouse; therefore, information specific for this project is needed for management of fish passage in relation to power production.

Table 1.--Physical and operational characteristics of turbines at Bonneville Dam's Second and First Powerhouses and at McNary Dam.[a]

	Bonneville Dam		
Parameter	Second Powerhouse	First Powerhouse	McNary Dam
Submergence of runner (ft) in relation to tailwater	-18 to -53	-5 to -40	-23 to -30
Horsepower (Hp)	110,000 @ 60' head	74,000 @ 60' head	111,300 @ 80' head
Discharge (ft^3/sec)	17,600 @ 60' head	12,300 @ 60' head	14,000 @ 80' head
Runner type	Kaplan	Kaplan	Kaplan
Number of blades	5	5	6
Runner dim. (ft)	27.5	23.3	23.3
Runner speed (RPM)	69.2	75.0	85.7
Specific speed[b]	137.4 @ 60' head	122.2 @ 60' head	119.5 @ 80' head
Percent efficiency[c] (%)	92.5 @ 60'& 110,000 hp	90.8 @ 60'& 74,000 hp	90.0 @ 80'& 111,300 hp
Plant sigma[d] (@ 65'F)	0.93 @ 60'& TW=14'	0.70 @ 60', TW=14'	0.76 @ 80',TW=260'

[a] English units are used by convention.

[b] Specific Speed = $(\text{RPM} \times \sqrt{\text{Hp}})/\text{Head}^{5/4}$.

c Data derived from Figure 8-02.1 of expected prototype performance of Bonneville Dam Second Powerhouse (Allis-Chalmers 1978), from Exhibit 2 (Bell 1981), and Exhibit 6 (Bell 1981), for the Second and First Powerhouse of Bonneville Dam, and Mc Nary Dam, respectively.

[d]

$$\text{Sigma } (\sigma) = \frac{\begin{pmatrix}\text{Atmospheric}\\ \text{pressure}\end{pmatrix} - \begin{pmatrix}\text{Water Vapor}\\ \text{pressure}\end{pmatrix} - \begin{pmatrix}\text{CL runner elev - TW elev}\\ \text{pressure differential}\end{pmatrix}}{\text{Head Pressure}}$$

Where CL=center line and TW=tailwater.

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 which have passed through the Bonneville Second Powerhouse turbines and bypass, and through the spillway (Fig. 1). Estimates of long- and short-term survival of marked chinook salmon using various passage routes are being compared to similar estimates for control groups released in the tailrace and in the river 2.5 km downstream. Long-term relative survival will be based on returns of tagged and branded adult fish to ocean fisheries, Columbia River fisheries, the Bonneville Dam Second Powerhouse fish trap, and Columbia River hatcheries. Short-term relative survival is based on recoveries of branded fish 157 km downstream from the dam at the head of the estuary at Jones Beach, River Kilometer (RKm) 75. Secondary objectives of the estuarine sampling are to evaluate the success of the release strategies, condition of test fish (descaling, injuries, size, and gill Na^{+}-K^{+} ATPase), and migration behavior.

During the second year of this study, in 1988, as in 1987, the spillway releases were cancelled due to insufficient river flow in this drought year. In 1988, fish planned for release in the spillway were instead released into the frontroll of the turbine discharge. Also in 1988, the downstream control release site was changed from the shoreline location used in 1987 to a mid-river site. The bypass and turbine release sites were the same as used in 1987 (Dawley et al. 1988).

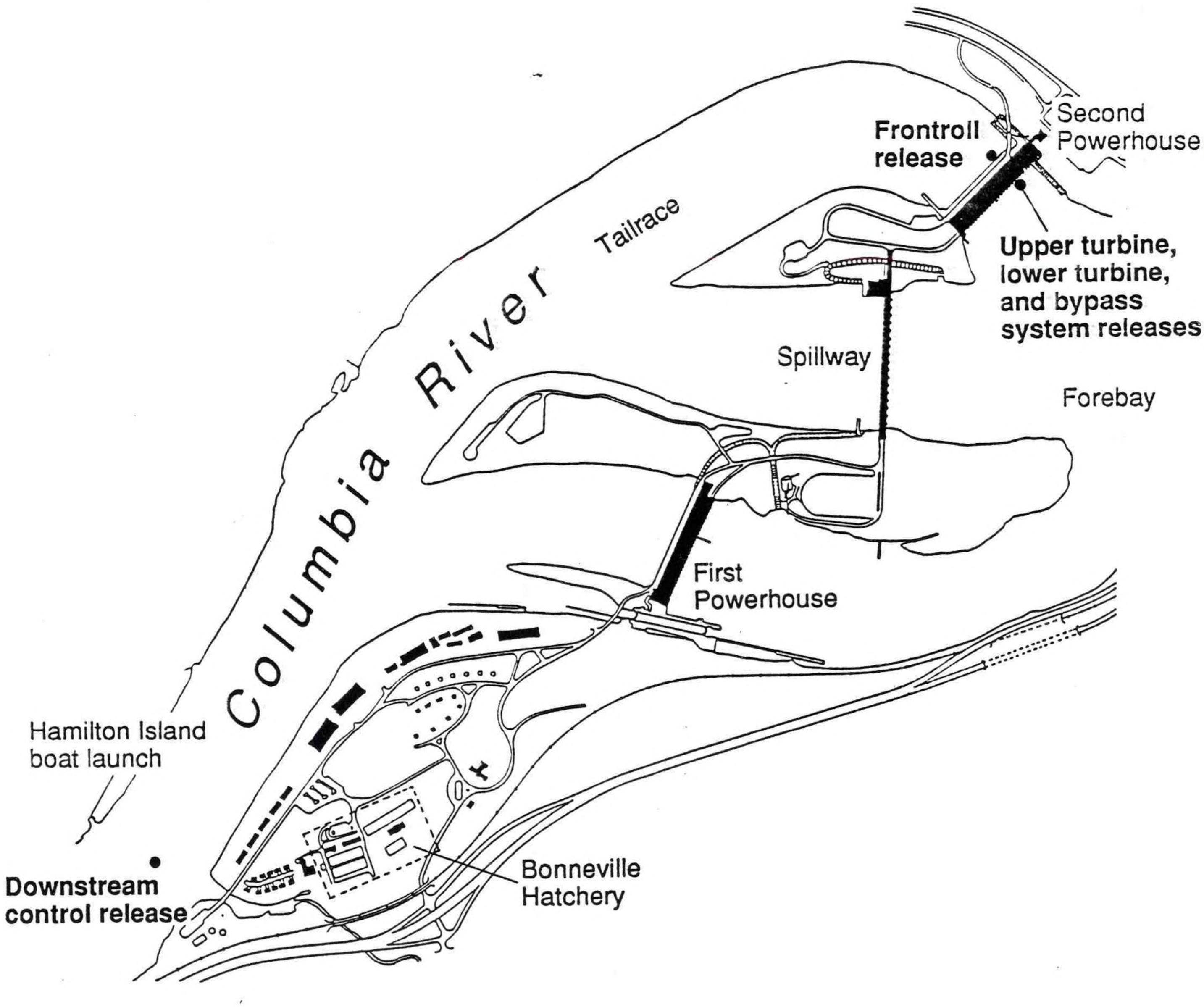

Figure 1.--Release locations for subyearling chinook salmon during the Bonneville Dam survival study, 1988.

METHODS

Test Fish

In 1988, about 1.8 million subyearling chinook salmon were reared 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 the Washington Department of Fisheries at Priest Rapids Hatchery. Eggs from early-spawning adults were obtained to allow sufficient rearing time to produce juveniles weighing 6.5 to 9.1 g (70-50 fish/lb) at release. Fish at this size were expected to migrate downstream faster and produce higher adult returns than the 4.4 to 4.6 g (102-98 fish/lb) fish used in 1987.

Marking Procedures

Test fish were marked from 13 June to 21 July, Monday through Friday, using two marking crews; one crew worked from 0600 to 1400 h and the second from 1430 to 2230 h. The experimental design was to mark 60 groups of about 30,000 fish per group, with each group having a unique brand (Mighell 1969) and coded wire tag (Bergman et al. 1968). Marking procedures were similar to those used in 1987, with the following changes: 1) the number of marked groups was reduced from 100 to 60, and the number of fish in each marked group was increased from 20,000 to 30,000; 2) pond dividers were placed in the Battery A holding ponds to allow separation of 20 uniquely marked groups rather than 10; 3) the marking period was increased from 4 to 6 weeks; 4) the number of marking trailers and tag injectors was reduced from four trailers containing a total of 10 injectors to one trailer with six injectors; 5) the tag injector and quality control systems were from the same, rather than two different, manufacturers; and 6) use of the pre-anesthetic system was discontinue to save time and effort (the anesthetizing of fish prior to dip netting is important for migrants, but appeared not to be important in marking these hatchery fish).

At Bonneville Hatchery, unmarked fish were transported by truck to Battery A from Batteries C and D by ODFW personnel. The marking trailer was set up at the north 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 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 mark groups did not differ in fish size, fish condition, rearing history, or mark quality: 1) the five marked groups needed for a single day's release were marked simultaneously rather than sequentially; 2) five of the six marking stations were dedicated to unique treatment groups, and the sixth station rotated equally between groups (Appendix Table A1); and 3) differences in mark quality between groups were minimized by rotating fish markers between stations, such that each marking team contributed equivalent numbers of marked fish to each treatment group (Appendix Table A2).

To maintain quality control in the tagging process, samples of about 100 fish from each marked group were collected about every 2 hours at the outfall pipe from the marking trailer and checked for tags. 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.

In contrast to methods used in 1987, the modified marking procedures used in 1988 required fewer people (24 rather than 60 fish markers, 2 rather than 8 laborers, and 2 rather than 4 supervisors); increased fish marker productivity (from 212 fish per marker-hour in 1987 to 325 fish per marker-hour in 1988); and lowered fish mortality during marking. In addition, estimates of tag loss (based on extended holding of samples of each marked release group) were between 0.6 and 2.4% ($\bar{x}$ = 2.0%, n = 9,536; Appendix Table A3). This was a substantial improvement from 1987 estimates of tag loss. Final release data used for adult recovery comparisons will include a correction for estimated tag loss.

Release Locations

The specific release locations and rationales for 1988 were as follows:

1) Upper Turbine--released in the intake of Turbine 17, just downstream from Gatewell B, and 1 m below the intake ceiling (elevation +6.5 m; Fig. 2). This release was made without an STS in place to simulate conditions fish would encounter while passing into an unscreened turbine intake at a depth where, under normal operation, they would have been intercepted by an STS.

2) Lower Turbine--released in the intake of Turbine 17, just downstream from Gatewell A, and 1 m below the effective depth of the emplaced STS (elevation +0.2 m; Fig. 3). This release was made with the STS in place to simulate conditions fish would encounter while passing into an intake below the interception depth of the STS.

3) Bypass System--released in the bypass system collection-channel just downstream from the Turbine 17B orifice and upstream from the control weir, downwell, and 1-m diameter outfall conduit (elevation +20.0 m; Fig. 4). This release was made to simulate conditions encountered by fish intercepted by an STS and shunted into the bypass channel.

4) Frontroll--released in the tailrace of the Second Powerhouse in the downstream portion of the Turbine 17 discharge, 30 m from the dam and 40 m upstream of the bypass system discharge (Fig. 5). Dye flushed from the frontroll release hose passes directly through the discharge from the bypass system. The frontroll release served as a control for test fish passing through the turbines and bypass system.

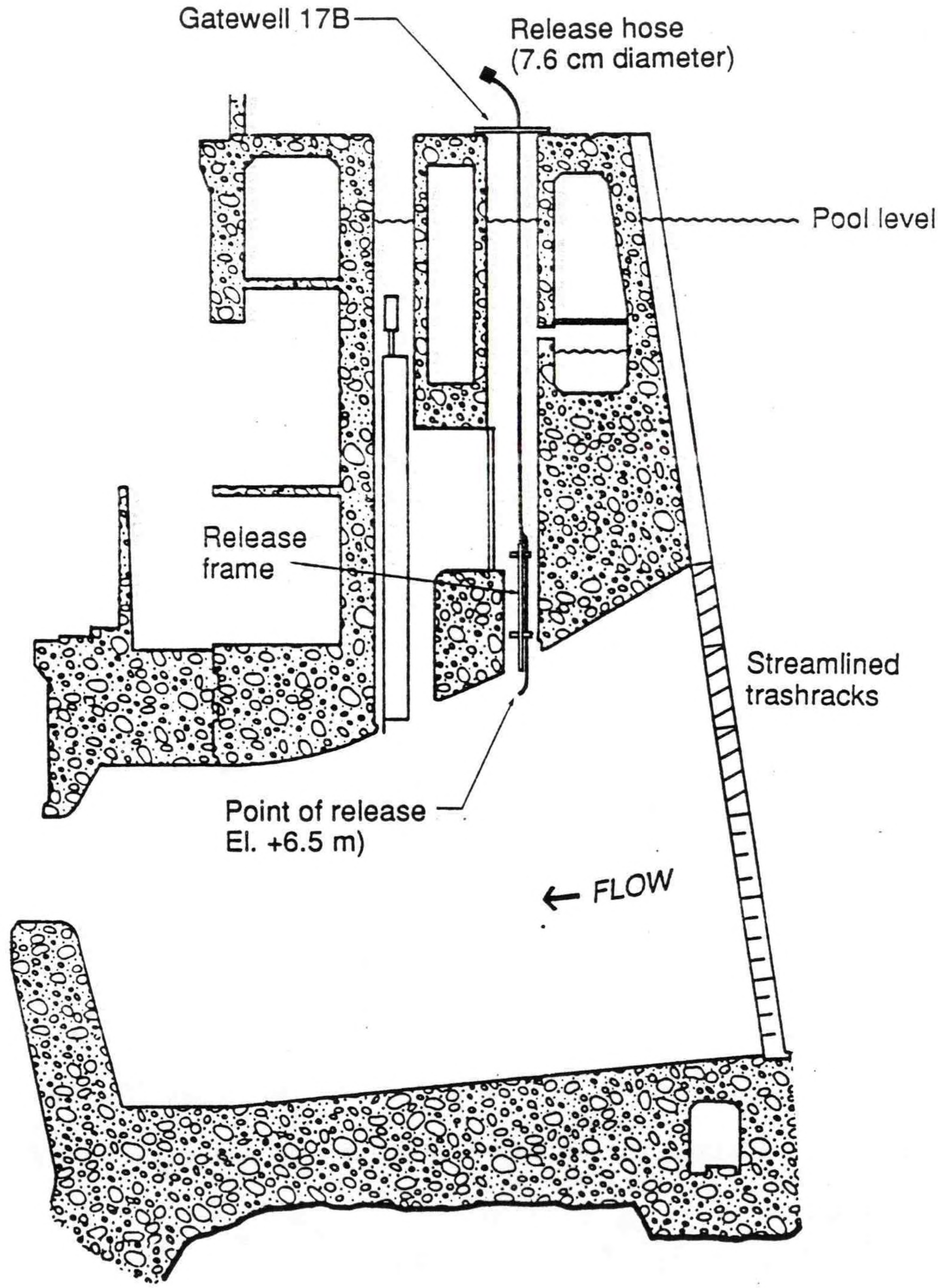

Figure 2.--Cross-section of Bonneville Dam Second Powerhouse depicting release location of upper turbine treatment group.

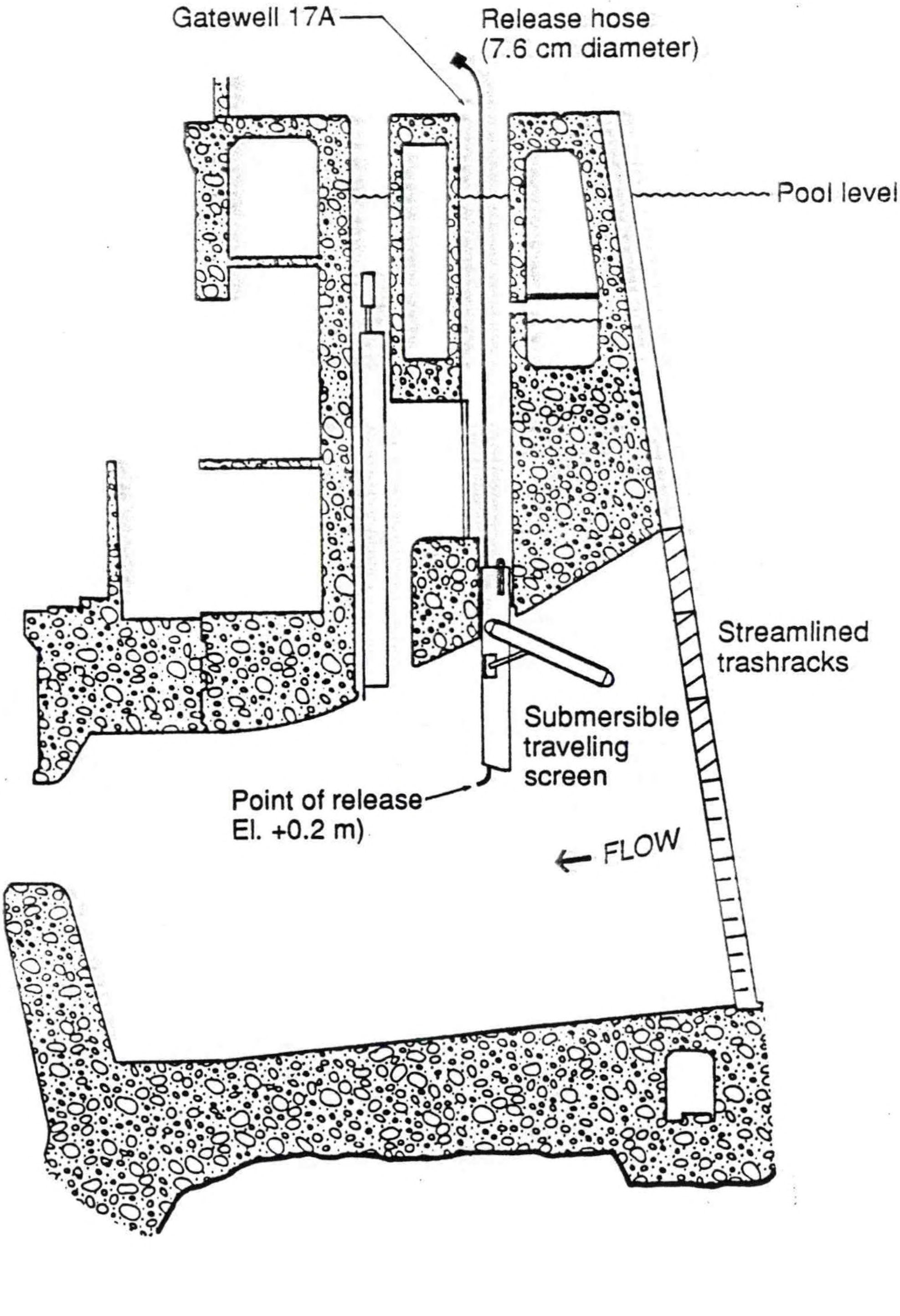

Figure 3.--Cross-section of Bonneville Dam Second Powerhouse depicting release location of lower turbine treatment group.

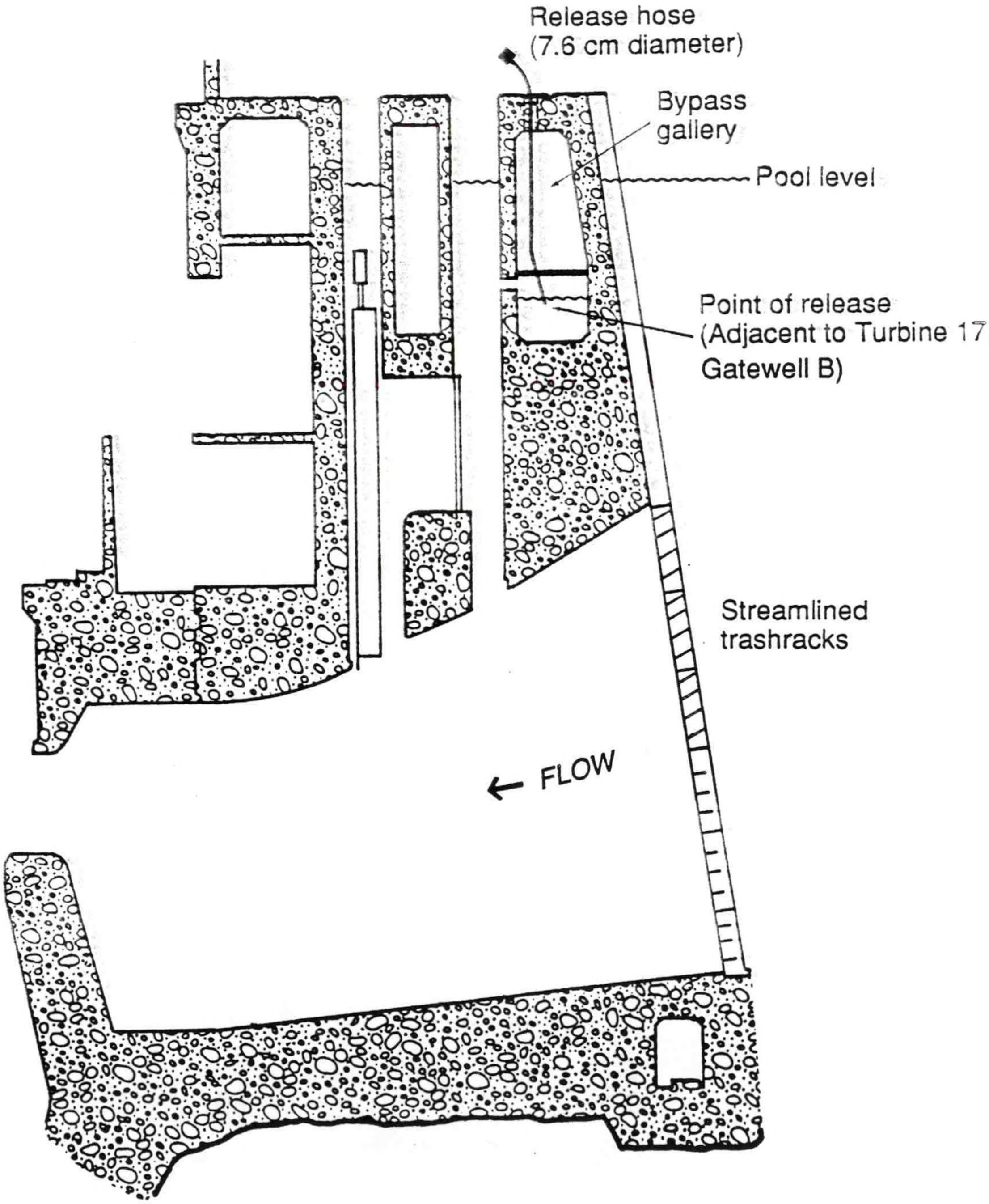

Figure 4.--Cross-section of Bonneville Dam Second Powerhouse depicting release location of bypass system treatment group.

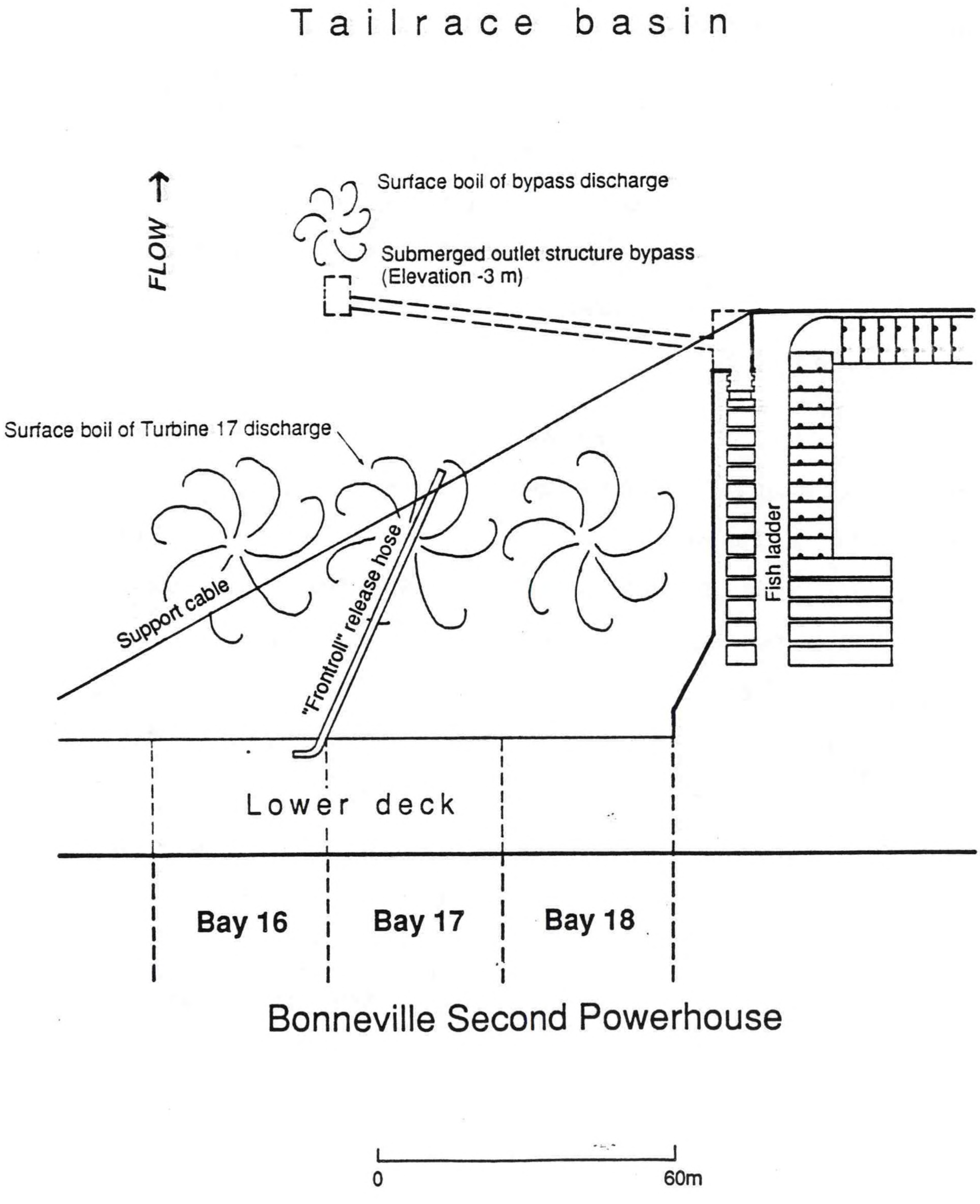

Figure 5.--Overhead view of Bonneville Dam Second Powerhouse depicting release location of the frontroll treatment group.

Recoveries of fish released at this site, when compared to recoveries of the downstream control groups, isolate effects of passage through the tailrace from effects of passage through the turbine or bypass system.

5) Downstream Control--released in mid-river, adjacent to the Hamilton Island boat launch ramp, about 2.5 km downstream from the dam. This release was presumed to be downstream from effects of the dam and away from predators inhabiting the shoreline. Recoveries of fish released at this site, when compared to recoveries of treatment groups, isolate the effects of passage through the Second Powerhouse and tailrace basin.

Release Procedure

Releases of about 150,000 marked fish were made during early morning darkness on each of 12 days. The releases took place during three time-series: six lots of marked fish were released from 27 June to 2 July, three lots were released from 13 to 15 July, and three lots were released from 22 to 24 July. The release schedule was influenced by several factors: 1) the desire to span the normal time period juvenile chinook salmon would pass Bonneville Dam; 2) logistic considerations (e.g., the time required to mark a group of fish, the desire to limit fish holding to less than 14 d between marking and release; and 3) the desire to complete testing before high water temperatures in late July. Each day's release consisted of five uniquely marked groups of about 30,000 fish/group, with one group released at each of the five release sites.

Marked fish groups for each release day were marked over the same three day period then held separately from 1 to 14 days prior to release. 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). Three trucks were used to transport fish. Two larger trucks (17,000- and 19,000-l capacities, subdivided into two compartments) were used to transport fish for the Second Powerhouse releases. A smaller truck (4,500-l capacity) was used to transport fish for the mid-river control release. Loaded trucks were driven to the Second Powerhouse and tempered with river water over a 3-hour period.

The release sequence for the Second Powerhouse treatment groups was varied according to the schedule in Appendix Table A4. Upper turbine or lower turbine groups were randomly paired with bypass or frontroll groups, and two simultaneous releases were made at each of two times, about 0200 and 0230 h.[1] These pairings were chosen so that the pattern of fish entering the tailrace would be similar at each release time. The turbine release groups entered the tailrace from the turbine discharge boil which dispersed fish over a large area (ca. 100 m^2; termed broadcast releases), and the bypass and frontroll groups entered the tailrace from a pipe or hose (termed point source releases). The truck containing the mid-river control group was driven to the Hamilton Island boat launch ramp and driven aboard a 20-m vessel (an LCM landing craft provided by the COE). At about 0300 h, the landing craft moved to mid-river and held position while the fish were released from the truck.

Turbine, bypass system, and frontroll releases were made from the transport trucks using 7.6-cm diameter smoothbore plastic hoses to direct the fish to the release point. All release-hose fittings were chamfered. Vertical distances from transport truck to the water surface were about 6 and 9 m, respectively, for turbine and bypass releases. To provide a similar vertical drop through the frontroll release hose, the end

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[1] On two occasions, we deviated from the release plan. On 30 June, the downstream control group was released at the Washington shoreline instead of the mid-river site. On 2 July, a portion of the upper turbine release group was inadvertently mixed into the downstream control group. Because of the 30 June release site problem, we released both marked groups at the downstream control release site. In the release process the fish initially marked as the upper turbine group suffered oxygen deprivation and some mortality. Recovery data from those marked fish were not used in the analyses.

of the hose was positioned 7 m above the tailwater surface and from that point test fish fell free to the water. Velocity differences between water exiting any of the release hoses and the surrounding water were calculated to be less than 15 m/sec--the lowest differential velocity shown to cause mortality of juvenile salmonids in laboratory tests (Groves 1972).

On release days, Second Powerhouse turbines 11, 16, 17, and 18 were started at about 2400 h. Turbines were operated at "name plate" specifications at near peak efficiency (66-67 MW electrical load) until about 0800 h. River flows during testing ranged from 2,700 to 4,600 m^3/sec (96,000 to 156,000 ft^3/sec); Second Powerhouse discharge ranged from 1,400 to 1,800 m^3/sec (51,000 to 62,000 ft^3/sec); and operating head was 17.9 to 20.4 m (59 to 67 ft). Effective head for Second Powerhouse turbines is about 0.4 m less than the operating head; under these conditions plant sigma varied from 0.76 to 0.96 and the calculated efficiency of the turbines remained nearly constant at 92.5%. The bypass system was automatically regulated to maintain standardized water flows at any combination of forebay and tailrace water levels. Flow data, operating conditions, and timing of releases are summarized in Appendix Table A5.

Recoveries at Jones Beach

Assessment of short-term survival among release groups was made from comparisons of branded fish recovered near the upper boundary of the Columbia River estuary at Jones Beach (a description of the site may be found in Dawley et al. 1985). Sampling was conducted by two crews, 7 days per week, 8 to 12 hours per day, beginning at sunrise (Appendix Table B1). Both purse seines (mid-river) and beach seines (Oregon shore) were used about every 3 days to determine whether Bonneville Dam study fish were migrating predominately in mid-river or nearshore. On other days, the gear type shown to catch the greatest number of study fish was used by both crews. In 1988, the majority of study fish migrated in mid-river and hence emphasis was placed on purse seining. Beach seining was limited to the Oregon shore. In 1987, most study fish migrated in shoreline areas, prompting additional beach seining on Puget Island and Washington shoreline sites. Sampling sites and fishing gear were described by Dawley et al. (1985, 1988).

All captured fish were processed aboard the purse seine vessels. The catch from each seine set was anesthetized using a solution of ethyl-*p*-aminobenzoate. Subyearling chinook salmon were examined for excised adipose fins, brands, descaling, and injury. Fork lengths of marked fish were recorded to the nearest mm. Brand information, fork length, and associated sampling data (vessel code, gear type, date, set number, and time of examination) were entered onboard into a computer database and printed to provide a paper backup.

Every marked fish with an illegible brand was sacrificed to obtain information from the coded wire tag. In addition, on Wednesday of each week, all marked test fish were sacrificed, and tag information used to evaluate errors in brand application or interpretation.

Purse seine catch data were standardized to represent a 10 set per day effort. Dates of median fish recovery for each marked group were determined using the standardized data. Mean lengths for each marked group were the averages of fish captured within 3 days of date of median recovery. Movement rates for each marked group were calculated as the distance from the downstream control release site (RKm 232) to Jones Beach (RKm 75) divided by the travel time (in days) from release date to the date of median recovery.

ATPase Analysis

Samples of about 20 fish each were periodically sacrificed at the hatchery and at Jones Beach to measure gill Na^+-K^+ ATPase activity (micromoles ATP-hydrolyzed per mg protein per hour). Gill Na^+-K^+ ATPase activity is considered a useful index for assessing the degree of smoltification of juvenile salmon in the hatchery and after migration to the estuary (Zaugg and McLain 1970). In the hatchery, samples were taken beginning 7 April and biweekly thereafter through 14 July. At Jones Beach, samples were taken on 6 July, 13 July, 24 July, and 29 July, targeting, respectively, groups released on 27 June, 2 July, 13 July, and 22 July. All analyses were performed by W. Zaugg and staff, NMFS, Cook, Washington.

Statistical Analysis

Differences among recovery percentages for each marked group at Jones Beach were evaluated by analysis of variance using a randomized block design where each release day was considered a block (Sokal and Rohlf 1981). Transformations of percentages were not required. 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).

Comparative survival estimates for the turbine and bypass treatment groups were calculated relative to the frontroll and downstream control groups as the ratio of treatment to control recoveries (x 100). Relative survival estimates can be used to gain insight into the location(s) of fish passage problems. Confidence intervals for relative survival estimates (Burnham et al. 1987) were calculated using standard errors from randomized block analysis of variance. Paired t-tests were used to evaluate the hypothesis that time (h) of release did not affect recovery percentages.

RESULTS

In 1988, a total of 1,813,318 fish were marked with freeze brands, coded-wire tags, and excised adipose fins (Table 2). A total of 9,129 study fish were recovered in the estuary (ca. 0.5% of those released); most were mid-river migrants captured with purse seines (Appendix Tables B2 and B3). Handling mortality was less than 0.5%.

Migration Behavior and Fish Condition

Movement rates of study fish from the release sites at Bonneville Dam to Jones Beach ranged from 12.1 to 26.2 km/day. Movement rates of fish from the last three release groups (22, 23, and 24 July) were uniformly higher than fish released earlier (Table 3). Assessment of migrational timing differences among treatment groups released on the same day showed no significant difference for 11 of 12 release lots ($\alpha = 0.05$) and no difference when the results of the individual tests were pooled ($\alpha = 0.10$) (See Appendix D, Part I for statistical approach). Timing differences among treatment groups for each of the 12 release lots were plotted (Appendix Fig. C1-C3) for comparison with the same data standardized for sampling effort (Figs. 6 and 7). Substantial differences between recovery patterns, observed vs. standardized data, were not apparent (Appendix Table B2).

The temporal catch pattern at Jones Beach of fish released during the first date series was bimodally distributed (Fig. 6); whereas, catch patterns for fish from subsequent release lots were more normally distributed (Fig. 7). Hence, data from the first release series were divided into two segments to evaluate possible differences in recoveries affecting survival estimates (Appendix Table B4). Other than growth, there were no apparent between-mode differences for any treatment group.

Comparison of fork length distributions of study fish at release to those at Jones Beach suggest that all groups grew during migration (Fig. 8; Appendix Figs. C4 and

Table 2.--Bonneville Dam survival study; releases of marked subyearling chinook salmon during June and July, 1988.

Marking dates	Release date	Number released[a]	Brand[b]	Wire tag code[c]
Upper Turbine Releases				
13-15 June	27 June	29,745	RDLU1	232502R3
15-20 "	28 "	30,720	RDLU3	232513R3
20-22 "	29 "	29,964	RDLY1	232522R3
22-24 "	30 "	30,067	RDLY3	232532R3
27-29 "	01 July	30,278	RDLI1	232542R3
01-06 July	13 "	30,260	LDLU1	232562R3
07-09 "	14 "	30,240	LDLU3	232608R3
11-13 "	15 "	30,676	LDLY1	232619R3
13-15 "	22 "	30,382	LDLY3	232628R3
15-19 "	23 "	30,068	LDLI1	232638R3
19-21 "	24 "	30,096	LDLI3	232649R3
	Total =	332,496		
Lower Turbine Releases				
13-15 June	27 June	29,929	RDTC1	232508R3
16-20 "	28 "	30,664	RDTC3	232519R3
20-22 "	29 "	29,868	RDLC1	232528R3
23-25 "	30 "	30,112	RDLC3	232538R3
27-29 "	01 July	29,817	RDLX1	232549R3
29 June - 01 July	02 "	30,432	RDLX3	232559R3
01-06 July	13 "	30,236	LDTC1	232604R3
07-09 "	14 "	30,069	LDTC3	232614R3
11-13 "	15 "	29,928	LDLC1	232625R3
13-15 "	22 "	30,096	LDLC3	232635R3
15-19 "	23 "	30,116	LDLX1	232644R3
19-21 "	24 "	30,079	LDLX3	232655R3
	Total =	361,346		

Table 2.--Continued.

Marking dates	Release date	Number released[a]	Brand[b]	Wire tag code[c]
Bypass System Releases				
13-15 June	27 June	29,899	RDTJ1	232501R3
15-20 "	28 "	30,291	RDTJ3	232511R3
20-22 "	29 "	29,999	RDLJ1	232521R3
22-24 "	30 "	30,085	RDLJ3	232531R3
27-29 "	01 July	30,269	RDLT1	232541R3
29 June - 01 July	02 "	30,296	RDLT3	232550R3
01 July	13 "	1,180	RDTJ1	232561R3[d]
01-06 July	13 "	29,097	LDTJ1	232561R3
07-09 "	14 "	30,217	LDTJ3	232607R3
11 July	15 "	2,938	LDTJ1	232616R3[e]
11-13 "	15 "	27,019	LDLJ1	232616R3
13 July	22 "	966	LDLJ3	232631R3[f]
13-15 "	22 "	30,679	LDLJ3	232626R3
15-19 "	23 "	30,046	LDLT1	232637R3
19-21 "	24 "	30,106	LDLT3	232647R3
	Total =	363,087		
Frontroll Releases				
13-15 June	27 June	29,666	RDUY1	232507R3
16-20 "	28 "	30,554	RDUY3	232516R3
20-22 "	29 "	30,363	RDTY1	232526R3
23-25 "	30 "	30,073	RDTY3	232537R3
27-29 "	01 July	30,470	RDTX1	232547R3
29 June - 01 July	02 "	30,110	RDTX3	232556R3
01-06 July	13 "	30,218	LDUY1	232602R3
07-09 "	14 "	30,202	LDUY3	232613R3
11-13 "	15 "	30,935	LDTY1	232622R3
13-15 "	22 "	29,112	LDTY3	232632R3
15-19 "	23 "	30,056	LDTX1	232642R3
19-21 "	24 "	30,117	LDTX3	232652R3
	Total =	361,876		

Table 2.--Continued.

Marking dates	Release date	Number released[a]	Brand[b]	Wire tag code [c]
Dwonstream Control Releases				
13-15 June	27 June	30,684	RDTU1	232504R3
15-17 "	28 "	30,716	RDTU3	232514R3
20-22 "	29 "	30,002	RDUC1	232525R3
20-24 "	30 "	30,068	RDUC3	232535R3[g]
27-29 "	01 July	30,235	RDTI1	232544R3
29 June - 01 July	02 "	30,732	RDTI3	232555R3
29 June - 01 July	02 "	30,274[h]	RDLI3	232552R3[h]
01-06 July	13 "	29,934	LDTU1	232601R3
07-09 "	14 "	30,237	LDTU3	232611R3
11-13 "	15 "	30,897	LDUC1	232621R3
13-15 "	22 "	30,576	LDUC3	232631R3
15-19 "	23 "	30,052	LDTI1	232641R3
19-21 "	24 "	30,106	LDTI3	232650R3
	Total =	364,239		

Total of all release groups = 1,813,318

[a] Number released not corrected for tag loss.

[b] Brand position RD (right dorsal) or LD (left dorsal) followed by the two-letter brand used. The numbers 1 or 3 indicate brand rotation.

[c] NMFS agency code (23) followed by two digit codes for data 1 and data 2; data 3 denotes three-code replicate wire.

[d] Incorrect brand; brand should have been LDTJ1.

[e] Incorrect brand; brand should have been LDLJ1.

[f] Incorrect tag; wire tag code should have been 232626R3.

[g] Released near shore at Hamilton Island boat launch ramp.

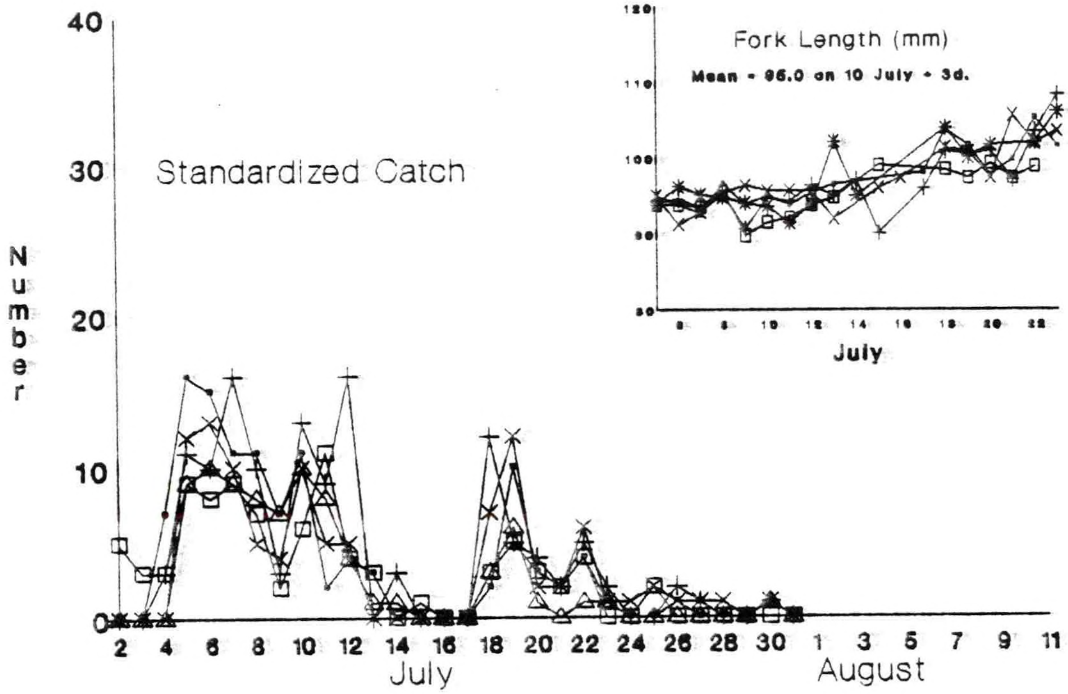
[h] Oxygen deprivation mortality of unknown extent prior to release; not used in analysis. Number released not included in release total.

Table 3.--Movement rates from Bonneville Dam to Jones Beach for marked groups of subyearling chinook salmon, 1988.

	Movement rate (km/day)*					
Release date	Upper turbine	Lower turbine	Bypass system	Frontroll	Downstream control	Mean
27 June	12.1	12.1	12.1	12.1	12.1	12.1
28 June	15.7	13.1	14.3	14.3	13.1	14.1
29 June	15.7	14.3	15.7	15.7	14.3	15.1
30 June	14.3	14.3	15.7	15.7	14.3	14.9
1 July	15.7	15.7	13.1	15.7	14.3	14.9
2 July	15.7	13.1	17.4	15.7	14.3	15.2
13 July	14.3	14.3	14.3	14.3	14.3	14.3
14 July	14.3	14.3	14.3	13.1	14.3	14.1
15 July	14.3	14.3	15.7	14.3	15.7	14.9
22 July	22.4	19.6	19.6	22.4	19.6	20.7
23 July	22.4	22.4	22.4	22.4	19.6	21.8
24 July	22.4	22.4	22.4	22.4	26.2	23.2

* Purse seine recoveries standardized to a 10 set per day effort (Appendix Table B2). Movement rate = distance from the control release site (RKm 232) to recovery site (RKm 75) ÷ travel time in days from release to median fish recovery.

28 June 1988 Release



1 July 1988 Release

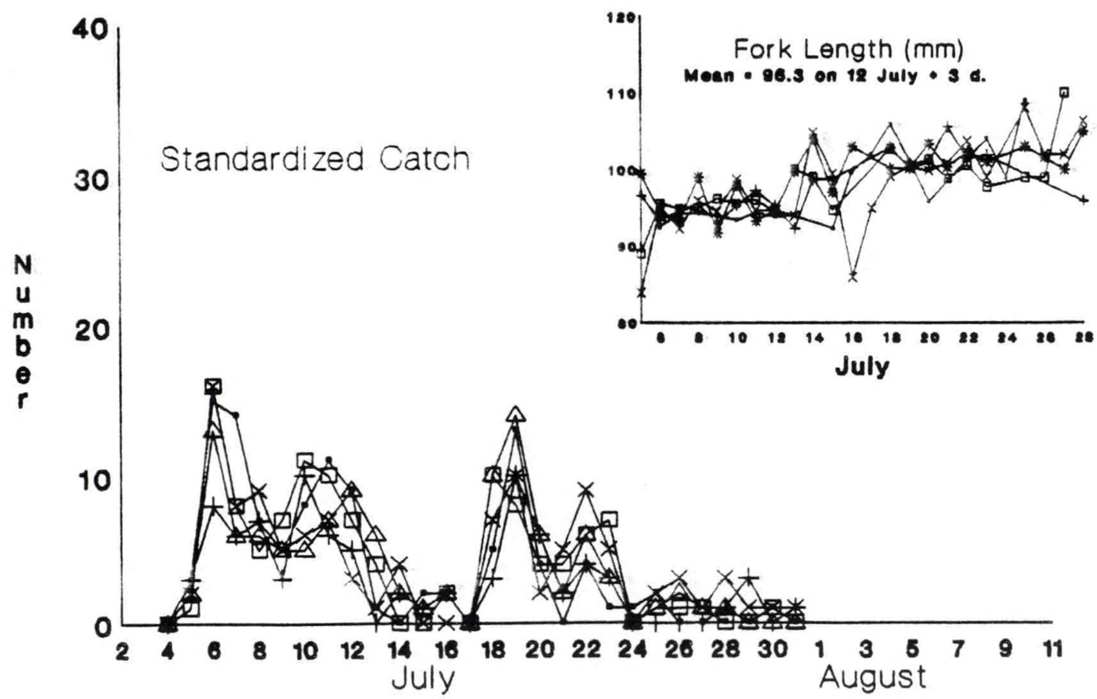
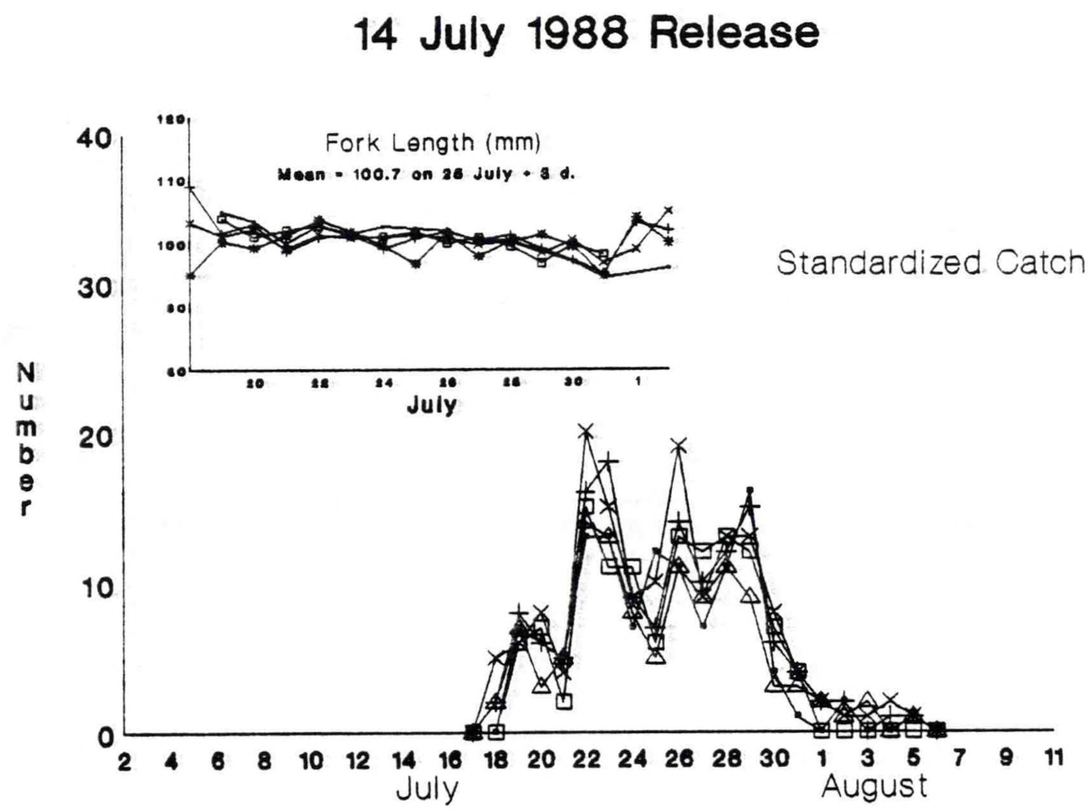


Figure 6.--Daily catches (standardized for effort) and daily mean fork lengths of subyearling chinook salmon recovered at Jones Beach, 1988. Mean fork length for the control group (within 3 days of the date of median recovery) is indicated. These data are representative of the first release series.



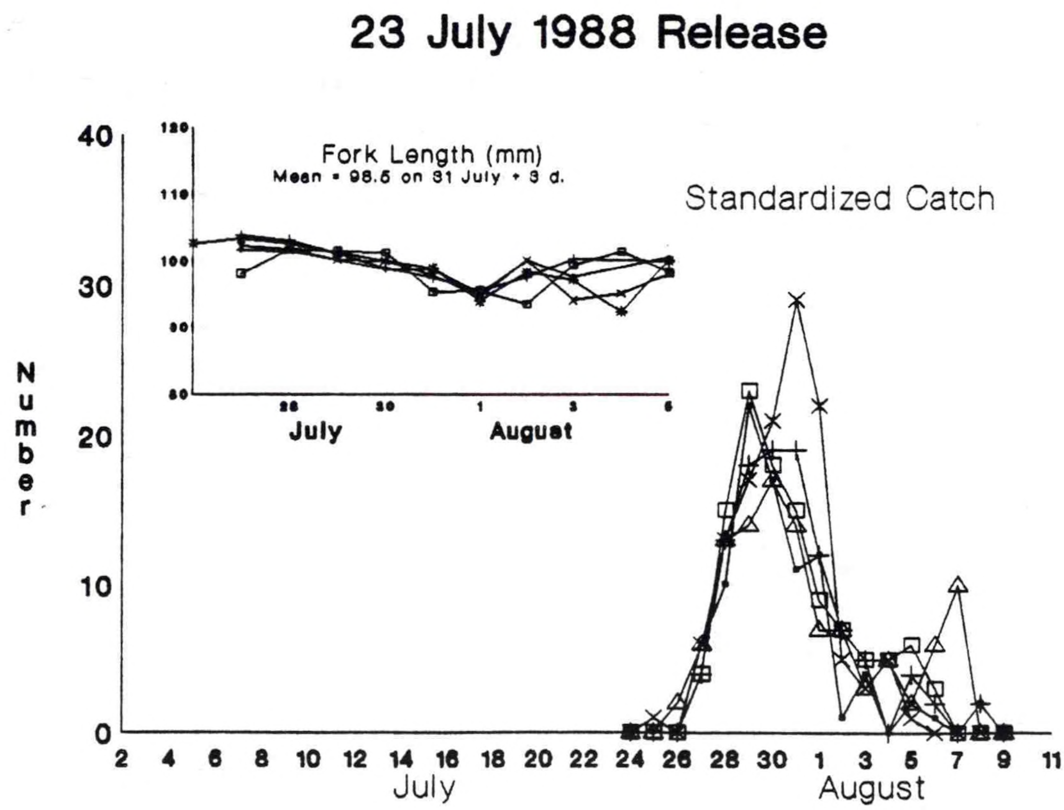


Figure 7. --Daily catches (standardized for effort) and daily mean fork lengths of subyearling chinook salmon recovered at Jones Beach, 1988. Mean fork length for the control group (within 3 days of the date of median recovery) is indicated. These data are representative of the second and third release series.

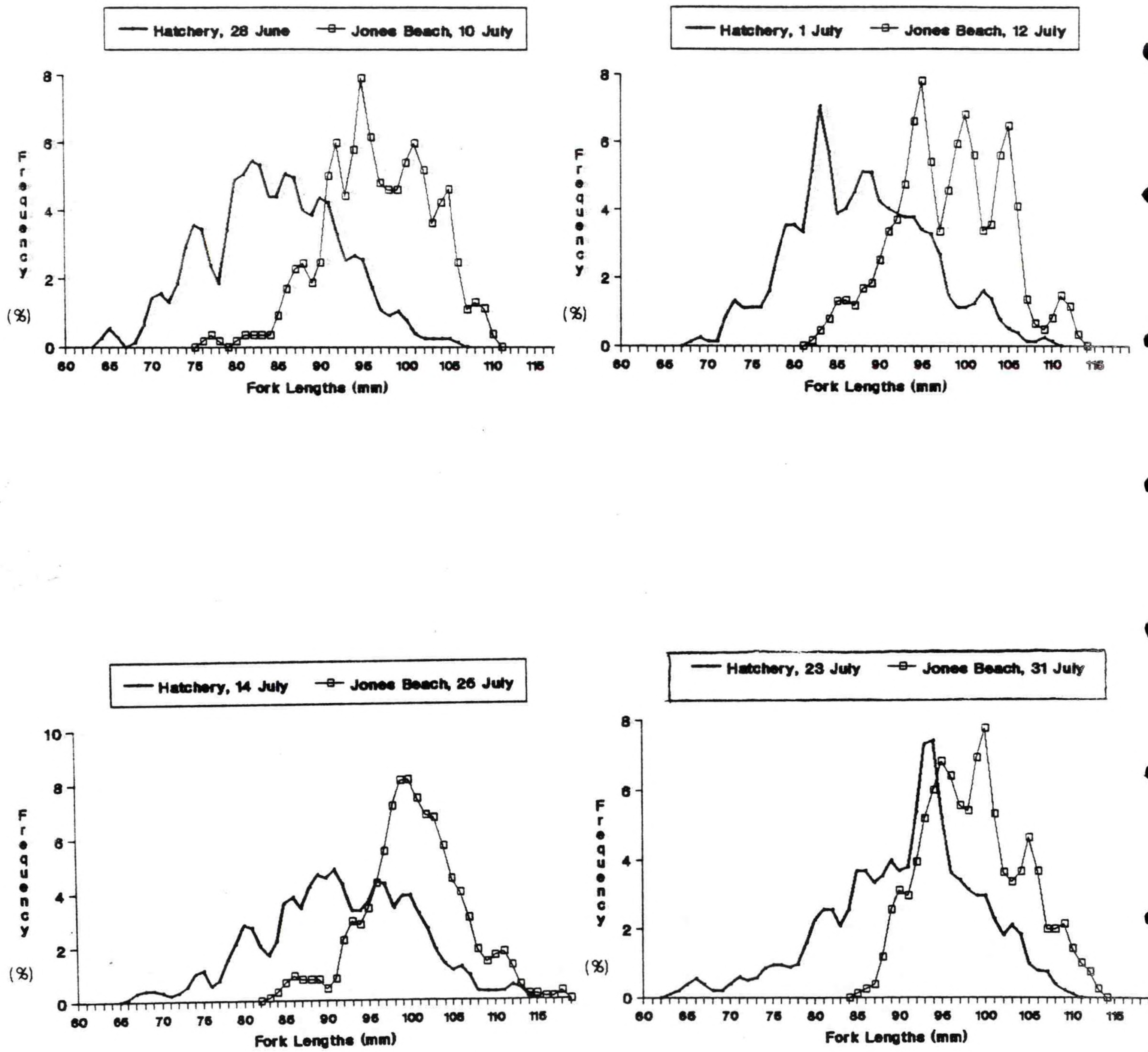


Figure 8.--Fork length distributions for fish at release and at recovery in the estuary, 1988. Representative releases are presented with release date and median recovery.

C5). The frequency distributions for the largest individuals were similar at both sites (allowing for a growth rate of 1 mm per day). However, the smallest individuals released during the second and third series were not observed at Jones Beach (previous sampling at Jones Beach indicates no size selectivity with purse seines for migrants within this size range; Dawley et al. 1986).

In the hatchery, ATPase activity of study fish peaked about 6 weeks prior to the start of marking, then declined (Fig. 9); during the hatchery monitoring period, mean ATPase activity was 15.3 (SE = 1.12). After migration to Jones Beach, the mean ATPase activity was higher ($\bar{x}$ = 30.6, SE = 1.57). Visual inspection of these limited data suggest no linear relationships among ATPase activity at Jones Beach (Fig. 9) and date (Fig. 6), fish size (Fig. 7 and 8), or movement rate (Table 3).

Descaling of test fish recovered at Jones Beach ranged from 1.8% to 2.9%; there were no apparent effects from treatment or date of release (Table 4). No injured or moribund test fish were recovered.

Juvenile Recovery Differences

Mean recoveries at Jones Beach from the upper turbine, lower turbine, bypass, frontroll, and downstream control groups were 0.50, 0.51, 0.44, 0.51, and 0.57%, respectively (Fig. 10). Statistical analyses of brand recoveries at Jones Beach (Table 5) indicate that recovery percentages for the downstream control groups were significantly greater (α = 0.05) than recovery percentages for the frontroll and turbine groups. The recovery percentages of the frontroll and turbine groups were, in turn, significantly greater (α = 0.05) than recovery percentages for the bypass groups (see Appendix D, Part II for statistical approach). Selected subsets of the recovery data were also statistically analyzed. These included: the full data set minus release Day 4 (when the control release was compromised); recovery data standardized to a 10 set per day effort with and without release Day 4 (only the purse seine data were used in this analysis

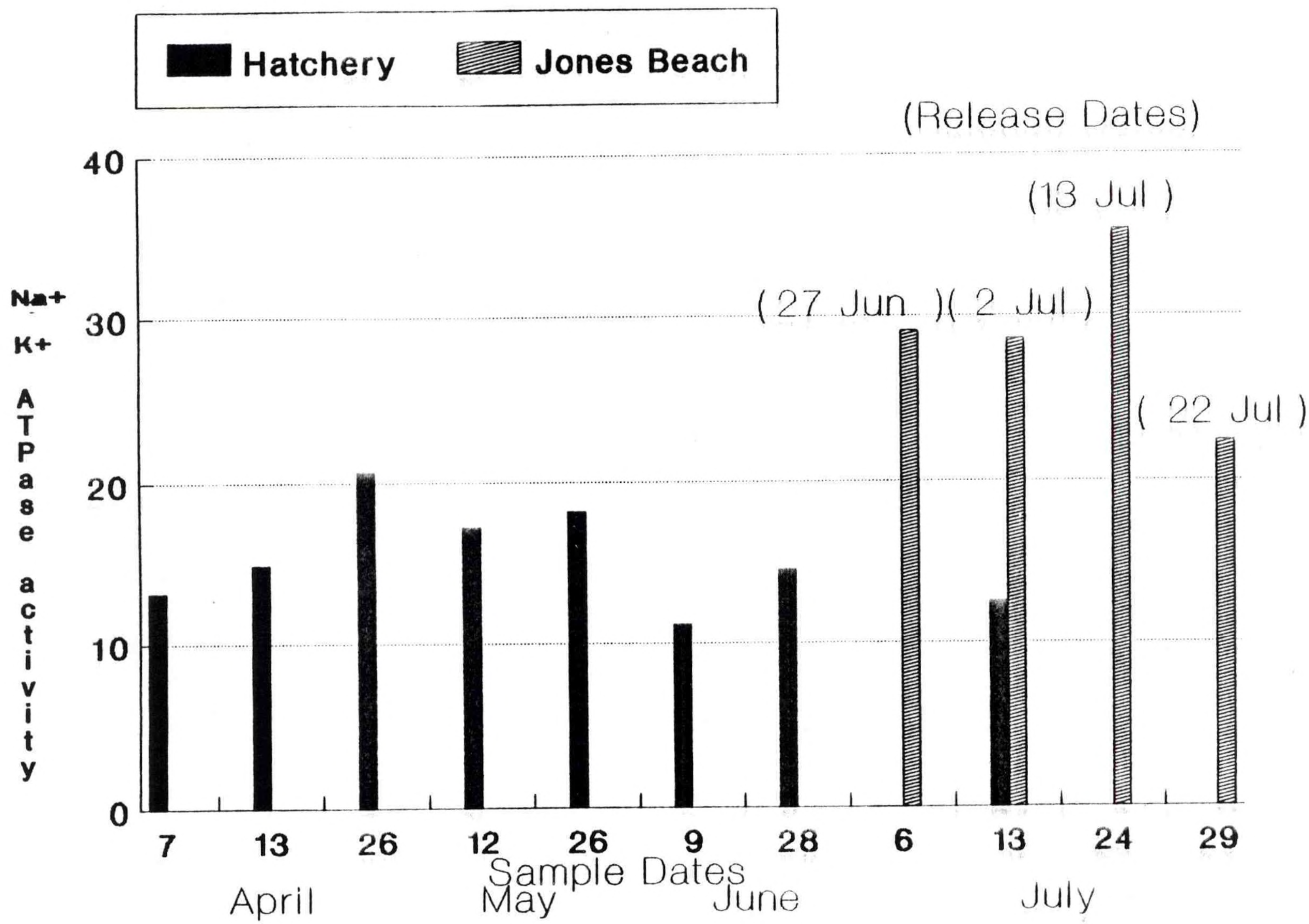


Figure 9.--Changes in gill Na^{+}-K^{+} ATPase activity in subyearling chinook salmon at Bonneville Hatchery prior to release and following migration to Jones Beach, 1988. Analyses by W. Zaugg (NMFS, Cook, Washington; units are micromoles ATP hydrolyzed per mg protein per hour.

Table 4.--Descaling among marked groups of subyearling chinook salmon recovered at Jones Beach, 1988.

Release date[a]	Recoveries									
	Upper turbine		Lower turbine		Bypass system		Frontroll		Downstream control	
	No.	%[b]	No.	%	No.	%	No.	%	No.	%
27 June	1	0.7	5	3.5	1	0.8	1	0.7	1	0.7
28 June	1	0.7	3	1.7	2	1.7	3	2.5	3	2.2
29 June	0	0.0	2	1.5	4	3.3	1	0.7	5	3.1
30 June	4	2.8	2	1.5	3	2.1	4	2.8	4	2.9[c]
1 July	1	0.6	1	0.8	6	4.2	5	3.1	6	3.8
2 July	-----[d]		2	1.4	1	1.0	0	0.0	2	1.3
13 July	5	3.0	2	1.1	6	4.1	2	1.2	5	2.9
14 July	4	2.4	4	2.0	6	3.9	4	2.3	7	3.3
15 July	7	4.5	5	3.3	5	3.5	4	2.3	8	3.8
22 July	6	3.5	5	2.8	7	5.5	5	3.0	7	3.3
23 July	6	4.5	5	3.2	3	2.3	2	1.3	3	1.6
24 July	2	1.3	5	4.2	2	1.5	2	1.4	6	3.0
Total	37	2.2	41	2.2	46	2.9	33	1.8	57	2.8

[a] All fish were released during early morning darkness.

[b] Percent of fish recovered.

[c] Released on the the shoreline at the Hamilton Island boat ramp (located downstream of the Dam).

[d] Mortality occurred at release; data not used in analysis.

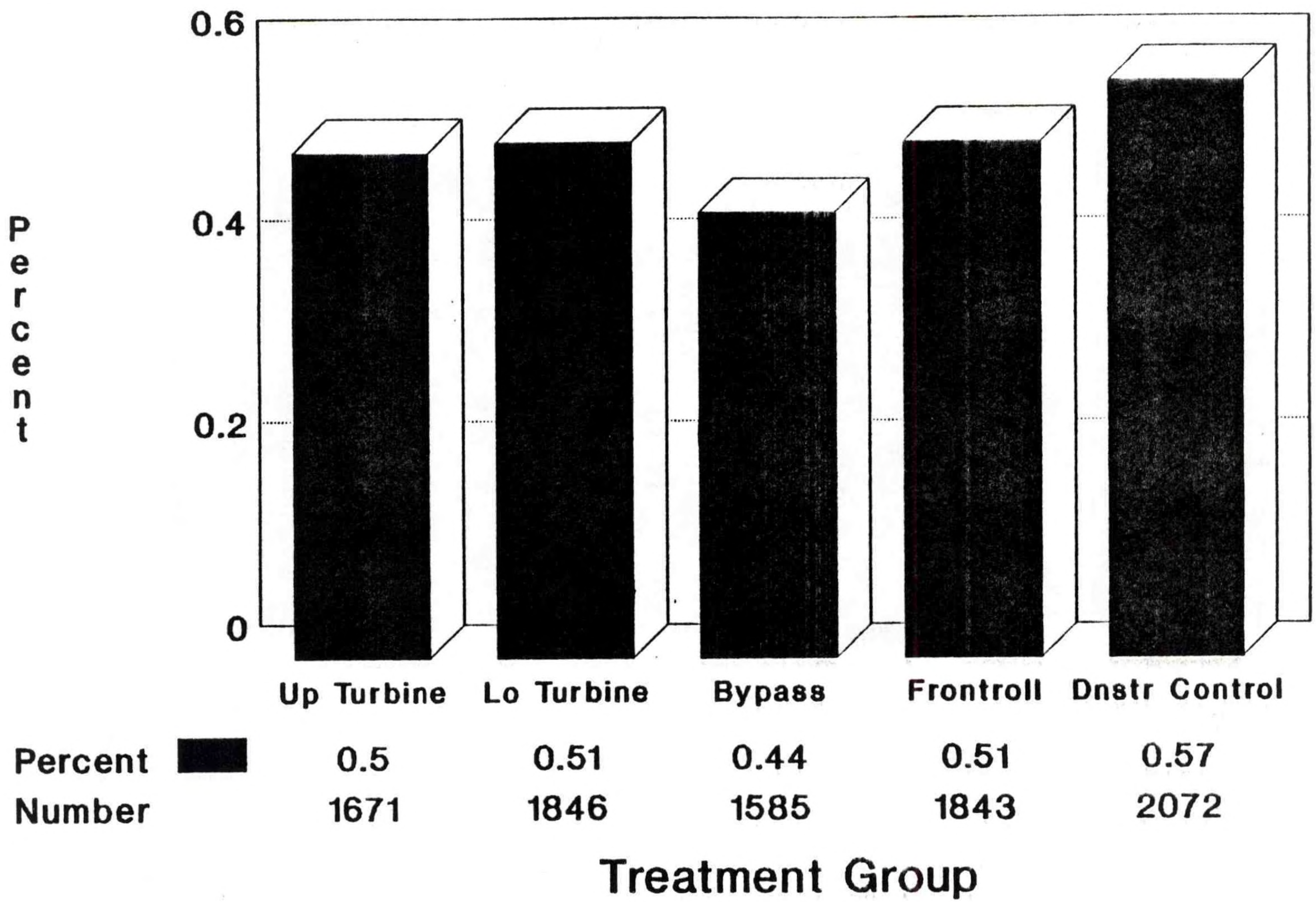


Figure 10.--Mean recovery percentages for treatment groups of subyearling chinook salmon following migration to Jones Beach, 1988.

Table 5.--Bonneville Dam survival study; percent estuarine recovery of branded subyearling chinook salmon, 1988.

	Percent recovered				
Release date[a]	Upper turbine	Lower turbine	Bypass system	Frontroll	Downstream control
27 June	0.47	0.48	0.40	0.50	0.43
28 "	0.48	0.56	0.38	0.38	0.45
29 "	0.47	0.46	0.41	0.48	0.54
30 "	0.48	0.46	0.48	0.47	0.46[b]
1 July	0.51	0.44	0.47	0.52	0.52
2 "	----[c]	0.48	0.33	0.46	0.50
13 "	0.54	0.58	0.50	0.56	0.57
14 "	0.56	0.66	0.50	0.58	0.70
15 "	0.50	0.51	0.48	0.57	0.68
22 "	0.57	0.58	0.40	0.58	0.68
23 "	0.44	0.52	0.45	0.52	0.62
24 "	0.51	0.40	0.43	0.49	0.67
Mean[d]	0.50	0.51	0.44	0.51	0.57
Total released	332,496	361,346	363,087	361,876	364,239
Total recovered	1,671	1,845	1,585	1,843	2,072

[a] Fish were released during early morning darkness.

[b] Released on the shoreline downstream from the dam at the Hamilton Island boat launch ramp.

[c] Mortality occurred at release; data not used in analysis.

[d] Weighted by number released; i.e., mean = (total recovered ÷ total released) X 100.

because the beach seine effort was inconsistent through the period and recoveries of marked fish by beach seine represented less than 5% of the total); and beach seine data only. Conclusions from these analyses were the same as those reached with the complete data set except for beach seine recoveries (Appendix Fig. C6) which were too few (408 total) for meaningful statistical conclusions.

Since it was not possible to release all treatment groups simultaneously, effects of release time was evaluated. We compared the 12 lots of recovery data (i.e., by release date) for first vs. last release time (0200 vs. 0230 h); all treatments were adjusted to an equal mean recovery percentage. The hypothesis that there was no significant difference between recoveries from first vs. last releases was rejected for point source releases (bypass and frontroll) ($t = -2.58$, $df = 11$; $\alpha = 0.05$), and not rejected for broadcast releases (upper and lower turbine) ($t = 0.40$).

Comparative Survival Estimates

Short-term survival of fish after passage through the turbines or the bypass relative to the frontroll release groups was estimated using Jones Beach recovery data (Table 6). Estimates of mean relative survival of the turbine groups were not significantly different from 100% ($\alpha = 0.05$). However, estimated mean relative survival of the bypass groups (85.7%) was significantly lower than 100% ($\alpha = 0.05$; 95% C.I., 79.9-91.5%).

Short-term survival of fish after passage through the dam and the tailrace basin relative to downstream control groups was also estimated from the Jones Beach recovery data (Table 7). The results indicated passage through the tailrace basin significantly lowered ($\alpha = 0.05$) the estimated relative survival of all treatment groups. Mean relative survival for the frontroll release groups, which experienced no treatment other than migration through the tailrace basin, was 89.5% (95% C.I., 84.7-94.3%).

Table 6.--Comparative survival (percent of frontroll)[a] estimates from Jones Beach sampling of marked groups of subyearling chinook salmon passing through Bonneville Dam Second Powerhouse, 1988.

Release date[b]	Upper turbine	Lower turbine	Bypass system
27 June	95.0	97.1	81.8
28 "	125.0	146.5	100.0
29 "	97.8	95.3	85.8
30 "	101.4	97.8	102.1
1 July	96.8	83.0	90.0
2 "	----[c]	103.9	71.7
13 "	96.9	103.5	89.1
14 "	95.9	113.1	86.2
15 "	88.8	90.4	84.5
22 "	97.5	100.7	68.6
23 "	85.2	99.8	86.6
24 "	104.8	81.7	88.5
Mean[d]	98.7	100.3	85.7
SE[e]	2.93	2.81	2.81

[a] (Treatment % ÷ Frontroll %) x 100.

[b] Fish were released during early morning darkness.

[c] Mortality occurred at release; data not used in analysis.

[d] Weighted by number.

[e] Empirical standard error = $\sqrt{MSE/n}$; MSE (mean squared error) from randomized block ANOVA; n = number of blocks.

Table 7.--Comparative survival (percent of downstream control)[a] estimates from Jones Beach sampling of marked groups of subyearling chinook salmon passing through Bonneville Dam Second Powerhouse and/or tailrace basin, 1988.

Release date[b]	Upper turbine	Lower turbine	Bypass system	Frontroll
27 June	110.3	112.7	95.0	116.1
28 "	106.5	124.8	85.2	85.2
29 "	86.0	83.8	75.5	87.0
30 "	104.3	100.6	105.0	102.9
1 July	97.9	84.0	91.0	101.1
2 "	----[c]	95.8	66.1	92.2
13 "	94.9	101.3	87.2	97.9
14 "	79.2	93.4	71.3	82.6
15 "	74.3	75.7	70.7	83.7
22 "	82.8	85.6	58.2	84.9
23 "	71.8	84.1	73.0	84.3
24 "	75.9	59.2	64.0	72.4
Mean[d]	88.3	89.8	76.7	89.5
SE[e]	2.43	2.33	2.33	2.33

[a] (Treatment % ÷ Control %) x 100.

[b] Fish were released during early morning darkness.

[c] Mortality occurred at release; data not used in analysis.

[d] Weighted by number.

[e] Empirical standard error = $\sqrt{MSE/n}$; MSE (mean squared error) from randomized block ANOVA; n = number of blocks.

Bypass release groups following migration through the tailrace basin had an estimated mean relative survival of 76.7% (95% C.I., 71.9-81.5%).

Brand Illegibility

On short-term survival estimates, the potential bias introduced by poor brand retention was minimized by using tag information in lieu of brand information for fish with illegible brands. Estimates of brand illegibility were obtained in the hatchery after holding samples of about 250 fish from each of the 60 marked groups for a minimum of 30 days, and after fish migrated to Jones Beach (Appendix C). In the hatchery sample, brand illegibility varied widely between groups (range 4.5 to 35.5%, N = 9,536), and the illegibility was significantly higher for the bypass groups ($\bar{x}$ = 19.5%; α = 0.05) than for the other groups (range of means 10.5 to 12.4%). At Jones Beach, the illegibility in the bypass groups was significantly higher ($\bar{x}$ = 15.9%; α = 0.05) than the other groups (range of means 6.8 to 12.3%). The lower illegibility observed at Jones Beach may be explained in part by the more smolted condition of the fish (more contrast between fish and brand).

DISCUSSION AND CONCLUSIONS

In 1988, recoveries of marked subyearling chinook salmon at Jones Beach indicated significantly decreased survival of fish released in the Second Powerhouse bypass system compared to other passage routes. In addition, the survival decrease associated with passage of fish through the tailrace basin appeared to be greater than passage through the turbine. Furthermore, results from estuarine sampling suggested that the transportation of downstream control groups from the shoreline to mid-river for release was successful at providing a control that was apparently less impacted by predators inhabiting shoreline areas. This was an important improvement in experimental design as all groups were now released at mid-river locations.

The lower recovery percentages of fish released into the bypass, as in 1987, remains unexplained. Several efforts by the COE were made to inspect the bypass system for physical problems during 1987 and 1988, but no major problems were identified. The water depth in the downwell portion of the bypass system was increased about 1 m for the final three release groups in 1988, but the short-term survival estimates remained about 14% lower than for the turbine releases.

By random chance, bypass groups were released first more often than frontroll groups (7 vs. 5 times), and there may have been greater predation on the first test fish entering the tailrace, with the greatest impact occurring on point source releases. The estimated difference in recovery percentage associated with being released first was -0.0298 ± 0.0115; $\bar{x} \pm SE$. Based on differences of mean recovery percentages, the net effect was to subtract 0.0025% (0.0298% ÷ 12 releases) from the mean of the bypass recovery percentage and add an equivalent amount to the mean of the frontroll recovery percentage. This is insignificant compared to the differences related to treatment. In 1989, randomizing of release timing will include a balance among treatments.

In 1988, movement rates of study fish to the estuary were two to three times higher than in 1987. Since river flows and the degree of smoltification (as indicated by levels of ATPase activity in fish recovered in the estuary) were similar for both years, the increased rate of migration in 1988 was probably due to the larger size and mid-river migration. As a consequence of the faster migration and larger size, we suspect that 1988 study fish were subjected to less predation in fresh water and a greater percentage of juveniles survived to enter the ocean than in 1987.

Significant differences in descaling of fish among treatment groups were not observed in 1988. Moreover, the low prevalence of descaled fish observed was consistent with prevalences previously observed in hatchery fish recovered at Jones Beach (Dawley et al. 1986). Taken together with the knowledge that not all descaled fish die and that fish showing signs of scale regeneration are frequently recovered at Jones Beach, these data suggest descaling was not a serious problem.

Comparative survival differences between treatments were not consistent through time. For marked lots from the first release series, recovery rates of treatment groups exceeded the control in 10 of 23 comparisons; this occurred in only 1 of 24 comparisons during the final two release series. The only obvious difference in recovery data between the first series and the others was the bimodal distribution of recoveries. The catch patterns were similar for all groups released the same day. There may have been differential predation on test fish by squawfish between the early and late release periods. Uremovich et al. (1980) reported a decline in squawfish abundance in the vicinity of Bonneville Dam during June and early July followed by a rapid increase in abundance in mid-July and August. Vigg et al. (1988) reported that June is the spawning period for squawfish in the John Day reservoir and that squawfish during this period have lower food consumption. Therefore, during the present study, the later release lots may have been subjected to higher predation than earlier lots, and the downstream controls may have escaped this predation by being released in fast-flowing water downstream from the dam.

Despite our efforts to sacrifice all fish with an illegible brand at Jones Beach, there was a 3% interpretation/recording error in the one-day-per-week subsample of sacrificed fish having legible brands (27 mismatches between recorded brand and tag information out of 848 comparisons). The effect of these errors was to remove fish from the bypass groups and add fish to the control groups; the other treatment groups were less affected (Table 8). When the corrections were extrapolated to the entire recovery data set, there was no change in statistical conclusions. Moreover, the sample size from the one-day-per-week sample is too small to justify any attempt to correct the data for the other 6 days. In 1987, brand to tag comparisons were made only once, and results showed a lower rate of error and no effect on bypass group data. In 1989, all branded fish will be sacrificed for tag identification. Final evaluation of comparative survival differences will be made using returns of tagged adults.

The utility of recovering downstream migrant salmonids in the estuary and using recovery precentages to estimate relative survival has been evaluated in several previous studies conducted by NMFS between 1966 and 1983 (Dawley et al. 1986). However, to make the transition between recovery rate and survival in this study several assumptions must be made. Some of those assumptions are as follows:

1) Release groups were identical except for the treatment (e.g., size, health, smoltification, and handling).
2) Errors in mark application and identification were insignificant compared to treatment differences.
3) Differences in release procedures (e.g., release-hose hydraulic head and exit conditions) had insignificant effects on survival compared to treatment differences.
4) Differences in release time and distribution into the tailrace had insignificant effects on survival compared to treatment differences.

Table 8.--Bonneville Dam survival study; changes in numbers of marked fish by treatment groups recovered during the one-day-per-week sampling for incorrectly identified or recorded brands, 1988 (N = 848).

Release date	Upper turbine	Lower turbine	Bypass system	Frontroll	Downstream control
27 June	-1	0	+2	-1	-1
28 June	0	-1	-1	0	0
29 June	0	-1	+3	0	0
30 June	0	0	-1	0	0
1 July	0	0	+1	0	+2
2 July	0	+1	+1	+1	-4
13 July	0	+1	0	+2	-1
14 July	-2	0	0	-1	0
15 July	+1	0	+1	0	+1
22 July	0	0	0	0	-1
23 July	+1	0	-1	-1	-1
24 July	0	+1	0	0	0
Totals	-1	+1	+5	0	-5

5) Differences in vertical and lateral distribution within the river downstream of the control release site had insignificant effects on survival compared to treatment differences.

6) Probability of recovery was equal for all treatments (groups were mixed).

We feel confident all of these assumptions are being met. Great care was taken to mark all treatments simultaneously, provide identical handling following marking, and minimize differences between release conditions. In 1988, results of mid-channel purse seine sampling at Jones Beach showed no indication of timing or size differences between treatment groups released the same day (using observed catches or catches standardized for effort). Additional sites were not sampled. In 1987, beach seine catch results from three beach sites (south, north, and mid-river shorelines) were similar and there was no evidence of timing or spatial differences between groups released the same day (Dawley et al. 1988). These results are consistent with the hypothesis of adequate mixing of study fish at Jones Beach in both years.

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A special thanks is given to the captain and crew of the COE ship *Essayons*. While conducting emergency dredging in the Jones Beach vicinity during the study period, the *Essayons* kept us informed about their immediate dredging plans and generally helped us coordinate fish sampling to provide maximum clearances for all vessels using the congested area.

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APPENDIX A. Marking and release information: schedules, randomization, tag loss percentages, and physical data.

Appendix Table A1.--Schedule for simultaneous marking of five treatment groups for the Bonneville Dam survival study, 1988.

		Number marked[a]				
Day	Marking time (h)	Bypass system	Upper turbine	Downstream control	Frontroll	Lower turbine
1	3.5	5,000[b]	2,500	2,500	2,500	2,500
1	3.5	2,500	5,000[b]	2,500	2,500	2,500
1	3.5	2,500	2,500	5,000[b]	2,500	2,500
1	3.5	2,500	2,500	2,500	5,000[b]	2,500
2	3.5	2,500	2,500	2,500	2,500	5,000[b]
2	3.5	5,000[b]	2,500	2,500	2,500	2,500
2	3.5	2,500	5,000[b]	2,500	2,500	2,500
2	3.5	2,500	2,500	5,000[b]	2,500	2,500
3	3.5	2,500	2,500	2,500	5,000[b]	2,500
3	3.5	2,500	2,500	2,500	2,500	5,000[b]
Totals	35.0	30,000	30,000	30,000	30,000	30,000

[a] Five of the six available marking stations were assigned to specific treatment groups throughout the marking. The remaining station alternated production among the five treatment groups. This schedule was repeated 12 times during the marking project.

[b] Includes 2,500 fish marked by the station assigned to this group and 2,500 fish marked by the alternating station.

Appendix Table A2.--Schedule used for random rotation of fish marking teams while marking five treatment groups for the Bonneville Dam survival study, 1988.

Marking team [a]	Sequence for marking treatment groups[b]									
1	FR	DC	UT	LT	BY	BY	UT	LT	DC	FR
2	DC	UT	LT	BY	FR	DC	LT	FR	UT	BY
3	UT	LT	BY	FR	DC	UT	FR	BY	LT	DC
4	LT	BY	FR	DC	UT	LT	BY	DC	FR	UT
5	BY	FR	DC	UT	LT	FR	DC	UT	BY	LT
6	No rotation[c]									
7	UT	LT	BY	FR	DC	LT	FR	BY	UT	DC
8	BY	UT	FR	DC	LT	FR	DC	LT	BY	UT
9	FR	BY	DC	LT	UT	DC	UT	FR	LT	BY
10	DC	FR	LT	UT	BY	UT	BY	DC	FR	LT
11	LT	DC	UT	BY	FR	BY	LT	UT	DC	FR
12	No rotation[c]									

[a] The sequence of rotations took approximately five days to complete and resulted in each marking team (one brander and one clipper/tagger) contributing equal numbers of marked fish to each of the five treatments.

[b] FR = front roll; DC = downstream control; UT = upper turbine; LT = lower turbine; BY = bypass. This sequence of rotations was repeated six times.

[c] Team worked at a marking station where wire tag codes and brands were alternated.

Appendix Table A3.--Results of tests evaluating tag loss among marked groups of subyearling chinook salmon after a 30-day holding period; Bonneville Dam survival study, 1988.

Tag code	Sample no.	Tag loss no.	Tag loss %	Tag code	Sample no.	Tag loss no.	Tag loss %
Upper turbine releases				Lower turbine releases			
232502R3	245	3	1.2	232508R3	224	5	2.2
232513R3	229	6	2.6	232519R3	167	4	2.4
232522R3	188	6	3.2	232528R3	149	1	0.7
232532R3	112	7	6.3	232538R3	126	0	0.0
232542R3	113	2	1.8	232549R3	146	1	0.7
232562R3	211	4	1.9	232559R3	188	3	1.6
232608R3	239	6	2.5	232604R3	152	4	2.6
232619R3	152	3	2.0	232614R3	147	2	1.4
232628R3	143	4	2.8	232625R3	131	0	0.0
232638R3	131	2	1.5	232635R3	157	2	1.3
232649R3	184	2	1.1	232644R3	173	4	2.3
				232655R3	239	1	0.4
Subtotals	1,947	45	x = 2.3	Subtotals	1,999	27	x = 1.4
Bypass system releases				Frontroll releases			
232501R3	89	2	2.2	232507R3	212	2	0.9
232511R3	82	0	0.0	232516R3	198	1	0.5
232521R3	120	1	0.8	232526R3	198	3	1.5
232531R3	106	1	0.9	232537R3	128	1	0.8
232541R3	159	3	1.9	232547R3	168	3	1.8
232550R3	105	2	1.9	232556R3	146	2	1.4
232561R3	83	2	2.4	232602R3	197	2	1.0
232607R3	85	3	3.5	232613R3	188	3	1.6
232616R3	80	1	1.2	232622R3	187	14	7.5
232626R3	106	1	0.9	232632R3	120	4	3.3
232637R3	147	2	1.4	232642R3	211	15	7.1
232647R3	138	0	0.0	232652R3	178	1	0.6
Subtotals	1,300	18	x = 1.4	Subtotals	2,131	51	x = 2.4
Downstream control releases							
232504R3	256	2	0.8				
232514R3	208	3	1.4				
232525R3	195	4	2.1				
232535R3	162	1	0.6				
232544R3	112	1	0.9				
232552R3	136	7	5.1				
232555R3	85	0	0.0				
232601R3	215	5	2.3				
232611R3	202	6	3.0				
232621R3	153	8	5.2				
232631R3	144	6	4.2				
232641R3	150	4	2.7				
232650R3	141	3	2.1				
Subtotals	2,159	50	x = 2.4				

Appendix Table A4.--Release sequences used during the Bonneville Dam survival study, 1988.

Date	First release (0200 h)	Second release (0230 h)
June 27	Lower turbine & Bypass	Upper turbine & Frontroll
28	Upper turbine & Frontroll	Lower turbine & Bypass
29	Lower turbine & Bypass	Upper turbine & Frontroll
30	Lower turbine & Frontroll	Upper turbine & Bypass
July 1	Lower turbine & Frontroll	Upper turbine & Bypass
2	Lower turbine & Bypass	Upper turbine & Frontroll
13	Upper turbine & Frontroll	Lower turbine & Bypass
14	Lower turbine & Frontroll	Upper turbine & Bypass
15	Upper turbine & Bypass	Lower turbine & Frontroll
22	Upper turbine & Bypass	Lower turbine & Frontroll
23	Lower turbine & Bypass	Upper turbine & Frontroll
24	Upper turbine & Bypass	Lower turbine & Frontroll

Appendix Table A5.--Flow data, operating conditions, tempering times and release times during the Bonneville Dam survival study, 1988.

METRIC UNITS

	Columbia R.		Second Powerhouse			Turbine 17			Release times (h)					Temper time
			Elevation											
Date	Flow ($k \cdot m^3/s$)	Temp. (°C)	Forebay (m)	Tailrace (m)	Flow[a] ($k \cdot m^3/s$)	Flow ($k \cdot m^3/s$)	Head (m)	Load (MW)	UT[b]	LT	BY	FR	DC	(h)
06/27	4.6	18.3	22.5	4.6	1.8	0.42	17.9	67	0411	0330	0330	0411	0530	2.00
06/28	4.2	18.3	22.7	4.3	1.7	0.40	18.3	67	0200	0240	0240	0200	0320	3.25
06/29	4.4	18.9	22.8	4.4	1.7	0.39	18.4	67	0230	0200	0200	0230	0310	3.00
06/30	3.2	18.9	22.8	3.7	1.6	0.39	19.1	67	0245	0200	0245	0200	0530[c]	3.50
07/01	2.8	18.9	22.7	3.3	1.6	0.38	19.4	67	0230	0200	0230	0200	0310	3.00
07/02	2.8	18.9	23.1	3.2	1.6	0.38	19.9	67	0340[d]	0207	0207	0240	0310[d]	3.00
07/13	3.9	19.4	22.9	4.1	1.6	0.39	18.8	66	0200	0230	0230	0200	0320	3.00
07/14	3.4	18.9	23.0	3.7	1.6	0.38	19.2	66	0230	0200	0230	0200	0300	3.00
07/15	3.4	18.9	23.1	3.7	1.6	0.38	19.4	66	0200	0237	0200	0237	0307	3.00
07/22	3.5	20.6	23.0	3.8	1.6	0.38	19.2	66	0215	0253	0215	0253	0323	3.00
07/23	3.0	20.6	23.2	3.4	1.5	0.37	19.8	66	0230	0200	0200	0230	0300	3.00
07/24	2.7	20.6	23.3	2.9	1.4	0.36	20.4	66	0200	0230	0200	0230	0255	3.00

Appendix Table A5.--Continued.

ENGLISH UNITS

	Columbia R.		Second Powerhouse			Turbine 17			Release times (h)					
			Elevation											Temper time
Date	Flow (k·ft³/s)	Temp. (°F)	Forebay (ft)	Tailrace (ft)	Flow[a] (k·ft³/s)	Flow (k·ft³/s)	Head (ft)	Load (MW)	UT[b]	LT	BY	FR	DC	(h)
06/27	164.2	65	73.7	15.0	62.4	14.7	58.7	67	0411	0330	0330	0411	0530	2.00
06/28	150.0	65	74.7	14.2	60.5	14.2	60.1	67	0200	0240	0240	0200	0320	3.25
06/29	155.5	66	74.8	14.3	60.1	13.9	60.5	67	0230	0200	0200	0230	0310	3.00
06/30	112.4	66	74.7	12.2	57.8	13.9	62.5	67	0245	0200	0245	0200	0530[c]	3.50
07/01	99.7	66	74.4	10.7	56.6	13.4	63.7	67	0230	0200	0230	0200	0310	3.00
07/02	100.7	66	75.9	10.5	55.1	13.5	65.4	67	0340[d]	0207	0207	0240	0310[d]	3.00
07/13	139.1	67	75.2	13.5	55.2	13.6	61.7	66	0200	0230	0230	0200	0320	3.00
07/14	120.4	66	75.5	12.3	54.8	13.4	63.1	66	0230	0200	0230	0200	0300	3.00
07/15	119.8	66	75.7	12.2	54.8	13.3	63.5	66	0200	0237	0200	0237	0307	3.00
07/22	124.7	69	75.5	12.4	55.2	13.4	63.1	66	0215	0253	0215	0253	0323	3.00
07/23	105.6	69	76.1	11.0	54.4	13.1	65.1	66	0230	0200	0200	0230	0300	3.00
07/24	96.0	69	76.5	9.6	51.2	12.8	66.9	66	0200	0230	0200	0230	0255	3.00

[a] Derived from Fig. 8-02.1 in Allis-Chalmer (1978).

[b] Codes for groups; UT = upper turbine, LT = lower turbine, BY = bypass system, FR = frontroll, and DC = downstream control.

[c] Release was made near shore at the Hamilton Island boat launch ramp.

[d] Both the downstream control and the upper turbine groups were released at the downstream control site.

APPENDIX B. Recovery of juveniles: sampling effort, selected physical data, daily recoveries, and data standardization.

Appendix Table B1.--Daily purse seine and beach seine fishing effort, water temperatures, and Secchi disk turbidity measurements at Jones Beach during the Bonneville Dam survival study, 1988.

	Number of sets		Temp.	Secchi		Number of sets		Temp	Secchi
Date	Purse	Beach	°C	m	Date	Purse	Beach	°C	m
22 Jun	0	3	17	1.5	21 Jul	13	2	20	1.1
23 Jun	2	3	17	---[a]	22 Jul	14	2	20	---
24 Jun	0	0	--	---	23 Jul	15	0	20	1.1
25 Jun	0	0	--	---	24 Jul	12	0	21	0.8
26 Jun	0	0	--	---	25 Jul	12	0	21	0.9
27 Jun	0	4	17	1.4	26 Jul	13	2	21	1.1
28 Jun	3	2	17	1.4	27 Jul	15	0	21	---
29 Jun	3	2	17	1.4	28 Jul	16	0	21	0.9
30 Jun	2	2	17	1.4	29 Jul	14	2	21	0.9
1 Jul	2	2	17	---	30 Jul	18	0	21	0.8
2 Jul[b]	2	2	17	---	31 Jul	17	0	21	0.9
3 Jul	3	4	17	--	1 Aug	12	0	21	0.8
4 Jul	3	4	17	1.8	2 Aug	11	3	21	1.5
5 Jul	10	2	17	1.1	3 Aug	10	0	20	---
6 Jul	10	0	17	0.9	4 Aug	6	0	21	---
7 Jul	16	2	19	1.1	5 Aug	9	0	20	1.4
8 Jul	17	1	19	0.9	6 Aug	0	0	20	---
9 Jul	15	5	20	0.9	7 Aug	2	4	20	0.8
10 Jul	17	0	20	0.8	8 Aug	4	0	20	---
11 Jul	18	0	21	0.9	9 Aug	3	0	20	---
12 Jul	10	1	21	0.9	10 Aug	4	0	21	0.9
13 Jul	7	9	21	0.9	11 Aug	0	4	19	0.9
14 Jul	9	3	19	1.1	12 Aug	0	5	--	---
15 Jul	6	10	19	0.9	13 Aug	0	0	--	---
16 Jul	4	7	19	0.9	14 Aug	0	0	--	---
17 Jul	4	6	19	0.9	15 Aug	2	5	21	---
18 Jul	6	10	20	0.9	16 Aug	0	5	21	1.4
19 Jul	13	3	21	0.9	17 Aug	2	3	21	---
20 Jul	18	0	20	1.1	18 Aug	1	3	21	1.1

[a] --- = data not available.

[b] First recovery of study fish.

Appendix Table B2.--Daily purse seine recoveries of marked groups, recoveries standardized for effort, dates of median fish recovery, mean lengths, and movement rates to Jones Beach; Bonneville Dam survival study, 1988.

Release date = 27 June (Julian 179) — Recapture information

Site[a] / Brand[b]	UT RDLU1			LT RDTC1			BY RDTJ1			FR RDUY1			DC RDTU1		
Date[c]	Act.[d]	FL[e]	Adj.[f]	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.
184															
185															
186							1	94.0	3						
187	8	94.3	8	8	91.3	8	9	91.8	9	12	92.3	12	18	96.1	18
188	11	94.0	11	14	95.4	14	12	91.3	12	13	94.2	13	12	91.4	12
189	15	93.3	9	23	93.7	14	10	97.0	6	16	95.3	10	14	92.5	9
190	14	95.6	8	16	93.8	9	9	91.2	5	11	94.0	6	3	100.0	2
191	10	92.2	7	8	94.4	5	10	94.6	7	11	93.9	7	8	97.1	5
192	28	92.5	16[g]	20	95.1	12[g]	16	91.9	9[g]	22	95.7	13[g]	19	95.2	11[g]
193	17	93.8	9	10	93.6	6	12	93.8	7	23	93.0	13	15	93.9	8
194	7	92.7	7	6	95.0	6	5	94.0	5	3	95.7	3	11	96.4	11
195	1	92.0	1	1	95.0	1	3	99.0	4				1	99.0	1
196				1	91.0	1				1	115.0	1	1	97.0	1
197													1	102.0	2
198															
199				1	99.0	2				1	93.0	2			
200	2	100.0	3	1	99.0	2	3	99.0	5	2	98.5	3	3	105.0	5
201	3	102.0	2	5	99.6	4	6	101.7	5	9	96.9	7	8	100.8	6
202	6	103.0	3	5	103.8	3	1	99.0	1	2	102.0	1	2	97.5	1
203	1	110.0	1	2	100.5	2	2	102.0	2	1	102.0	1			
204	4	103.0	3	7	100.9	5	7	101.6	5	6	100.2	4	4	103.5	3
205	2	98.5	1	3	100.0	2	2	92.0	1	2	99.5	1			
206				2	102.5	2	1	97.0	1				1	104.0	1
207	1	97.0	1							1	100.0	1			
208							1	105.0	1				1	118.0	1
209															
210				1	110.0	1	1	90.0	1						
211	1	116.0	1	1	121.0	1	1	101.0	1	1	109.0	1			
212				1	110.0	1	1	98.0	1				1	109.0	1
213				1	97.0	1	1	101.0	1						
214															
215															
216															
217															
218															
219															
220															
221															
222															
223															
Totals:	131	93.3	91	137	94.2	102	114	93.8	92	137	94.5	99	123	95.0	98
Movement rate[h]	12.1			12.1			12.1			12.1			12.1		

Release date = 28 June (Julian 180) — Recapture information

Site[a] / Brand[b]	UT RDLU3			LT RDTC3			BY RDTJ3			FR RDUY3			DC RDTU3		
Date[c]	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.
184										1	102.0	5			
185										1	96.0	3			
186	2	100.5	7	1	92.0	3				1	98.0	3			
187	16	95.6	16	11	94.2	11	9	93.9	9	9	94.2	9	12	95.0	12
188	15	93.9	15	10	94.4	10	10	96.2	10	8	93.8	8	13	91.2	13
189	18	92.6	11	25	93.4	16	14	95.1	9	14	93.5	9	16	93.3	10
190	19	96.6	11[g]	17	95.5	10	13	94.8	8	12	95.6	7	9	95.2	5
191	10	93.8	7	5	90.6	3	11	94.8	7[g]	3	89.7	2[g]	6	96.3	4
192	19	94.9	11	22	94.7	13[g]	17	93.6	10	11	91.5	6	17	95.6	10[g]
193	4	93.8	2	17	94.2	9	15	91.4	8	20	92.1	11	9	95.7	5
194	4	97.3	4	16	96.3	16	4	93.8	4	4	93.8	4	5	95.6	5
195	2	96.5	3				1	102.0	1	2	92.5	3			
196				3	97.0	3	1	95.0	1						
197										1	96.0	2			
198															
199															
200	1	103.0	2	7	101.0	12	2	105.5	3	2	99.0	3	4	100.5	7
201	13	101.6	10	7	100.3	5	8	100.5	6	6	97.3	5	16	100.7	12
202	5	97.6	3	7	100.9	4	2	101.5	1	5	99.2	3	3	97.3	2
203	3	99.7	2	2	97.0	2				3	97.3	2	2	105.5	2
204	6	105.2	4	7	103.4	5	2	102.0	1	6	98.8	4	8	101.8	6
205	2	101.5	1	3	108.3	2	1	106.0	1				2	103.5	1
206													1	100.0	1
207										3	108.3	2	2	104.5	2
208	1	105.0	1	2	108.5	2							1	96.0	1
209				2	106.0	1							1	104.0	1
210													1	106.0	1
211				1	105.0	1									
212	1	103.0	1				1	109.0	1				1	105.0	1
213															
214															
215															
216															
217															
218															
219															
220															
221															
222															
223															
Totals:	141	94.6	111	165	94.5	128	111	94.1	80	111	93.0	91	129	95.0	101
Movement rate[h]	15.7			13.1			14.3			14.3			13.1		

Appendix Table B2.--Continued.

Release date = 29 June (Julian 181) — Recapture information

Site[a] Brand[b]	UT RDLY1			LT RDLC1			BY RDLJ1			FR RDTY1			DC RDUC1		
Date[c]	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.
184															
185															
186	1	101.0	3	1	101.0	3				1	96.0	3			
187	12	95.9	12	9	94.0	9	8	97.0	8	7	95.0	7	8	94.0	8
188	9	94.2	9	10	95.3	10	18	93.6	18	14	92.9	14	15	94.1	15
189	23	93.8	14	14	97.5	9	14	93.4	9	25	92.4	16	21	94.0	13
190	11	93.7	6	13	94.5	8	10	94.5	6	10	95.5	6	12	97.8	7
191	7	94.6	5[d]	9	93.6	6	6	93.5	4[d]	7	95.4	5[d]	13	91.7	9
192	15	91.5	9	10	94.4	6[d]	8	96.5	5	17	92.4	10	18	94.7	11[d]
193	12	93.2	7	17	93.9	9	11	90.9	6	11	93.8	6	17	94.4	9
194	8	95.4	8	2	92.5	2	7	94.4	7	3	95.7	3	5	96.8	5
195										1	85.0	1	1	100.0	1
196	1	95.0	1	1	100.0	1				1	91.0	1	1	105.0	1
197															
198							1	99.0	2						
199							1	101.0	2	1	95.0	2			
200				2	93.0	3				3	102.3	5	5	101.6	8
201	5	103.8	4	13	100.0	10	6	100.7	5	12	102.2	9	7	97.3	5
202	8	97.8	4	7	101.1	4	3	100.7	2	5	98.2	3	10	98.1	6
203	1	107.0	1	4	95.0	3	1	96.0	1	3	104.7	2	1	106.0	1
204	9	98.7	6	4	102.8	3	8	103.5	6	6	102.3	4	5	102.0	4
205	6	98.7	4	3	106.0	2	1	109.0	1	4	103.5	3	1	101.0	1
206				2	110.0	2	2	103.0	2				1	98.0	1
207	1	103.0	1	2	101.0	2							3	102.7	2
208	1	99.0	1	1	104.0	1	1	110.0	1	1	105.0	1	2	108.5	2
209													2	105.5	1
210	4	108.0	3												
211										1	101.0	1			
212							1	100.0	1						
213													1	116.0	1
214															
215															
216															
217															
218															
219															
220															
221															
222															
223															
Totals	134	93.5	98	124	94.8	93	107	93.7	86	133	93.4	102	149	93.4	111
Movement rate[h]	15.7			14.3			15.7			15.7			14.3		

Release date = 30 June (Julian 182) — Recapture information

Site[a] Brand[b]	UT RDLY3			LT RDLC3			BY RDLJ3			FR RDTY3			SC RDUC3		
Date[c]	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.
184															
185															
186															
187	6	93.8	6	7	94.9	7	14	95.9	14	13	95.1	13	13	98.2	13
188	15	93.8	15	10	96.1	10	8	94.0	8	10	92.8	10	11	95.5	11
189	13	94.6	8	18	95.9	11	13	94.8	8	14	91.9	9	11	96.0	7
190	7	97.4	4	7	97.7	4	12	95.9	7	7	94.7	4	9	96.4	5
191	3	96.3	2	6	95.7	4	6	98.5	4	8	95.4	5	3	94.3	2
192	16	97.8	9	13	93.1	8	21	95.4	12[d]	18	94.3	11[d]	12	93.1	7
193	12	93.3	7[d]	20	93.9	11[d]	10	91.9	6	14	95.3	8	16	96.1	9[d]
194	9	96.9	9	1	93.0	1	4	94.0	4	6	93.2	6	4	98.5	4
195				1	108.0	1	2	94.0	3						
196	2	98.5	2				3	104.0	3	1	105.0	1	1	101.0	1
197	1	102.0	2				1	97.0	2						
198															
199	1	98.0	2				1	102.0	2						
200	2	100.5	3	4	100.0	7	4	103.0	7	5	99.8	8	2	99.0	3
201	20	99.8	15	14	99.9	11	10	100.5	8	9	101.4	7	13	98.9	10
202	6	101.0	3	7	100.0	4	7	103.7	4	9	97.1	5	9	104.8	5
203	1	107.0	1	1	95.0	1	2	101.0	2	2	97.5	2			
204	12	101.8	9	8	102.3	6	9	101.3	6	7	103.1	5	9	104.4	6
205	2	100.5	1	3	102.3	2	1	106.0	1	3	99.0	2	4	102.8	3
206				2	98.5	2	2	97.5	2	1	102.0	1	3	103.0	2
207				3	103.0	2							1	96.0	1
208	3	101.0	2				4	108.0	3	5	102.2	4	2	103.5	2
209				1	104.0	1	2	101.5	1	1	108.0	1	1	105.0	1
210													2	109.0	1
211				1	95.0	1									
212															
213															
214															
215															
216															
217															
218															
219															
220															
221															
222															
223															
Totals	131	96.4	100	127	94.7	94	136	95.0	107	133	94.1	102	126	95.6	93
Movement rate[h]	14.3			14.3			15.7			15.7			14.3		

Appendix Table B2.--Continued.

Release date = 1 July (Julian 183) — Recapture information

Site[a] / Brand[b] / Date[c]	UT RDLI1 Act.	UT RDLI1 FL	UT RDLI1 Adj.	LT RDLX1 Act.	LT RDLX1 FL	LT RDLX1 Adj.	BY RDLT1 Act.	BY RDLT1 FL	BY RDLT1 Adj.	FR RDTX1 Act.	FR RDTX1 FL	FR RDTX1 Adj.	DC RDTI1 Act.	DC RDTI1 FL	DC RDTI1 Adj.
184															
185															
186															
187	3	97.0	3	3	96.7	3	2	99.5	2	1	89.0	1	2	84.0	2
188	15	92.5	15	8	93.4	8	13	94.4	13	16	95.6	16	16	95.2	16
189	22	94.3	14	10	94.6	6	10	93.3	6	13	94.8	8	12	92.3	8
190	12	94.3	7	12	95.6	7	10	99.0	6	8	96.6	5	15	95.9	9
191	7	94.9	5	5	93.0	3	7	91.7	5	10	96.2	7	8	94.5	5
192	14	93.4	8	17	95.3	10	9	98.1	5	18	95.6	11	10	98.8	6
193	19	94.4	11[g]	11	97.4	6[g]	12	93.3	7	18	96.1	10[g]	13	94.7	7
194	9	93.9	9	5	95.2	5	9	94.7	9	7	95.7	7	3	94.7	3[g]
195	1	94.0	1				4	103.0	6[g]	3	100.0	4	1	94.0	1
196				2	97.5	2	2	104.0	2	1	95.0	1	4	101.0	4
197	1	102.0	2	1	105.0	2	1	99.0	2	1	99.0	2			
198	1	105.0	2												
199															
200	3	104.0	5	2	103.0	3	7	104.3	12	6	102.3	10	4	101.3	7
201	17	101.2	13	13	99.5	10	18	100.2	14	11	100.5	8	13	100.1	10
202	8	95.8	4	10	100.8	6	10	103.3	6	8	101.3	4	4	99.8	2
203				2	105.5	2	3	100.3	2	5	98.8	4	6	100.8	5
204	6	101.3	4	5	101.4	4	8	102.3	6	9	100.6	6	13	103.7	9
205	1	104.0	1	5	101.8	3	4	101.0	3	9	97.8	6	8	99.8	5
206	1	99.0	1												
207	2	109.0	2				1	103.0	1	1	99.0	1	2	108.0	2
208							2	101.5	2	1	99.0	1	4	102.0	3
209							1	100.0	1	1	110.0	1	1	102.0	1
210				1	96.0	1	1	105.0	1				4	106.3	3
211				4	105.5	3							1	105.0	1
212	1	96.0	1							1	111.0	1	1	95.0	1
213				1	119.0	1							1	104.0	1
214															
215															
216															
217															
218										1	104.0	1			
219															
220															
221															
222															
223															
Totals	143	94.1	108	117	95.7	85	134	96.6	111	149	96.2	115	146	96.3	111
Movement rate[h]	15.7			15.7			13.1			15.7			14.3		

Release date 2 July (Julian 184) — Recapture information

Site[a] / Brand[b] / Date[c]	MC RDLI3 Act.	MC RDLI3 FL	MC RDLI3 Adj.	LT RDLX3 Act.	LT RDLX3 FL	LT RDLX3 Adj.	BY RDLT3 Act.	BY RDLT3 FL	BY RDLT3 Adj.	FR RDTX3 Act.	FR RDTX3 FL	FR RDTX3 Adj.	DC RDTI3 Act.	DC RDTI3 FL	DC RDTI3 Adj.
184															
185															
186															
187										1	97.0	1			
188	2	94.5	2	3	93.0	3	3	96.7	3	6	97.5	6	4	95.3	4
189	11	97.0	7	14	99.5	9	15	96.6	9	16	98.8	10	8	93.3	5
190	7	99.9	4	15	99.0	9	2	98.5	1	9	97.6	5	9	98.7	5
191	4	103.3	3	4	96.3	3	10	93.8	7	6	92.7	4	7	93.6	5
192	12	97.5	7	16	96.9	9	13	99.7	8	14	96.2	8	15	99.2	9
193	20	96.8	11	16	97.8	9	9	99.0	5[g]	15	99.7	8	16	95.6	9
194	5	98.8	5[g]	3	101.3	3	4	98.8	4	6	100.0	6[g]	8	97.5	8
195	1	101.0	1	1	100.0	1	2	102.5	3	3	102.7	4	4	94.5	6[g]
196	1	107.0	1	2	102.0	2[g]	1	96.0	1	4	101.8	4	1	102.0	1
197	1	105.0	2	2	102.5	3				1	103.0	2	1	107.0	2
198				1	109.0	2									
199	1	98.0	2	1	98.0	2							1	106.0	2
200	4	100.3	7	3	105.7	5	2	102.0	3	2	100.0	3	3	95.3	5
201	7	100.7	5	13	102.3	10	3	97.3	2	6	105.5	5	15	101.1	12
202	6	106.2	3	11	102.2	6	11	102.8	6	6	102.3	3	9	103.8	5
203	3	97.7	2	2	96.5	2	2	100.0	2	2	102.5	2	4	100.5	3
204	5	101.2	4	15	102.3	11	5	101.2	4	10	103.0	7	10	104.1	7
205	6	98.8	4	3	104.7	2	5	98.6	3	6	104.7	4	7	101.1	5
206										3	98.0	2	2	105.5	2
207	1	99.0	1	1	99.0	1				1	105.0	1	4	105.0	3
208				1	107.0	1				5	105.6	4	1	86.0	1
209							1	102.0	1	3	104.3	2	1	106.0	1
210	1	100.0	1	1	105.0	1	1	105.0	1	1	99.0	1	2	97.5	1
211	1	97.0	1	1	108.0	1	1	100.0	1				1	106.0	1
212	2	103.5	1	1	105.0	1	2	103.0	1	1	105.0	1			
213															
214															
215	1	105.0	1												
216															
217															
218															
219															
220															
221															
222															
223															
Totals	102	98.3	75	130	99.4	96	92	98.0	65	127	98.3	93	133	97.4	102
Movement rate[h]	15.7			13.1			17.4			15.7			14.3		

Appendix Table B2.--Continued.

Site[a]	UT			LT			BY			FR			DC		
Brand[b]	LDLU1			LDTC1			LDTJ1			LDUY1			LDTU1		
	Release date = 13 July (Julian 195) — Recapture information														
Date[c]	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.
184															
185															
186															
187															
188															
189															
190															
191															
192															
193															
194															
195															
196															
197															
198															
199							1	105.0	2						
200	5	105.2	8	3	100.3	5	1	109.0	2	4	105.3	7			
201	10	99.8	8	8	100.6	6	10	99.1	8	14	101.8	11	11	98.9	8
202	9	104.2	5	16	99.6	9	18	100.2	10	8	100.1	4	10	101.0	6
203	5	101.0	4	2	96.0	2	3	103.7	2	10	104.0	8	4	93.5	3
204	23	103.2	16	28	101.3	20	20	104.0	14	24	104.2	17	25	102.4	18
205	20	101.5	13	24	98.7	16	15	101.6	10	17	100.8	11	26	99.3	17
206	9	99.2	7[e]	9	98.8	7[e]	8	102.1	7[e]	9	100.0	7[e]	7	98.4	6[e]
207	7	99.6	6	5	100.4	4	11	104.2	9	8	100.3	7	9	102.6	7
208	16	96.9	12	16	101.8	12	11	102.5	8	21	99.7	16	13	101.1	10
209	12	100.3	8	12	99.3	8	12	97.6	8	9	97.6	6	14	100.2	9
210	13	99.2	8	12	102.1	8	9	102.4	6	15	98.6	9	18	99.4	11
211	9	97.4	6	14	95.0	10	10	101.1	7	11	100.5	8	9	99.2	6
212	10	95.2	6	7	97.6	4	5	100.6	3	9	99.4	5	9	97.7	5
213	8	97.5	5	12	97.3	7	4	101.5	2	4	95.3	2	9	96.4	5
214	4	95.3	3	2	92.0	2	1	98.0	1	1	108.0	1	2	98.0	2
215										1	99.0	1	1	110.0	1
216				1	92.0	1	1	92.0	1				1	88.0	1
217	1	101.0	2												
218				1	100.0	1	1	100.0	1						
219															
220															
221															
222															
223										1	103.0	3			
Totals	161	100.6	117	172	100.1	122	141	102.2	101	166	101.3	123	168	100.5	115
Movement Rate[d]	14.3				14.3			14.3			14.3			14.3	

Site[a]	UT			LT			BY			FR			DC		
Brand[b]	LDLU3			LDTC3			LDTJ3			LDUY3			LDTU3		
	Release date = 14 July (Julian 196) — Recapture information														
Date[c]	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.
184															
185															
186															
187															
188															
189															
190															
191															
192															
193															
194															
195															
196															
197															
198															
199				1	109.0	2	1	95.0	2				3	103.3	5
200	9	105.0	7	10	101.6	8	9	100.2	7	8	103.4	6	8	101.1	6
201	11	103.5	6	11	102.9	6	6	99.2	3	13	101.0	7	14	102.1	8
202	7	99.9	5	7	98.7	5	7	101.6	5	3	102.0	2	5	99.0	4
203	18	102.8	13	22	101.0	16	19	103.8	14	21	102.7	15	28	101.3	20
204	19	101.4	13	27	101.2	18	18	101.8	12	17	101.1	11	23	100.7	15
205	9	102.6	7	11	99.1	9	10	99.5	8	13	101.0	11	11	100.9	9
206	15	102.3	12[e]	8	100.8	7[e]	6	96.7	5[e]	7	101.7	6	12	101.3	10[e]
207	14	102.3	11	18	101.7	14	14	101.6	11	17	99.9	13[e]	25	100.7	19
208	11	100.4	7	15	100.5	10	13	97.9	9	18	100.9	12	13	99.7	9
209	18	100.4	11	19	101.3	12	17	100.2	11	21	99.5	13	21	100.2	13
210	22	98.5	16	21	99.1	15	12	101.3	9	17	96.8	12	18	98.4	13
211	8	97.1	4	11	97.2	6	6	99.5	3	13	99.8	7	15	100.5	8
212	2	94.5	1	6	95.2	4	5	94.8	3	6	98.2	4	7	96.9	4
213				3	103.3	2	3	104.0	2				3	99.0	2
214	2	96.0	2	2	102.0	2	1	100.0	1				1	105.0	1
215							2	96.0	2				1	119.0	1
216				1	111.0	1							1	86.0	2
217	1	98.0	1	1	105.0	1	1	101.0	1				1	88.0	1
218															
219															
220															
221															
222															
223															
Totals	166	101.7	116	194	100.9	138	150	100.8	108	174	99.9	119	210	100.7	150
Movement Rate[d]		14.3			14.3			14.3			13.1			14.3	

Appendix Table B2.--Continued.

	Release date = 15 July (Julian 197)															Release date = 22 July (Julian 204)														
Site[a/]	UT			LT			BY			FR			DC			UT			LT			BY			FR			DC		
Brand[b/]	LDLY1			LDLC1			LDLJ1			LDTY1			LDUC1			LDLY3			LDLC3			LDLJ3			LDTY3			LDUC3		
	Recapture information															Recapture information														
Date[c/]	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.
184																														
185																														
186																														
187																														
188																														
189																														
190																														
191																														
192																														
193																														
194																														
195																														
196																														
197																														
198																														
199																														
200																														
201	5	96.8	4	5	103.4	4	3	102.0	2	5	100.6	4	3	102.0	2															
202	5	100.2	3	3	103.0	2	4	101.5	2	9	100.6	5	15	103.9	8															
203	3	100.7	2	5	103.6	4	11	98.5	8	2	93.0	2	6	101.7	5															
204	22	103.2	16	21	102.5	15	14	101.8	10	20	103.4	14	22	103.6	16															
205	18	101.8	12	14	101.2	9	18	103.6	12	24	99.8	16	36	100.7	24															
206	9	101.0	7	10	101.2	8	9	100.6	7	10	98.0	8	17	100.2	14															
207	5	101.0	4	10	102.1	8	12	98.8	10[g/]	13	99.5	11	15	100.1	12[g/]	1	115.0	1	2	103.0	2	1	107.0	1						
208	16	102.3	12[g/]	18	98.9	14[g/]	10	101.8	8	17	100.2	13[g/]	12	98.1	9	7	103.4	5	7	108.7	5	9	105.4	7	10	105.0	8	12	104.5	9
209	13	100.2	9	11	100.2	7	16	100.7	11	11	99.3	7	13	100.5	9	28	99.1	19	14	98.9	9	6	103.8	4	17	103.0	11	20	100.4	13
210	15	99.4	9	14	96.4	9	12	100.8	8	24	98.9	15	22	99.2	14	25	101.8	16	28	102.5	18	18	100.4	11	23	102.9	14	25	99.8	16
211	14	97.5	10	20	99.8	14	9	99.7	6	12	99.0	9	19	99.3	14	36	99.3	26[g/]	24	100.0	17	24	99.4	17	30	101.6	21[g/]	40	99.5	29
212	18	97.7	10	10	95.3	6	11	97.4	6	13	98.2	7	14	97.7	8	31	100.8	17	33	98.5	18[g/]	20	100.4	11[g/]	27	98.0	15	51	99.0	28[g/]
213	4	98.5	2	9	96.3	5	7	98.7	4	6	98.8	4	8	94.6	5	21	98.0	12	30	97.1	18	30	98.8	18	31	96.5	18	24	97.2	14
214	3	98.0	2	3	97.7	2	4	96.3	3	4	98.0	3	1	100.0	1	14	95.1	12	19	98.7	16	6	93.8	5	11	94.6	9	18	94.8	15
215	1	92.0	1							4	98.3	4	2	93.0	2	2	93.5	2	12	95.3	11	4	95.8	4	7	97.7	6	2	96.0	2
216	1	99.0	1							1	110.0	1	2	95.0	2	3	94.0	3	3	97.0	3	1	93.0	1				4	98.3	4
217	2	92.5	3																			1	101.0	2	2	100.5	3	3	103.3	5
218				1	99.0	1	3	100.3	3				1	106.0	1	2	97.0	2	2	96.0	2	1	95.0	1				2	92.5	2
219																														
220																														
221																						1	103.0	2						
222																									1	105.0	3			
223										1	93.0	3				1	98.0	3				1	100.0	3				1	106.0	3
Totals	154	100.5	107	154	99.8	108	143	101.3	100	176	99.3	126	208	100.5	146	171	99.6	118	174	99.0	119	123	99.3	87	159	100.0	108	202	98.7	140
Movement Rate[h]	14.3			14.3			15.7			14.3			15.7			22.4			19.6			19.6			22.4			19.6		

Appendix Table B2.--Continued.

Release date = 23 July (Julian 205) — Recapture information

Site[a] / Brand[b]	UT LDLI1			LT LDLX1			BY LDLT1			FR LDTX1			DC LDTI1		
Date[c]	Act.[d]	FL[e]	Adj.[f]	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.
207													1	97.0	1
208							2	102.5	2				0	-	0
209	9	100.2	6	6	102.5	4	9	103.2	6	6	98.0	4	9	102.1	6
210	16	101.3	10	21	103.0	13	21	102.4	13	24	101.7	15	21	101.6	13
211	31	100.1	22	25	101.0	18	20	101.1	14	32	101.4	23	24	100.2	17
212	31	98.6	17[g]	35	98.8	19[g]	31	99.9	17[g]	33	101.2	18[g]	38	99.9	21
213	18	98.5	11	33	97.3	19	24	98.8	14	25	95.2	15	50	97.6	29[g]
214	15	95.0	12	14	95.4	12	8	93.8	7	11	95.4	9	27	94.6	22
215	1	100.0	1	8	97.5	7	8	98.0	7	8	93.4	7	5	100.0	5
216	4	97.5	4	5	100.2	5	3	97.0	3	5	99.2	5	3	94.0	3
217	0	-	0	0	-	0	3	92.3	5	3	101.3	5	3	95.0	5
218	2	100.5	2	4	99.8	4	2	100.0	2	5	98.2	6	1	98.0	1
219	0	-	1	0	-	2	0	-	6	0	-	3	0	-	0
220	0	-	0	0	-	0	2	99.0	10						
221	1	96.0	2	1	98.0	2									
222															
223															
Totals	128	99.0	88	152	99.2	105	133	100.0	106	152	99.2	110	182	98.5	123
Movement Rate[h]	22.4			22.4			22.4			22.4			19.6		

Release date = 24 July (Julian 206) — Recapture information

Site[a] / Brand[b]	UT LDLI3			LT LDLX3			BY LDLT3			FR LDTX3			DC LDTI3		
Date[c]	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.	Act.	FL	Adj.
207															
208															
209	1	105.0	1	4	116.5	3	1	110.0	1	1	115.0	1	4	105.5	3
210	15	106.5	9	12	108.0	8	14	105.7	9	10	108.2	6	20	105.1	13
211	17	104.4	12	18	104.8	13	23	103.2	16	28	105.5	20	28	104.2	20
212	33	102.3	18	30	103.0	17	28	101.6	16	35	101.3	19	62	102.1	34[g]
213	38	98.0	22[g]	24	101.3	14[g]	34	98.9	20[g]	30	100.6	18[g]	38	100.9	22
214	17	98.0	14	13	99.8	11	11	100.3	9	17	100.0	14	23	98.6	19
215	12	101.0	11	3	96.3	3	3	102.7	3	9	96.2	8	10	101.5	9
216	5	101.0	5	6	103.0	6	3	98.7	3	8	96.8	8	6	97.7	6
217	2	94.5	3	1	108.0	2	1	103.0	2	1	108.0	2	2	96.0	3
218	7	100.1	8	4	101.3	4	9	99.4	10	3	100.7	3	4	98.3	4
219	0	-	4	0	-	4	0	-	5	0	-	2	0	-	2
220	0	-	0	1	109.0	5							0	-	0
221	1	95.0	2	1	100.0	2							1	103.0	2
222															
223															
Totals	148	101.1	109	117	102.9	92	127	101.5	94	142	101.8	101	198	102.1	137
Movement Rate[h]	22.4			22.4			22.4			22.4			26.2		

a/ Site codes are: UT = Upper Turbine, LT = Lower Turbine, BY = Bypass, FR = Frontroll, DC = Downstream Control (mid-river), SC = Shoreline Control (downstream), MC =Mid-river control release of a group which had unknown mortality prior to release (not used in analysis).

b/ Brand codes are: 1st. two characters, RD = right dorsal position, LD = left dorsal position; 3rd and 4th characters = brand symbol; 5th character = brand rotation where 1 = upright and 3 = symbol rotated 180 degrees.

c/ Date are in Julian format (leap year 1988).

d/ Act. = Actual daily purse seine catch of the particular mark group.

e/ FL = Daily mean fork length (mm). Note: The FL listed under totals for each mark is the mean fork length for the mark group +3 days of the date that the median fish was captured.

f/ Adj. = Adjusted daily purse seine catch obtained by standardizing the daily purse seine effort to 10 sets for Julian dates 184-223; a total of 4 marked fish were captured subsequent to day 223 and were omited from the analysis.

g/ Day that the median fish was captured (adjusted effort).

h/ Movement rate (Km/d) = 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 B3.--Daily beach seine recoveries and mean lengths at Jones Beach for marked fish groups released during the Bonneville Dam survival study, 1988.

	Upper turbine			Lower turbine			Bypass			Frontroll			Downstream control		
Release date 27 June (Julian 179)															
Brand[a]	RDLU1			RDTC1			RDTJ1			RDUY1			RDTU1		
	Jul.[b]	n[c]	FL[d]	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL
	184	1	70.0	187	1	94.0	185	1	84.0	185	1	94.0	190	1	91.0
	187	4	91.5	189	1	96.0	187	4	92.8	187	1	87.0	191	1	87.0
	189	1	93.0	197	2	92.5	191	2	96.0	189	1	98.0	194	1	87.0
	200	3	103.3	200	2	101.5	196	1	87.0	190	1	98.0	196	1	95.0
				201	1	95.0	197	1	106.0	198	2	99.5	197	1	98.0
							200	2	100.0	200	3	96.7	198	1	95.0
							201	1	106.0	204	1	93.0	199	1	108.0
													201	1	97.0
Total[e]		9	89.4		7	95.8		12	96.0		10	95.2		8	94.8
Release date 28 June (Julian 180)															
Brand	RDLU3			RDTC3			RDTJ3			RDUY3			RDTU3		
	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL
	184	1	94.0	187	1	94.0	187	1	93.0	187	1	90.0	186	1	83.0
	187	2	89.5	189	1	95.0	191	1	85.0	195	1	99.0	189	1	87.0
	194	1	88.0	195	1	95.0	200	2	102.0	197	1	102.0	195	2	92.0
	199	1	98.0	197	1	90.0	201	1	96.0	200	3	98.0	197	1	96.0
	200	1	104.0	199	1	96.0							198	3	97.3
				200	2	100.0							200	1	104.0
Total		6	94.7		7	95.0		5	94.0		6	97.2		9	93.2
Release date 29 June (Julian 181)															
Brand	RDLY1			RDLC1			RDLJ1			RDTY1			RDUC1		
	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL
	187	1	95.0	186	1	101.0	187	5	91.8	189	1	100.0	187	1	90.0
	189	1	84.0	190	1	99.0	189	1	94.0	195	1	90.0	191	1	84.0
	197	1	90.0	195	1	90.0	190	2	92.0	196	2	89.0	194	1	94.0
	198	1	106.0	197	2	97.5	191	2	89.0	197	1	96.0	195	1	93.0
	200	2	106.5	198	1	99.0	197	1	93.0	198	1	111.0	199	1	94.0
				199	1	89.0	199	2	89.5	199	2	100.5	200	8	101.8
				200	4	98.5	200	3	97.3	200	4	103.3	201	1	98.0
				204	1	93.0									
Total		6	96.3		12	95.9		16	93.2		12	98.5		14	93.5
Release date 30 June (Julian 182)															
Brand	RDLY3			RDLC3			RDLJ3			RDTY3			RDUC3[f]		
	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL
	194	1	86.0	189	1	93.0	187	2	91.0	189	1	94.0	187	1	93.0
	195	2	87.5	191	2	90.0	195	1	95.0	195	1	80.0	194	1	96.0
	198	3	93.0	195	2	87.5	196	1	102.0	197	2	93.0	195	3	103.3
	200	5	102.0	196	1	94.0	197	1	107.0	198	1	88.0	197	1	97.0
	201	2	98.5	197	2	97.5	198	1	99.0	200	4	101.0	198	1	95.0
				198	1	99.0	200	3	100.0				200	5	101.0
				200	3	101.7									
Total		13	93.4		12	94.7		9	99.0		9	91.2		12	97.6
Release date July 1 (Julian 183)															
Brand	RDLI1			RDLX1			RDLT1			RDTX1			RDTI1		
	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL
	189	1	92.0	190	1	95.0	189	1	92.0	190	1	81.0	196	1	120.0
	191	1	88.0	195	4	92.3	195	2	93.0	194	1	85.0	197	2	99.5
	197	2	87.5	196	1	101.0	197	3	96.3	196	1	103.0	198	1	86.0
	198	2	97.0	197	3	96.7	198	1	103.0	197	2	92.5	199	1	95.0
	199	1	102.0	200	3	102.7	200	2	98.0	200	6	103.0	200	5	97.4
	200	4	107.3	201	1	108.0							201	1	106.0
Total		11	95.6		13	99.3		9	103.0		11	92.9		11	100.6

Appendix Table B3.--continued.

	Upper turbine			Lower turbine			Bypass			Frontroll			Downstream control		
Release date July 2 (Julian 184)															
Brand	RDLI3[a]			RDLX3			RDLT3			RDTX3			RDTI3		
	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL
	195	1	86.0	190	1	100.0	190	1	92.0	190	1	95.0	195	1	92.0
	196	1	102.0	195	2	91.0	191	1	97.0	195	3	100.0	196	2	97.0
	197	2	88.0	197	1	104.0	197	3	97.7	196	2	92.5	197	6	100.7
	198	2	99.0	198	5	98.8	200	4	103.5	197	2	98.5	198	3	94.3
	199	1	106.0	200	4	104.3				198	1	101.0	199	2	102.0
	200	4	106.8	201	3	107.7				199	1	99.0	200	8	101.0
				203	1	111.0				200	3	97.7			
Total		11	98.0		17	102.4		9	97.6		13	97.7		22	97.8
Release date July 13 (Julian 195)															
Brand	LDLU1			LDTC1			LDTJ1			LDUY1			LDTU1		
	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL
	200	1	101.0	201	1	100.0	200	2	107.0	200	1	104.0	203	2	96.5
	201	1	98.0	211	2	91.0	201	1	104.0	225	1	101.0	211	1	104.0
	211	1	90.0				228	1	105.0	231	1	109.0			
Total		3	96.3		3	95.5		4	105.3		3	104.7		3	100.2
Release date July 14 (Julian 196)															
Brand	LDLU3			LDTC3			RDTJ3			LDUY3			LDTU3		
	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL
	208	1	98.0	220	1	110.0	203	1	98.0	201	1	109.0	208	1	100.0
	211	1	98.0	225	1	106.0							228	1	108.0
				231	1	105.0									
Total		2	98.0		3	107.0		1	98.0		1	109.0		2	104.0
Release date July 15 (Julian 197)															
Brand	LDLY1			LDLC1			LDLJ1			LDTY1			LDUC1		
	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL
	211	1	105.0		(none)		208	1	84.0		(none)		203	1	106.0
													208	1	82.0
Total		1	105.0		0	---		1	84.0		0	---		2	94.0
Release date July 22 (Julian 204)															
Brand	LDLY3			LDLC3			LDLJ3			LDTY3			LDUC3		
	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL
	220	1	98.0	220	2	95.5	220	2	90.5	215	3	100.0	215	1	90.0
							224	1	104.0	220	1	96.0	224	4	95.0
										224	1	102.0	228	1	114.0
										228	2	103.5	231	1	96.0
Total		1	98.0		2	95.5		3	97.3		7	100.4		7	98.8
Release date July 23 (Julian 205)															
Brand	LDLI1			LDLX1			LDLT1			LDTX1			LDTI1		
	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL
	220	1	93.0	225	1	98.0	215	1	100.0	220	1	97.0	211	1	98.0
	224	1	105.0	231	2	110.5	224	1	109.0	224	1	100.0	225	1	94.0
	225	1	100.0							228	2	101.0	228	1	104.0
	228	1	109.0												
Total		4	101.8		3	104.2		2	104.5		4	99.3		3	98.7
Release date July 24 (Julian 206)															
Brand	LDLI3			LDLX3			LDLT3			LDTX3			LDTI3		
	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL	Jul.	n	FL
	224	2	96.5	211	1	94.0	215	2	105.0	215	1	105.0	215	1	90.0
	228	2	110.0	228	1	122.0	225	1	106.0	225	2	98.0	220	1	100.0
	229	2	104.5	229	1	110.0				228	1	100.0	225	1	110.0
										229	1	103.0	228	2	104.0
Total		6	103.7		3	108.7		3	105.5		5	101.5		5	101.0

Appendix Table B3.--continued.

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[a] Brand codes: 1st. two characters, RD = right dorsal position, LD = left dorsal position; 3rd. and 4th. characters = brand symbol 5th. character = brand rotation, where 1 = symbol upright and 3 = symbol rotated 180 degrees.

[b] Jul. = Julian date of recovery at Jones Beach.

[c] n = number recovered.

[d] FL = daily mean fork length (mm).

[e] Total = total beach seine catch (under n); mean fork length for the entire season (under FL).

[f] Control release made on the shoreline at Hamilton boat ramp site.

[g] This group not used in analysis due to unquantified mortality prior to release; released with the downstream controls.

Appendix Table B4.--Bimodal distribution of Jones Beach recoveries for subyearling chinook salmon released during the first six days of the Bonneville Dam survival study, 1988.

	Recoveries (% of release)									
	Upper Turbine		Lower Turbine		Bypass System		Frontroll		Downstream Control	
	Mode		Mode		Mode		Mode		Mode	
Release date	I[c]	II[d]	I	II	I	II	I	II	I	II
27 June	0.39	0.08	0.37	0.11	0.31	0.10	0.39	0.10	0.35	0.08
28 June	0.37	0.11	0.43	0.13	0.32	0.06	0.30	0.09	0.30	0.15
29 June	0.34	0.13	0.30	0.15	0.31	0.10	0.34	0.14	0.38	0.16
30 June	0.29	0.19	0.30	0.16	0.33	0.15	0.32	0.16	0.29	0.17
1 July	0.35	0.16	0.28	0.16	0.28	0.19	0.33	0.19	0.29	0.23
2 July	----[e]		0.26	0.22	0.21	0.12	0.30	0.17	0.27	0.24
Mean[f]	0.35	0.13	0.32	0.16	0.29	0.12	0.33	0.14	0.31	0.17
No.	526	199	587	281	534	220	593	258	570	312

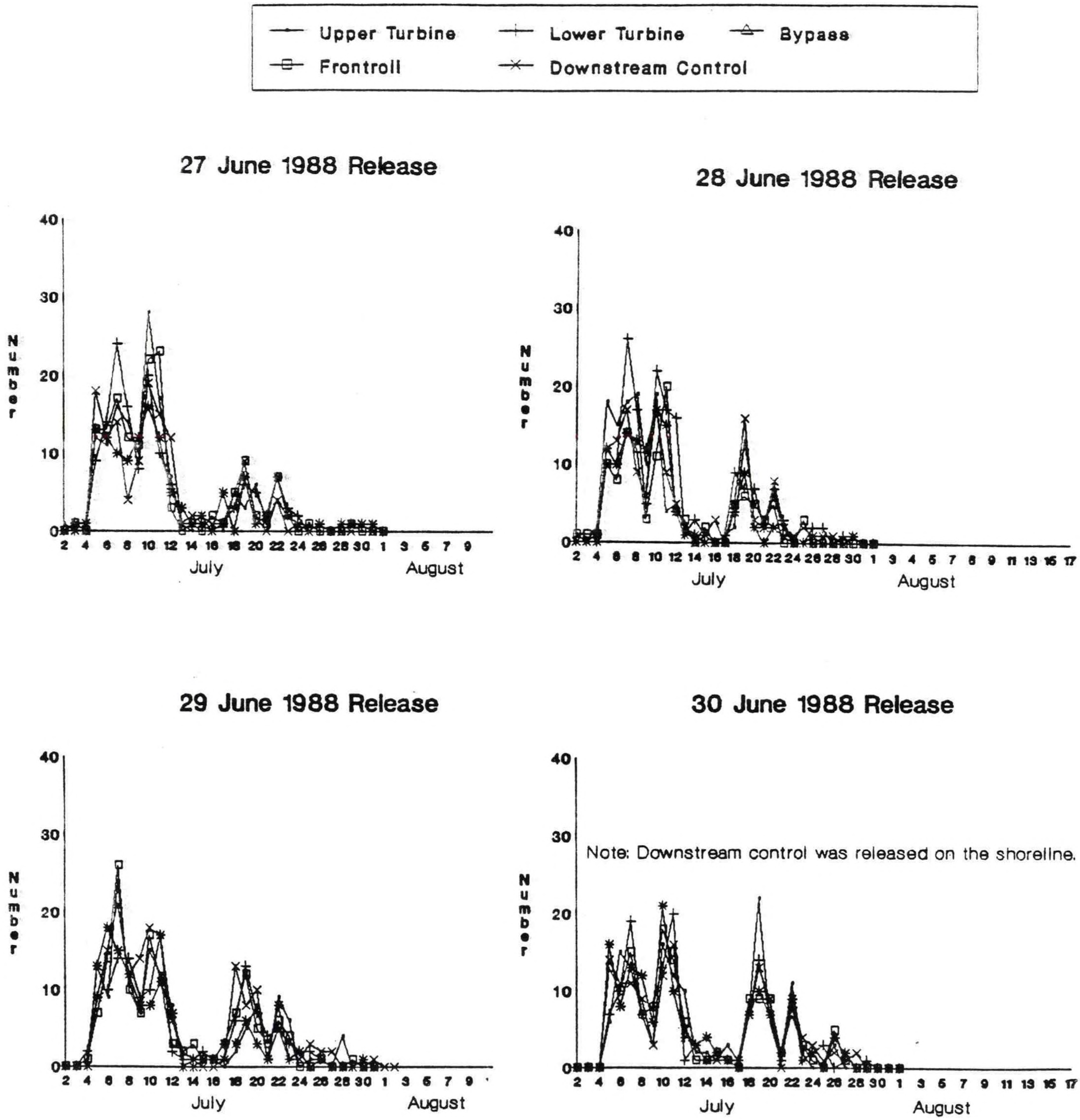
[c] Mode I = recovery through 16 July.

[d] Mode II = recovery subsequent to 16 July.

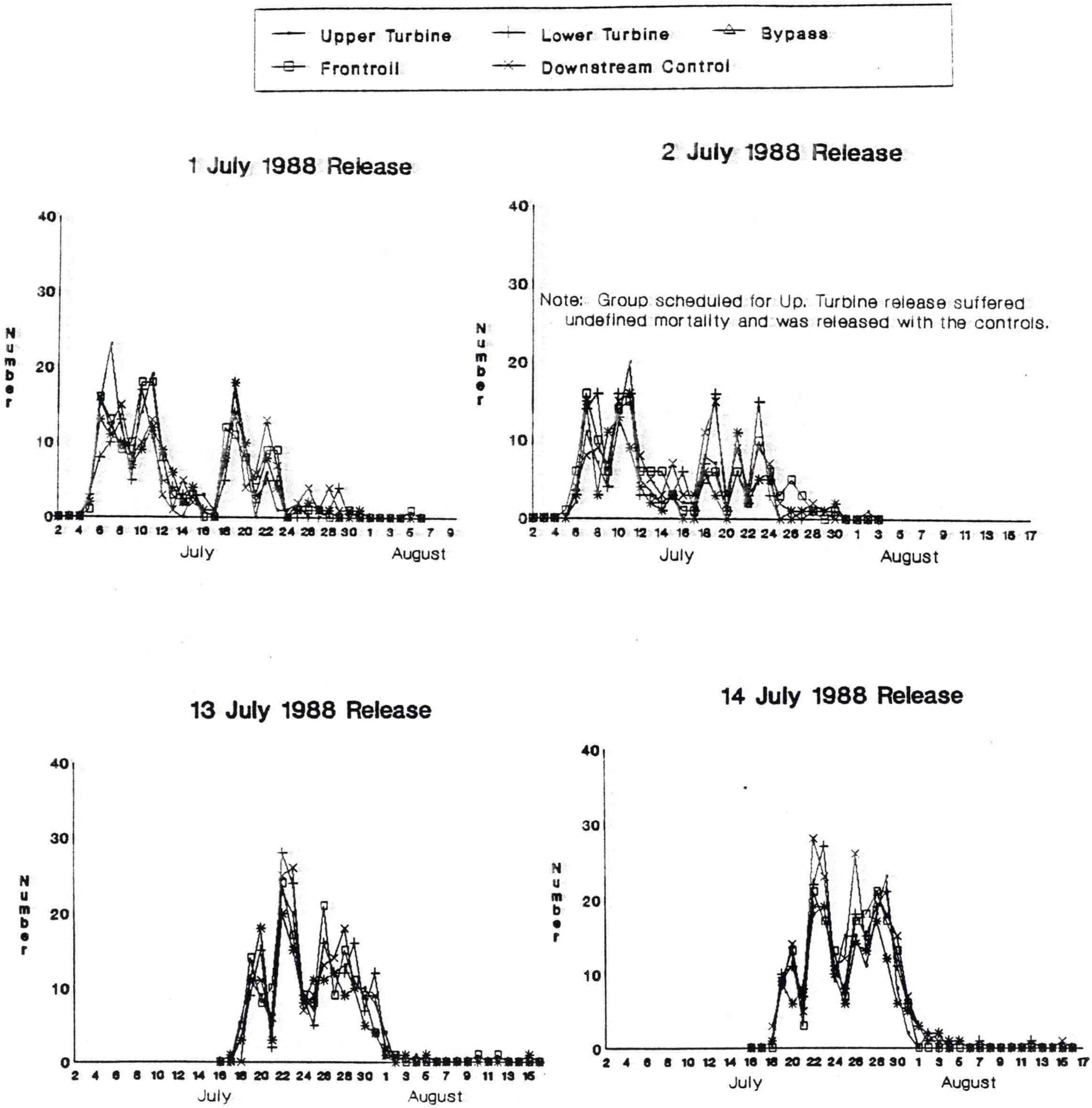
[e] Mortality occured at release; data not used in analysis.

[f] Weighted by day.

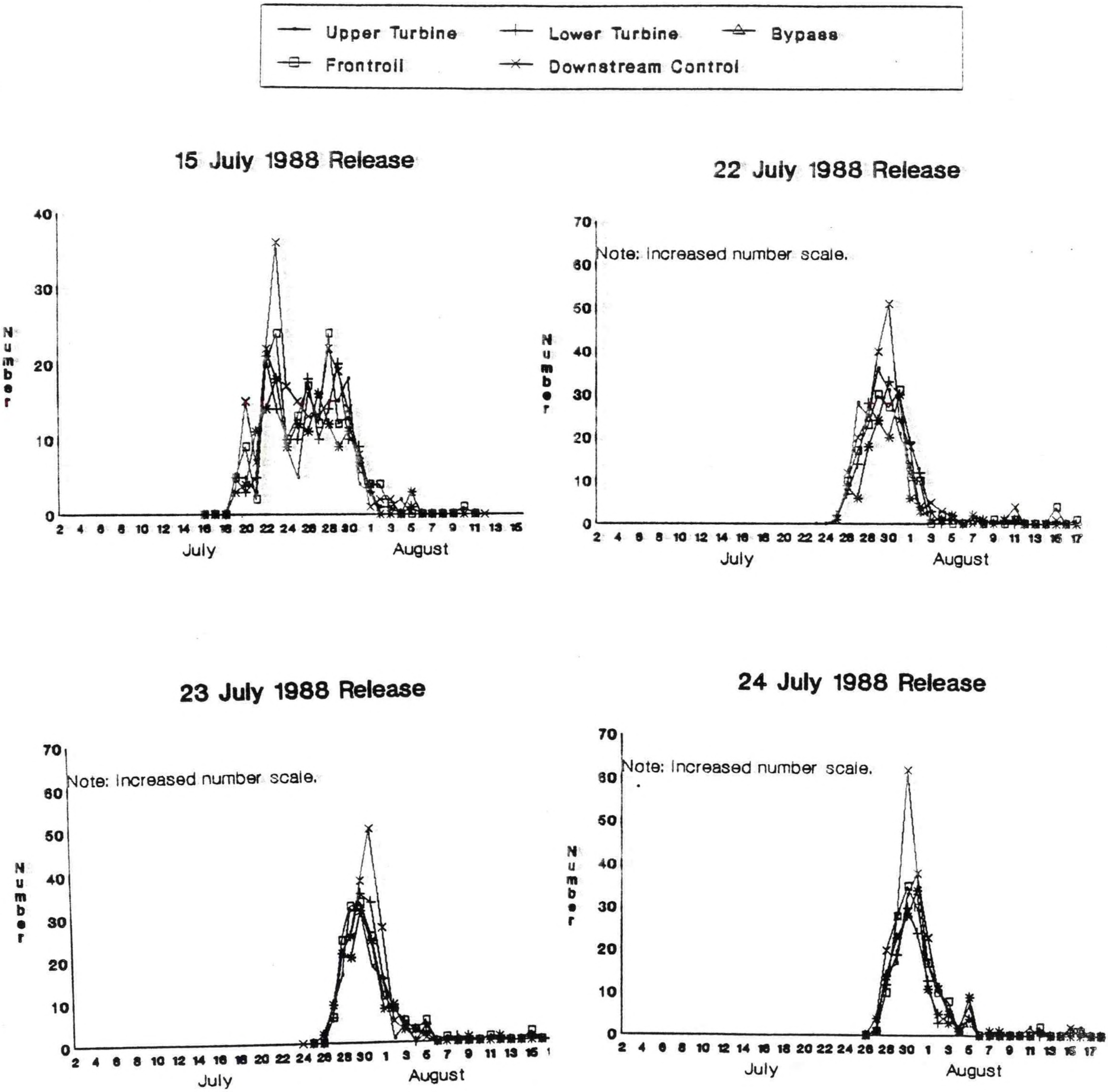
APPENDIX C: Supplemental figures used in analysis.



Appendix Figure C1.--Daily catches by treatment group of subyearling chinook salmon released on 27, 28, 29, and 30 June 1988; catches are purse seine plus beach seine observed catch.

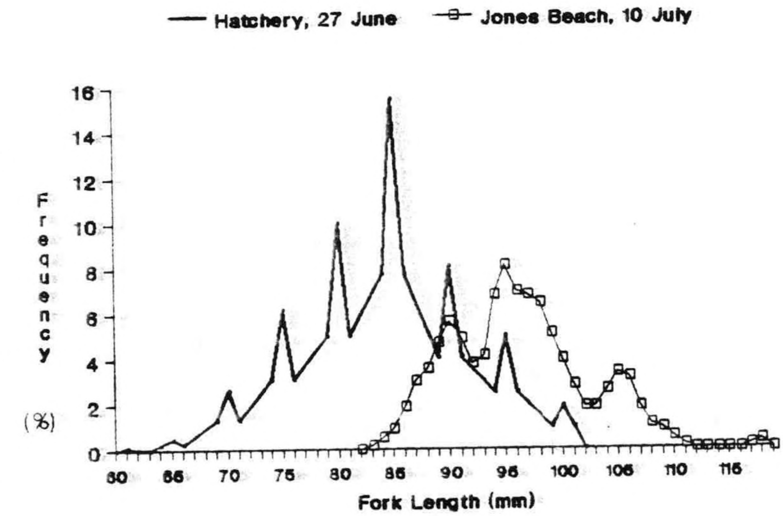


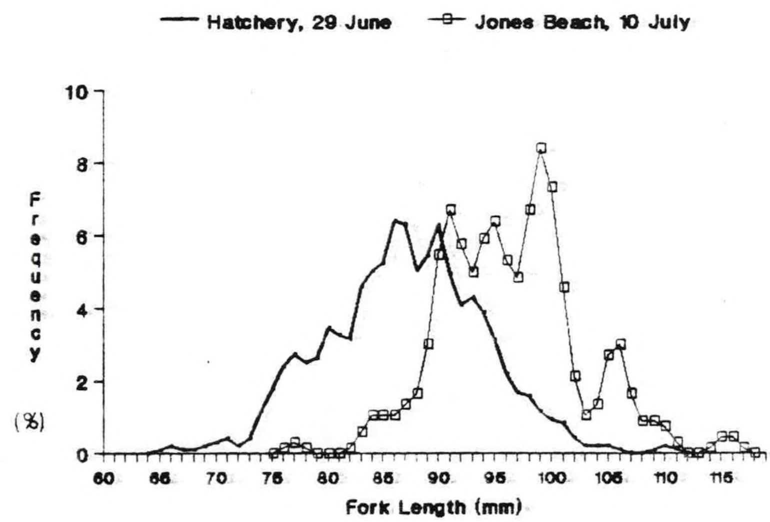
Appendix Figure C2.--Daily catches by treatment group of subyearling chinook salmon released on 1, 2, 13, and 14 July 1988; catches are purse seine plus beach seine observed catch.



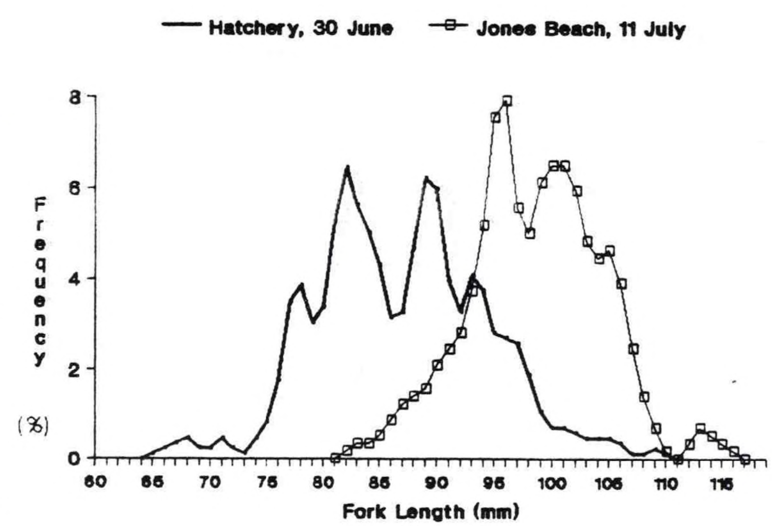
Appendix Figure C3.--Daily catches by treatment group of subyearling chinook salmon released on 15, 22, 23, and 24 July 1988; catches are purse seine plus beach seine observed catch.

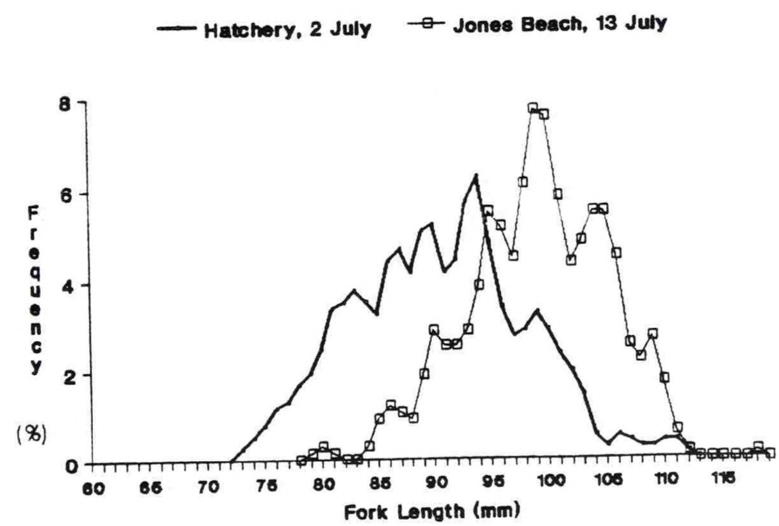
Length Distributions at the Hatchery and after Migration to the Estuary, 1988





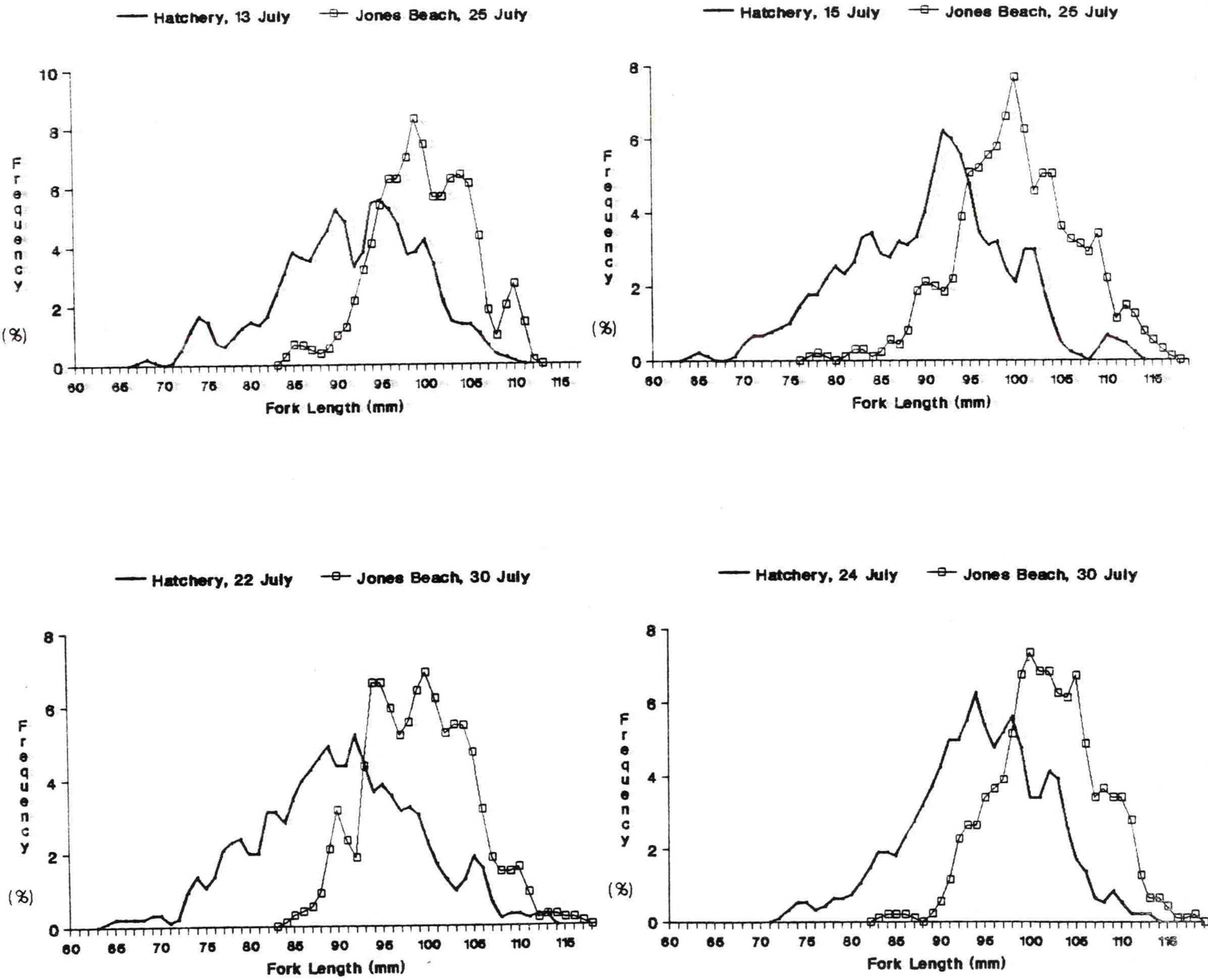
● Hatchery data rounded to nearest 5 mm.



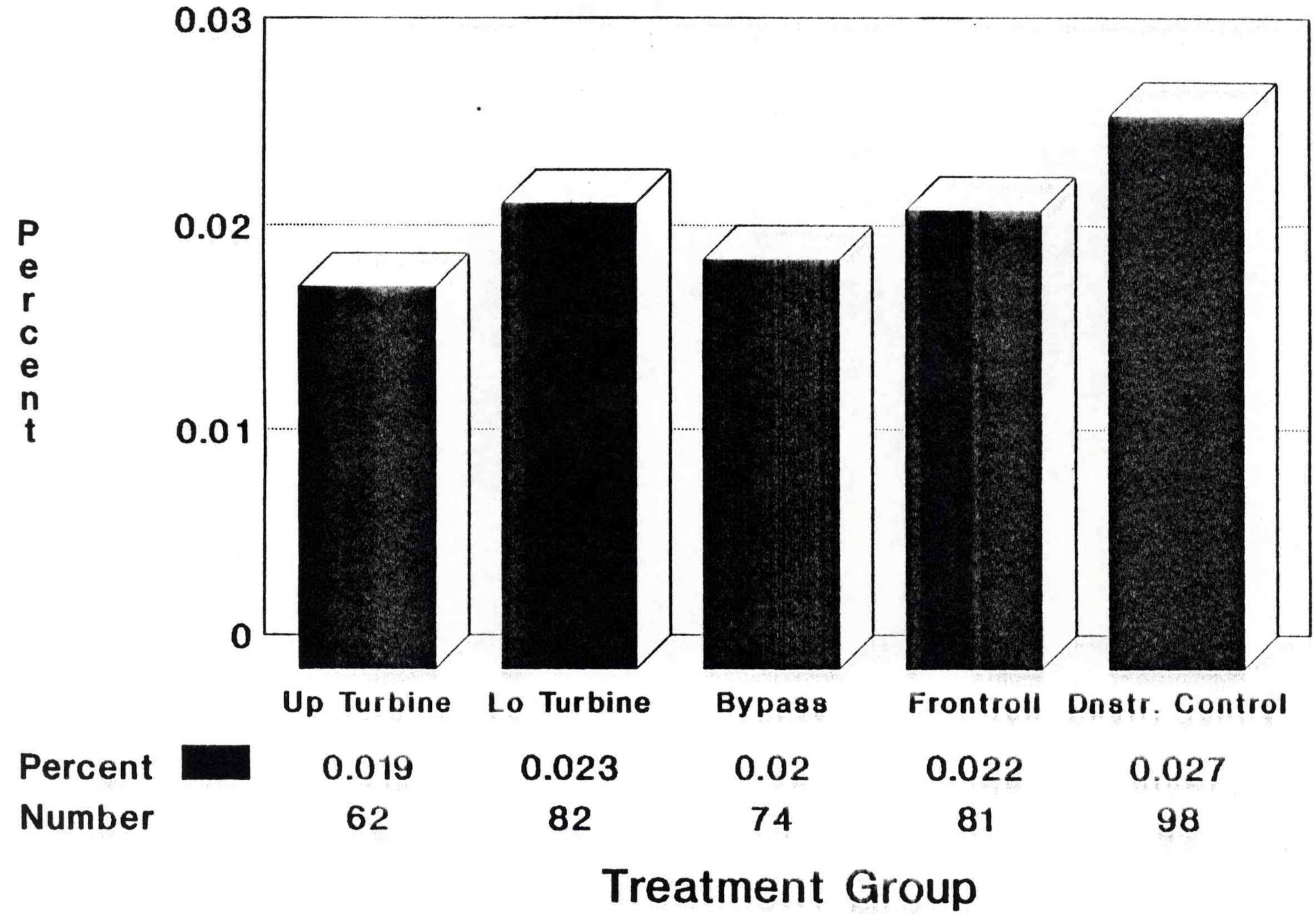


Appendix Figure C4.--Fork length distributions of juvenile subyearling chinook salmon at release and after recovery in the estuary, 1988. Release date and median date of recovery are indicated; data for additional release groups are provided in the report.

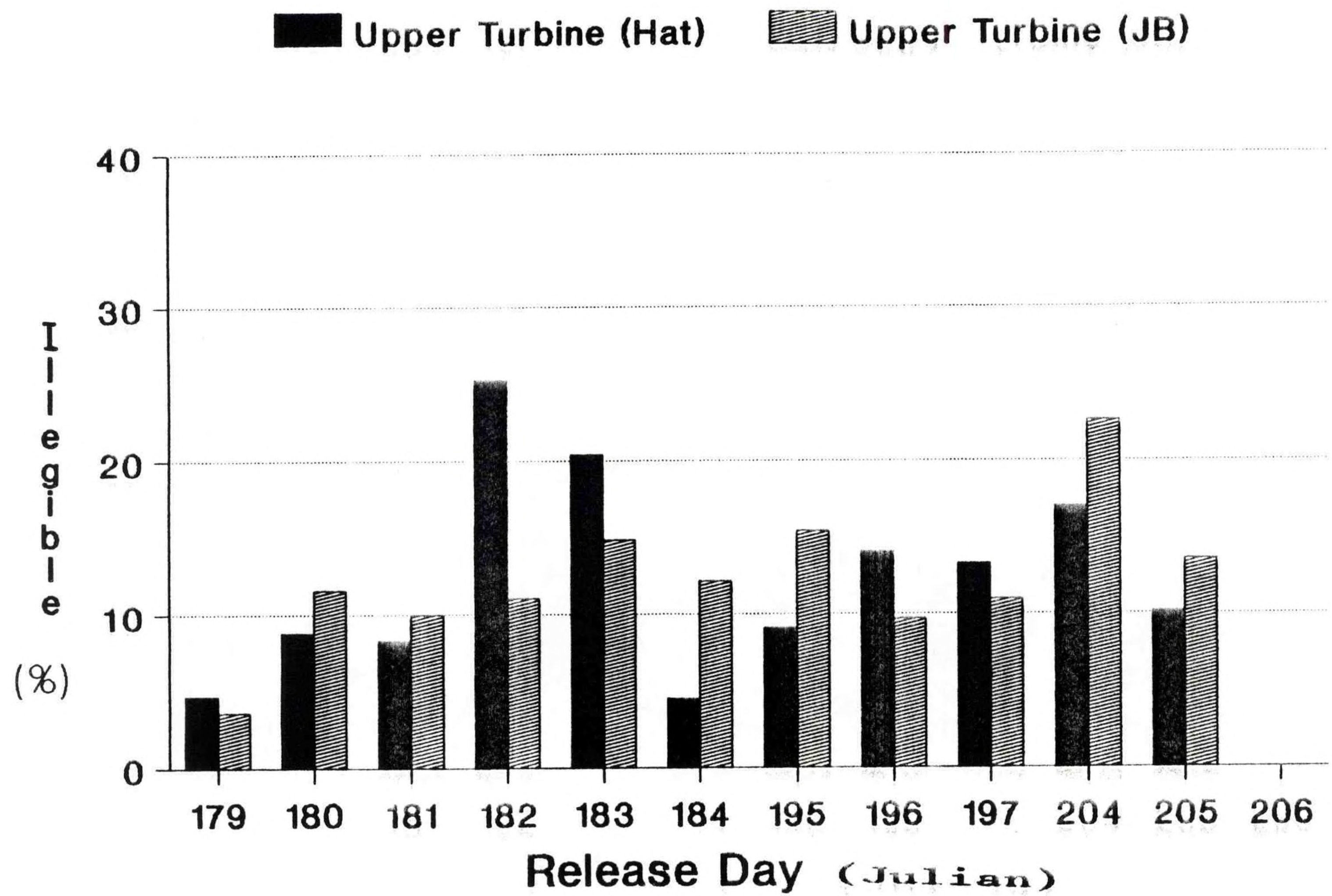
Length Distributions at the Hatchery and after Migration to the Estuary, 1988



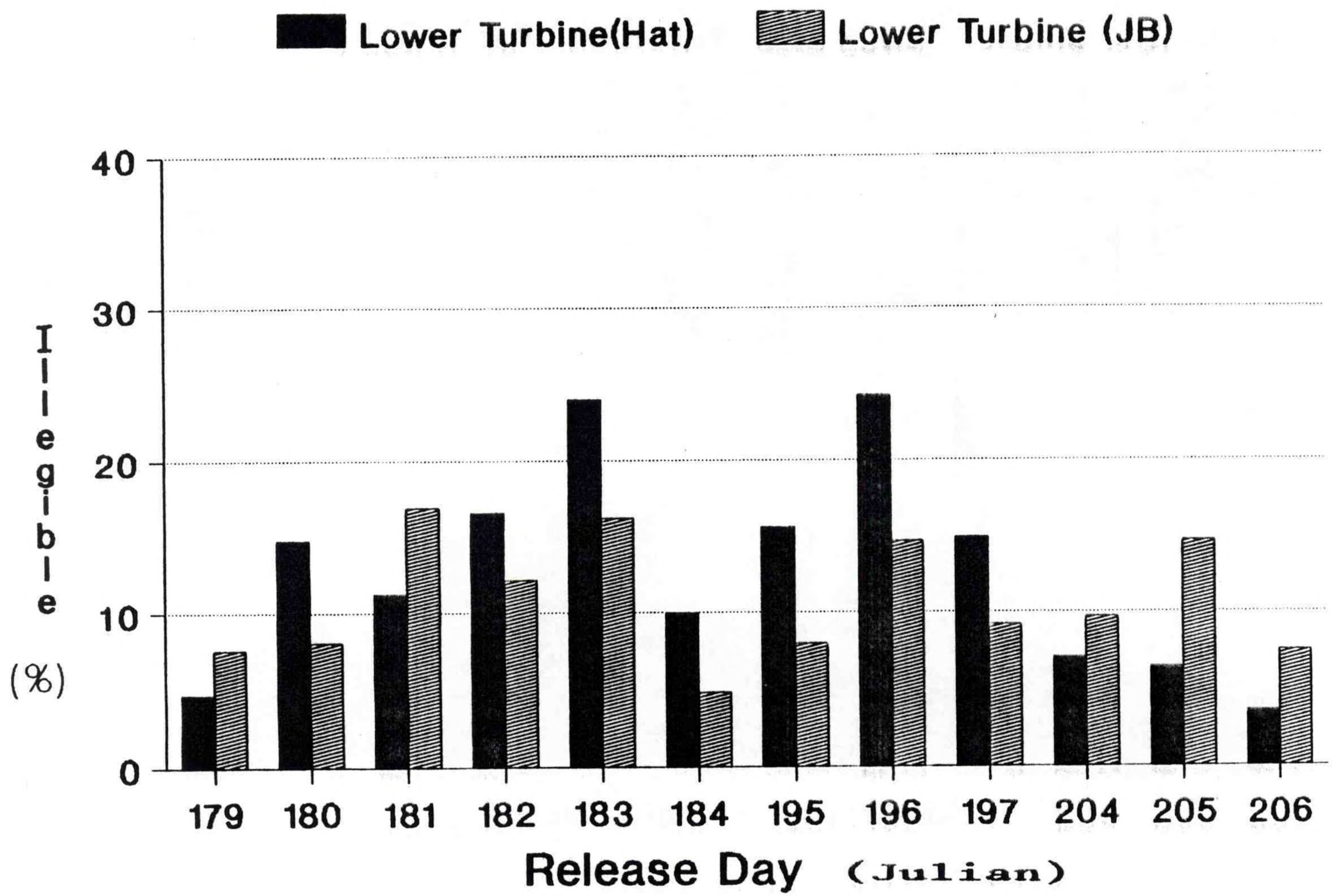
Appendix Figure C5.--Fork length distributions of juvenile subyearling chinook salmon at release and at recovery in the estuary, 1988. Release date and median date of recovery are indicated; data for additional release groups are provided in the report.



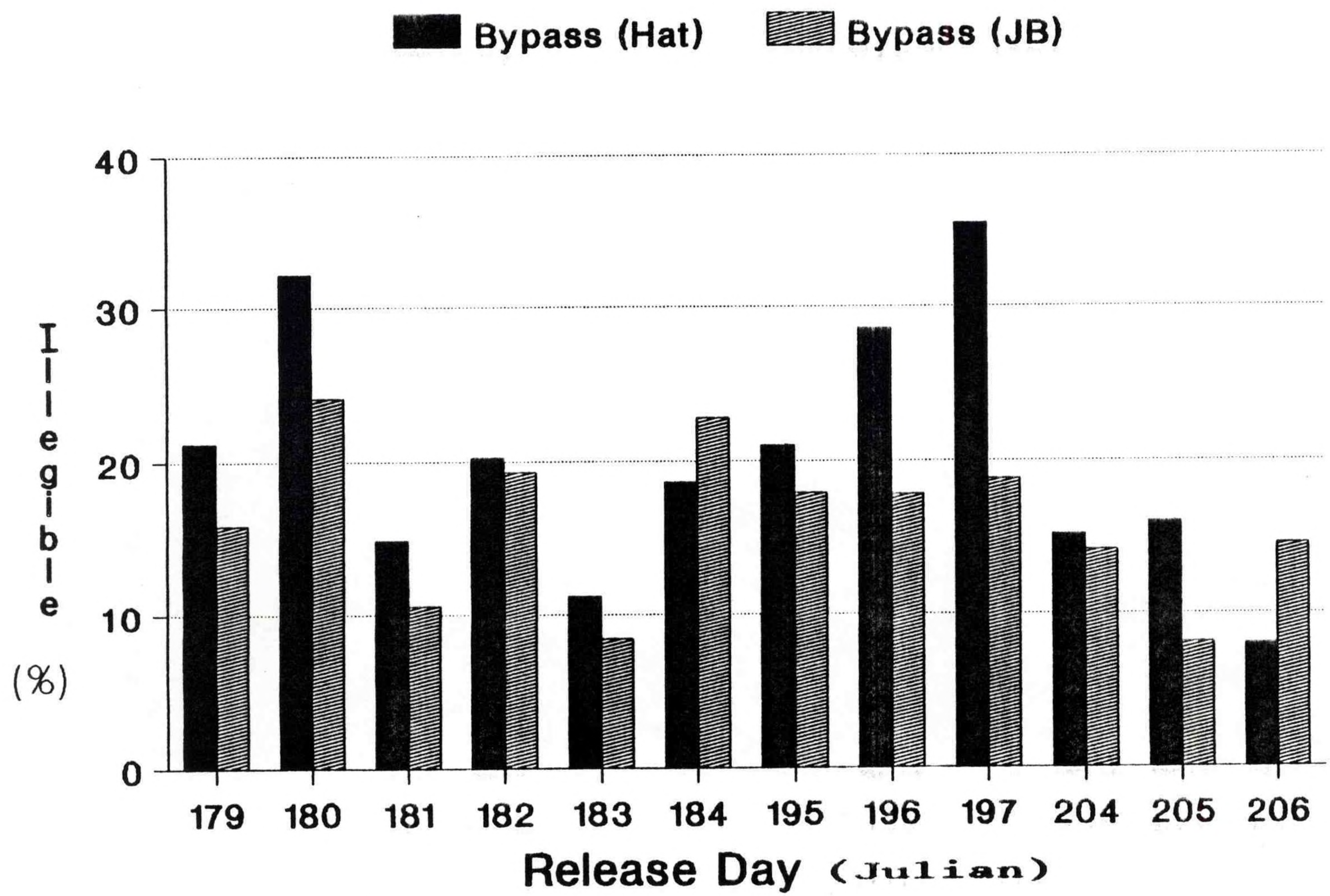
Appendix Figure C6.--Mean recovery percentage by beach seine for treatment groups of subyearling chinook salmon following migration to the estuary, 1988.



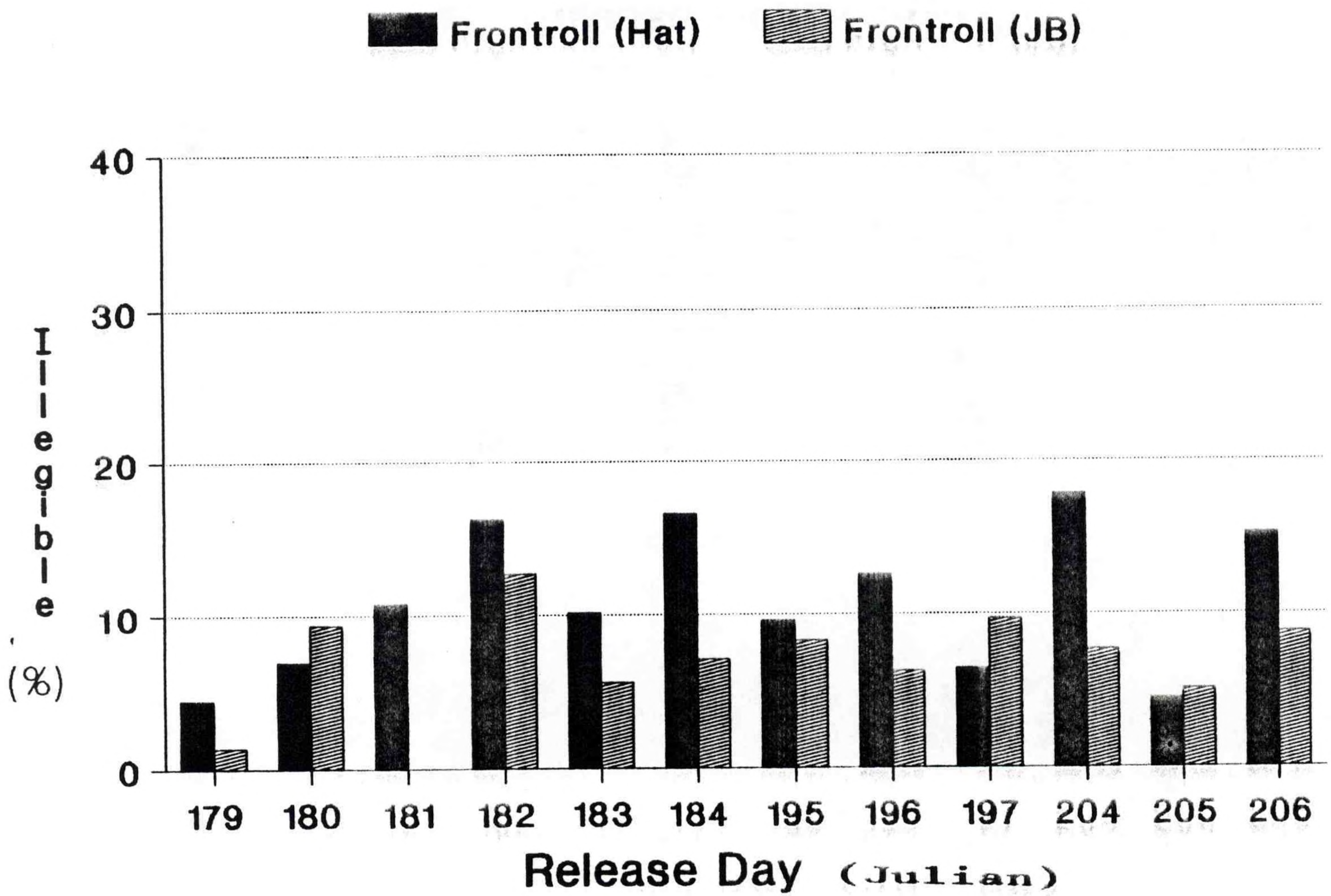
Appendix Figure C7.--Percentages of illegible brands in upper turbine release groups held in the hatchery (Hat) for 30 days or following migration to Jones Beach (JB), 1988.



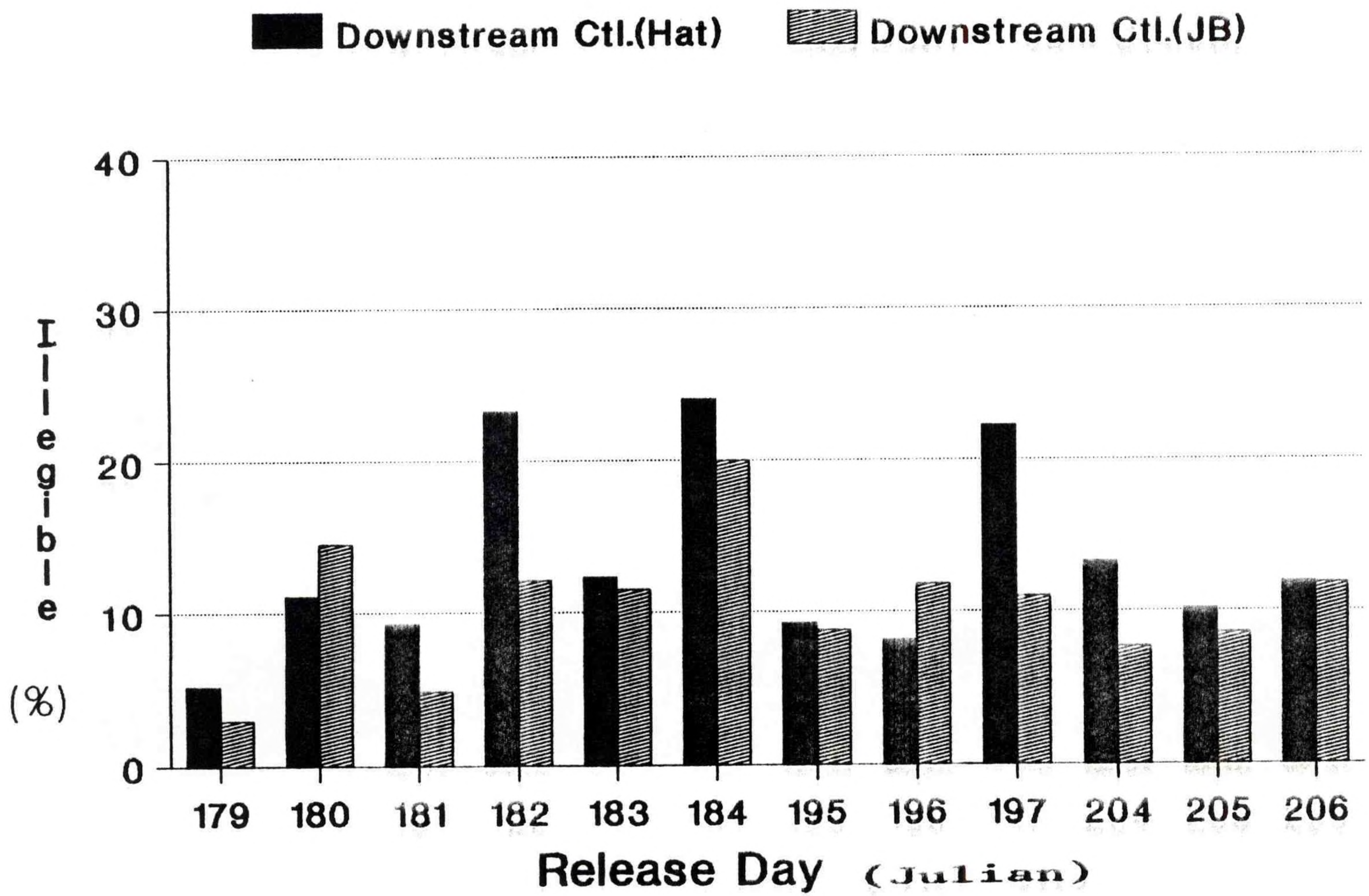
Appendix Figure C8.--Percentages of illegible brands in lower turbine release groups held in the hatchery (Hat) for 30 days or following migration to Jones Beach (JB), 1988.



Appendix Figure C9.--Percentages of illegible brands in bypass system release groups held in the hatchery (Hat) for 30 days or following migration to Jones Beach (JB), 1988.



Appendix Figure C10.--Percentages of illegible brands in frontroll release groups held in the hatchery (Hat) for 30 days or following migration to Jones Beach (JB), 1988.



Appendix Figure C11.--Percentages of illegible brands in downstream control release groups held in the hatchery (Hat) for 30 days or following migration to Jones Beach (JB), 1988.

APPENDIX D: Statistical analysis.

Appendix D. Statistical evaluation of juvenile catch results, Bonneville Dam survival study, 1988.

Part I. Chi-square goodness of fit analysis was used to evaluate differences among observed purse seine recoveries (Appendix Table B2) through time for different treatment groups released on the same day (Sokal and Rohlf 1981). A nonsignificant result indicates that there was equal probability of capture at Jones Beach for each treatment group (i.e. that the groups were adequately mixed).

H_o: There was homogeneity between recovery distributions of treatments.

The data were analyzed in a contingency table where the rows were recovery days and the columns were the five release locations (treatments). Each cell in the table was the number of recoveries for a particular treatment on a particular day. The days were combined when all cell numbers were less than five because chi-squared contingency analysis requires a minimum expected value of 5 in most cells. The cells that were combined usually had very little data in them (a lot of l's and 0's), and the treatments appeared to be quite similar in those cells. The test evaluates the magnitude of the relative deviation of the observed cell counts with the expected cell counts under the hypothesis for $\alpha = 0.05$. There are (t-1)*(d-1) degrees of freedom (df) for the test, where t = number of treatments and d = number of days.

Block	Date	Chi-sq.	df	p-value	Result
1	27 June	48.10	40	0.178	non-significant
2	28 June	60.23	40	0.021	significant
3	29 June	44.53	44	0.449	non-significant
4	30 June	40.87	44	0.607	non-significant
5	1 July	44.24	40	0.297	non-significant
6	2 July	42.11	36	0.223	non-significant
7	13 July	41.49	52	0.852	non-significant
8	14 July	30.63	48	0.976	non-significant
9	15 July	58.54	52	0.248	non-significant
10	22 July	37.25	28	0.113	non-significant
11	23 July	39.10	28	0.079	non-significant
12	24 July	28.45	28	0.441	non-significant

The 12 tests independently examined the same hypothesis, therefore their results can be combined to get an overall test. This combined significance test assume that twice the negative natural logarithm of a p-value has a chi-square distribution with two df and the sum of independent chi-squares is again a chi-square with df equal to the sum of the individual df's (Fisher 1944). The test is:

p-value	-2ln(p-value)	df
0.178	3.452	2
0.021	7.726	2
0.449	1.601	2
0.607	0.998	2
0.297	2.428	2
0.223	3.001	2
0.852	0.320	2
0.976	0.049	2
0.248	2.789	2
0.113	4.361	2
0.079	5.077	2
0.441	1.637	2
Total Chi-square =	33.440	24, p-value=0.100

The results of this analysis indicates there is a lack of evidence to reject the null hypothesis, therefore, we conclude that the release groups are mixed upon arrival at Jones Beach.

Part II. Analyses of treatment effects with Analysis of Variance (ANOVA) using a randomized block design where each release day was considered a block (Sokal and Rohlf 1981).

A. Estuarine recovery percentages: Full data set using all release days, all release groups, purse seine and beach observed catch.

H_o:Mean recovery percents for each treatment are equal.

ANOVA Table

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	SIGN
Treatment	0.1059632	4	0.0264908	9.674172	0.0000
Block	0.1378411	11	0.0125310	4.576196	0.0001
Error	0.117747	43	0.0027383		
Total	0.3615513	58			

Note: there was one missing observation (Upper Turbine group on 2 July), therefore degrees of freedom (df) were reduced by one to accommodate the estimated value.

The H_o is rejected at $\alpha = 0.05$.

The treatment means are ranked using Fisher's Protected Least Significance (FPLSD) test (Petersen 1985).

$$FPLSD = T_{(\alpha=0.05)(df)}\sqrt{2(MSE)/r} = 0.0432$$

where T = Student's Tabular T value
MSE = Mean square error term in the ANOVA table
r = number of blocks

Any pair of treatment means differing by more than FPLSD were judged to be significant. The following shows these differences in a rank order, where underlined means are not significantly different at $\alpha = 0.05$

Treatment Mean (%)				
Downstream Control	Lower Turbine	Front-roll	Upper Turbine	Bypass System
0.57	0.51	0.51	0.50	0.44

B. Subset of observed estuarine recovery percentages--data from 2 July removed (upper turbine released was canceled).

H_o:Mean recovery percents for each treatment are equal.

ANOVA Table

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	SIGN
Treatment	0.0915727	4	0.0228932	8.015394	0.0001
Block	0.1181501	10	0.0118150	4.13669	0.0006
Error	0.1142461	40	0.0028562		
Total	0.3239689	54			

The H_o is rejected at $\alpha = 0.05$.

FPLSD = $T_{(\alpha=0.05)(df)}\sqrt{2(MSE)/r} = 0.0461$

Treatment Mean (%)				
Downstream Control	Lower Turbine	Front-roll	Upper Turbine	Bypass System
0.57	0.51	0.51	0.50	0.45

C. Subset of observed estuarine recovery percentages--data from 30 June removed (control group was released on the shoreline).

H_o:Mean recovery percents for each treatment are equal.

ANOVA Table

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	SIGN
Treatment	0.119221	4	0.0298052	11.165624	0.0000
Block	0.131829	10	0.0131829	4.938568	0.0001
Error	0.1041057	39	0.0026694		
Total	0.3551557	53			

Note: there was one missing observation (upper turbine group on 2 July), therefore df were reduced by one to accommodate the estimated value.

The H_o is rejected at $\alpha = 0.05$.

FPLSD = $T_{(\alpha=0.05)(df)}\sqrt{2(MSE)/r} = 0.0445$

Treatment Mean (%)				
Downstream Control	Lower Turbine	Front-roll	Upper Turbine	Bypass System
0.58	0.52	0.51	0.50	0.43

D. Subset of observed estuarine recovery percentages--data from 30 June and 2 July removed.

H_o:Mean recovery percent for each treatment are equal.

ANOVA Table

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	SIGN
Treatment	0.1042098	4	0.0260525	9.268402	0.0000
Block	0.1096358	9	0.0121818	4.33377	0.0007
Error	0.101192	36	0.0028109		
Total	0.3150376	49			

The H_o is rejected at $\alpha = 0.05$.

FPLSD = $T_{(\alpha=0.05)(df)}\sqrt{2(MSE)/r} = 0.0481$

Treatment Mean (%)				
Downstream Control	Lower Turbine	Front-roll	Upper Turbine	Bypass System
0.59	0.52	0.52	0.50	0.44

E. Purse seine recovery data standardized to a constant ten set per day effort (Appendix Table B2).

H_o:Mean recovery percent for each treatment are equal.

ANOVA Table

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	SIGN
Treatment	0.0378295	4	0.0094574	6.270029	0.0005
Block	0.0671663	11	0.0061060	4.048161	0.0004
Error	0.0648588	43	0.0015083		
Total	0.1698546	58			

Note: there was one missing observation (upper turbine group on 2 July), therefore df were reduced by one to accommodate the estimated value.

The H_o is rejected at $\alpha = 0.05$.

$FPLSD = T_{(\alpha=0.05)(df)}\sqrt{2(MSE)/r} = 0.0320$

Treatment Mean (%)				
Downstream Control	Front-roll	Lower Turbine	Upper Turbine	Bypass System
0.39	0.36	0.35	0.35	0.31